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Electric Vehicles Charged Forward

Meeting Our Future Energy Needs: What Role Will Renewables and Energy Efficiency Play?

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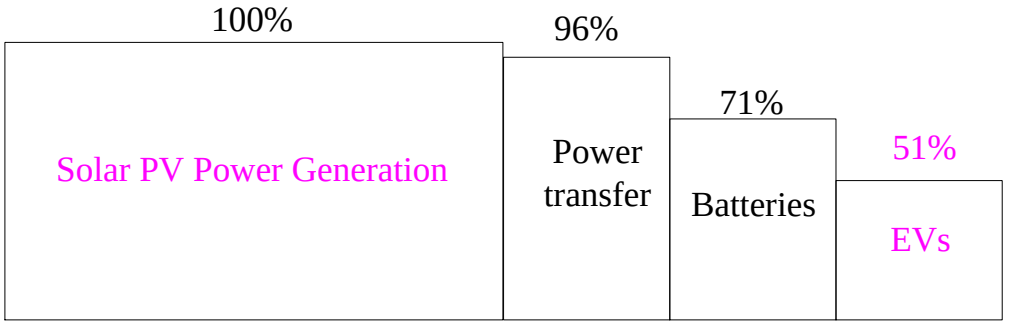
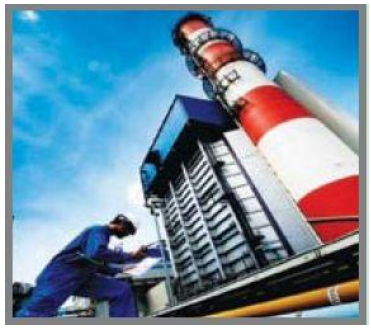
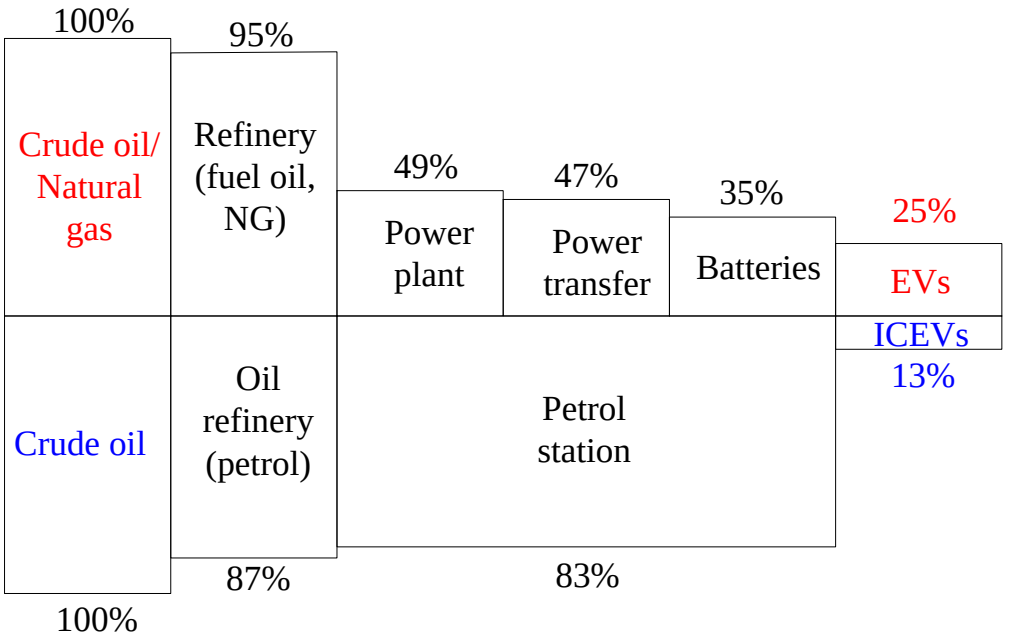
Agenda

- Introduction to EV and Plug-in HEV Technologies
  - What role will EVs play?
- Introduction to global EV Deployment and Policy Progress
- Development roadmap for EV commercialization
- Conclusions

What Role Will EVs Play?





