

# Building energy management technology based on big data of demand response

2018. 6. 5

**paran**  
energy



# Contents





# Electric mgmt. = Supply mgmt. + Demand mgmt.

## These days

### 1) uncertainty of the power supply and demand

Investment costs: the future power plant construction costs  
average 5 trillion won

Construction of location problem, NIMBY phenomenon

Rapid increase in electricity demand (an increase of annual average  
of 2.5%)

### 2) energy and environmental issues

High oil prices, energy depletion problem

Climate change agreement, by emissions problem of greenhouse  
gas (CO<sub>2</sub>, etc.) have been serious

Society expansion of interest in **demand management** in all areas.



Electric mgmt. = Supply side mgmt. + Demand side mgmt.

Demand side mgmt. = Energy Efficiency + Demand Response



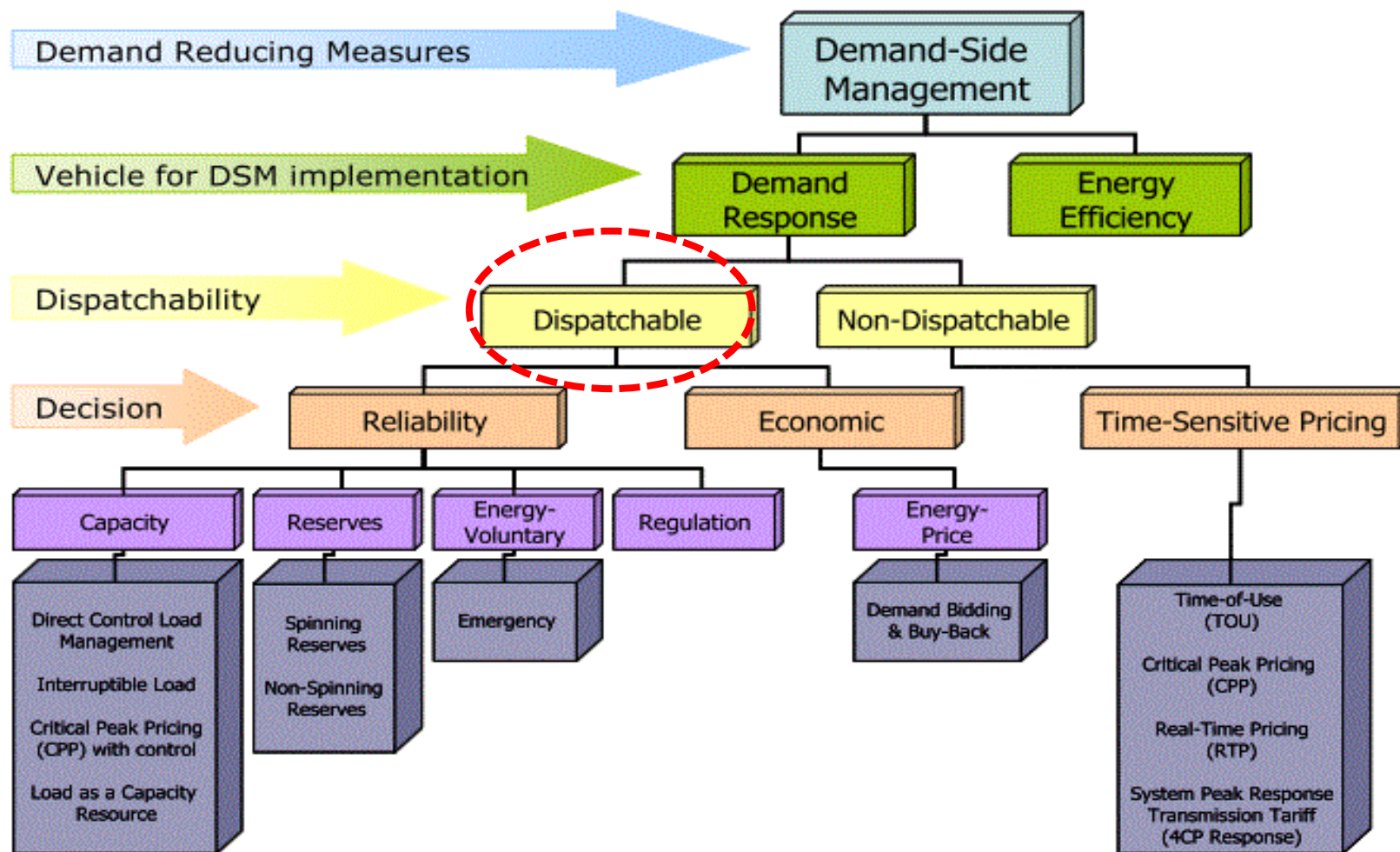
Electricity generate  
[MegaWATT]



Electricity cutoff  
[NegaWATT]



## Demand Response Categories





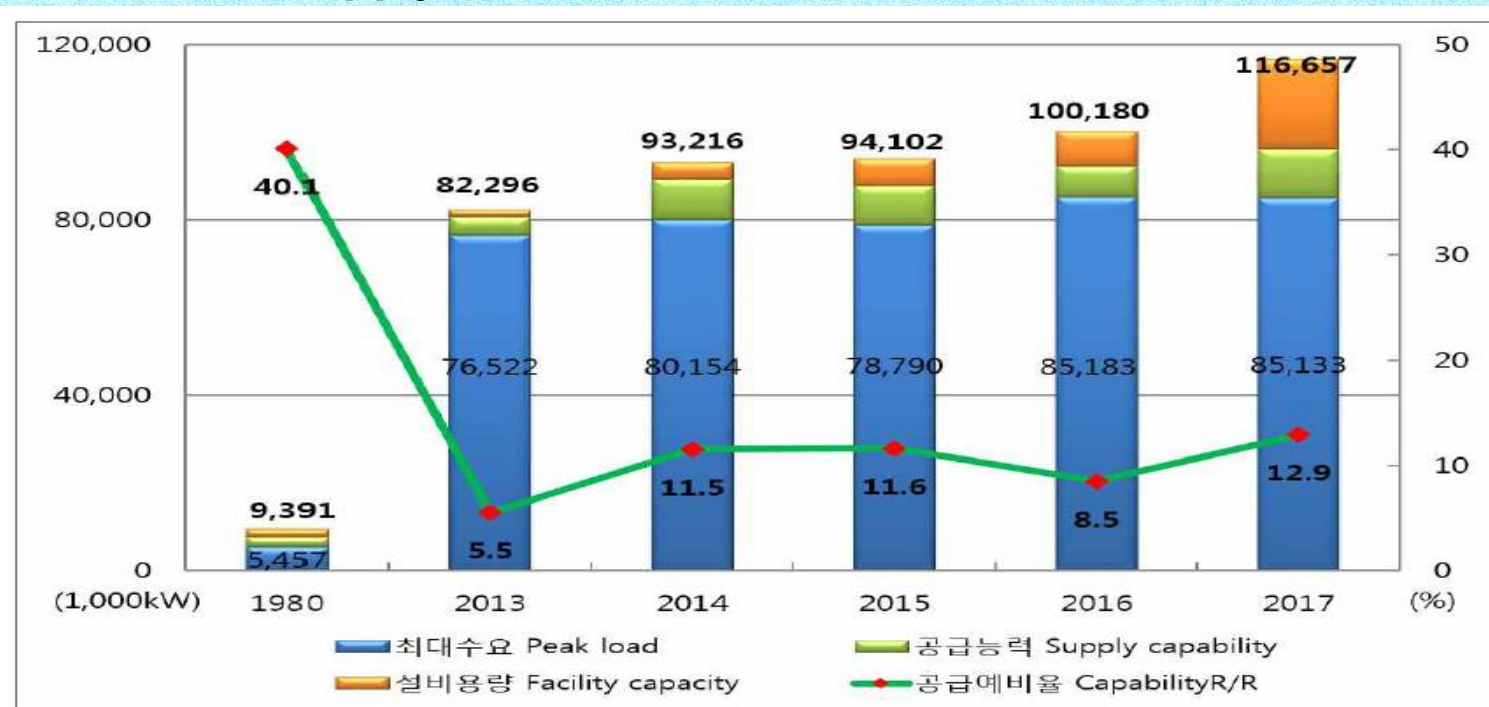
# Part 1

## Supply & Demand in Korea



# 1. Supply pattern in Korea

## ◆ Trend of Power Supply & Demand



(단위 Unit : 천kW, % 1,000kW, %)

