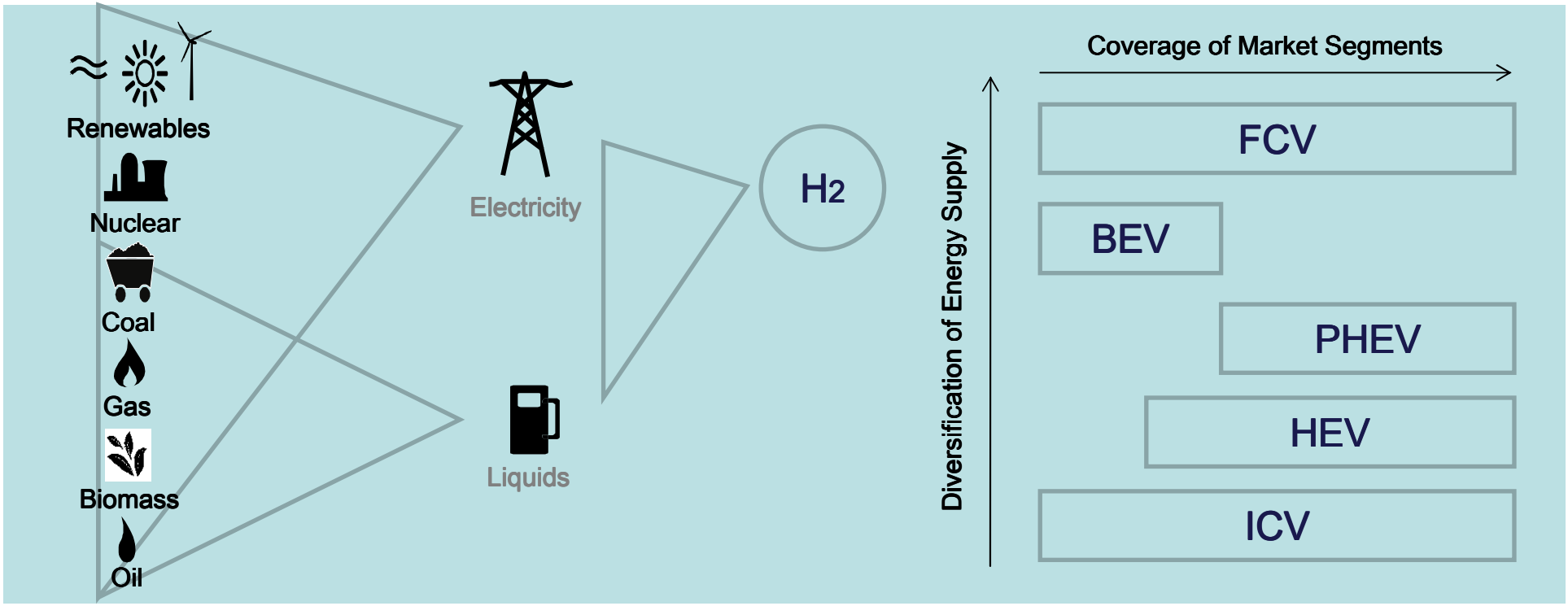
Sustainable Mobility – Fuel Cell Vehicles

