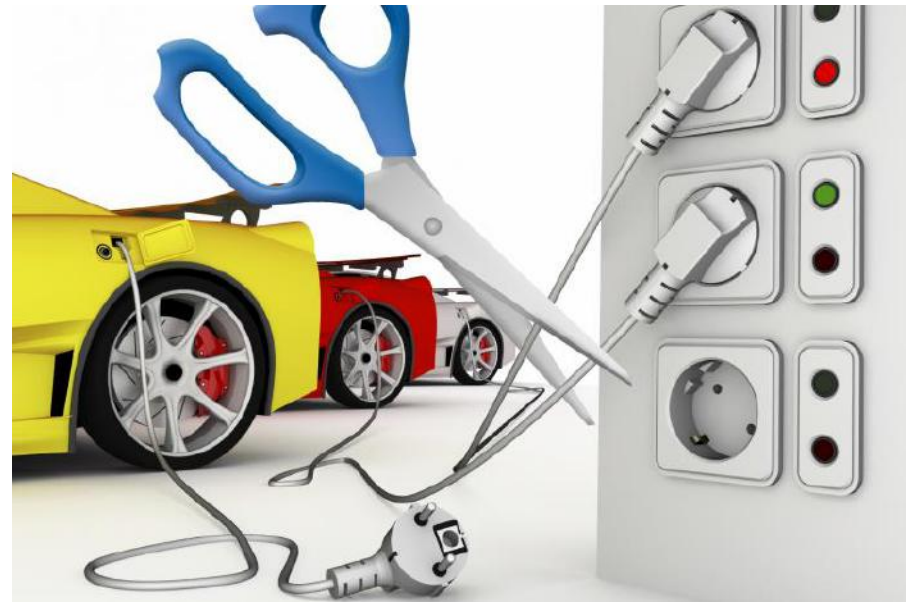




LARGE SCALE TESTING OF WIRELESS CHARGING IN SWEDEN

Stefan Pettersson, Jonas Andersson, Tommy Fransson,
Maria Klingegård, Johan Wedlin

OVERVIEW

1. Short facts about Viktoria Swedish ICT
2. About the WiCh project
3. Regulations and Approval
4. User study
5. Conclusions



WIRELESS CHARGING OF ELECTRIC VEHICLES



SHORT FACTS ABOUT VIKTORIA SWEDISH ICT



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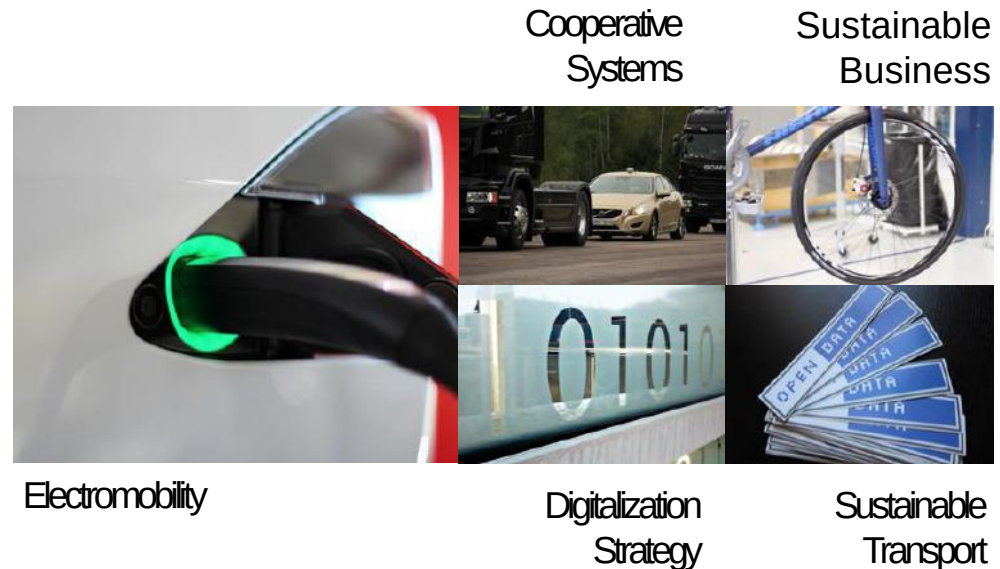
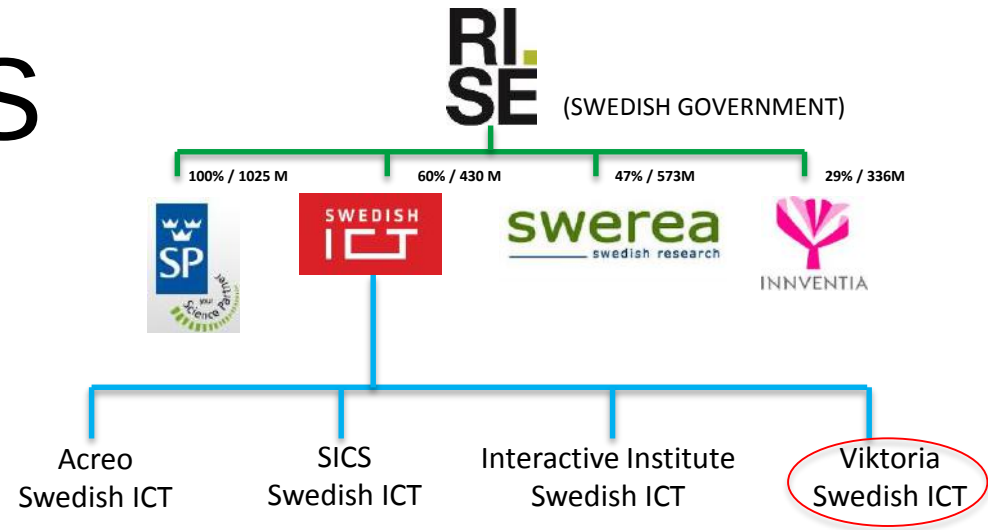
TOWARDS SUSTAINABLE MOBILITY



