FINPRO

Electric Vehicles South Korea

Seoul, 2010

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Executive Summary

- 17 million cars are registered in South Korea as of May 2010 and 17% of Korea's greenhouse gas emissions are from road transportation.
- Korea had been putting more effort on development of fuel cell electric vehicles (FCEV) until the government's "Low Carbon Green Growth"policy was introduced in October 2009.
- Hybrid cars are already commercialized and are the most actively developed type of 'green cars' in Korea. The market size of local hybrid vehicle is about 70,000 units in 2010 .
- Low-speed electric vehicles or neighborhood electric vehicles (NEV) with a maximum speed of 60km/h were introduced in the local market by CT&T in 2008. →The speed limit of nearly 80% of roads in Seoul is 60km/h. NEVs are allowed to run on designated driveways from March 30, 2010.
- Korea's first Full-Speed Eelectic Vehicle(FSEV) or pure EV for mass production, Blue On, was launched by Hyundai Motor in September 2010.
- FSEVs are being developed by major large OEMs while NEVs or ICE-converted electric vehicles are interests of SMEs. Existing ICEs can be legally refitted to electric versions and run from November 2010. → Eased SMEs entry to EV market.
- Electric buses are also introduced in the domestic market by Hyundai Motor and Hankuk Fiber.
- Major EV manufacturers are Hyundai-Kia, CT&T, AD Motors, TOP R&D, Leo Motors, Oullim Motors. Daewoo Bus and Hankuk Fiber make electric buses.
- The world's first Online Electric Vehicle (OLEV) which pick ups electricity from power cable buried underground through a noncontact magnetic charging method was introduced in March 2010, in cooperation with Korea Institute of Science and Technology (KAIST) and Seoul City. It is now being used by the city 's amusement park as shuttle.
- Korea has leading positions in lithium battery technologies through LG Chem and SK Energy, with a global market share of over 20% of next generation battery.

Executive Summary - continue

- 16 battery charging facilities in 9 cities have built in Korea (mainly in government premises) . There are no established standards for EV charging technologies yet . However, by 2011, the Korean government is to complete standardization of the technologies and to make EV- related laws.
- Main players in charging infrastructure sector include KEPCO, Hyundai Motors, LS Industrial Systems, LS Cable, Hyundai Heavy Industries, Samsung Electro Mechanics, SK Energy, GS Caltex, Samsung C&T and telecom companies like KT, SK Telecom, and LG U+.
- Korean government plans to replace up to 10% of the nation's passenger vehicles with EVs by 2015, and 20% by 2020 and also set a goal of becoming the world's fourth largest EV market by 2015.
- Tax reduction up to 3.1 million KRW (around 2,000 EUR) when purchasing hybrid cars since July 2009. Support for pure electric vehicles is not available yet.
- High price of EVs and lack of charging infrastructure are the major hurdles for Korea's EV growth. EVs are nearly double of conventional vehicles' price and there are only 16 charging facilities in 9 areas as of early 2010. Full-scale introduction of EV charging infrastructure is to be realized from 2015.
- For coming 5 years, NEVs and ICE-converted EVs will act as a stepping stone of full deploy of EV market.
- Full deploy of EV market can be realized faster depending on government's policies and supports on charging infrastructure and standardization of charging technologies which are keys for EV market growth.
- EV industry is asking the government for an early establishment of charging infrastructure while calling for reduced power rates and car grants to encourage the purchase of EVs.

Introduction

- Big OEMs involve in development of all phases of electric vehicles such as HEV, EV (100% electric), and FCEV, but not in NEVs. NEVs and multi-purpose electric utility cars are developmed by SMEs.
- SMEs and automobile components makers are also joining EV business by importing foreign EV cars and converting ICEs. Market entry barriers for component companies seem comparatively low.
- Government's supports and big OEMs' focus have been on hybrid and fuel cell vehicles until 2009 when the current government's policy to early deploy electric vehicles on commercial scale began encouraging the industry to quickly turn their focuses to the EV market.

HEV

- HEV in Korea is in commercialization phase.
- Korea's hybrid vehicle market is expected to grow to 200,000 cars on the roads by 2013 from 70,000 in 2010. Government plans to invest 150 billion KRW in Hybrid vehicle development for 5 years from 2009.
- Hyundai Motor released its first LPG powered & lithium polymer batteries adopted hybrid vehicle, Elantra LPI HEV in 2009 and plans to launch a gasoline-electric hybrid vehicle by the end of 2010. (In mass production phase)

EV

- Korea's first full speed electric vehicle, Hyundai Motor's Blue On, launched in Sept. 2010.
- A few small-sized NEV models introduced by SMEs.
- Electric buses developed & under test driving.

FCEV

- FCEV in Korea is still development phase.
- Hyundai unveiled its Tucson/ ix35 Hydrogen Fuel Cell Electric Vehicle with a similar performance to ICE & global top fuel cell system efficiency of 62% at the 2010 Geneva Motor Show. It will start producing FCEVs in small quantities in 2012.

Introduction - continue

- In cooperation with Seoul city and Korea Institute of Science and Technology (KAIST) , Online Electric Vehicle (OLEV) was developed in March 2010. This world's first OLEV gathers power magnetically from electric strips buried below the road's surface as it travels.
- The Korean battery manufacturers are planning to concentrate on lithium-ion battery business with more strategic focus on global sales than domestic one. They increase the share of their overseas sales over 70%. LG Chem, Samsung SDI, SK Energy are big 3 players in Korean EV battery market.
- Korean government set a plan for mass production of EV (2011), however, it suffers from difficulties encouraging the spread of EVs due to the lack of charging facilities. There are only 16 EV charging facilities in 9 cities at the moment.
- Through smart grid project, slow charger (3.3kW, 7.7kW) and rapid charger (50kW) were locally developed. The Korean government plans to heavily invest in smart grid project for lowering import expenses from energy , creating jobs, and utilizing the Korean market as a test bed of smart grid technologies to lead global market.
- Seoul operates around 50 electric vehicles as of October 2010, but charging facilities are available almost only from government premises.
- **Issues to be solved for full EV deploy** :
  - Lack of charging facilities & convenient access to power sources
  - High price of EVs
  - Designating roads for Evs (Local administrators are slow in responding)
  - Safety measures (Some retrofiting electric cars got on fire during test)
- EV industry is asking the government for an early establishment of charging infrastructure while calling for reduced power rates and car grants to encourage the purchase of EVs.

Introduction – EV Trends of Major OEMs

HYUNDAI
KIA
KIA MOTORS

► Had been focused on FCEV until 2009. Plans to produce FCEV in small quantity from 2012

► Started manufacturing LPG-powered HEV

► Launched Korea's first pure EV (or FSEV), Blue On, in September 2010. Will produce around 2,500 units by 2012 and start mass production in 2013.

► Full 'green car' line ups including PHEV, FSEV, and FCEC to be set by 2012.

►Introduced Korea's first electric bus "Elec-city" in June 2010.

GM DAEWOO

► Has been checking the market opportunities while conducting demo projects for FCEV using HydroGen3 and Chevrolet Equinox since 2005

► Will bring GM's PHEV model, Chevrolet Volt to Korea for test drives in 2011

► Developed its first full-speed electric vehicle, Lacetti Premiere EV compact sedan in September 2010 and will carry out test drives by end of October.

SAMSUNG
RENAULT SAMSUNG MOTORS

► Renault plans to produce its electric verson of Fluence Z.E. which is based on its Korean subsediary, Renault Samsung Motors' sedan, SM3, in Busan plant from 2012.

SSANGYONG

► Developed diesel hybrid vehicles using its strong deisel car know-how

► Ssangyong has been under court protection since early 2009

Government

¶ Korea does not produce any oil in the country and the transport sector accounts for 20 percent of the country's energy consumption. To overcome the country's dependence on oil, President Lee Myung-bak suggested "Low Carbon-Green Growth" as a national vision in October 2009.
¶ Also, by extension of low carbon green growth, he recently announced plans to speed up mass production of EVs to better cope with global environmental protection trends and high fuel prices.

- Relavant ministries and government agencies became busy with preparing EV strategies and companies, universities, and research institutes' interest for electric vehicles sharply increased.

- Ministry of Knowledge Economy (MKE), who is in charge of expansion of EV supplies, launched "Green Car Forum" in association with EV experts from government, academia, and business sectors in order to establish detailed strategies for development and commercialization of green cars.

- Green Car Roadmap will be made by October 2010 and reinforced further in a bid to commence full-scale EV supply strategies.

- Municipalties began to designate EV driveways, large retailers consider building charging facilities for their customers, and car makers start preparing for mass production.

- EV manufacturing industry is now asking the government for an early establishment of charging infrastructure, while calling for reduced power rates and car grants to encourage the purchase of EVs.

Government - continue

- Lee Myung-bak government has an intention to grow EVs as a new growth engine.
- Government announced a FSEV promotion plan that includes the supply of one million EVs by 2020.
- Government made an amendment on EV related traffic laws so NEVs can drive on designated roads from March 2010 and existing ICEs can be legally converted to electric versions and run from November 2010. → Eased SMEs entry to EV market.
- Separate pricing system for EV charging was set in July 2010.
- **Government programs to become 4th largest EV market:**
  - Technology project for strategic development of clean diesel car components industry
  - Clean Diesel National Assembly Forum
  - 2010 Green Car Forum
- **Policy on early deploy of EV production includes:**
  - To speed up mass production of small sized EVs to 2011 and mid-sized EVs to 2014 originally from 2017.
  - By 2015, to replace up to 10% of the nation's small-sized passenger cars with EVs, to take up 10% of global EV market share, and to become the world's 4th largest EV market.
  - Concentrated R&D investment (400 billion KRW) on high-performance batteries and other related systems by 2014.
- Biggest barriers of full deploy of EVs: High battery price (close to 50% of the total vehicle price) & Long battery charging hours (over 7 hours at 220V): **Feasibility analysis on development of battery switching type EVs will be conducted by 1H of 2011, if proves feasible and economic, the development will begin in 2012.**
- EVs will be categorized as environment-friendly cars which public organizations mandatorily purchase and the purchase quota will gradually increase to 20% in 2011, 30% in 2011, and 50% in 2013. Also, car manufacturers' eco-friendly car sales quota will be increased to 7.5% in 20111 from 6.6% this year.

Government – Supports & Plans

- **Government's current supports:** up to 3.1 million KRW mainly through tax reduction for hybrid vehicles, starting from July 2009. NO support for EVs yet: various support schemes are under consideration.
- **Government's support plans:**
  - To offer subsidies of up to 20 million KRW (around 50% of conventional gasoline vehicles' price) to public organizations when purchasing EVs until 2012 in order to speed up EV penetration and core components development.
  - Other supports such as tax reduction, free parking, bonus system based on greenhouse gas emission level, etc for EVs are also considered.
  - In order to encourage development of core components, the government plans to provide tax reduction up to 20% on new growth engine components and 25% on source technologies (in case of SMEs, 30% and 35% respectively). Also, the government build "Green Network" to improve cooperation among the local parts companies and various government supports will be offered through the Green Network.
- **Plans for building charging infrastructure include:**
  - Current 16 charging facilities in 9 cities will be used as a reference for wider spread of EV infrastructure in the future.
  - Nationwide charging infrastructure roadmap will be built by 1H of 2011 and 2.2 million charging stations will be built by 2020 with an investment of 111 million EUR from government.
  - Support to local governments for building charging facilities will be provided until 2012 and to private companies from 2013.
  - Electric cars and charging facilities will be supplied first to some selected cities in more need of EVs and that EV's effects are expected in. And also, various public uses of EVs will be continuously developed. (National parks, eco parks, post offices, airport shuttles, traffic ticket officers, etc)
- **Seoul metropolitan government:**
  - city has a plan to invest 10.9 billion KRW in 2010 to supply 'Green Cars' such as electric bus, e-official vehicles, e-two wheelers and also to build infrastructures for EV operations.
  - Seoul city plans to use 35 NEVs on a trial basis in 2010 at fire departments, patrol officers, and parking management. Also, the city has plans to apply new green technologies to city buses and switch buses and taxies to green-cars by 2020.

Major EV Players in Korea

FSEV

- Hyundai-Kia
- GM Daewoo
- Renault Samsung
- SsangYong

NEV

- CT&T
- AD Motors
- Leo Motors
- TOP R&D

2-WHEELER

- Ecocar
- Unistar
- S&T Motors
- Leo Motors

WORK MACHINE

- Doosan
- Soosung
- HHI
- Halla-Cinox

INVERTER

- LSIS
- LS Mtron
- Daewoo
- PNE

BATTERY

- LG Chem
- SK Energy
- SB LiMotive
- Sebang

MOTOR

- Hyosung
- Hyundai Mobis
- LSIS
- HHI
- S&T Deawoo

BMS

- Leo Motors
- Nexcon
- Powerlogics

INFRASTRUCTURE

- KEPCO
- GS Caltex
- SK Energy
- Samsung C&T

TELECOM COs

- KT
- SK Telecom
- LG U+

CHARGER

- Kodi-s
- Soosung
- Signet System

ORGANIZATION

- MEK
- ME
- MOCT
- KAIST
- KAICA
- KATECH

EV Manufacturers in Korea

Hyundai-Kia Motors	**CT&T**	**GM Daewoo**	**AD Motors**
Leo Motors	**TOP T&D**	**Oullim Motors**	
Power Plaza	**Renault Samsung**	**Ssang Yong Motor**	

- Big OEMs are competing for preoccupancy of EV market.
  - **Hyundai** launched the country's first all-electric vehicle, Blue On, this fall and plans mass production ready by 2012.
  - **Renault Samsung** also set plans for mass production of Fluence Z.E. in Busan from 2012.
  - **GM Daewoo** also introduced Lacetti Premiere EV in September this year.
- The leading company in NEV segment is a golf cart maker, **CT&T**. The company started mass production in 2008 and sells its electric city car 'e-Zone' and the golf cart and utility model 'c-Zone' in Korea, USA, Japan, and other countries.
- **AD Motors** produces NEVs in its Hwaseong plant with an annual capacity of 8,000 units.
- Automobile component maker, **Leo Motors** converts conventional ICEs to electric verson and also develops its own EV models. Leo Motors is also a market leader in electric scooter segment.
- Several companies are entering EV markets by importing foreign electric cars and at the sam time plan to develops their own models.
- **Samyang Ocptics** has exclusive right to manufacture, assemble and market ZAP's complete line of electric trucks, vans, motorcycles, scooters in Korea. The company also currently develops its own EV models.
- Another golf cart & folklift maker, **Halla-Cinox** signed a deal with Vantage for its EV sales in Korea.

