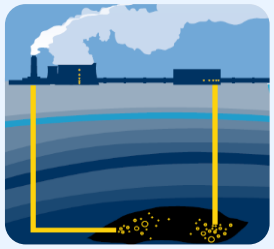








Rapid charging network study

A study commissioned by
Transport for London

20th May 2015

Element Energy Ltd

Celine Cluzel
Principal Consultant
celine.cluzel@element-energy.co.uk

Agenda

- Project background and technology introduction
- Consultation and case studies
- Next steps
- Appendix

A series of drivers are contributing to an increasing requirement for electric mobility in London

Policy context, environmental drivers

- Various drivers are **supporting the move towards zero-emissions transport in London**, including:
  - London's air quality issues, particularly in the centre where it is in breach of EU regulations
  - National CO_2 decarbonisation targets

London's response to-date

- London has responded to these challenges through introducing new policies, including:
  - The planned **Ultra Low Emissions Zone**, from 2020
  - Only **zero-emissions capable taxis** to be licensed from 2018

The Rapid Charging Network Study

- Transport for London (TfL) has commissioned Element Energy to carry out desk-based research and a consultation to :
  - Provide **evidence of best practice in deploying (fast and) rapid charging networks elsewhere**
  - Identify the key barriers/challenges to deploying a rapid charging network in London
  - **Highlight how the London-specific barriers and challenges identified have been tackled elsewhere**, providing TfL with a solid evidence base to feed into further work on deploying rapid chargers to London

Electric infrastructure requirements

- A series of new infrastructure deployments are required to support this transition to low / zero-emission vehicles:
  - Good progress is being made in supporting the **electric private vehicle fleet**, with a widespread 3-7kW **charging network deployed** in London (1,400 charge points)
  - However, many **commercial fleets** operate on tougher duty-cycles and will **require a rapid charging network** in order to adopt plug-in vehicles (and meet the zero-emission requirements in the case of taxis)

A range of rapid charging connectors are available for different vehicle types, with varying power requirements and costs

	Slow/standard charge points <7 kW AC	Fast charge points 7 to 22kW AC	Rapid charge points 43 kW AC- 50kW DC
Outlet	 **3-pin AC**  **Type 1 AC**  **Type 2 AC**	 **Type 2 AC**	 **Type 2 AC**  **CHAdeMO DC**  **Combo CCS DC**
Charging mode	▪ Single phase AC charging ▪ Typically mode 2 charging (32A max with residual current device, but no data connection)	▪ Single or 3-phase AC charging (22kW requires 3-phase) ▪ Typically mode 3 charging (32A max with data connection)	▪ Type 2 uses 43kW 3-phase AC mode 3 charging (32A max with data connection) ▪ CHADeMO or CCS Combo use 50kW DC mode 4 (125A max with data connection)
Cost	▪ c. £10k on-street (mainly due to cost of Traffic Order and other planning processes) ▪ <£2k off street	▪ Costs for 7kW similar/ close to 3kW ▪ Costs for 22kW: £12k-15k ▪ c. 80% installed are 7kW in the UK	▪ Indicative unit costs for 43kW-50kW: c. £38-45k ▪ Can be higher if electricity distribution network upgrade is needed

Source: Element Energy, OLEV, Zap-map.com. Costs are indicative production +installation, connection costs will vary across sites

CCS = Combined Charging System

AC = Alternative Current, DC = Direct Current

Compatibility of rapid charging technology varies with electric vehicle models and brands

Compatibility of today's EVs and planned London ZE taxis with different rapid charging technologies

	43kW Type 2 AC	CHAdeMO DC	CCS DC
PHEV/ RE-EV	 Metrocab  London Taxi Co  Karsan 	 London Taxi Co MITSUBISHI	 London Taxi Co
BEV		 Nissan MITSUBISHI KIA PEUGEOT NISSAN CITROËN TESLA	

Type 2 but only fast-charge compatible (22kW)

Type 2 but not rapid/fast-charge compatible

- Plug-in-hybrid EVs or Range-Extended EVs:
  - The majority of today's **PHEVs** are Type 2, but **not compatible with any of the rapid charging** standards
  - The **LTC and Karsan Hackney Carriages are compatible** with rapid charging, but **not the Metrocab**
- For full-electric Battery Evs:
  - **All three rapid charging standards are required** to charge the full range of models available from OEMs
  - Only the **Nissan Hackney Carriage is compatible with CHAdeMO** DC charging

