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Mapping Electric-Mobility: Standards Infrastructure for Market Uptake

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Research question

In the context of the automotive industry:

*What specific standardization infrastructure contributes to ensuring global market uptake of the electric-vehicle ecosystem?*

Focus:

- **Systemic standardization approach**
- **Standardization paradigms within the automotive industry**
- **Corporate strategy**
Outline

1. Motivation
2. Background
3. Results and recommendations
4. Conclusions and future research
EV standardization extends far beyond the vehicle

Managerial challenges facing EV-ecosystem stakeholders that have global operations

- Limited empirical research on paradigm for standardization infrastructure of EV-ecosystem
- But importance of standardization for market uptake identified
1 Motivation

Research approach

Methodology:
Comparative and qualitative analyses of standardization infrastructures

Aim:
- Contribute to research on the automotive industry’s standardization paradigm
- Compensate for the standards implementation dilemma
- Conceptualize a method to avert risk by determining the standards infrastructure and central standards
Standards for market uptake

- Companies invest in ensuring compliance with current requirements and with statutory provisions and regulations (Gerst and Xudong, 2013)

- Standards compliance...
  - Can limit the risks associated with corporate innovation activities.
  - Can limit the expenditures for the adjustment of the products.
  - Is favorable if industry is integrated into the standards-development process (Ghiladi et al, 1998; EC, 2008; VDA, 2011).

- Standards meet the demands, if they....
  - Allow for adoption of both a mature and a “new” technology. (Swann, 2000)

- Ambiguity remains for certification and type approval, when...
  - There is no globally applicable set of regulations and standards.
  - Deviating focal requirements hamper the effects of standards.
  - Requirements are grounded on standards in place for conventional technology (Gerst and Jacobs, 2012; Gerst and Xudong, 2013).
The EV infrastructure’s standardization paradigm

- Technology-convergent topics: activities of organizations overlap
  (Edelhoff, 2011; Van den Bossche et al, 2008; Riemer, 2010)
  - Example: ISO TC 22 SC 21 “Electrically propelled road vehicles”
    IEC TC 69 “Electric road vehicles and electric industrial trucks”

- Generally accepted paradigm for standardization of the EV-ecosystem
  - Example: Germany (c.f. Hölk, 2012)

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- But: focal/ consortia/ de facto/ proprietary standards also apply!
### Mapping the standardization infrastructure – data and methodology

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* Topic ≈ Technical domain or standardization corpus as assigned by the expert groups

- Comparison of standards recommended for market uptake
- Identification of Intersections → Pivotal topics and “central” Standards
Mapping the standardization infrastructure – topics

**INS 2010 Proportion %**
- Certification, Legislation
- Functional Safety
- System Design
- Vehicle Performance
- Diagnostics
- Powertrain Control
- Electric Drive
- Vehicle Battery
- Fuel Cell
- High-Voltage System

**NPE 2011 Proportion %**
- EV – Vocabulary
- Cycle Mopeds & Motorcycle Appl.
- Hybrid Electric Vehicles
- Functional Safety
- Environmental Conditions
- Measurement of EV Performance
- EV – Communication
- Charging Systems
- Vehicle Safety & Personnel Protection
- Wiring, Connectors, Controllers, Rotating...
- Batteries
- EMC

**ANSI 2012 Proportion %**
- Education and Training
- Vehicle Components
- Vehicle User Interface
- Infrastructure Installation
- Energy Storage Systems
- Communications
- Charging Systems
ISO, IEC, SAE, UL, CEN standards dominate

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ISO, IEC, SAE, UL, CEN standards dominate

SDO International
- ISO: International Organization for Standardization
- IEC: International Electrotechnical Commission
- IEEE: Institute of Electrical and Electronics Engineers
- CEN: European Committee for Standardization
- CENELEC: European Electrotechnical Standardization

SDO US
- ANSI: American National Standards Institute
- SAE: Society of Automotive Engineers, Inc.
- ASTM: American Society for Testing and Materials
- NIST: National Institute of Science and Technology
- UL: Underwriters Laboratories, Inc.

