Value creation through electric vehicles

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Roland Berger
Strategy Consultants

El Escorial, July 29th, 2009
Objectives of the document

➤ Introduce our expertise and credentials in Electric Vehicles
➤ Review outlook and trends – common ground
➤ Share the perspective in the issue from a Government's point of view
➤ Debate the potential implications and options
Contents

1. Brief introduction of Roland Berger and credentials
2. Electric vehicles outlook and trends
3. The country and Government's perspective – case examples
4. Implications and options – debate
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We are the leading management consultancy in Utilities

SELECTED EXAMPLES

Source: Roland Berger Strategy Consultants
The Automotive Competence Center advises leading companies in the automotive industry

Selected clients

<table>
<thead>
<tr>
<th>OEMs</th>
<th>Suppliers</th>
<th>Services Providers</th>
<th>Financial Investors</th>
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<tr>
<td>DAIMLER CHRYSLER</td>
<td>Visteon</td>
<td>SIAT</td>
<td>Deutsche Bank</td>
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<td>NISSAN</td>
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<td>Volkswagen Bank</td>
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<td>SIEMENS</td>
<td>MAHAG</td>
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<td>RENAULT</td>
<td>JOHNSON CONTROLS</td>
<td>TOYOTA Financial Services</td>
<td>Norwegian Sun Venture</td>
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<td>GM</td>
<td>DENSO</td>
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<td>SIEMENS</td>
<td>Volkswagen Bank</td>
<td>The Blackstone Group</td>
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<td>BMW</td>
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<td>FEURECIA</td>
<td>debis</td>
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<tr>
<td>HONDA</td>
<td></td>
<td>European</td>
<td></td>
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</tbody>
</table>

1) Clients which had made public our assistance

Source: Roland Berger Strategy Consultants
We are the leading Strategy Consultancy in Electric Vehicles – all major European efforts

**E-MOBILITY CLIENTS**

- **Enel**
- **edp**
- **RWE**
- **Governo de Portugal**
- **Daimler Chrysler**
- Italian car manufacturer

**SELECTED E-MOBILITY ENGAGEMENTS**

**ELECTRIC UTILITIES**

- Strategy and business model definition and quantification
- Cross industry technical standardization
- Implementation and execution of model/concept
- Joint pilot structuring and steering - development

**OEMs**

- Cooperation agreements and negotiations
- Partner and model solution

**Governments**

- Vision, architecture, concept and business case
- Network of partners - design and establishment

Source: Roland Berger Strategy Consultants
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Fundamental framework in place and strong forces at work in favor of e-mobility

Customer acceptance

> High fuel prices lead to **advantages in life cycle-costs** for electric vehicles
> Cost differences of about 15 to 30% expected\(^1\)
> Rapidly increased acceptance – RB surveys

Political backing

> EU: strict fleet CO\(_2\) emission targets for car manufacturers
> USA: zero emission cars as condition for market access
> China: significant problems with traffic pollution

New car manufacturers:
Miles, Think!, Tesla

New business models: Project Better Place, City of Westminster, Electric cars – now!

Battery technology innovation

> Li-ion technology is becoming ready for **mass production**
> Range extenders and battery swap stations **solve limitations on range**

\(^1\) Example for 2020 (EVs / PHEVs) in Germany; depending on country-specific price and tax framework

Source: Roland Berger Strategy Consultants
High share of CO₂ emissions by vehicles is triggering reductions measures across the World

**Anthropogenic CO₂ emissions (%; 2007)**

- Power plants: 25.0%
- Domestic fuel and small consumers: 23.0%
- Industry: 19.0%
- Combustion of biomass: 15.0%
- Trucks: 6.0%
- Passenger cars: 5.5%
- Air traffic: 3.0%
- Other traffic: 2.0%
- Ships on open sea: 1.5%

In Europe: Road transport ~ 20%, passenger cars ~ 12%

**Reduction policies**

*Source: VDI; EU; Rew Center on Global Climate Change; Roland Berger Strategy Consultants*
The willingness to spend more on a car with reduced CO₂ emissions has grown over the last two years – Roland Berger Survey 09

How much extra would you be willing to spend on a new car in order to make an active contribution to cutting carbon emissions?

