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Luxury Electric and Plug-in Hybrid Vehicles in South Korea:
2013 to 2020 Modeling and Analysis of Costs Per Mile, Load Demand, and Policy

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Contents

South Korea's Electric Vehicle and Related Battery and Infrastructure Market Could Evolve into a Lucrative Opportunity for Foreign Firms

Suitable Market for Electric Vehicles

- Electricity Prices are 50% Below OECD Mean
- Gasoline Prices are 76% Above OECD Mean
- Electric Grid with 4% transmission loss and less than 20 minutes black out time per year

Electric Vehicle and Related Technology Opportunities

- More than 37% of Korea's vehicles sold in 2009 were larger than compact vehicles
- Import market with a CAGR of 18.53% and with 75% of them 2,000cc and larger
- Electric Vehicles (EVs) and Plug-in-Electric-Hybrids (PHEVs) could account for a cumulative share of 39% of all new personal vehicles sold in 2020

Market Demand and Technology Transfer

- Consumers demand high-performance vehicles: possibly large lucrative EV and PHEV import market
- With battery and related infrastructure technology key to EV and PHEV deployment, demand for technology transfers, licensing, production networks, joint ventures, and mergers and acquisitions could create opportunities for foreign technology companies and advisory firms.

Key Terms

- Plug in Electric Hybrids (PHEV): Electric Vehicles (EV); Internal Combustion Engine (ICE); Vehicle to Grid (V2G) – buying and selling electricity

Long Range Luxury EVs and PHEVs

Changing Technology, Not Consumer Behavior

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Pure EV

EV (Electric Vehicle)

Tesla Model S (2012)

- **Base Price**: $57,400 (160 miles / $71,400 (240 miles) / $83,900 (300 miles)
- **Engine:** Electric Drive
- **Range:** 160 / 230 / 300 miles
- **Battery Manufacturer : A123**
- **Battery cost and Size:** $500 kWh– 42 kWh / 75 kWh / 95 kWh est.
- **MPG (MPG_e):** 100

Tesla Blue Star (2012+) (Concept Phase)

- **Base Price**: $30,000
- **Engine:** Electric Drive
- **Range:** 160 / 230 / 300 miles (estimated)
- **Battery Manufacturer : A123**
- **Battery Cost and Size:** $500 kWh – 42 kWh / 75 kWh / 95 kWh est.
- **MPG (MPG_e):** 100

Luxury PHEV

PHEV (Plug-in-Hybrid Electric Vehicle)

Fisker Karma (2010)

- **Base Price**: $87,900
- **Engine:** Plug-in-Electric Hybrid with 2.0 Liter / Electric Drive
- **Range:** 50 Miles Electric / 250 Miles Gasoline
- **Battery Manufacturer:** A123
- **Battery Cost and Size :** $500 kWh - 22 kWh
- **MPG (MPG_e):** 100

Fisker Nina (2012) (Concept Phase)

- **Base Price**: $48,000- (Without Incentive)
- **Engine:** Plug-in-Electric Hybrid (unknown engine specs)
- Range: 50 Miles Electric / 250 Miles Gasoline (estimated)
- **Battery Manufacturer:** unknown - possibly A123
- Battery Cost and Size: $350 kWh est. - 22 kWh
- MPG (MPG_e): 100 (estimated)