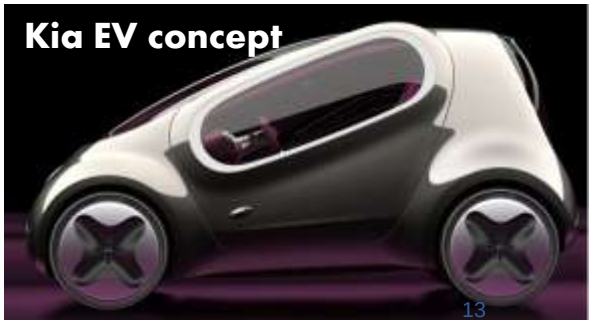
Major EV Models in Korea

TYPE	FSEV			NEV		ELECTRIC BUS	
Maker	Hyundai Motor	Renault Samsung	GM Daewoo	CT&T	AD Motors	Hyundai Motor	Hankuk Fiber
EV model	 **Blue On** Compact car	 **SM3** Compact mid size sedan	 **Lacetti** Compat mid size sedan	 **e-Zone** Compact car	 **Change** Compact car	 **Elec-city** Low-floor bus	 **e-Primus** Low-floor bus
Seat	4	5	5	2	2	51	49
Max speed	130km/h	140kn/h	165km/h	60km/h	60km/h	100km/h	100km/h
Drive range /Single charge	140km	160km	160km	100km	120km	120km	120km
Battery	Lithium-ion polymer 16.4kW/h	Lithium-ion polymer 24kW/h	Lithium-ion polymer 31kW/h	Lithium polymer 10.1kW/h	Lithium iron-phosphate 10kW/h	Lithium-ion polymer 95kW/h	Lithium-ion 102kW/h
Development Status	➢ Released test cars (Aug. 2010) ➢ Plans to produce in small quantities in the 1st half of 2011	➢ Plans to produce in small quantities in the second half of 2011	➢ Released test cars (Sept. 2010)	➢ Released test cars (Aug. 2010)	➢ Under performance certification test	➢ Released test cars (Aug. 2010)	➢ Under performance certification test

Source: Ministry of Environment, October 2010

Hyundai-Kia Motors

Establishment	1976 (Hyundai)
Sales (2009)	Hyundai: 3,133,060 vehicles / Kia: 1,651,920 vehicles
Products	EV, HEV, FCEV, Electric bus
EV models	Blue On (4 seat compact car), Elec-City (bus)
Key people	John-hee Hong, Director (In charge of EV)/ Ho-min Lee, General Manager (EV Dept) Jinho-Park, General Manager (Battery)/ Tae-won Lim, Director (FCEV),
Website	http://worldwide.hyundai.com/, www.kiamotors.com
Business highlights	➢ The largest car manufacturer in Korea but 48,5 % of total production outside Korea . ➢ The motor group had been focusing more on FCEV than EV until 2009. ➢ Hyundai produced Korea's first pure electric vehicle (Blue On) in Sept. 2010. Around 2,500 units will be produced by 2012 and start mass production in 2013. ➢ Kia also introduced Vega EV in 2010 Geneva Motor Show. ➢ Hyundai introduced Korea's first electric bus "Elec-city" in June 2010. ➢ Plans to set up full 'green car' line ups including PHEV, FSEV, and FCEC by 2012. ➢ Will put more effort in producing HEVs for the time being while continue EV R&D activities as several years will be needed until full blossom of EV & FCEV market.



Hyundai-Kia Motors - continue

Business Highlights

➢ **Hybrid Electric Vehicle (HEV)**: After the first concept car in 1995, Hyundai released its first LPG powered hybrid vehicle, Elantra LPI HEV, in 2009 and plans to launch a gasoline-electric hybrid vehicle by the end of 2010. The technology and all key components in the LPI HEV were developed by Hyundai and its local partners. Used LG Chem's lithium polymer batteries.

➢ **Fuel Cell Electric Vehicle (FCEV):** Hyundai-Kia is known to have obtained advanced technologies in FCEV. Hyundai unveiled its Tucson/ ix35 Hydrogen Fuel Cell Electric Vehicle (FCEV) at the 2010 Geneva Motor Show. By 2012, Hyundai plans to begin manufacturing FCEVs in the low thousands and delivering them to fleet customers in Korea.

➢ **Blue On (Pure EV):** Korea's first full speed electric vehicle designed based on Hyundai i10 hatchback
- – Maximum speed: 130 km/h, Drive range: 140 km/single charge
- – Battery: SK Energy's lithium-ion polymer batteries with a capacity of 16.4kWh. 30% lighter and 40% smaller than conventional NiH2. 25 minutes to charge up to 80% when using high-capacity electricity (380V) and 6 hours to charge 90% when using regular residential electricity (220V).
- – 44 companies participated in Blue On development and 34 companies among them are SMEs.
- – 90% of the components used by Blue On are produced by domestic industries.
- – 40 billion KRW (25.4 million EUR) invested
- – 30 Blue Ons will be offered to government fleets by this fall and they will be used for 2 years for development of electricity-charging infrastructure, quality assessment, and PR purposes.
- – Plans to produce around 2,500 units by 2012 and start mass production in 2013.

➢ The motor group currently supports 219 of its part suppliers as much as 76 billion KRW in order to secure sufficient EV components and production facilities, and plans to increase support scale in the future.

Hyundai-Kia Motors: HEV & FCEV Projects

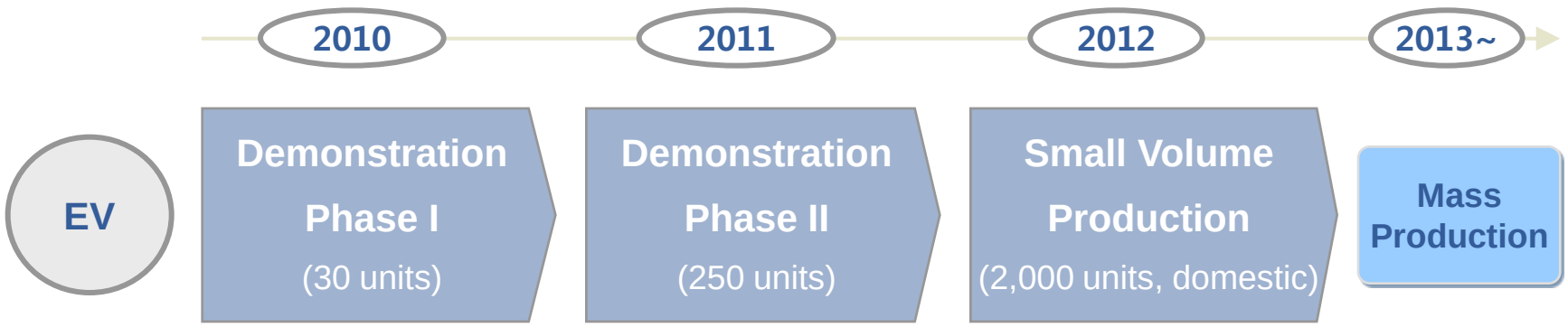
Hyundai Motor:

- i-flow HEV & HND-4 PHEV introduced in 2010 Beijing International Automotive Exhibition
- Sonata HEV planned to launch in US late 2010
- Elantra LPI HEV in Korean market from 2009
- ix-Metro HEV & i10 EV introduced in 2009 Frankfurt Auto Show
- BLUE-WILL PHEV concept car introduced in 2009 Seoul Motor Show
- Hydrogen FCEV production planned to begin in small quantities in 2012

Kia Motor:

- Sorento Hybrid to be in production in 2012
- Optima HEV available in the North American market in early 2011
- Ray PHEV Concept car introduced in 2010 Chicago Auto Show
- Forte LPI HEV mass production begun in 2009
- Cee'd HEV & Soul HEV Concepts premiered in Paris Motor Show 2008
- Mohave FCEV concept introduced in 2008
- Sportage FCEV concept introduced in 2004
- HEV production plan for 2010: 30,000 units

Hyundai-Kia's EV Development Plan



- **1st Step : BlueOn EV - Demonstration phase I (30 units)**
  - Government organization & Jeju smart grid demonstration site (2010 ~ 2011)
- **2nd Step : BlueOn EV - Demonstration phase II (250 units)**
  - Public institutions, local governments (verifying EV technology & installing infrastructure)
- **3rd Step : CUV EV - Small volume production (2,000 units)**
  - Expansion of supply (Public institutions, local governments, public enterprises), achievement of price competitiveness (parts sharing with BlueOn)
- **4th Step : Mass production**
  - US & European market targeted

Source: Hyundai Motor, Oct. 2010

Hyundai-Kia's Greencar Roadmap

Phase 1 (1995 ~ 2004) Core Technology Development	Phase 2 (2005~2009) Hybrid Mass production	Phase 3 (2010 ~) Expansion Green Car Line-up

1995 · 2000 · 2004 · 2006 · 2009 · 2010 · 2012

HEV

Concept

Verna/Pride (Demonstration)

Elantra/Forte LPi

Sonata/Lotze

HE/Plug-in

EV

SantaFe EV (Hawaii, Jeju Demonstration)

i-10 (Blue On) Demonstration

EV Mass Production

FCEV

Concept

Tucson/Sportage (US Fleet Program)

Fuel Cell System Development (Domestic Fleet Program)

Mohave

Small Production

Hyundai/Kia has been developing Eco-Technology since 1995 and will establish full green car line-up by 2012

Source: Hyundai-Kia Motors, 03. 04. 2010

CT & T

Establishment	2002 (established by former Hyundai Motor employees)
Turnover	
Products	NEVs
EV models	e-Zone (NEV), c-Zone(electric golf cart and multipurpose utility EV), C² (e-sports car)
Key people	In-soo Lau 이상무???…
Website	http://eng.ctnt.co.kr/ , http://www.ctntunited.com/
Business highlights	➢ Has been focused on lower priced low and mid-speed EVs which major OEMs are not showing much interest. Plans to broaden product category to high-speed vehicles ➢ Small-sized 2-seat NEV, “e-Zone” is currently on sale in Korea, Japan, the U.S. and other countries. Lead acid or lithium polymer batteries are fitted. ➢ Electric multi amphibious vehicle introduced in 2010 Detroit Auto Show: six-wheeled, four-passenger EV .

e-Zone: Low-speed pure electric vehicle that can travel with a speed limit of 60 km/h. Offering a drive range of up to 100 km in a single charge with its advanced technology, lithium polyer battery.

C²: Elctric sports car

CT & T - continue

Business Highlights

➢Has a unique global operating system called R.A.S. (Regional Assembly and Sales System) that includes an assembly plant, with a capacity of over 10,000 electric vehicles annually, a retail showroom, a theme park, and more.
➢ Plans to expand the number of Regional Assembly and Sales centers to 40 in the US and open 30 new centers in Europe as well as 10 in Asia
➢ Has developed two 20-seat electric bus models with a max of 80km per hour, driving ranges of 80-120 km per charge, and a six-hour recharge time. The bus is 40 % lighter than other conventional buses with the same capacity. The estimated cost is 80 million KRW.
➢ Production sites in South Korea and China. Plans to produce in USA from the end of 2010.
➢ Shipped more than 38,000 units to Japan and US in 2009, and its domestic production is expected to grow with a plan to build a local assembly line capable of producing 10,000 EVs per year
➢ Cooperates with LG Chem, SK Energy, LS Industrial Systems, POSCO, and Hanwha L&C.
➢ Production estimate for 2010: 30 000 vehicles
➢ Production goals for 2013: 300 000 vehicles

GM Daewoo Auto & Technology

Establishment	
Sales	Total Sales (2009): 578 758 vehicles
Products	
EV models	Lacetti Premiere EV
Key people	
Website	http://www.gmdaewoo.co.kr/kor/index.jsp
Business highlights	➢ Has been checking the market opportunities while conducting demo projects for FCEV using HydroGen3 and Chevrolet Equinox since 2005 ➢ Will bring GM's PHEV model, Chevrolet Volt, to Korea for test drives in 2011 ➢ Developed its first full-speed electric vehicle, Lacetti Premiere EV compact sedan in September 2010 and will carry out test drives by end of October. Maximum speed of 165km/h and drive range of 160/charge. 8-10 hours for charge at 220V. More than 50 Koran companies participated in development. ➢ Plans to launch Euro-5 standard clean diesel vehicles and develops 2nd generation mild hybrid cars.




AD Motors Co., Ltd.

Establishment	1999
Turnover	3.4 billion KRW (2009)
Products	Low & mid-speed EVs, Powertrain parts, Renewable energy technology
EV models	Aurora, Change, COVI
Key people	Bong-sun Ryu/Vice President
Website	www.admotors.com
Business highlights	► Developed small-sized NEV, Aurora, in 2008 and produced pilot car in 2009 ► Main NEV model, ”Change” for mass production and domestic sales from September 2010. Maximum 60km/h, 70-110km/single charge, Lithium-ion battery fitted, charged in 4 hours at 220 volts. 1,880,000 KRW/basic model and 22,300,000 KRW/premium model ► 4 seater full-speed EV, ”COVI I” to be unveiled in April 2011. ► Plans to expand to full-speed EVs ► Monthly production capacity to be expanded from 500 to 2000 during 2010

Leo Motors Inc.

