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Electric Road Systems: a solution for the future?

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www.piarc.org

Electric Road Systems: a solution for the future?

Content of this presentation:

- PIARC Special Project – ERS: a solution for the future?
- ERS: technical aspects.
- ERS: development challenges and opportunities.

Electric Road Systems: a solution for the future?

PIARC Special Project – ERS: a solution for the future?

Electric Road Systems: a solution for the future?

PIARC Special Project

PIARC Special Project mechanism aims to respond to emerging issues in the road sector within a limited time frame (12 months).

Special Project on ERS was proposed by Sweden and it was actively supported by Portugal and United Kingdom.

The following PIARC Technical Committees were involved:

- TC D.1 **Road asset management**.
- TC B.4 **Freight transport**.
- TC E.2 **Environment Considerations in Road Projects and Operations**.

Selected external consultant: **Transport Research Laboratory (TRL).**

Electric Road Systems: a solution for the future?
PIARC Special Project

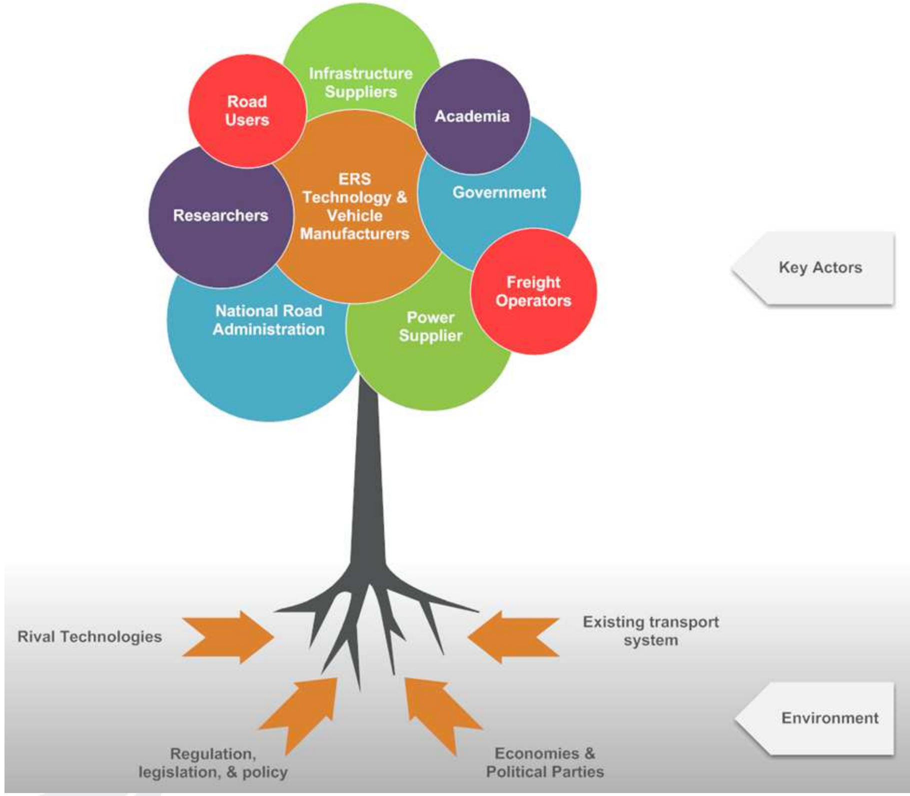
The report offers a **global perspective** on ERS both geographically and across road sector including perspective of NRAs, researchers, ERS developers, freight industry, vehicles manufacturers, energy providers…

The study had three interlinked phases:

- **State-of-the-art** review and stakeholder engagement,
- Technological and implementation **feasibility assessment**,
- Exploration of the **business model** for ERS uptake.

Conclusions and recommendations.

The study includes the perspective of **HIC and LMIC**, and a review of stationary charging and other alternatives to fossil fuel propulsion technologies.



Electric Road Systems: a solution for the future?
PIARC Special Project

Section 1 provides an introduction and background to the project, outlines the project objectives, and sets out the scope of the report.

Section 2 describes the methodology and approach employed and the activities undertaken by the project team.

Section 3 presents the findings from Task 1. This includes a description of the various types of ERS concepts, and the results from the literature search, stakeholder survey and interviews, and the LMIC workshop.

Section 4 presents the findings from Task 2 which is an evaluation of ERS technologies and their perceived advantages and disadvantages.

Section 5 presents the business model from a road owner's perspective. This includes the results from a UK-focussed cost-benefit analysis and discussion on how it could vary for different countries and scenarios.

Section 6 presents the project conclusions based on the work undertaken on Tasks 1, 2 and 3.

Section 7 presents recommendations for PIARC, road administrations and LMIC based on the conclusions found from this study.

Appendix A provides a copy of the survey questions and interview topics.

Appendix B contains details of the case studies reviewed in this project.

Appendix C compares the advantages and disadvantages of the different ERS technologies.

Appendix D provides a risk assessment of each ERS concept.

Appendix E summarises the findings from the LMIC workshop.