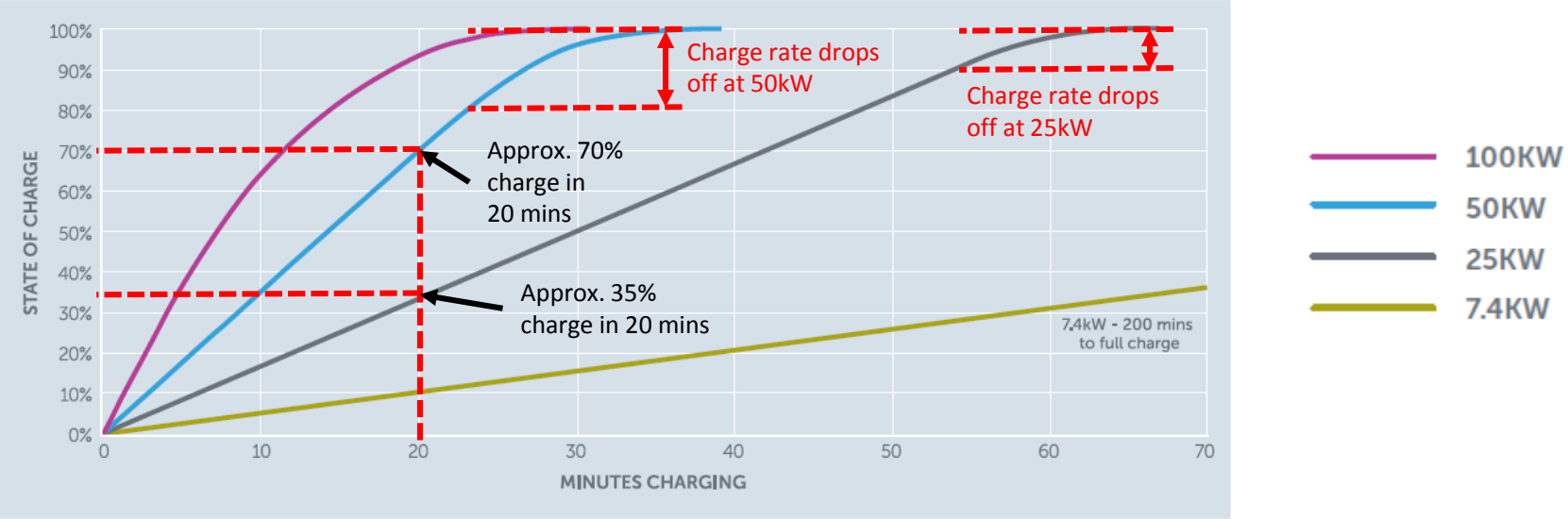
Source: Element Energy, UK Electric Vehicle Equipment Supply Association, Energy Saving Trust

PHEV = Plug-in Hybrid Electric Vehicle, REEV = Range-Extended Electric Vehicle, BEV = Battery Electric Vehicle

The charging curve for different charging speeds has implications for the end-user experience and commercial model envisaged

Compatibility of rapid charging varies with different vehicle types and brands

Impact on charge rate as battery fills



- The rate at which batteries are charged (in kW of power) varies with the battery's state of charge:
  - At low charge rates, charging is almost linear throughout the charging process
  - At rapid charge rates however (e.g. 50kW), the charging rate drops off significantly as the battery becomes full
- This behaviour has a number of implications for rapid charging networks:
  - It can make it difficult to accurately charge users starting/ending at different states-of-charge, when using a time-charge basis
  - It can incentivise users to keep charging for longer, if being charged on a kWh basis

Source: BEAMA

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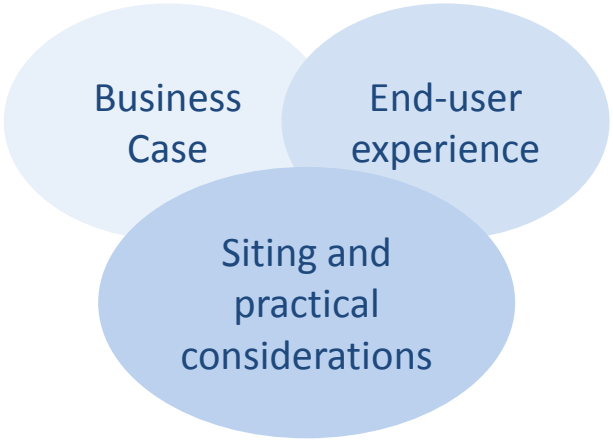
We have consulted widely with rapid CP network operators, to understand best practice across three main themes

