Heavy Duty HFCV
Safety Issues and Research plan in KOREA

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1. Background & Necessity of Technology
2. Trends domestic and abroad, Environments
3. Project organization and Execution Strategy
"The fourth industrial revolution is not something new, but it's an extension of the innovation activities we have always been doing.."
**Background & Necessity (1/4)**

1. **Protect Environment** (Greenhouse Gas, Emissions)
2. **Stabilize Traffic Accidents**
3. **Assessment & Inspection Technology / Test Devices**
4. **Regulation / Int’l Harmonization**

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**Strengthen Air Quality in Urban Areas**

**Ban on sales of IC vehicles** (Mandatory Sales of Zero-emission Vehicles)

- **Reduce GHG**

**Manage Particulate Matters (PM2.5)**

- **HFCV Deployment and Promotion Policy**

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**Review of Ban on Sales for IC vehicles**

<table>
<thead>
<tr>
<th>Country</th>
<th>Time</th>
<th>Regulation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>‘25~</td>
<td>Ban</td>
<td>Agreed in Nat’ls Assembly(‘16.6)</td>
</tr>
<tr>
<td>Nederland</td>
<td></td>
<td></td>
<td>Senate Agreed(‘16.4)</td>
</tr>
<tr>
<td>Germany</td>
<td>‘30~</td>
<td>Ban</td>
<td>Senate Agreed</td>
</tr>
<tr>
<td>India</td>
<td>‘40~</td>
<td>EV only</td>
<td>Announcement by Transport Minister(‘17.4)</td>
</tr>
<tr>
<td>England</td>
<td></td>
<td>EV only</td>
<td>Announcement by Government(‘17.7)</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td>Ban</td>
<td>Announcement by ENV Minister(‘17.7)</td>
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</tbody>
</table>

**Strength Fuel Economy**

<table>
<thead>
<tr>
<th>Country</th>
<th>‘17 ~ ‘25</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>40 → 56 mpg (+40%)</td>
</tr>
<tr>
<td>Europe</td>
<td>130 → 80 g/km (+39%)</td>
</tr>
<tr>
<td>China</td>
<td>6.4 → 4.0 L/100km (+38%)</td>
</tr>
<tr>
<td>Korea</td>
<td>140 → 82 g/km (+41%)</td>
</tr>
</tbody>
</table>

- Increase FE by 5% every yr from 2015
- In case of noncompliance, ban on sale of conventional vehicles or prorated penalty

**Mandatory share of ZEV**

- **US**
  - 2018: 2.50% (PHEV 6% EV, FCEV)
  - 2025: 16%

- **China**
  - 2018: 10% (EV FCEV)
  - 2025: 12%

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**Road Map for Hydrogen Economy in KOREA**

- Reduce PM Jobs
- New Growth Engine
- Energy Independence
- Roadmap for H2 Economy Promotion

<table>
<thead>
<tr>
<th>Year</th>
<th>2018</th>
<th>2025</th>
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<tbody>
<tr>
<td>H1</td>
<td>2</td>
<td>35</td>
</tr>
<tr>
<td>H2</td>
<td>18</td>
<td>300</td>
</tr>
<tr>
<td>H3</td>
<td>30</td>
<td>685</td>
</tr>
<tr>
<td>H4</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>H5</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 3

Background & Necessity (2/4)

1. Protect Environment (Greenhouse Gas, Emissions)
2. Stabilize Traffic Accidents
3. Assessment & Inspection Technology / Test Devices
4. Regulation / Int’l Harmonization

Cause for Accidents involving HDV

Various Cause for Accidents / Firs

Reflect commercial HFCV characteristics & Need to improve accidents safety

’18 Statistics of Accidents involving HDV (Fatal > 3, Casualties > 20)

Trends in Latest 5 years

<table>
<thead>
<tr>
<th>Year</th>
<th>No.</th>
<th>Death No.</th>
<th>Injured No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>86</td>
<td>1,833</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>75</td>
<td>1,643</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>64</td>
<td>1,284</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>55</td>
<td>1,067</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>48</td>
<td>962</td>
<td></td>
</tr>
</tbody>
</table>

Vehicle Types

- Buses casualties 50.0%
- Buses 50.0%
- Passenger 29.5%
- Trucks 9.6%
- Other 10.1%
- Taxi 4.5%