South Korea's EV & PHEV Market Forecasts

From Start Ups to a Major Market

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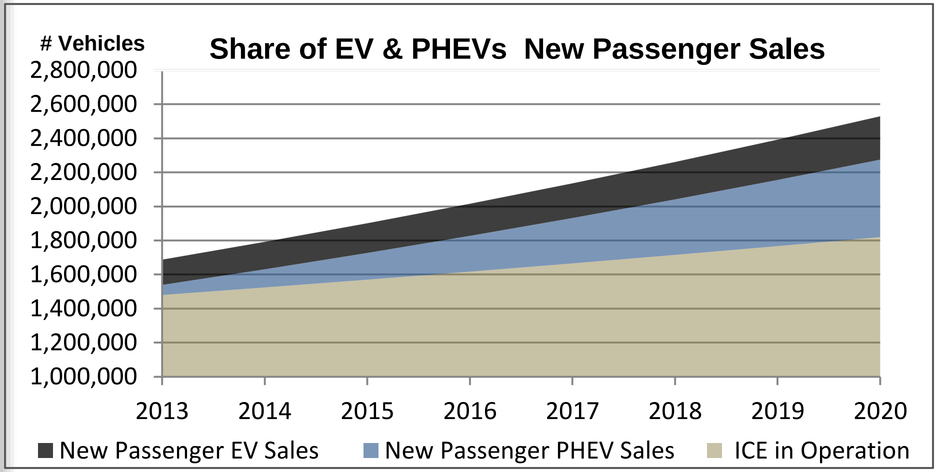
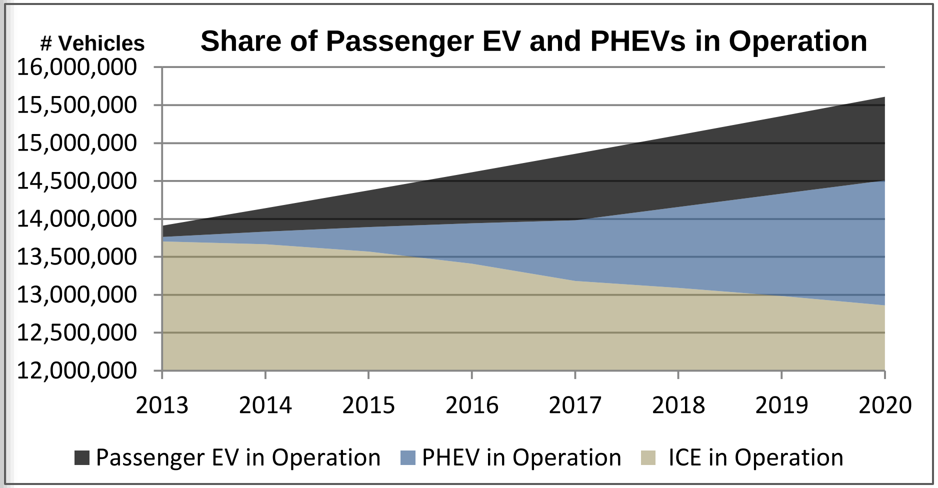
EVs and PHEVs Edge Closer to 40% of Vehicles Sold



- **High New Vehicle Sales Growth Rate**
  - •33.89% CAGR for PHEVs: 2013 - 2020
  - •9% CAGR for EVs sold: 2013 - 2020
- **Approaching 40% Share of Total New Sales**
  - •14% of New Passenger Vehicles Sold in 2013
  - •39% of New Passenger Vehicles Sold in 2020

Transforming 1/5 of Korea's Vehicle Fuel Mix by 2020



- **Share of Total in Operation**
  - •1.5 % Total Vehicles in Operation by 2013
  - •21% - 1//5 of Total Vehicles in Operation by 2020
- **2.7 Million Plug-ins in Operation by 2020**
  - •1.1 Million EVs in Operation
  - •1.6 Million PHEVs in Operation

Source: Korea Automobile Manufacturers Association / Korea Power Exchange Study on PHEVs in Korea / KPMG Analysis on EVs in Korea

EV & PHEV Costs-Per-Mile Modeling

Fisker & Tesla compared with ICE Models

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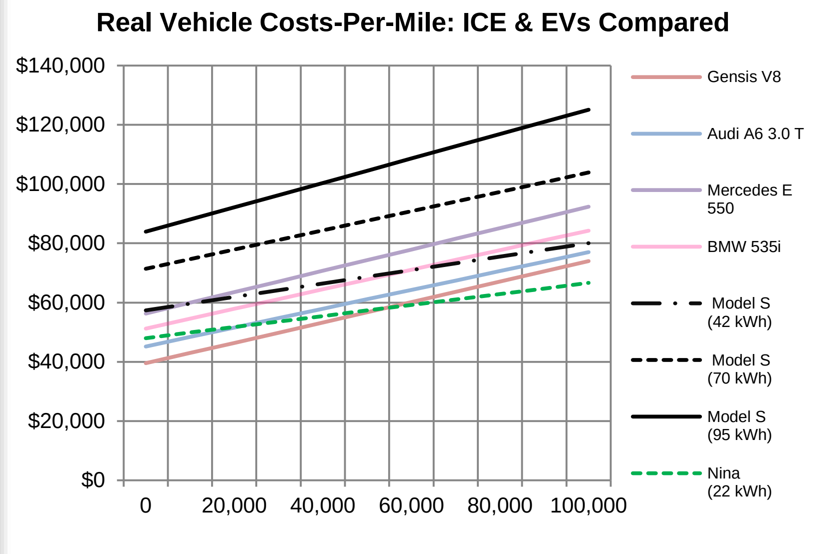
Luxury Vehicle Costs Per Mile With Korean Energy Prices

Grouped by Class, 0-60 Performance, and Price Range: Vehicles with South Korean Energy Prices