HYUNDAI·KIA MOTORS

Challenges of Sustainability

KEY SOLUTIONS for THE ISSUES

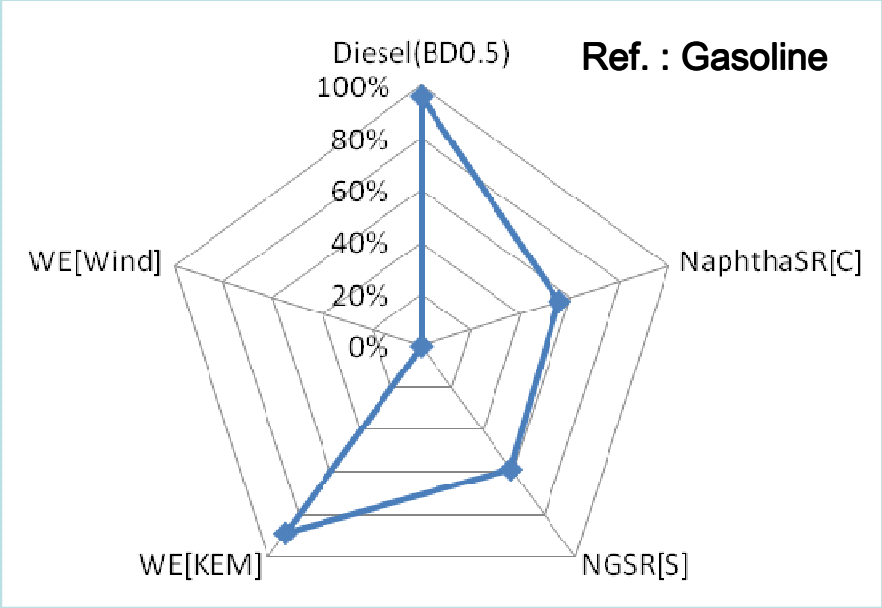
Future Energy System and Automobiles



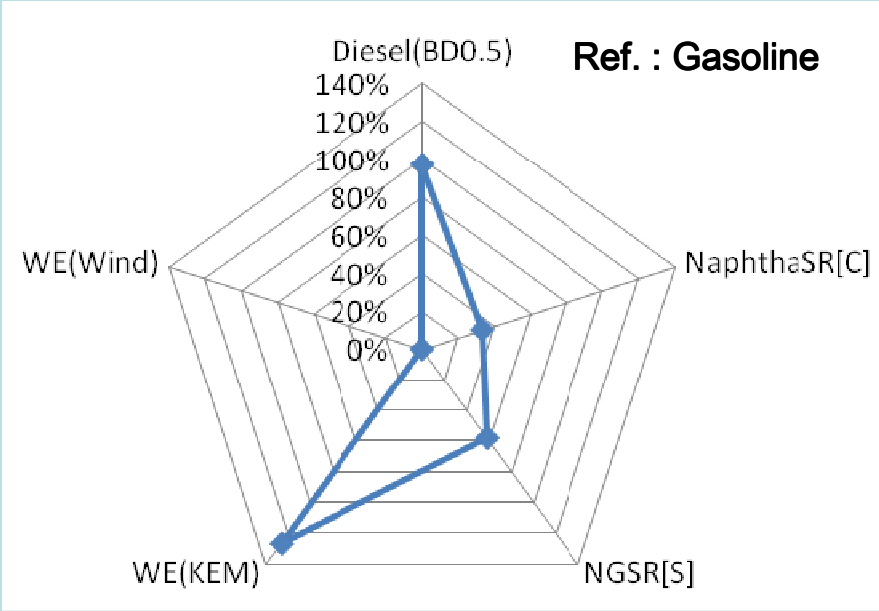
- New Transportation Fuel : Hydrogen and Electricity
- Improvement of Efficiency : Electrification of Powertrain

Fossil Fuel Consumption & GHG Emission

Fossil Fuel Consumption



GHG Emission



Diesel (BDO.5) = 50% Biodiesel

WE[Wind] = Water Electrolysis from Wind

WE[KEM] = Water Electrolysis from Korea electricity mix

NGSR[S] = NG Gas Steam Reforming at local H2 station

NaphthaSR[C] = central naphtha steam reforming; H2 tube trailer delivery

Hyundai & KIA Development History

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

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

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

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

2000 ~ 2002
- ***Santa Fe FCV*** (75kW, 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 (2004)

Tucson FCV II (2007)

	Tucson FCV	Tucson FCV II
Fuel Cell Power	80 kW, UTCP	100 kW, HMC
Aux. Power	LiPB	Super-capacitor
Motor System	80 kW	100 kW
H_2 Tank	3.6 kg H_2 @ 350 bar	3.6 kg H_2 @ 350 bar

Sportage FCV II & Borrego FCV

- Sportage FCV II (2008)
- Borrego FCV (2008)

	Sportage FCV II	Borrego FCV
Fuel Cell Power	100 kW, HMC, Metal BP	115 kW, HMC, Carbon BP
Aux. Power	Super-capacitor	Super-capacitor
Motor System	100 kW	115 kW
H_2 Tank	3.6 kg H_2 @ 350 bar	7.9 kg H_2 @ 700 bar