Appendix F describes the cost-benefit analysis model used in Task 3.

Appendix G presents summary sheets for each ERS concepts.

Appendix H is a bibliography for further study of ERS.

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PIARC Special Project

ERS concepts

Environmental and social impacts

Cost-benefit analysis

Stakeholders perspective

Risk assessment

Types of business models

Technical feasibility and challenges

Future ERS

Case studies

Rival and complementary technologies

Impact on infrastructure and maintenance

Implementation in LMIC

Comparison of different ERS technologies

Regulatory framework and standards

Conclusions

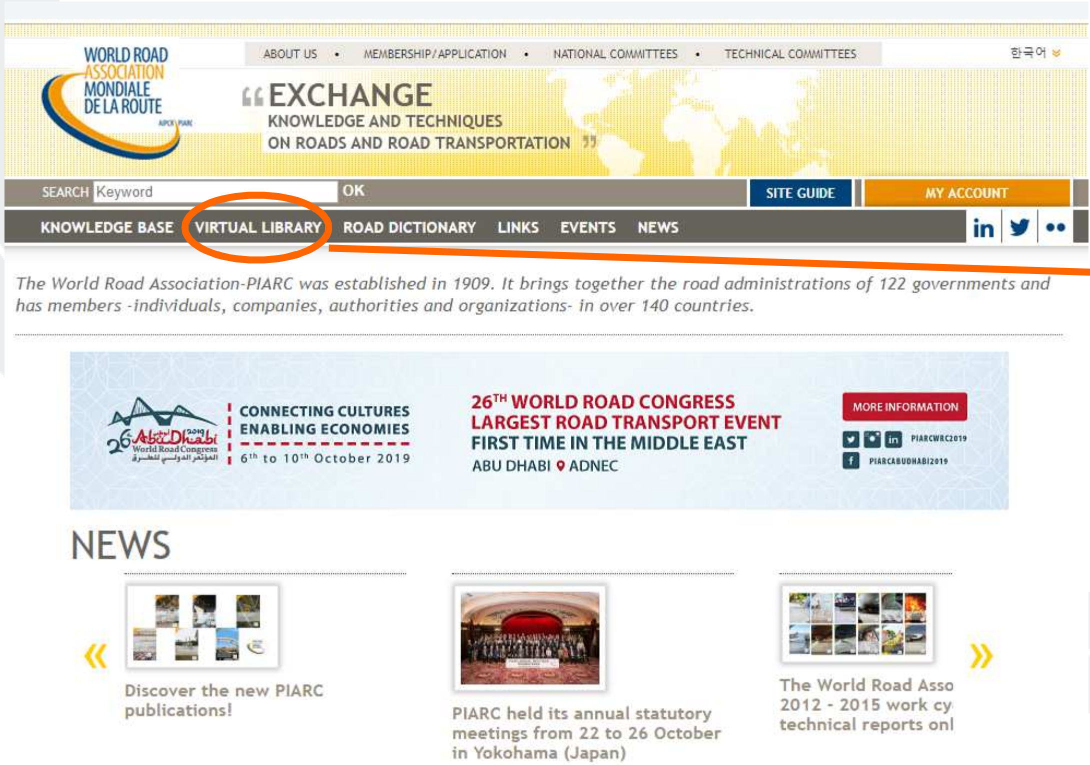
Recommendations

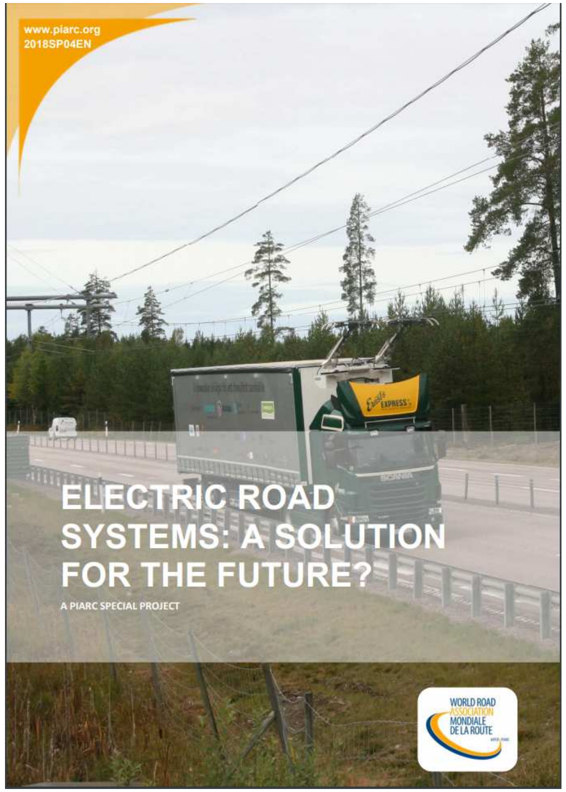
Safety and security

Electric Road Systems: a solution for the future?
PIARC Special Project

The report is available for free at www.piarc.org in English version (free registration).

French and Spanish versions will be available in the following weeks.





