Fuel Choices Initiative 2014

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A Solution to Energy and Global Warming:

Electrification of Ground Transportation Systems Based on OLEV and SMFIR

Nam Pyo Suh

Cross Professor Emeritus, MIT

President (2006-2013), KAIST

Thank you for the invitation to speak.

How can we reduce CO_2 emission to prevent Global Warming predicted by IPCC?

- Reduce the consumption of fossil fuels such as coal, natural gas, and oil.

- How?

Two Major Sources of CO_2

- Ground transportation systems (cars, buses, etc.)
- Electric Power Plants, especially those that use coal

Solutions:

- Electrification of the Ground Transportation Systems (EGTS)

- Green electric power plants
  -- no emission of CO_2

Expected Results from EGTS

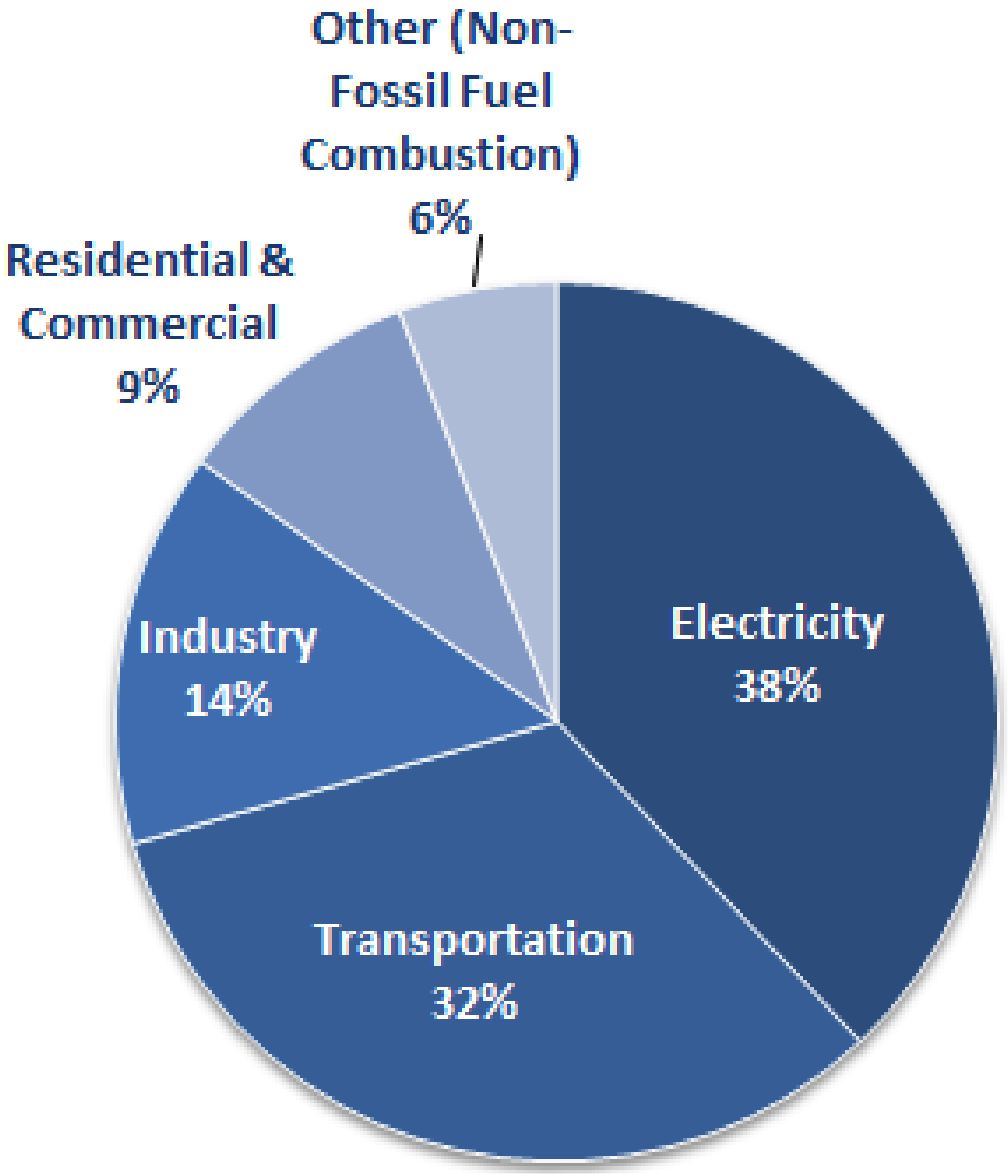
- 30% reduction in CO_2 emission
- 30 to 50% reduction in oil consumption