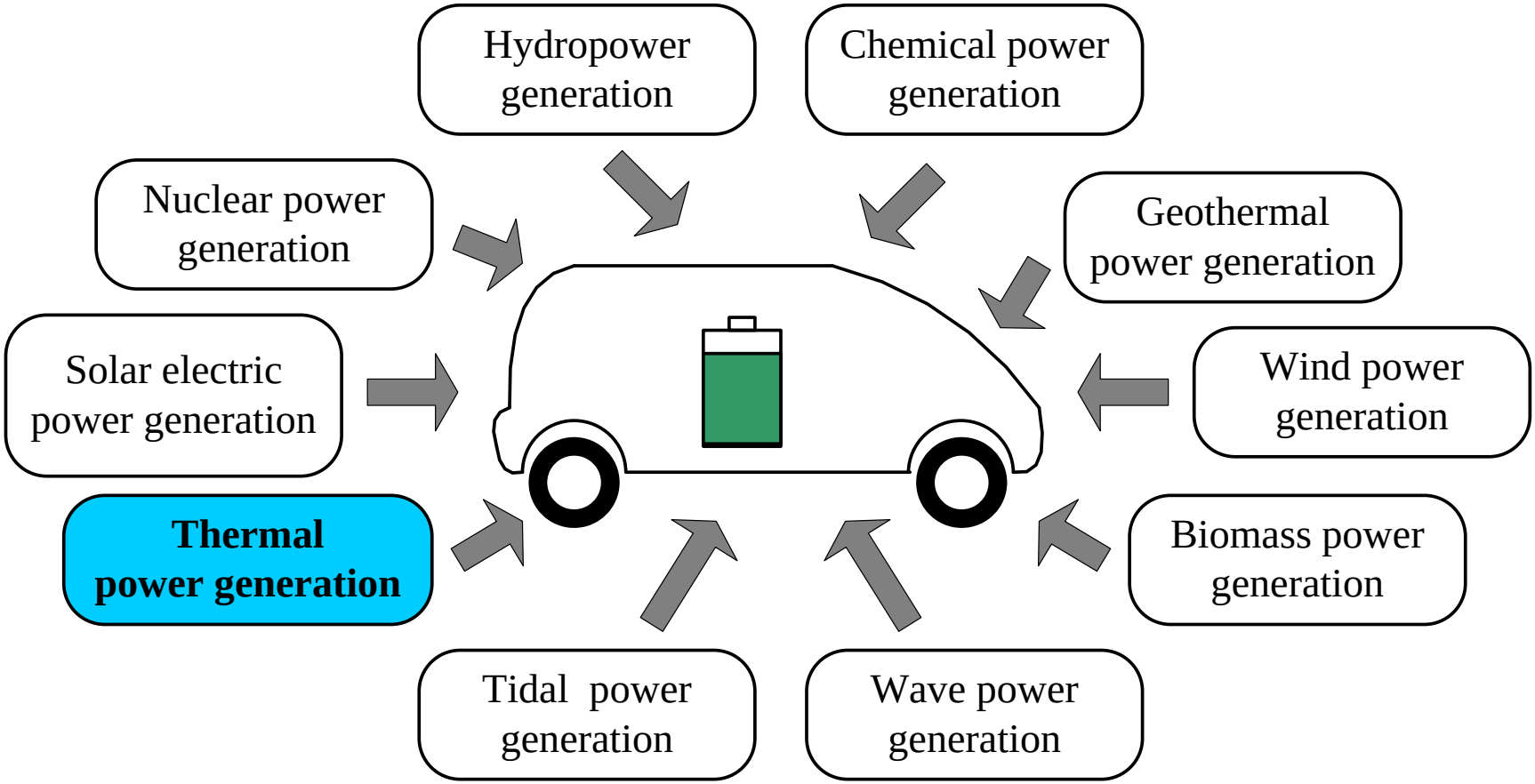


- EVs make land transport more energy efficient.
- Renewables make EVs more environmentally friendly.

EVs Make Land Transport More Energy Efficient

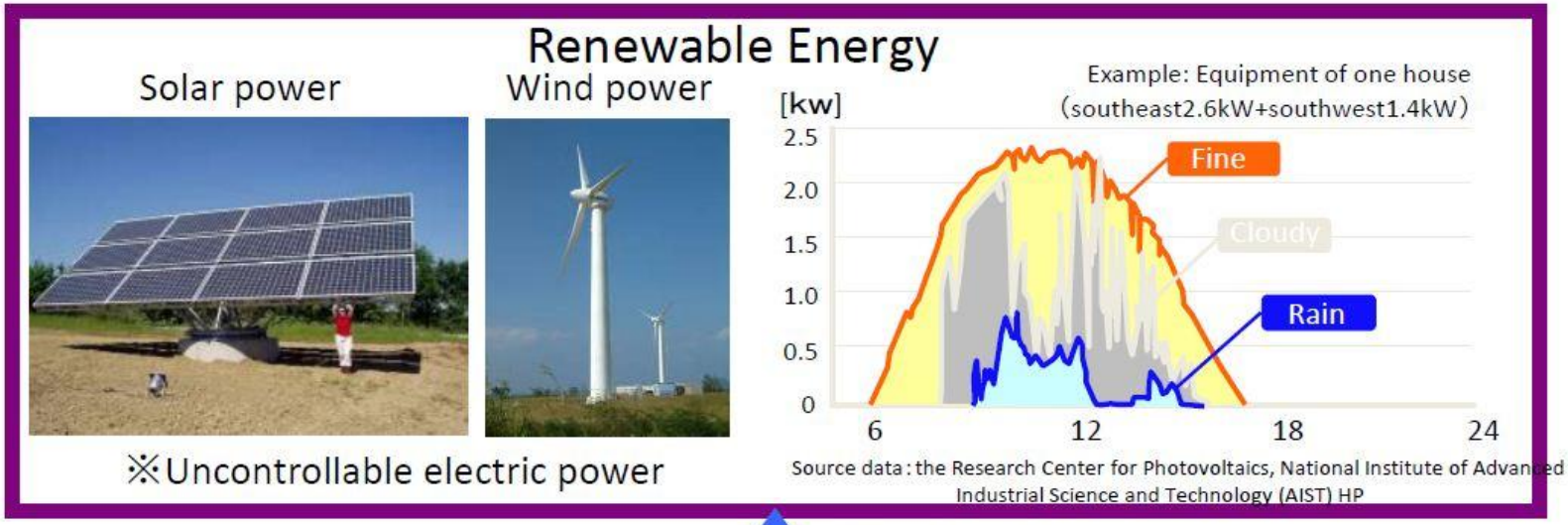
	Start-Stop	Mild Hybrid	Full Hybrid	Plug-in Hybrid	Plug-in Range Extender EV	Electric Vehicle
Functionality	• Engine start- stop at idle	• Engine off on deceleration • Mild regenerative braking • Electric power assist	• Full regenerative braking • Engine cycle optimization • Electric launch • Limited pure electric drive • Engine downsize	• Plug-in rechargeable • More electric drive during charge-depletion • Reduced refueling	• Full-function electric drive • Initial pure electric range • Significantly reduced refueling	• Plug-in recharge only • 100% pure electric range • No refueling
FUEL ECONOMY	• +2-4%	• +10-20%	• +30-50% Cars • +20-40% Trucks	• +100% in charge depletion • same as full hybrid afterward	• Electricity only in EV range • same as full hybrid afterward	• Electricity only

