

Interplay & Synergy between Renewable Energy Resources and Electric Vehicles

March 28th 2012, Mexico

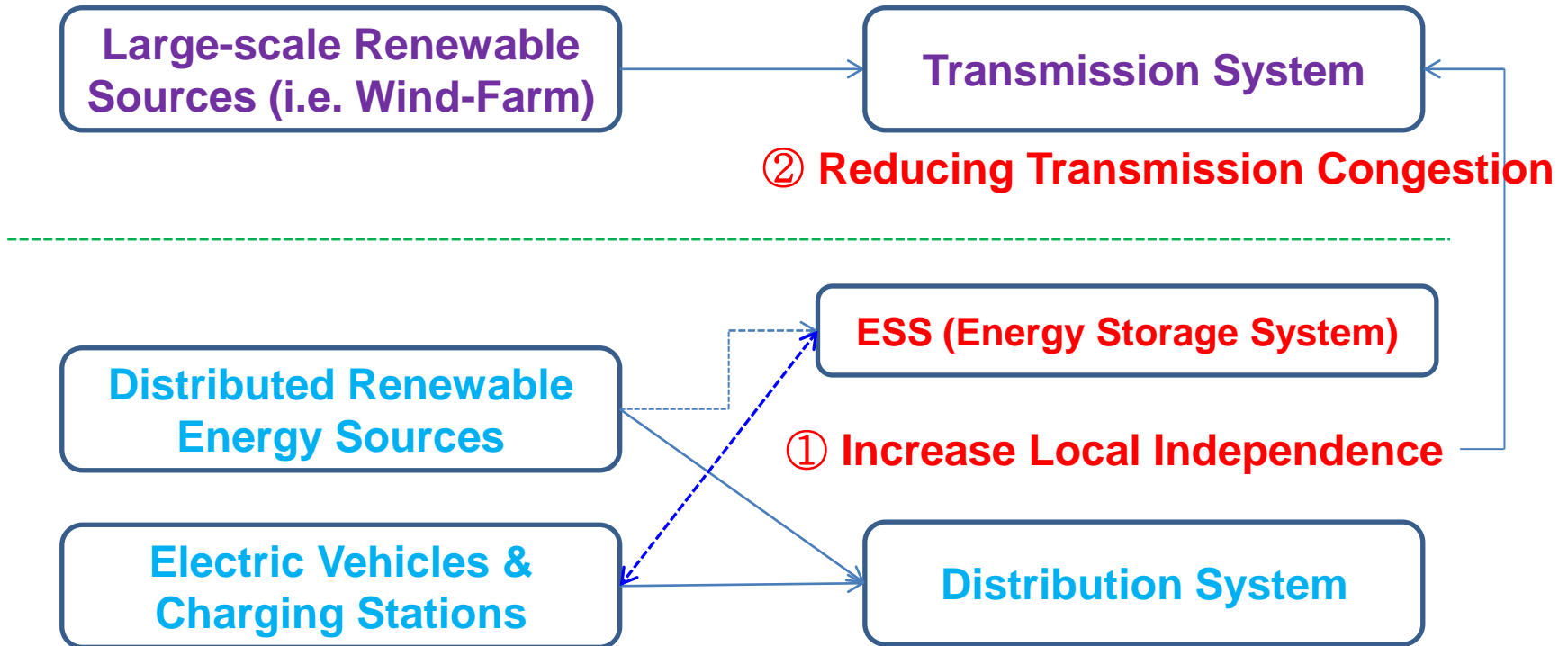


Dong-Joo Kang

Operation Issues with EVs & Renewables

Interaction between Power System and 'EVs & Renewables'

* Required to **increase transmission capacity & ESS (Energy Storage System)**



- (1) Renewable energy sources provide electricity but increase the fluctuation.
- (2) Electric vehicles could do **a Buffering Function as Energy Storage System** between renewable energy and demand variations

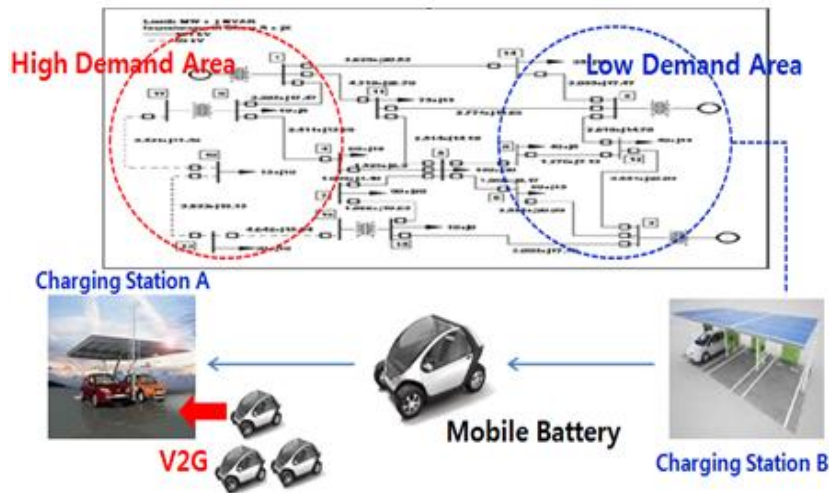
Issues on Electric Vehicles

G2V & V2G Services [1]

Increasing Geographic & Temporal Flexibilities in Power System Operation

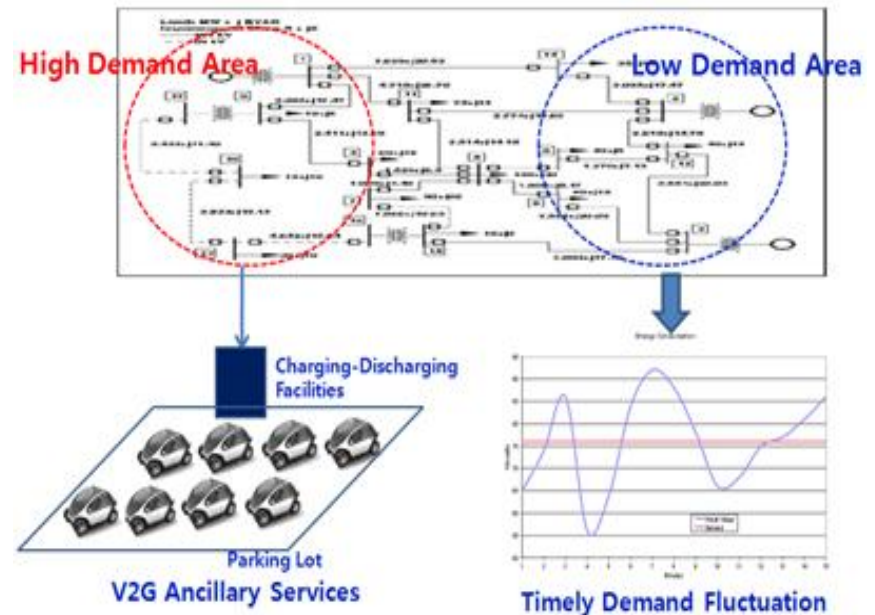
- Electric Vehicles basically increase the electricity demand, but they also contribute to **reducing the power system fluctuations** by V2G ancillary services

[Geographical Domain]



Electric Vehicles are acting
as a Mobile Batteries in Power System

[Time Domain]