<table>
<thead>
<tr>
<th>Germany [%]</th>
<th>France [%]</th>
<th>UK [%]</th>
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<td><strong>2007</strong></td>
<td><strong>2009</strong></td>
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<tr>
<td>x&gt;2,000</td>
<td>14%</td>
<td>10%</td>
</tr>
<tr>
<td>€1,000-2,000</td>
<td>27%</td>
<td>23%</td>
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<tr>
<td>€500-1,000</td>
<td>15%</td>
<td>13%</td>
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<tr>
<td>€100-500</td>
<td>9%</td>
<td>7%</td>
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<tr>
<td><strong>2007</strong></td>
<td><strong>2009</strong></td>
<td></td>
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<tr>
<td>x&gt;2,000</td>
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<tr>
<td>€1,000-2,000</td>
<td>22%</td>
<td>23%</td>
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<tr>
<td>€500-1,000</td>
<td>17%</td>
<td>13%</td>
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<tr>
<td>€100-500</td>
<td>12%</td>
<td>10%</td>
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</table>

Source: Roland Berger Strategy Consultants customer survey
The EU is supporting this trend by introducing aggressive CO₂ fleet emissions targets

**Status Quo**

- **Engagement** of ACEA to reduce CO₂ emissions to 140 g/km in 2008 and to 120 g/km in 2015
- The EU commission is asking the EU 27 members to reduce emissions to no more than **130 g/km in 2012**
  - (5,2 l Petrol, 4,8 l Diesel)
- **Target for 2020**: 95 g/km
  - (4,0 l Petrol, 3,6 l Diesel)
- **Possible scenario**: Target is 70 g/km starting from 2025 (2, 9 l Petrol, 2,6 l Diesel)

Source: ACEA; Press; European Parliament; Roland Berger Strategy Consultants
Plug-in-hybrids (PHEV) and Electric Vehicles (EV) are the only chance to effectively reduce emissions in the M/T – L/T

Possible car portfolio with PHEV / EVs

<table>
<thead>
<tr>
<th>Segment</th>
<th>CO₂ Emissions 2020</th>
<th>CO₂ Emissions 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big SUV</td>
<td>95 g/km</td>
<td>125 g/km</td>
</tr>
<tr>
<td>Compact SUV</td>
<td></td>
<td></td>
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<tr>
<td>Luxury car</td>
<td></td>
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<tr>
<td>Big car</td>
<td></td>
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<tr>
<td>Medium car</td>
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<td></td>
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<tr>
<td>Compact car</td>
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</tbody>
</table>

Source: JD Power; BMW; Roland Berger Strategy Consultants
Electric vehicles are also far more energy efficient than vehicles with conventional engines – full cycle

Comparison of well-to-wheel efficiency – Conventional Engines and EV

| Electric Vehicle (electricity from NG\(^1\)) | 29% = 42% X 92% X 75% |
| Electric Vehicle (electricity from Coal) | 24% = 35% X 92% X 75% |
| Conventional engine | 17% = 83% X 20% |

\(^1\) NG: Natural Gas; 2) Well-to-Wheel

> The efficiency of an electric vehicle has a comparative advantage due to, mainly, the electric motor efficiency and the low grid transmission losses.

> Electricity to EV could be generated from other sources – more efficient than NG or Coal (hydro) –, or from renewable sources (wind, solar, etc.)

> Oil refining is efficient, though the energy efficiency of a typical internal combustion gas engine is low (17%-23% range).

Source: Roland Berger Strategy Consultants
Technological advancements of Li-Ion batteries seem to have overcome all obstacles for mass production.