Establishment	2005
Turnover	10 b KRW from e-bikes alone in 2010(e)*
Products	EV power trains, Electric scooter, EVs, BMS, power pack, conversion kit, multilayer motor, etc.
EV models	Hilless (electric scooter), Eleven (high-speed electric motocycle)
Key people	Robert Kang/CEO, John Lee/CTO Hyung-gu Kim/General Manager
Website	www.leomotors.com
Business highlights	► Has designed many original EVs and Plug-In Hybrid EVs ► Converted four types of passenger cars, two types of trucks, and one type of bus including Morning (Kia), Matiz (GM Daewoo), Cube (Nissan),RAV4 (Toyota) , 24-seat bus (Hyundai Motor). All converted vehicles are high-speed, highway compatible EV's. ► Succeed in development of Zinc Air Fuel Cell (ZAFC) and plans to introduce ZAFC EVs as early as March 2011. ► Produces monthly over 1,000 Hilless.

TOP R&D Co., Ltd.

Establishment	2003
Turnover	1.5 billion KRW (2008)
Products	Special-purpose EV, NEV, Amphibious EV, Military EV, Car parts, Medical equipment, Engineering
EV models	iPlug (NEV), MAV EV-88, MAV EV-64
Key people	
Website	www.top-rd.com
Business highlights	➢ Develops multi amphibious EVs and NEVs. ➢ Newly developed NEV, “iPlug” is the smallest 4-seat EV in Korea with a range of 80-110km per charge. Maximum speed: 60km, 220V chargeable. Mass production from the summer 2011. ➢ Plans to build a plant in Korea investing 10.5 b KRW and to produce 3 types of EV such as amphibious cars, golf carts, and NEVs. Annual production capacity: 12,000 units ➢ Under development of several other special-purpose vehicles like shuttle, leisure, fire, rescue, fishing, ski, etc. ➢ Hyundai-Kia Motor’s tier 1 R&D company ➢ Local EV inverter maker, GND Wintech, merged TOP R&D in Sept. 2010.

Oullim Motors Inc.

Establishment	2007 (Formerly Proto Motors established in 1997)
Products	Sports car and coach maker, E-sports car Converting ICEs to EV
EV models	SPIRRA EV
Key people	Han-chul Kim, President Dong-hyuk Park, CEO
Website	http://www.oullimmotors.co.kr/
Business highlights	➢ Korea's first supercar manufacturer by acquiring Proto Motors, the Korea's first supercar maker in 2007. ➢ Specializes in redesigning existing models to electric cars and convertibles. ➢ Developed an electric sports car, Spirra EV, in cooperation with a Dutch company, AGV(All Green Vehicle) and started test drives in August 2010. SPIRRA EV can run 365km per charge and its maximum speed is 305km/h. ➢ Plans to export Spirra EV to USA in 2011. ➢ Partnerships with Hyundai-Kia Motors and GM Daewoo.

SPIRRA

Power Plaza Co., Ltd.

Establishment	1993 (Auto components supplier)
Products	Industrial converter, EV components including power train, charger, BMS, motor, etc
EV models	Yebbujana (pure EV) Converted 2 ICE trucks (Labo & Bongo III)
Key people	Sung-ho Kim, CEO
Website	www.powerplaza.com
Business highlights	➢ Started EV building in 2008 ➢ Specializes in EV conversion (takes only 1 week to convert conventional power train to electric motor) ➢ First Korean company converted trucks to EV ➢ Focuses on EV power pack development ➢ Participated in 2010 ZERO RACE ➢ Yebbujana: Ultra-light carbon fiber body, lithium-ion polymer battery, max speed: 150km/h, max drive range: 250/charge, 2 seats

Renault Samsung Motors

Establishment	2000
Total sales	197, 024 vehicles (2009)
Products	Passenger cars
EV models	Fluence Z.E.
Key people	
Website	http://www.renaultsamsungm.com/
Business highlights	➢ Significant investment for developing rechargeable cells for HEVs ➢ Cooperates with SK Energy and SB LiMotive in EV development ➢ Renault plans to produce its electric verson of Fluence Z.E. which is based on its Korean subsediary, Renault Samsung Motors' sedan, SM3, in Busan plant from 2012. ➢ HEV & EV Projects and plans: – eMX: (Eco Motoring Experience) prototype introduced in 2009 Seoul Motor Show – SM3 based EV to be introduced in Korea late 2011

Renault's Fluence Z.E. Concept Car

Renault's electric concept car at Busan Motor Show 2010

SsangYong Motors

Establishment	1954
Turnover	Total Sales (2008): 82 405 vehicles (Looking for a new capital investor)
Products	Passenger cars
EV models	-
Key people	
Website	http://www.smotor.com/en/index.jsp
Business highlights	➢ Has strong know-how in diesel cars and developed diesel hybrid cars ➢ Introduced HEV & EV Concept cars: -Korando C (C200) EV introduced in 2010 Busan International Motor Show - C200 Eco HEV introduced in 2009 -Kyron HEV introduced in 2008 ➢ Uses its own control system and domestic components including elelctric motor, motor controller, and high voltage batteries for its hybrid vehicles ➢ Ssangyong has been under court protection since early 2009.

Samyang Optics Co., Ltd.

Establishment	1972
Turnover	26.3 billion KRW (2009)
Products	CCTV Lens, Interchangable lens
EV models	No own brands yet.
Key people	Mu-gak Hwang, Deputy General Manager tobyfor1@gmail.com /+82 2 6005 8703
Website	www.syopt.co.kr
Business highlights	➢ Optical instrument maker. ➢ Imports EVs from ZAP (US-based EV manufacturer) and ZAP Jonway (China) and distributes them to the Korean market ➢ Signed a distribution agreement with ZAP for the exclusive rights to manufacture, assemble and market ZAP's complete line of electric trucks, vans, motorcycles, scooters and ATVs in Korea. ➢ Undergoing tests with prototype EVs ➢ Plans to locally produce EVs in small quantity in the future (No schedule fixed yet) ➢ Interested in distributing other international brands to the Korean market.

Electric Buses

- Main players:
  - Hybrid and Fuel Cell Bus: Daewoo Bus and Hyundai Motor
  - Pure Electric Bus: Hyundai Motor, Hankuk Fiber, and CT&T (to launch next year)

- Hybrid and fuel cell electric buses have been developed and put in test drives in Korea. The first hybrid bus was jointly developed by Daewoo Bus Corporation and Hyundai Heavy Industries (HHI) in 2007. Core components including generator and control system were developmed by HHI while the car body and the engine were developed by Daewoo.

- Eight diesel hybrid buses will be put on roads in 6 cities including Busan and Daejeon for test drives from January 2011. Korea Petroleum Association representing 4 local refineries invested 5 billion KRW in the development of these hybrid buses in line with the enactement of new laws on environment-friendly vehicles in May 2009 which applies also to clean diesel cars. Daewoo Bus will produce these diesel hybrid buses while Korea Institute of Machinery & Materials will be responsible for R&D, distribution, and operation. 50-60% of high quality diesel produced by Korean refineries are currently exported. By increasing clean diesel vehicles in the country, the huge expense for import of LPG and CNG can be significantly reduced.

- With know-how obtained through years of experience, Deawoo Bus plans to get ready for mass production of diesel hybrid buses by 2012.

Electric Buses - continue

- **Hyundai Motor** launched the nation's first 100% electric bus "Elec-City" in June 2010 and started test drives. Elec-City can transport up to 51 passengers with three 100kW electric. It has a maximum speed of 100km/h and can drive up to 120km per charge. The cost of operating Elec-City is only 29% of the cost of operating a CNG bus.
- **Hankuk Fiber** also developed pure electric bus "e-Primus" in cooperation with HHI and it is currently under performance certification test. e-Primus runs 120km with a 20-minute-long speedy charging and the maximum speed is 100km/h. ithium-ion polymer batteries are used. The 15 electric buses will be available in Seoul from November 2010.
- **CT&T** plans to roll out its first battery-powered buses next year. Two 20-seat models with a maximum speed of 80km/h, driving ranges of 80-120km/charge, and a six-hour recharge time. The estimated cost is 80 million KRW ($66,528). It is powered by a 120-kilowatt motor from Higen Motors and uses batteries from SK Energy and LG Chem. It features a power control unit from LS Industrial Systems. The lightweight materials from Hanwha L&C and POSCO and a special chassis jointly developed with the Korea Automotive Technology Institute.
- Seoul Metropolitan City will provide electric buses more actively from 2011 and plans to change the half of present buses to electric versions by 2020. Charging facilities and smart chargers for electric vehicles will be installed in local offices ans parking lots in large marts.

Hankuk Fiber

Hyundai Motor

CT&T

Electric Two-Wheelers

- In Korea there are over 2.4 million two-wheelers including 50cc scooters on the road. Korea's 2-wheeler industry is sandwiched between cheaper products from developing countries and better technologies from advanced countries.
- Korea's electric 2-wheeler market is a nascent stage.
- Government is encouraging the spread of electric 2-wheelers. It plans to provide a grant to shops replacing their existing engine 2-wheelers to electric ones.
- Ministry of Knowledge Economy has a plan to develop 110cc electric two-wheelers for post offices and introduce a prototype in March 2011:
  - Max speed: 70km/h, Drive range: 50km/charge, Charging time: 3.5 hours at 220V)
  - 10 two-wheelers per year will be provided to post offices, smart grid test bed in Jeju, and related ministries until 2013 when upgraded versions will be introduced.
  - Participating companies: LG Innotek, Sungkyunkwan University, Woory Industrial, VC Tech, VINA Tech, PNE Solution, and The Korea Society of Autumotive Engineers
  - Investment: 7.8 billion KRW for 3 years/ Daelim Car Consortium
- Seoul city has been providing electric 2-wheelers to private sectors for test runs since 2008 and plans to expand the scale from 2010.
- An electric motorcycle will cost 3 million KRW while the conventional engine motorcycle 1.3 million KRW.
- Major electric 2-wheeler makers are Unistar, Ecocar, S&T Motors, and Leo Motors.

ECOCAR

S&T Motors

ECOCAR

Leo Motors

Electric Work Machines

- In the Korea's work machine segment, mainly hybrid vehicles are developed at the moment starting from 2009.
- All-electric work machines are not yet in the market except a few forklift models.
- Excavators are the most common type of work machines to be developed to a hybrid version. Forklifts and wheel loaders are expected to follow the trend.
- Major work machine makers in Korea are Doosan Infracore, Soosung Lift, Hyundai Heavy Industry and Halla-Cinox.
- Doosan Infracore started developing diesel engine-electric motor hybrid excavators as a government project in early 2009 with an aim to put them on the market in 2011. Until 2014, around 18 billion KRW will be invested in the project which develops 22 ton hybrid excavators. This hybrid vehicles are expected to increase the energy efficiency up to 35%.
- Hyundai Heavy Industry (HHI) introduced the Korea's first hybrid excavator in October 2010. This hybrid excavator shows a 25% upgraded fuel efficiency and the mass production of the vehicle will began in the 1H of 2011.
- HHI also showed a 30ton electric excavator consuming only 30% of conventional engine-powered excavators at the construction equipment expo

Work Machine Production in Korea (2008)

(Source: KOCEMA/ Unit: vehicle)

Item	Excavator	Loader	Dozer	Crane	Dump Truck	Forklift	Drills	Total
Production	30,808	5,477	-	2,167	934	34,992	119	74,497

Doosan Infracore e-forklift

Soosung electric lift

Halla-Cinox electric forklift

Doosan Infracore Hybrid Excavator

EV Components Suppliers in Korea

- **Korean companies are known to have the world class battery technologies, with over 20% of global market share by Samsung SDI and LG Chem.**
- **However, most of core components inside of batteries are imported from Japan. The capacitor technology is low and major local makers are SMEs.**
- **Technology competence of other components except battery like motor, inverter, condenser are relatively low. However, SMEs are very active in improvement of their technologies.**

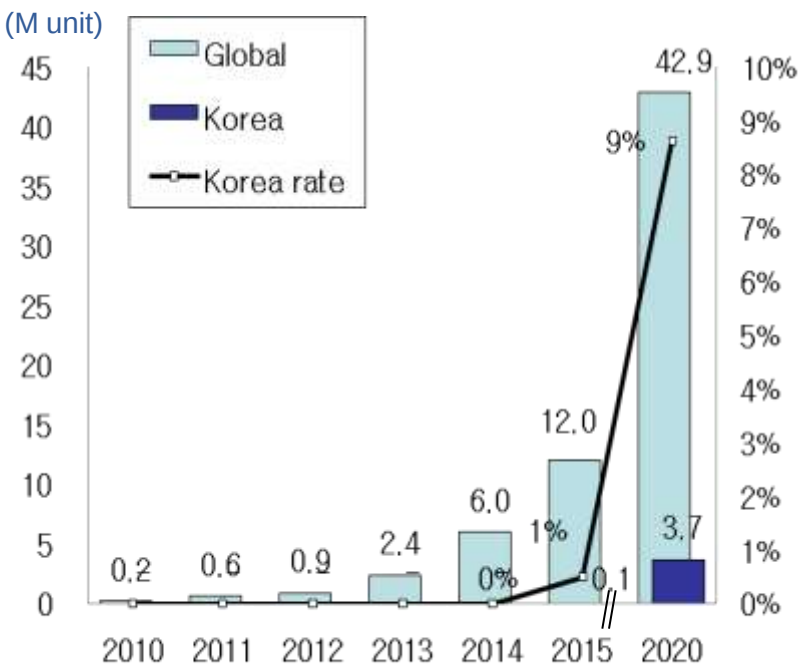
BATTERY	LG Chem, SK Energy, SB LiMotive (Samsung SDI), KOKAM, Enertech, EIG Battery, Sebang Global Battery, Sang Sin EDP
BMS	Nexcon Technology, Powerlogics, Leo Motors
MOTOR	Hyundai Mobis, MB Corp, Hyosung Power & Industrial Systems Performance Group, LS Industrial Systems, Hyundai Heavy Industries, S&T Daewoo, VC Tech, Kinemotion
INVERTER	LS Industrial Systems, LS Mtron, Daewoo Electronic Components, PNE Solution, Dawin Electronics, Infineon Tech
CONDENSER	Samwha Capacitor, Samwha Electronic, Sungmoon Electronics, Pilkor Electronics, Nuintek, Nesscap
CONVERTER	Dongah Elecomm, Clover Hitech