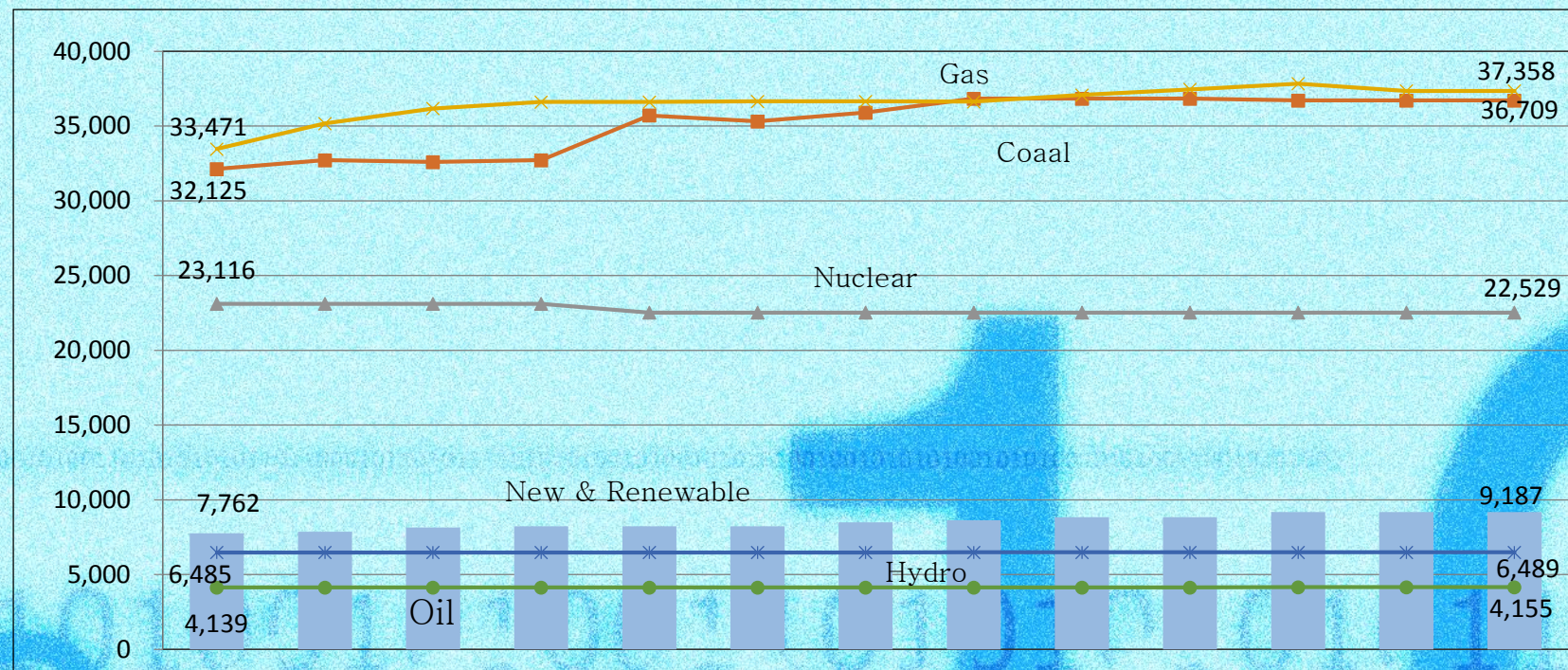
연도 Year	1980	2013	2014	2015	2016	2017
구분 Item						
설비용량 Facility capacity	9,391	82,296	93,216	94,102	100,180	116,657
공급능력 Supply capability	7,645	80,713	89,357	87,926	92,395	96,095
최대수요 Peak load	5,457	76,522	80,154	78,790	85,183	85,133
설비에비율 * Capacity R/R	72.1	7.5	16.3	19.4	17.6	37.0
공급에비율 * Capability R/R	40.1	5.5	11.5	11.6	8.5	12.9
발생일시 Peak Time	11.20(목) 18:00	1.3(목) 11:00	12.17(수) 11:00	2.9(월) 11:00	8.12(금) 17:00	12.12(화) 10:00



# 1. Supply pattern in Korea

## ◆ Trend of Generating Capacity by Source

(Unit : MW)

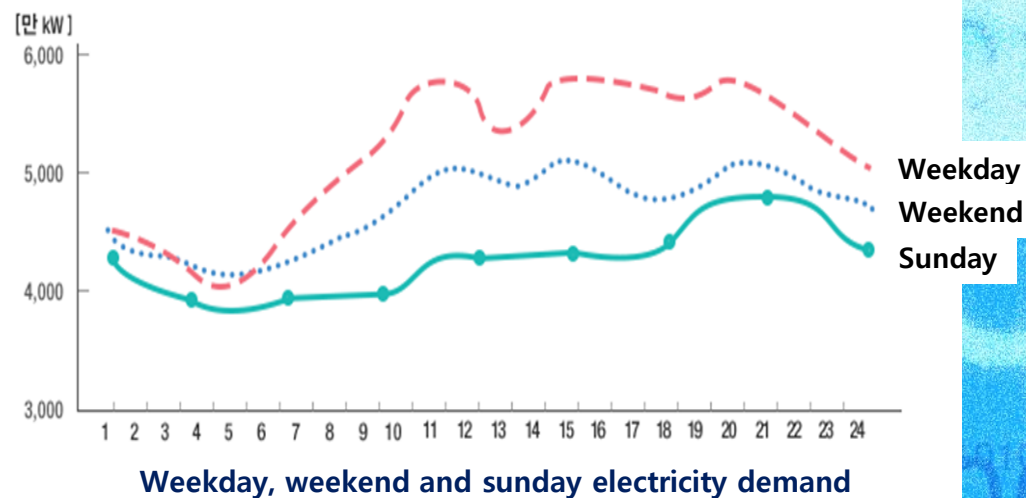
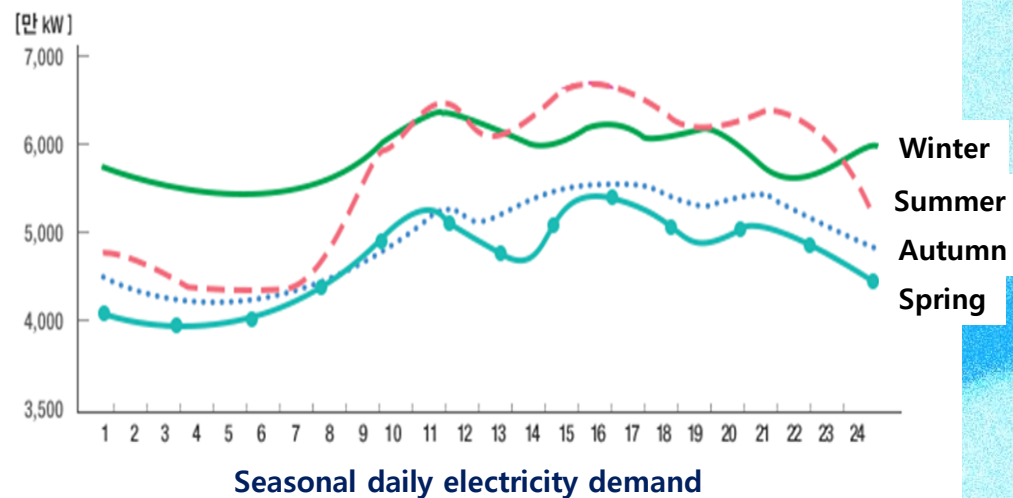
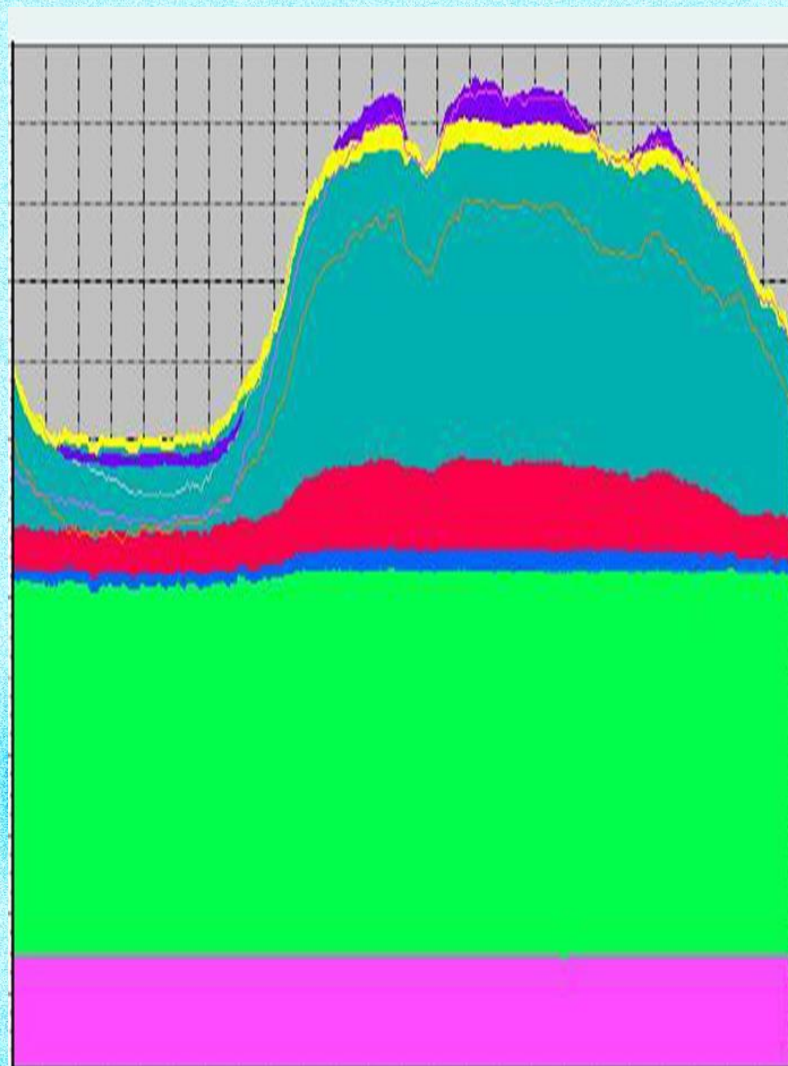


Year month	2017. 2	2017. 3	2017. 4	2017. 5	2017. 6	2017. 7	2017. 8	2017. 9	2017. 10	2017. 11	2017. 12	2018. 1	2018. T2
Facility cap.	107,098	109,493	110,671	111,292	113,705	113,351	114,206	115,249	115,900	116,278	116,908	116,428	116,428
Coal	32,125	32,720	32,595	32,713	35,711	35,311	35,906	36,832	36,832	36,832	36,709	36,709	36,709
Nuclear	23,116	23,116	23,116	23,116	22,529	22,529	22,529	22,529	22,529	22,529	22,529	22,529	22,529
Gas	33,471	35,172	36,180	36,611	36,611	36,657	36,657	36,633	37,076	37,454	37,838	37,358	37,358
Hydro	6,485	6,485	6,484	6,484	6,484	6,484	6,485	6,487	6,487	6,487	6,489	6,489	6,489
Oil	4,139	4,139	4,139	4,139	4,139	4,139	4,139	4,139	4,139	4,139	4,155	4,155	4,155
Renewable	7,762	7,862	8,158	8,228	8,231	8,231	8,490	8,628	8,837	8,837	9,187	9,187	9,187