Usage (commercial)

- Fixed route 36.4%
- Chartered 36.4%
- Truck 13.6%
- Rent 9.1%
- Taxi 4.5%

’18 Casualties (Death 3,781 / Injured 323,037)

‘18 Vehicle registration ratio

- Sedan 80.5%
- Com. 19.1%
- Special 0.4%

‘18 Death/Injured Ratio

- Sedan 58.5%
- Commercial 23.7%
- Bike 4.2%
- Pedestrian 51%
- Others 0.4%

Various Accidents

- Rear 18%
- Side 22%
- Frontal 7%
- Rollover 1%
- Others 51%
Consider various accidents & Need to reinforce safety of H2 leakage in HFC HDV
CHAPTER 4

Background & Necessity (3/4)

1. Protect Environment (Greenhouse Gas, Emissions)
2. Stabilize Traffic Accidents
3. Assessment & Inspection Technology / Test Devices
4. Regulation / Int’l Harmonization

- No test and inspection protocols for HFC HDV
  - KMOVSS 91: Rollover regulation was revise but detail test protocols is not yet provided also simulation
  - KMOVSS 111: Regulation of power of traction motor is not cover the motor performance on multi power source.
- No test devices and inspection procedures in periodic inspection for leakage of CHSS in-use HFC HDV
- No safety regulation for HDV CHSS
  - KMOVSS for the CHSS isn’t harmonized with GTR 13. Test Devices need to upgrade.

Necessity for Development of Safety assessment technology & Test devices
Background & Necessity (4/4)

1. Protect Environment (Greenhouse Gas, Emissions)
2. Stabilize Traffic Accidents
3. Assessment & Inspection Technology / Test Devices
4. Regulation / Int’l Harmonization

- UN GTR 13 2 Phase
- IWG vice-chair & TF leader
- Domestic committee consultation
- Harmonize KMVSS to GTR 13-2


Amendment of a Reasonable safety level of GTR

- 01 Expand Vehicle Type
- 02 Receptacle
- 03 Improve & update
- 04 Fire test
- 05 ISO Harmonization

Establishment and operation of the consultation body on the internationalization
Trends of Policies for HFCV

Each country announced development & promotion of HFCV

- **2019 Government announcement of Roadmap for promotion of hydrogen Economy**
- **Establishment of special purpose corporation for Installation/Operation of H2 fueling station**
- **Various subsidies for HFCV deployment (Bus : Grant 500,000 US $)**

- **Announcement of three-phase roadmap for promoting hydrogen society**
- **At 2020 Tokyo Olympic, Plan to announce H2 society (over 100 H2 Buses, 160 charging stations)**
- **Wide Deployment of Eco-friendly H2 Bus for Public Transport (grant of up to 80% bus price)**

- **China Government announced HFCV Bus Roadmap(H2 Vehicle: 2020(3,000 units), 2025(10,000 units))**
- **At 22 Olympic Winter Games, Open the Era for H2 vehicles (2,000 H2 Buses)**
- **Mandatory Sales of Vehicles with new energy (subsidy : No EV(‘20년), H2 Bus(.0.5 mil RMB¥))**

- **H2 Industries are being established in California**
- **DOE promotes pilot projects**
- **Strengthen Mandatory sales of Zero-emission vehicles**

- **EU and members promote and deploy H2 vehicles and Infrastructure in parallel**
- **Consider ban on sale of vehicles with IC engine, Subsidy for Eco-friendly vehicles (England, France ; 120,000 Euro)**
- **In 200 major cities, Low EM Zone(LEZ), regulate vehicles with diesel engine**
Ministry of Land, Infrastructure and Transport

Regulation

- Completion of harm. GTR 13
  - KMVSS 11, 17, 91, 111

- CHSS Parts Regulation
  - In progress with GTR 13
  - Direction: Manufacture may choose the GTR and Current regulation

- Introduce UN R 134 (19.12.16)

- EC 79/2014 will be repeal
  - Receptacle, Material, LHSS will be added

- Harmonization of domestic regulation with UN R 134

Global Technical Regulation Phase 2 in progress

- **TF1** | Expansion of scope (leader: Korea)
- **TF2** | Receptacle
- **TF3** | Update & Amend current GTR 13
- **TF4** | Fire test
- **TF5** | Harmonization with SO
- **IWG meeting** | 3 times/yr, TF: An necessary
**Status of Hydrogen HDV**