Batteries

Overall Introduction & Trend - Global EV and Rechargeable Battery Market

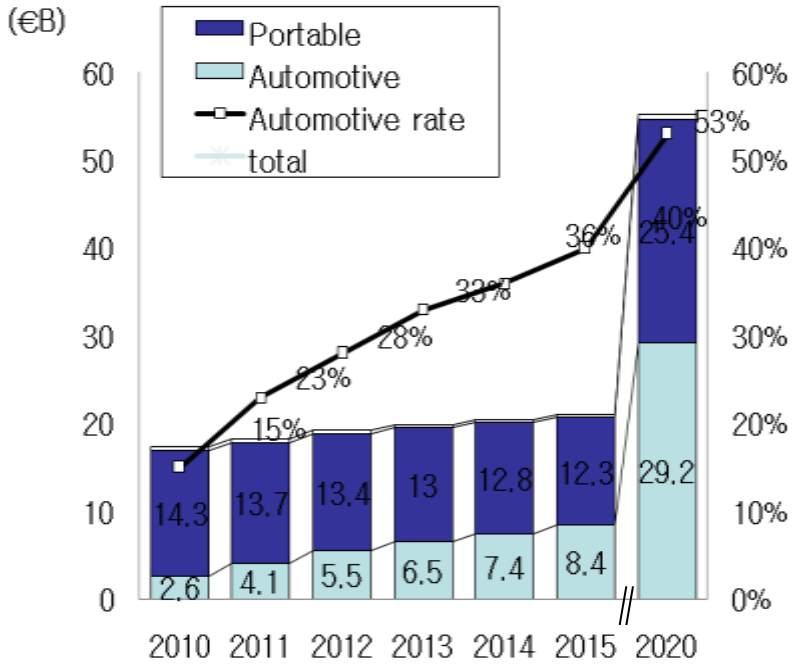
In 2020, the global EV market is expected to grow rapidly to more than 20-fold since 2010. Due to the increase in global EV production, rechargeable battery market for automotive will take up over 50 percent of all global rechargeable battery market and reach €29.2 B in 2020.

Global EV market



- **The global EV market is expected to reach 4.2 M units by 2020 from 0.2 M units in 2010.**

Global Rechargeable Battery Market



- **Rechargeable Battery market for automotive will take up more 50 percent of all rechargeable battery market and reach €29.2 B in 2020.**

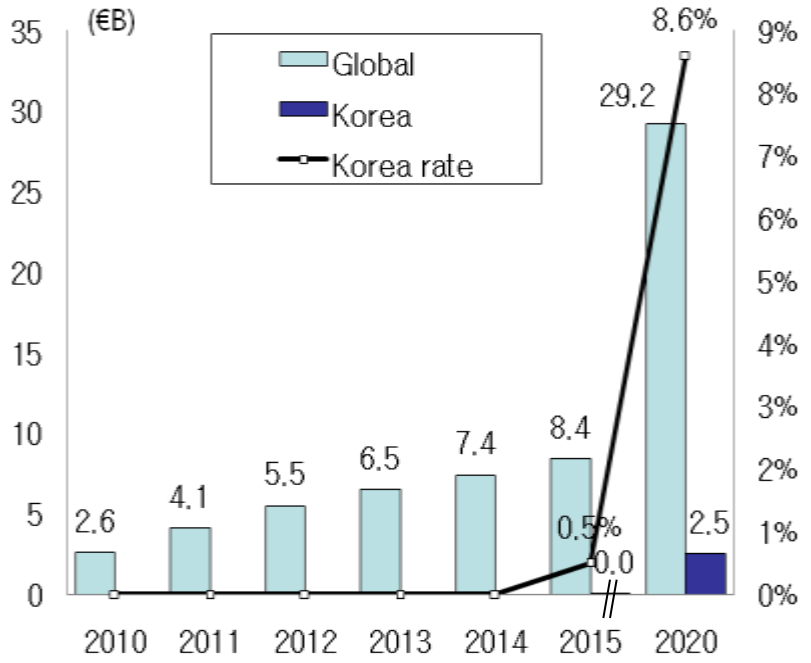
Notes: Assumption(In 2020, EV is expected to account 5% of global automotive market)

Source: IBK Investment Security(2010), The Ministry of Knowledge Economy(2010.10), Institute of Information Technology(2009), WesleyQuest Analysis

Overall Introduction & Trend – EV Battery Market and Export rates of Korea

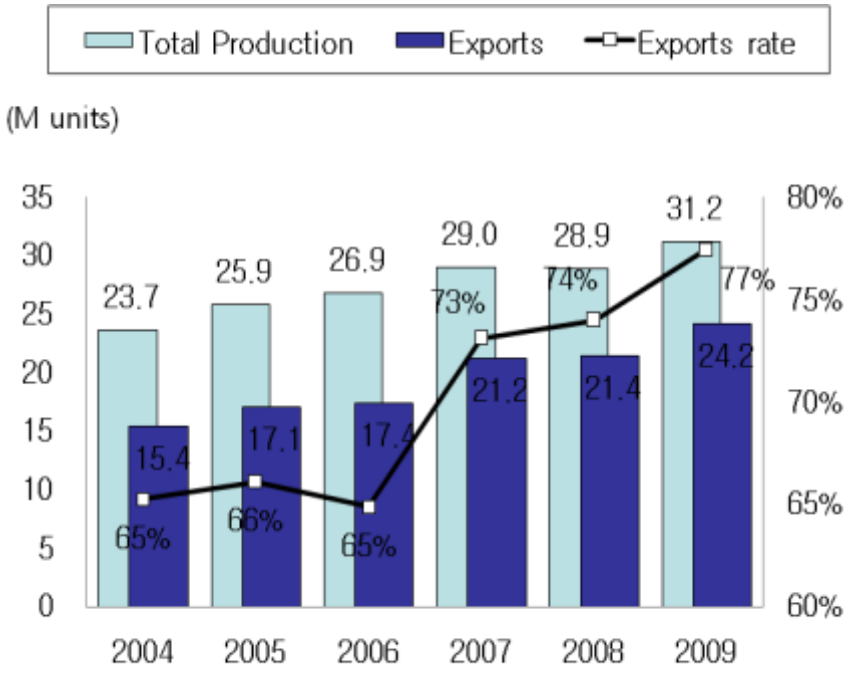
However, the Korean domestic EV battery market is expected to take up only 8.6 percent of global EV battery market in 2020. Therefore Korean battery manufacturers have chosen globalization strategy which aims to increase their overseas sales.

Automotive Rechargeable Battery Market



- **The Korean domestic EV battery market is expected to reach €2.5B in 2020.**
- **However, Korea will take less than 10% of global EV battery market in 2020.**

Korea's Rechargeable Battery export volume



- **Korean battery manufacturers have more strategically focused on global sales than domestic one. They increase the share of their overseas sales over 70%.**

Source: Statistics Korea(2010), Korean Agency for Technology and Standards(2010), Institute of Information Technology(2009)

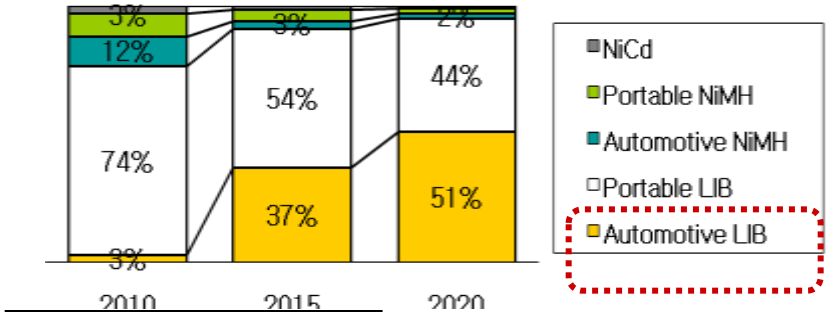
Technology

The Korean battery manufacturers plan to concentrate on LIB(Lithium-Ion Battery) business, since Korean companies are more competitive than Japanese companies in LIB market than in NiMH market. The Korean battery manufactures holds world class LIB technology, can leverage its experience from portable LIB production, and achieve economics of scale in procurement and production.

Rechargeable Battery type

	Lead	NiCd	NiMH	LIB(Li-Ion)
Commer-cialized	1980s	1960s	1990s	1991s
Pros	• Wide range of temperature • Low cost	• Rapid charge • Mid cost	• Stable Mid Cost	• High capacity
Cons	• Heavy	• Environmental contamination • Memory effect	• Degradation	• High cost • Low safety (Protection circuit needed)
Use	• Car, Industrial	• Military, Power Tool, Portable audio device	• Home cordless phone, HEV	• Mobile IT devices, EV

- **Korean battery manufacturers expect LIB to be dominant in EV battery market.**



Reason of Korean companies' LIB concentration

Current technology level

- **NiMH: uncompetitive against Japanese companies with long R&D experience**
- **LIB: World class manufacturing technology against Japanese companies**

LIB technology level by conuntries

	Japan	Korea	USA	China
Mfg.	100	90~100	30	50
Component/Material	100	50	40	40
Original Technology	100	30	80	10

Existing capability leverage

- **Korean player' LIB manufacturing experience from Portable device production (Mobile Phone, Laptop…)**

Economic of scale

- **LIB for Mobile device + EV… More buying power, lower cost of good sold, cost leadership**

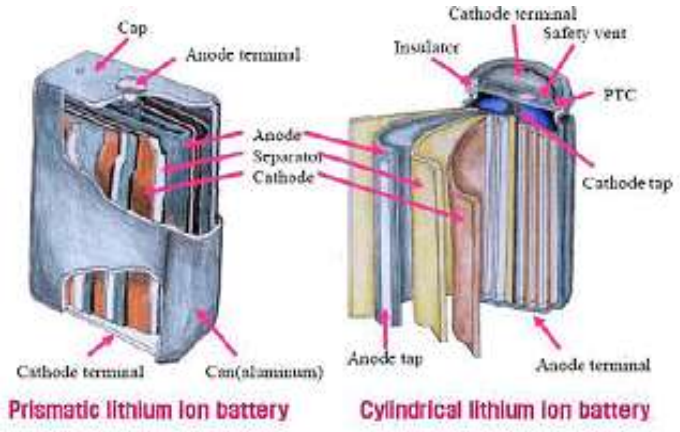
Note: Mfg(Manufacturing)

Source: Institute of Information Technology(2009), Industry officials Interviews, WesleyQuest Analysis

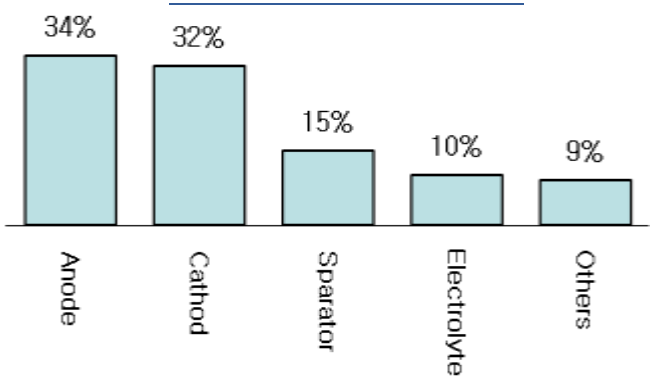
Technology - continue

The anode and cathod accounts for high portion of the total LIB production cost. The Korean companies plan to develop more competitive technology in object of making high density, lower cost LIB.

Rechargeable Battery Component/Technology Development



LiB cost breakdown



Part		Description	Material	R&D
Electrode	Anode	• Either of two points (or terminals) by which an electric current enters or leaves a battery or other electrical device	• Black lead	• High capacity /high safety material (Next generation Si, Sn materials)
	Cathode		• $LiCoO_2$	• Low cost /High capacity material • Low cost, High capacity material • Non cobalt ($LiMn_2O_4$, LiMnP, $LiFePO_4$)
Separator		• A machine for separating electronodes	• Polymer porous film	• Low cost, High strength, No resistance material
Electrolyte		• A liquid that an Li+ ion can pass	• Organic solvent	• Incombustible electrolyte material

Source: Institute of Information Technology(2009), KETI, Industry officials Interviews, WesleyQuest Analysis

Main Player

LG Chem, Samsung SDI, SK Energy are big 3 players in Korean EV battery market.