Renewables for EVs



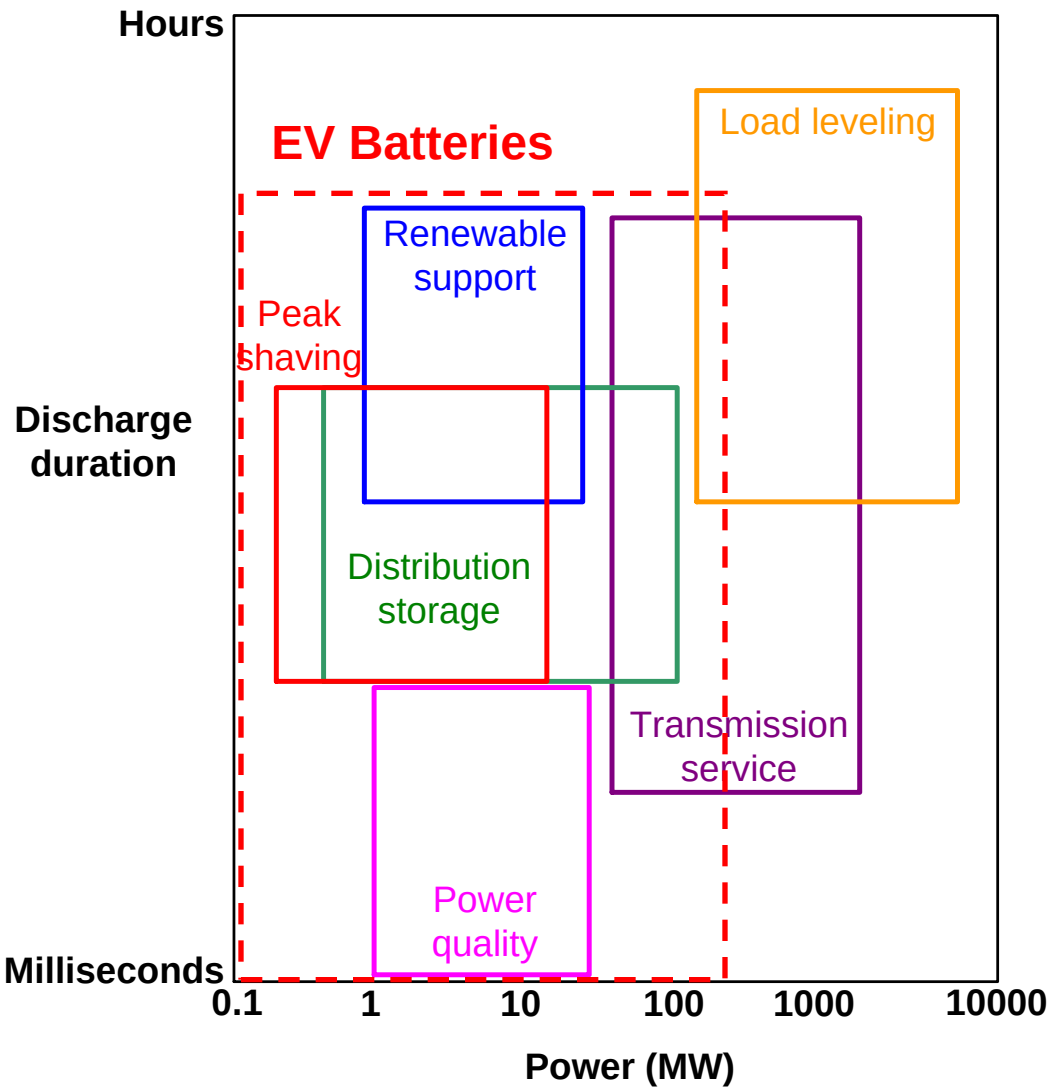
Renewables Make EVs More Environmentally Friendly

EVs Make Renewables Stable



- EV batteries are energy buffers of intermittent energy sources

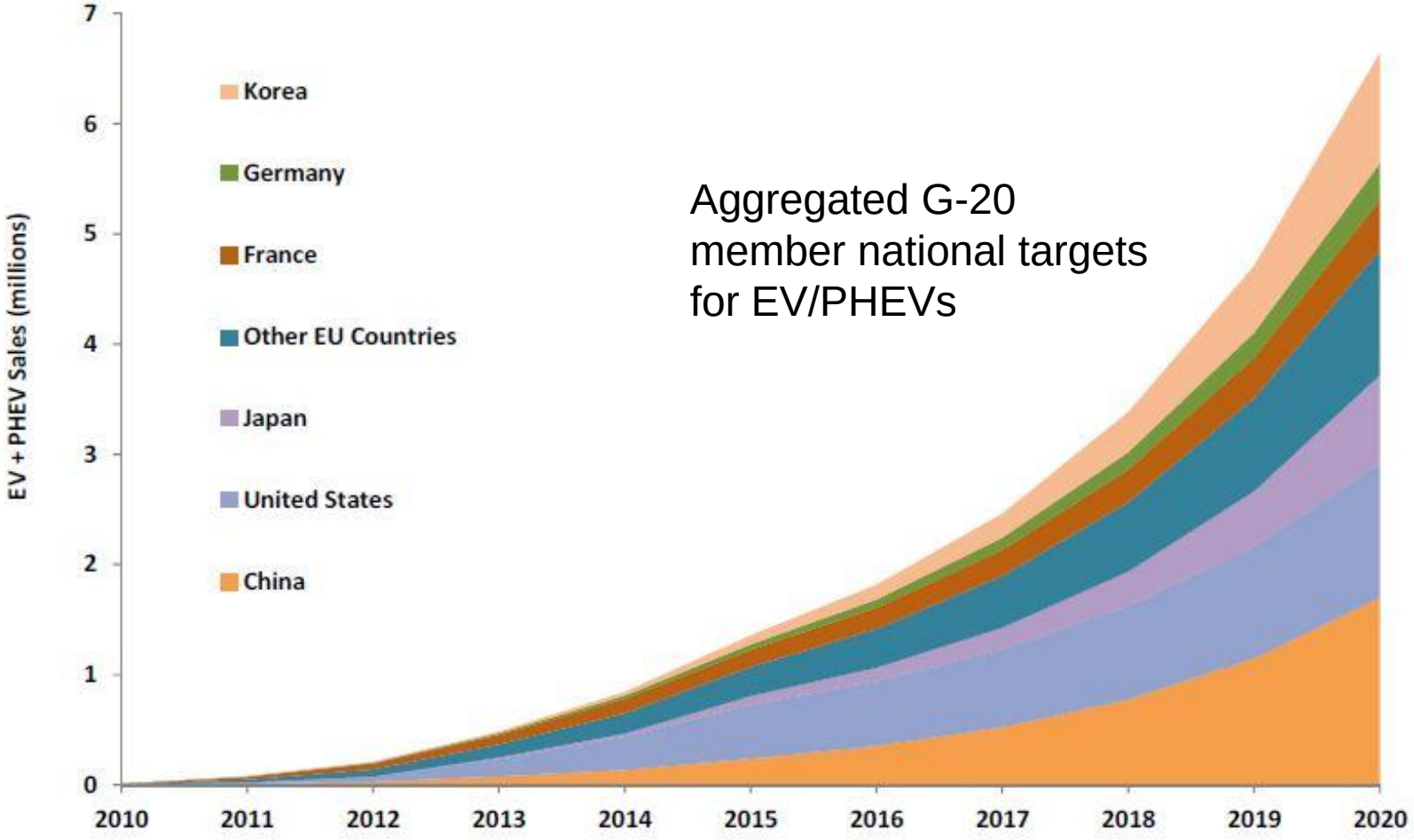
Vehicle to Grid (V2G) Applications



- keep voltage and frequency stable
- provide spinning reserves (meet sudden demands for power).
- buffer renewable power sources, by storing excess energy produced and providing it back to the grid during high load periods.