Current Energy Usage in Transportation

- In 2013, the worldwide usage of petroleum = 92 million barrels / day
- IC engines use ~ 70% of world's oil
- Korea's consumption of petroleum = ~2.4%
- Korea's consumption of oil for transportation = 68%
- The U.S. consumption = ~ 19%
- U.S. consumption of oil for transportation = 71%

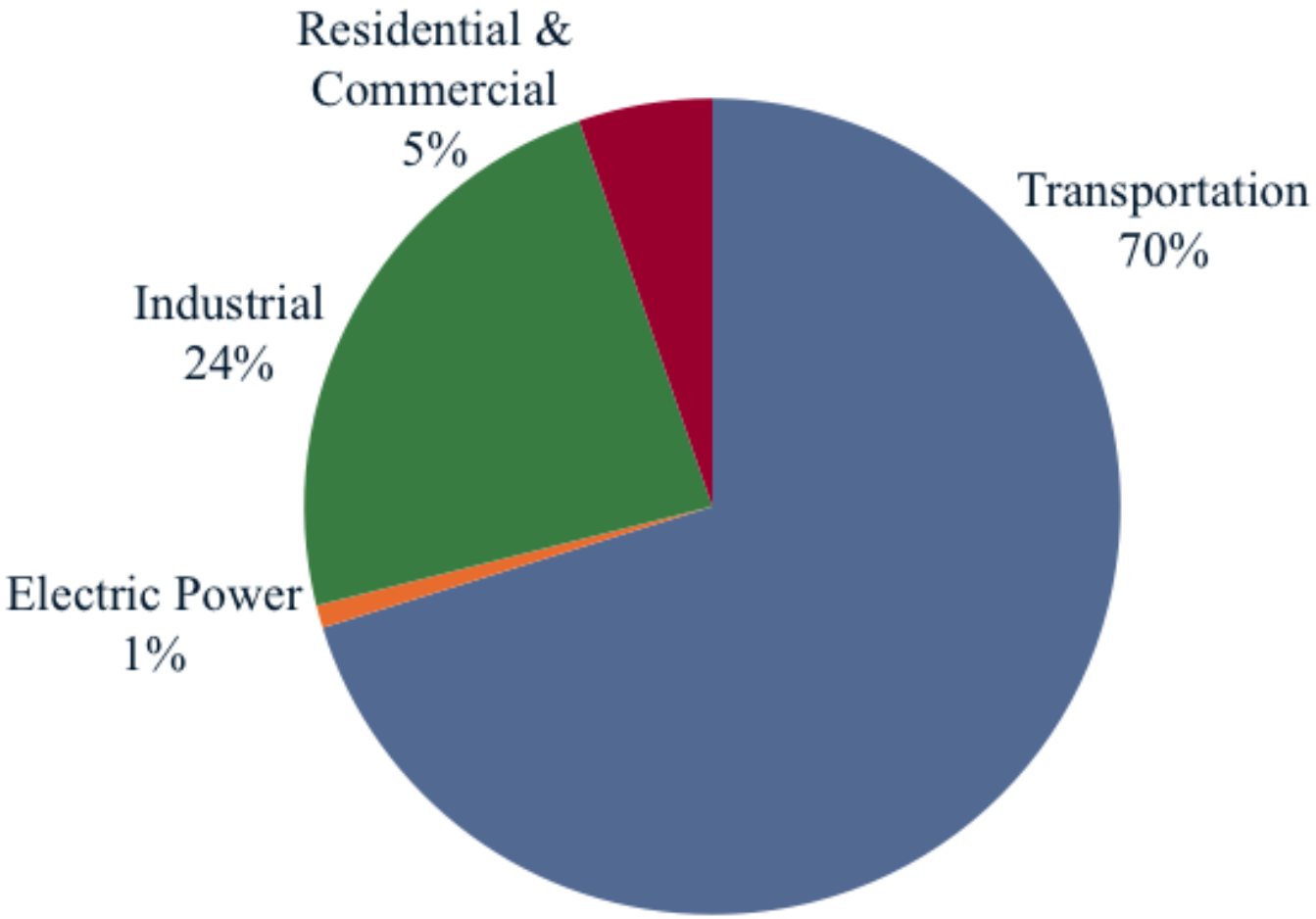
Current CO_2 Emission in the U.S.