Main players in Rechargeable Battery Industry

Name	Description	Sales (2009, €B)	EV Battery business plan	Battery Business Portion(%)	Person in Charge	Contact Info (phone)
LG Chem (www.lgchemir.com)	• The largest Korean chemical company (manufacturer, supplier, and exporter petrochemical goods, plastics, flooring, and automoble parts.)	8.6	• LiBs and Li-polymer-B production from small batteries for mobile devices to advanced automotive batteries : ~2013 €1B Investment(Ochang Techno park), Detroit Factory, USA(250K/year), GM(Main Customer, Volt 250K/year)	10% (€860M)	Deputy Jaeyeon Kwak	02-3773-3682
Samsung SDI (www.samsungsdi.com)	• The leading eco-friendly clean energy company (Rechargeable battery, xEV, energy storage system)	2.2	• 2010 HEV LIB production • ~2015 HEV LIB global market share 30% plan	43% (€940M)	Wonsuk Jung	031-8006-3308
SB LiMotive (www.sblimotive.co.kr)	• Electrified power train solution service provider (Samsung SDI : Bosch 50%:50%)	N/A	• ~2010 prototype development • 2013~ mass production • BMW(main customer)	N/A	Deputy Hyowoong Kim	031-8006-3264
SK Energy (www.skenergy.com)	• Oil refining and marketing company	22.4	• LIB seperater production	2% (€440M)	Manager Kyuwon Jung	031-210-8064
SK Mobile Energy (www.skme.co.kr)	• Various Eco-friendly battery manufacturer (subsidiary of SK holdings)	9.5M	• 2009, Mitsubishi Fuso Truck & Bus Corporation HEV LIB LOI • 2010, Certified supplier of Hyundai motors LIB • Main customer: Mitsubishi Fuso Truck & Bus Corporation(Daimler Group), CT&T, Hyundai motors	100% (€9.5M)	President Kwansup Choi	041-550-9591

Source: IR annual report, WesleyQuest analysis

Value Chain in EV Battery Maket

The Value chain of EV battery is divided into three compositions: 1) Material, 2) Component/ Package, and 3) Cell. The end product is delivered to EV manufacturer such as GM, Hyundai motors.

Main Players by Value Chain

Material

- Anode
  - OCI Materials, Tonen Specialty Separator Korea, Carbonix
  - Under consideration: SK Energy, CSTech
- Cathode
  - L&F, Ecopro
  - Under consideration: Toray Advanced Materials Korea, Dea-jung Chemicals & Materials, Jesechem
- Electrolyte: Hanwha Chemical
- Etc: Iljin Group(Electrodeposited Copper Foil), Youlchon Chemicals(Polymer battery Pouch)

Equipment

- Lead Welding: SFA Engineering
- Charger/discharger: Nexcontech, Seltron, taekyungtech
- Testing Device: HanrimPostech, WonATech Suntech(Packaging device)
- Coater: Naraenanotech

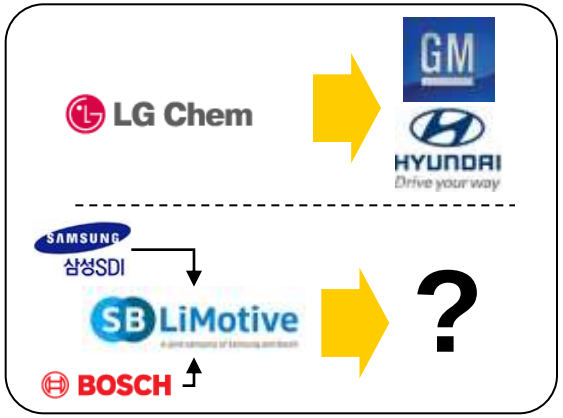
Component / Package

- PCM: : Nexcontech, Powerliogics, Kokam Engineering
- PTC: Shinwha Intertek
- Can: ShangsinEDP
- Capaciator: LS Cable, Nuintek
- Lead Tab: LTK

- Package: Youngbo Engineering, Seahantech, HanrimPostech, Elentec, SMC

Cell

- Main Player
  - LG Chem, Samsung SDI, SK Mobile Energy
- Minor Player
  - Kokam Engineering, Seahantech, Finecell(Polymer), E Square Technologies(Polymer), Korea Powercell(Coin-type battery for toy)



Note: PCM(Protection Circuit Module), PTC(Positive Temperature Coefficient)

Source: Institute of Information Technology(2009), KETI, Industry Officials Interview, WesleyQuest Analysis

Infrastructure

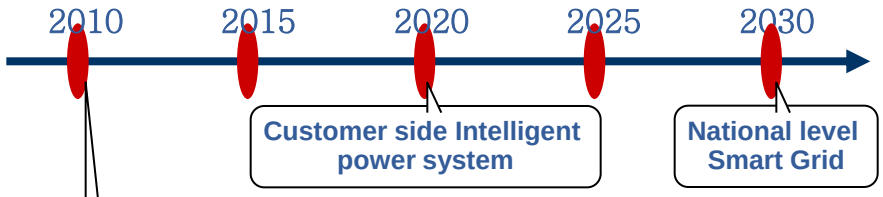
Summary on Charging Infrastructure

- As Korea attains more efficient and stable power infrastructure compared to other countries, the need to improve its system is comparatively lower. However, the Korean government plans to heavily invest in the Smart Grid on the purpose of 1) lowering import expenses from energy, 2) creating jobs, and 3) utilizing Korean market as a test bed of Smart Grid Technology to lead global market. In this sense, it is prospected that intense investment on EV charging infrastructure will be made 2013 to 2017.
- The construction of EV charging infrastructure will begin from 2015 and the market size is expected to grow up to €100M by 2020. In the early stage, household charging type will be introduced. Then the rapid charging and replacing batteries will follow. At the last stage, the contactless/road charging is expected to be dominant.
- Major players are KEPCO, Hyundai Motors, LS group(LS Industrial systems, LS Cable), Hyundai Heavy Industries, Samsung group(Samsung Electro Mechanics), Telecommunication companies(KT, SK Telecom, LG U+), Energy companies(SK Energy, GS Caltex), and Construction companies(Samsung C&T).
- The value chain of EV charging infrastructure is divided into 3 parts: Component/Module, Set/System, and Installation.
- There are no established standards for EV charging technologies yet nor legal duties to abide because EV market is still in the incubation period. However, by 2011, the Korean government is to complete standardization of the technologies and to make EV- related laws.
- The Korean government is planning to invest total of €111M till 2020, in order to establish EV charging infrastructure.
- There are business opportunities for foreign companies in the following sectors 1) city EV charging infrastructure technology sector, 2) Battery/replacing infrastructure sector, and 3) V2G(Vehicle to Grid) service sector.
- Korean government is currently supporting OLEV(Online EV) as the new Strategic business model.

Overall Introduction & Trend – Korean Government's Smart Grid & EV Roadmap

As Korea attains more efficient and stable power infrastructure compared to other countries, the need to improve its system is comparatively lower. However, the Korean government plans to heavily invest in the smart Grid on the purpose of 1) lowering import expenses from energy, 2) creating jobs, and 3) utilizing Korean market as a test bed of Smart Grid Technology to lead global market. In this sense, it is prospected that intense investment on EV charging infrastructure will be made intensively 2013 to 2017.

Korea's Smart Grid Development Plan



2009.6
- –Smart green vision setting
- –Jeju Smart Grid test bed plan (3,000unit-scaled)
- –Strategic alliance of U.S gov,- Korea gov.

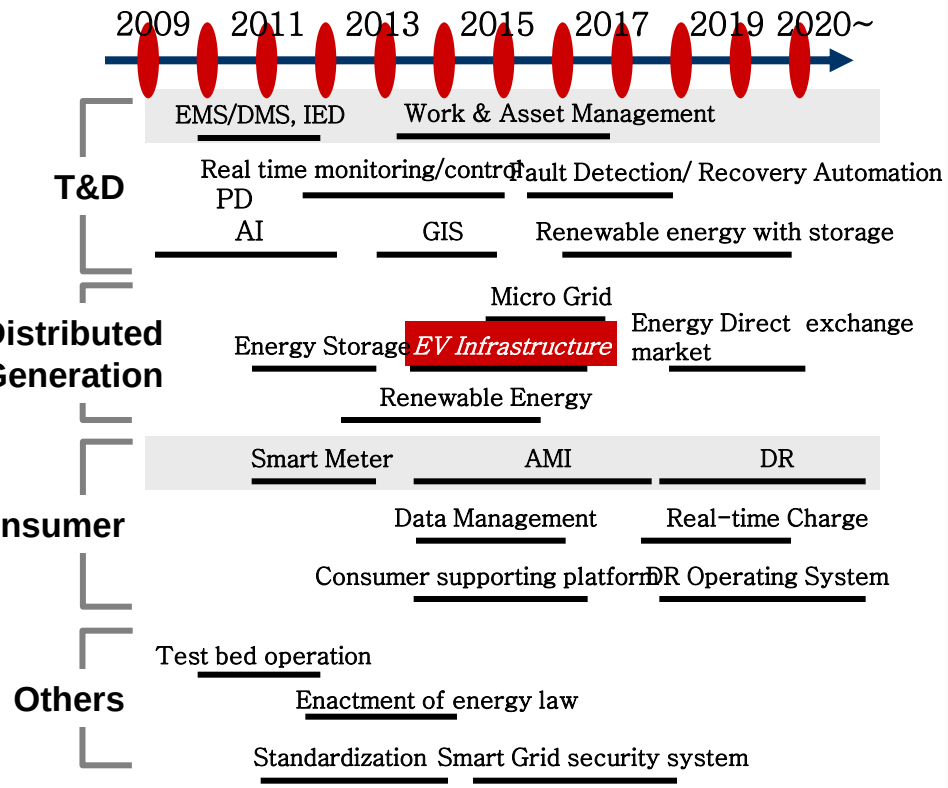
2009.8
- – Smart Grid Roadmap the first draft of Smart Grid

2009.11: Smart Grid Roadmap final version

2010~2013
- –Smart Meter distribution in stages
- –2010: Enactment of intelligent power network promotion law(tentative)
- –2011: Model city selection, AMI distribution

2012
- –Technology modulization and Model city completion

Korean Government Smart Grid Roadmap



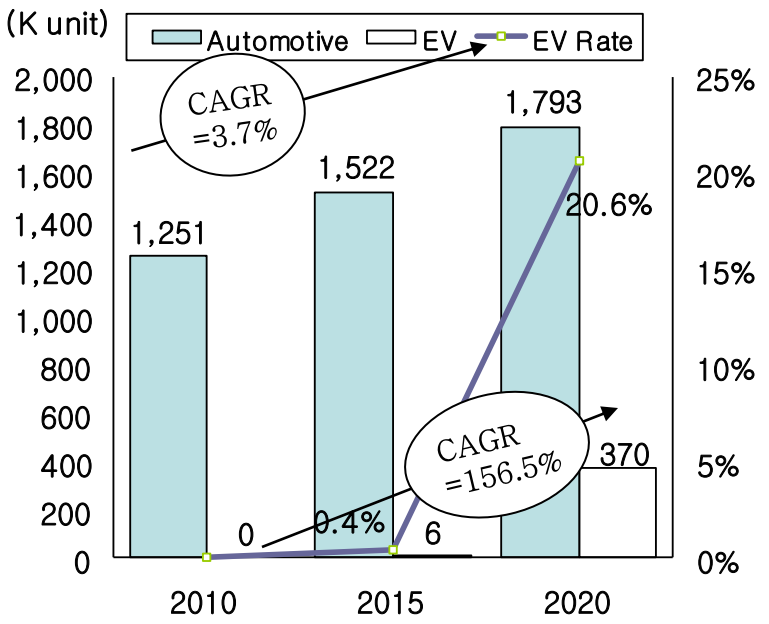
Note: T&D(Transmission and Distribution), EMS(Energy Management System), DMS(Distribution Management System), PDAI(Power Distribution Automation and Intellactualizaion) ,GIS(Geographical Information system), IED(Intelligent Electronic Device), AMI(Advanced Metering Infrastructure), DR(Demand Response)

Source: The Ministry of Knowledge Economy(2010.10), WesleyQuest Analysis

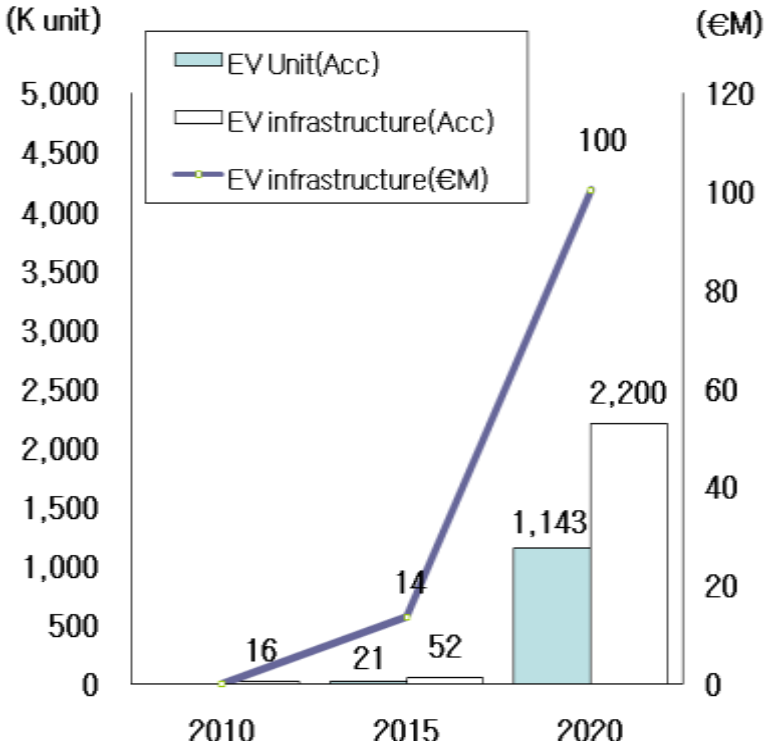
Overall Introduction & Trend - EV and EV Charging Infrastructure market forecast

EV market is anticipated to rapidly grow from 2015 and the construction of its supporting for EV Charging Infrastructure will also begin to boom around the same period, By 2020 the market size is anticipated to grow up to €100m.