## 2. Demand pattern in Korea

### ◆ Power Electricity demand pattern in Korea

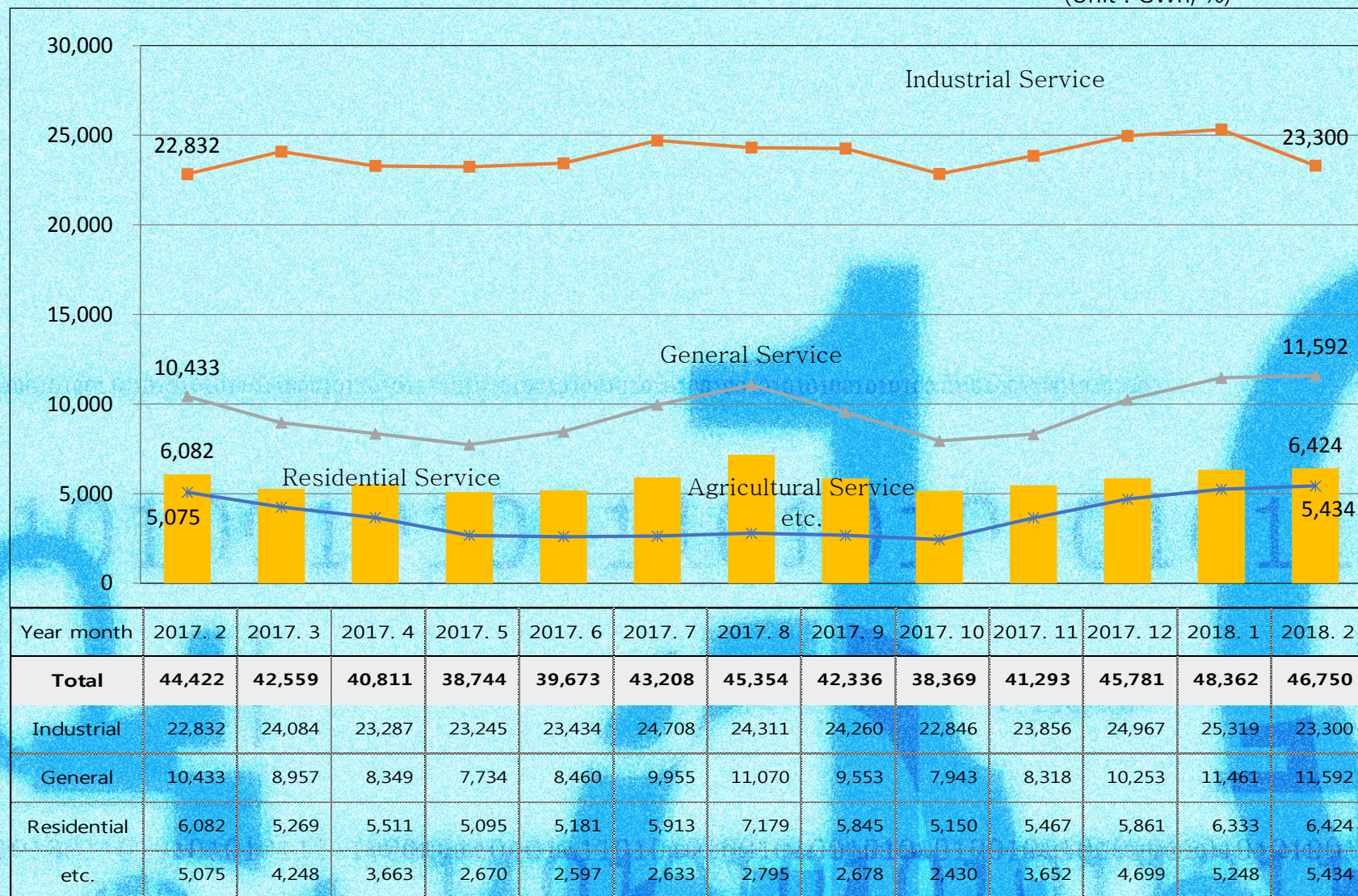




## 2. Demand pattern in Korea

### ◆ Trend of Power Sold by Segments

(Unit : GWh, %)





## 2. Demand pattern in Korea

### 2011. 9. 15 Large-scale power outage situation

Rapidly increasing power demand, the power reserve is less than or equal to 3 million kW in 13:10, with the following two million kW to 25 minutes, And plummeted to 1 million kW or less in 35 minutes, power exchanges distribution transformer tap adjustment (12:50, 1 million kW), **an autonomous power-saving (14:01, 950,000 kW), direct load control (14:01, 890,000 kW) correspondence.** [9.15 Electric Newspaper]





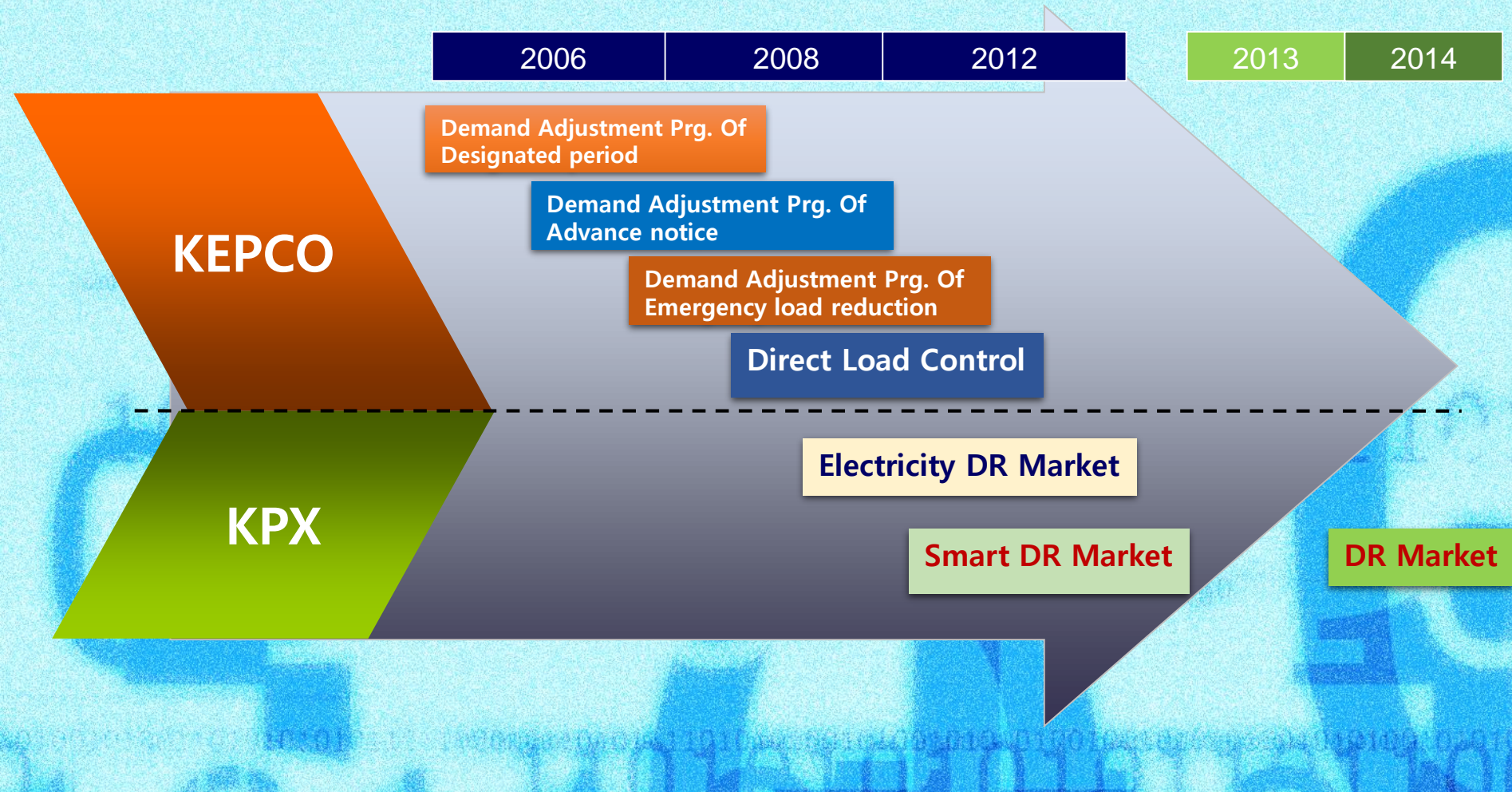
## Part 2

# Demand Response in Korea



# 1. Demand Response Program

## ◆ History of DR program





# 1. Demand Response Program

## ◆ Past DR Business

### ○ Program improvement : (from 2008 summer)

- Existing schemes: specified period of time, the weekly notice, emergency power-saving, direct load control system such as
- The bid to kpx with fixed price different method the existing system (in the case of the above item 1)
- After bidding, paid the amount of money that has been successful bid for the bid has been consumers (market introduction of the system)
- Demand Response Company is appeared

#### Power System Status

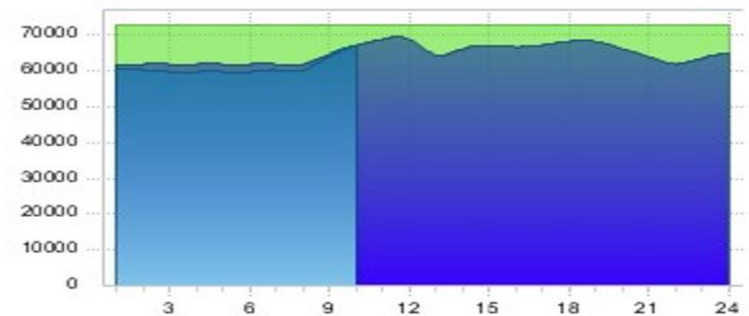
2010.01.12 10:24

▶ MORE

##### Grid Status

Supply Cap.	72,957MW	Demand	68,408MW
Forecast D.	68,663MW	Reserve	4,549MW

SMP (Won/kWh)	Max.	Min.	Average
	252,78	107,91	135,14



### ○ Improvement purposes:

- Business expansion for consumers load (recognition of the importance and necessity, case benchmarking overseas)
- Preparation of Smart Grid, which is based real-time pricing
- Prepare a deal with the same treatment as the power supplied the future of consumer
- Ensure the good quality of consumer members



