Sustainable Mobility – Fuel Cell Vehicles

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Agenda

- History
- Technology Development
- Current Activities
- Deployment Strategy
Hyundai & KIA Development History

2008 ~ 2009
- *Borrego FCV* (115 kW, HMC)
- *Sportage FCV-II* (100 kW, HMC)

2007 ~ 2008
- *Tucson FCV-II* (100 kW, HMC)
- *Low Floor FCBus II* (200 kW, HMC)
- *I-Blue FCV* (Concept)

2005 ~ 2006
- *Tucson FCV, Sportage FCV* (80 kW, HMC)
- *Low Floor FCBus* (160 kW, HMC)

2004 ~ 2005
- *Tucson FCV* (80 kW, UTCP)
- *Sportage FCV* (80 kW, UTCP)

2000 ~ 2002
- *Santa Fe FCV* (75 kW, UTCP)

Korea, MKE Fleet Program
(2006.08 ~ 2010.07)
※ MKE: Ministry of Knowledge Economy
Similar to US DOE

USA, DOE Fleet Program
(2004.09 ~ 2009.12)

CaFCP
(2000.11 ~ Present)
Tucson FCV & Tucson FCV II

- Tucson FCV II (2007)

<table>
<thead>
<tr>
<th></th>
<th>Tucson FCV</th>
<th>Tucson FCV II</th>
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</thead>
<tbody>
<tr>
<td>Fuel Cell Power</td>
<td>80 kW, UTCP</td>
<td>100 kW, HMC</td>
</tr>
<tr>
<td>Aux. Power</td>
<td>LiPB</td>
<td>Super-capacitor</td>
</tr>
<tr>
<td>Motor System</td>
<td>80 kW</td>
<td>100 kW</td>
</tr>
<tr>
<td>H₂ Tank</td>
<td>3.6 kg H₂ @ 350 bar</td>
<td>3.6 kg H₂ @ 350 bar</td>
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# Sportage FCV II & Borrego FCV

<table>
<thead>
<tr>
<th></th>
<th>Sportage FCV II</th>
<th>Borrego FCV</th>
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</thead>
<tbody>
<tr>
<td><strong>Fuel Cell Power</strong></td>
<td>100 kW, HMC, Metal BP</td>
<td>115 kW, HMC, Carbon BP</td>
</tr>
<tr>
<td><strong>Aux. Power</strong></td>
<td>Super-capacitor</td>
<td>Super-capacitor</td>
</tr>
<tr>
<td><strong>Motor System</strong></td>
<td>100 kW</td>
<td>115 kW</td>
</tr>
<tr>
<td><strong>H₂ Tank</strong></td>
<td>3.6 kg H₂ @ 350 bar</td>
<td>7.9 kg H₂ @ 700 bar</td>
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</table>
# Low Floor FCBus

- **FCB I (2006)**
- **FCB II (2008)**

<table>
<thead>
<tr>
<th></th>
<th>FCB I</th>
<th>FCB II</th>
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<tbody>
<tr>
<td><strong>Fuel Cell Power</strong></td>
<td>160 kW, HMC</td>
<td>200 kW, HMC</td>
</tr>
<tr>
<td><strong>Aux. Power</strong></td>
<td>Super-capacitor</td>
<td>Super-capacitor</td>
</tr>
<tr>
<td><strong>Motor System</strong></td>
<td>240 kW</td>
<td>300 kW</td>
</tr>
<tr>
<td><strong>H₂ Tank</strong></td>
<td>40 kg H₂ @ 350 bar</td>
<td>30 kg H₂ @ 350 bar</td>
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San Francisco – LA Trip without Refueling, 396 mi (2008)

The public-road test program started at the Golden Gate Bridge in San Francisco and, via I-5 Highway, concluded at Los Angeles, covering approximately 396 miles on single fueling.

- Additional drivable distance: 75 miles
- Total Range for this test run: 471 miles
- Avg. fuel efficiency for the run: 60.47 mpg
## Safety Verification

<table>
<thead>
<tr>
<th>Test Item</th>
<th>Test Code</th>
<th>Test Set-up</th>
</tr>
</thead>
</table>
| **Sled Impact Test** (Hyundai Internal) | Tracing of 75kph (Impact : 40G)                | Test : He gas, 30bar  
No Leak, Check the deformation of H\textsubscript{2} storage and delivery system |
| **Side Impact Test (FMVSS 305)** | 54kph                                          | Test : He gas, 10bar  
No Leak for 1.5hrs  
Check the deformation of H\textsubscript{2} storage and delivery system.  
Check the H\textsubscript{2} tank burst pressure. |
| **Rear Crash Test (FMVSS301)**  | 48kph                                          | Test I : He gas, 30bar  
Test II : He gas, 350bar  
No Leak in the H\textsubscript{2} storage and delivery system |
Cold Start

Start Up at -20 C

• Vehicle was soaked at -20 C for 24 hours in the environment chamber
• Start up at without external power supply

Winter Test (Cold start)
Durability

- Hyundai FC ('08)
- DOE (80°C↑)
- DOE (80°C↓)
- Ballard FC ('04)
- Ballard FC (2005)
- Ballard FC (2003)
- Ballard FC (2002)
Cost Target

Challenging Issues
- Low cost stamped BOP
- Mass production of stack components (Unavailable for automated stacking)
- Mass production of BOP components

Scenarios
- Year: '07, '08, '10, '12, '20
- Scale: 10s FCVs, 100s FCVs, 1,000s FCVs, 10,000s FCVs, 100,000s FCVs
- Cost: Material Costs (Unit: US$)
USA, DOE Fleet Program

1. Objective - Verification of commercialization of FCEV
3. Vehicles : 33 Tucson/Sportage FCVs
4. Partners
   - Chevron (Hydrogen Filling Station)
   - UTC Power (Fuel Cell Stack)
   - Hyundai-Kia (Vehicle Development & Maintenance)
Korea, MKE Fleet Program

1. Objective - Verification of commercialization of FCEV
2. Period: 2006. 8 ~ 2010. 7
3. Vehicles: 30 FCVs, 4 FCBuses
4. Partners
   - Fuel Cell Stack & Vehicle Development: Hyundai-Kia Motors
   - Hydrogen Fueling Station: 10 (5 new stations)
     • Operation
       Hyundai Motors(2), KOGAS(1), GS-Caltex(1), SK-Energy(1)
     • Construction
       Hyundai Motors(2), KIST/Hyundai Motors(1)
       Dongdeok Industrial Gas(1), SPG Chemical(1)
   - Education & PR: NGVTEK (HMC's affiliates)
   - Researches commissioned: KIST, Konkuk Univ., Ulsan Univ.
Roadmap for FCV Development

FCEV Commercialization

2nd Gen. (2005 - 2008)
3rd Gen. (2009 - 2011)
4th Gen. (2012 - 2014)
5th Gen. (2015 - )

Preliminary Research
Prototype Development
Small Scale Production
4th Generation FCV

2012 Series Production

- Small scale production
- 100kW PEMFC with metallic bipolar plate
- Lithium Polymer battery
- more than 60% system efficiency
- -20°C cold startup capability
Thank You