ELECTRICAL CARS

Ll. Miralles
OUTLINE

• INTRODUCTION
• MARKET ANALYSIS
• CONNECTORS AND REGULATIONS
• OWNERSHIP COST
• CERN CASE
• CONCLUSIONS
INTRODUCTION
INTRODUCTION

• PROS
  – Energy obtained from batteries, initial charge obtained from external power supply. Regenerative braking.
  – Considered zero emission at local level. Depending of the energy mix for recharging the overall emissions could be higher or lower than ICE emissions.
  – High efficiency 90% electrical motor vs 40% ICE engine. Simple powertrain architecture.
  – Smooth acceleration. Low noise.

• CONS
  – Range of autonomy and costs. Both aspects due to batteries.
  – Dependence of charging infrastructure.
  – No relevant development on the batteries technology over the next years, so the progress on the range of the EV is expected to be rather small.

<table>
<thead>
<tr>
<th>Battery type</th>
<th>Lead acid</th>
<th>Nickel-metal hydride</th>
<th>Li-Ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy density (Wh/kg)</td>
<td>30-50</td>
<td>60-120</td>
<td>90-190</td>
</tr>
<tr>
<td>Cyclability</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Range of temperature (°C)</td>
<td>-20/50</td>
<td>-20/65</td>
<td>-20/60</td>
</tr>
<tr>
<td>Safety measures</td>
<td>Good thermic stability</td>
<td>Good thermic stability</td>
<td>Mandatory safety measures ¹</td>
</tr>
</tbody>
</table>

¹ Need to use battery management system for individual cell monitoring
## MARKET ANALYSIS

### ELECTRIC VEHICLES

<table>
<thead>
<tr>
<th></th>
<th>Nissan Leaf</th>
<th>Renault ZOE</th>
<th>Mitsubishi iMiEV</th>
<th>Volkswagen e-UP!</th>
<th>Renault Kangoo</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle segment</strong></td>
<td>Hatchback</td>
<td>Hatchback</td>
<td>Hatchback</td>
<td>Hatchback</td>
<td>Van</td>
</tr>
<tr>
<td><strong>Price (€)</strong></td>
<td>30.190</td>
<td>24.290</td>
<td>-</td>
<td>20.800</td>
<td>30.000</td>
</tr>
<tr>
<td><strong>Battery rent (€/month)</strong></td>
<td>-</td>
<td>79</td>
<td>-</td>
<td>-</td>
<td>86 (^1)</td>
</tr>
<tr>
<td><strong>Battery energy (kWh)</strong></td>
<td>24</td>
<td>22</td>
<td>16</td>
<td>18.7</td>
<td>22</td>
</tr>
<tr>
<td><strong>Range (km)</strong></td>
<td>200</td>
<td>210</td>
<td>150</td>
<td>160</td>
<td>170</td>
</tr>
<tr>
<td><strong>Electric consumption (kWh/km)</strong></td>
<td>0.18</td>
<td>0.15</td>
<td>0.16</td>
<td>0.14</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>Power (kW)</strong></td>
<td>80</td>
<td>65</td>
<td>47</td>
<td>60</td>
<td>44</td>
</tr>
<tr>
<td><strong>Battery type</strong></td>
<td>Lithium ion</td>
<td>Lithium ion</td>
<td>Lithium ion</td>
<td>Lithium ion</td>
<td>Lithium ion</td>
</tr>
<tr>
<td><strong>Normal charging</strong></td>
<td>AC mode 3, max 32A1P</td>
<td>AC mode 3, up to 64A3P</td>
<td>AC mode 3, max 16A1P</td>
<td>AC mode 3, max 16A1P</td>
<td>AC mode 3, max 16A1P</td>
</tr>
<tr>
<td><strong>Fast charging</strong></td>
<td>CHAdeMO 50kW (40 min)</td>
<td>AC mode 3 43kW (30 min)</td>
<td>CHAdeMO 50kW (30 min)</td>
<td>Combo2 50kW (30 min)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Charger connectors</strong></td>
<td>Type 1, CHAdeMO</td>
<td>Type 2</td>
<td>Type 1, CHAdeMO</td>
<td>Combo 2</td>
<td>Type 2</td>
</tr>
<tr>
<td><strong>Trunk capacity (l)</strong></td>
<td>370</td>
<td>338</td>
<td>227</td>
<td>255</td>
<td>3400 (^4)</td>
</tr>
</tbody>
</table>

\(^1\) Battery rental price depends on amount of kilometres per year

\(^2\) Renault offers a battery rental with the price depending on the contract time. For the two first years: 83€/month; beyond 2 years: 73€/month. [5]

\(^3\) Current Lithium ion batteries can only be fast charged until 80% capacity SoC

\(^4\) Cargo volume
Household and industrial plugs are not considered safe enough for the permanent use with electric vehicles. The power requirements are very different, and only with dedicated electric vehicle supply equipment (EVSE) a basic communication between EV and mains is established, so that the EV is informed about the power capability (mode 3 charging) of the AC mains.