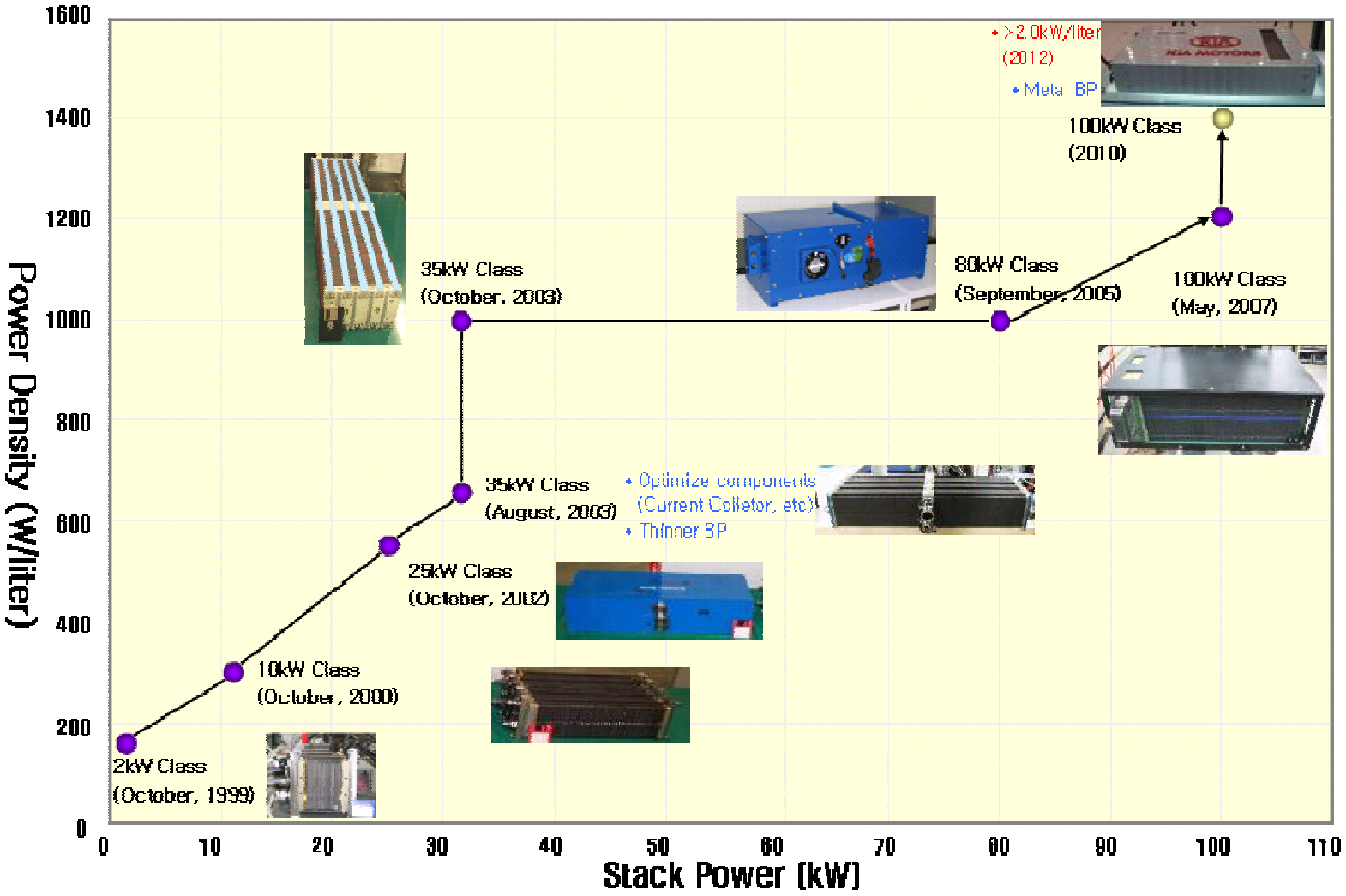
Low Floor FCBus

FCB I (2006)

FCB II (2008)

	FCB I	FCB II
Fuel Cell Power	160 kW, HMC	200 kW, HMC
Aux. Power	Super-capacitor	Super-capacitor
Motor System	240 kW	300 kW
H_2 Tank	40 kg H_2 @ 350 bar	30 kg H_2 @ 350 bar

HMC Fuel Cell Stack



Driving Range

San Francisco – LA Trip without Refueling, 396 mi (2008)