Electric Road Systems: a solution for the future?

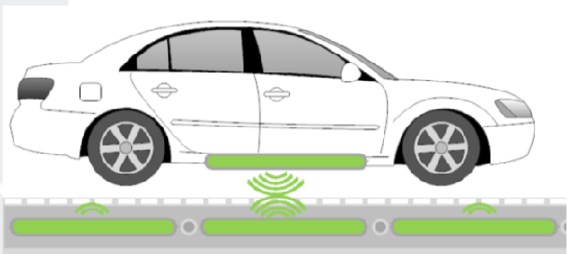
ERS: technical aspects

Electric Road Systems: a solution for the future?

Types of ERS

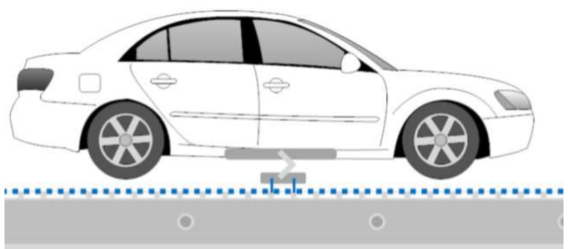
Definition: *A system capable of charging electric vehicles **dynamically on-route at traffic speeds***

Types: *Three of technology (similar functions, very different designs & markets)*



Inductive (Wireless)

Qualcomm, BOMBARDIER, Oak Ridge National Laboratory, SAET, INTIS, Politecnico di Torino, Dongwon OLEV, Electreon, circe, The University of California 1868, Momentum Wireless Power



Conductive Rail

HONDA, ELWAYS, ALSTOM, ELONROAD, VOLVO

Conductive Overhead

SIEMENS, SCANIA

+ many other collaborators

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Inductive (Wireless) Overview

KAIST / Dongwon OLEV public road demonstration, South Korea

Trenched copper/litz coils with a ferrite core and concrete foundations with asphalt overlay

FABRIC closed track demonstration, Italy

Trenched copper litz coils sealed in hot pour bitumen adhesive

Roadside Requirements:

- grid connection transformer, inverter, cabling
- power electronics, switching boxes between coils
- high capacity battery & compensation
- V2I and I2G communications system
- monitoring unit, cooling unit
- safety/security infrastructure

Many different designs, dimensions, power requirements, construction depths and techniques, essentially no interoperability between concepts

Electric Road Systems: a solution for the future?

Conductive Rail Overview

Channelled rail embedded in pavement, flush with surface

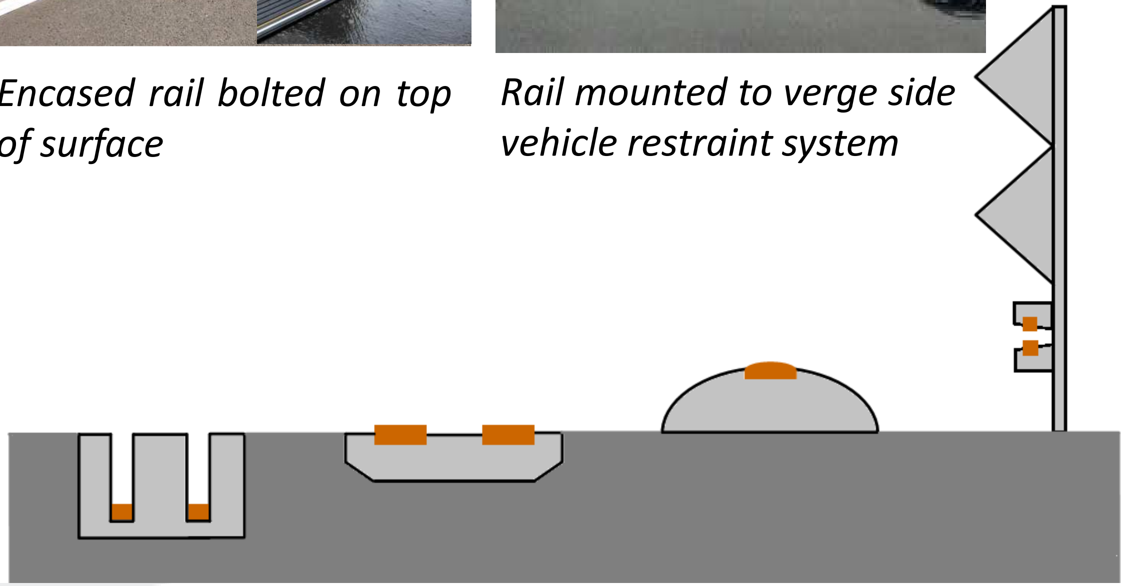
Flat rail embedded in pavement

Encased rail bolted on top of surface

Rail mounted to verge side vehicle restraint system

Roadside Requirements:

- available grid connection
- transformer, rectifier, power electronics
- switching units, low/high voltage cabling
- I2G/V2I communications systems (DSRC/wifi tags, etc.)
- High-capacity storage batteries, air conditioning unit
- remote sensing ICT
- safety/security infrastructure



Electric Road Systems: a solution for the future?