Source: U.S. EPA(2012)

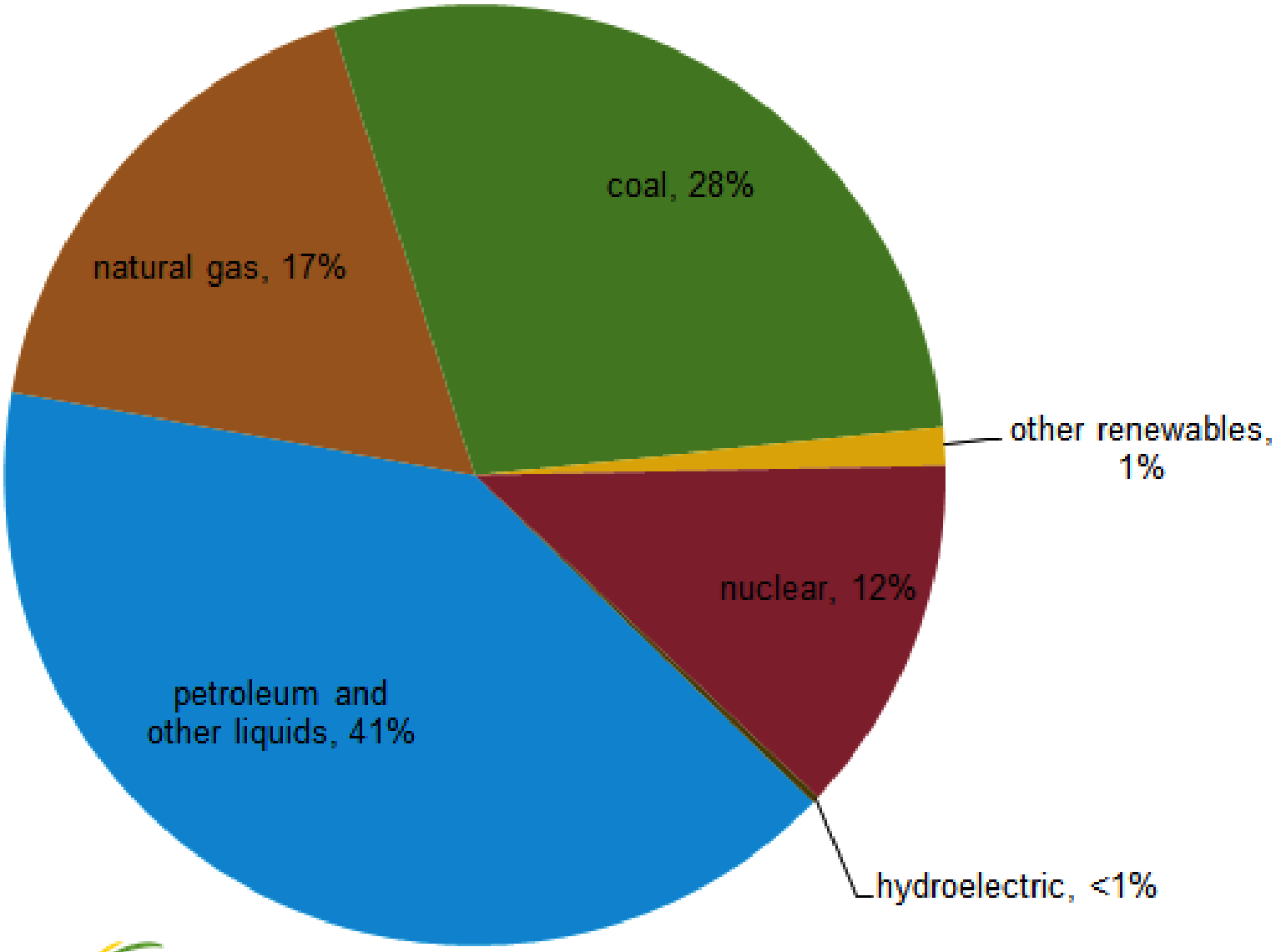


U.S. Petroleum Consumption by Sector (2010)

Source: U.S. Department of Energy, "Total Energy: Monthly Energy Review. March 28, 2012.



South Korea total primary energy consumption by fuel type, 2012



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Source: U.S. Energy Information Administration

Two Issues in Internal Combustion (IC) Engines

- CO_2 emission

- Low fuel efficiency (well-to-wheel) of IC engines
  - In comparison to electrical motors
  - We can save 30 to 50% of oil by replacing IC engines with electric drives

Most Transportation Systems Use IC Engines!

- IC engine is the primary power plant in automobiles
- IC engines have low “well-to-wheel” efficiency: 17 to 20%.
- 62% chemical energy lost in IC engines.
- 32% of CO_2 emission is due to IC engines.