Wide consultation across the key rapid CP stakeholders

- We have consulted with a total of 11 networks across 7 countries, covering a range of geographic extents, different funding and operational structures
- Our consultation covered both network operators, equipment and service providers
- We have also consulted current and future rapid CP users, including London taxi and private hire drivers

Three main themes explored for the challenges and barriers to rapid CP deployment



Siting/practical	Business case	End-user experience
• Site identification • Land ownership • Impact of planning policy and local regulation • Technical/safety • Electricity distribution network impact	• Funding • Commercial model • Ownership • Public/private split • Supplier arrangements	• Targeted vehicle types and priority • Billing and customer interactions • Interoperability with other networks and service providers

CP = Charge Point

A wide variety of rapid CP network configurations exist, from design, to supplier arrangements, governance, funding and commercial strategies

Commercial arrangements can vary widely across networks:

- **Public/private-funded**, privately run networks
- **Privately-funded networks** operating on a commercial basis
- Networks **owned and operated by electricity network** operators
- Organically-grown networks, **owned and operated by Local Authorities** but publically funded

Multiple stakeholders are involved in deploying CP networks:

- **Owner/operator**: responsible for developing the business model and operating the network
- **Equipment provider**: responsible for supplying and maintaining the equipment
- **Project manager**: optional stakeholder to manage the deployment of the network
- **CP installer**: separate contractor responsible for deploying (and sometimes maintaining) CPs
- **Back-office operators**: responsible for ensuring the reliability of the network, availability of data to users and managing network interoperability, etc.

Multiple CP designs:

Various CP designs exist, including:

- Station design:

- Individual CP design:

CP = Charge Point

Key barriers to deployment and relevance to the case of London was discussed with London Boroughs that have deployed rapid CPs

Emerging results – excerpt

Siting and practical considerations

- Siting is seen as the number 1 barrier for urban rapid CP deployment
- Early engagement with the many key stakeholders is key, particularly in urban areas: investors, land owners, DNOs, planning authorities, parking authorities, transportation /highways authorities
- Well-funded and dedicated project management resource is seen as key to a successful rollout

Business Case

- Long-term contractual commitments are key to attracting private sector investment (> 10 year sought by investors)
- Procuring CP equipment separately to operating contracts is seen as best practice
- Electricity network upgrade costs can be a significant overall cost component – used as initial site selection filter
- Tender documentation must be carefully prepared, with expert advice

End-user experience

- Many users are seen to prefer rapid charging to other slower facilities – like using WIFI and/or have a coffee during charging
- Increasing tendency to deploy more than one rapid CP per location – reduces 'queuing anxiety', cost advantages etc.
- Booking is not seen as essential in the early rollout phase
- Consistent pricing between sites is seen as a significant advantage
- Risk of danger for pacemaker users is seen as a risk in urban settings

DNO: Distribution Network Operator

Case studies (1 of 2)

	Ecotricity network (UK)	Fastned network (NL)
Description	• Largest UK rapid CP network, covering all the major UK motorway service stations • > 200 rapid CP sites already deployed, with more planned under the RCN project • Currently free to use for all users, no immediate plans to start charging	• Largest Dutch rapid CP network, with a deal to deploy rapid charging 'stations' (i.e. multiple units under a canopy) across all the Dutch motorways • Target of > 200 rapid CP stations, 26 deployed to date, also looking to expand to urban areas • Monthly billing of customers per kWh used
Funding	• Funding split between Nissan (equipment and installation), Ecotricity (electricity and operation) and service station operators (providing land via a contract with Ecotricity)	• Entirely privately funded through selling share 'certificates', with minimum investment of €10 • Developed as commercial proposition, with breakeven at 15 charges per day, or c. 5 years
Governance	Owner-operator: ecotricity Equipment supplier: DBT Charging Electric Vehicles Project management: Zero Carbon Futures CP installation: British Gas Back office: Charge Point	Owner-operator: FASTNED Equipment supplier: ABB Project management: FASTNED CP installation: ABB Back office: NOW! INNOVATIONS

CP = Charge Point

RCN: Rapid Charging Network, EC funded project deploying c.74 rapid CP in the UK

Case studies (2 of 2)