Electric Vehicles Charged Forward

- Transport accounts for about 27% of the world's final energy use and 23% of energy-related CO_2 emissions



Source: G-20 clean energy and energy efficient deployment and policy progress 2011

China's National Targets for EV/PHEVs

Electric Vehicle Sales/stock targets	Fiscal Incentives	Other targets/data
Stock target of 10 million hybrids, plug-in hybrids and EVs by 2020. About half expected to be plug-in vehicles	Maximum Yuan 60 000 (USD 9100) per vehicle in pilot cities (total 1.76 billion by 2012)	Pilot programme for electric vehicles in 5 cities.

Source: G-20 clean energy and energy efficient deployment and policy progress 2011

United States' National Targets for EV/PHEVs

Electric Vehicle Sales/stock targets	Fiscal Incentives	Other targets/data
Stock target of 1 million by 2015	USD 7 500/vehicle	American Recovery and Reinvestment Actincluded USD 2.4 billion for battery and electric drive component manufacturing,and for electric drive demonstration and infrastructure investments

Source: G-20 clean energy and energy efficient deployment and policy progress 2011

Japan's National Targets for EV/PHEVs

Electric Vehicle Sales/stock targets	Fiscal Incentives	Other targets/data
PHEV/EV sales target of 15% to 20% of total LDV sales in 2020	Incentive budget USD 300 million/year(2010)	2 million normal chargers and 5 000 quick chargers by 2020

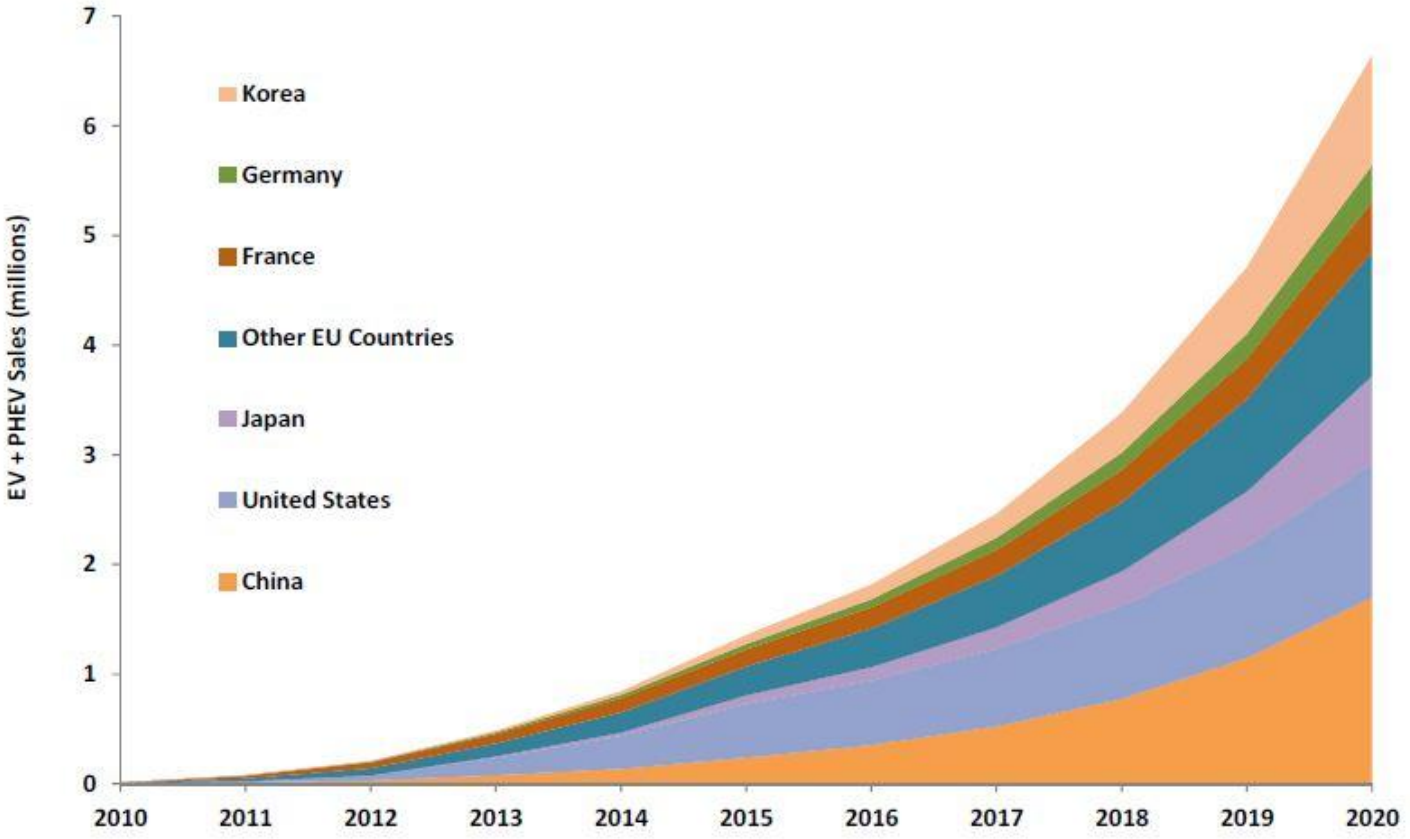
Source: G-20 clean energy and energy efficient deployment and policy progress 2011

France's National Targets for EV/PHEVs

Electric Vehicle Sales/stock targets	Fiscal Incentives	Other targets/data
Stock target of 2 million PHEVs/EVs by 2020	Incentive budget 560 million Tax credit through 2012. EUR 400 million	Government fleet commitment of 50,000 EVs

Source: G-20 clean energy and energy efficient deployment and policy progress 2011

Aggregated G-20 member national targets for EV/PHEVs



- The aggregated targets reach 7 million vehicle sales in 2020, with nearly 25 million cumulative over that period.
- It would be a positive achievement, it would still only represent about 2% of the world vehicle fleet in 2020 and account for less than 1% of electricity demand.