Conductive Overhead Overview

Sweden, Germany, USA demonstrations underway

Verge side (option for median masts with arms spanning both directions)

Copper cables fed through hangers and tensioned

Rectifier substation and power electronics required every 1-4km

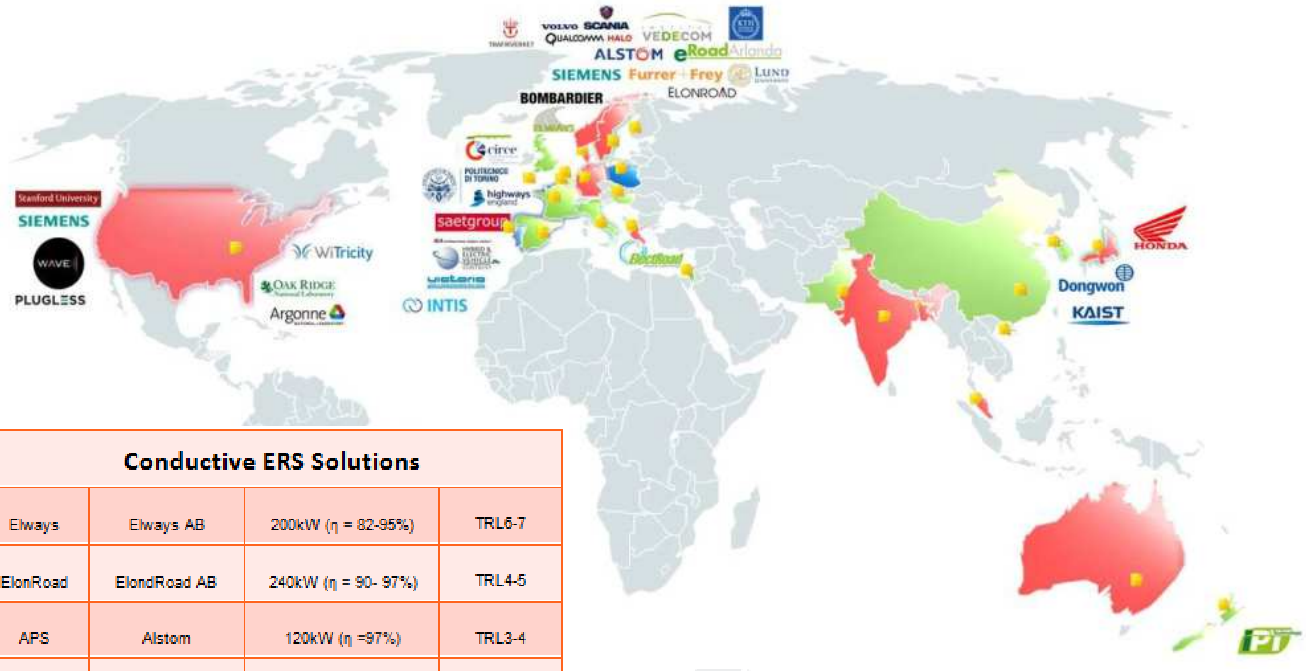
Roadside Requirements:

- grid connection, transformer, medium voltage switchgear, rectifiers, controlled inverter
- V2I and I2G communications system
- monitoring unit, cooling unit
- safety/security infrastructure
- verge side vehicle restraint system

Many of the same infrastructural components used as in rail. Requires VRS along entire installation. Lengthy construction times

Electric Road Systems: a solution for the future?
State of Development

Inductive ERS Solutions			
OLEV	Dongwon Inc.	15-85kW (η =71-91%)	TRL9
CWD	Politecnico di Torino (FABRIC)	20kW (η =75-85%)	TRL3-4
IPV	SAET Group (FABRIC)	20kW (η =70-80%)	TRL3-4
PRIMOVE	Bombardier	200kW (η =69-90%)	TRL5-6
HALO	Qualcomm (FABRIC)	20kW (η = 80%)	TRL3-4
WPT	Oak Ridge National Laboratory	20kW (η =88-95%)	TRL3-4
INTIS	Integrated Infrastructure Solutions	60kW (η = 88-93%)	TRL3-4
Electroad	Electreon Inc.	20kW (η = 88-90%)	TRL5-6
Victoria	CIRCE	50kW (η =92%)	TRL 7-8
Momentum Charger	Momentum Dynamics	300kW (η = 95%)	TRL3-4
WPT	University of California	200kW (η = 60%)	TRL3-4
+ 19 static inductive systems			



Conductive ERS Solutions			
Elways	Elways AB	200kW (η = 82-95%)	TRL6-7
ElonRoad	ElondRoad AB	240kW (η = 90- 97%)	TRL4-5
APS	Alstom	120kW (η =97%)	TRL3-4
HPDC	Honda R&D	450kW (η = 95%)	TRL4-5
eHighway	Siemens AG	500kW (η = 80-97%)	TRL7-8
+ 8 static conductive systems (non-cabled)			