	Base Price	Performance (0-60)	Class	Engine Size	Combined MPG /MPGge	Energy Korea 4th Qtr 2009	Fuel Cost/Mile
Tesla Model S (EV)	$57,400	5.6	Mid-Size	0	100 (est)	$.10 kWh	$0.033
Fisker Nina (PHEV)	$48,000	5-6 est	Mid-Size	2.0 Liter T/Electric	100 (est)	$.10 kwh / 5.33 Gallon	$0.05
Gensis V8	$39,500	5.3	Mid-Size	4.6 Liter (4627 cc)	19	5.33 Gallon	$0.28
Audi A6 3.0 T	$45,200	5.9	Mid-Size	3.0 Liter (2995cc)	21	5.33 Gallon	$0.25
Mercedes E 550	$56,300	5.2	Mid-Size	5.5 Liter (5461 cc)	18	5.33 Gallon	$0.30
BMW 535i	$51,250	5.7	Mid-Size	3.0 Liter (2979 cc)	20	5.33 Gallon	$0.27

PHEVs and 160 Mile Range (42 kWh) EVs Competitive by 2011/2012



● Luxury PHEVs Are Most Economical

- •Smaller Batteries (22 kWh) lower costs-per-mile

● Battery Size, Density, & Prices are Key to EVs-PHEVs

- • Battery Life Cycles are No Longer the Issue. A123 and LG Chem now have batteries that can last through a 5000 charge life cycle (10 years)
- •The Tesla Model S includes three ranges with three battery sizes: 160 Miles (42 kWh), 240 Miles (70 kWh), and 300 Miles (95 est. kWh)

● Base Price Matters

- •EVs and PHEVs will have higher base prices because of the inclusion of battery costs, but these costs can be recovered if the battery is not too large and gasoline prices are relatively high coupled with low electricity prices

Source: AAA, Your Driving Costs 2009; U.S. Department of Energy – Battery and Electric Energy Report Monterey County – The Herald; Fisker Automotive; Tesla Motors; BMW; Hyundai Motors; Audi; Mercedes; Consumer Guide Auto – Tesla Model S 2012 Prices

EV & PHEV 4-Door Sedan Costs-Per-Mile

Fisker & Tesla Models Compared to Representative ICE

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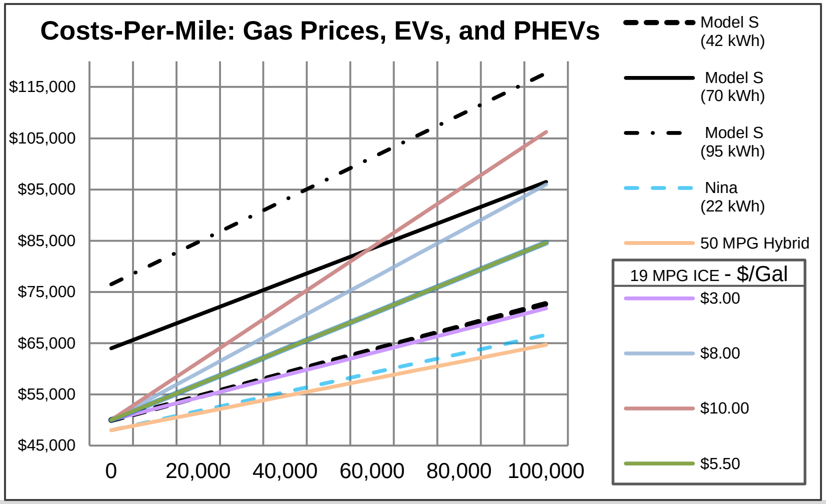
High Performance $50,000 PHEV (19 MPG) & EV Costs Per Mile



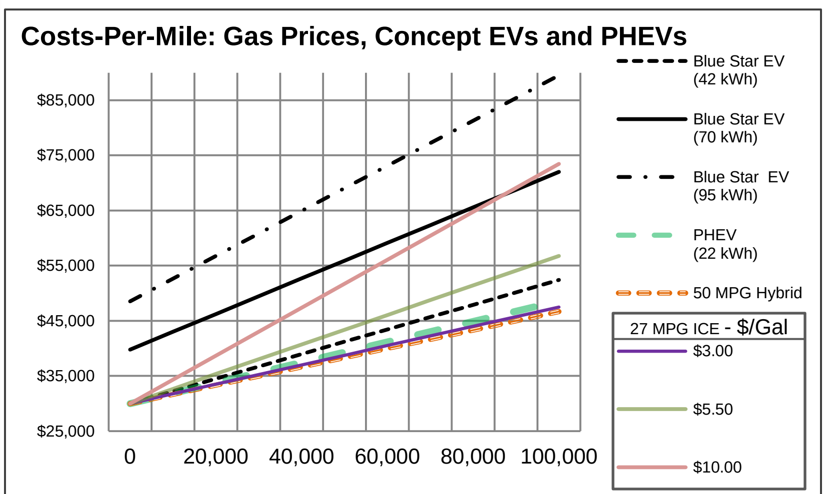
●Representative Full-Size 19 MPG ICE Model

- A 160-Mile Range EV Near as economical as a 27 MPG at U.S. $3/gal gasoline prices, but not as economical as a 50 MPG ICE Sedan at $5.33 Gal (4th Qtr 2009 Korea Prices)
- A PHEV is as almost as economical as a hybrid and more economical than a 19 MPG ICE at U.S. and Korean ($5.50/gal) gasoline prices.