Challenges for EV/PHEV Commercialization

- Reduce upfront cost of EVs and PHEVs
  - Reduce battery costs
- Increase driving ranges of EVs
  - Increase battery energy density
- Build infrastructure for V2G operation
  - Prolong driving range and mitigate “range anxiety”
- Develop a commercially viable business model
  - Share costs and benefits among stakeholders

EVs on the Road

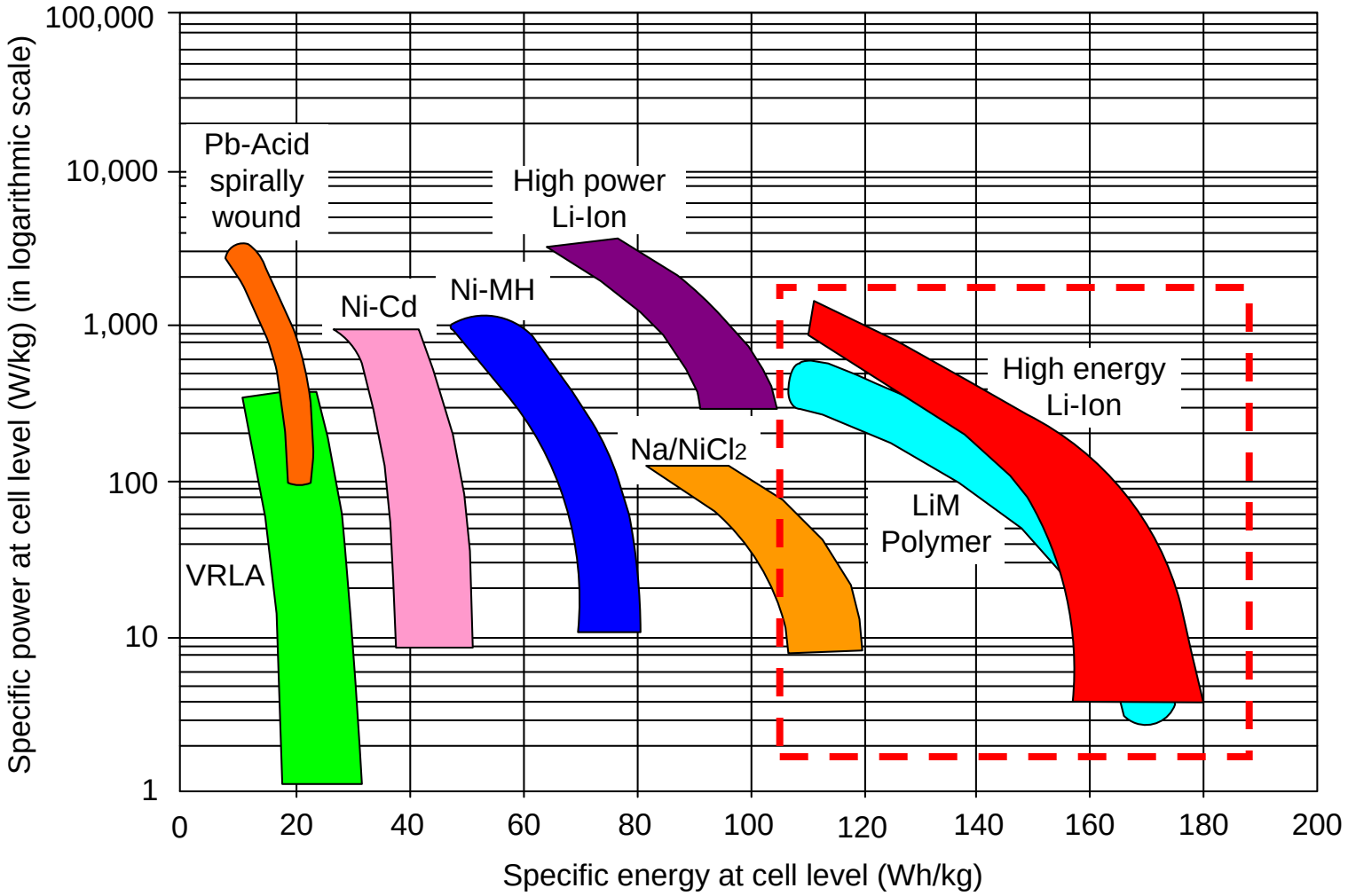
Mitsubishi Motors

Nissan

Tesla Motors

They are expensive because of the on-board battery

EV Batteries



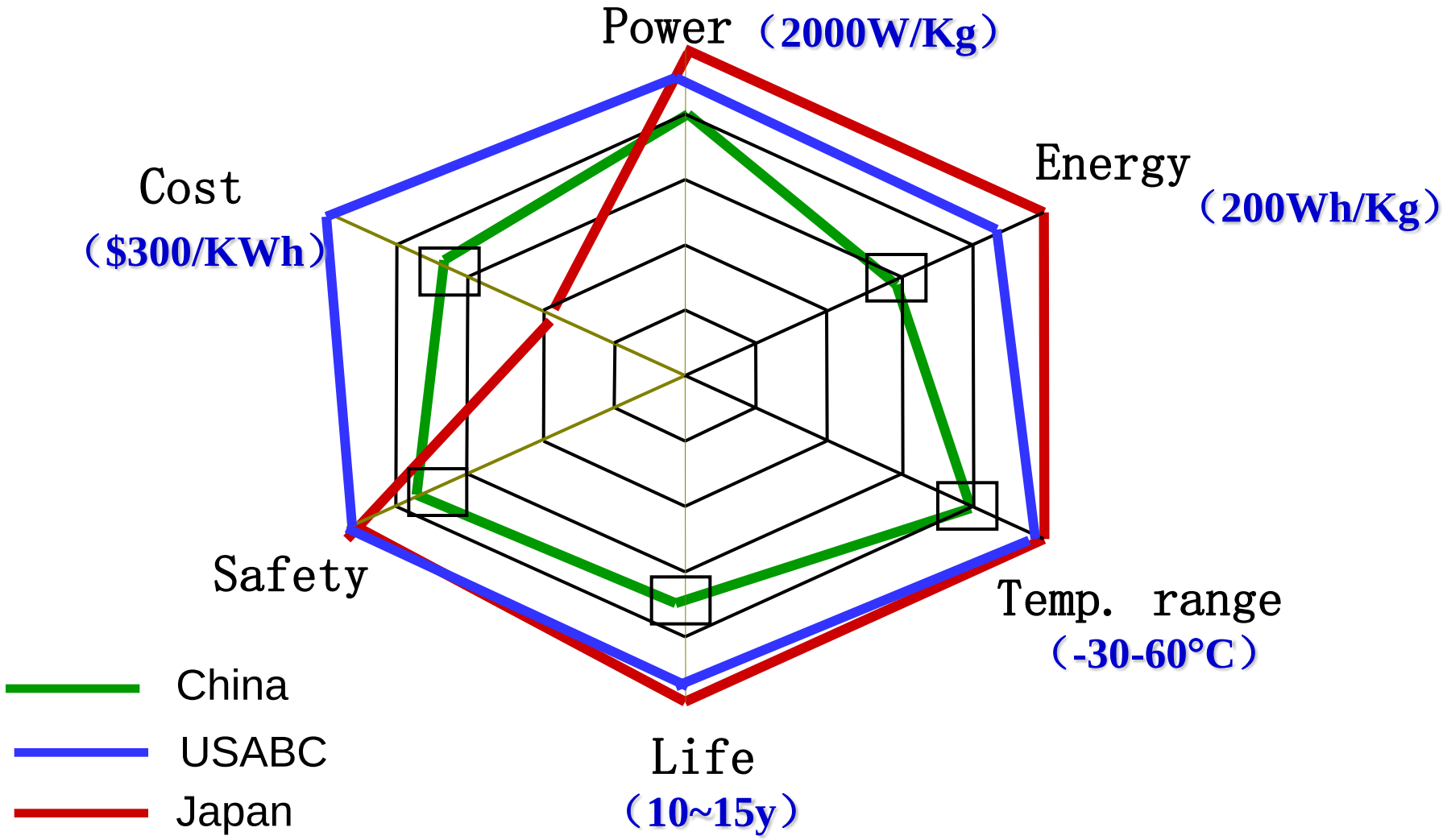
Li-Ion batteries are viable for EV applications

Lithium-ion Battery Characteristics