SDO China
- CHINA GB/T: Voluntary National Standard
- China Professional: Professional Standard of Energy Industry

National SDO
- DIN: DIN Deutsches Institut für Normung e. V.
- VDE: Verband der Elektrotechnik Elektronik
- BSI: British Standards Institution
- CSA: Canadian Standards Association
- MLIT: Japanese Ministry of Land, Infrastructure, Transport
- JEV: Japan Electric Vehicle Association Standards
- JSA: Japanese Standards Association

Intersections
- INS∩NPE: 33%
- INS∩ANSI: 19%
- NPE∩ANSI: 29%
- INS∩NPE∩ANSI: 18%
Only the ANSI-EVSP compendium includes standards from SSOs and consortia

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Standards for EVs have long-term validity and are developed every time hype arises.
### Distribution of institutional standardization across fields of activity

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**Scale**

- >0
- >5
- >10
- >30
- >50
- >100

ICS = International Classification for Standards
Summary of results and implications for our model

- The more comprehensive the innovation and technological convergence, the greater the diversity of the issues that shape the overall infrastructure:
  - Ambiguous assignment of topics and ICS classes
  - Overlapping fields of institutional activities

- Insufficient consideration of...
  - Regulations (and mandatory standards)
  - Standards from the key markets of China and Japan
  - Consortia standards

- Impact of industry- and market-specific entities (IEC, SAE, UL)

- Small set of “central” standards that is to support market uptake
  - Lack of mutual understanding of “international” infrastructure
  - Having the same goals does not necessarily lead to application of the same standards

The business imperative:

→ Determine the company-specific standardization infrastructure
Conceptual framework – management of technical and market uncertainties to attain commercialization

**3 Recommendations**

- Clarify stakeholders’ opportunities for decreasing risk by leveraging implementation of central and peripheral standards selected according to the company’s innovation policy and competitive strategies.

**Sufficient conditions for selecting standards:**

- **Central**: Strong market-relevance requirement or mandatory for market entry (implement, support, or oppose)
- **Peripheral**: Market relevance, but not a market-entry requirement (take into consideration, monitor)
Conclusions and future research

- Special considerations for standardization of the EV ecosystem:
  - Extensive standardization activities in the transition period
  - Partial relevance of backward compatibility with established standards
  - Fragmented global standardization infrastructure, which extends beyond ISO and IEC when the standards of the biggest sales markets differ

- Managerial implications for standardization of innovation:
  - Potential reduction of risk through standards compliance when market entry and diffusion depend on the ability to comply with subsystems mutual standards (certification and type approval)
  - Prerequisites for a performance-based innovation strategy:
    - Infrastructure provides leeway for proprietary approaches
    - Company supports standards ex ante wherever possible

- Future Research
  - Discussion of compelling requirements for central standards
  - Empirical evidence for effects of standards on market uptake of the EV ecosystem
Thank you for your attention!

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Germany, Sindelfingen
References

Electric mobility – systemic standardization Approach

Figure: Topics of Electric Mobility Standardization, Author’s Illustration, based on ANSI EVSP (2012)
The automotive industry’s CO$_2$-emission targets

Source: Daimler internal, 2013
The automotive industry’s annual sales figures

Passenger Cars Sales Figures (million units)

- China
- USA
- WEU
- Japan
- Brasilien
- Deutschland
- Russland
- Indien
HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)

SITUATION: THERE ARE 14 COMPETING STANDARDS.

14?!
RIDICULOUS!
WE NEED TO DEVELOP
ONE UNIVERSAL STANDARD
THAT COVERS EVERYONE'S
USE CASES.

YEAH!

SOON:

SITUATION: THERE ARE 15 COMPETING STANDARDS.

SOON:

SITUATION:
one really thick
standard
with 14
independent
chapters.
Transition to and requirements for a “new” mobility system – the EV ecosystem

Factors contributing to the transition

▲ Rising political pressure on CO2-emission regulation of passenger cars
▲ Intensified bonus-malus system for fleet consumption targets
▼ Competing technological systems and solutions
▼ Market demand and sales of ZEVs are lacking to date (2012: <200tsd units)

Requirements for the transition

► Solutions must meet consumer demands and enable a network effect
► Industrial and political institutions must stimulate a competitive socio-technical ecosystem
► (Further) development and harmonization of standards are needed to achieve feasibility, credibility and proliferation
**Distribution of topics and institutional activities for the intersection between INS, NPE and ANSI**

<table>
<thead>
<tr>
<th>Topics*</th>
<th>IEC</th>
<th>ISO</th>
<th>SAE</th>
<th>UL</th>
<th>CEN</th>
<th>Share</th>
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<tbody>
<tr>
<td>Batteries</td>
<td></td>
<td></td>
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<tr>
<td>Vehicle Safety &amp; Personnel Protection</td>
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<tr>
<td>EMC (Electro-Magnetic-Compatibility)</td>
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<tr>
<td>Wiring, Connectors, Controllers, Rotating machines</td>
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<tr>
<td>Environmental Conditions</td>
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<tr>
<td><strong>Share</strong></td>
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<td>31%</td>
<td>20%</td>
<td>6%</td>
<td>3%</td>
<td></td>
</tr>
</tbody>
</table>

*According to NPE’s assignment of topics

- Small set (18%) of standards referenced by all expert assessments
- Identified set of standards: Central standards for the EV ecosystem?