	ESB network (IE)	Transport Scotland network
Description	• Pan-Irish network (various speeds) deployed by the Irish state-owned utility group ESB • Aim for > 100 rapid CPs along Irish main roads • Initially free to use to all users	• LA-led organically-grown network, aiming to cover main Scottish motorways every 35 miles, as well as urban areas to support vehicle fleets • Initially free to use for all users
Funding	• Network deployment (equipment, civils and network upgrades) entirely funded by ESB, land provided by private sector in most cases • Developed as a commercial proposition, with costs recovered from DUoS charges and profits split evenly with land owners	• Funding from OLEV and Transport Scotland to cover all civils, equipment and network upgrades • Individual LAs free to apply for funding to design, build and then operate the network • Initially free, LAs to decide individually on future costs
Governance	Owner-operator: ESB Equipment supplier: DBT Charging Electric Vehicles Project management: ESB CP installation: ESB Back office: pod POINT, IBM	Owner-operator: Various LAs Equipment supplier: Various via framework Project management: Individual LAs CP installation: Various via framework Back office: charge your car

CP = Charge Point, LA = Local Authority, DUoS = Distribution Use of System

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Next steps

Next steps for the study

- **June 2015** – Final report delivery

For any further comments or questions, feel free to get in touch with the team at Element Energy, including:

- Celine Cluzel (celine.cluzel@element-energy.co.uk)
- Elise Ravoire (elise.ravoire@element-energy.co.uk)

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We have targeted our consultation at the rapid charging networks that were deemed most relevant to London (1 of 2)

Network	Description, extent, technology	Backing	Data source
ecotricity	• Free network covering majority of UK motorways • >220 rapid CP sites (mixture of CHAdeMO, AC, CCS)	NISSAN	Ecotricity, CPS, APT, Nissan, ZCF
rcn rapid charge network	• Two road axes: North-South and East-West connecting major roads/ports in UK and Ireland • 74 CCS/CHAdeMO/AC rapid CPs	TEN-T EA Trans-European Transport Network Executive Agency; NISSAN; BMW; Renault	CPS, APT, Nissan, ZCF
source LONDON	• London-wide network, annual membership fee and access to Ecotricity network • C. 1,400 3-7kW charge points	Bolloré	Source London lessons learned guidance (TfL)
CHARGE& DRIVE	• Largest Nordic rapid-charging network, covering Sweden, Finland and Norway with PAYG CP • 75 rapid CPs currently, aim for 145 rapid out of c. 500 overall by end of 2015	Fortum Next generation energy company	Fortum, Renault Norway
FASTNED	• Netherlands-wide rapid charging network, based at services stations, PAYG and subscription options • Full highway coverage (>200) sought (currently 26, installing 1 per week), extension along highways in SE (35), DK (23), DE (67), NL (35) as well as in Dutch cities	TEN-T EA Trans-European Transport Network Executive Agency	Fastned

CPS: Charging Point Services PAYG: Pay As You Go ZCF: Zero Carbon Futures

We have targeted our consultation at the rapid charging networks that were deemed most relevant to London (2 of 2)

Network	Description, extent, technology	Backing	Data source
Auchan	• Planned France-wide charging network, offering free charging to Nissan users via a smart card • 130 rapid chargers to be installed at Auchan stores by end 2015, to add to 120 already at Nissan dealers	NISSAN sodetrel	Nissan
WEST COAST ELECTRIC HIGHWAY	• Network running North-South across West-Coast US, linking with other local urban networks • Aiming to deploy rapid CP every 25 miles across California, Oregon and Washington states	Various EV-focused and other AQ federal funds	Drive Oregon
CHAdeMO	• Various rapid-charging networks, backed by OEMs, fuel retailers and Governments • >3,000 CHAdeMO chargers in Japan[4], Ministry of Economy, Trade & Industry long-term aim for 36,000	Various OEMs, municipalities, fuel retailers	Nissan
TRANSPORT SCOTLAND	• Local-Authority led rapid CP network across Scotland, coordinated by Transport Scotland • Aim to have one rapid CP every 35 miles along major roads, plus plans to deploy in urban areas	Office for Low Emission Vehicles TRANSPORT SCOTLAND	*Transport Scotland*
ESB	• Government-backed and utility-led extensive fast and rapid charging network across Ireland • Deploying a wide range of chargers, including 100 rapid CPs across Ireland's motorways	Funding based on levy on electricity charges	*ESB*

We also spoke with Dundee Council, who have deployed rapid CPs for electric taxis