●U.S. and Korea Gasoline Prices

- Full Size and 160-Mile Range EVs are presently more economical than 19 MPG ICE at Korea's average gasoline prices.
- Pure Hybrids enjoy high fuel efficiency and the best costs-per-mile. However, they compromise speed and power.

Mid-Size $30,000 PHEV (27 MPG) & EV Costs Per Mile



●Representative Mid-Size 27 MPG ICE Model

- A 160 Mile Range Mid-Size EV Near as economical as a 27 MPG ICE with $4/Gallon gasoline, and this EV is as economical as a 50 MPG ICE Sedan at $5.33 Gal (4th Qtr 2009 Korea Prices)
- A 160-Mile Range Mid-Size EV is as economical as a 27 MPG ICE with $3.00/gal gasoline and a 240-Mile range EV with $10/gal gasoline.
- PHEVs are near as economical as a 50 MPG Hybrid and $3.00/gal gasoline run ICE

●U.S. and Korea Gasoline Prices

- Full Size and 160-Mile Range Mid-Size EVs are presently more economical than 27 MPG ICE at Korea's average gasoline prices, but not more economical than one running on gasoline at U.S. prices.

Source: Korea Automobile Manufacturers Association / Korea Power Exchange Study on PHEVs in Korea / KPMG Analysis on EVs in Korea

Costs Per Mile and Modeling Battery Prices

EVs will become economical in the U.S. by 2016, and 2012 in Korea

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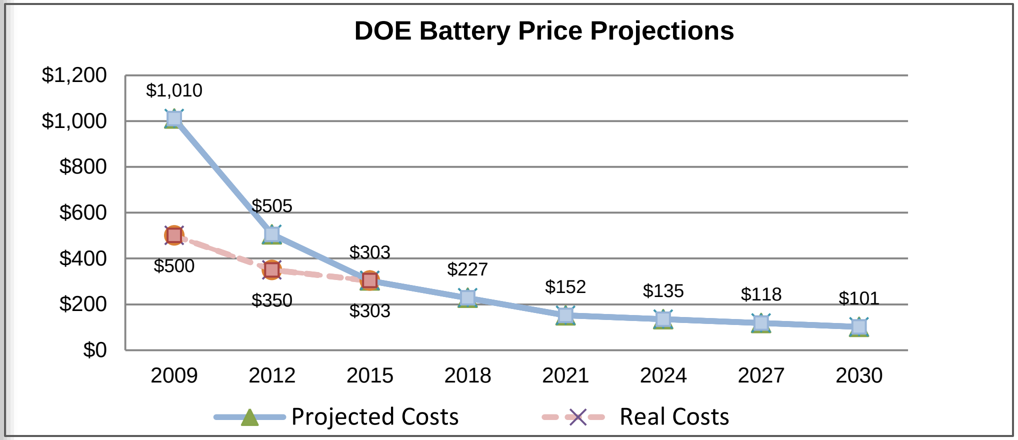
Falling Battery Price Projections and the Economics of EVs