Korean EV Market



Korea EV Charging Infrastructure Market



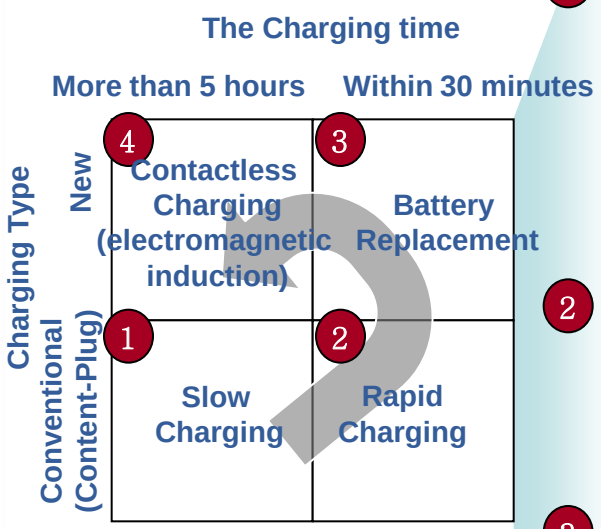
- **The Korean government plans to increase the number of EV up to 10% of total compact cars' annual production by 2015 and the accumulated number of EV to 1 million by 2020.**
- **The Korean government plans to install 2.2 million EV charging stations by 2020.**

Note: Acc(Accumulated)

Source: The Ministry of Knowledge Economy(2010.10), WesleyQuest Analysis

Overall Introduction & Trend – EV Charging Type change

Although slow charging type is now being adopted in Korea, the revolution of EV is anticipated to go through the stage of Rapid charging type and battery replacement type stage and then finally to the contactless/road charging stage.



"Although slow charging Type is now adopted in Korea, Rapid Charging type and Battery Replacing Type is aggressively tried and will become widespread. Finally Contactless/Road Charging is expected to be popular."
– Senior Researcher, LG Economic Research Institute

EV Charging Infrastructure Type

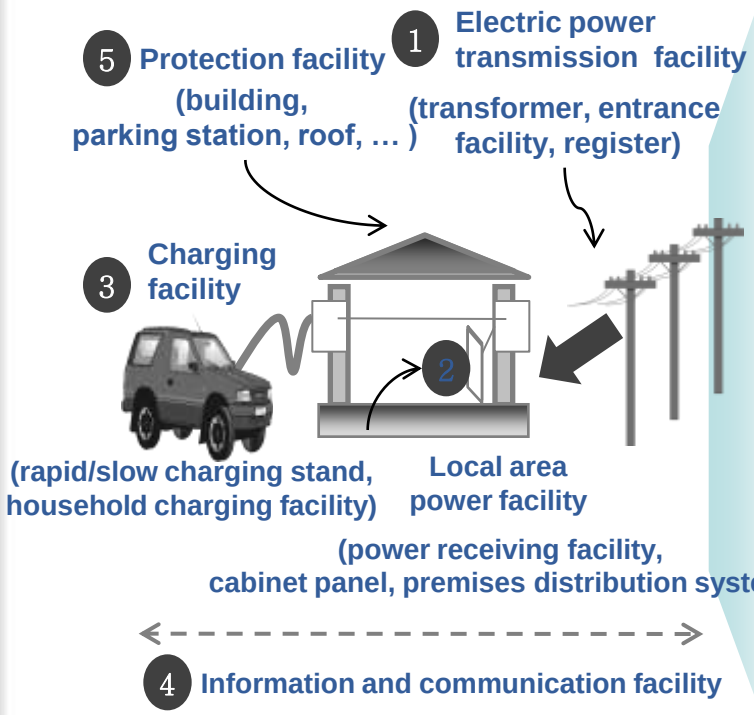
	Type	Use	Place	Pros	Cons
1	Slow Charging	Household Charging	• Residential Building, company parking lot	• Low effort • Cheaper (midnight) • Low installation cost • No Lithium battery degradation[1)]	• Long time • Electric shock risk • Difficult in puplic housing
		Public Charging Stand	• Public parking lot, shopping mall, etc • Long-time parking lot	• Low worry about low remaining energy • Lower installation cost	• More expensive EC (daytime)[2)] • Charging congestion
2	Rapid Charging	Public	• Accessible place (Gas station, Highways…)	• Short time • Low worry about low remaining energy	• More expensive EC (daytime) • Charging congestion • LIB degradation • High installation cost • Electric shock risk
3	Battery Replacement	Public	• Only Battery change station	• Very short time • No need for Battery maintenance	• Hard to visit battery station
4	Contactless Charging	Public	• On the Road	• No battery (Cheaper and lighter, no expensive battery) • No charging congestion	• Only in installed areas • Highest installation cost & More expensive EC (daytime) • Power overload risk in daytime

1) Degradation: Bad for its performance and quality 2) EC: electric charges
Source: LG Economic Research Institute, International Electric Standard board, KEPCO, WesleyQuest Analysis

Main Players

In Korea, EV charging infrastructure is divided into five sectors; Electric power transmission facility, Local area power facility, Charging facility, Information and Communication facility, and Protection facility. The major companies already have the head start on investing on each of areas.

EV charging sectors



Main Players

	Name	Description
1	KEPCO	• Largest electric power supply company in Korea
	Hyundai Motors	• Largest automaker in Korea
2	LS Industrial Systems	• Electronic product and automation machinery manufacturing company
3	Hyundai Heavy Industries	• Largest heavy industry company in Korea
	Samsung Electro-Mechanics	• Largest electronic component manufacturing company
	LS Cable	• Global 3rd largest cable, chemical and engineering manufacturer
4	KT	• Telecommunication company (Voice, Wireless, Wired, and Internet communication company)
	SK telecom	
	LG U+	
5	SK Energy	• Oil refining and marketing company
	GS Caltex	
	Samsung C&T	• Largest construction and trading company in Korea

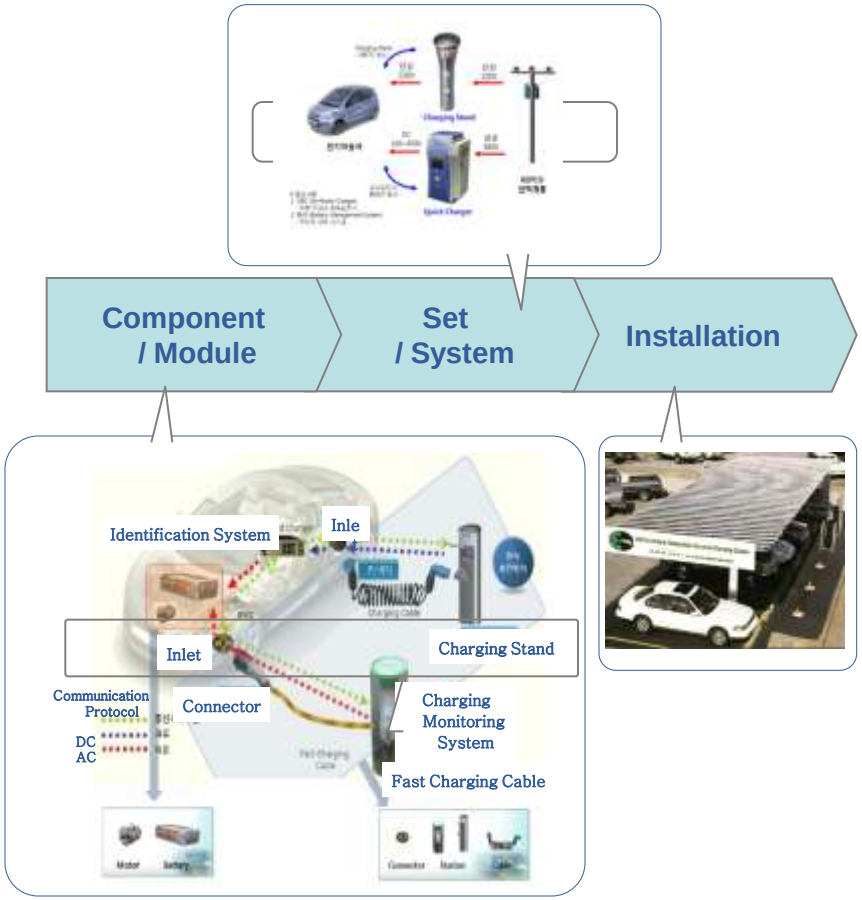
Note: Main player's partnership is not strongly tied now, because EV charging infrastructure market is at the early stage. However, the partnership among main players can be reasoned in Jeju test bed consortium(p.20)

Source: IR Data, WesleyQuest Analysis

Value Chain

The Value chain of EV Charging infrastructure is divided into three phases: Component/Module, Set/System and Installation. System companies currently leads technology development.

EV charging Infrastructure Value chain



Main Players of Each Value Chain

Component /Module	Set /System	Installation	other
• Inlet: N/A • Connector: N/A • Cable: LS Cable • Monitoring Device: Nexcontech, SK Energy, Kodi-S, P&E Solution • Car Identification Module : SK Energy, Kodi-S • Interface part: Automobile part institute, P&E Solution • Charging Stand: Kodi-S, P&E Solution	• LS Cable • SK Energy • Kodi-S • Automobile part institute • P&E Solution • Signet System	• KEPCO • GS Park 24 • Samsung C&T (Construction)	•KAIST (R&D)

Source: Korea Institute of Energy Technology Evaluation and Planning, WesleyQuest Analysis

Technology – EV Charging Infrastructure standard

KEPCO and Hyundai KIA automotive group suggested the 1st EV charging interface technology standard. Korean government is seeking to make it the global standard. However, there is no detailed technology standards yet.

EV Charging Infra installation standard (draft)

Standard	Contents
Installation environment	• A place without water-flooded • 3m x 6m space per 1 unit (additional area is needed for Protection facility) • Cautious near combustible or flammable materials
Electric power transmission standard	• Provide low voltage charging (maximum 499kW) space (and transformer space) with customer's requests • Rapid charging: 3-phase 4-wire 380V • Slow charging: 2-phases 2 wire 220V • EV electric charges = general electric charges (until EV exclusive electric charges set up)
Register	• Electronic Register facility outside apart.(if many, integrated) • Remote reading, time, season detection function.
Safety regulation	• The distance between charging stands : Same <the metManager of Inflammables and explosives administration> • LPG(Liquefied Petroleum Gas) storage facilities: Same < the act of LPG safety management and enforcement regulations>

- EV exclusive electric charges set up
- In 2011, nation-wide EV charging network set-up

Source: KEPCO, Hyundai-Kia Automotive, WesleyQuest Analysis

Government roles and ongoing R&D projects

The government has a plan to set up its role as a standard coordinator, which will develop EV and perform the overall standardization. The tasks will include 1) developing standard, 2) connecting standard and patent, and 3) supporting commercialization process.

EV related law enactment and revision

Acts	Contents	Note
Automobile management Act (special law for slow-speed EV)	• Safety standard, moving areas for Slow-speed EV	2010.3 enforce -ment
Regulation on automobile safety standard	• A fine for no moving zone of EV	2010.3 enforce -ment
Regulation on Automobile safety standard	• The standard of Electric regenerative breaking system, storage, drive motor etc.	2009.1 Revisio n
Eco- friendly automobile development and supply promotion Act	• The definition of eco-friendly auto mobile • 5-year basic plan and annual implementation plan • Fund for EV technology development • Tax favor for EV purchase • Basis regulation	1994.9 enact -ment

EV Charging Infrastructure long-term investment plan

(€M)	~2012	~2020	~2030	Total
Public Investment	**146**	**648**	**807**	**1,601**
Infrastructure establishment	23	194	-	217
IHD	13	24	-	36
EV Charging	*4*	*151*	*-*	*156*
EV	6	19	-	25
Technology development	123	454	807	1,384
Private Investment	**591**	**4,675**	**9,848**	**15,113**
Infrastructure establishment	451	3,965	7,718	12,134
Smart meter/IHD	197	814	206	1,218
Communication Infra	156	685	11	853
EV Charging	*-*	*139*	*2,856*	*2,994*
Renewable Energy	-	1,929	3,511	5,440
Power network building	98	398	1,134	1,629
Technology development	140	710	2,129	2,979
Total Infrastructure establishment	474	4,159	7,718	12,351
Total Technology development	263	1,164	2,936	4,363
Total EV Charging	*4*	*290*	*2,856*	*3,150*

Source: LG Economic Research Institute, International electricity Standard Meeting (2010), KEPCO, WesleyQuest Analysis

Government roles and ongoing R&D projects

In Korea, EV Charging Technology R&D is led by Private sector. Among the 11 national-wide Smart Grid projects led by the Korean government, there are no on-going R&D project on EV charging technology.

EV technology R&D budget plan

(€M)

Type	Key Technology	2009-2012		2013-2030		Total
		Public	Private	Public	Private	
Mass storage and Long life energy storage system for green car	• Energy density Improvement • Durability improvement • Battery Package and safety Improvement • Easy installation in vehicle	5	10	30	63	108
High efficiency green car components	• Large density drive motor/inverter /power module…	10	3	18	6	37
Plug-in System Infrastructure technology	• *Movable charger* • *Smart rapid Charging* • *Charging Interface development and vehicle Standardization*	9	9	31	63	111
Hydrogen fuel vehicle commerciali-ization	• Fuel battery system • Key materials • Hydrogen storage technology • Fuel battery performance and Price Reduction	40	532	94	625	1,291
Total		63	554	173	756	1,547

National-wide Smart Grid Projects

(€M)

Project Name	Agency	Period	Budget
Intelligent power distribution	• KEPCO	2005.10 -2010.9	14.5
Digital transformer substation	• KEPCO	2005.10 -2011.9	12.1
Integrated power management	• Kyung won University	2005.10 -2010.9	16.1
Power line communication /Ubiquitous technology	• KEPCO, KERI	2005.10 -2011.9	21.4
Intelligent transmission network monitoring	• KERI	2005.10 -2010.9	7.6
K-EMS(Korean-type energy management system)	• KEPCO	2005.10 -2010.10	24.9
Power semiconductor technology(distributed generation and inverter)	• COSAR	2005.10 -2009.11	23.2
IT based power transmission control	• KEPCO	2005.10 -2009.11	19.3
Active type power facility monitoring	• KDN	2005.10 -2009.11	10.3
Integrated EMS (micro grid)	• KEITRA	2007.9 -2012.8	8.8
Smart grid test-bed establishment	• KEPCO	2008.12 -2013.11	50.6
Total 11 Project			208.9

Note: KEITRA(Korean Electrical Industry technology Research Association), COSAR(Consortium of Semiconductor Advanced Research), KERI(Korea Electrotechnology Research Institute)

Source: The Ministry of Knowledge Economy(2010.10), Korea Institute of Energy and Resources technology Evaluation and Planning, WesleyQuest Analysis

Opportunity for Foreign(Finnish) Companies

Korea is uncompetitive in city EV charging technology, Battery Replacement/Recycling, and V2G services, thus foreign companies' R&D cooperation is in need. However, except for these subjects, Korea considers foreign companies as competitors in global market.