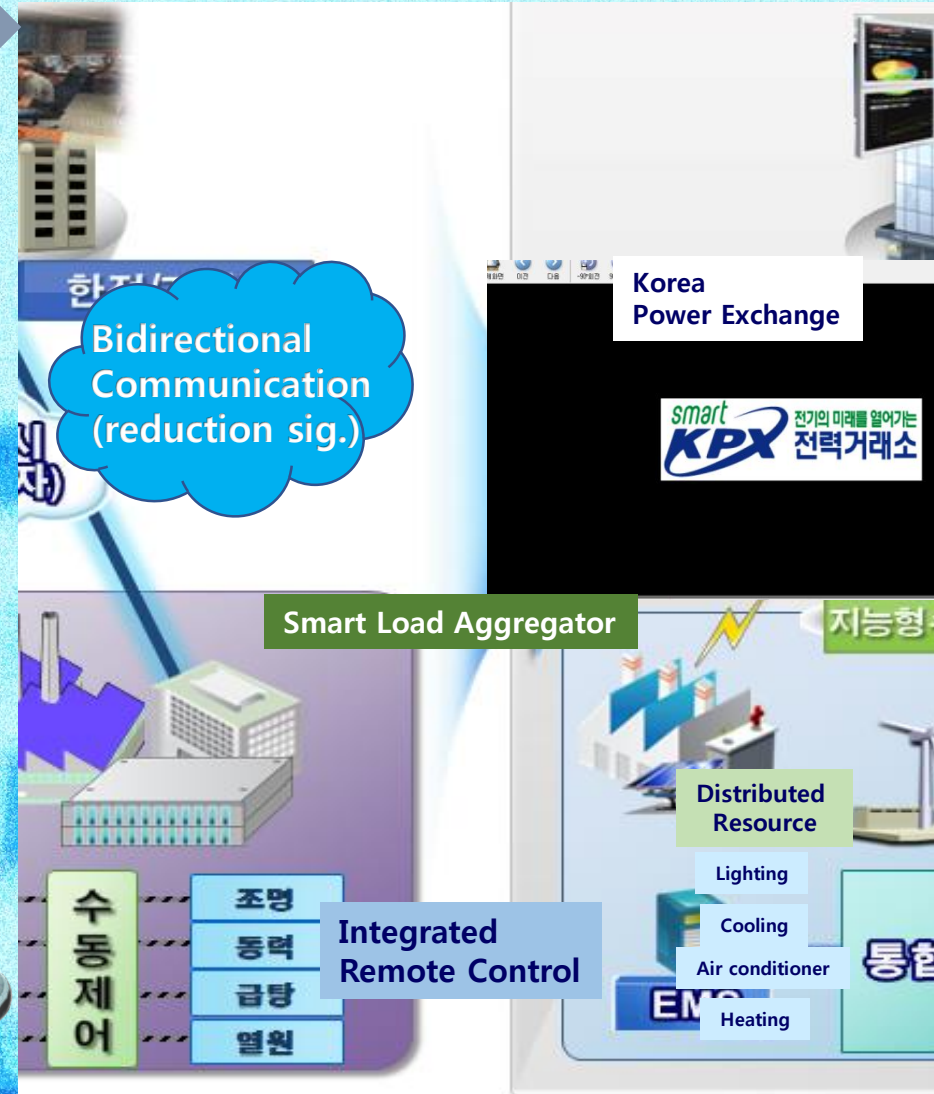
# 1. Demand Response Program

## ◆ Past DR Business

### Smart DR market outline

- Customers to contract to reduce demand  
Case of a power shortage, the reduction of demand by the instructions on the Exchange
- Payment of capacity charges for the quarter contract capacity
- During the reduction of demand, reduction charges (incentives) paid
- 1 year 30 times, limit of 60 hours  
The 1st reduction once 2-4 hours load commitments
- Contract of 1 year unit  
(2012 opened in July-December)
- Capacity price is determined by the bid  
Maximum 641,000 won ~ 161,000 won lowest / kW- year
- Reduction of financial support: the level of the best 550 won / kW
- Capacity fee reduction when contract breach (less than 80%)

### <Smart DR Concept map>





## 2. Demand Response Market

### Appearance of new Demand Response Market

#### ➤ Technical characteristics between resources

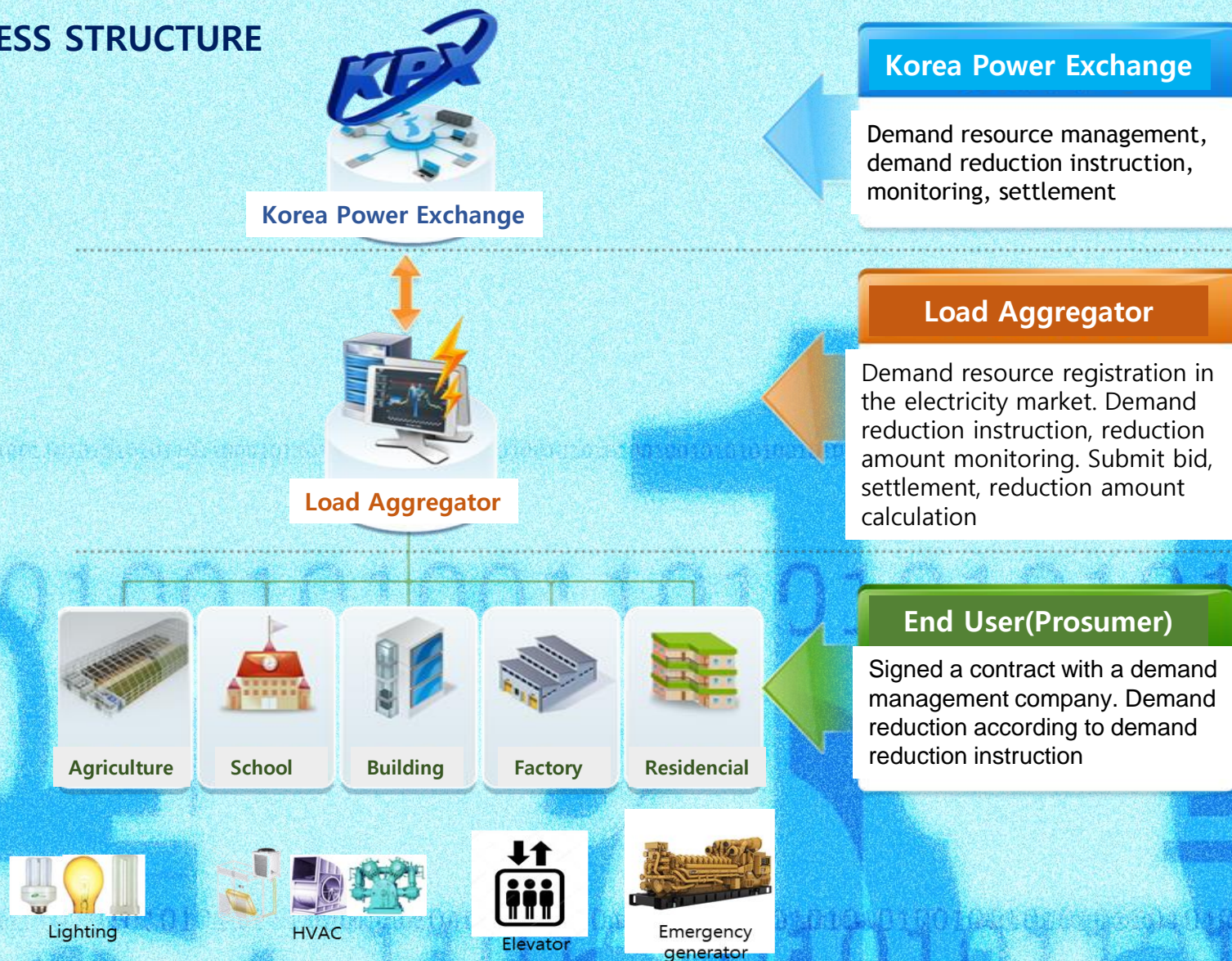
And recognized technical differences between or resources equate the demand's Council and power resources

	(Peak Shaving DR) Reliability DR	(Payment Saving DR) Economic DR	Generator (LNG)
Electricity trading	<b>Mandatory Reduction Capacity(kW)</b>	Reduction Energy(kWh)	Supply Capacity, Generaton Energy, Ancillary Service
Reduction possible time	<b>Except weekend, holliday workday 9am~8pm (except 12~13)</b>	<b>Everyday except weekend, holliday</b>	Every hours except overhaul or fault state
Response Time	<b>1 hour Ahead</b>	1 day Ahead	1 hour ahead(Hot)
Reduction Duration	<b>Max 4 hours/ Min 2 hours</b>	Bidding	Continue/ Min. 2 hours
Mandatory reduction hour	<b>60 hours/year</b>		Continue
Reduction Times	<b>Max 2 times/ day</b>		Operating generation Plan



## 2. Demand Response Market

### BUSINESS STRUCTURE





## 2. Demand Response Market

### Basic Settlement unit Price, monthly (2017)

Calculated based on unit price of existiong generator capacity market

2017-1 Basic Settlement unit Price (Won/kW)			19,894.70	2017-2 Basic Settlement unit Price (Won/kW)			22,779.43
(2017.1.1 ~ 2017.6.30.)				(2017.7.1 ~ 2017.12.31.)			
. Monthly Basic Settlement unit price(Won/kW-m)				. Monthly Basic Settlement unit price(Won/kW-m)			
Month	Unit price	Remark(day)		Month	Unit price	Remark(day)	
January	4,994.68	20		July	5,395.95	21	
February	4,475.45	20		August	4,930.56	22	
March	3,767.84	22		September	3,694.44	21	
April	1,462.24	20		October	1,142.18	16	
May	1,335.86	20		November	2,919.16	22	
June	3,858.63	21		December	4,697.14	19	
Total	19,894.70	123		Total	22,779.43	121	