Interactive version: here

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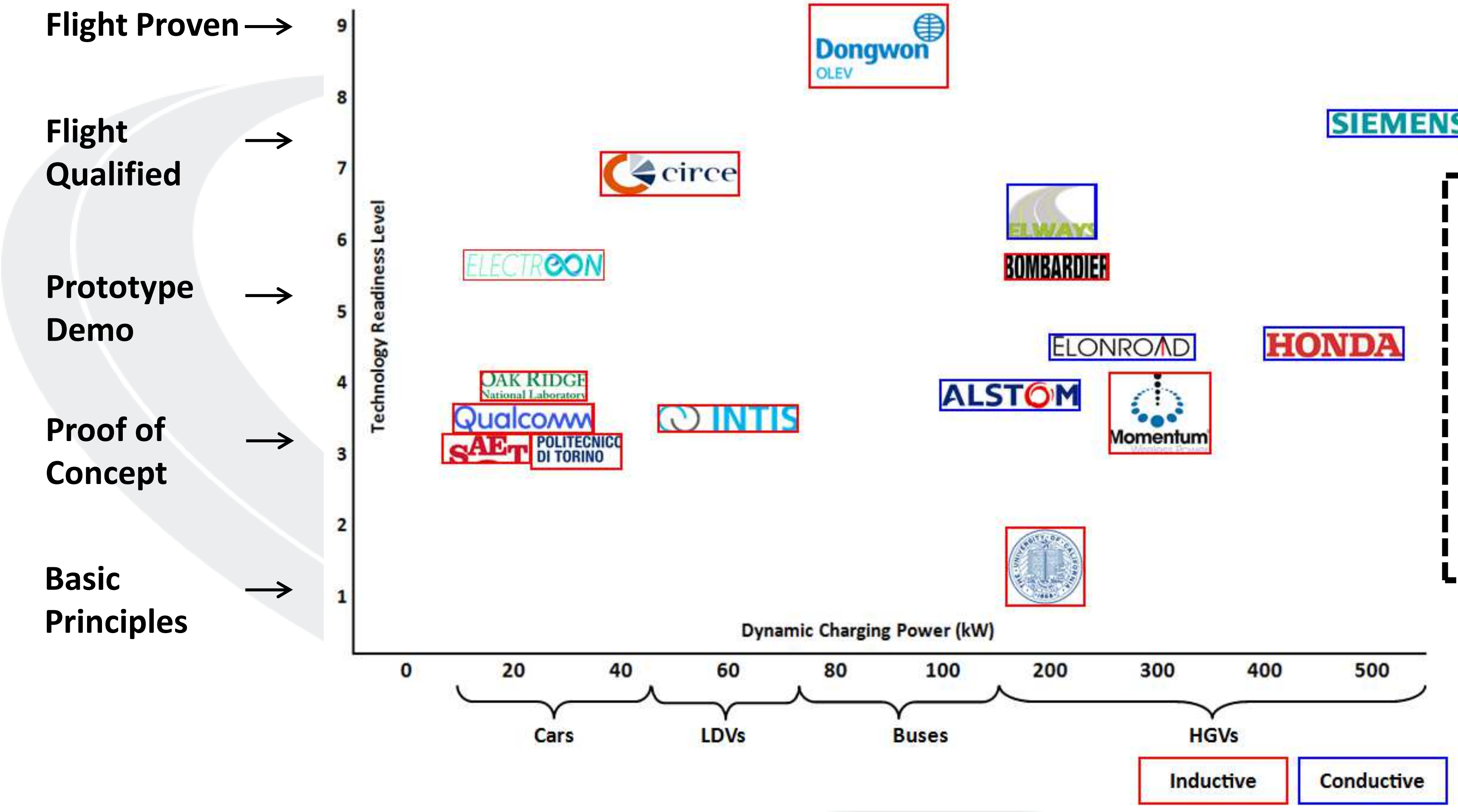
Electric Road Systems: a solution for the future?
State of Development



Time to Deployment/TRL (Stakeholder Estimates)

Inductive: 6 Yrs, TRL5

Rail: 6 Yrs, TRL5

Overhead: 5 Yrs, TRL6

Electric Road Systems: a solution for the future?

ERS: development challenges and opportunities.

Electric Road Systems: a solution for the future?
Opportunities

Understanding the ERS market:

Freight industry (HGVs) and public transport operators (buses) are likely first adopters of ERS.

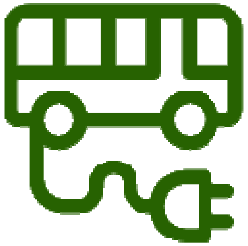
Private **passenger cars** (LVs) are likely to charge at home if possible, as this is likely to be cheaper and more convenient than public charging facilities.

Private cars would only need ERS under very specific circumstances (over 90% of the rides are short and urban), while **autonomous shared cars** could need furthermore ERS.

Static charging facilities could be a significant competitor technology for LVs (less relevant to HGVs and buses) but **they also play a complementary role on the EV uptake**.