- **City Bus**
  - Stack: 95kW x 2ea
  - Tank: 33kg
  - **Pressure**: 700bar/6EA
  - Driving range: 440km

- **Garbage truck**
  - Under development

- **SORA**
  - Stack: 228kW
  - Tank: 24kg
  - **Pressure**: 700bar/10EA
  - Driving range: 200km

- **Truck**
  - Stack: 114kW
  - Tank: 7kg
  - Pressure: -
  - Driving: 200km

- **Yutong city Bus**
  - Stack: 60kW
  - Tank: 25kg
  - **Pressure**: 350bar/8EA
  - Driving range: 500km

- **Dongfeng Truck**
  - Stack: 32kW
  - Tank: 9.3kg
  - **Pressure**: 350bar
  - Driving range: 320km

- **Citaro (Daimler)**
  - Stack: 85kW
  - Tank: 60kg
  - **Pressure**: 350bar/8EA
  - Driving range: 483km

- **A330 (Van Hool)**
  - Stack: 300kW
  - Tank: -
  - **Pressure**: 350bar/-EA
  - Driving range: 1,000km more

- **VDL 200 (Wright)**

- **Urbino (Solaris)**

- **350bar city Bus**
Status of Market trends for Hydrogen HDV

Ministry of Land, Infrastructure and Transport

- '18: Operating two H2 buses (Seoul, Ulsan)
- '19: Deploy 21 H2 buses in 7 cities
- Roadmap for H2 Economy: ’20(300 units), ’21(665 units), ’22(1000 units)

- Pilot project of city buses is being conducted in Tokyo
  - ’18(2 units), ’19(5 units) are being operated
  - H2 bus ’20(100 units), ’30(1200 units)

- First commercially operating buses: 159 units
  - During Int’l meetings of G20, APEC, etc. H2 buses are being operated
  - H2 Commercial vehicle ’20(3,000 units), ’25(10,000 units)

- In California, Pilot Project and Assessment
  - ’19, 68 H2 buses are being operated. (over 300 units accumulate)

- European Pilot Project
  - ’19: 294 units are being operated
  - JIV1 (142 units of H2 Buses)
  - JIV2 (152 units of H2 Buses)
Comprehensive Review in Korea

**Policy**
1. Low and Zero-emission policy (GHG)
2. Amendment of GTR 13 Phase 2
3. Harmonize Domestic regulation with GTR 13

**Market**
1. Purchasing Assistance policy at national level
2. Expect to develop of HFC HDV
3. Export of HFC Truck & Expect the expansion of HFC HDV

**Technology**
1. Secure technology for CHSS with 700bar and PRD, etc.
2. Immature technology for periodic inspection of In-use HDV and test devices
3. Upgrade facility and develop test equipment

- Securing safety for HFC HDV to support the policy
- Urgent development for Inspection protocol & test equipment
- Utilizing developed equipment
- Participating in IWG GTR 13-2
- Securing safety of leakage for In-use & accidents
- Securing the reliability for the developed equipment
- Reducing Research Cost
- Propose the regulation for the HFC HDV
Ministry of Land, Infrastructure and Transport

• Build the monitoring system & develop crash testing Scenarios
• Develop inspection technology of in-use Hydrogen HDV
• Develop Safety Assessment for CHSS in HDV

Development of safety regulation & test equipment to secure safety of hydrogen HDV

Vision

Securing World-class Hydrogen HDV safety (H2 leakage Zero)

Goal

Core value

Safety

Internationalization

Responsibility

Safety assessment & Inspection technology

• Develop Regulations for safety assessment & inspection
• International harmonization & internationalization of regulation

International Harmonization

Development of test Devices for HDV & CHSS

• Develop Test facilities of motor power performance
• Develop inspection devices & CHSS test equipment

Main Subject

1. Develop rollover/crash regulation & Internationalization
2. Develop regulation and test equipment of Multi power parallel drive system
3. Develop Inspection technology and Test devices
4. Develop CHSS regulation & Test equipment

Strategy Direction
Title: Development of Safety Assessment Technology & Test Devices of HFC Bus
Period / Budget: 2020 ~ 2024 / $25 million(grant)