Increasing Geographic & Temporal Flexibilities

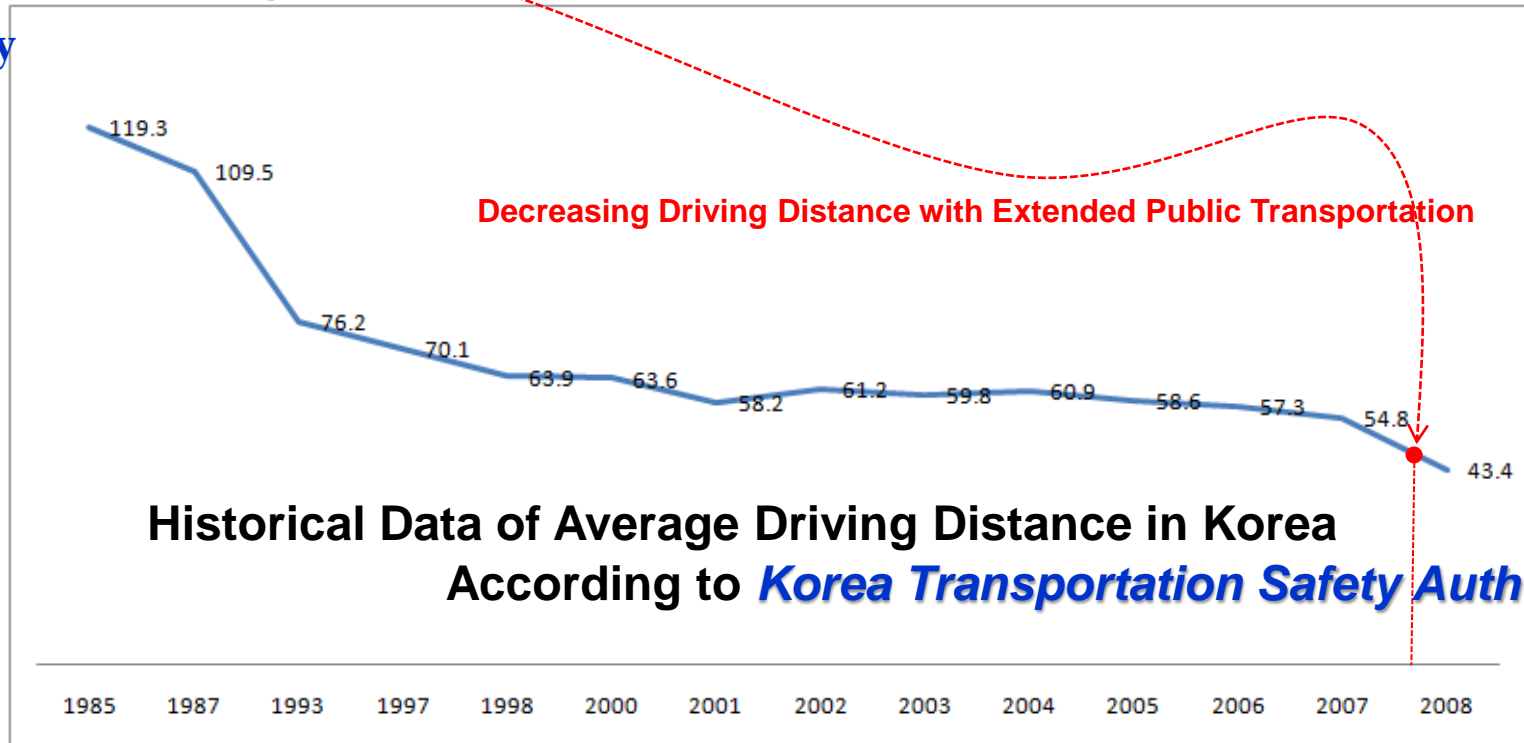
G2V & V2G Services [2]

- Time-domain flexibility will be the main contribution to operation flexibilities considering the average driving distances.
- Most of electric vehicles will move around within a city or limited distances

Yr 2008

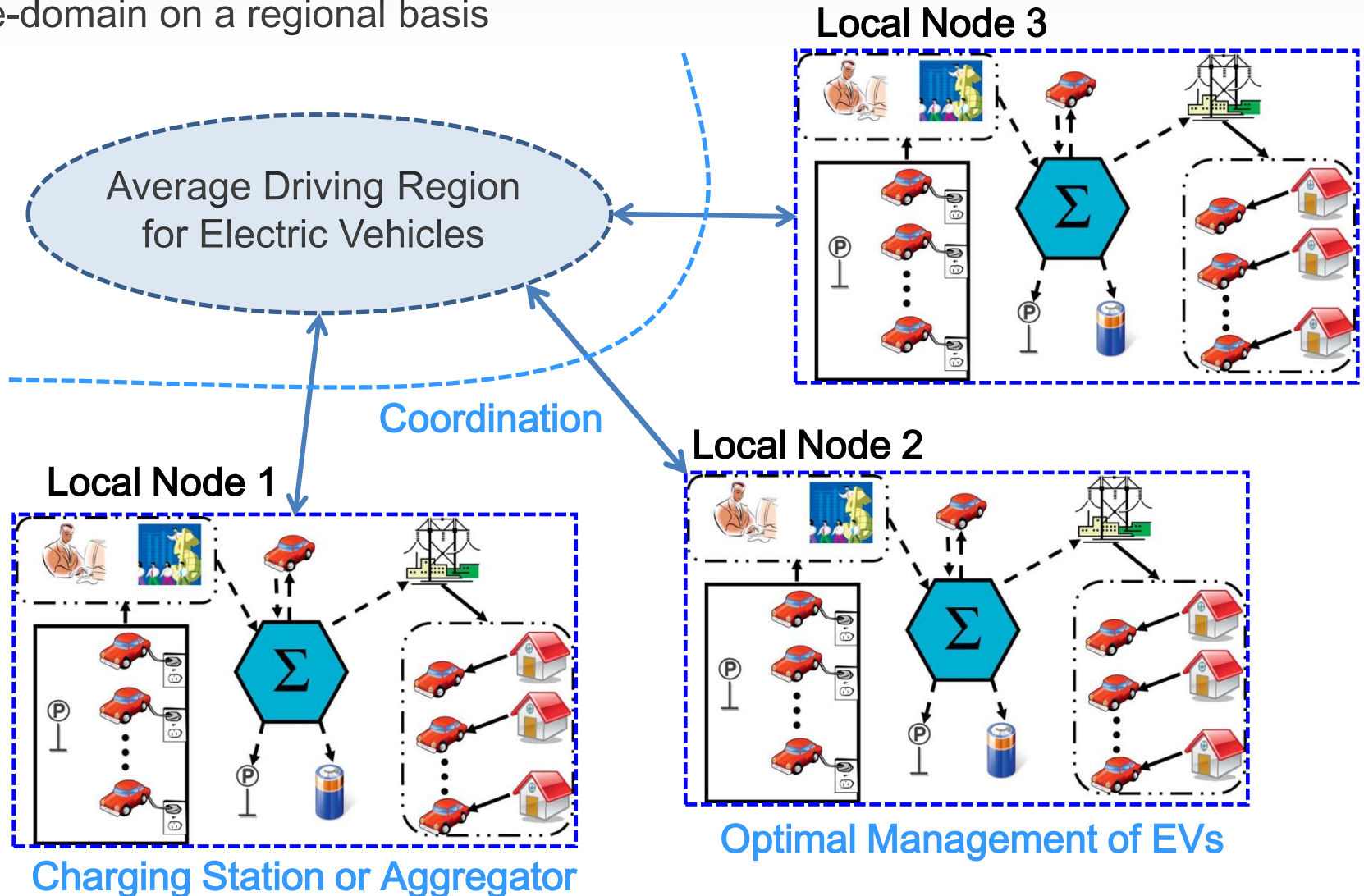
$$\underline{45.9\text{km/day}} \times 365\text{day} \times 16.79\text{M} = 281,291\text{M km/yr}$$

km/day



G2V & V2G Services [3]