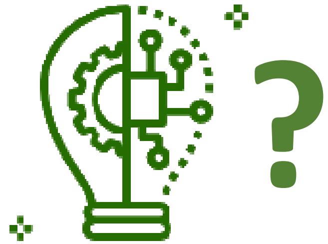
Adapting vehicles to ERS has a user cost => Only worth it if significant use: private cars?

KEY QUESTION: Who are we designing the ERS for? A system designed solely for HGVs may look very different to a system aimed a more mixed user group both technically and in terms of the business model.

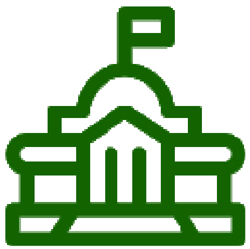


Electric Road Systems: a solution for the future?

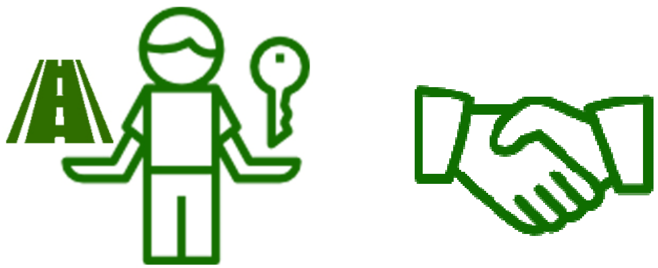
Challenges 1/2



Key barriers: high **capital cost** (for installation, maintenance and administration) and risks associated with relatively **immature technology**.



A key message from stakeholders was that **government support is critical** to ERS development and in addressing industry concerns.



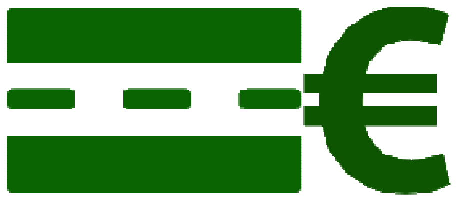
Responsibility for ownership and operation of ERS technology remains to be defined. Most likely **private public partnership** would be needed for implementation. Modifications to the existing regulatory framework and concessions will be needed.

Electric Road Systems: a solution for the future?
Challenges 2/2

How many kms of ERS do we need?

Freight operators only require 25km per day of charging at ERS to achieve satisfactory payback compared to diesel.

20,000km of conductive rail ERS could provide €3.1bn annual savings compared to diesel use.

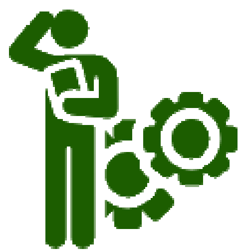


Interoperability:

Currently a variety of technologies have been developed and demonstrated with no interoperability between or within concept types.

The various **conductive solutions proposed are all inherently non-interoperable**.

The **interoperability considerations for inductive power transfer systems are more advanced.**



Electric Road Systems: a solution for the future?

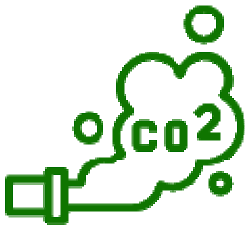
Business model and government support 1/2

Funding mechanism: user-payer principle, but not only.

ERS can allow Governments to meet **carbon reduction targets**. Some governments may wish to **partially subsidise** ERS (at least initially to encourage take-up).

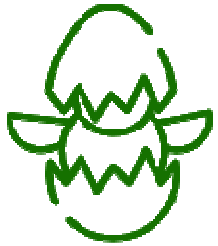
Users of ERS should have reduced costs compared to conventional fuels to support ERS development.

Electrifying only 5% of road network could produce a 50% GHG reduction of road transport.

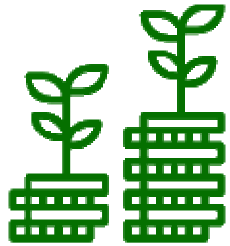


Electric Road Systems: a solution for the future?

Business model and government support 2/2



Chicken and egg situation: hauliers only likely to purchase ERS equipment for their fleet if there are sufficient routes to use it and funders only willing to invest in installing the technology if there are sufficient vehicles with the equipment installed.



⇒ **Government support is required** for funding/part funding the initial investment and through policies and financial incentives to promote up-take.

KEY MESSAGE: Policy and regulatory framework clarity and stability overtime is essential.

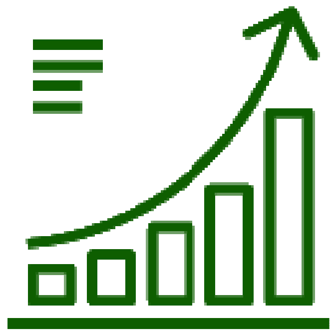
Electric Road Systems: a solution for the future?

UK 2018 business model case study 1/2

Significant assumptions still needed in terms of take-up, electricity mark-up and operational costs etc. as these are currently unknown.