- 25% of energy is exhausted as high temperature gas in IC engines.

Shortcomings of All Battery-Powered Electric Vehicles

- Use of a Large Bank of Batteries
- Expensive
- Heavy
- Bulky
- Large
- Long charging times
- Efficiencies of batteries: 80% to 90%
- Safety
- Finite supply of lithium

Our Solution:
On-Line Electric Vehicle (OLEV)

- Wireless supply of electric power to moving vehicle from underground power supply system
- Small battery on board for autonomous mobility on roads without the underground power supply
- Only 5 to 20% of the roadways need to have the underground power supply system
- Cheaper than diesel or natural gas buses (much lower operating cost)

Basic Technologies

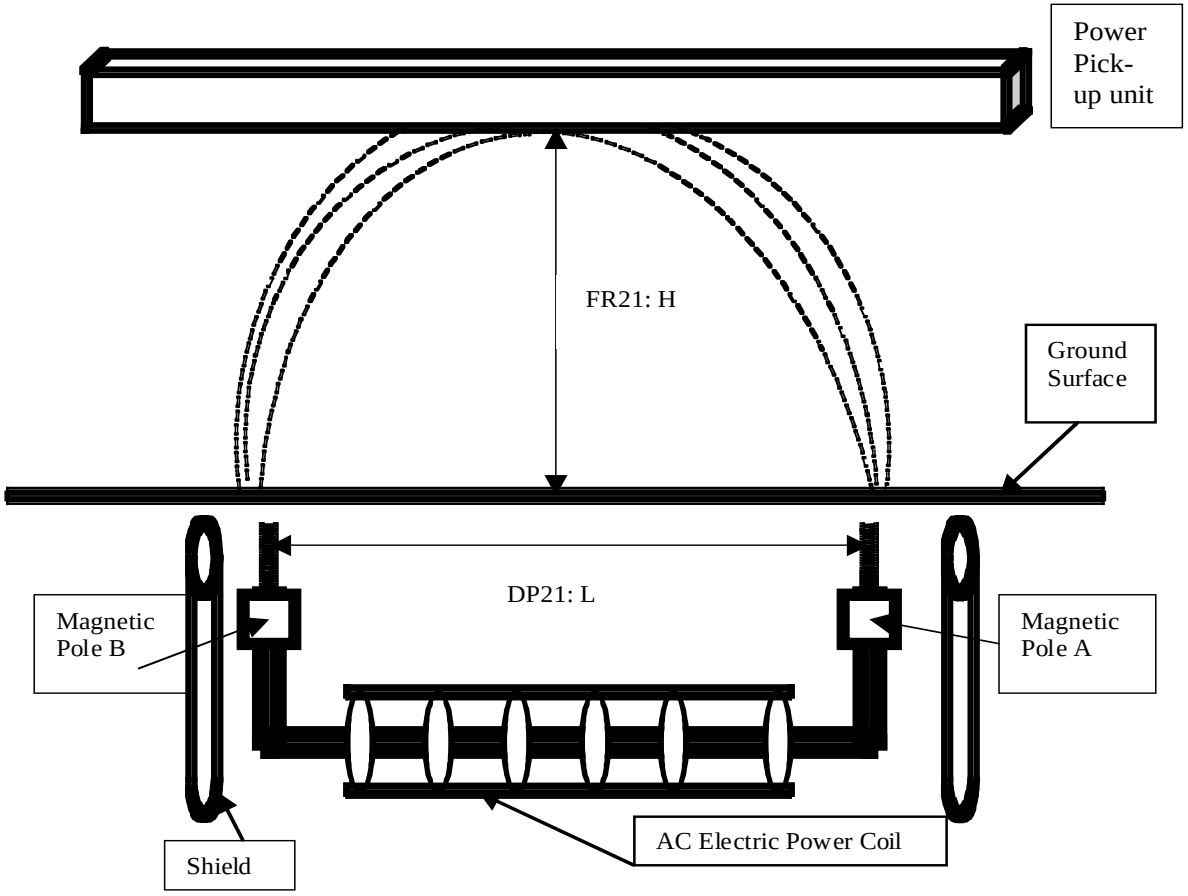
- SMFIR (Shaped Magnetic Field in Resonance)
  - Wireless transmission of electric power from underground power supply station to the electric vehicle