	Lithium cobalt oxide ($LiCoO_2$)	Nickel, cobalt and aluminum (NCA)	Nickel-manganese-cobalt (NMC)	Lithium polymer ($LiMn_2O_4$)	Lithium iron phosphate ($LiFePO_4$)
Energy Wh/kg or L	Good	Good	Good	Average	Poor
Power	Good	Good	Good	Good	Average (lower V)
Low T	Good	Good	Good	Good	Average
Calendar life	Average	Very Good (if charge at 4.0 V)	Good	Poor	Poor above 30°C
Cycle life	Average	Very good (if charge at 4.0 V)	Good	Average	Average
Safety*	Poor	Poor	Poor	Average	Good
Cost/kWh	Higher	High	High	High	High
Maturity	High	High	High	High	Low

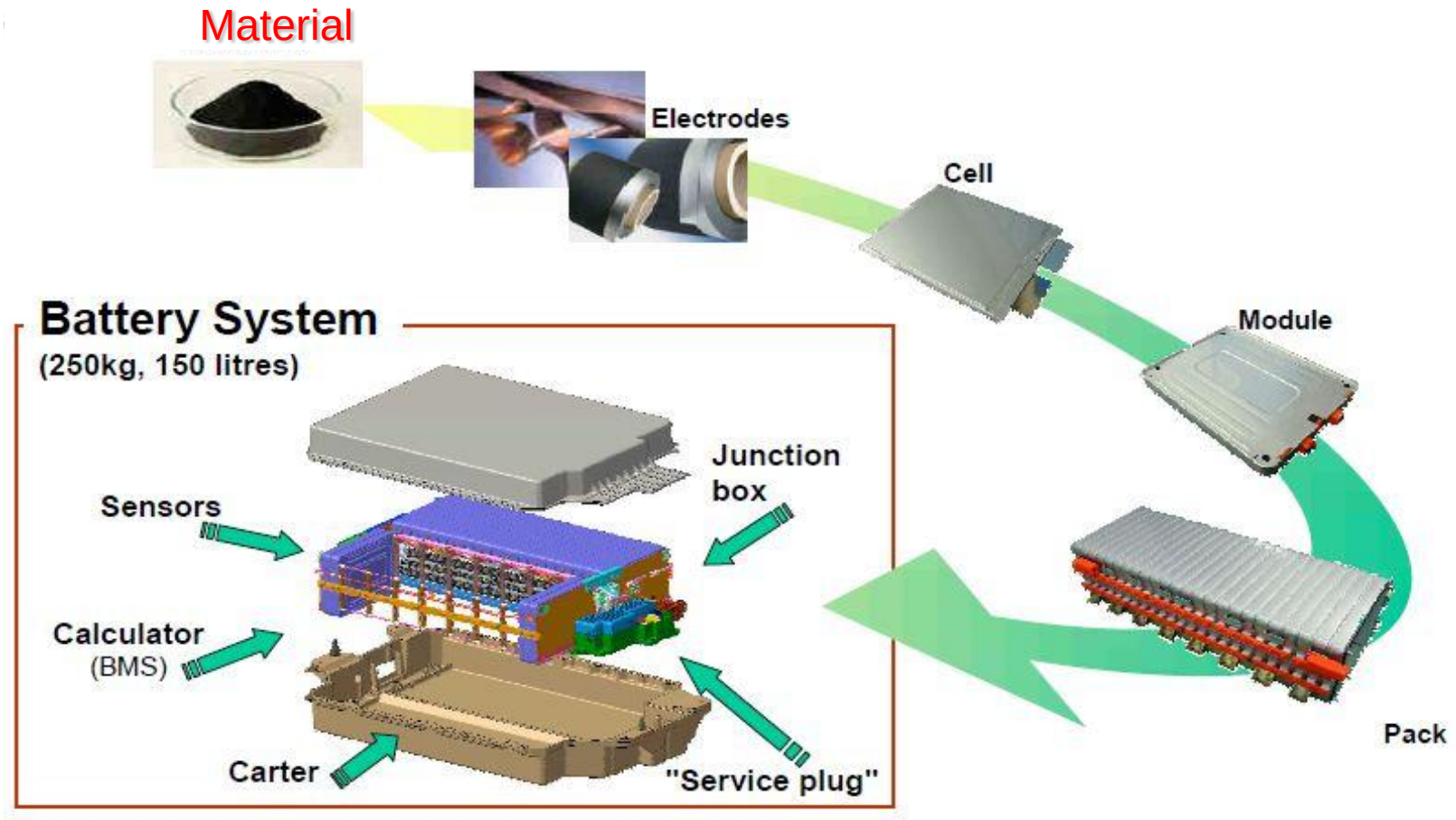
Source: IEA 2010: Technology Roadmap: Electric and plug-in hybrid electric vehicles

