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Estimating Electric Energy Consumed According to Penetration of Electric Vehicles in Jeju Island in Korea

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Introduction 1

- Brief explanation on estimating electric energy consumed due to penetration of EVs
- It is an example for Jeju province, the biggest island in South Korea.
- And then I hope to explain that penetration of EVs can lower the cost to supply electric energy in whole nation, and we can save energy and decrease greenhouse gas.

Introduction 2

- In 2011 year, the Jeju governor made plan to penetrate EV and replace all cars with EVs until 2030 year.
- In the plan:
  - 2017 year 10% EV penetration
  - 2020 year 30% EV penetration
  - 2030 year 100% EV penetration
- In university, the study on estimating electric energy consumed by EV according to EV penetration must be done.

Estimating Increase of Electric Energy According to Penetration of Electric Vehicles at the Jeju Island in Korea

The yearly total energy consumed by the EVs E

$$E = \sum_i \frac{N_i L_i}{\alpha_i} \times 365 \qquad \text{(kWh)}$$

where:

α_i : fuel Economy (km/kWh)

N_i : number of Electric vehicles

L_i : driving distance during a day (km)

Formally Expressed Fuel Economy of EVs in Korea

Model	Combined Fuel Economy [km/kWh]	1-time Charging Driving Distance [km]	Curb Weight [kg]	Release year
LEAF	5.2	132.00	1,520	2014
Soul	5.0	148.00	1,508	2014
Spark EV	6.0	128.00	1,240	2014
BMW i3	5.9	132.00	1,300	2014
SM3 Z.E.	4.4	135.00	1,580	2013
Ray	5.0	91.00	1,185	2012
Change	4.3	50.00	8,400	2012

Predicted No. of EVs to be penetrated in Jeju Island

Year	Predicted No. of cars			Goal of EV penetration	Predicted No. of EVs		
	Official	Private	Business		Official	Private	Business
2016	698	223,832	38,083	5.0%	138	11,192	1,904
2017	735	234,294	40,971	10.0%	175	23,429	4,097
2018	773	244,756	43,859	16.0%	213	39,161	7,017
2019	810	255,218	46,747	23.0%	250	58,700	10,752
2020	848	265,680	49,636	30.0%	288	79,704	14,891