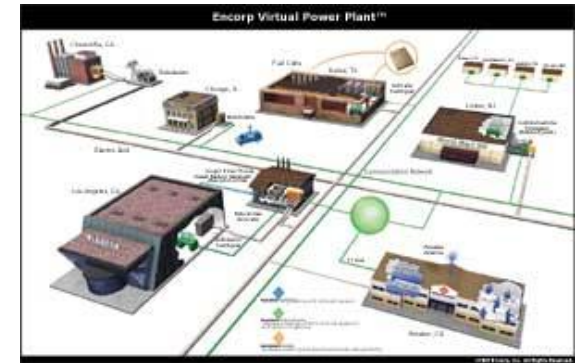
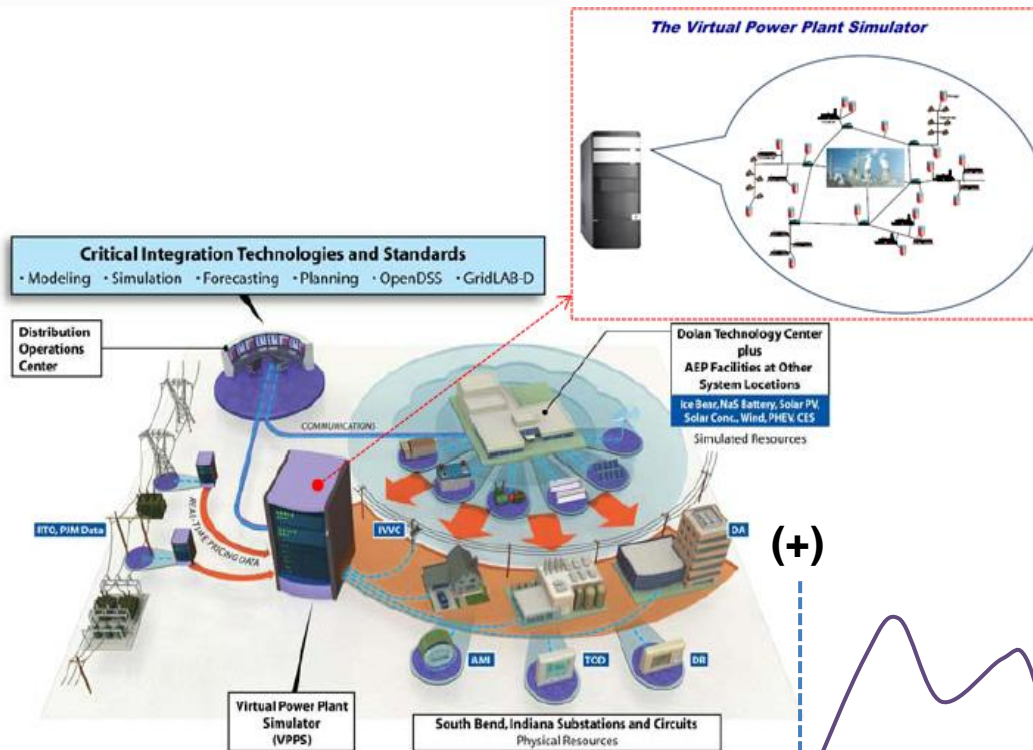
- The optimal management of many electric vehicles and coordination between multiple aggregators will increase the flexibility of system operation in time-domain on a regional basis



G2V & V2G Services [4]

Integration of individual components within software based architecture

- Emergence of VPP (Virtual Power Plant)



Net Output

(+)

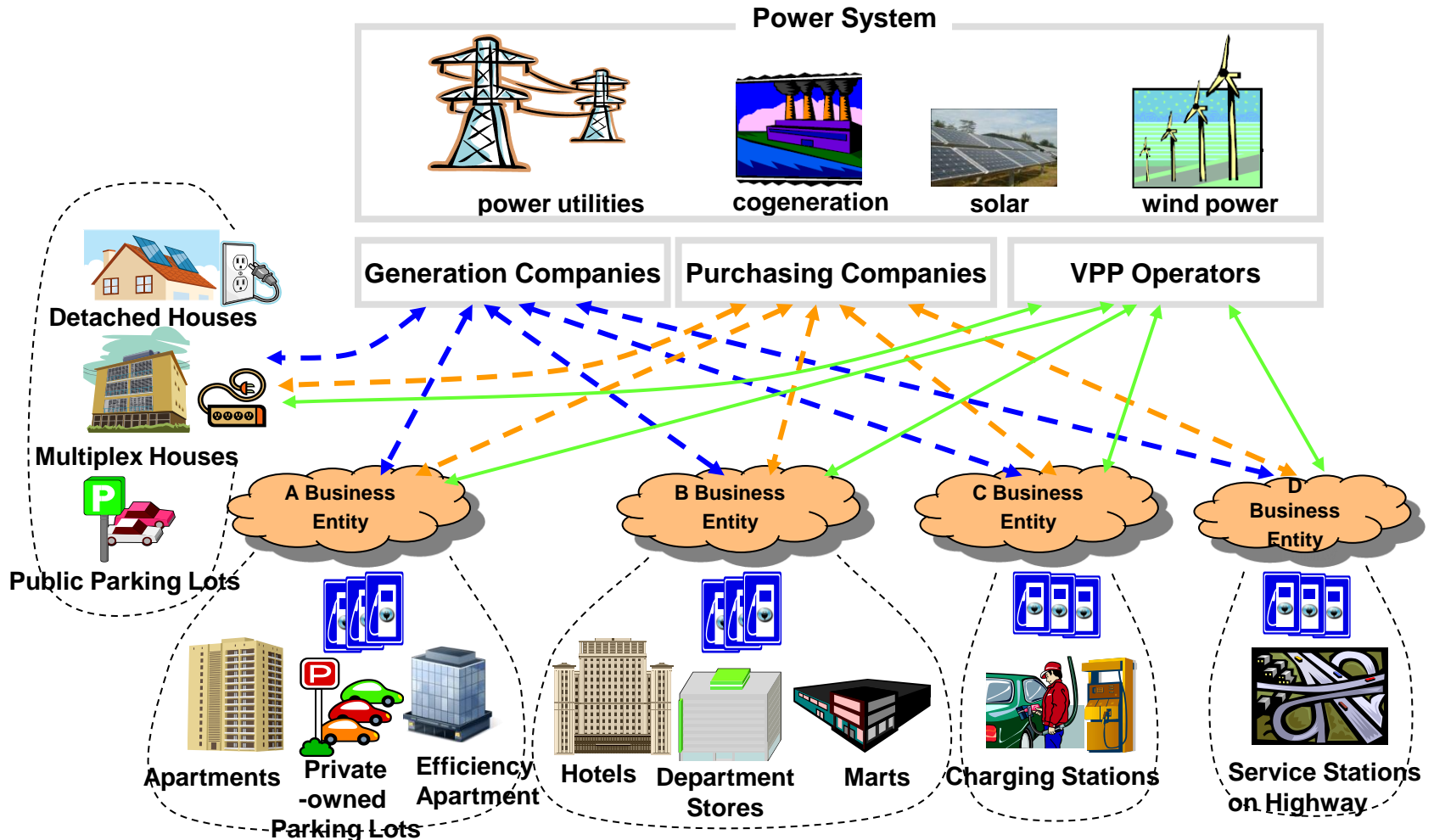
(-)

시간

Software based interconnection between different physical entities such as renewable energy sources, electric vehicles, smart homes, etc.

