Hydrail Project in Korea

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Motive

- High quality service of public transportation
  - Flexible operation: no overhead wire
  - Scheduled operation: railway service
  - Easy access: platform on the ground

- Environment
  - Zero emission

- Energy/Economy
  - Alternative energy
Smog, air pollution
→ Fuel cell
Traffic congestion
→ Rail system
Oil crisis
→ Alternative Energy
R&D Structure

Hydrogen and Fuel Cell System for Transportation

- the Ministry of Science and Technology
  - Feasibility study
  - Basic and core technology
- the Ministry of Commerce, Industry and Energy
  - Develop the major parts
  - Develop the system for individual use
- the Ministry of Construction and Transportation
  - Integrate the individual technologies
  - Regulation, Infrastructure, Public transportation
- Local Governments
  - Construct the infrastructure
  - Manage the operation
the Ministry of Science and Technology
- 21st century Frontier Project: Study on hydrogen production, storage and utilization at Hydrogen Energy Center since 2003

the Ministry of Commerce, Industry and Energy
- Next Generation Growth Engine Project: Study on the manufacture of fuel cell stack, BOP and Demonstration program ☞ The development of 80 kW and 200 kW fuel cell stack is underway for the use in transportation. The test drive of the onboard vehicle is also underway.

the Ministry of Construction and Transportation
- National Transportation Key Technology R&D project: Develop hybrid bimodal tram with hybrid propulsion system of fuel cell and battery (or super capacitor)
- Plan: Hydrogen based public transportation system, the related infrastructure and regulation, Hydrogen supply system
The Government Laws

Promotion of Public Transportation (1. 2005)

- Clause 3 (Government Duty) ①: Develop and provide environment-friendly public transportation vehicle
- Update the plans every five years
- Promotion and support: Priority signal, support financially operators and model cities

Promotion of Movement of the Weak (12. 2005)

- Update the plans every five years
- Detailed standard for the structure and material of public vehicle → the Ministry ordinance
- Clause 26 ① : Develop and supply standard no step bus
Approach to Railway with Fuel Cell

Rail/Track Transportation

1st phase
- Tram for city service

2nd phase
- LRT for city service
- Local Train

3rd phase
- Compact subway train
Project Flow

Project 1

- Modular composite body
- Virtual rail
- Automated operation
- Fuel cell system

Project 2

- System engineering
- Infrastructure standard
- Operation system
- Maintenance based on railway system

Project 3

- Fuel cell propulsion
- Hydrogen infrastructure
- Regulation
- Standardization

Bimodal Tram

Operation System and Infrastructure

Hydrogen Public Transportation System

Prototype Tram

Hydrogen Public Transportation
Hybrid System

Hybrid Power Plant

FC System
- Fuel Cell Operation
- Fuel Cell
- Air Supply

HV DC/DC Converter
HV Battery Li Polymer

Electric Drive Train
- Inverter
- Motor

Climate Control
- Heater
- Air Conditioner
- Inverter (AUX)
- Motor (AUX)
# Battery System

## 22Module (8S1P X 22)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical Capacity</strong></td>
<td>80.0 Ah</td>
</tr>
<tr>
<td><strong>Nominal Voltage</strong></td>
<td>651.2 V</td>
</tr>
<tr>
<td><strong>Charge Condition</strong></td>
<td></td>
</tr>
<tr>
<td>Max. Current</td>
<td>160.0 A</td>
</tr>
<tr>
<td>Voltage</td>
<td>739.2 V</td>
</tr>
<tr>
<td><strong>Discharge Condition</strong></td>
<td></td>
</tr>
<tr>
<td>Continuous Current</td>
<td>400.0 A</td>
</tr>
<tr>
<td>Peak Current</td>
<td>640.0 A</td>
</tr>
<tr>
<td>Cut-off Voltage</td>
<td>598.4 V</td>
</tr>
<tr>
<td><strong>Cycle Life [@ 80% DOD]</strong></td>
<td>&gt; 1,500 Cycles</td>
</tr>
<tr>
<td><strong>Operating Temp.</strong></td>
<td></td>
</tr>
<tr>
<td>Charge</td>
<td>0 ~ 40 °C</td>
</tr>
<tr>
<td>Discharge</td>
<td>-20 ~ 60 °C</td>
</tr>
<tr>
<td><strong>Dimension</strong></td>
<td></td>
</tr>
<tr>
<td>Thickness (mm)</td>
<td>1,650 mm</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>478 mm</td>
</tr>
<tr>
<td>Length (mm)</td>
<td>412 mm</td>
</tr>
<tr>
<td><strong>Weight (g)</strong></td>
<td>400 kg</td>
</tr>
</tbody>
</table>
Project Flow