### 3. Technology in Demand Response



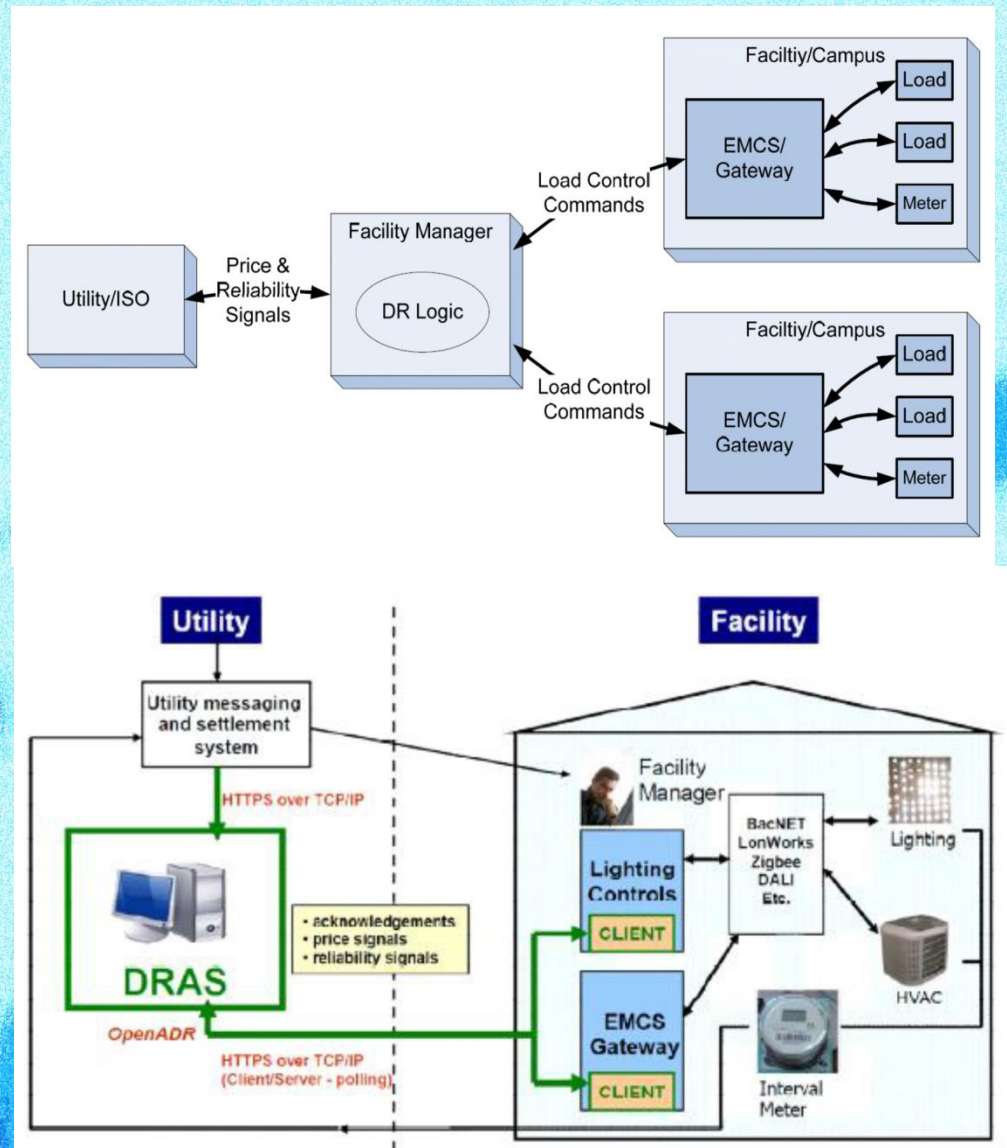
#### OpenADR

(Open Automated Demand Response)

: standard communication protocol of demand response

1) C&I energy management or control system for domestic electricity demand use automated DR to utilize communication standard

2) OpenADR applied at KPX, PG&E, SCE, SDG & E and other electric utilities

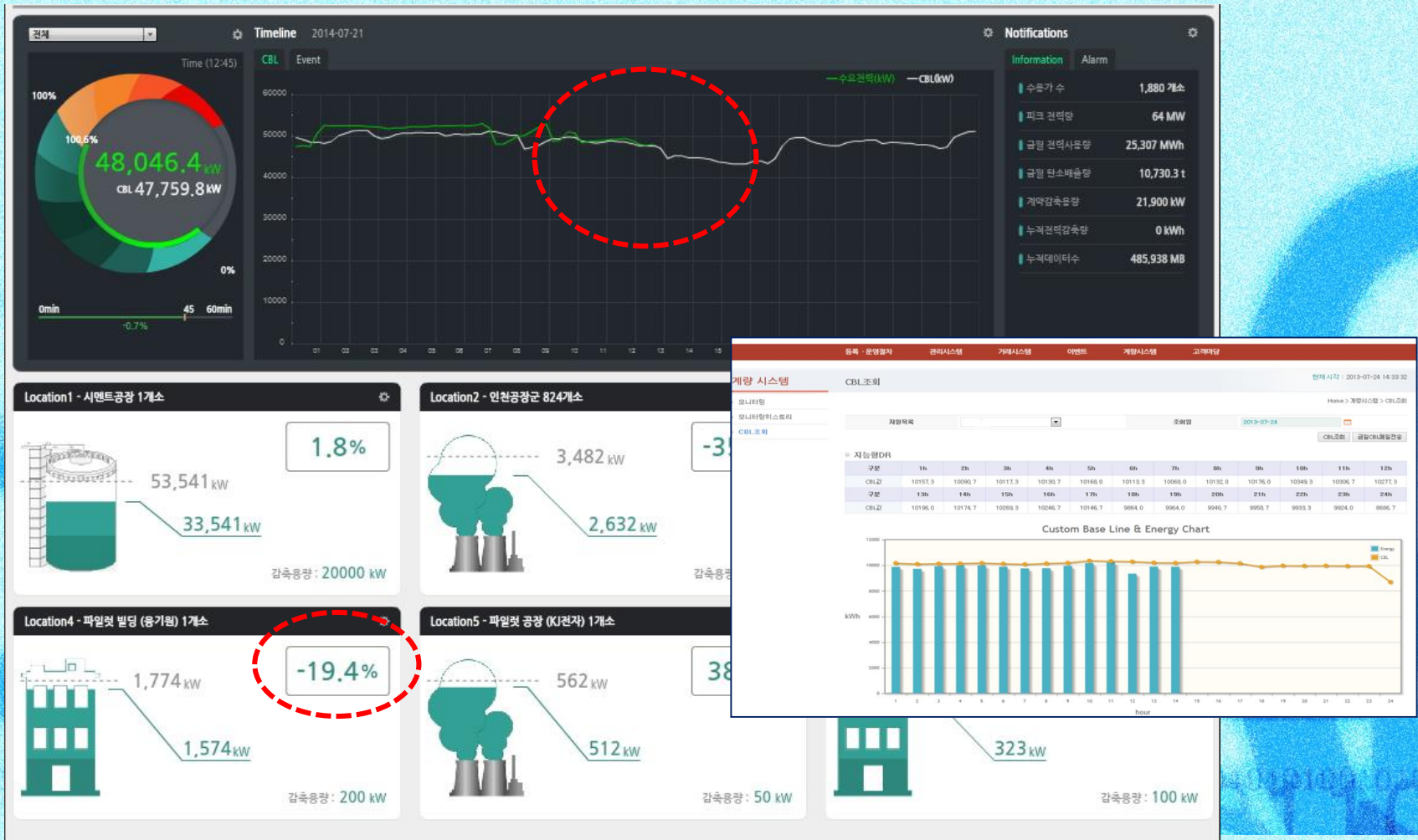




### 3. Technology in Demand Response

#### ► DR Resource Real-time Monitoring

Comparison of power usage in real time with CBL of the day: It is possible to decide whether or not to reduce additional, real-time results can be confirmed