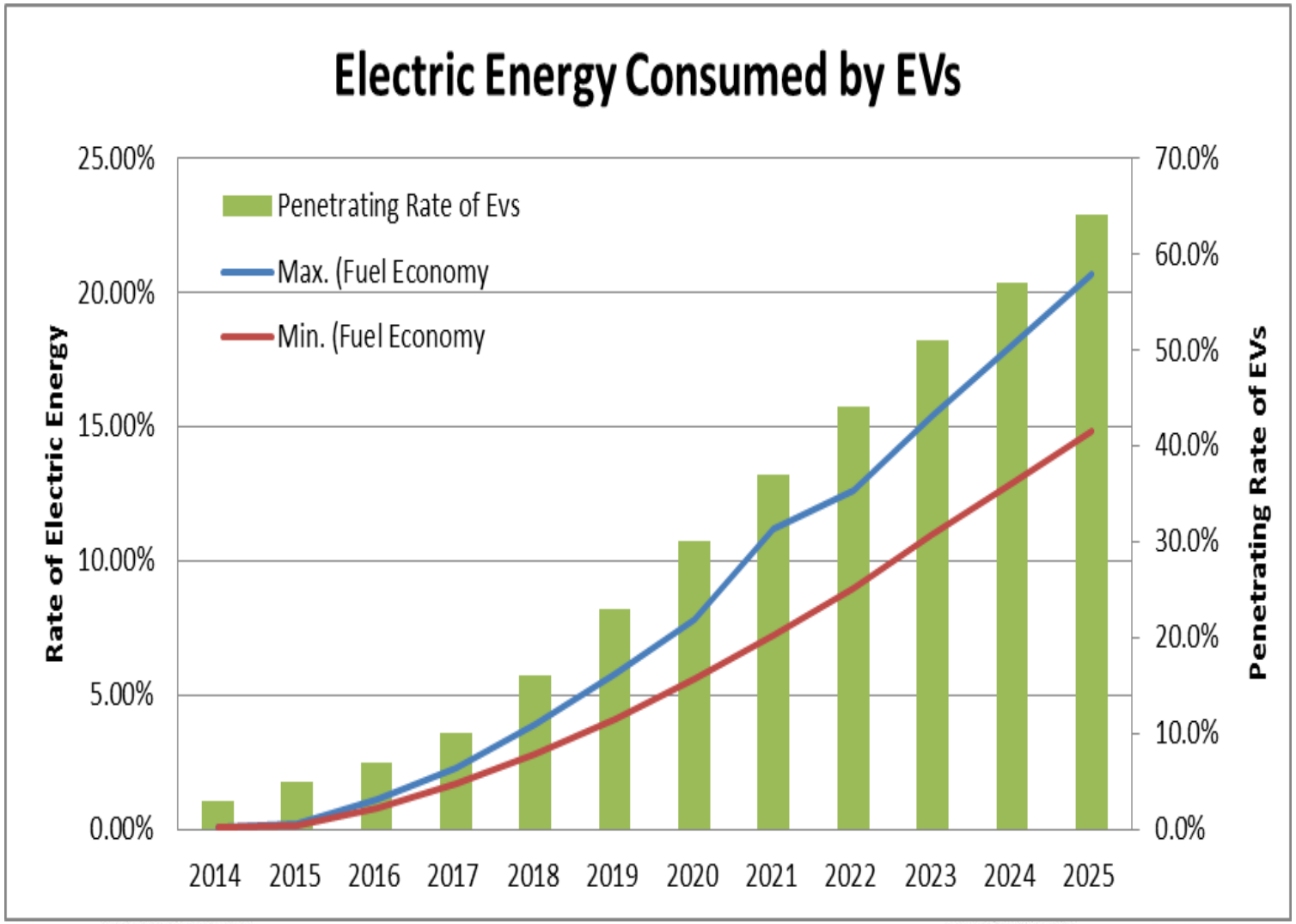
Average Daily Driving Distance of the Passengers Cars in Jeju Island

Usage purpose	Daily driving Distance (km)
Official usage	36.5
Non-business personal usage	32.4
Business usage	101.7