WIRELESS CHARGING OF ELECTRIC VEHICLES

SHORT FACTS

- Established in 1997 (a **non-profit research institute**)
- **Owned by Swedish government**
- Located at Lindholmen in Göteborg, Sweden
- Around 65 persons and growing
- Approximately half PhD's or higher degree



WIRELESS CHARGING OF ELECTRIC VEHICLES



OVERALL AIM

ELECTROMOBILITY

The overall aim of all activities in the Electromobility area is to increase the knowledge and contribute to the conversion from fossil fuels to more electric kilometers in all type of transportations!

30-35 projects
16 researchers



WIRELESS CHARGING OF ELECTRIC VEHICLES



ABOUT THE WICH PROJECT



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SCOPE & POTENTIAL

The aim of the WiCh project is to BUILD KNOWLEDGE about induction charging regarding user behaviors, technologies, costs, societal effects, etc.

Wireless charging has the potential to:

- Be convenient;
- Smoothen out the energy consumption - easier connection leads to more frequent connection;



thereby constituting an enabling technology for mass introduction of Plug In EVs.



WIRELESS CHARGING OF ELECTRIC VEHICLES



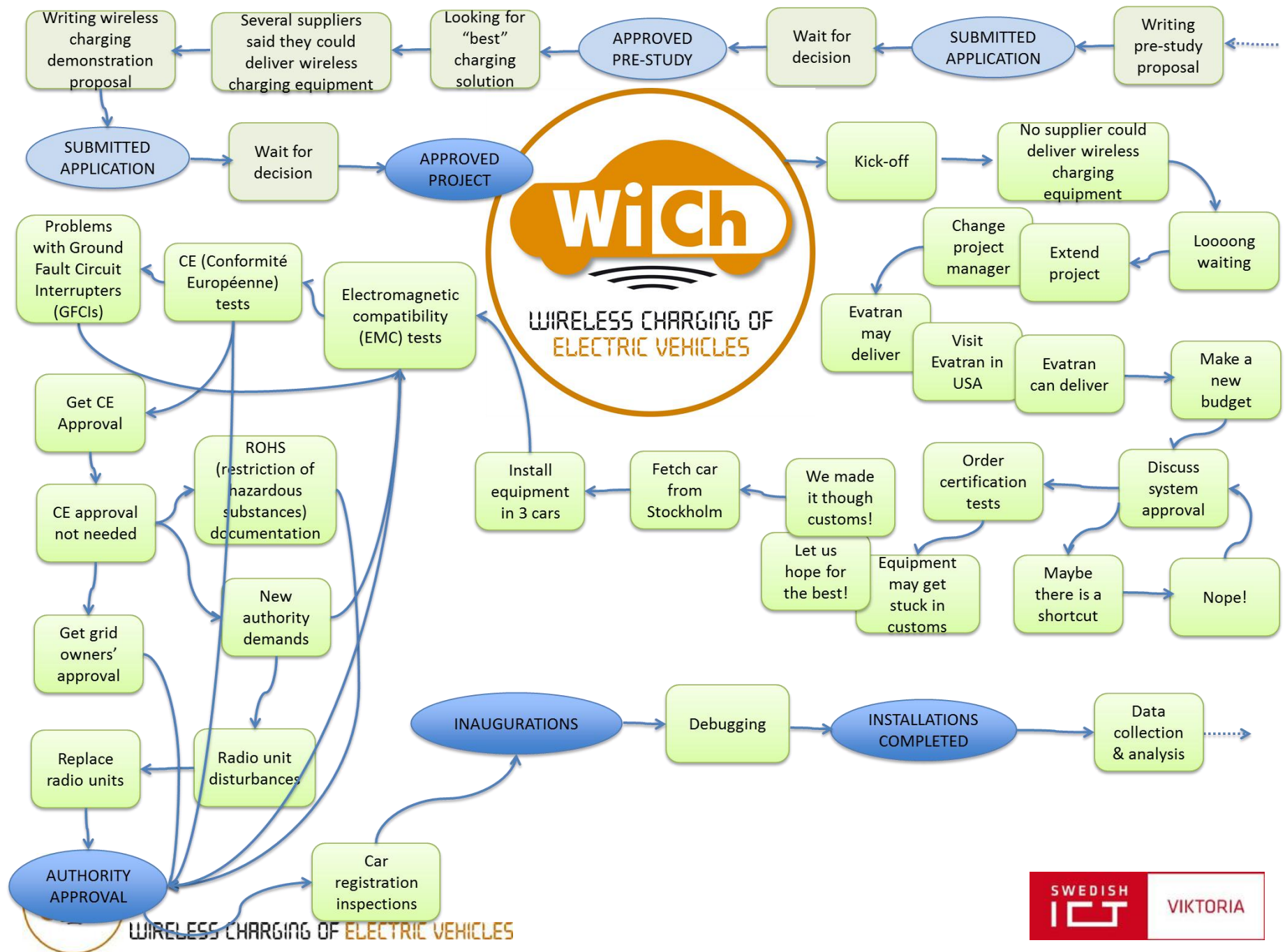
MARKET STUDY

Many actors, but only one that could supply an aftermarket solution.



WIRELESS CHARGING OF ELECTRIC VEHICLES





REGULATIONS AND APPROVAL



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AUTHORITIES AND REGULATIONS

- Electromagnetic Compatibility
 - Swedish Post and Telecom Authority (radiated and conducted emissions)
 - Grid Harmonics (TSO)
- Magnetic Field Exposure
 - Swedish Work Environment Authority
- Electrical Safety - Low Voltage Directive
 - Swedish National Electrical Safety Board
- Traffic Safety
 - Swedish Transport Agency
- RoHS
- ICNIRP
- Waste Electrical and Electronic Equipment



GETTING APPROVAL FOR USAGE

Non-European certified equipment

Customs (Tullverket)

- Arrival → customs' storage (Tullager) → paragraph 17 appendix 72 approval → 3 months of testing without import → back to customs' storage → CE approval → import

Swedish Transport Agency (Transportstyrelsen) – **approval April 30 2015**

- Electromagnetic Compatibility (EMC-directive)

The Swedish Post and Telecom Authority (Post och Tele Styrelsen)

- Monitors the electronic communications and postal sectors in Sweden

Swedish National Electrical safety board (Elsäkerhetsverket)