Golden Gate Bridge

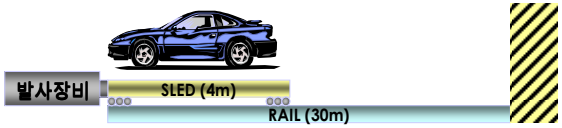
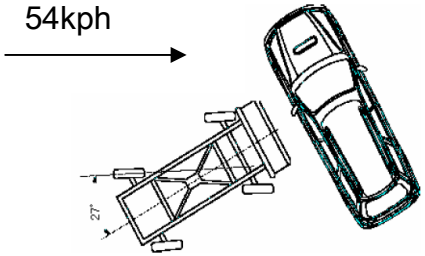
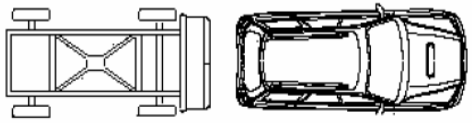
I-5 Highway

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 : 75miles
- Total Range for this test run : 471miles
- Avg. fuel efficiency for the run : 60.47mpkg

Los Angeles

Safety Verification

Test Item	Test Code	Test Set-up
Sled Impact Test	Tracing of 75kph (Impact : 40G) 	 Test : He gas, 30bar No Leak, Check the deformation of H_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_2 storage and delivery system. Check the H_2 tank burst pressure.
Rear Crash Test (FMVSS301)	48kph 	 Test I : He gas, 30bar Test II : He gas, 350bar No Leak in the H_2 storage and delivery system