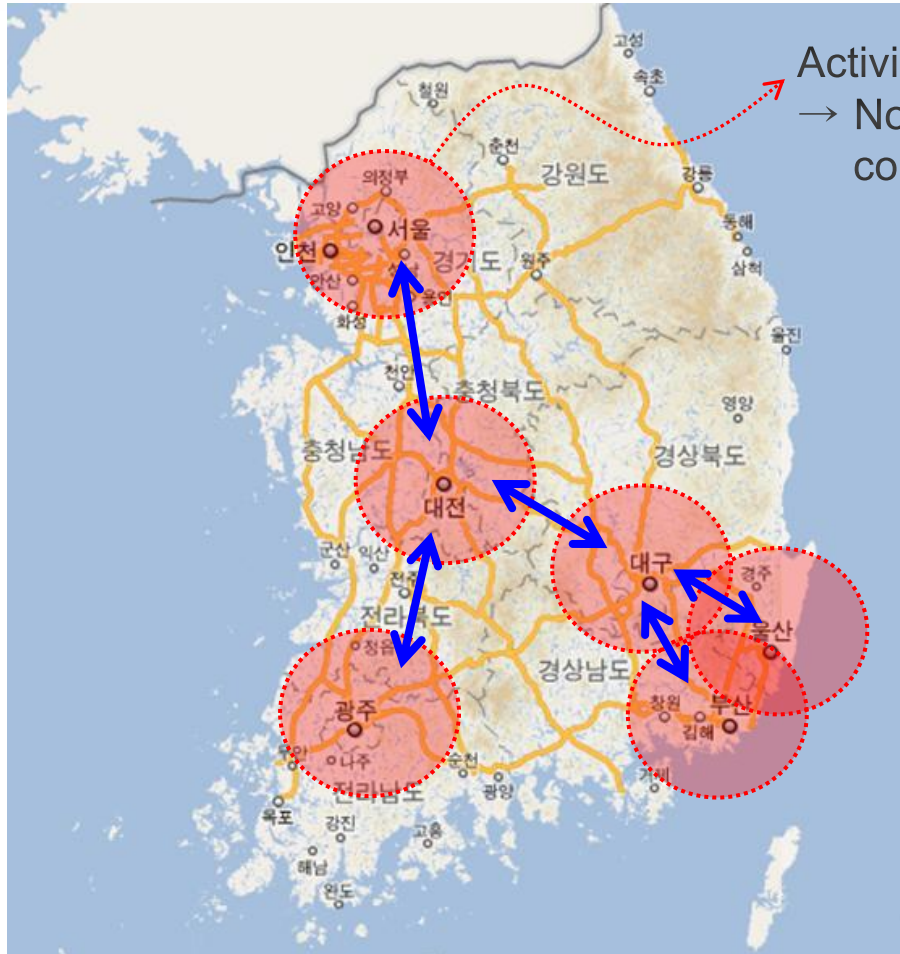
G2V & V2G Services [5]

- Many business entities expected to emerge → Strengthening VPP structure
- More interactions occurred between EVs and Power System



G2V & V2G Services [6]

Electric Vehicles as Storage Capacity



Activity Region of Electric Vehicles in Major Cities
→ No meaning on Geographical Flexibilities considering Transmission Network

Flexibilities on time-domain

will be more significant in the region

But, it could **reduce the transmission congestion indirectly** between the regions by increasing the independence of individual regions on energy supply-demand

Aggregation of Electric Vehicles

- **Large scale of ESS**
- + Renewable Energy Sources**
- VPP (Virtual Power Plant)

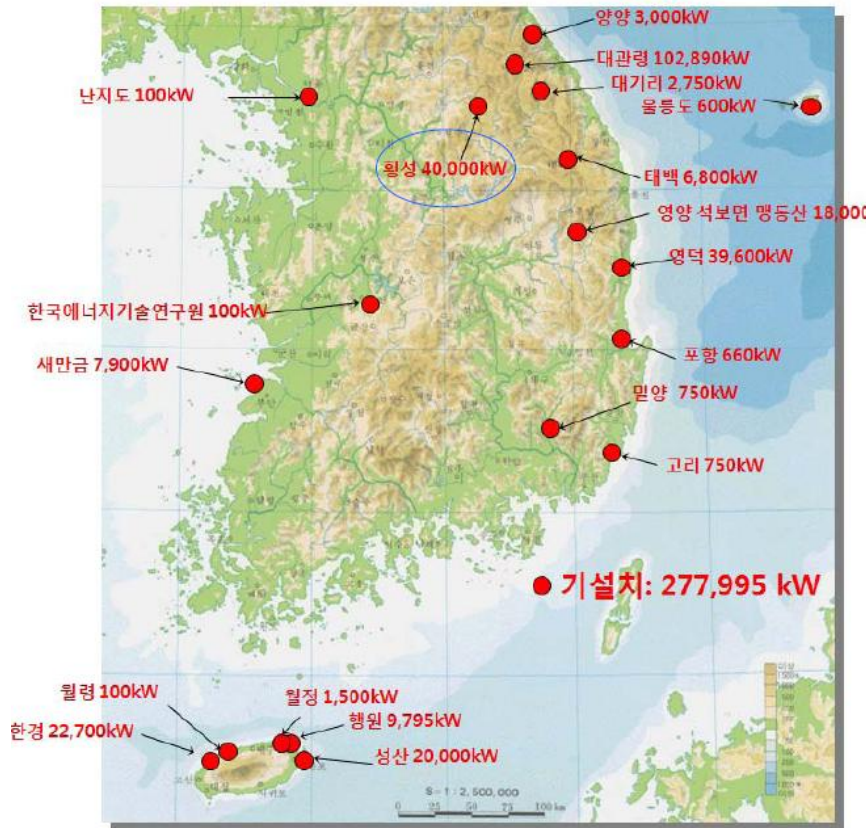
We need...

- **Reinforcement of power distribution network**
 - Most of charging stations are interconnected to distribution power network
- **Deployment of enough charging stations and EVs**
- Advanced operation solutions are required to deal with **stochastic characteristics of many EVs**
 - Charging Stations, Aggregators, VPPs, etc.
- Deregulation and institutional support to facilitate business models with G2V(charging) and V2G(ancillary services)
- **Interplay with renewable energy sources** will increase both system stability and economic efficiency

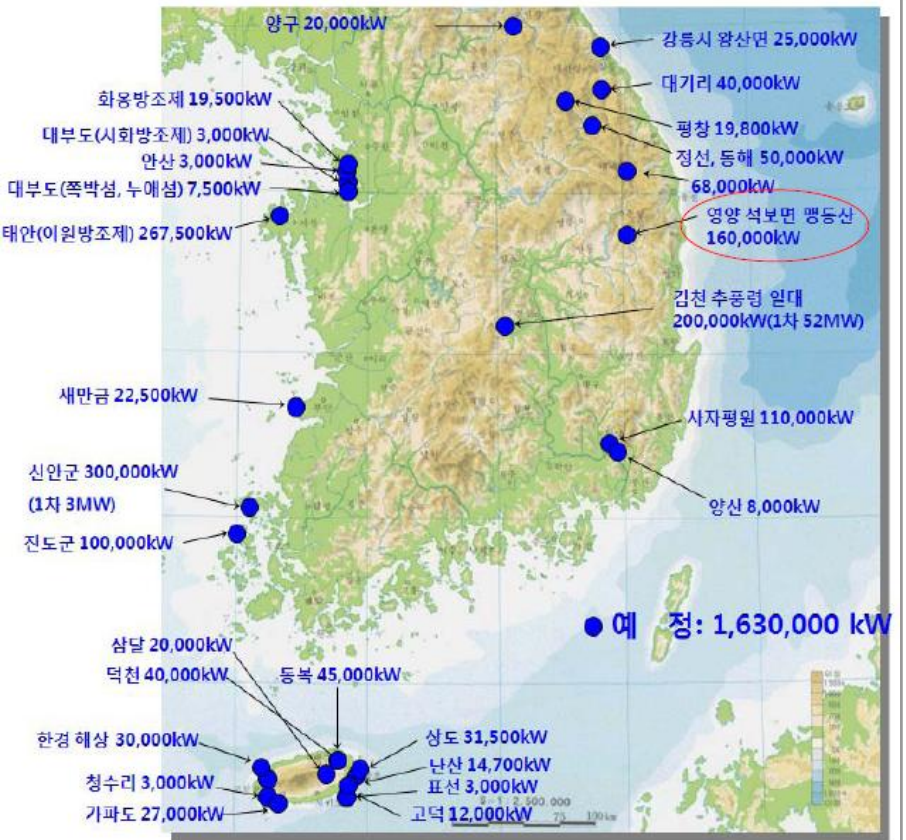
Issues on Renewables

Wind Power Generation in Korea

• Existing Status 278MW (0.4%)



■ Plan 1,630MW (2%)



➔ Increasing wind power penetration with the rapid development of wind turbine technology

Wind Power Generation in Jeju [1]