EV Charging technology competitiveness comparison(Global vs. Korea)

	R&D subjects	Global	Korea	Uncompetitive
Material /components	Low price/High performance battery	R&D	R&D	
	EV Charging device	R&D	R&D	
	EV battery rental/recycling business	Practical	R&D	V
	The next generation charging device	Future Technology	Future Technology	
	The next generation EV material/component	Future Technology	Future Technology	
Charging Infrastructure	Model city charging network technology	Practical	R&D	V
	Major city charging network technology	Practical	R&D	V
	EV identification/billing network module	R&D	R&D	
	Charging Infrastructure service(ex. Credit card billing service)	Practical	R&D	V
	Driving information recording interface	Future Technology	Future Technology	
	EVICT service platform upgrade	Future Technology	Future Technology	
V2G	PCS[1)] technology for V2G	R&D	R&D	
	Advanced EV and VPP[2)] technology	Future Technology	Future Technology	
	V2G services(Business Model and Pricing system design)	Practical	Future Technology	V
	V2G Service System Modeling	R&D	R&D	
	V2G interconnection	R&D	R&D	

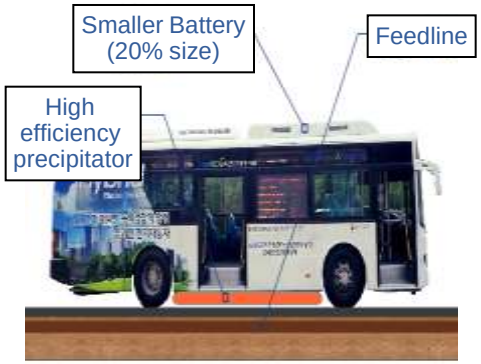
1) PCS: Power Conditioning System, 2) VPP: Virtual Power Plant,
Source: The Ministry of Knowledge Economy(2010.10), Korea Institute of Energy Technology Evaluation and Planning, WesleyQuest Analysis

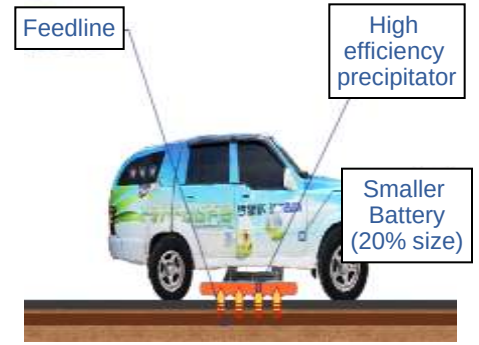
New Business Model

OLEV(On Line Electric Vehicle) is now being tested in 2 Big Cities(Seoul and Daejeon) in Korea, which is to be commercialized in 2012. Korean "OLEV" is more preferable and the adoption of "Better Place business model " is expected to be delayed.

EV Charging Infra related New Business Model

OLEV(On Line EV)





- **OLEV(On Line Electric Vehicle)s can be operated without recharging process, passing over certain tracks under which power coils are buried.**
- **Korea Advanced Institute of Science and Technology (KAIST) conducted a test drive of the On Line Electric Vehicle (OLEV) in the city for commercialization (2009.8).**
- **Mass production prototype development in 2012**

Supported

Better Place Model
(Battery Change)

- **At Better Place battery switch stations, drivers enter a lane and the station takes over from there. The car proceeds along a conveyor while the automated switch platform below the vehicle aligns under the battery, washes the underbody, initiates the battery release process and lowers the battery from the vehicle. The depleted battery is placed onto a storage rack for charging, monitoring and preparation for the another vehicle. A fully-charged battery is then lifted into the waiting car.**

Not Supported

Source: KAIST, Business Analyst / Industry Official Interview, WesleyQuest Analysis

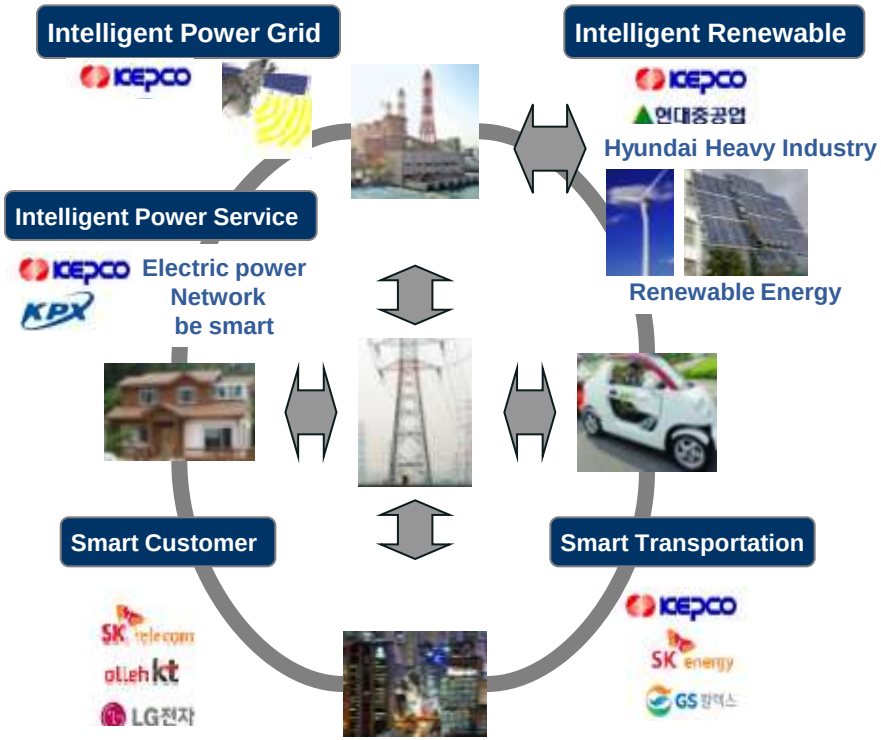
Best Practice - Smart Grid Jeju test bed

Jeju Smart Grid test bed aims to develop optimal Smart Grid business models and to test Smart Grid technologies for commercialization and export.

- 2009.12~2013.05 : €150M Investment (Public: €43M, Private:€107M)
- 12 consortiums(171 companies) in five main themes(Intelligent Power Grid, Intelligent Power Service, Smart Customer, Smart Transportation, Intelligent Renewable)
  : 2Electrical Substations, 4 Power distribution networks, 6,ooo Smart green homes

Jeju Smart Grid Ted Bed

Five Main Themes of Jeju Smart Grid test bed



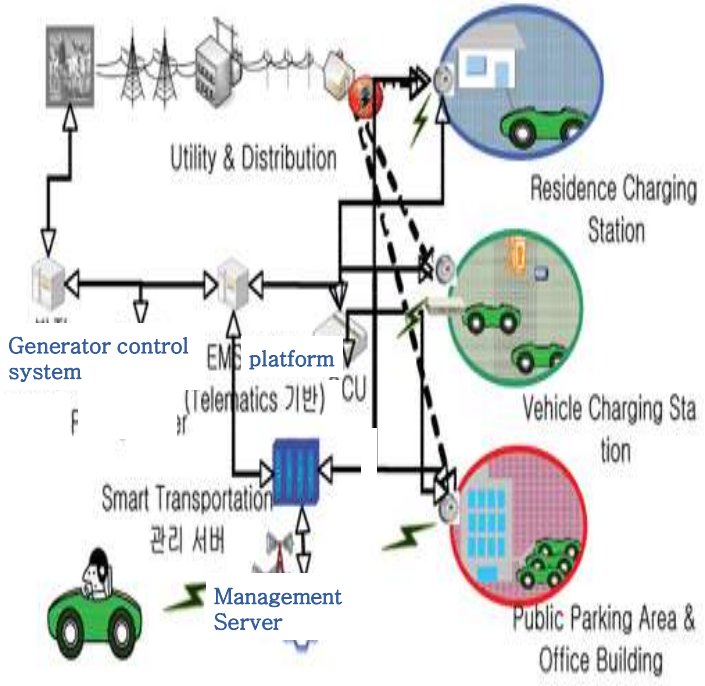
Source: Smart Grid Development Agency, KEPCO, WesleyQuest Analysis

Best Practice-Smart Grid Jeju test bed

There are three consortiums in the Smart Transportation Sector of Jeju Smart Grid test bed. They are testing EV technologies, such as rapid/slow/contactless charging, car sharing, and so on.

Smart Transportation of Jeju Smart Grid Ted Bed

Smart Transportation Service



Consortiums

Consortiums	Period	Proof technology/providing Services
KEPCO	2009.12 -2013.5	•Rapid Charger: 14 units •Slow Charger: 22 units •Large Capacity battery: 1unit •Contactless Charging Area: 4 places
SK Energy	2009.12 -2013.5	•EV : 72 units •Rapid Charger: 14 units •Slow Charger: 75 units •Car sharing / Rental •Emergency Roadside Service •V2G •Telematics
GS Caltex	2009.12 -2013.5	• EV Charging Station – Providing electrical power on Peak(electrical load), reselling electrical power – Solar energy connection – Electric dispersion • Real time EV management – Charging information check(Smart phone) • Car Sharing / Rental

Source: Smart Grid Development Agency, WesleyQuest Analysis

Conclusion

- Korea's EV status:
  - Big OEMs are currently exporting clean diesel cars to Europe and plan to improve their gasoline-based hybrid car technologies. SMEs are already selling NEVs and big OEMs produce full-speed electric vehicles in small volumes for government's fleet programs.
  - Korean battery makers holds world class technologies and foreign OEMs are competively demanding Korean-made batteries.
  - Local governments are designating driveways for NEVs and large marts are planning to build charging facilities for their customers.
  - ⇨ When big OEMs get ready for mass production and the government provides a significant amount of supports, the demand for EVs can be triggered much earlier.
- Airport, factories, large scale research centers, tourist attractions have a potential demand for hundreds of NEVs. Plus amusement parks and national parks where are already using converted EVs from golfcarts also have a demand for another hundreds of small-sized EVs.
- Nationwide interest toward electric vehicle is growing rapidly, however, the industry still hesitate to make a bold investment in the EV business.
- Although the ultimate forms of green cars will be pure EV and FCEV, several years will be needed for the full commercialization of EV and FCEV. Until then, hybrid cars and NEVs will be the leaders of the market.
- Strategic approaches to lead the global EV market are needed: I) Improve technologies in clean diesel and hybrid cars and secure an early mass production systems, II) At the same time, conduct technology development on EV and FCEV which will be fully commercialized later stage.

Appendix

44 Participating Companies in Hyundai Motor's Blue-On Development Project

Electric Vehicles			
Hyundai Motor			
Drive and Power Conversion System			
Inverter	**Motor**	**Reducer**	**Renerative brakes**
LS Industrial Systems	Hyosung	Hyundai-Wia	Mando
Nuintek	Saeil Industries	Woosu AMS	LG Innotek
LS Cable	Leejo Metal	Il Kwang Metal Works	GMS
JY Proto		Samgong Gear	Conti Automative
			Seoyoung
Energy Storage/Charging System			
Battery System	**LDC**	**Battery Pack**	**Charger**
SK Energy	Hyundai Mobis	Hyundai Mobis	Mando
SKME	Orient Electronics	Halla Climate Control Corp	Infineon
Yong Sung Electric Devices MFG	Digital Electronics	Inzi Controls	Free Scale
	Yongin Electronics	Shinyoung	
		LS Industrial systems	
		Kefico	
Core Common-Components Development			
Air Conditioning System	**Cluster assy**	**High-Voltage Changing Port**	**High-Voltage Wiring**
Halla Climate Control Corp	Denso PS	Yura Corp	Kyungshin
Woory Industrial Company	Daea Indsutrial	Korea Precision	Korea Electric Termianl
Wonjin Electronics	Yushin Industrial	Jinyang Corp	TycoAMP
Husung	Optrex		
	Seungil Eletronics		

EV Charging Type in Korea

There are four EV Charging types in Korea, which includes ; 1) Rapid Charging, 2) Slow Charging, 3) Replacing batteries, and 4) Contactless Charging. However, Replacing batteries is not taken by Korean companies.