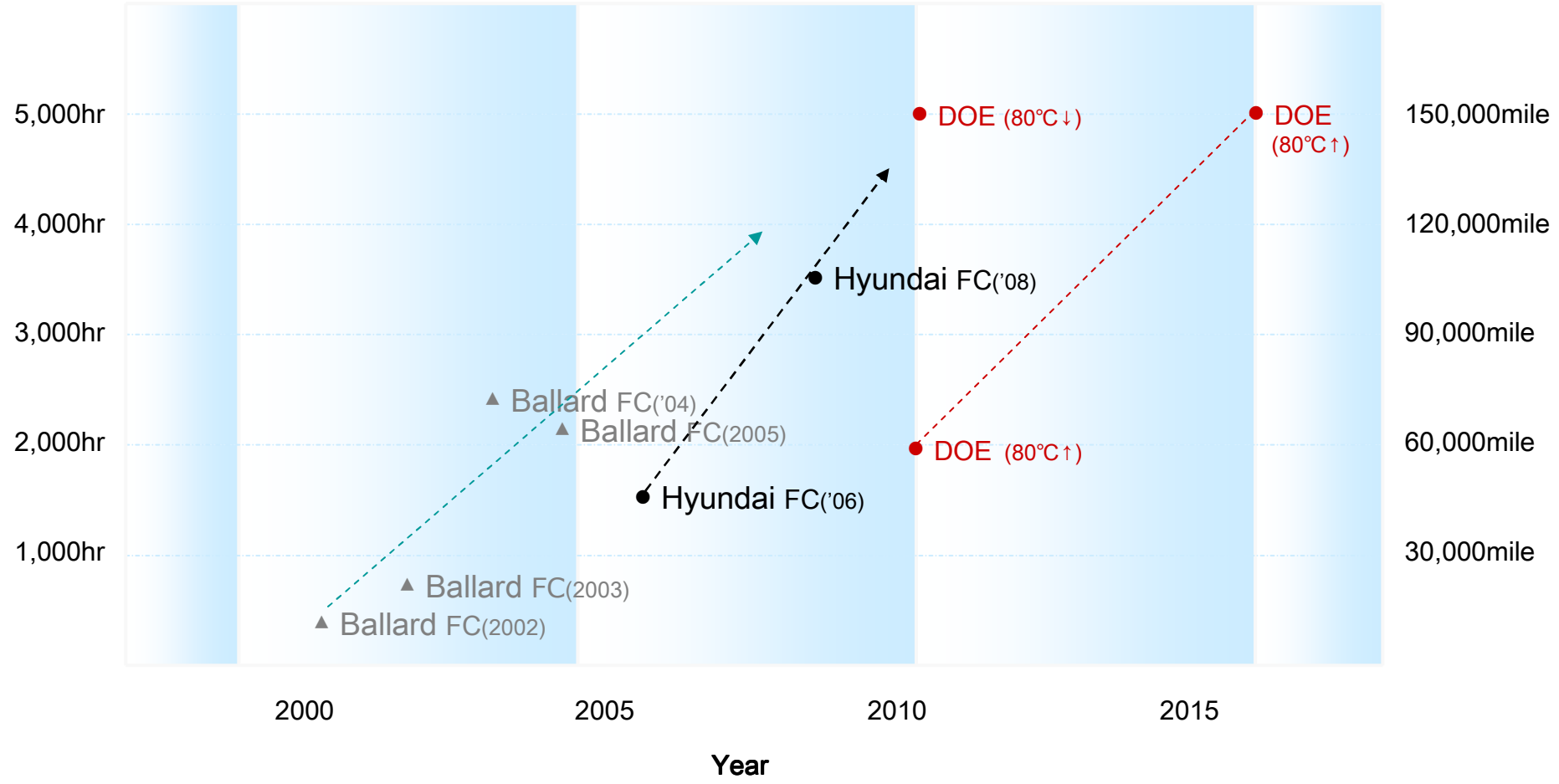
Cold Start

➢ Start Up at -20℃

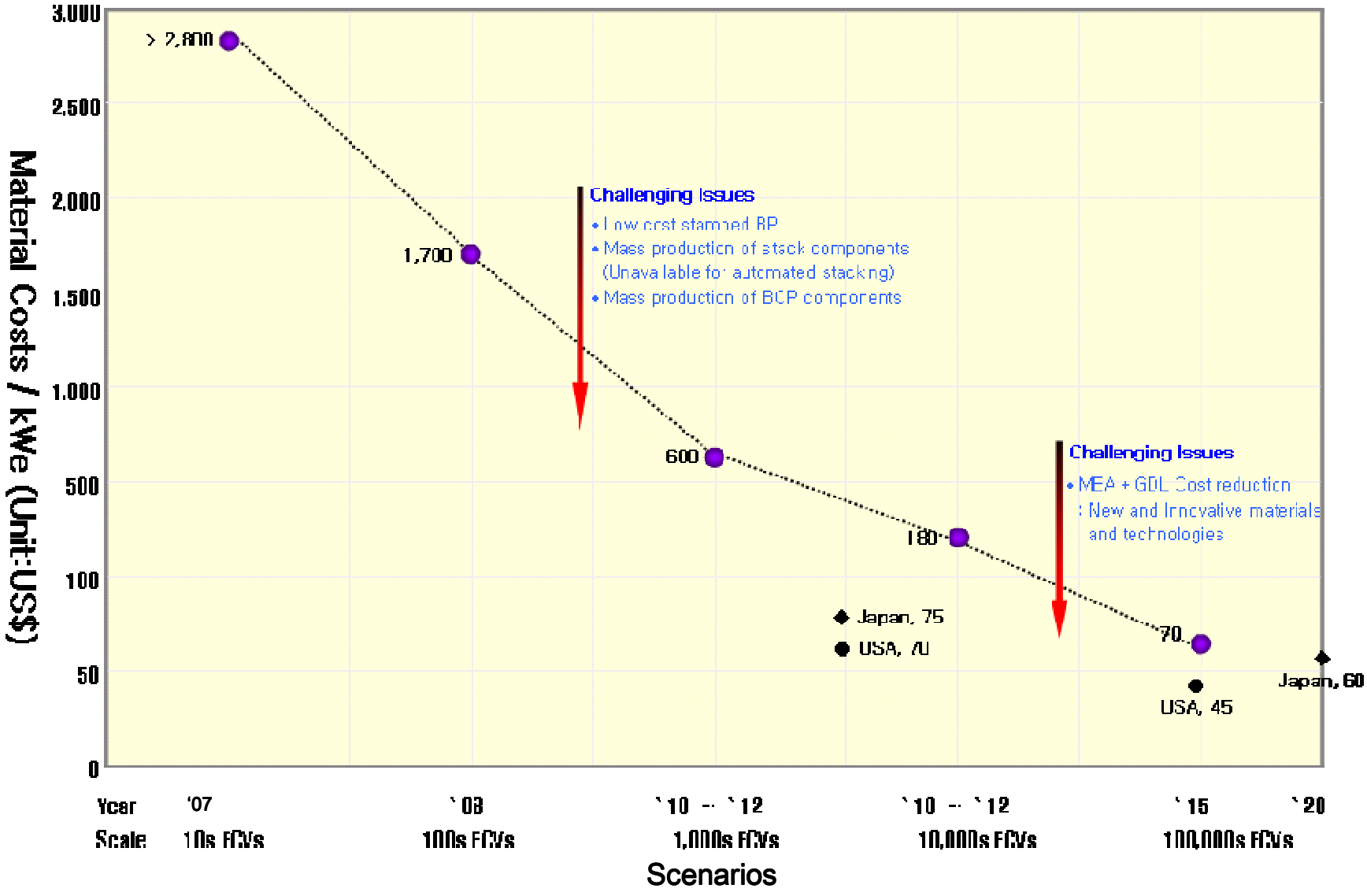
- Vehicle was soaked at -20 ℃ for 24 hours in the environment chamber
- Start up at without external power supply

