

# Hydrogen Fuel Cell Powered Train Project

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# Introduction

- Respond to Paris Climate Agreement in 2015
- The use of fuel cell for railway has benefits in energy efficiency, zero emission and cost savings without electrification facilities of railroad
- Hydrogen fuel cell application to automobile and bus is popular. But, its application to railway is comparatively limited at the moment.
- Key issues of the project
  - Hybrid power system of HFC and secondary cells
  - Power conversion of regenerated energy
  - Propulsion system for the effective use of traction motors
  - Auxiliary power unit for grid-connection
  - Smart energy management system based on IoT technology

# Concept of the Project

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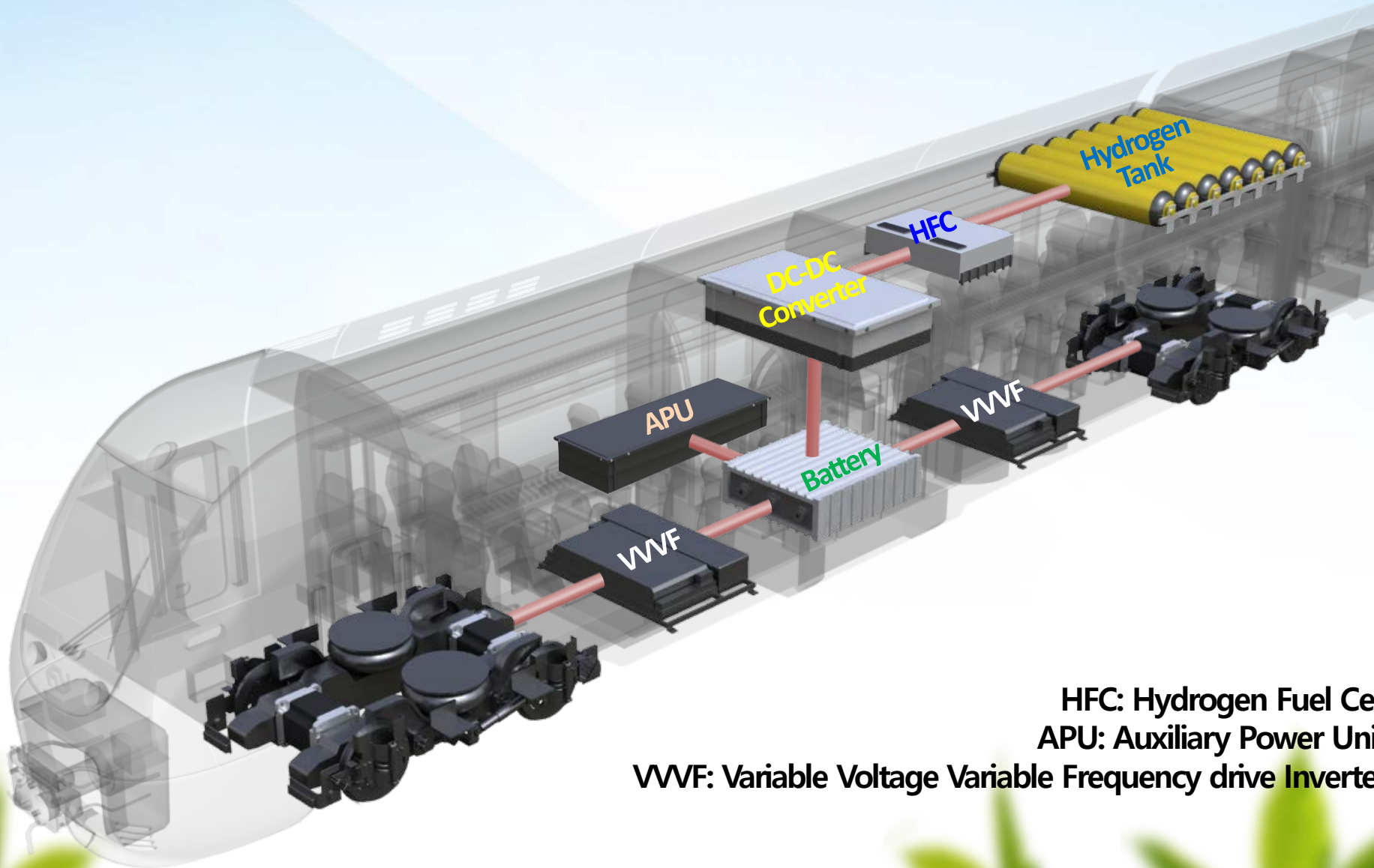
# Current State

- There is no HFC train in Korea.
- HFC automobile/bus were developed and used in 2018 PyeongChang winter Olympic town in Korea.