EV Charging Type

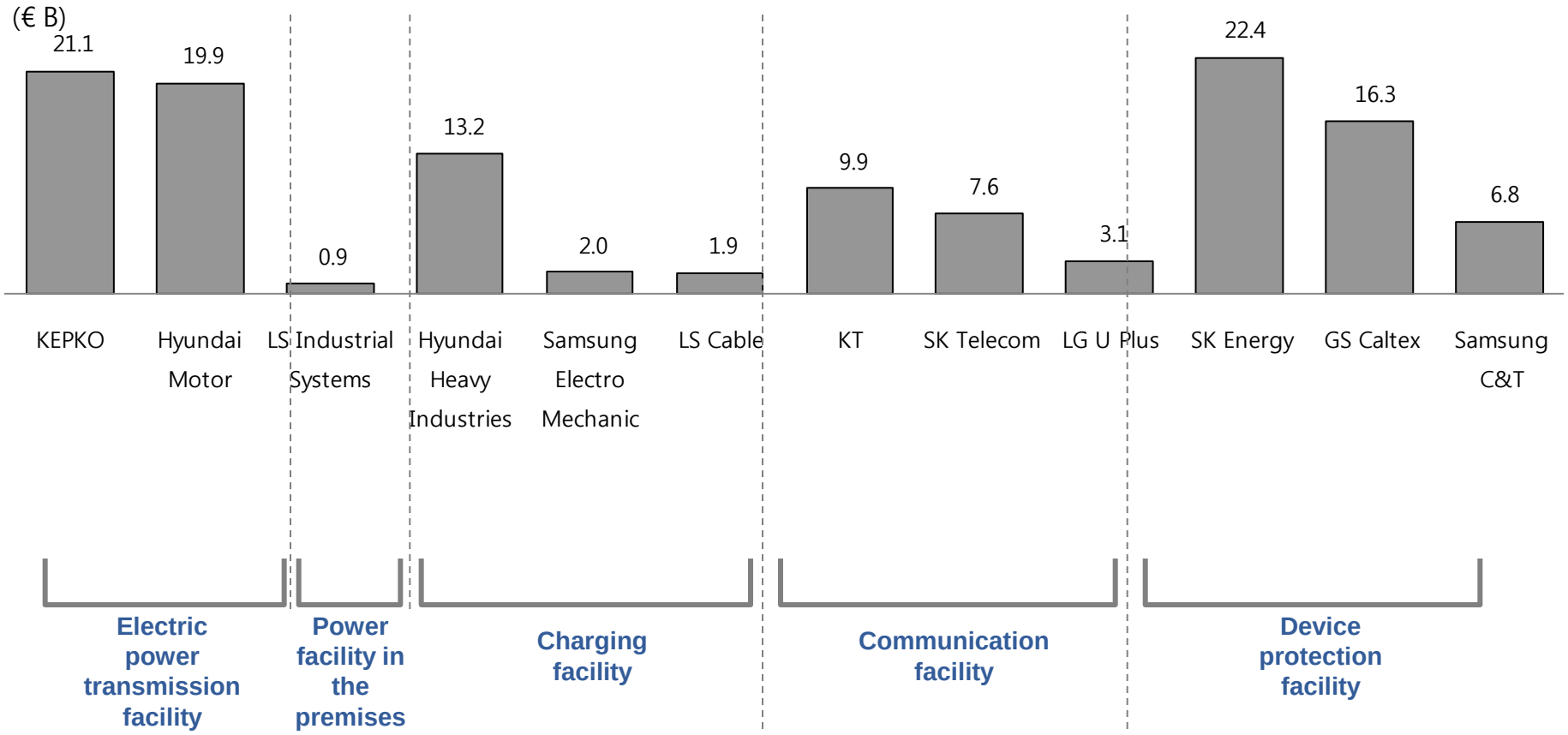
Type	Use	Place	Pros	Cons	Power	Real time fee	Voltage	Charging hour	Major Players
Slow Charging	Household Charging	• Residential Building, company parking lot	• Low effort • Cheaper (midnight) • Low installation cost • No Lithium battery degradation[1)]	• Long time • Electric shock risk • Difficult in public housing	• 1~2 kW (2~7 kW Charging only)	• Unnecessary (Avoid progressive fee, monthly charging fee sum-up)	• AC 220V	• 4-8 Hr	• GS Park24, Samsung C&T (Construction sector)
	Public Charging Stand	• Public parking lot, shopping mall, etc • Long-time parking lot	• Low worry about low remaining energy • Lower installation cost	• More expensive EC (daytime) • Charging congestion	• 2-15 kW	• Possible	• AC 220V	• 2-5 Hr	• LS Cable, SK Energy, Signet System, Kodi-s, Soosung, PSTek, Nexcon Technology
Rapid Charging	Public	• Accessible place (Gas station, Highways …)	• Short time • Low worry about low remaining energy	• More expensive EC (daytime) • Charging congestion • LIB degradation • High installation cost • Electric shock risk	• 20-200 kW	• Possible	• DC 500V (Less)	• ~0.5 Hr	
Battery Replacement	Public	• Only Battery change station	• Very short time • No need for Battery maintenance	• Hard to visit battery station	• N/A	• Possible	• N/A	• N/A	• N/A
Contactless Charging	Public	• On the Road	• No battery (Cheaper and lighter without expensive battery) • No charging congestion	• Only in installed areas • Highest installation cost & More expensive EC (daytime) • Power overload risk in daytime	• 62 kW	• N/A	• AC 440V	• N/A	• KAIST Consortium (Hyundai Heavy Industries, SK Energy, Hyundai, LG Chem, Samsung SDI)`

1) degradation: Bad for its performance and quality

Source: LG Economic Research Institute, International Electric Standard Board, KEPCO, WesleyQuest Analysis

EV Charging Infrastructure Main Player

EV Main Players' Sales Figure in each of the charging facility sector



Source: Fnguide, IR Data, WesleyQuest Analysis

EV Charging Infrastructure Main Player(1/3)

Category	Name	Description	Sales (2009, €B)	Business Plan (EV Charging Infrastructure)	Person in Charge	Contact Info (phone)
Electric power transmission facility	KEPCO (www.kepco.com)	• State-owned electric power supplement company in Korea	21.1	• Main agency of Korean government in EV charging infrastructure construction and EV charging technology R&D	Manager Youngchan Kim	02-3456-3716
	Hyundai-Kia Motors (www.hyundai.com)	• Korea largest automobile company	19.9	• EV manufacturing • EV charging technology standard setting with KEPCO	Manager Homin Lee	031-368-7307
Local area power facility	LS Industrial Systems (www.lsis.biz)	• Electrical devices manufacturer (power distribution system, power system automation)	0.9	• EV Charging stand manufacturing and EV charging Infrastructures construction	Section Cheif Jeayoung Jang	010-4309-5967
Charging facility	KAIST (www.kaist.ac.kr)	• National university specializing in science and technology	N/A	• 2009~ OLEV(Online EV) development	Team leader Sungwoon Joe	042-350-6681
	KATS (www.kats.go.kr)	• Founded in 2010 by govenment, • EV technology standardization	N/A	• 2010~ EV Charging system and battery performance technology standardization	The Ministry of Knowledge, Economy's business	
	KATECH (www.katech.re.kr)	• Auto technology research Institute	N/A	• EV componets and new technogy R&D	Senior researcher Chanjoog Kim	041-559-0124
	Hyundai Heavy Industries (www.hhi.com)	• Global leading ship building company	13.2	• 1993~EV, power conversion system, train-control & diagnosis system, manufacturing charger, management system	Manager Sungwon Lee	052-202-2816
	Samsung Electro-mechanics (www.sem.samsung.com)	• Samsung subsidiary electronic components manufacturer	2.0	• EV charging system for parking lot of residential complex	Senior researcher Joonsuk Choi	031-210-6648

Note. N/A:Non-profit organization, Manager: Manager / Source: WesleyQuest Analysis

EV Charging Infrastructure Main Player(2/3)

Category	Name	Description	Sales (2009, €B)	Business Plan (EV Charging Infrastructure)	Person in Charge	Contact Info (phone)
	LS Industrial Systems (**www.lscable.co.kr**)	• Electric power device and optical communication solution provider	1.9	• 2009~ rapid EV charging system commercialization	Manager Kiyoul Hong	031-428-4181
	Mando (**www.mando.com**)	• Auto parts and modules manufacturer	0.9	• EV embedded charging system, charger, condenser development (with Hyundai Mobis)	Manager Hyungtea Moon	031-629-2440
	Nexcontech (**www.nexcontech.com**)	• Cell-phone battery, EV Charger, Power storage equipments producer	0.1	• 2009~ Involved in Smart Grid test bed project managed by KEPCO	Team Leader Namsoo Kim	010-9251-260
	Soosung (**www.soosung.com**)	• Compressor's parts and construction machinery manufacturer	16.3M	• 2010~ rapid charging system Annually 2,500 EV production in China	Deputy Manager Sungmo Lee	032-820-5153
	Kodi-s (www.kodi-s.com)	• Display-producing machinery manufacturing company	15.9 M	• 2008~ produced EV parts and Chargers • 2009~ rapid charger market in Korea and China	Manager Sukcheon Mo	010-4583-5981
	PNS solution (www.pnesolution.com)	• Chargers and EDLC1) manufacturer	13.7M	• Eco-friendly EV battery system development	Deputy Manager Homin Kim	010-9808-2800
	PStek (www.pstek.co.kr)	• Market leader of electrical control system in Korea	7.7M	• Export plan of PHEV, HEV charger to Japan	Deputy Manager Kwangil Kim	011-9622-0310
	Signetsystem (www.signetsys.com)	• Electric locomotive battery charger, and inerter manufacturer	4.2M	• Rapid charger development	Chief YongWon Choi	010-6642-5916

Source: WesleyQuest Analysis

EV Charging Infrastructure Main Player(3/3)

Category	Name	Description	Sales (2009, €B)	Business Plan (EV Charging Infrastructure)	Person in Charge	Contact Info (phone)
Communication facility	Sktelecom (www.sktelecom.com)	• Telecommunication company (Voice, Wireless, Wired, and Internet communication company)	7.6	• Mobile telemetics development	Manager WhoJoong Kim	02-6100-2209
	KT (www.kt.co.kr)		9.9		Director Hongbum Jun	031-727-0114
	LG U+ (www.lguplus.com)		3.1		LG Chem's business	
	LG CNS (www.lgcns.com)	• IT service company	1.1	• Rapid Charging system development with Signet system	Chief Researcher Hyungkee Park	02-6710-3323
Device Protection System	SK energy (www.skenergy.com)	• Oil refining and marketing company	22.4	• EV battery, charging stand development and system construction	Manager Kwanghoon Kim	042-866-7723
	GS Caltex (www.gscaltex.co.kr)		16.3	• EV sharing and rental service • Charging infrastructure construction	Deputy Manager Sunghyun Shu	02-2005-1681
	Samsung C&T (www.samsungcnt.co.kr)	• Largest construction and Trading company in Korea	6.8	• EV charging station in apartment • Charging plug-in system	CVNet's business	
	Hyundai Elevator (www.hyundaielevator.co.kr)	• Elevator, escalator, logistic system manufacturer	0.5	• EV charging facility building	N/A	Under consideration
	GS park24 (www.gspark24.co.kr)	• Parking service	4.7	• Use GS Caltex station as EV charging station	Deputy Manager Hyosun Kim	02-3465-3628
	CVNet (www.cvnet.co.kr)	• PHEV Charging Station development	N/A	• Self-charging system development	Team Leader Jeahyung Lee	031-8022-3863
	TIS (www.tis21.com)	• Parking management system	N/A	• Rapid charger and total solution service provider	Director Chulbea Kang	010-5765-7894

[1] EDLC: Electric Double Layer Capacitor / Source: WesleyQuest Analysis

Jeju Smart Grid Test-Bed Consortium Companies (Smart Transporation)

Consortium Participants

KEPCO Consortium

Charging Device	LS Cable, LS Industrial systems, Samsung C&T, Hyosung, KAIST, Green Power, Taekwang E&C, PNE
Operation System	Wooam, Sanion, HERIT, Techwin
Information Security	Lotte data communication company, Future systems
Services	LG U+, Sejin, Sundo soft
Quality	Samhwa capaciator

SK Energy Consortium

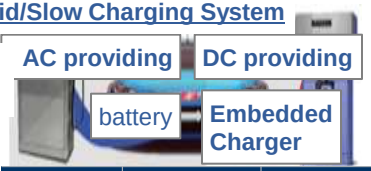
Standardi-zation	KATECH(Korea Automotive Technology Institute)
Battery	SK Energy
EV	CT&T, Donghee Industrial, Samsung motors
Charger	Hyundai Heavy Industries, EN technologies, ILJIN Electric, KODI-S, Byucksan Power
Charger Operation	SK Networks, Ahn Lab, iSET
Standardi-zation	KERI(Korea Electro technology Institute), KATECH, Jeju National University

GS Caltex Consortium

Communicati on/Security	SK Telecom, Infosec
Communi-cation	KT
System Integration	LG CNS
Charger	ABB Korea
Energy Storage	LG Chem, Nexcon technology
Parking System	GS Park 24
Fuel Cell	GS FuelCell

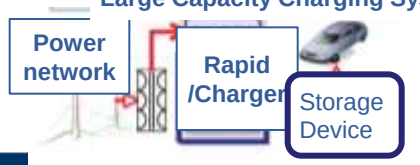
Proof technology

Rapid/Slow Charging System



	Rapid Charging	Slow Charging
Voltage	DC 400V	AC 220V
Capacity	50kW	7.7kW
Time	20min	3-4hours

Large Capacity Charging System



Contactless charging System

EV Operation Support	Smart EV Charging	Electrical Power System Stabilization	Telematics Services
• Car sharing • Car rental • ESR(Emergency Roadside Service)	• Charging station membership and network • Rapid/Slow Charging Service	• Virtual Power Plant (Electricity reselling) • Smart Grid + Renewable energy	• Charging Station search • Supplemental Service (Battery state , billing information…)

Charging Station	Supplement Power	Real Time EV Management	EV Sharing & Rental Service
• Rapid/Slow Charging Service • Independent pole-type charging device • Billing through ICT	• Peak time electricity reselling • Smart Grid + Renewable energy • Dispersed generation system • Energy storage	• Real time car information service (Smart phone)	• Car sharing • Car rental