Domestic plugs, however are considered safe enough for emergency charging together with an in cable control box (ICCB). This is called mode 2 charging.
### Connectors and Regulations

<table>
<thead>
<tr>
<th>Modes/Levels</th>
<th>Current type</th>
<th>Operation Characteristics</th>
<th>Type 1</th>
<th>Type 2</th>
<th>Type 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IEC max Power (1P / 3P) [kW]</td>
<td></td>
<td>1P</td>
<td>3P</td>
<td>1P</td>
</tr>
<tr>
<td>IEC 61851 / SAE J1772</td>
<td></td>
<td>Domestic plug (not allowed in US)</td>
<td>12A</td>
<td>-</td>
<td>10A</td>
</tr>
<tr>
<td>1</td>
<td>AC 3.7 / 11</td>
<td>Domestic plug + IGBT (control pilot)</td>
<td>32A</td>
<td>32A</td>
<td>32A</td>
</tr>
<tr>
<td>2 / 1</td>
<td>AC 7.4 / 22</td>
<td>Charging station / wall box (V2G possible)</td>
<td>80 A (USA only)</td>
<td>-</td>
<td>63A</td>
</tr>
<tr>
<td>3 / 2</td>
<td>AC 57.5 / 100</td>
<td>Offboard Charger</td>
<td>Combo 1 200A</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4 / 3</td>
<td>DC 400Amps</td>
<td>Offboard Charger</td>
<td>Combo 1 200A</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- **European Standard**
- **Japanese Standard**

Cost between 400 and 1500 euros
Cost of charging station (4) 8000 euros
OWNERSHIP COST

• Purchase cost highly dominated by government subsidies, dealer incentives and taxation.
• Low maintenance costs of the EV 160 euros/year wrt to ICE 250 euros/year.
• No database exists for batteries maintenance.
• Equal insurance costs. 400 euros/year.
• Equal tyre cost replacement. 400 euros/60000 Km.
• 15000 Km/year.
• Gas price 1.3 euro/Lt
• Electricity price 0.09 euro/kWh
Total cost of ownership

- ICE Vehicle
- Volkswagen e-up
- Renault Kangoo
- Nissan Leaf
- Nissan Leaf batt. rent
- Renault Zoe

Distance (km)
Costs (£)
Ownership Cost

Costs per distance of the vehicles

- ICE
- Volkswagen e-Up
- Renault Kangoo
- Nissan Leaf
- Nissan Leaf batt.rental
- Renault Zoe
1180 vehicles, about 150 LS1
Category A: 24%, Category B: 70%, Category C: 1%, Category D: 5%
Total cost of ownership

- ICE Vehicle
- Volkswagen e-up
- Renault Kangoo
- Nissan Leaf
- Nissan Leaf batt. rent
- Renault Zoe

Costs (€)

Distance (km)

90%
CONCLUSIONS

• Electrical vehicles can be an economical beneficial solution due to low maintenance and exploitation costs. High mileage.
• The cost of ownership is dominated by the initial cost.
• The CERN case does not match with the EV optimal scenario. Low mileage.
• The charging posts is a non negligible cost and risk (technology and standards).
From these forecasts, the Total Costs of Ownership (TCOs) for different powertrains are calculated for first, second and third owners during the vehicle lifetime over the period 2015-30. The result is a strong convergence in the unsubsidised ownership costs of plug-in electric powertrains with conventional ICEs and HEVs, even on a 4-year (first owner) basis. For context, the range of 4-year TCOs for conventional and plug-in cars is inside the cost of several of the most popular optional extras, such as parking sensors and satellite navigation, which are of the order £500-£1,000. Crucially, all powertrains (except H₂ fuel cells) on average have lower ownership costs in 2030 compared with petrol ICEs in 2015, despite a backdrop of rising fuel and electricity prices. BEVs, in particular, reach near TCO parity with diesel ICEs, the cheapest powertrain, for the first owner in 2030. Over the life of the vehicle, the TCO of ultra-low emission vehicles falls significantly below conventional vehicles, even after the costs of home charging points is included.