- OLEV (On-Line Electric Vehicle)
  - EV that propels with the electric power received from the underground power supply wirelessly while in motion or stationary

Basic Wireless Power Transfer Technology

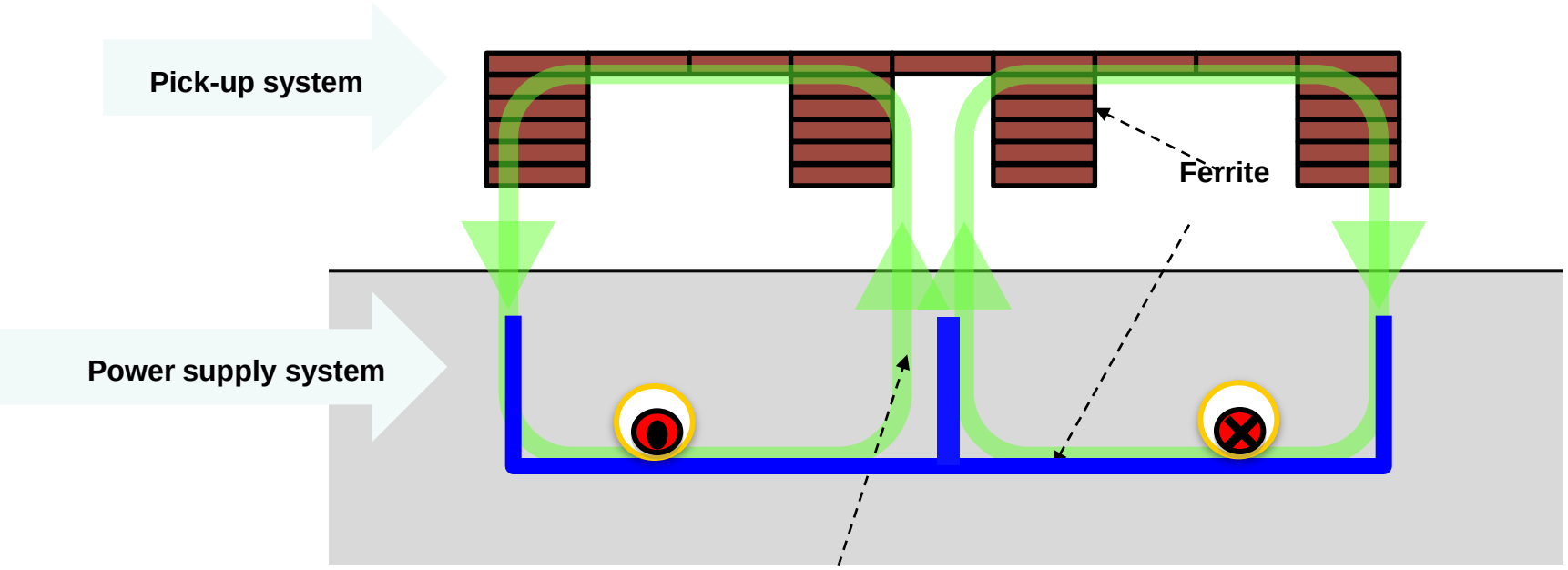
SMFIR (Shaped Magnetic Field in Resonance)