	Automobile (Hyundai NEXO)	Hyundai HFC bus
Weight of vehicle	1.8 tons	15 tons
Type of fuel cell	PEMFC, 135kW	PEMFC, 200kW
Speed	180km/h	103km/h
Refueling and drive	600km	440km
Braking	hydraulic system	hydraulic system
Tank (hydrogen amount)	700bar (6.33kg)	350bar (40kg)

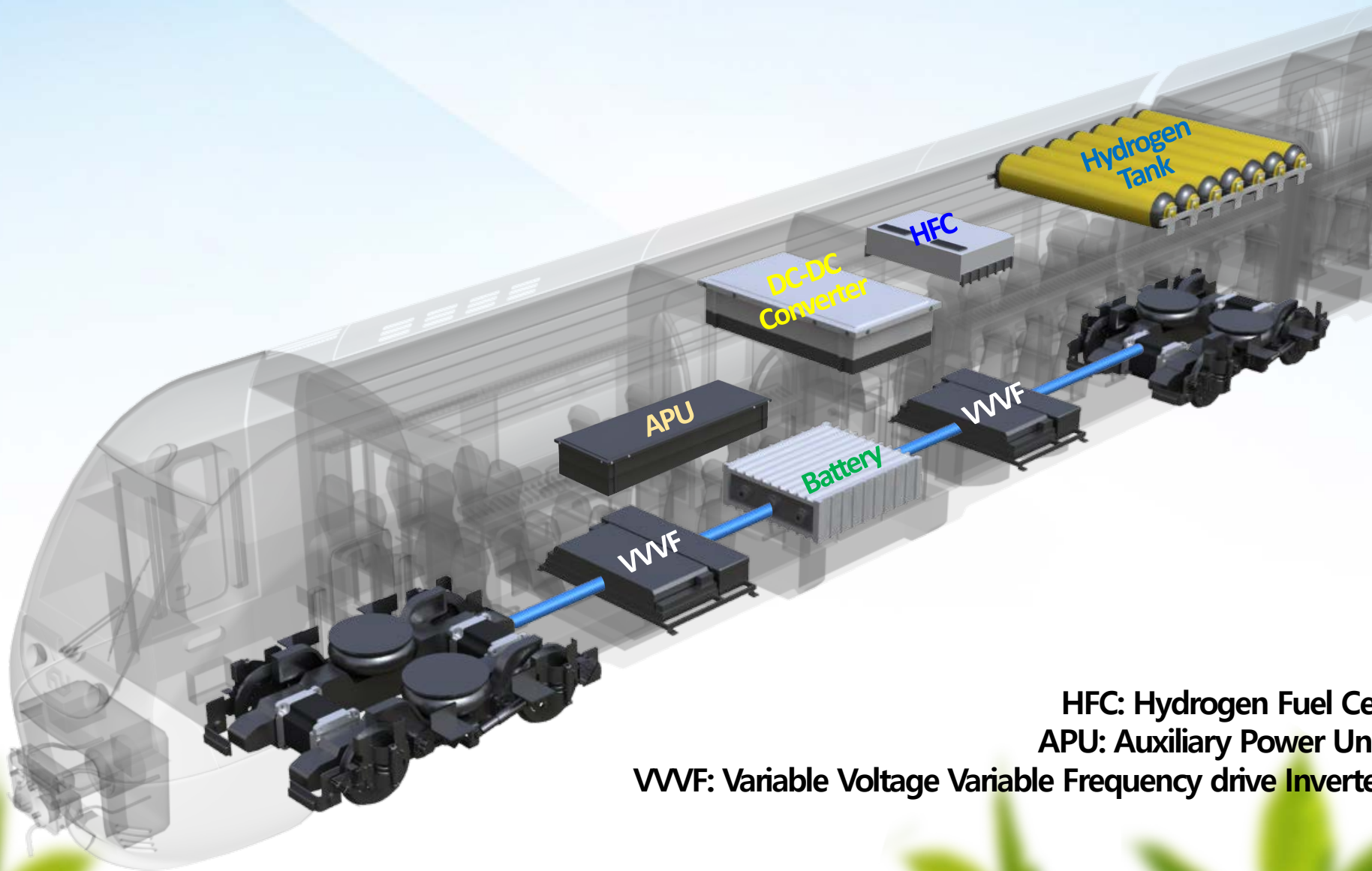


# Schematic diagram of powering



**HFC: Hydrogen Fuel Cell**  
**APU: Auxiliary Power Unit**  
**VVVF: Variable Voltage Variable Frequency drive Inverter**

# Schematic diagram of braking



**HFC: Hydrogen Fuel Cell**  
**APU: Auxiliary Power Unit**

**WVF: Variable Voltage Variable Frequency drive Inverter**

# Overview of the Project

- HFC train with hybrid power system of 1.2MW
  - (Sub 1) Hybrid propulsion system of HFC and battery
    - System engineering of HFC train
    - Power system of fuel cell and battery
    - DC-DC converter for HFC system
    - High power density propulsion system
    - Auxiliary power unit for grid-connection
  - (Sub 2) Operation management technology of HFC train
    - Develop new train structure for HFC system
    - Standard and verification of the HFC train
    - Operation and management of the HFC train
    - Refueling facility

# Roadmap of the Project

2018

2019

2020

2021

2022

## (Sub 1) Hybrid propulsion system of HFC and battery

- Specification of the fuel cell system and main devices

- Design and manufacture the devices
- Prepare FC system

- Verify the devices (unit/assembly)
- Manufacture tester

- Support installing devices on the HFC train
- Analyze performance

- Support test

- Concept/basic design of the train
- Management and verification plan
- Refueling spec.

- Detailed design of the train
- Analyze the operation requirement
- Plan refueling

- Build the train
- Plan the operation and performance verification
- Design the refueling

- Test the train
- Verify the operation and performance
- Build the refueling

- Test run
- Tech. and maintenance /repair standard
- Verify the performance of the refueling

## (Sub 2) Operation management technology of HFC train



# Output of the Project

- The Prototype HCF train: speed  $\geq 110$  km/h, output 1.2 MW, 600 km with a full tank