- Jeju to take a testbed role before applying various SG technology to the mainland of Korea

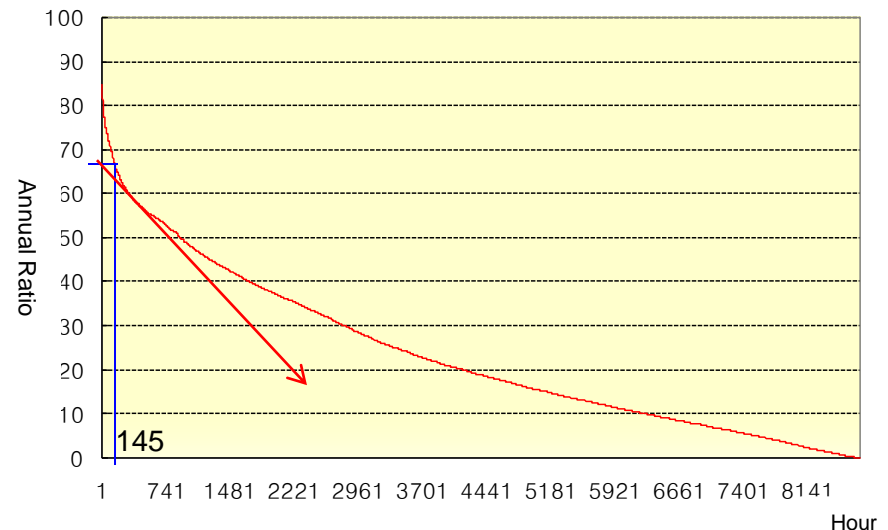


Wind Power in Jeju (2010.06)

Under Operation	Under Construction	Plan (2010~2011)	Ave. Usage Ratio (2009)
79MW	8MW	93MW	24.23%

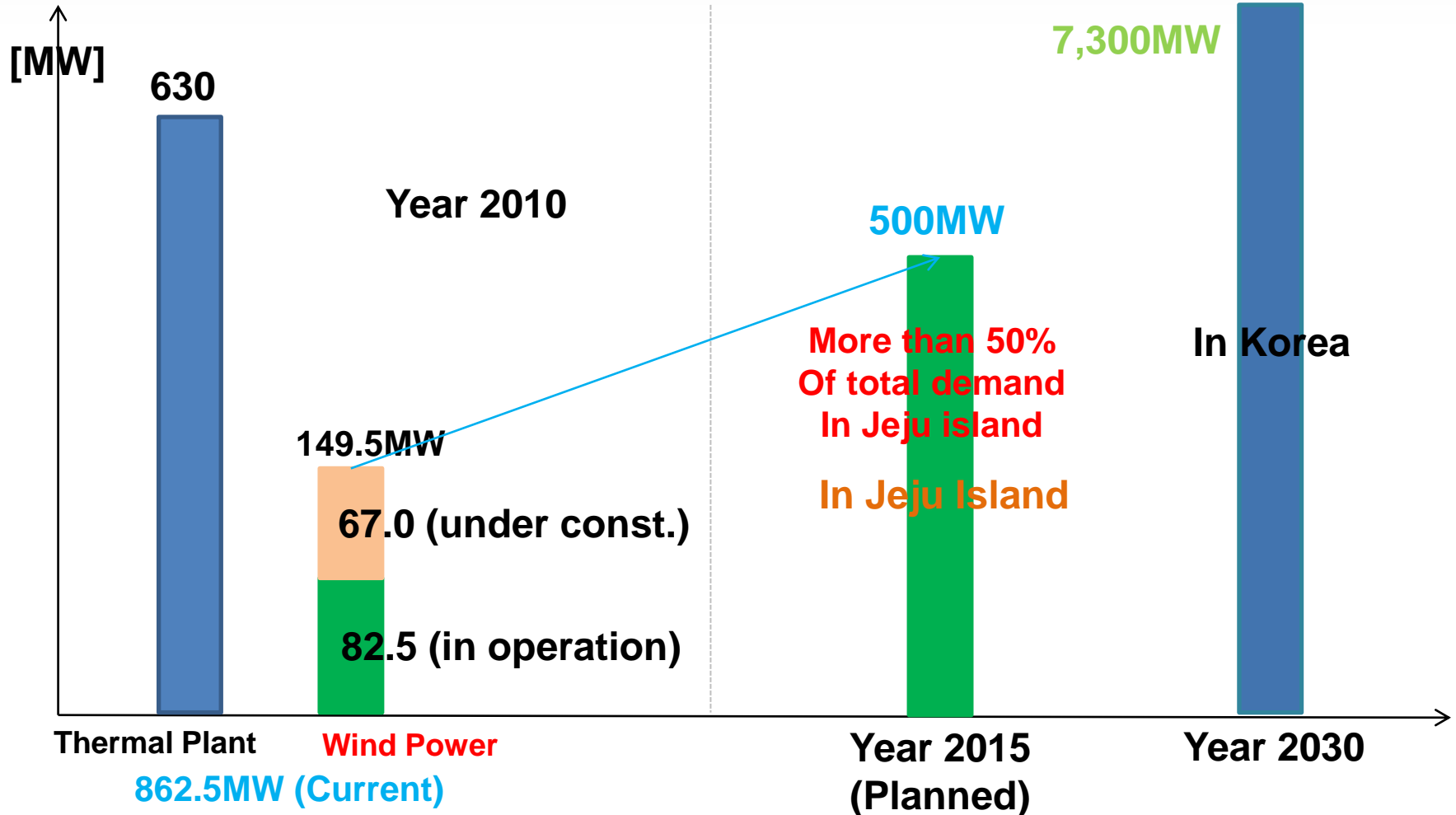
Analysis of operating hours for the year (2009)

	90% over	80% over	70% over	67% over
Annual operating hours (H)	0	11	102	145
Annual Ratio (H/8760)	0	0.13%	1.16%	1.66%



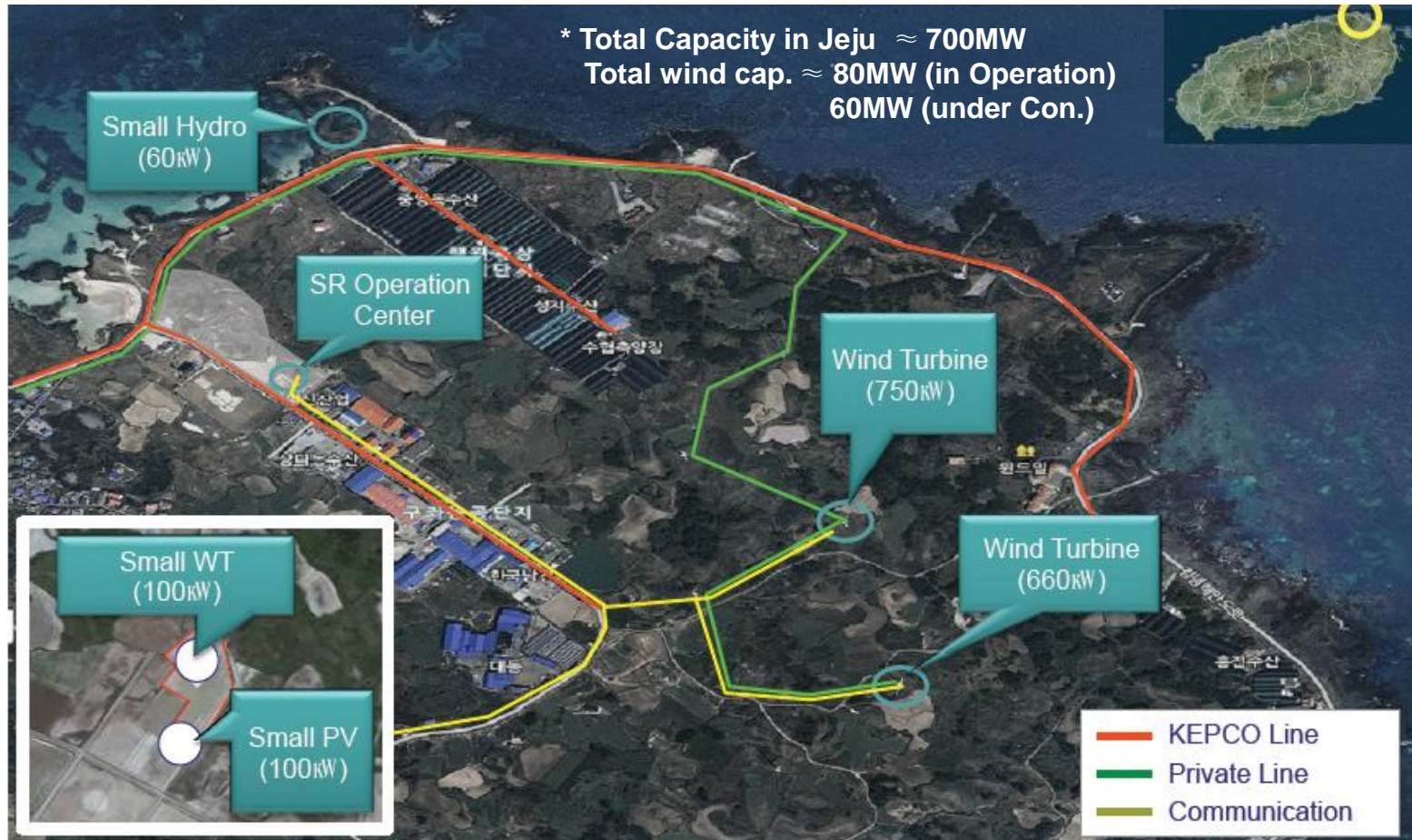
Wind Power Generation in Jeju [2]