State-of-the-art of Li-Ion batteries technology

### KEY FACTS

<table>
<thead>
<tr>
<th>SECURITY</th>
<th>SOLUTION</th>
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<tr>
<td></td>
<td>The use of new materials (Iron phosphate and manganese) avoid &quot;overheating&quot;</td>
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<table>
<thead>
<tr>
<th>DURABILITY</th>
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<tr>
<td>The new batteries assure &gt; 3,000 timecycles without significant load reduction</td>
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<table>
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<tr>
<th>COSTS</th>
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<tr>
<td>The use of new materials allow lower costs (Target: &lt; 150 EUR/kWh in 2020)</td>
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<table>
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<tr>
<th>AVAILABILITY</th>
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<tr>
<td>Production has started already</td>
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</table>

Source: CARB battery study 07, Roland Berger Strategy Consultants
By 2020 all established OEMs and a lot of new players will have entered the EV market in the EU

EU: Overview of estimated electric vehicle market penetration

**First Mover Wave**
- 2008-2010: Limited volume of "a new type of EVs"
  - New Prius Plug-in
  - Mitsubishi MiEV
  - Opel E-Flex
  - Miles XS 500
  - Tesla Whitestar

**"Second" Mover Wave**
- 2011-2015: Positive market response and volume ramp-up
  - Nissan "Citycar"
  - All major players enter the EV market
  - MB EV Citycar
  - BMW
  - VW NSF EV-Vers.

**Broad Market Penetration**
- 2016-2020: Second Generation EVs at competitive costs and improved performance
  - Renault "Citycar"
  - "Second" Movers benefit strongly from the first wave
  - Chinese and all other Players enter the market with comp. EVs
  - BYD
  - Miles 2. Gen
  - Ford
  - Fiat

Source: Roland Berger Strategy Consultants
### OUTLOOK AND TRENDS

#### Many players are already actively moving – public cases

<table>
<thead>
<tr>
<th>Company</th>
<th>Details</th>
</tr>
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</table>
| RWE | > Pilot together with Daimler in Berlin  
> Some governmental support |
| Dong Energy | > Joint company with Project 'Better Place' in the course of incorporation  
> Commercialization of infrastructure and a Renault Nissan-EV |
| EDF | > Cooperation with local authorities and operators of shopping malls infrastructure tests in UK  
> Fleet test with Toyota for testing PHEVs in the EDF-fleet  
> Tests with about 30 cars (EVs / PHEVs) from Dassault and Heuliez |
| E.ON | > Stake in consortium (amongst others VW for fleet test) with PHEVs in Germany (max. 25 cars)  
> Study PHEVs with "Green party" and solar association |
| Vattenfall | > Cooperation of the Portuguese government with Renault Nissan (Partner of "Project Better Place" – supporting the development of infrastructure and fiscal benefits for EVs |

**Sources:** Companies, Roland Berger Strategy Consultants analysis
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Speed of market transition to electric vehicles per country depends on specific country framework

**Market share of electric vehicles (illustrative)**

- **A** Forced transition
  - Legislation/regulation rules transition towards electric vehicles
  - Examples: ban of scooters with combustion engines from different Chinese cities

- **B** Commercial breakthrough
  - E-mobility players actively develop market – including infrastructure offer
  - Speed for market penetration depends on specific framework (prices, taxes, road toll, etc.)
  - Attractive offers and price advantage vs. combustion engine drives transition

- **C** Customer movement
  - Even without actively pushing the market some people will change
  - "Green issues" and early adopters drive market transition

Source: Roland Berger Strategy Consultants
Project Better Place addresses the issue of autonomy offering battery charging and replacement spots

Concept business model "E-Mobility": Project Better Place

**Vehicle offer**
- Focus on **pure EVs** ("Zero-Emission")
- **Fast battery exchange** to solve range issue
- Client owns vehicle or leases vehicle from OEM
- **PBP own battery** (part of mobility offering)

**Infrastructure offering**
- **Offer to client to upgrade electric infrastructure** at home (where necessary)
- **Wide area infrastructure** at public places
- **Proprietary IT-Solution** (without Com-Module no access)
- **Wide area availability** of battery exchange stations

**Sales & Service**
- **Mobility offering similar to "Mobile communication"** (incl. battery leasing and electricity supply) over own distribution channel
- Customer gets **mobility contract directly from PBP** (or in OEMK shop?)
- **Fleet customers get** at the beginning (or always?) the **complete offer** (vehicle/battery/electricity?) from PBP
- Own service network?