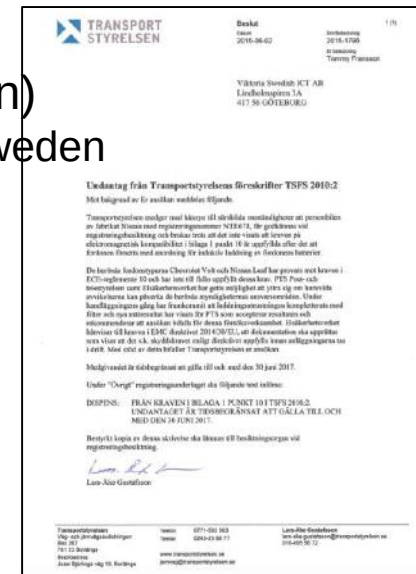
- Electrical safety testing (Low Voltage Directive)
- EC/EEA Declaration Of Conformity
- Electromagnetic Compatibility (EMC-directive)

Swedish Environmental Protection Agency (Naturvårdsverket)

- RoHS (Restriction of Hazardous Substances)
- WEEE (Waste Electrical and Electronic Equipment)



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LAUNCH MAY 2015



WIRELESS CHARGING OF ELECTRIC VEHICLES

Stockholm City Hall



USER STUDY



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FIELD TRIAL

- Research questions
 - Is inductive charging more convenient than cable charging?
 - Does inductive charging of electric vehicle cause more frequent connection of electric vehicles to the grid?
- Data collection
 - Digital survey
 - Interviews
 - Data loggers: position and charging



USER LOCATIONS

20 vehicles with inductive charging
used in **municipality services**



- **Gothenburg – 14 vehicles**

- Göteborg Energi
- Gatubolaget
- Park & Naturförvaltningen

- **Uppsala – 1 vehicle**

- Vattenfall

- **Stockholm – 5 vehicles**

- Stockholmshem
- Familjebostäder
- Grannsamverkan
- Trafikkontoret



WIRELESS CHARGING OF ELECTRIC VEHICLES



THE TYPICAL DRIVER

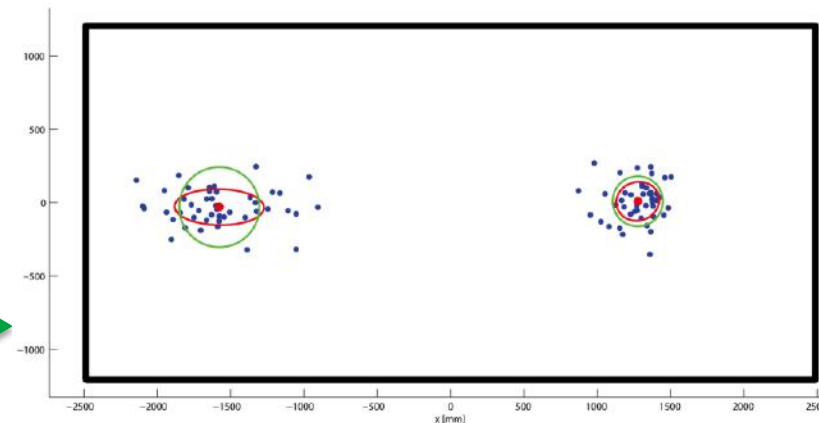
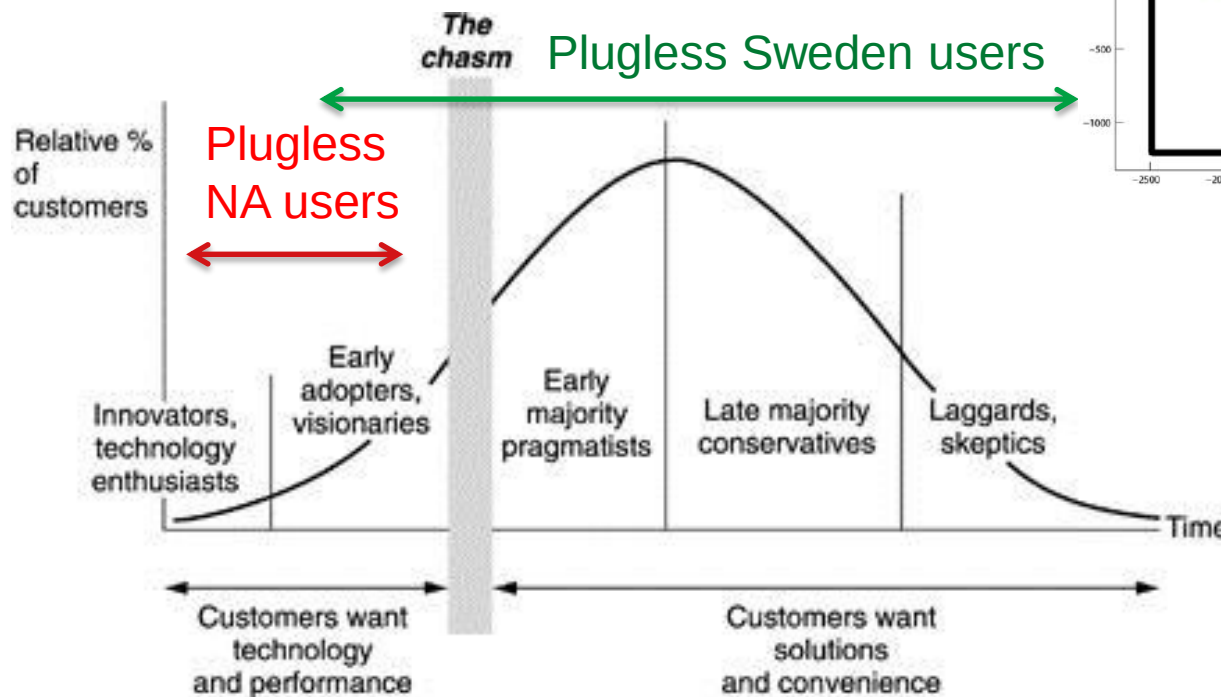