- Power system of HFC and battery
- High efficiency DC-DC converter for HFC system
- High power density propulsion system
  - permanent magnet synchronous motor & silicon carbide inverter
- Auxiliary power unit for grid-connection
- Hydrogen refueling facility for the prototype HCF train
- Propose the tech. standard of the HFC train
- Operation and management plan of the HFC train

# Future application of the HFC

## Light rail train/Tram

- Electrification facilities are not necessary : Cost saving of infrastructure construction and maintenance/repair, Reduce the safety accident by electric shock from electrification facilities
- Existing lines are used without any modification
- Provide environment-friendly scenery without electric wires

## Replace the old diesel locomotive

- Reduce emission and air pollution by diesel
- Replace the aging diesel locomotives (over 25 years)

# Future application of the HFC

## Commuter train

- One hundred thirty one diesel commuter trains are operated on the eleven lines. Most of them are planned to be replaced with electrification. Some of them are hopefully replaced with hydrogen fuel cell trains.

## For next generation

- In the near future, LRT, commuter trains and trams are promising with hydrogen fuel cell power. Depending on the development speed of fuel cell system, some of the metro trains and heavy railway trains are expected to be replaced by hydrogen FC trains.

# Term and Budget

April, 2018 ~ December, 2022 (4 years 9 months)

- 1<sup>st</sup> year: 2018.04. ~ 2018.12.(9 months)
- 2 ~ 5<sup>th</sup> year: 12 months/each project year

Total budget: 22,800,000 US \$

- Government: 20,000,000 US \$
- Partner companies: 2,800,000 US \$ (cash/in kind)

# General Issues

- Relieve the uneasiness of the people for the use of hydrogen
- Verify the safety of hydrogen vehicles
- Government's policy support and legal modification are necessary to extend the application of HFC trains
- Communication and Cooperation between industry-academy-research institute

