UNDERSTANDING THE AUTOMOTIVE INDUSTRY
German OEM behaviour during the last 20 years and its implications

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Developing Sustainable Technology Diffusion Pathways for Alternative Mobility Technologies

Background
- Grantham Institute for Climate Change
- Climate-KIC (Knowledge and Innovation Community – EU)
- Energy Adviser (Parliamentary Office for Science and Technology)
- Manufacturing Engineer (Daimler Buses North America)
- Mechanical Engineering & Business Administration (RWTH Aachen)
- Industrial Design and Innovation (Ecole Centrale Paris)
The challenge
Transition towards Electric Cars

ICE
PHEV
EV
HEV
FCEV
Changes in propulsion technology

Photos: Imapusrams, S 400 HYBRID, Mario Roberto Duran Ortiz, Avda, Steve Jurvetson (all Wikipedia Commons users), stevelyon (Flickr)

Electric Vehicle Symposium 2013 - EVS27
Barcelona 17th - 20th Nov 2013
Changes in manufacturing
For the Automotive Industry

Or threat?
Role of the industry for the economy

**Market**
- Car stock: 29 mil (UK), 42 mil (Germany)
- Market sales: 1.9 mil (UK), 2.9 mil (Germany)
- Share of CO₂ caused by transport: 13% (UK), 14% (Germany)

**Automotive Industry**
- Cars produced: 1.3 mil (UK), 12.7 mil (Germany)
- Jobs: 0.7 mil (UK), 5 mil (Germany)
- Turnover: 50 (UK), 317 bil (Germany)

**Industrial Landscape (OEMs)**
- Jaguar, Ford, Nissan, MINI, and many more
- and many more

Electric Vehicle Symposium 2013 - EVS27
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Questions?

- Develop and to achieve Sustainable Technology Diffusion Paths for Alternative Mobility Technologies.
- Are the current policies adequate to reach sustainability goals?
- Is it possible to predict the consequences of governmental policies and industrial strategies on the transition outcomes for the industry?

Need to understand automotive industry
The study
Understanding the automotive industry
Motivation for study

Fig 2. Multi-level perspective on transitions (adapted from Geels, 2002, p. 1285)

(Geels, 2002)
Obtaining parameters for model

- Technology choice, Research and Development Production, Manufacturing, etc.
- Behavioural patterns
- Triggers
- Time scales
- Typical responds
Study of BMW, Daimler and VW since 1990

Scientific journals and press

Annual reports
Timelines
The results
BMW, Daimler and VW since 1990
Landscape (the regime)

Landscape & regime for automotive industry

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<thead>
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ACEA agreement average of 140 g/km of CO2 by 2008

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ACEA agreement average of 140 g/km of CO2 by 2008

Strict ZEV standards announced in California

ZEV relaxed

US White House Blueprint for Secure Energy Future (focus on batteries, no hydrogen)

Toyota Prius
Honda Insights

Competitors

Germany/EU

USA

Mood

Fuel cell hype

EV hype

Hydrogen hype (Daimler)

Crisis is main topic

Hybrid race due to success of Toyota Prius

SUV boom

EVs solution for future

Crisis
**Story of BMW**

**Landscape & regime for automotive industry**

**Crisis is main topic**

**Fuel cell hype**

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**Volt, Leaf, iMiEV, SmartEV**

**EVs solution for future**

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**First EV concept E1**

**Disappointing experiences with EV and FC**

**Tests with LNG vehicles**

**Efficiency improvements (GDL common rail diesels, valvetronic engine)**

**Change of opinion on hybrids**

**New CEO**

**BMW i3 EV unveiled. Scheduled for 2013**

**BMW i3 EV launched**

**Trials with combustion of hydrogen since 1979**

**750HL hydrogen combustion prototype**

**15 750HL hydrogen combustion vehicles for expo 2000**

**Announcement that 750HL goes in series 2002**

**128 vehicle speed record with hydrogen**

**100 BMW combustion hydrogen demonstrator 750HL leased out**

**Hydrogen Combustion stopped**

**BMW Nixes BLUETEC Alliance**

**Collab with GM and Daimler announced**

**SB LiMotive battery cooperation**

**Toyota EV cooperation 2012/2013**

**BMW i3 EV test fleet launched**

**Collaboration with SGL Carbon and partly purchase 2011**

**Joint Venture with PSA on Hybrid Tech**

**Toyota EV cooperation 2012/2013**

**BMW ACTIVE EV test fleet launched**

**Germany/EU**

**USA**

**Competitors**

**Mood**

**BMW**

**Internal**

**R&D and trials**

**Product/concept**

**Collaboration**
Story of Daimler

Landscape & regime for automotive industry

SUV boom

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Stop of H2 ICE

Dornier Fuel Cell team switched from space work on fuel cell vehicle

First FCEV Necar I

FCEV Necar II

FCEV Necar III

C NECAR IV, A, sandwich floor

CEO: "100k FCEVs in 2004"