The outputs of the model are:

- **The annual system operational costs**, i.e. the maintenance and administration costs, plus the cost of the electricity used by the users.
- **The annual benefits** accrued from selling electricity to the users.
- **Annual societal benefits** (both in terms of absolute and monetary values); namely reduction in the CO_2 emissions, and reduction of the PM and NOx emissions at the tailpipe.
- **Cumulative balance and payback time**.

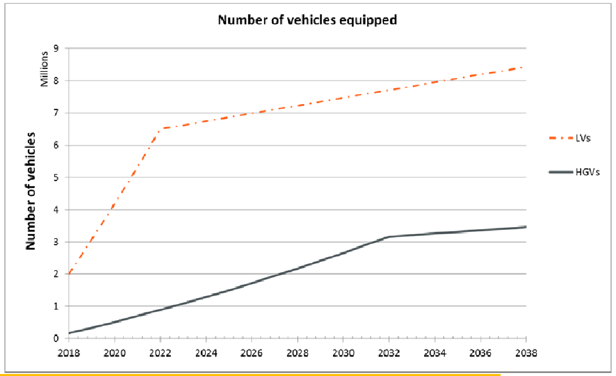


Electric Road Systems: a solution for the future?

UK 2018 business model case study 2/2

Technology penetration assumptions:

- Annual take-up rate for both LVs and HGVs: 5%
- Initial percentage of equipped LVs and HGVs: 5%
- Limit to the technology penetration in the LVs fleet: 30%
- Limit to the technology penetration in the HGVs fleet: 75%



	Electricity mark-up 10% (similar to domestic price)		Electricity mark-up 65%	
System	Break-even year	Savings after 20 years	Break-even year	Savings after 20 years
Inductive_{min}	>20 years	-0.4M£	6	5.7 M£
Iinductive_{max}	>20 years	-9.0 M£	>20 years	-2.9 M£
Overhead_{min}	>20 years	-4.0 M£	>20 years	-0.2 M£
Overhead_{max}	>20 years	-4.7 M£	>20 years	-1.0 M£
Rail_{min}	>20 years	-0.4 M£	6	4.7 M£
Rail_{max}	>20 years	-2.5 M£	13	2.7 M£

Portugal abril 2019:

Gasolina 98 em superfícies comerciais: 1.45 €

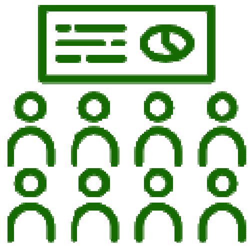
Gasolina 98 em autoestrada: 1.80 €

Margem (Mark-up) aceita hoje pelos usuarios: 24%

Electric Road Systems: a solution for the future?
Recommendations for National Road Authorities 1/3

First steps:

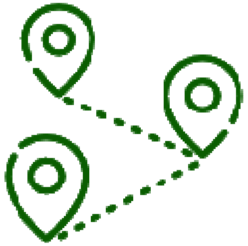
- Participation in **international conferences**.
- Join **PIARC** and other international technical committees .
- Prepare a **feasibility study**: Safety; Technical feasibility and market-readiness; Specifications for the installation of ERS equipment into vehicles; and Specifications for road installations.
- **Promote the use of low carbon vehicles**.



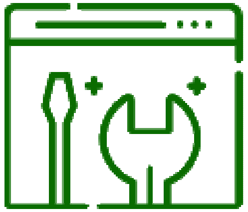
Electric Road Systems: a solution for the future?

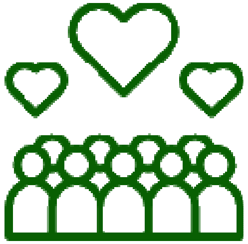
Recommendations for National Road Authorities 2/3

Intermediate steps:



- Assess the **potential impacts** of ERS
- Identify **suitable routes** for ERS
- Develop **guidelines** for ERS systems
- Identify **specifications and standards** that will require modifications
- Commission **research**
- Discuss the possibility of **installing ERS** with government and policy levers to encourage
- Create a **cross-industry forum**
- **International standards and guidelines**
- **Including ERS** as part of their low carbon vision
- **Gain public support**





Electric Road Systems: a solution for the future?

Recommendations for National Road Authorities 3/3

Advanced steps:

- **Participation in trials.**
- **Work with government** - Work with national government to ensure the regulatory framework is flexible enough to adapt to new transport technologies and business models.
- **Publish results** of trials.

Electric Road Systems: a solution for the future?
Conclusions 1/2

The majority of the **inductive ERS** systems (50%) scored between TRL 3 and 4, only two systems had over 6.

The majority of the **conductive ERS** systems (60%) scored between TRL 4 and 5, the remaining two systems had a TRL between 6 and 8.

The KAIST/Dongwon **OLEV (from South Korea) and the SIEMENS (from Sweden)** systems appear to be the most advanced inductive and conductive ERS technology respectively and those **closest to market readiness**.

Risk assessments should be conducted for individual technologies and designs.