Reduce Upfront Cost of EVs and PHEVs



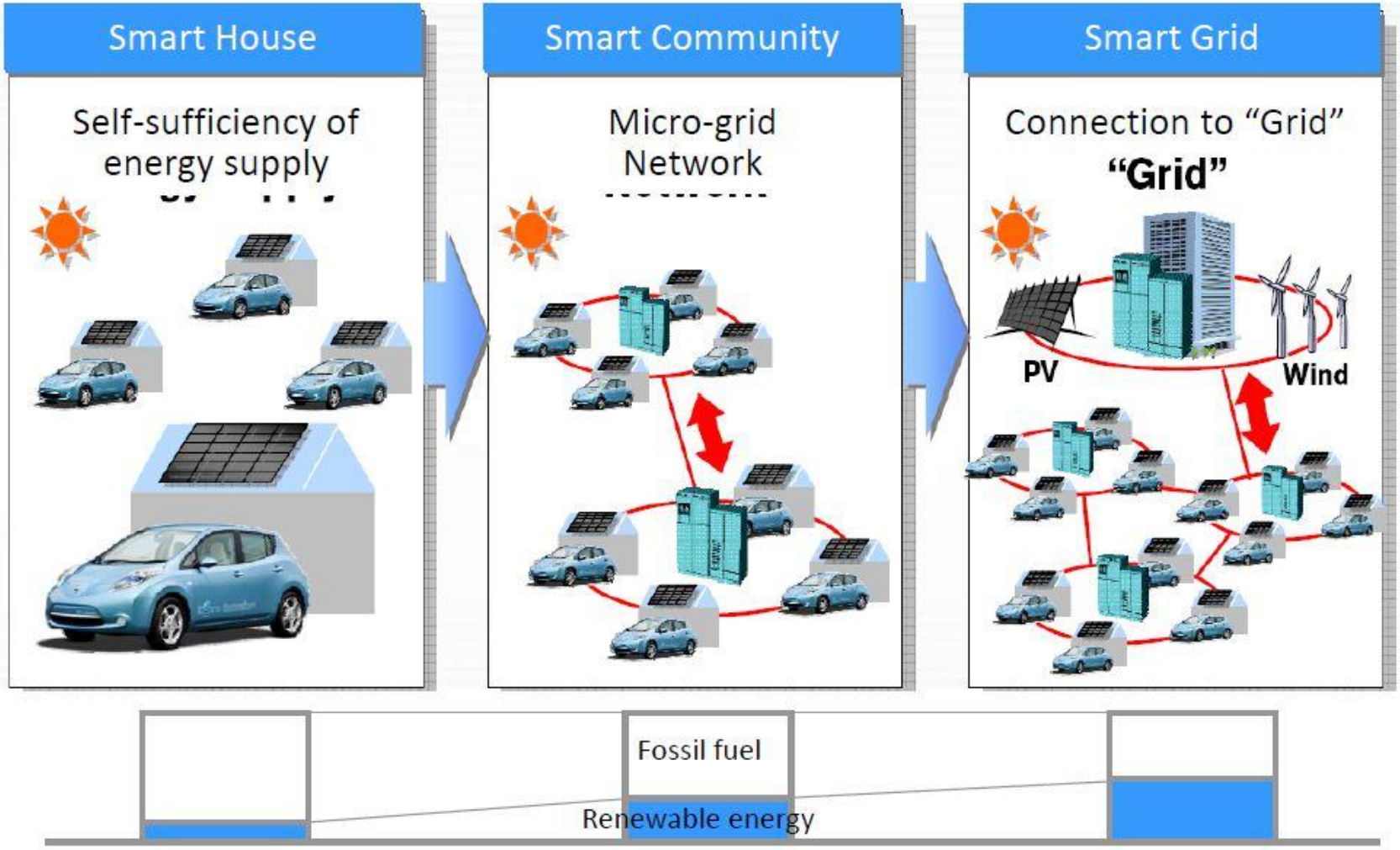
The 2010 production costs for lithium-ion battery packs in China were between USD 500-800 per kWh.