### 3. Technology in Demand Response



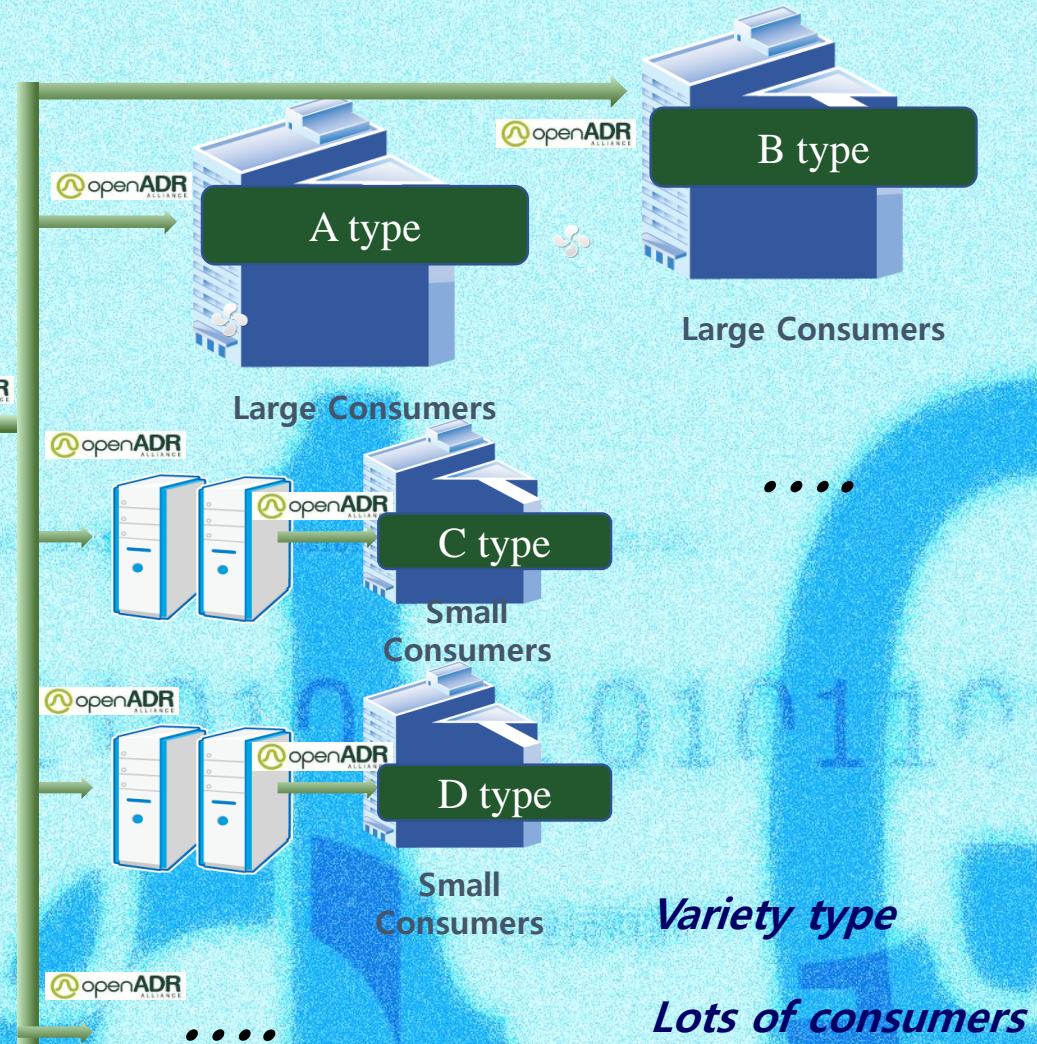
#### Designing Portfolio



**Load Aggregator**  
*(Total Operation Center)*

#### Competitiveness of Load Aggregator

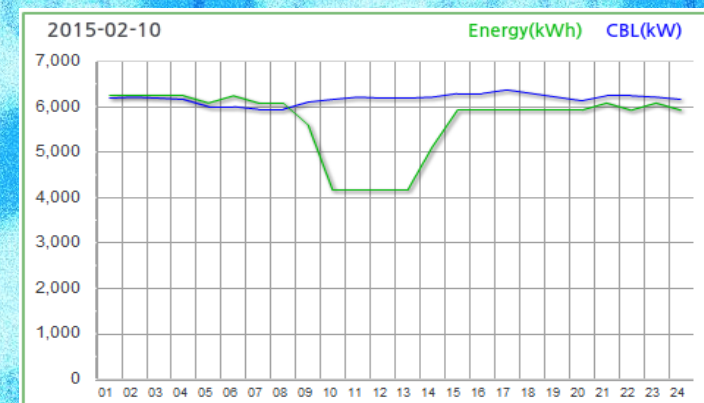
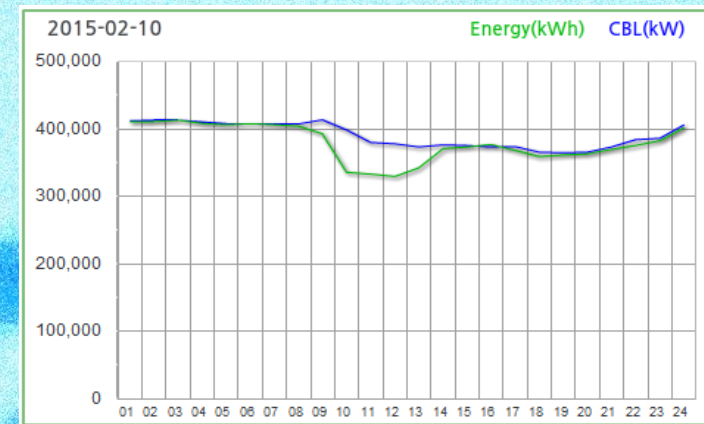
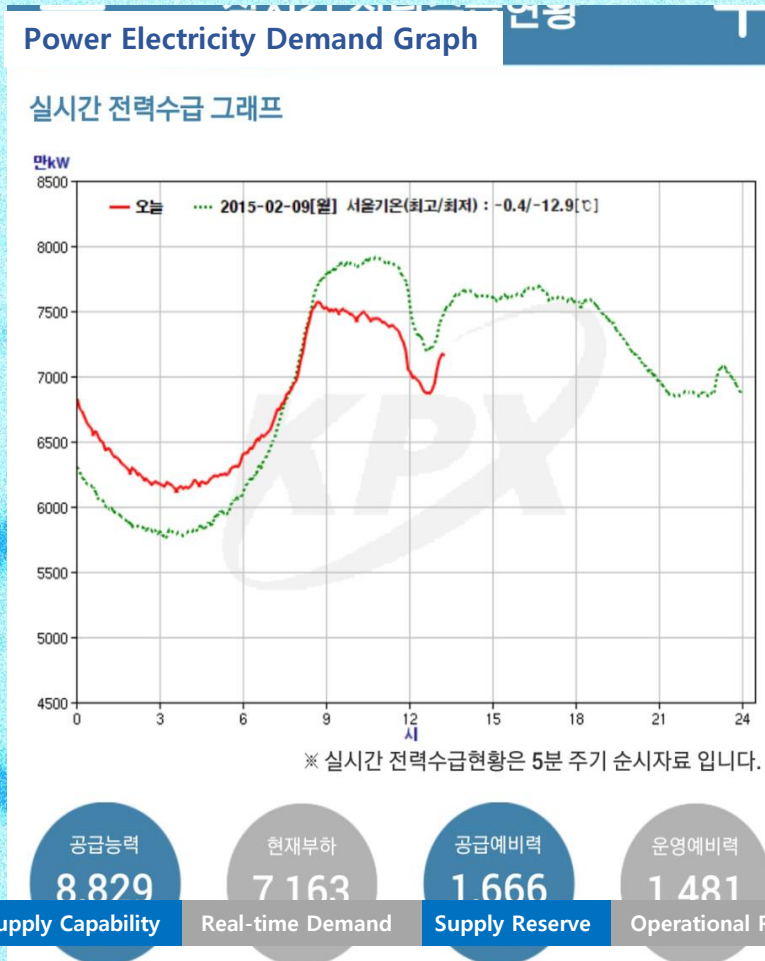
- 1) Integrated CBL Optimal Management
- 2) Understanding/analysis of each consumer characteristics
- 3) Forecasting of variability by consumer schedule
- 4) Efficient utilization of reserve resources(consumer)





## 4. Performance in Demand Response

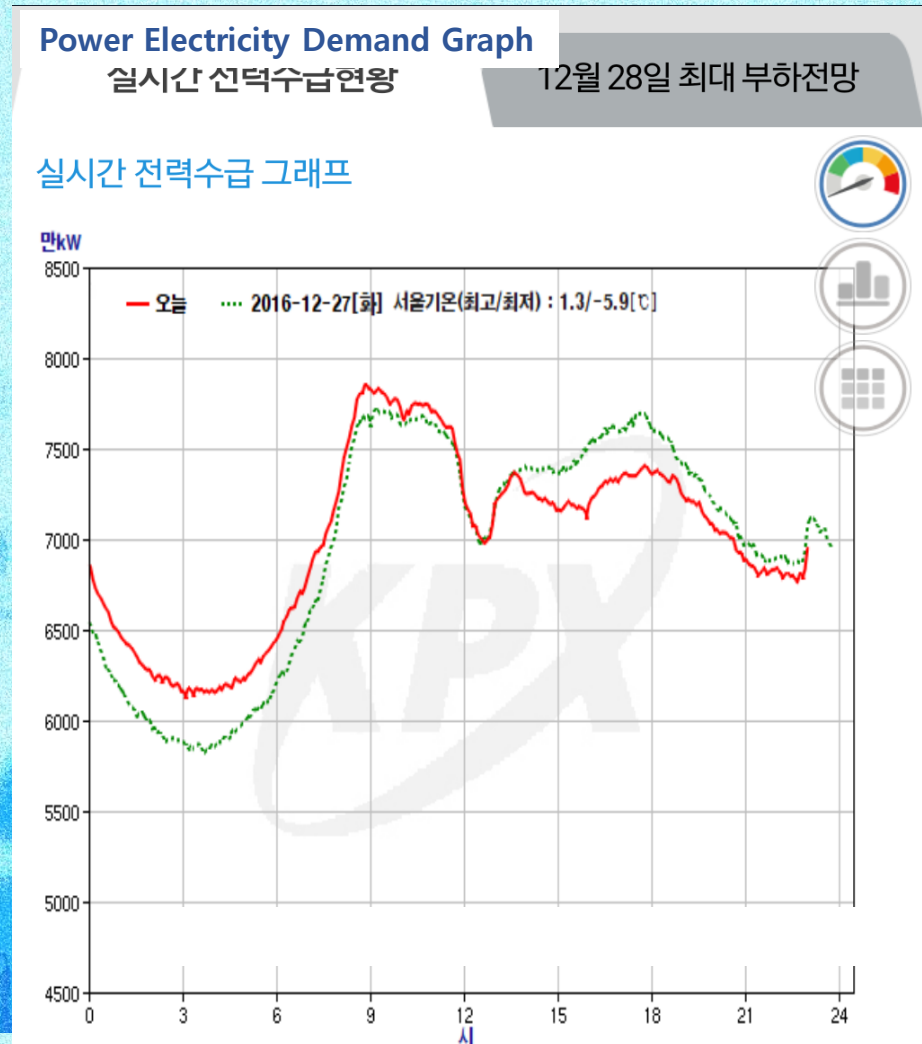
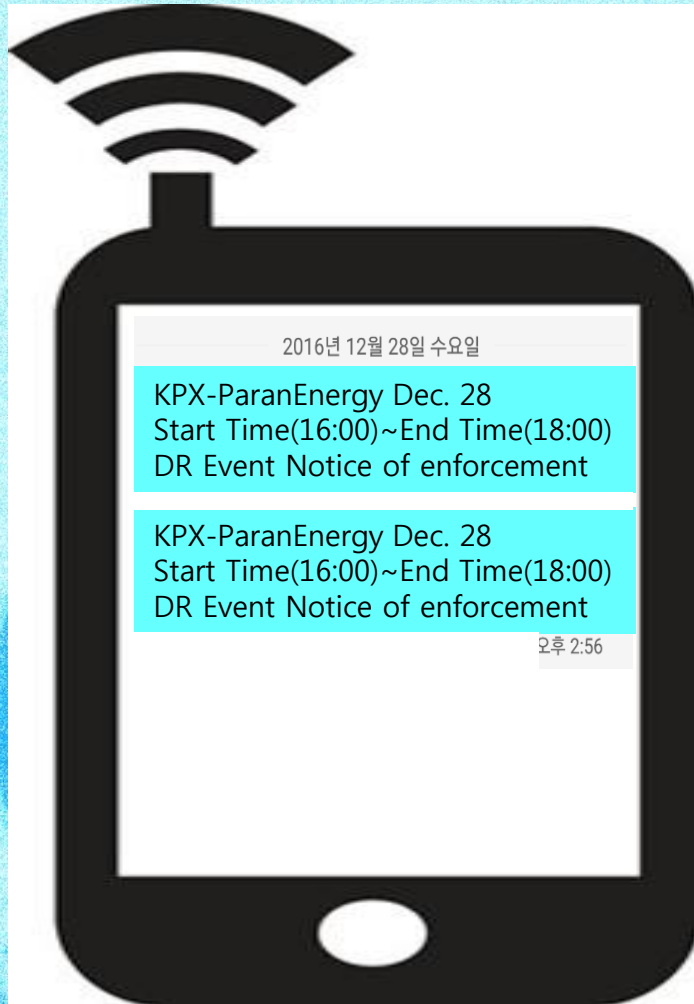
Result by reduction of consumer or DR players on February 10, 2015 in response KPX request reduction instruction.  
From 09:00, it shows high performance with active participation.