Project 1 - Modular composite body - Virtual rail - Automated operation - Fuel cell system

Project 2 - System engineering - Infrastructure standard - Operation system - Maintenance based on railway system

Project 3 - Fuel cell propulsion - Hydrogen infrastructure - Regulation - Standardization

Prototype Tram

Hydrogen Public Transportation System

Bimodal Tram

Operation System and Infrastructure

Hydrogen Public Transportation System

Prototype Tram

Hydrogen Public Transportation

Korea Railroad Research Institute
Integrated Operation/Information System

- Central Control Center
  - Integrated operation (data base)
  - Operation/information system (data base)
  - Transit system (traffic control, maintenance, AGS and precise docking)

- Video monitoring system
  - Monitor the vehicle, station and operation
  - Real time monitoring with IP network, CCTV control
  - Quick response to the unexpected accident, Video multicast

- Tram operation computer
  - Position on the virtual rail, Tram operation condition
  - Feedback the operation interval, Double-checking system for safety
  - Information on station-CCC-tram, Separate display module
  - Interface with the tram control computer
Test Bed

- System engineering
- Standard infrastructure
- Operation system
- Maintenance system
- Refueling system

Operational infrastructure
Test bed

[Image description: A diagram showing the relationship between different systems and infrastructure related to test beds.]
Test Bed

Central Control Center

Communication

Monitoring System

CCTV

VMS

Priority Signal

Information/Guide Tram

Station Information

Modular Station

Refueling

Bimodal Tram

Operation Computer

Onboard Computer

Display/Information (driver/passenger)

Overpass/Bridge

Test Bed
# Station and Transit Center

## Guidance System
- Precise docking
- Magnetic guidance
- Platform size and standard

## Modular Station
- Fare collect, screen door
- Safety from fire/accident
- Central monitor and control
- Comfortable indoor

## Information
- Passenger safety
- Operation information

## Transit
- Systematize the transit depending on the routes, function and connection

### Concept Design

- Closed type
- Semi open type
- Open type
Project Flow

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- Standardization

Bimodal Tram

Operation System and Infrastructure

Hydrogen Public Transportation System

Prototype Tram

Hydrogen Public Transportation
Step by Step Goal

Hydrogen Tram to Train
## Work Scope

<table>
<thead>
<tr>
<th>Theme</th>
<th>Sub-theme</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuel cell propulsion system</strong></td>
<td>Propulsion and control</td>
<td>➢ Traction inverter, motor and controller</td>
</tr>
<tr>
<td></td>
<td>BOP for rail system</td>
<td>➢ BOP for the safety and performance of hydrogen train</td>
</tr>
<tr>
<td></td>
<td>Interface fuel cell and propulsion system</td>
<td>➢ FC controller and traction controller</td>
</tr>
<tr>
<td></td>
<td>System integration, test and evaluation</td>
<td>➢ Establish the procedure for the test and evaluation of fuel cell powered train (reliability, safety, durability)</td>
</tr>
<tr>
<td><strong>Infrastructure, Supply and Safety</strong></td>
<td>Production and storage</td>
<td>➢ Replace substation with fuel cell system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>➢ Technology combined with the existing railway system</td>
</tr>
<tr>
<td></td>
<td>Supply system</td>
<td>➢ Delivery technology like Pipe-line supply</td>
</tr>
<tr>
<td></td>
<td></td>
<td>➢ Integrated network for central delivery</td>
</tr>
<tr>
<td></td>
<td>Management</td>
<td>➢ Standard for safety and design</td>
</tr>
</tbody>
</table>
Report on electrified railway system in Seoul

- Most troubles are from substations and catenary wires.
- Need a substitute system
## Initial Cost

### Electrified AGT vs Fuel Cell AGT

<table>
<thead>
<tr>
<th>Cost (ratio)</th>
<th>Vehicle</th>
<th>Infrastructure*</th>
<th>Propulsion system</th>
<th>Total</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-AGT</td>
<td>1</td>
<td>5 M $/km</td>
<td>1</td>
<td>1.05</td>
<td>Total extension 12.7 km</td>
</tr>
<tr>
<td>Fuel Cell AGT</td>
<td>1.5</td>
<td>--</td>
<td>10</td>
<td>1</td>
<td>Estimated in 2007</td>
</tr>
</tbody>
</table>

* Except the land acquisition cost

- Cost of fuel cell system is so noncompetitive at the moment
- Nevertheless, the total initial cost is more competitive with FC system
- Cost for fuel, maintenance and operation of FC AGT depends on the technology
- Durability of fuel cell system needs much improvement
Korea Construction Fair 2007
Thank you for your attention

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