Research Roadmap

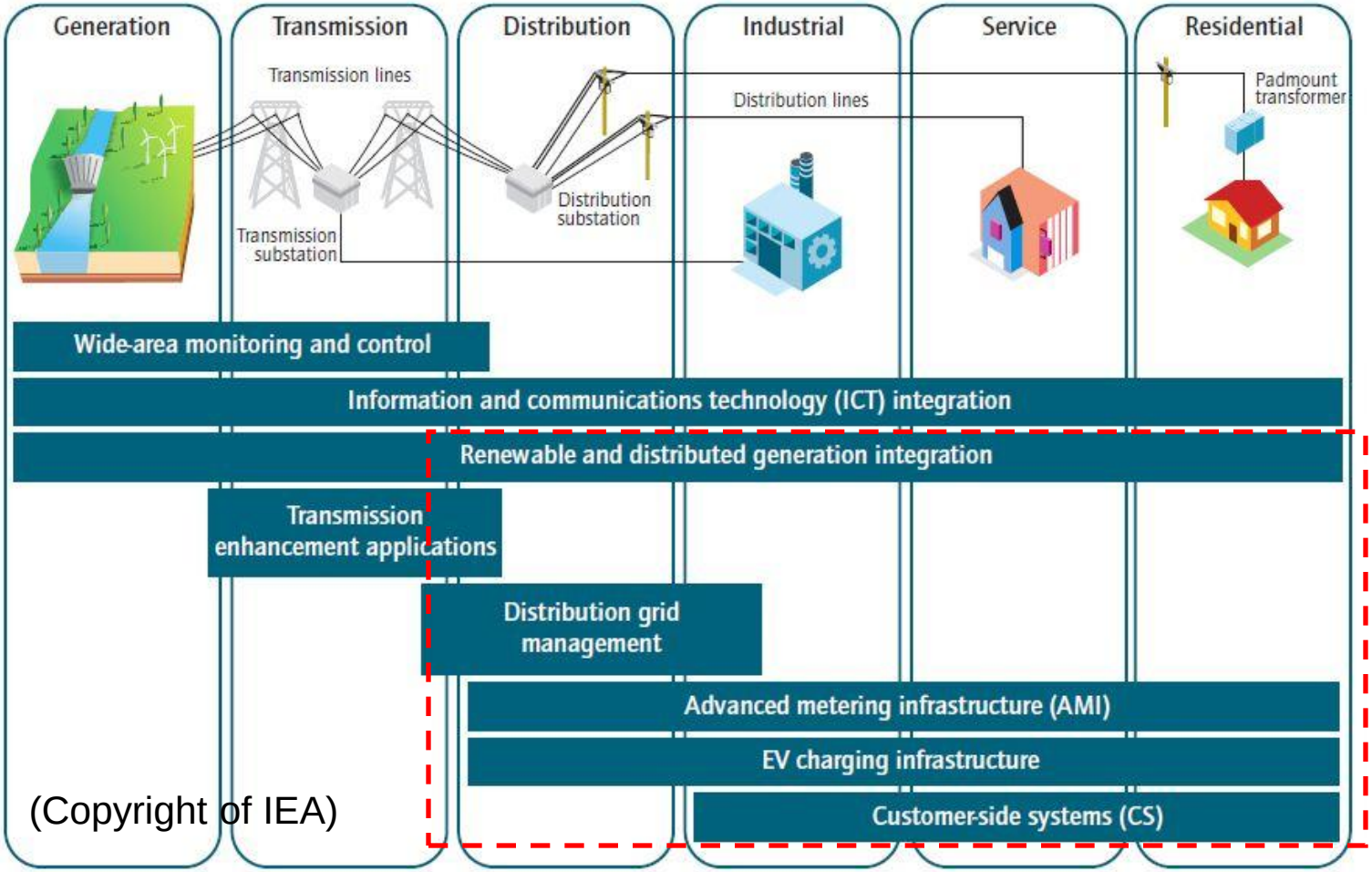


- Reduce upfront cost and increase driving range of EVs
  - Breakthrough on battery chemistry

Develop Infrastructure for V2G Operation

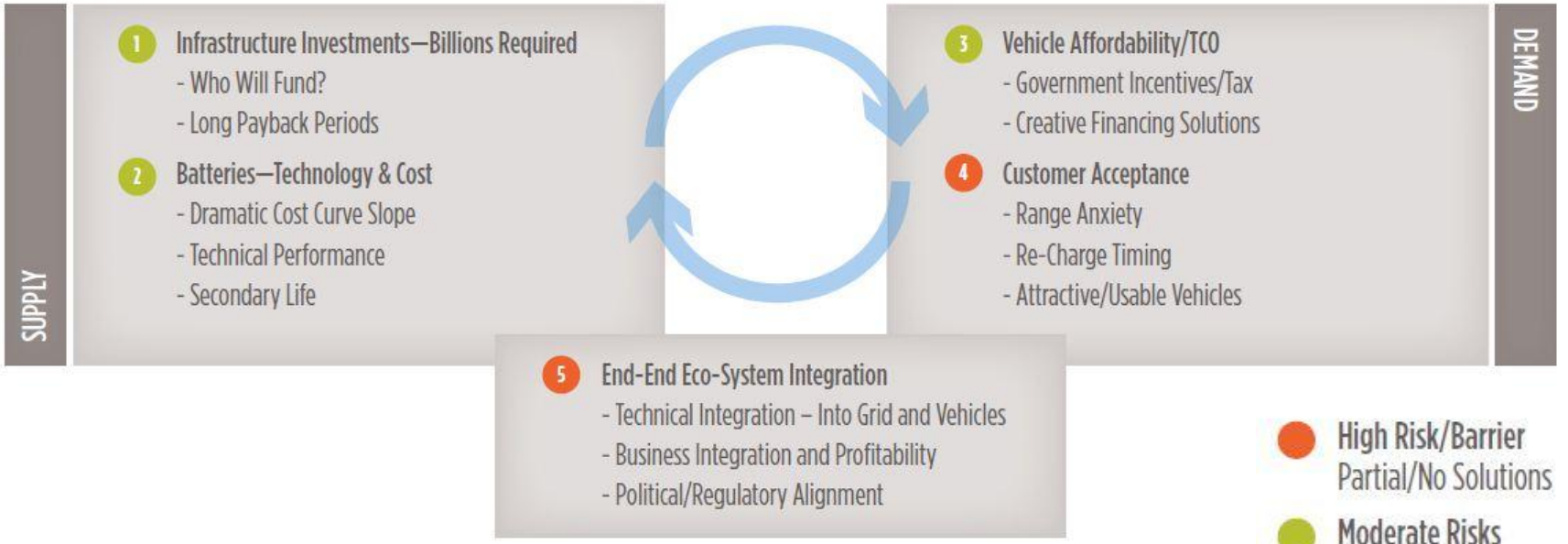


EV and Renewable Applications



- Renewables make EVs more environmentally friendly
- EVs make intermittent renewables more stable with the help of smart grids

Commercially Viable Business Model



- The industry cannot indefinitely rely on government funding.
- Develop new business models
  - share the cost of charging infrastructure, such that revenue collected from services can help off set the cost of infrastructure.

Source: World Bank 2011: The China New Energy Vehicles Program: Challenges and Opportunities

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Conclusions

- EV and Plug-in HEV Technologies
  - EVs make land transport more energy efficient
  - Renewables make EVs more environmental friendly
  - EVs can make intermittent renewables stable
- Global EV Deployment and Policy Progress
  - There has been a positive achievement
  - Battery capacities, durability should be improved
  - Sufficient charging infrastructure should be deployed
- Development Roadmap for EVs Commercilization
  - Reduce upfront cost of EVs and PHEVs
  - Increase driving ranges of EVs
  - Build infrastructure for V2G operation
  - Develop a commercially viable business model

Thank you ! Questions?