Winter Test (Cold start)

Durability


5,000hr
4,000hr
3,000hr
2,000hr
1,000hr
150,000mile
120,000mile
90,000mile
60,000mile
30,000mile
DOE (80℃↓)
DOE (80℃↑)
Hyundai FC('08)
Ballard FC('04)
Ballard FC(2005)
DOE (80℃↑)
Hyundai FC('06)
Ballard FC(2003)
Ballard FC(2002)
2000
2005
2010
2015
Year

Cost Target


Material Costs / kWe (Unit:US$)
3,000
2,500
2,000
1,500
1,000
500
100
50
0
> 2,800
1,700
600
180
70
Challenging Issues
• Low cost stamped BP
• Mass production of stack components
(Unavailable for automated stacking)
• Mass production of BOP components
Challenging Issues
• MEA + GDL Cost reduction
: New and Innovative materials
and technologies
Japan, 75
USA, 70
Japan, 60
USA, 45
Year
'07
`08
`10 -- `12
`10 -- `12
`15
`20
Scale
10s FCVs
100s FCVs
1,000s FCVs
10,000s FCVs
100,000s FCVs
Scenarios

USA, DOE Fleet Program

1. Objective
   - Verification of commercialization of FCEV
2. Period : 2004. 12 ~ 2009. 12
3. Vehicles : 33 Tucson/Sportage FCVs
4. Partners
   * Chevron (Hydrogen Filling Station)
   * UTC Power (Fuel Cell Stack)
   * Hyundai-Kia (Vehicle Development & Maintenance)

Chino Station (2005. 2.18)