## 4. Performance in Demand Response

Dec.28, 2016 14:00~18:00 (4h) Participation Result at winter reduction test  
Give a graph of issuance and participation status



※ 실시간 전력수급현황은 5분 주기 순시자료입니다.  
(단위 : 만kW, %)



## Part 3

# Building Energy Management

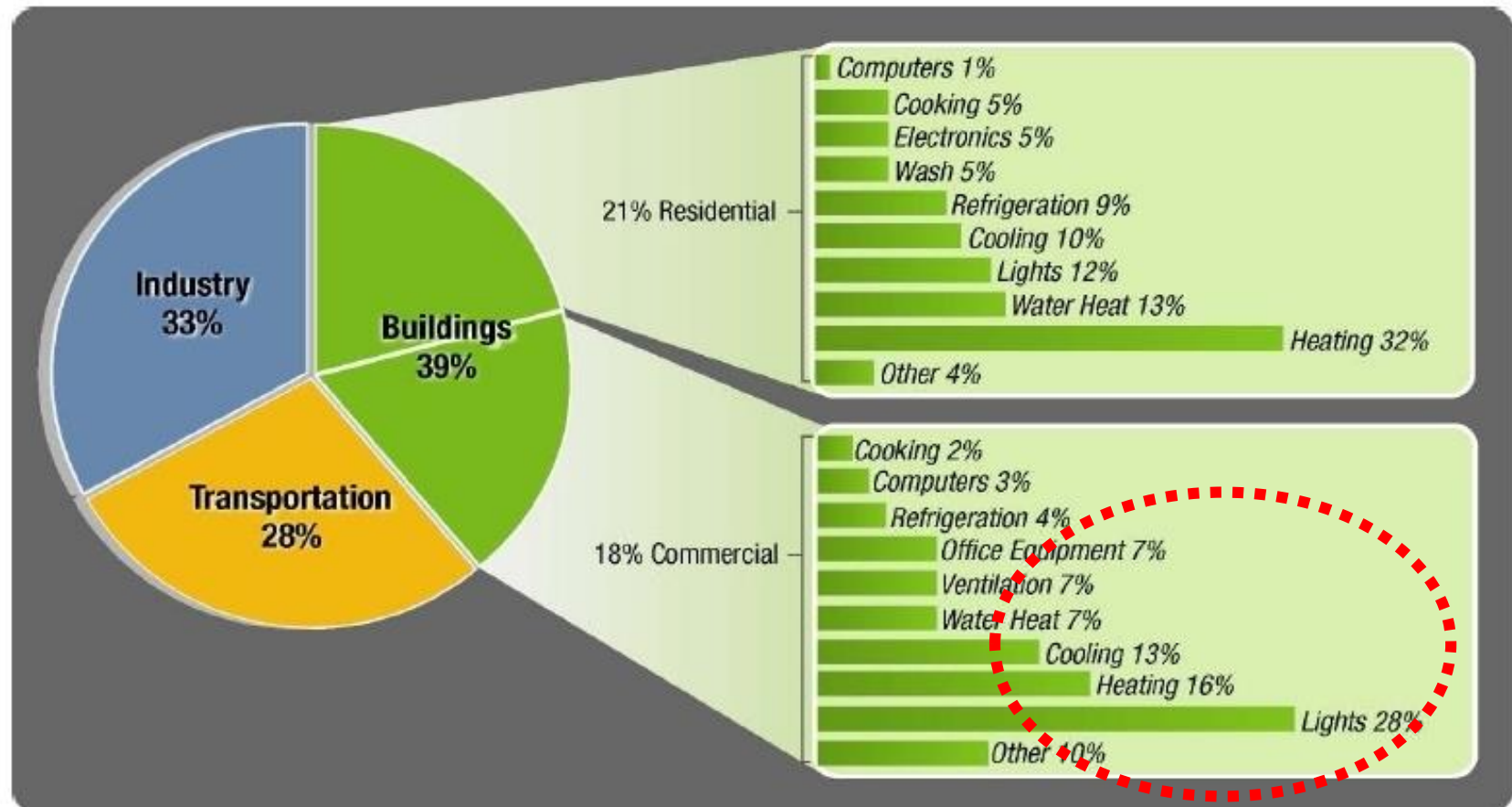


# 1. Building Power Demand

## US building energy use classification

**Buildings consume 39% of total U.S. energy**

• 71% of electricity and 54% of natural gas



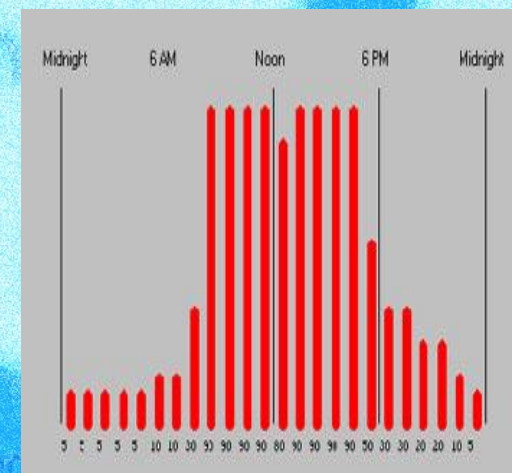
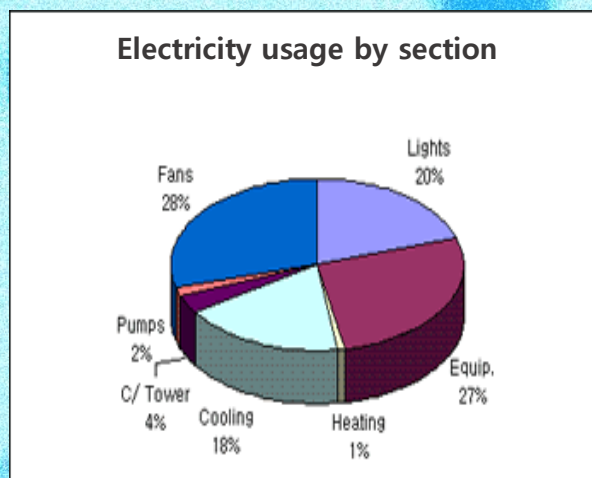


# 1. Building Power Demand

DR potential can be estimated through building energy use classification

- ❑ N Bldg.
- ❑ Electricity Usage  
5,160.0 [MWh]/Year
- ❑ Part by usage :  
Fan 28%  
Outlet(27%),  
Lighting(20%),  
Cooling(18%),  
Cooling tower(4%)

Classification	Content
Property	Center commercial, urban redevelopment
Area	1,232.34 m <sup>2</sup>
Use	Office, lease
Information	Underground 2-6 Floor: Parking underground first floor: dining room, parking, ground first floor: lobby, bank, ground floor 2-18: bank, office



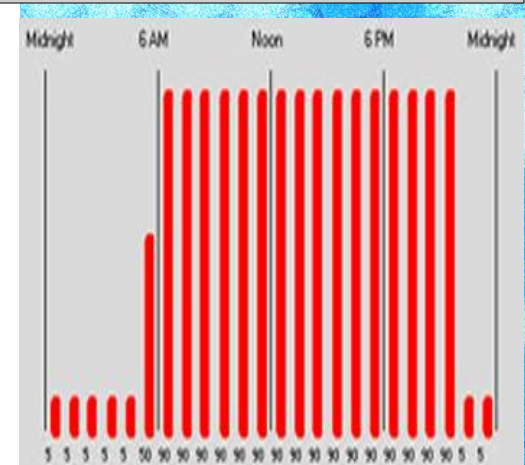
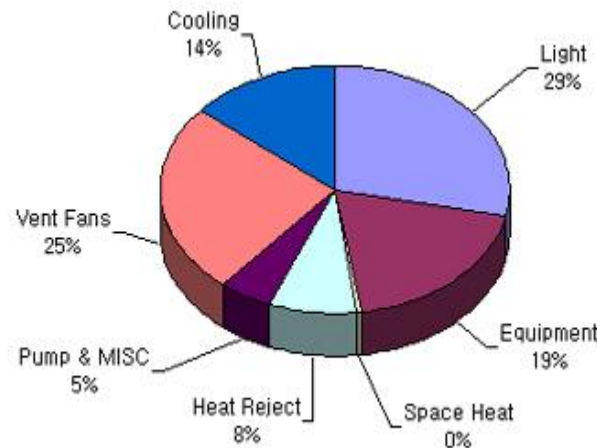


# 1. Building Power Demand

DR potential can be estimated through building energy use classification

- ❑ **C Bldg.**
- ❑ **Electricity Usage**  
**14,441 [MWh]/Year**
- ❑ **Part by usage :**  
**Lighting(29%),**  
**Fan(25%),**  
**Outlet(19%),**  
**Cooling(15%),**  
**Cooling tower(8%),**  
**Pump(4%)**

Classification	Content
Property	Commercial area and one aesthetic area
Area	5,202 m <sup>2</sup>
Use	Office, newspaper, gallery (1720m <sup>2</sup> ), Art Hall (866 seats)
Information	The ground 21 floors + basement fourth floor + octa Puchun (highest height 107M) standard floor of floor height 4.2M





# 1. Building Power Demand

□ **General Power(B), Industrial Power(B)** : Contract power 300kW or more

Classification		Demand Charge (per kW)	Energy charge (per kWh)			
			Time zone	Summer (Jul~Aug)	Spring /Autumn (Mar~ Jun, Sep ~Oct)	Winter (Nov~ Dec)
High Voltage [A]	Option 1	6,990	Off-peak	59.10	59.10	65.30
			Mid-peak	112.20	82.40	110.40
			On-peak	192.50	112.40	165.60
	Option 2	8,050	Off-peak	53.80	53.80	60.00
			Mid-peak	106.90	77.10	105.10
			On-peak	187.20	107.10	160.30
High Voltage [B]	Option 1	6,420	Off-peak	57.50	57.50	63.60
			Mid-peak	109.90	80.60	108.00
			On-peak	189.40	110.20	161.90
	Option 2	7,140	Off-peak	53.90	53.90	60.00
			Mid-peak	106.30	77.00	104.40
			On-peak	185.80	106.60	158.30

Time zone	Summer	Spring /Autumn	Winter
	Jul~Aug	Mar~ Jun, Sep~Oct	Nov~Dec
Off-peak	23:00~09:00	23:00~09:00	23:00~09:00
Mid-peak	09:00~11:00	09:00~11:00	<a href="#">09:00~10:00</a>
	12:00~13:00	12:00~13:00	<a href="#">12:00~17:00</a>
	17:00~23:00	17:00~23:00	<a href="#">20:00~22:00</a>
On-peak	11:00~12:00	11:00~12:00	<a href="#">10:00~12:00</a>
	13:00~17:00	13:00~17:00	<a href="#">17:00~20:00</a> <a href="#">22:00~23:00</a>