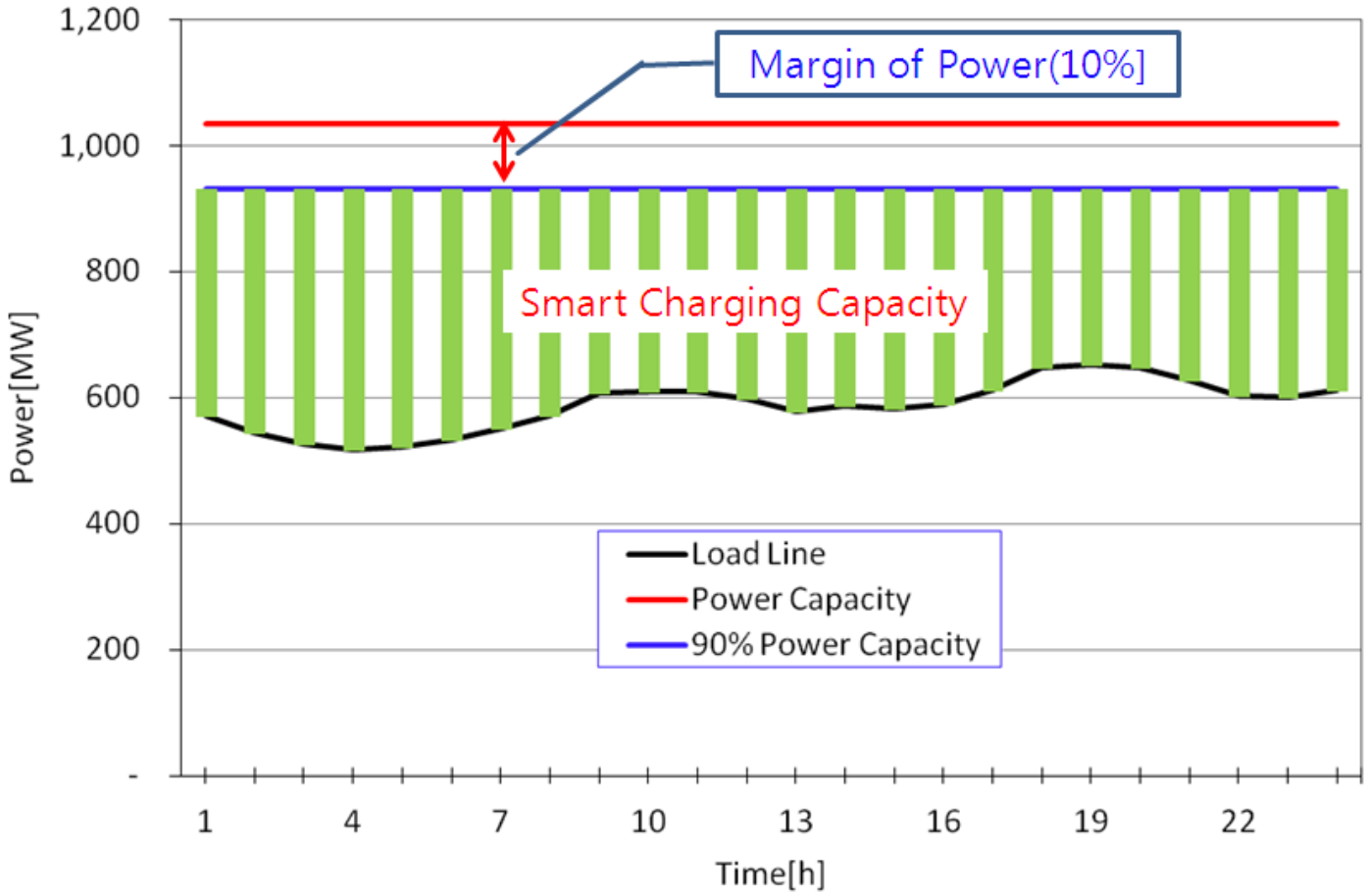
Estimation of the Electrical Energy Consumed by the EVs In Jeju Island

Year	Predicted Total electric energy [GWh]	EV Penetration rate	Electric energy consumed by EV[GWh]		Electric energy rate consumed by EV[%]	
			Max. (Fuel Economy =4.3)	Min. (Fuel Economy =6.0)	Max. (Fuel Economy =4.3)	Min. (Fuel Economy =6.0)
2016	4,161	7.0%	47.6	34.1	1.1%	0.8%
2017	4,234	10.0%	100.3	71.9	2.3%	1.7%
2018	4,314	16.0%	168.9	121.0	3.9%	2.8%
2019	4,385	23.0%	255.0	182.7	5.8%	4.1%
2020	4,435	30.0%	348.6	249.8	7.8%	5.6%
2025	4,405	64.0%	915.1	655.8	20.7%	14.8%