Korea, MKE Fleet Program

1. Objective - Verification of commercialization of FCEV

2. Period : 2006. 8 ~ 2010. 7

3. Vehicles : 30 FCVs, 4 FCBuses

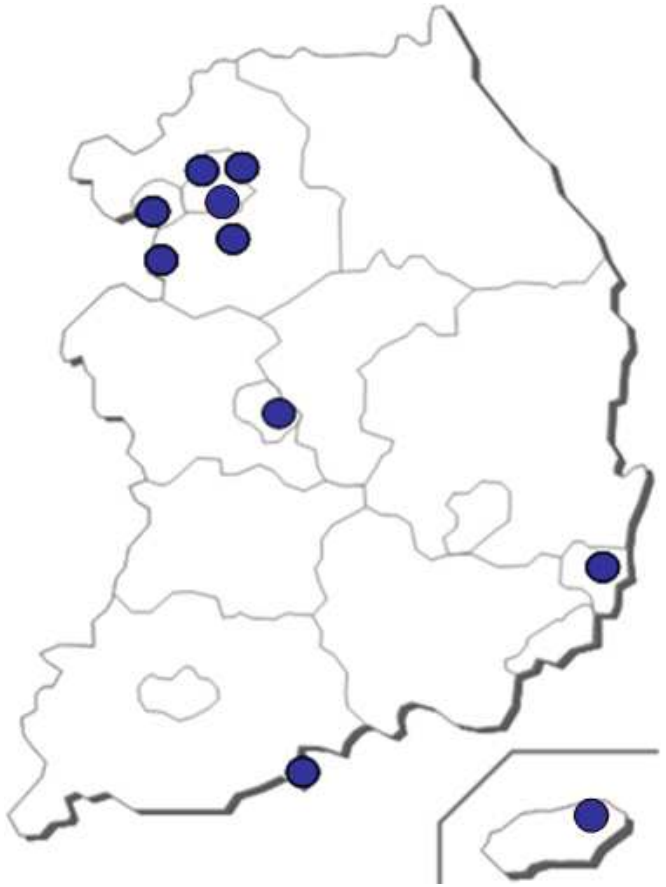
4. Partners

- **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.**



Hyundai's Product Strategy

Fuel Cells

Santa Fe FCV

- Feasibility Test of FCV

Next Generation FCV

- Small Scale Production

Tucson FCV

- Preliminary Road Test

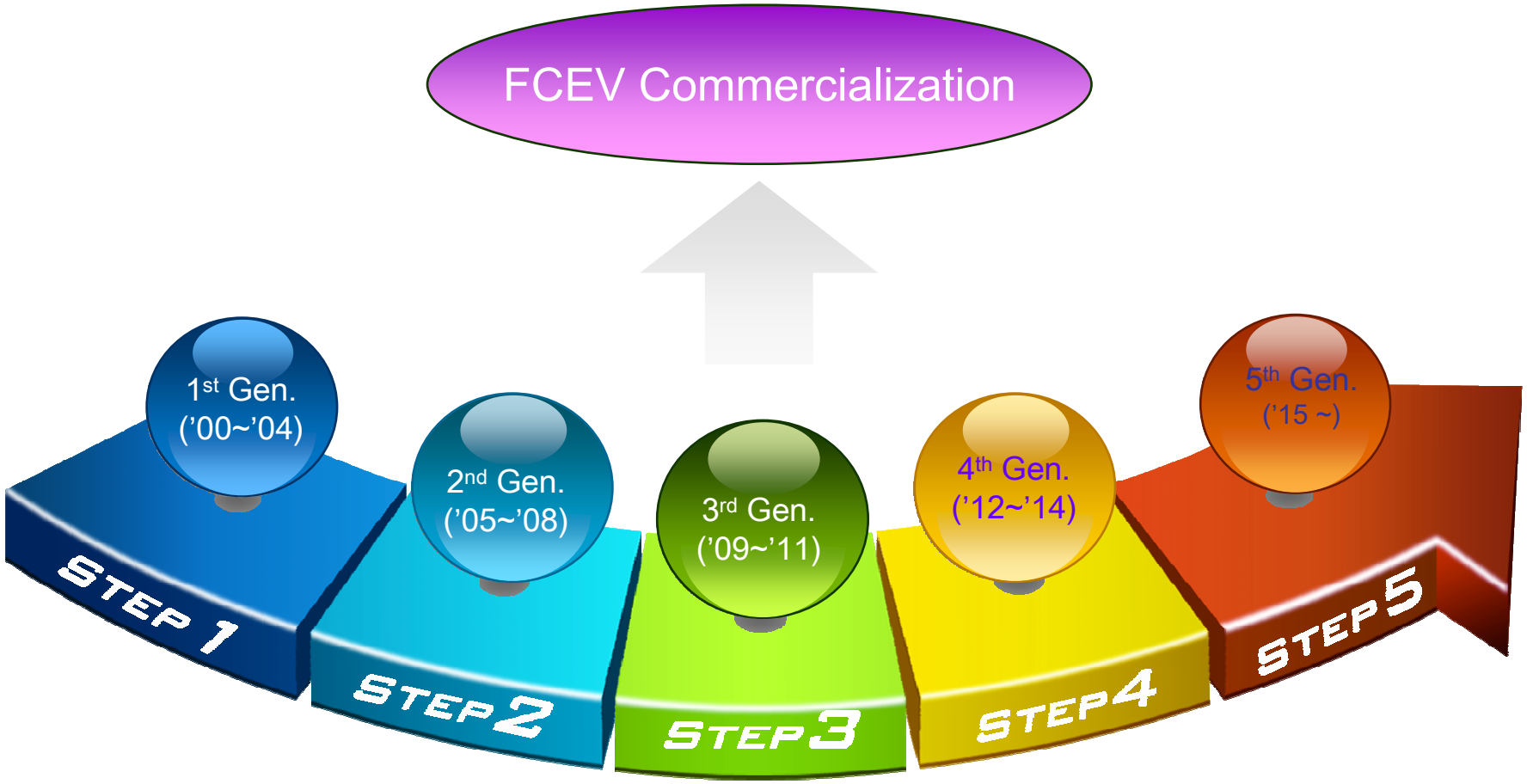
2nd Gen. Tucson FCV

- Prototype Development

Next 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

Roadmap for FCV Development



Thank You