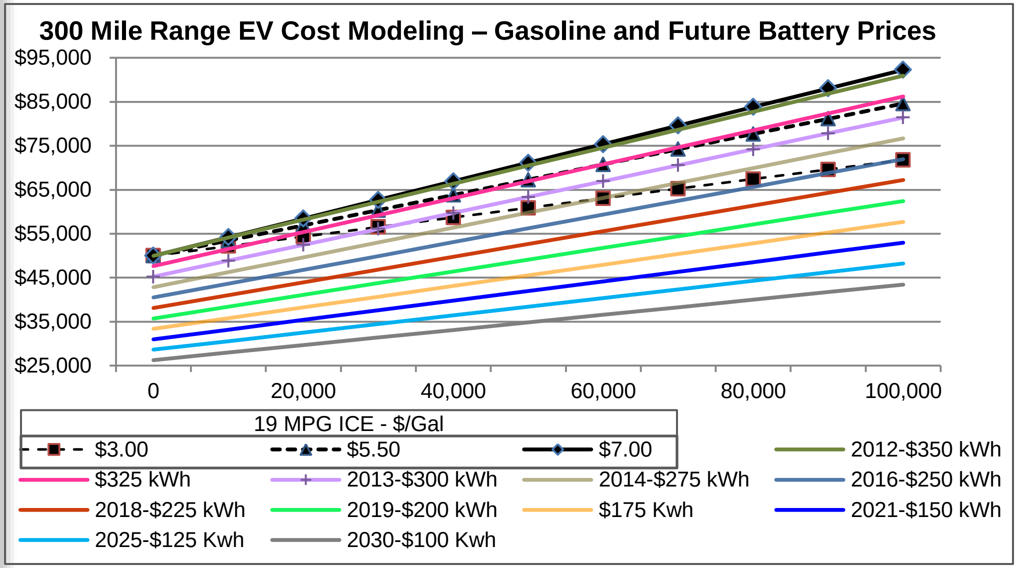
Department of Energy Projections

- Battery Prices are Falling Faster than Expected
- Innovation Disparity Between Companies
- Real Costs Reflect Disclosures in the Media

A Sample of Key Battery Players

- A123 ($500 per kWh)
- Nissan Leaf – ($375 kWh)
- Ener1
- LG Chem ($5-600 per kWh)

Modeling Various Battery Prices on Costs Per Mile



Source: U.S. Department of Energy, The Recovery Act: Transforming America's Transportation Sector

Battery Prices and 300 Mile Range EV

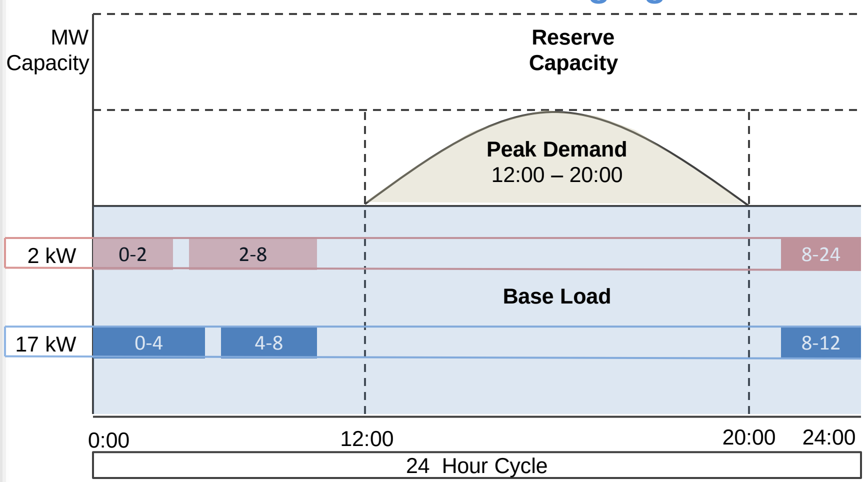
- Vehicle Base Prices were adjusted to reflect changing battery costs and cost-per-mile adjust to reflect future projected changes in per kWh battery costs (DOE Data)
- Each battery price is tagged with its projected year of production where data is available. Ex. 2018-$225 kWh
- At $3.00/gal, battery prices have to fall to $250 kWh (the year 2016) for a 300 mile range EV to become economical, and to $325 per kWh if compared to an ICE run on $5.50/gal gasoline (by 2011 or 2012)

Longer Life Cycles

- With new batteries lasting 100,000 Miles and still with 80% charge capacity, they are quickly becoming economical in terms of costs-per-mile.

Small EV Base Load Demand and Smart Grid Charging Management

Illustrative Model: Charging Times



●17 kW Charger Time

- •4 to 10 hours
- •Model Assumption – 4 hours
- •2 Charging Periods per 24 hours outside of peak period

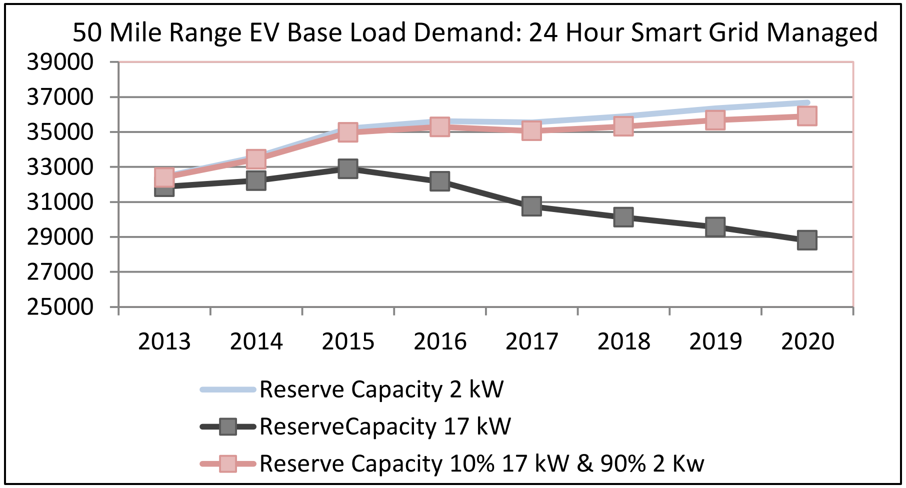
●2 kW Charger Time

- •6 – 58 hours
- •Assumption – 6 hours
- •2 Charging Periods per 24 hours outside of Peak Period