- SMFIR (Shaped Magnetic Field in Resonance)
- OLEV (On-Line Electric Vehicle)



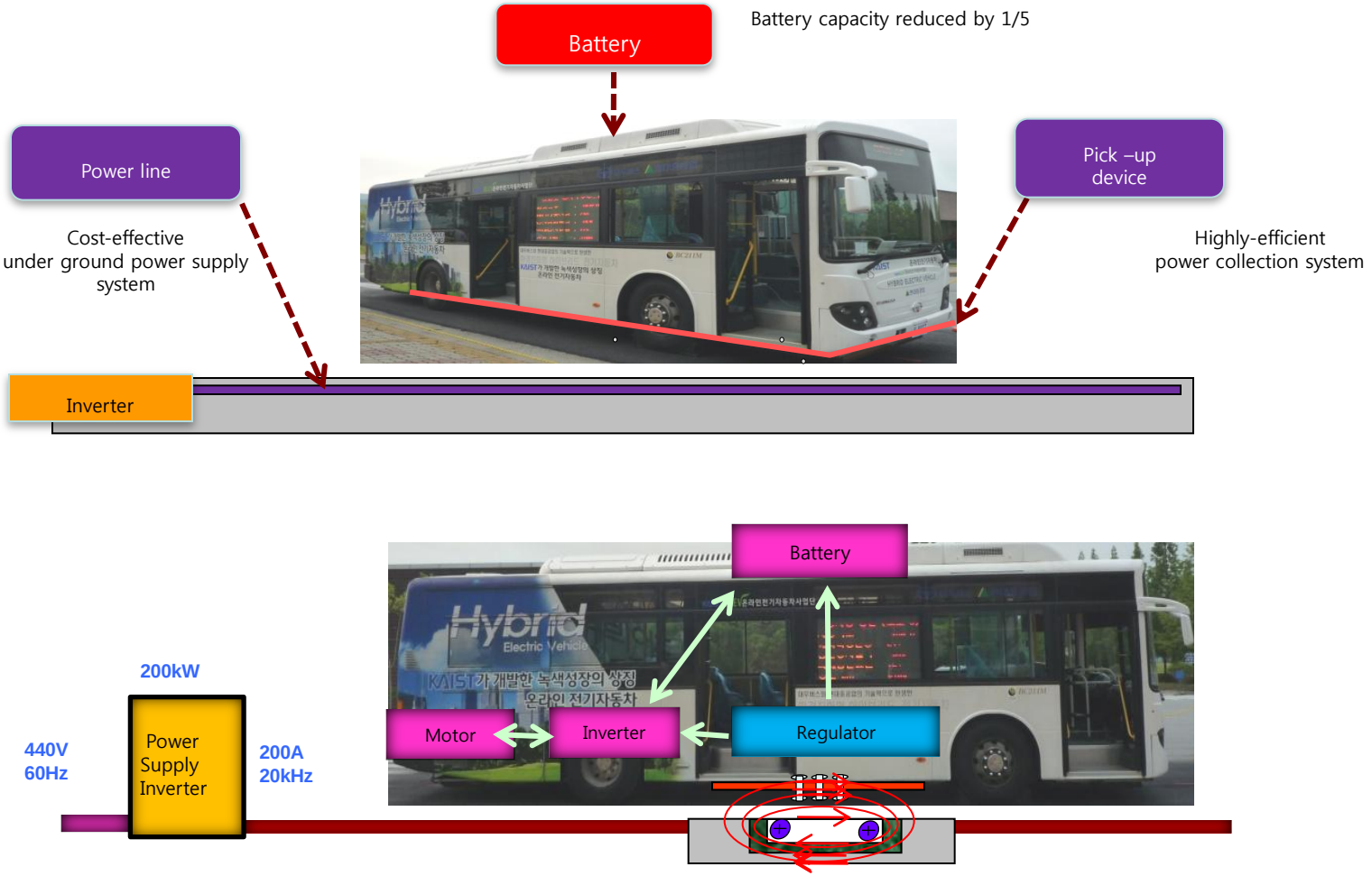
Concept & Core Technology
- Core Technology -