- More than 50% of total demand in Jeju island will be provided by wind power energy till 2015



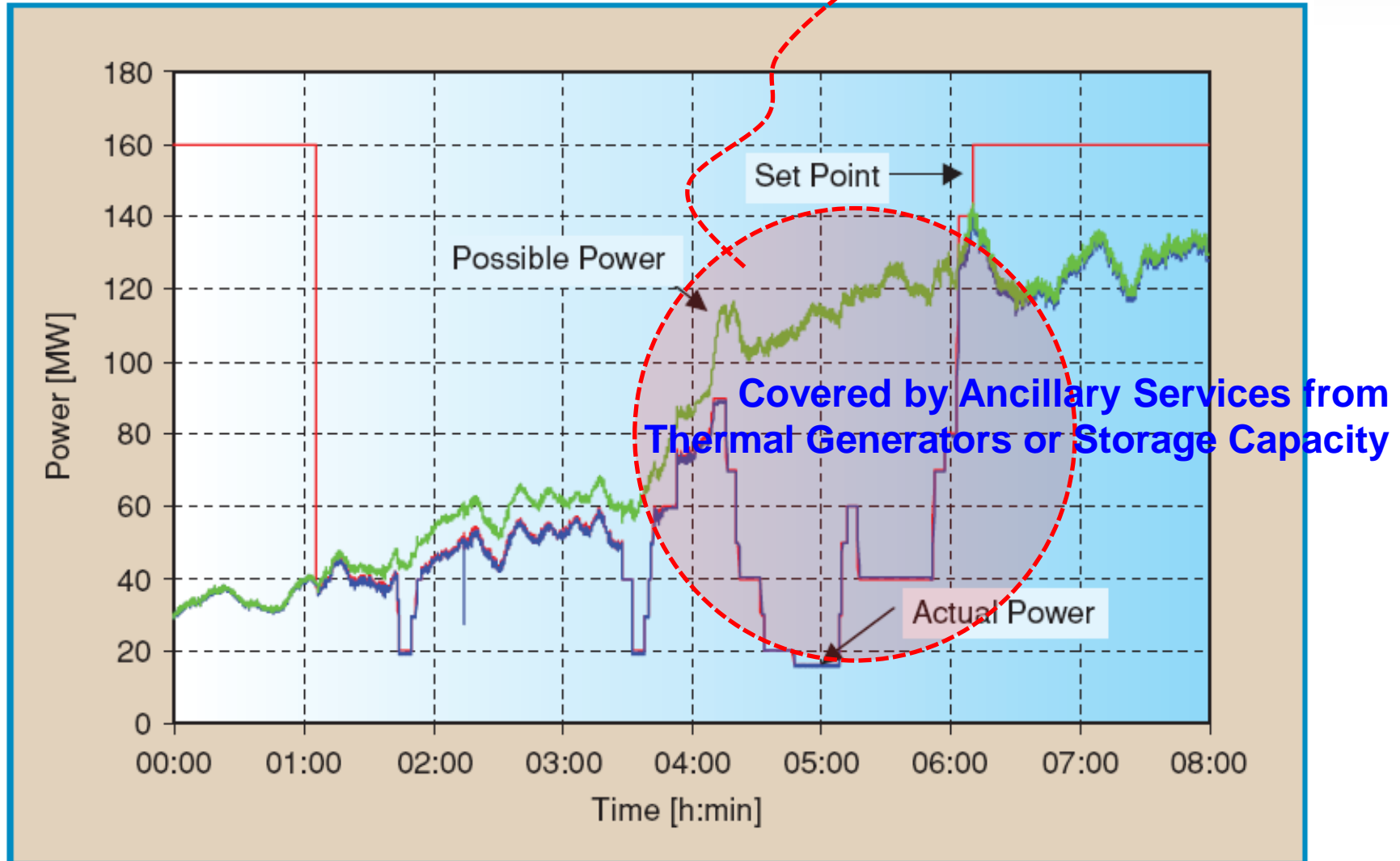
Wind Power Generation Testbed in Jeju island

- Entire Demand in Demonstration Site $\approx 18\text{MW}$ (max)
- Renewable Energy in Demonstration Site $\approx 5\sim 6\text{MW}$



Fluctuations from Renewables

Overproduction or Underproduction from Renewables



Paradigm Change on System Operation

**Increased Uncertainties
in Power System**

- Energy Buffer Required
- New Operation Strategy

Paradigm Change on Generation

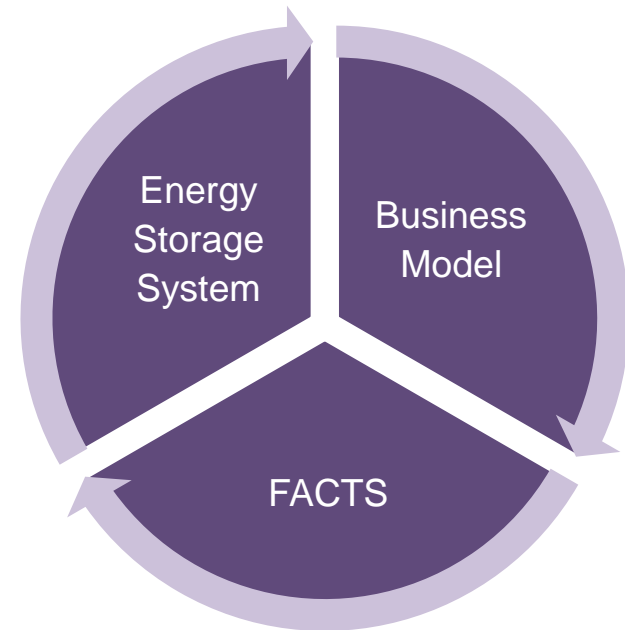
- Centralized large scale Generator
→ Distributed Generator
- Increasing Operation Efficiency
(Load Factor)