●2 kW and 17 kW Charging Scenarios

- •Time Spaced around Peak Demand Period and based on minimum charging times of a 2kW and 17kW charger

Short Range EVs Charging Managed by Smart Grid



Source: Korea 4th Power Planning Data, Tesla Motors

●50 Mile EV Charge Every 1.25 Days, 3 times day

- •2.16 million Charging Every day with only a 30 or so hour time period to manage charging demand for 2.7 million vehicles. Each Vehicle Charges every 1.25 days with a 50 mile range
- •This Model divides up charging times for a 24 hour period based on two charging speed models (mentioned above), and around peak hour period.

●Power Outage Certain if Charging uncontrolled

- •Exceeding Base Load capacity is possible without a Smart Grid.
- •Small EVs Charge More frequently due to smaller battery size, and thus pose a greater risk to exceeding peak capacity

EV Costs-Per-Mile & Changing Battery Prices

300 Mile Range Capable EVs Are the Standard

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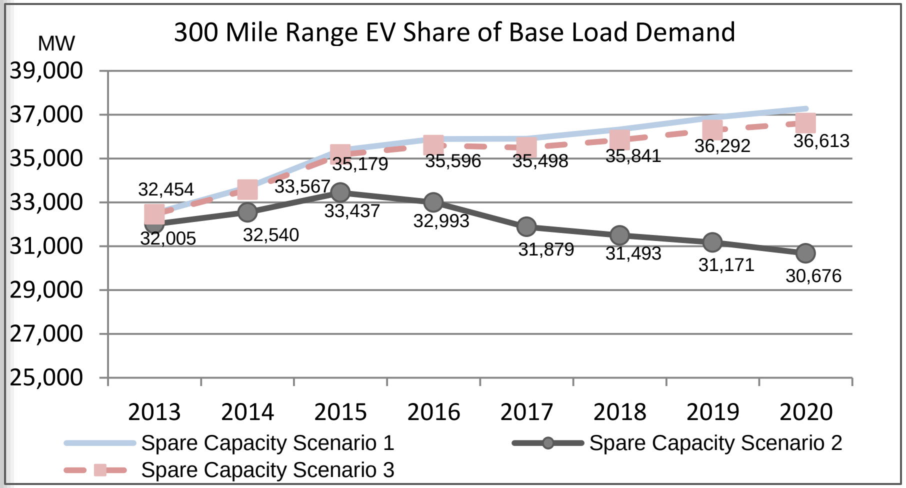
Long Range EV Charging Demand – No Smart Grid



●300 Range EV Recharges Every 6.5 Days

•Drive 40 Miles Per day:415,000 Charging every day with 156 hours to manage Charging Demand – Each Vehicle Charges every 6.5 days with a 300 mile range

●Spare Capacity Scenarios 1, 2, and 3

Scenario (1): EVs Using a 2 kw Charger

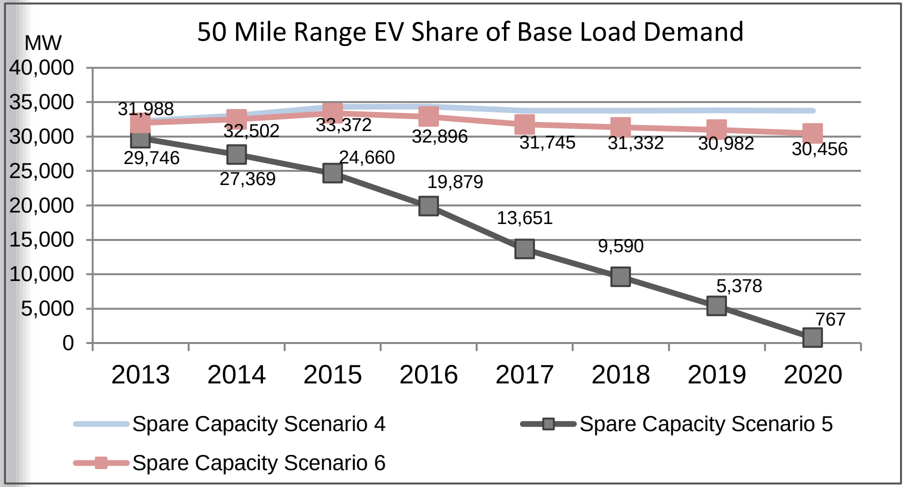
- (6 to 58 hours charge time)