FCEV Necar V

Diesel HEV E500

FCEVs expected in 2012-15

FC EV F600 HY

FCEVs in 2008

B, FC PHEV concepts in Detroit

FC HEV F800

FCEV F125

CEO: "FCEV in 2015 on market"

CDI technology

Mild-hybrid and start-stop

Bluetic-Diesel in USA & 2008 in Europe

Stop of H2 ICE

SmartV announced

Smart sales below expectations

Smart fortour pressue

Low sales 8600 jobs lost

Smart fortour stopped

A class EV 2010

100 Smart EV

SmartEV trial in Berlin

SLS EV

1000 smartV 200 B FCEV

B, FC PHEV concepts in Detroit

1000 smartV A Class

3rd gen fortour

Smart scooter & BEV for 2014

Crisis

Sust.division restructuration

1000 smartEV 20B FCEV

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Daimler

Ballard FCs for bus

Stake in Ballard

JV Ford Ballard

Cal FC Partnership Ford, Ballard, BP, Shell

Ballards sells FCEV division

Ballard FC deal

Ford leaves JV

10% Tesla, 1000 batteries for smart EV

Internal R&D and trials Product/concept Collaboration

Germany/EU USA Competitors Mood
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### Timeline

- **1990's**
  - New CEO (with engine background)
  - EU discusses 140 g CO2 limit by 2008
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  - Toyota Prius launched
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- **2000's**
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  - EU discusses 130 g CO2/km limit by 2015, 95g by 2020
  - ACEA agreement on average of 140 g/km of CO2 by 2008

### Mood

- Product/concept
- R&D and trials
- Collaboration

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**VW**

- Capri Project 96-2000, Golf HEV (20 kW FC) concept
- FC concept (PSI in 2001)
- Touareg H2 and e-gas plant
- Golf TDI BlueMotion
- Touareg & Q5 Hybrid
- A3 HEV concept
- Golf Blue e-motion
- Golf TDI Diesel-HEV Concept
- Cross Coupe HEV concept
- A4 e-tron
- Golf BEV Audi e-tron
- Electric, gas and CNG up
- e-up! concept
- A3 e & e-tron
- up! concept
- e-up! EV show case
- Plan to launch 6 PHEV in 2014
- 7 years “Best New Engine Award” (1L TSI, More powerful engine to sedans)
- Focus on highly efficient combustion
- Natural gas vehicles
- Second-generation biofuels (e.g., BTL and cellulosic ethanol)
- Lupo 3L
- Audi A2 3L
- VW 1-liter car
- Pilot plant for Start diesel
- Diesel Polo Bluemotion
- 1-liter car revised
- Golf Blue Motion
- XL1 PHEV prototype
- Touareg & Q5 Hybrid
- Cross Coupe HEV concept
- A3 HEV concept
- Golf TDI Diesel-HEV Concept
- Golf Blue e-motion
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**Competitors**

- Toyota
- Honda
- Daimler
- Tesla
- Volt
- Leaf
- iMiEV
- SmartEV
- Model Fuels Consortium
- Lichtblick 2.0L VW CHPs
- Biofuel Cooperation
- Coop with Rosneft (CNG)
Comparison

Landscape & regime for automotive industry

- **EU discusses 140g CO2 limit by 2008/09**
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- **Toyota Japan launches 2nd gen Prius**
- **Tesla success story Volt, Leaf, iMiEV, SmartEV**
- **Competitors USA Germany/EU**
- **Mood 10 130 150 170 190 210 230 [g CO2 / km]**

1990 91 92 93 94 95 96 97 98 99 2000 01 02 03 04 2005 06 07 08 09 10 11 12 2013 [g CO2 / km]
The conclusions

Technology choices: behavioural patterns of German car manufacturers
Common patterns with regard to pressures

- No changes without significant external pressures
  - Emission targets in Europe
  - ZEV in California
  - Perception of rising fuel prices

- Regulations and consumer pressure are main drivers for technology change while national/global economic indicators not

- Research subsidies not sufficient

R&D bound to long term goals and decisions
Common patterns with regard to solutions

- New solutions are created through combinations of available internal solutions
- However, disruptive only triggered by disruptive (internal) events
  - New CEOs
  - Competitor’s ‘success’ (Toyota Prius, Daimler FCEV)
  - Consumer pressure
- Knowledge on disruptive or less familiar technologies is obtained from third parties

Future work: Quantification of findings
Thanks for attention

Acknowledgments

- Grantham Institute for Climate Change (Imperial College London)
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