Power Quality and Generation

- Intermittent Generation
- Reserve Requirement
- Inter-area Oscillation

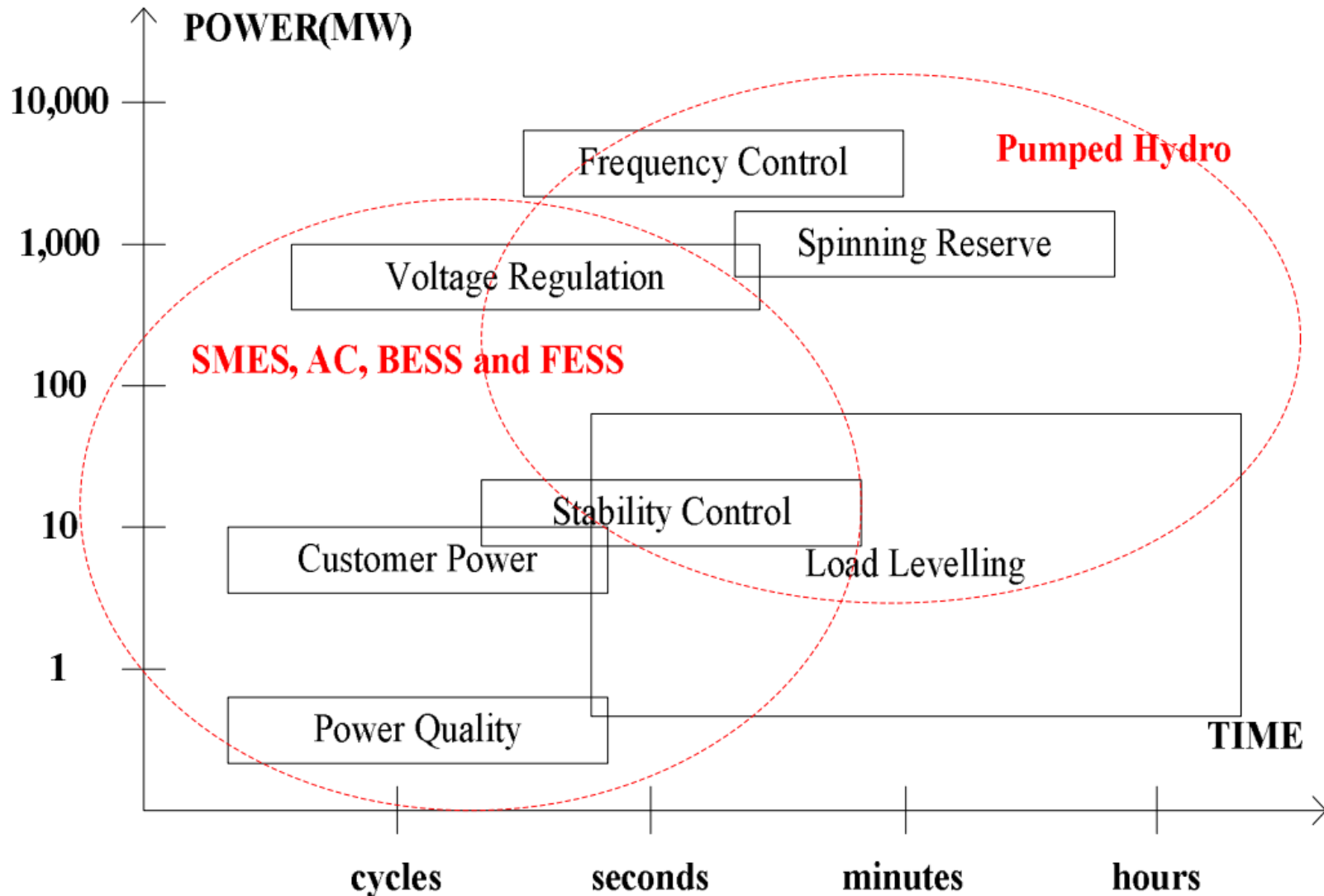
Robustness and Stability of Power System

- Power Flow Control
- Damping Control
- Robustness and Stability

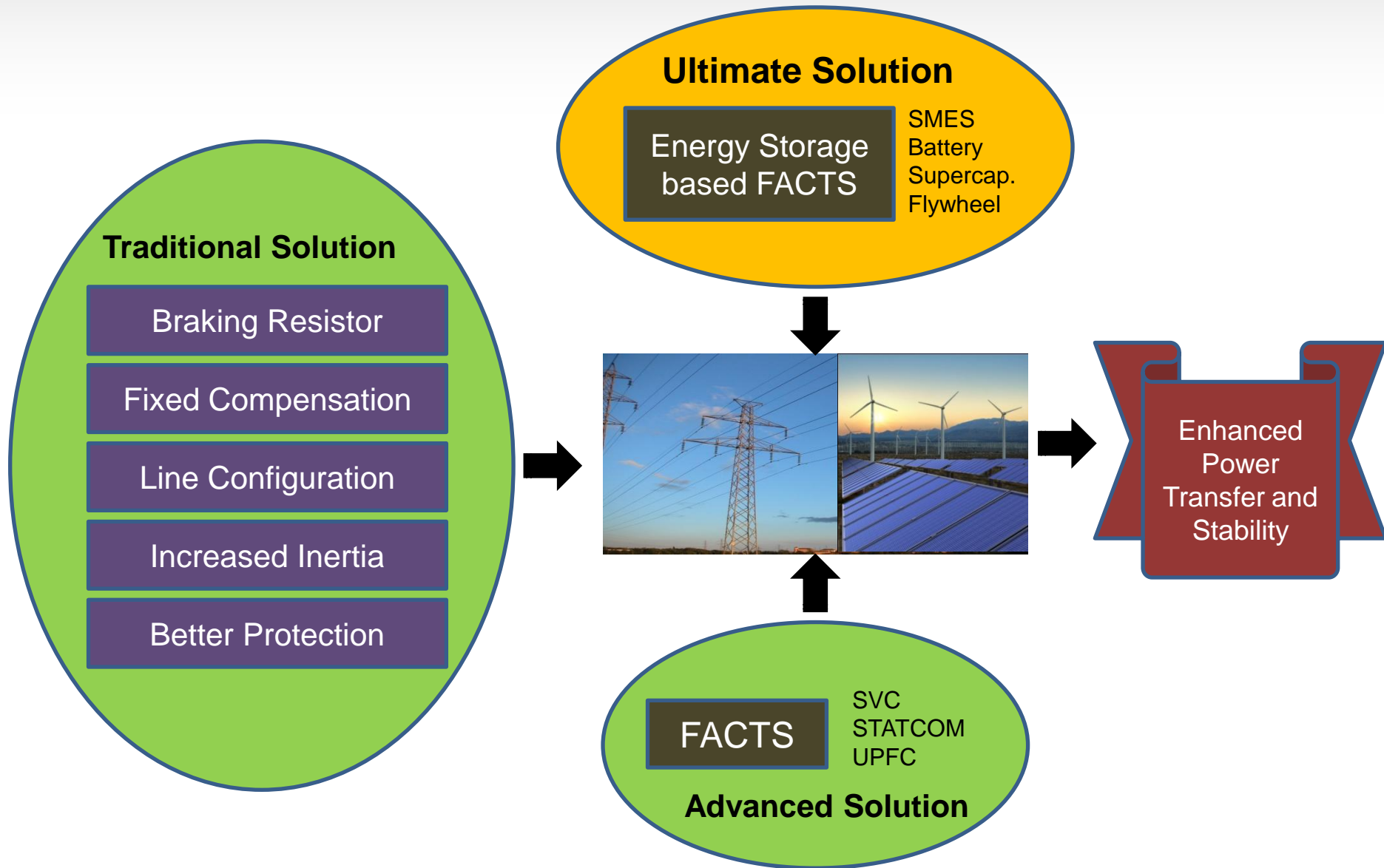


Various Kinds of Ancillary Services

Ancillary Services are more important in Smart Grid with increasing renewable energy sources and other uncertainties