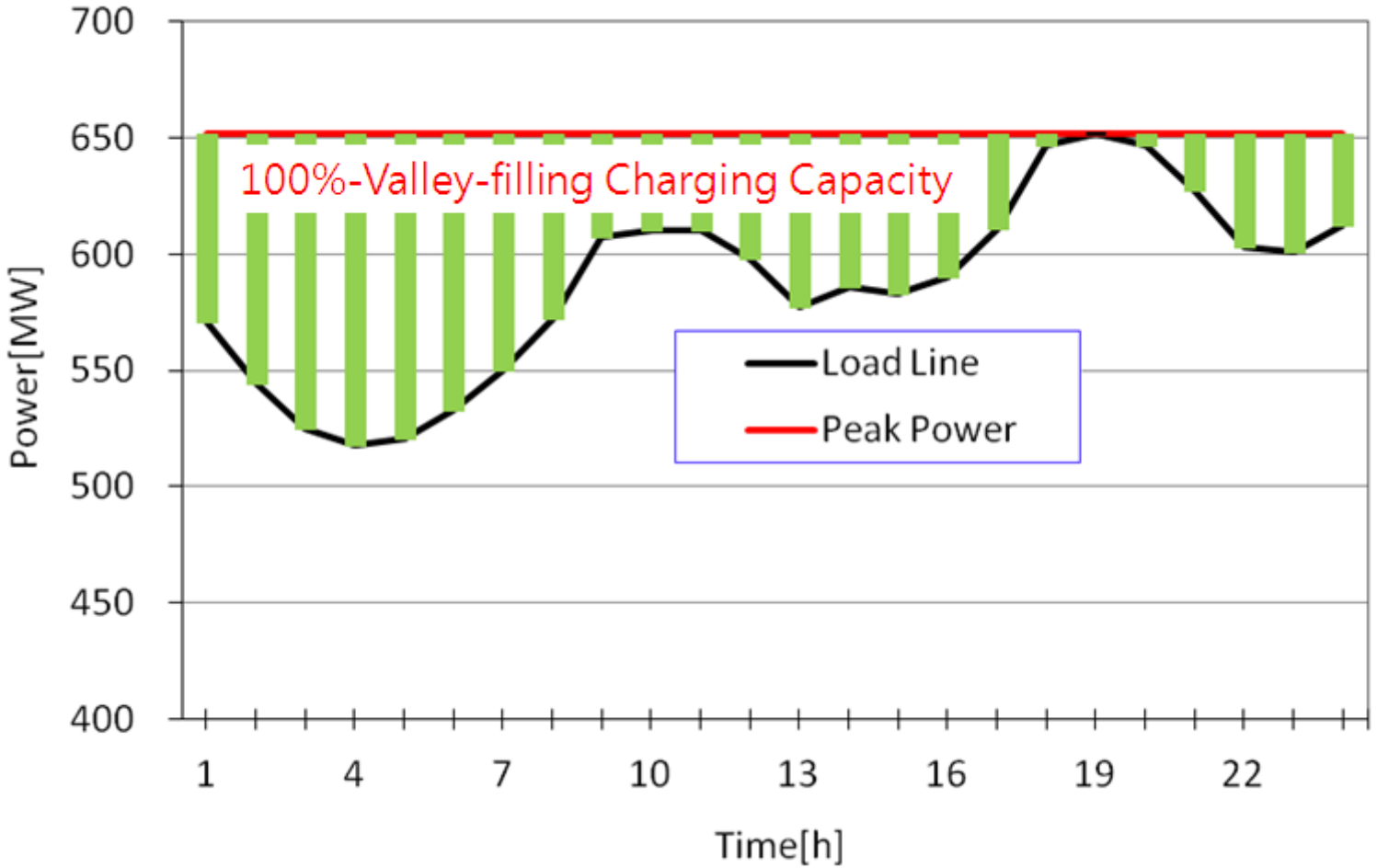
Electric Energy Consumed by EVs



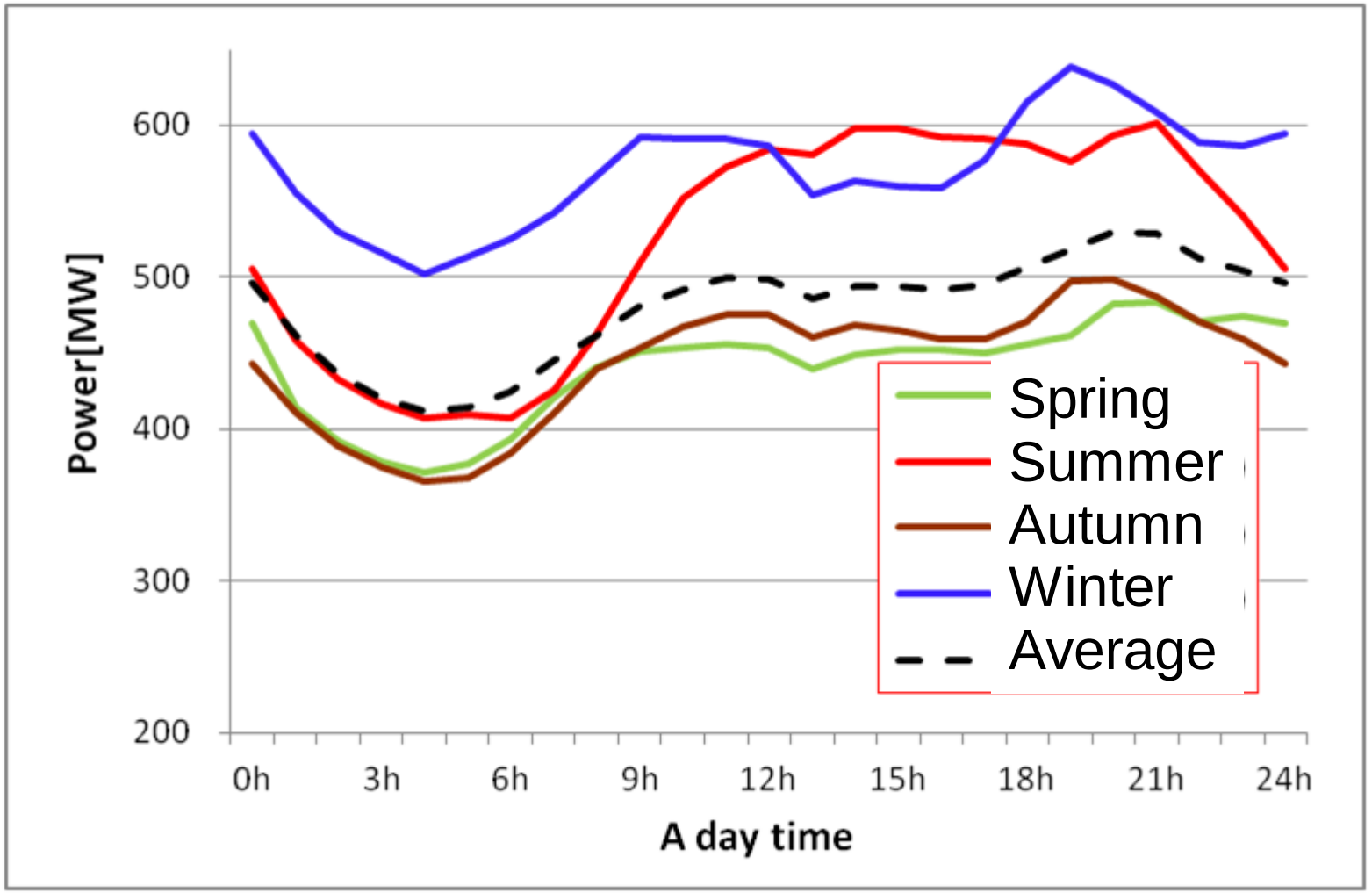
The Concept of Smart Charging Capacity, in the Electric Energy Supplying System