Scenario (2): EVs Using a 17 kw Charger

- (4 to 10 hour charge time)

Scenario (3): 90% 2 kW and 10% 17kW Charger

Short Range EV Charging Demand– No Smart Grid



●50 Mile EV Recharge Every 1.25 Days

•2.16 million Charging Every day with only a 30 or so hour time period to manage charging demand for 2.7 million vehicles. Each Vehicle Charges every 1.25 days with a 50 mile range

●Spare Capacity Scenarios 4, 5, 6

•Same sequences as 1, 2, and 3 as listed above

●Power Outage Certain if Charging uncontrolled

•Even at Base Load, exceeding capacity is possible

Source: Korea 4th Power Planning Data, Tesla Motors

Long Range Versus Short Range Impact

Short Range EV Charging Can Result in Black Outs

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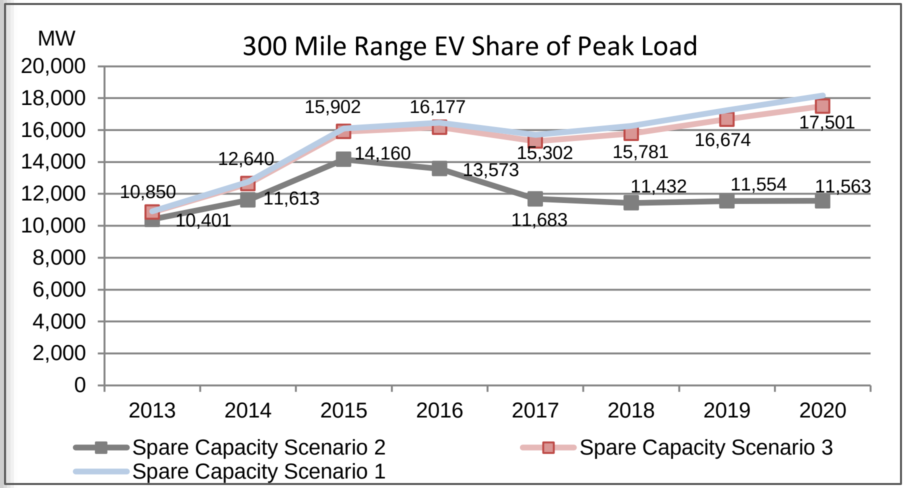
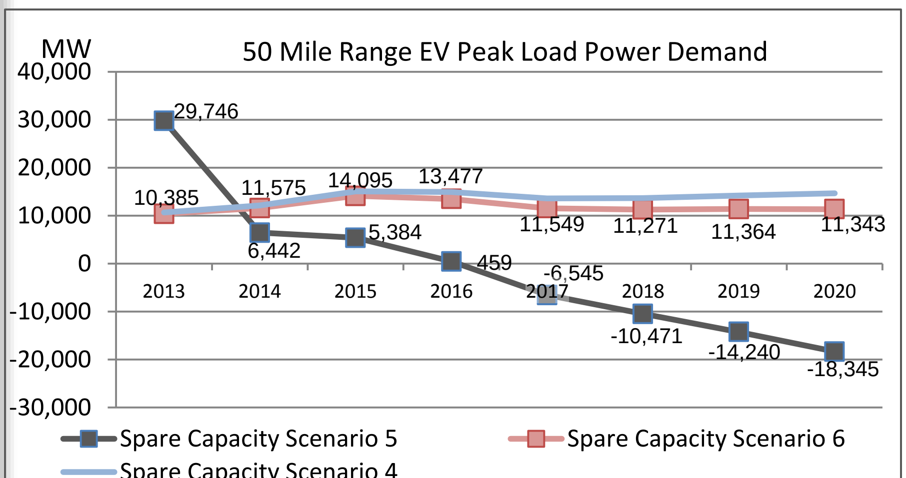
Long Range EV Charging at Peak Load – No Smart Grid



- **Longer Range, less frequent charging**
- **11,563 MW Reserve Capacity at 17 kW Charging**
- **Scenario 1, 2, and 3 Assumptions Remain the Same**

Short Range EV Charging at Peak Load – No Smart Grid



- **Shorter Range, more frequent charging**
- **18,345 MW Deficit**
  - A Westinghouse Light Water Reactor can supply 1,400 MW
  - 13 New Nuclear 1,400 MW Reactors needed to supply 2.16 million Mini EVs Charging at Peak Hour
- **Demand Management by 2020?**
  - Serious Problems Await without Demand Management , Smart Grid Infrastructure, and Policies in Place Before EVs deploy in mass