**Part 1**
Dev. Crash regulation & Internationalization
1. Dev. crash testing Scenario base on the monitoring analysis
2. Dev. Rollover / crash regulation
   - 2-1 Rollover(vehicle & simulation) Testing protocols
   - 2-2 Crash testing protocols
3. Legislation & Internationalization
   - 3-1 Propose the domestic regulations
   - 3-2 Propose the Int’l regulations

**Part 2**
Dev. regulation and test equipment of Multi power parallel drive system
1. Dev. Regulation for the Parallel drive system
   - 1-1 Power assessment regulation for fuel cell and drive system
2. Dev. Integrated performance test equipment for drive system
   - 2-1 Dev. test equipment of multi power parallel drive system

**Part 3**
Dev. Periodic inspection Regulation and Devices
1. Dev. inspection protocols & devices for permeation of CHSS
   - 1-1 Dev. protocol to verify permeation rate
   - 1-2 Dev. inspection device to verify permeation rate (1ea)
2. Dev. Inspection protocols & Devices for H2 exhaust system
   - 2-1 Dev. protocol to verify H2 exhaust system
   - 2-2 Dev. inspection device to verify H2 exhaust system (1ea)
3. Dev. Non-destructive inspection protocols
   - 3-1 Establishment of non-destructive inspection results DB
   - 3-2 Dev. algorithm to check the crack using inspection devices

**Part 4**
Dev. HDV CHSS regulation & Test equipment
1. Dev. fire test protocols & Burner (1ea)
2. Dev. test equipment for GTR harmonization (7ea)
3. Dev. HDV CHSS test protocols & equipment
   - 3-1 Upgrade hydraulic & pneumatic Test protocols in HDV CHSS
   - 3-2 Dev. test equipment For HDV CHSS (8ea)
Overview

- Collect & analysis of Accidents data of HFC Bus
- Upgrade domestic facility for GTR
- Ensure Operational & Accident Safety of in-use HFCV
  - Periodic inspection
  - Crash safety
    - RESS
    - CHSS
    - Fuel cell
    - Motor

Development of crash safety regulation
- Rollover & simulation
- Crash test

Development of periodic inspection Reg. & devices

Development drive system reg. & test equipment
- Reg. of drive system & test equipment

HDV CHSS regulation & test equipment
- Fire
- HDV CHSS test protocol & equipment
## Project Roadmap

### Year

<table>
<thead>
<tr>
<th>1&lt;sup&gt;st&lt;/sup&gt; year</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; year</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; year</th>
<th>4&lt;sup&gt;th&lt;/sup&gt; year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urgency</td>
<td>Advance</td>
<td>Legislation &amp; internationalization</td>
<td></td>
</tr>
</tbody>
</table>

### Development

**Crash Regulation & Internationalization**

- Testing scenario of fuel system integrity of H2 bus in crash
  - Rollover test & Simulation Reg.
  - Reg. for fuel system integrity of hydrogen bus in crash
- Strategy for Reg. & internationalization
  - Propose of domestic regulation & Internationalization
- Internationalization

**Dev. Regulation & test equipment of Multi power parallel drive system**

- Research Reg. & Std.
- Testing method & Regulation
  - Design of Integrated performance test equipment
  - Evaluation of test equipment
  - Enhance facility & Reliability verification
  - Support Internationalization

**Dev. Periodic inspection Regulation & Devices**

- Inspection technology and device for permeation & regulation
- Establish legal system/ Enhance facility & Reliability verification
- Inspection technology and device for Exhausting system & regulation
- Non-destructive Inspection technology optimization
- DB for composite material defects
- Pilot project for Non-destructive Inspection Reg.

**Dev. HDV CHSS reg. & Test equipment**

- Fire test protocol & equipment
- Enhance facility & Reliability verification
- Upgrade domestic facility for GTR
- Enhance facility & Reliability verification
- Assessment Device for high capacity CHSS & Hydraulic Assessment Technology, Regulation

### Output

- Crash scenario
- Rollover test protocol
- Crash test protocol
- Test protocol for multi Power drive system
- Test equipment
- Inspection protocol & device of permeation
- Inspection protocol & device of emission
- Non-destructive Inspection protocol
- Fire test protocol & equipment
- GTR certi. equipment
- HDV CHSS test protocol & equipment
Thank you