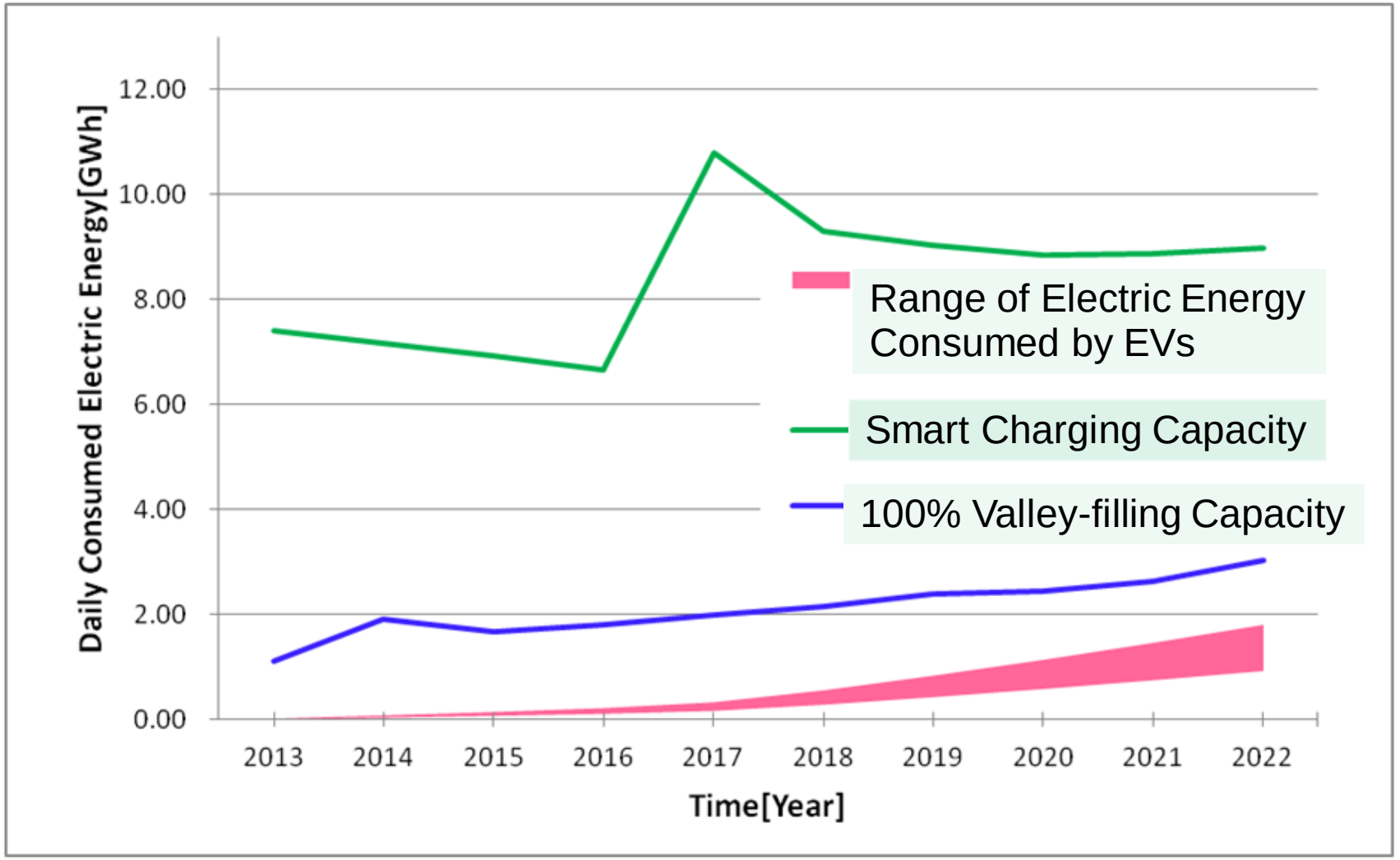
The Concept of 100% Valley-filling Charging Capacity, in the Electric Energy Supplying System