Source: Korea 4th Power Planning Data, Tesla Motors

V2G and Discharge Rates

Important, but Charging rate is more critical

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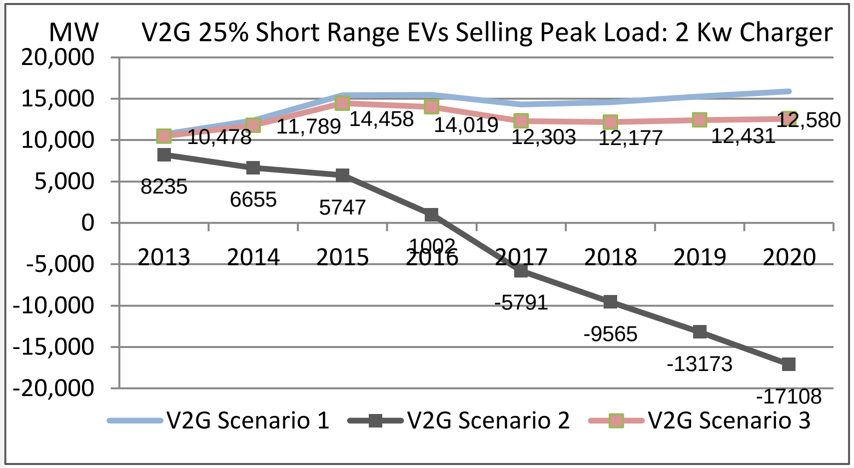
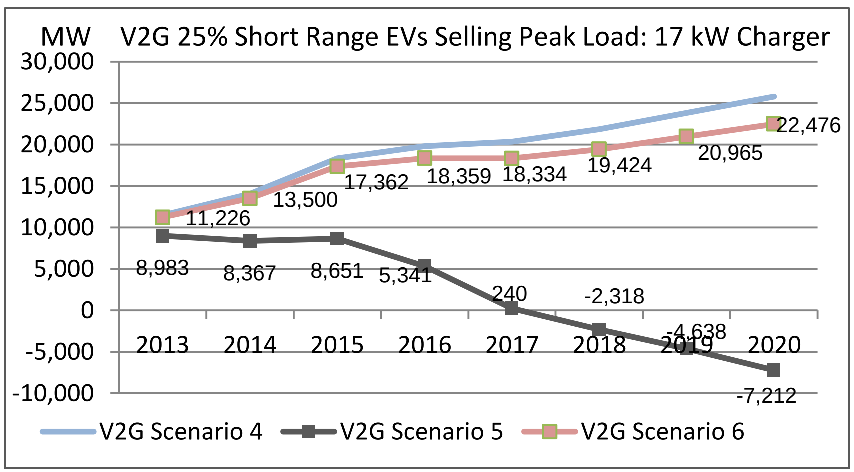
V2G: 25% Selling at Peak Hour with 2 kW Discharge – No Smart Grid



- **Smart Grid and V2G**
  - Assumes 25% Vehicles (625,000) Selling with 415,000 EVs Buying
- **Charging Speeds Remain Key**
  - If Charging 2.7 million short range EVs without peak hour demand management with a 17 kW Charger as in scenario 2, Korea would be 17,108 Megawatts short of supply in 2020
- **Discharge Speed is Equally Crucial**
  - However, rapid discharge can reduce lifecycle and increase cost-per-mile with more frequent battery replacement

V2G: 25% Selling at Peak Hour with 17 kW Discharge – No Smart Grid



Source: Korea 4th Power Planning Data, Tesla Motors

- **Smart Grid and V2G**
  - Assumes 25% Vehicles Selling with 2.16 million EVs Buying at a given moment in time
  - Scenarios remain the same
- **Faster Discharge Helpful, but Not as Important as Charging Speed**
  - 5 Nuclear Reactors Short of Demand at Peak Hour if with 166,000 Vehicles Charging with a Stage 2 17kW Charger (Scenario 5)
  - Scenarios are in same sequence as 1, 2, and 3, only relabeled as 4,5, and 6.

Short Range EVs

Difficult to Justify Battery Costs

Pose Risk to Stressing Generation Capacity even with Smart Grid managed

More Costly on Infrastructure than Long Range EVs even with Smart Grid

Long Range EVs

6.5 days in Between Charging from Larger Battery Sufficient without Smart Grid

Less Costly on Infrastructure Due to Larger Batteries and Infrequent Charging

More Profitable for the Private Sector: better incentives to innovate

Luxury EV & PHEVs will succeed in the short to mid-term

Mini and/or Economy Size EVs may fail

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Questions?