- Age range : 26-76+ (main part 36-55 years old)
- EV usage: Nissan leaf, Chevrolet Volt
- EV Experience: more than 12 months
- EV Ownership: **vehicle fleets** (they do not own the vehicle themselves)
- Tasks: Use the vehicle as part of their daily work routines
- Driving distance a day: 20-30 kilometer
- Frequency of use: 1-2 times a week



DIFFERENT USER GROUPS

- Discrepancies of Plugless users in North America and Sweden regarding issues with:
 - Technology
 - Alignment



Fleet versus
private users

DIGITAL SURVEY

Comparative study to identify the behavioural changes and experiences related to wireless charging

2015

May

June

July

Aug

Sep

Nov

Dec

2016

Jan

Feb

Mars

April

May

STAGE 1: Cord Charging

STAGE 2: Wireless charging

M1

Q1

65 answers

M3

Q2

56 answers

M5

Q3

44 answers

Q4

Submitted –
waiting for
answers



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RESULTS – STEP1: USING CABLE

- 65 respondents to questionnaire Q1 capturing the experience of cord charging
- In general a positive attitude towards electric vehicles
- There is a range anxiety among many drivers
- Charging takes too long time
- Handling the charging equipment – most think it works fine, but some problems are mentioned:
 - Forgetting to plug in the car
 - Forgetting to un-plug the car when driving away
 - Dirty cable
 - Poor usability of the plug hatch on the car
 - A large proportion of drivers consider it important to make it easier to charge electric vehicles



RESULTS- STEP 2: INTRODUCING INDUCTIVE CHARGING

- 56 (Q2) and 44 (Q3) respondents capturing the experience of charging with wireless charging
- General experiences of inductive charging
 - Simple, easy
 - Difficult to park
 - Some technical problems
 - Works fine during winter conditions



CHARGING BEHAVIOUR

- The amount of time standing still to motivate a start of charging is shorter for wireless charging compared to charging with cable.
 - the reason to not activate the charging: “The car is parked too short period of time ” dropped from 36% with cable to approx. 5% for wireless charging (i.e., the parking time becomes less of an issue).
 - However, there are problems to park correctly on first attempt: *“Today, I see no time gain in using inductive charging”*



CONCLUSIONS



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PRELIMINARY RESULTS

- Research questions
 - Is inductive charging more convenient than cable charging? **Yes, it seems so - when technology works!**
 - Does inductive charging of electric vehicle cause more frequent connection of electric vehicles to the grid? **Maybe, but some contradictory results!**
 - To be further investigated during autumn 2016



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