# HFC Train in the City



# Goals and Activities(1)

## System engineering of the HFC train

- Goal: speed  $\geq 110$  km/h, run 600 km with a full tank
- 2019: Design the train in detail and manufacture the main devices

## Power system of HFC and battery(1)

- Goal: Storage tank 700bar, 600 km with a full tank, power 1.2MW
- 2019: Design the hybrid power system in detail and manufacture  
Design the fuel cell system and BOP

# Goals and Activities(2)

## Power system of HFC and battery(2)

- Goal: efficiency  $\geq 95\%$
- 2019: Design the DC-DC converter in detail and manufacture  
Design the BMS algorithm

## High power density propulsion system

- Goal: efficiency of permanent magnet synchronous motor  $\geq 96\%$ ,  
power density of propulsion system 0.13kW/L,  
regenerated energy  $\geq 99\%$
- 2019: Develop control algorithm for motor-inverter  
Simulation test of the performance  
Design the permanent magnet synchronous motor and manufacture



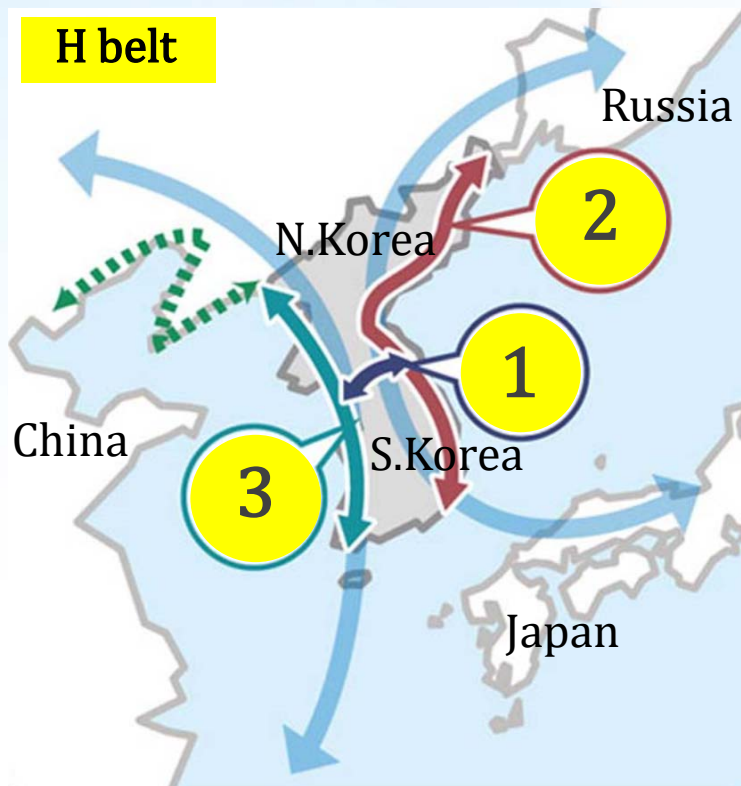
# Goals and Activities(3)

## Auxiliary power unit for grid-connection

- Goal: time for grid-connection  $\leq 3$  seconds, voltage/current, total harmonic distortion of auxiliary power unit  $\leq 3\%/ 5\%$
- 2019: Design the auxiliary power unit and manufacture  
Simulation test

# Korea New Economy Plan

When peaceful mood comes to the Korean peninsula,



1. Border area peace belt
  - Ceasefire line (155 miles),
  - Demilitarized zone(DMZ)
  - Clean area
  - Wild life reserve: animals and plants
  - Plan: Ecology, peace and security tourist region
2. Pan-East sea economy belt
  - Plan: New renewable energy and resource-based economy belt
3. Pan-West sea economy belt
  - Plan: Manufacturing and logistics-based economy

**One market: Freedom of movement, Market expansion**

# Along the Peace Belt

## When peaceful mood comes to the Korean peninsula,

We hope that zero emission train like hydrogen train runs along the boarder area peace belt or to the north in some day.



# Request

## What we are interested in/need

- 1) The international joint research with Korea Railroad Research Institute
- 2) Authentication process and standards for the application of HFC train in the U.S./Europe
- 3) Road map for the hydrogen economy and the policy in the U.S.
- 4) Economic analysis for the hydrogen fuel cell train system in the U.S./Europe

# Thank you

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# for your attention