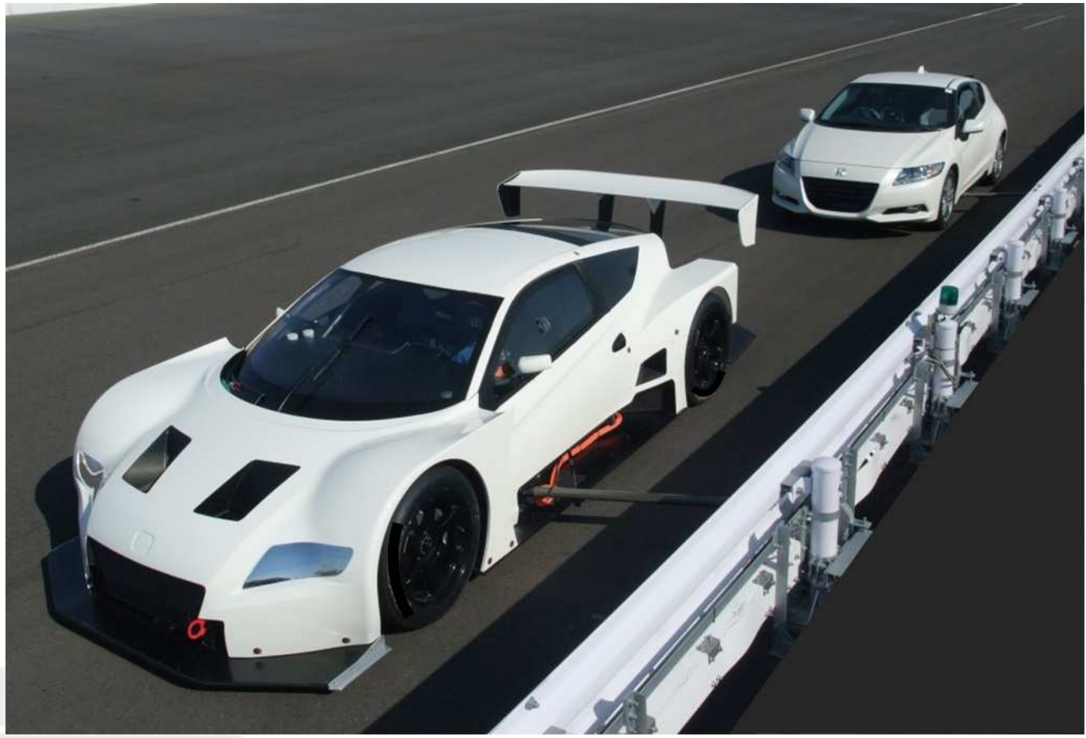
Static charging solutions and electric battery technology are seen to be complimentary to ERS development and implementation. Advancements in these areas should see an increased uptake of EVs

Electric Road Systems: a solution for the future?
Conclusions 2/2

The **CBA shows that some types of ERS are financially viable** if sufficient capital investment can be made, as long as the electricity mark-up and uptake is sufficient.

There is a need to better understand the market for ERS, in particular if **LVs** will use the system and the role of alternative technologies and other future social and technological changes (**autonomous electric shared vehicles**).

ERS has the potential to play a **major role in the decarbonisation of road transport**, but **in the short term is most likely to be adapted by specific parties to meet localised needs rather than a universal solution**.



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Thank you for your attention.

Obrigado pela sua atenção.

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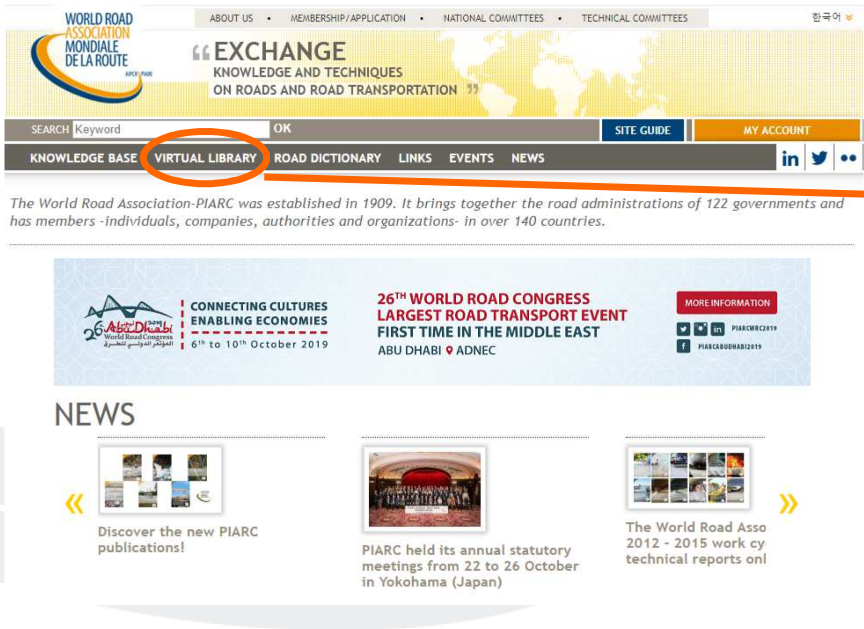

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