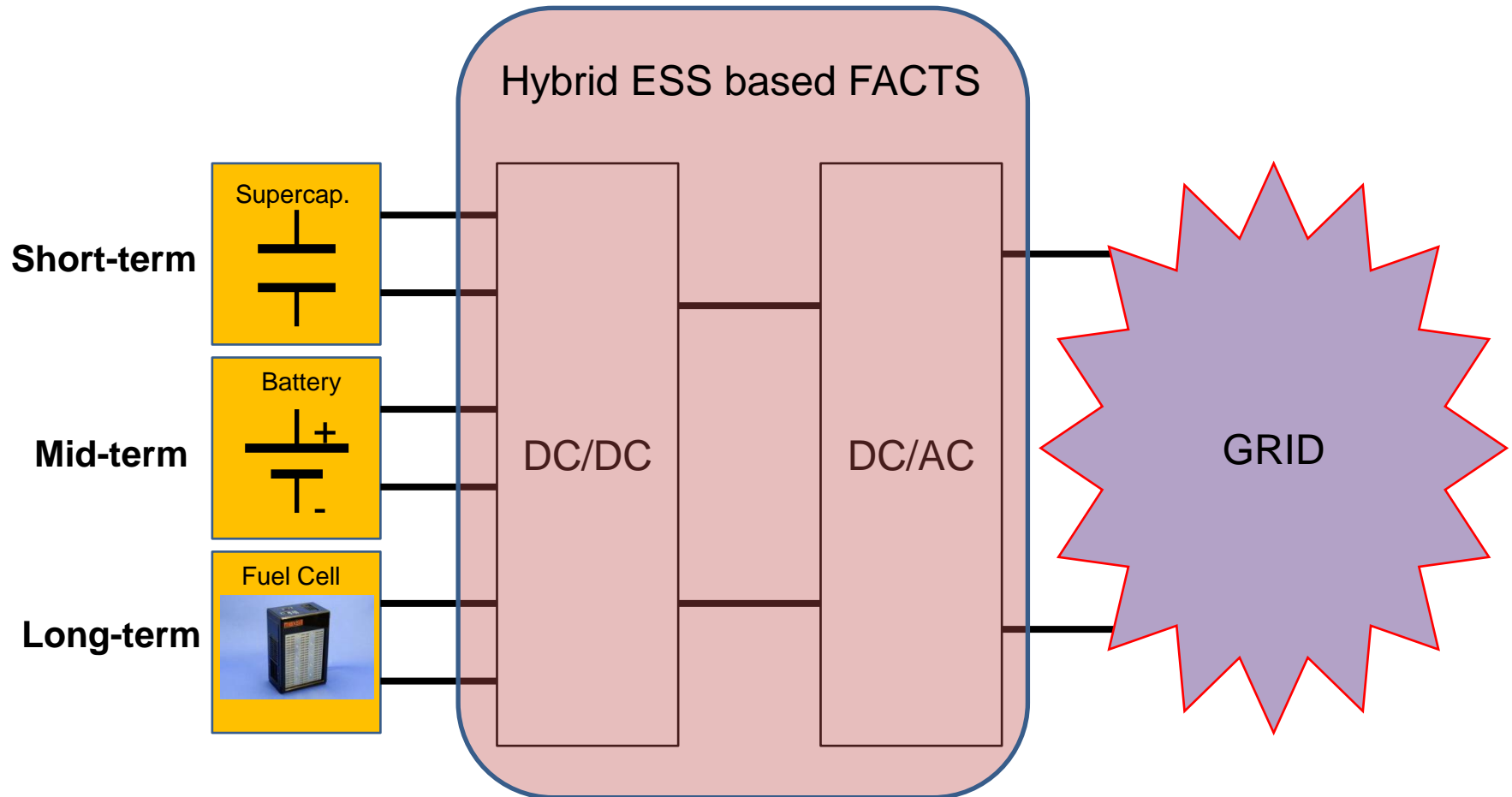


Solutions - ESS based FACTS [1]

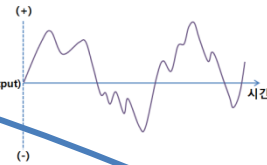
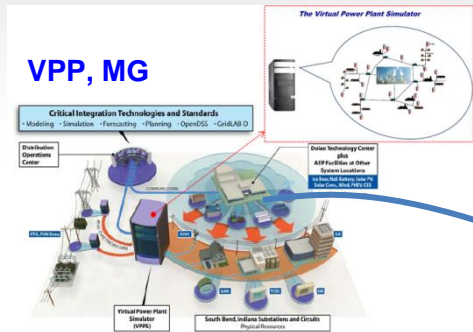


Solutions - ESS based FACTS [2]

Hybrid Operation Scheme incorporating super-capacities, batteries, fuel cells
→ EVs can contribute to energy storage scheme as one of battery sources



Mitigation of Transmission Congestion



Transmission Line

Reducing power flow on transmission line by Increasing Regional Independence

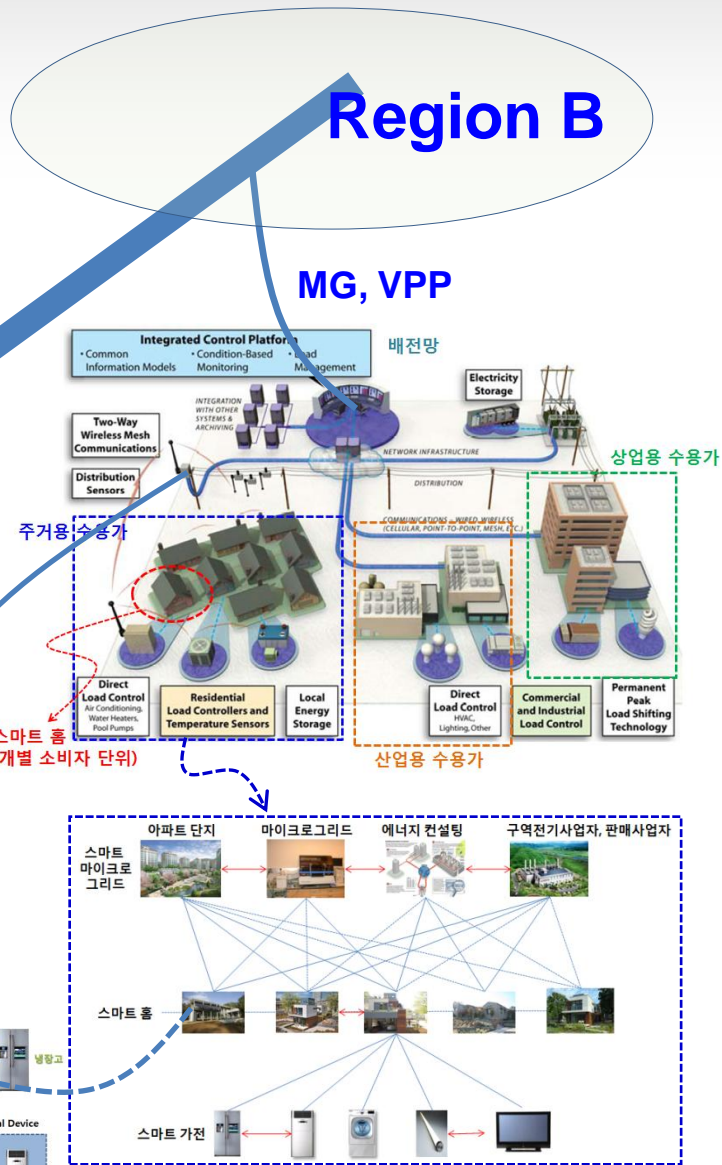


Wind-Farm

Region A



Charging Stations



Conclusion

- The **interplay** between renewable energy resources and electric vehicles will **mitigate the fluctuations** from renewable energy sources and **increase the flexibility** on system operation.
- The renewable energy sources and electric vehicles have a **complementary relationship**. This concept could be developed into **VPP (Virtual Power Plant)**.
- Electric vehicles will provide **various ancillary services** in cooperation with other compensation facilities and storage devices.
- The interplay could be facilitated by **the optimal design of RTP (real-time pricing)**.



DO YOU HAVE
ANY QUESTIONS?