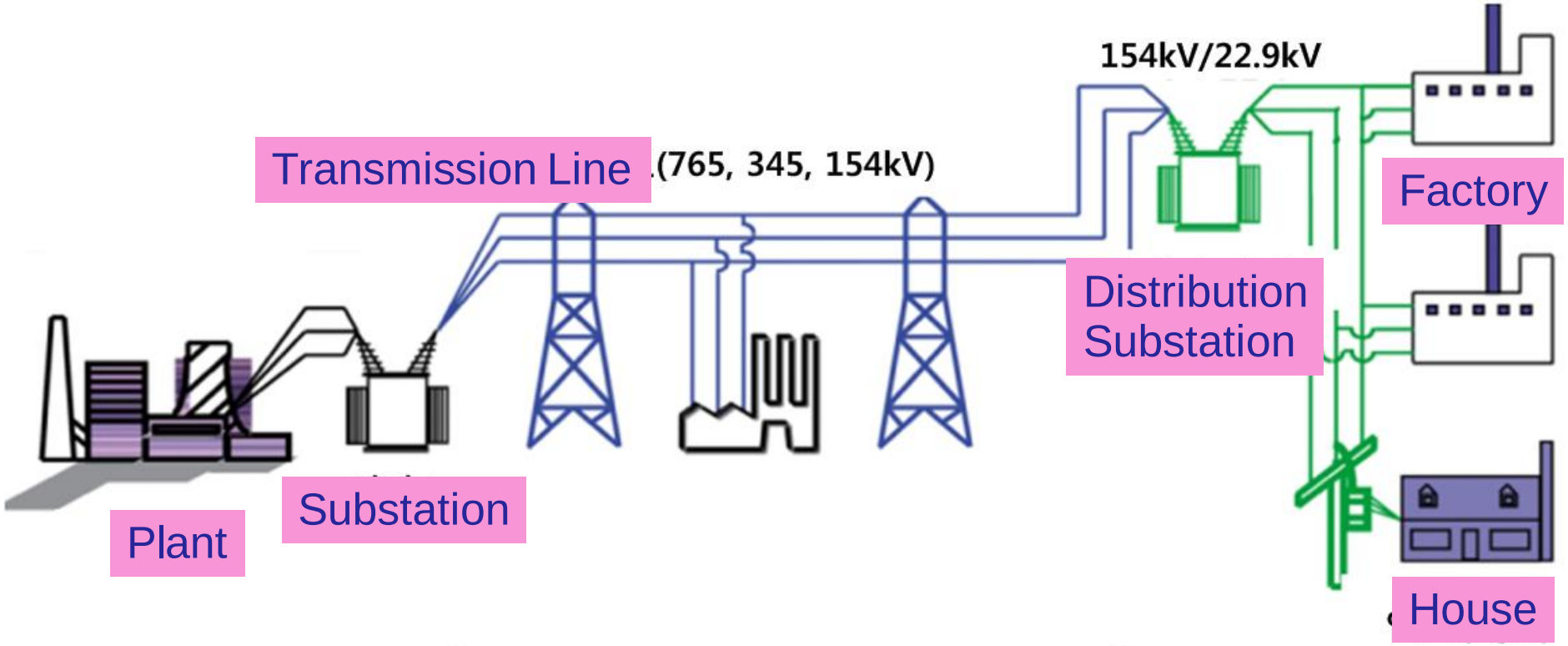
4 Season Electric Load Lines in Jeju



Capacity of Electric Grid Supplying Electric Energy for EVs



※ Power Grid System Supplying Electric Energy



Generation Stage → Transmission Stage → Distribution stage

Conclusion 1

The calculation results show that

- the rate of the electric energy used by the EVs will become to maximally 2.3% of total electric energy consumed in Jeju at the 2017 year when the penetration rate of EVs in passenger cars becomes 10%,
- and the rate of the electric energy consumed by the EVs will become to maximally 7.8% of the total electric energy at the 2020 year when the penetration rate of EVs in passenger cars becomes 30%.

Conclusion 2

The study shows that

- We, present power grid, can supply electric energy for 30% EVs of whole passenger cars during midnight time without additive investing or constructing in the generation stage of the power grid,
- resultantly, we can save energy because we supply for EV the electric energy to be unused and abandon during midnight time and then we can decrease greenhouse gas.

- Awareness
  - ✓ Though in generation stage capacity supplying electric energy sufficient, in distribution stage capacity supplying electric energy may be insufficient.
  - ✓ In building EV charging Infra, shortage of the distribution capacity may be a big obstacle and the capacity of distribution substations and transformers must be checked if they are sufficient or insufficient.

Thank you for your attention!

Thank President Yossapong Laoonual for invitation and giving the chance to greet you and introduce my study and opinion on EV.

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- **1991-present : Professor, Dept. of Electrical Eng.**
- **2015-present : Dean of Electrical Engineering College**
- **2007-2009 : Director of e-Learning Center of Jeju University**
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