KAIST newly invented and developed the SMFIR technology, which enables the enough power capacity, business-competitive transmission efficiency with the sufficient air gap for power transmission while the vehicle is in operation.



Shaped Magnetic Field in Resonance

Concept of OLEV



※ KAIST is demonstrating the core technology by using both power supply system under ground and power collection system attached to bus.

Commercial Operation of OLEV in Korea since 2011

- Industrial City Gumi
- Seoul Grand Park
- KAIST campus

Operating In Gumi City, an Industrial Center in Korea

(August 6, 2013)


2013년 7월, 구미시 간선 버스노선으로 운영


HYUNDAI
버스전용차로

Electrical Drives are much more efficient than piston-type IC engines!

- Electric drives are ~ 60% more efficient than piston-type IC engines, (Rao, 2012)

- Other estimates: Electric drives are ~ 40% to 60% more efficient

OLEV was Selected as One of the 10 Emerging Technologies of the World

(World Economic Forum of Davos, 2013)

- In Korea
  - Installed in Gumi City, one of the major industrial city
  - Seoul Grand Park
  - KAIST Campus
  - World Expo (2012)
- In the U.S.
  - Negotiating with a number of cities, airport, campus
  - Needs more activities
- In Europe and Other Asian Countries
  - No major activities

Electric Drive vs IC Engines

- Energy conversion efficiency of electric power plants: 40% (coal), up to 60% (combined cycle)
- Efficiency of electric motors: >90%
- Electric power transmission line loss: about 8%
- SMFIR loss: 20%
- Well-to-wheel efficiency of EV: 27%
- **Well-to-wheel efficiency of electric drives is 35% to 50% greater than vehicles with IC engines**
- [Rao's estimation: 60% greater than IC engines]

Electricity Cost vs CNG Cost (Gumi City)

(Source: Professor D. H. Cho of KAIST)

- **35 km round trip**
- CNG cost = $20.58 per run
- Electricity cost = $3.92 per run

- **10-year Fuel Cost**
- CNG cost = $4.5 million
- Electricity cost = $860,000

Projected Cost of 10-Year Operation of Buses in Gumi

(Source: Professor D. H. Cho of KAIST) (in $1,000.00; 35 km/run)

Note: The cost OLEV buses are high due to low initial production volume.

	EGTS with Gov.Subs.	CNG with Gov.Subs	EGTS w/o Gov.Subs.	CNG w/o Gov.Subs.
Bus (6 buses)	$ 900	$ 600	$2,700	$1,200
Energy cost (10 round trips/day/bus)	$860	$4,500	$ 860	$4,500
Charging infrastructure	$ 900		$ 900	
Carbon tax		$ 401		$ 401
Total Cost	$2,660 (5,060) inc bat cost	$5,501	$4,460	$6,101

Summary

- EGTS will reduce the overall consumption of energy.
- EGTS will clean up the environment.
- EGTS will bring in a new era of technology innovation.
- EGTS will spur economic growth.
- Our posterity will live in a cleaner environment.

Thank you.