**Distribution / Invoicing electricity**
- "Large customer" contract with utility
- **High share of renewable energies** (to ensure positive CO2 figure "Well-to-Wheel")
- Invoicing / payment through proprietary IT-system

Source: PBP, Roland Berger Strategy Consultants
Some Governments have been defining key aspects of their E-Mobility model architecture

Key elements to be defined from a Government’s perspective

- **A** Value Chain
  - Value chain configuration
  - Key activities

- **B** Players and business models
  - Players: Network operators, virtual or integrated retailers
  - Simple to integrated business models
  - “Open” / “Closed” electricity retail – RAB?
  - Payment and billing model
  - Universal / non-universal charging

- **C** Charging infrastructures
  - Free vs. regulated electricity price
  - Maximum for charging service?

- **D** Price (charging service and electricity)

- **E** Vehicle-to-Grid (V2G)
  - V2G implementation term
  - Which market conditions?

Source: Roland Berger Strategy Consultants
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Electric vehicles could offer several tangible value creation opportunities – need to clarify/quantify model?

**Direct advantages**
- Battery development: key for wind portfolio
- Cars as batteries: for optimum dispatching
- Development of smart grid network architecture

**Energy distributor / infrastructure provider**
- Energy supply for EVs / hybrids – increased demand
- Operation of charging infrastructure "at home" or in public places, Call / Billing (direct customer access)
- Provision of fast-charging infrastructure for surcharge

**B2B- (Location-) Partner**
- B2B- location partner – build / operate charging infrastructure with investment of partners (parking lots, shopping malls, …)
- B2B-fleet customers – build / operate charging infrastructure for customers

**Grid-for-Vehicle (G4V)/ Vehicle-to-grid (V2G)**
- G4V – central charging control EVs / hybrids
- As a future perspective – V2G
- Second use of old batteries to store electricity

**Additional B2C-Offerings**
- Combined products – Smart Home & Drive, Customized Infrastructure – package micro-generation
- Other billing models, e.g. flat rate
- Additional content based services, e.g. parking guiding system

Clarification of business model and quantification needed
- Positioning in value chain
- Implications for core business
- Business plan
- Partnerships
- Value proposition

Source: Roland Berger Strategy Consultants
Conclusiones

• Sistema energético sostenible ✓
• Nueva economía ✓
• Empleos verdes (el tema mañana) ✓

• Muchas gracias a ISTAS por la invitación y a ustedes por su atención.

• Contacto:  Joao_Saint-Aubyn@es.rolandberger.com
**Second coming**

Batteries have been around for over 200 years, and as early as 1900 they were already being used to power cars.

- **1800** - Alessandro Volta invents the voltaic pile – the first battery
- **1832** - Robert Anderson invents the first electric carriage
- **1859** - French inventor Gaston Plante develops the first practical rechargeable lead-acid battery – the basis of today’s conventional car battery
- **1897** - Regenerative braking first used in a car to recharge its battery, by P. A. Darracq in Paris
- **1899** - Waldmar Jungner invents the nickel-cadmium rechargeable battery. Almost 100 years will pass before it is used in hybrid cars
- **1900** - **MORE ELECTRIC AND STEAM-POWERED CARS ON THE ROAD THAN THOSE POWERED BY THE INTERNAL COMBUSTION ENGINE**
- **1908** - Henry Ford launches the Model-T
- **1912** - Electric car production peaks
- **1930s** - Electric cars all but gone from the streets
- **1970s** - M. S. Whittingham at Binghamton University, New York, proposes a design for lithium batteries
- **1975** - The nickel hydrogen battery patented – rapidly adopted for powering low Earth orbit satellites
- **1986** - The nickel-metal hydride battery (NiMH), a variation on nickel hydrogen, patented by entrepreneur and inventor Stanford Ovshinsky
- **1990** - Commercialisation of the NiMH battery
- **1991** - First commercial lithium-ion battery sold by Sony of Japan
- **1997** - Toyota Prius hybrid electric car launched, partly powered by NiMH batteries
- **2006** - Tesla Motors launches the world’s first all-electric production car – the Tesla Roadster – powered by lithium-ion batteries
- **2009** - US government pledges to invest $2 billion in battery development

Source: NewScientist July 20th (“Electric cars: Juiced up and ready to go”)
Smaller, lighter, better batteries

Packing a big punch for their size, lithium-ion batteries are the most likely to power the electric cars of the near future.

Source: NewScientist July 20th ("Electric cars: Juiced up and ready to go")