## 2. Building DR Potential and system

### ◆ Building DR Potential & Resource in Korea

Building	Peak Demand (kW)	Ratio year (%)	Demand Response quantity [kW]	Ratio equipment (%)	Demand Resource	Emergency Generator [kW]
A bldg.	2,757	7.25	200	18.14	HVAC	1,000
B bldg.	7,572	3.81	288.5	18.29 -	Lighting Freezing	6,250
C bldg.	480	10.4	50	52.1	Air conditioner	500
E bldg.	991	4.57	21.96	6.7 3.03	HVAC Lighting	500
F bldg.	1,757	2.28	40	7.59	Lighting	650
H bldg.	1,956	3.22	63	8.44 -	HVAC Frozen	1,500
I bldg.	1,829	5.63	103	13.67 8.74 10.93 0.82	Cooling Air condi. Fountain Lighting	1,500
J bldg.	3,198	8.16	261	60.67 6.25 4.63	Freezing HVAC Other power	2,000
K bldg.	1,633	6.87	112.5	5.74 17.61 7.65	Lighting Cooling Other power	1,000

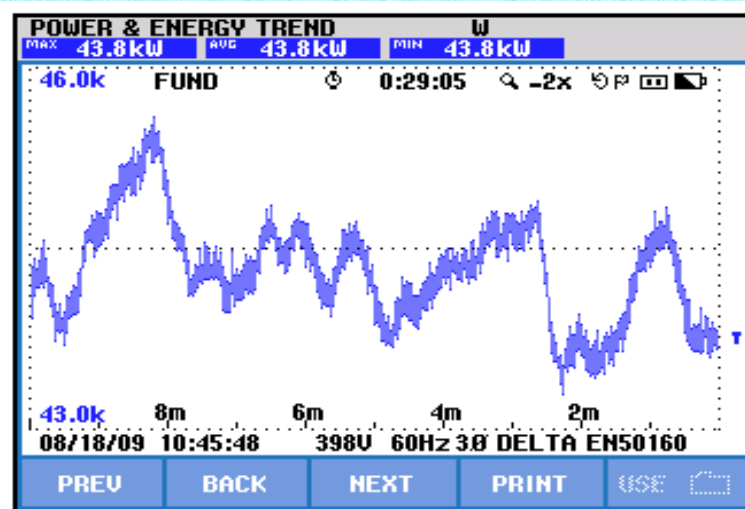


## 2. Building DR Potential and system

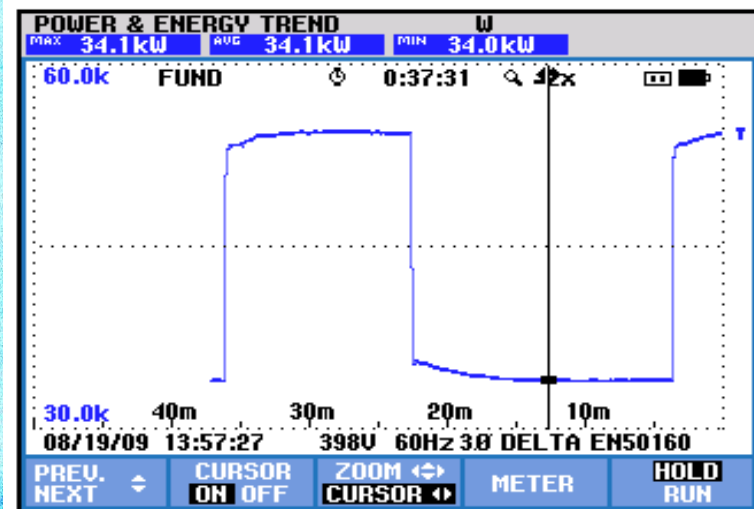
The main part of building consists of the HVAC. Air conditioners for the office compressor 7.5KW \* 2 units and blower which is composed of 3.75KW every floors.

Measurement Data is office, for cooling air conditioner 2 Set (air conditioners 1set compressor 7.5KW \* 3 units, blower Measured in all the configuration) has been bitten by 5.5KW. Spec. Power 56KW (28KW \* 2 set), the combat force. It is an average 44.5KW.

To have refrigerator measurements are used for the cooperation of the building (Spec.99.1KW, refrigerating capacity 333,500kcal / Hr)  
The measured refrigerator that is operated with a Cycle.  
Average combat force that it is a 45KW.



<Freezer, Power trend 1>

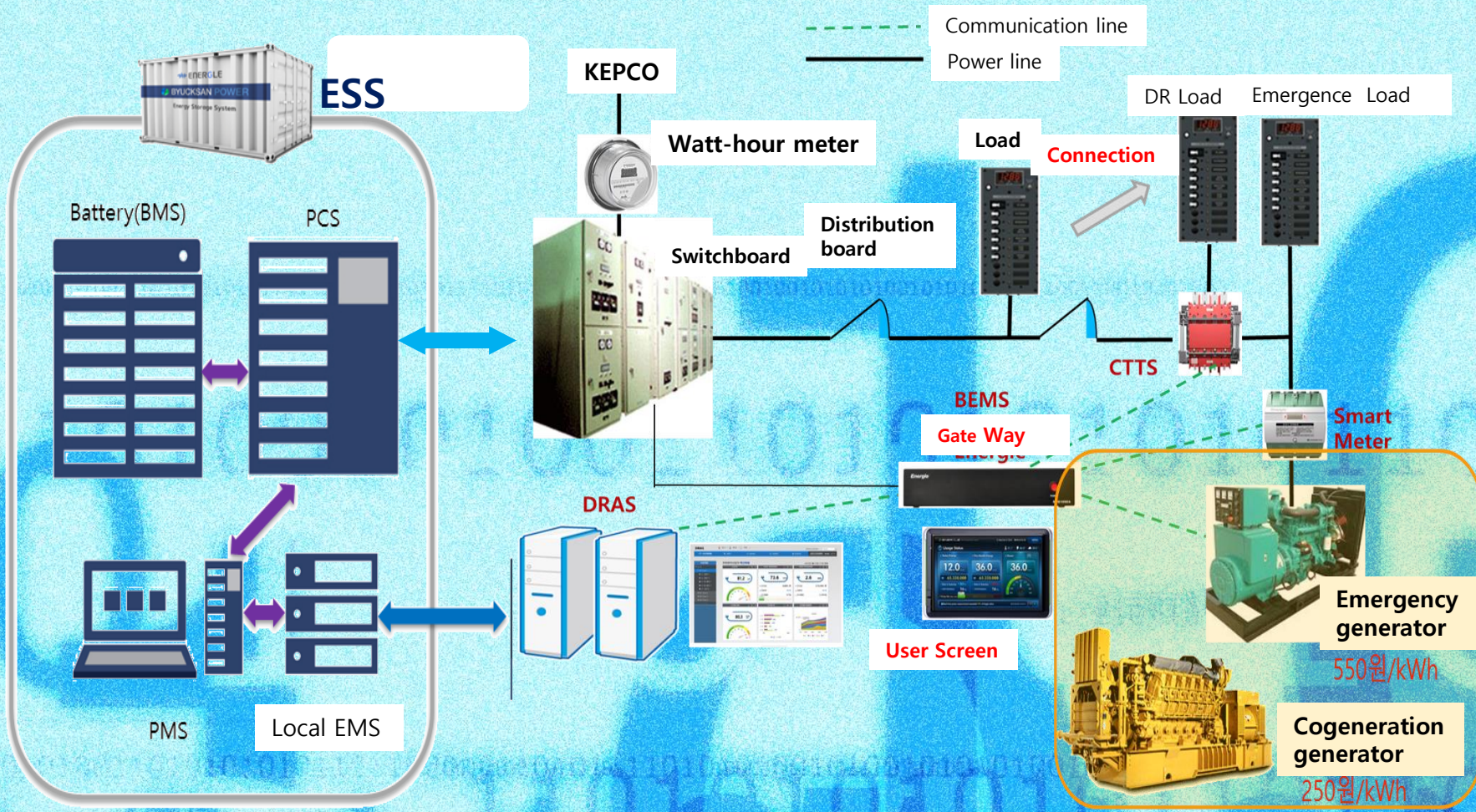


<Air conditioner, Power trend 2>



## 2. Building DR Potential

Cogeneration generators and emergency generators, ESS is available to be replaced DR resource. Then Fuel cost, wiring correction, instantaneous power failure and so on are needed essentially.





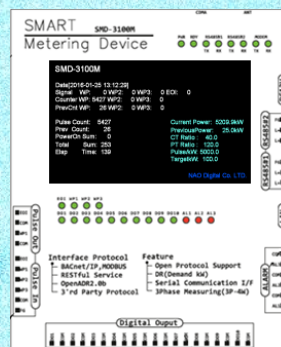
## 2. Building DR Potential and system

Directly to the Electricity meter for requirements and KPX and LA receive real-time electric usage data through wired/wireless (CDMA or LTE-m)



KEPCO Power meter

WP  
EOI  
GND



Protocol Interface

Pulse (single)	15min data:0~95 date:96,97,98 mode:99	0: 15Min	1: 5Min1st 2: 5Min2nd 3: 5Min3rd	과거 99일까지 읽기가능 (addr 100 단위/일)
kWh (float)	15min data:0~190 date:192,194,196 mode:198	4: 15Min	5: 5Min1st 6: 5Min2nd 7: 5Min3rd	과거 49일까지 읽기가능 (addr 200 단위/일)

5-minute power meter reading

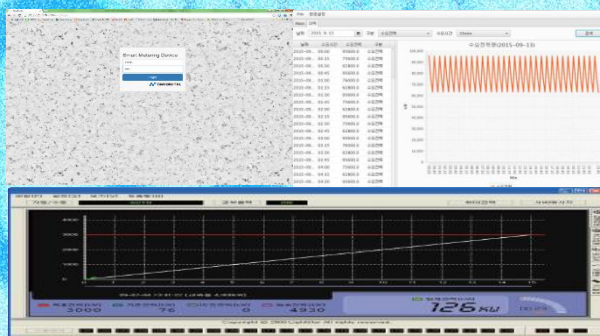
Wired or CDMA network  
Real-time data transfer



Data

Expression(Web)

- REST ful Service



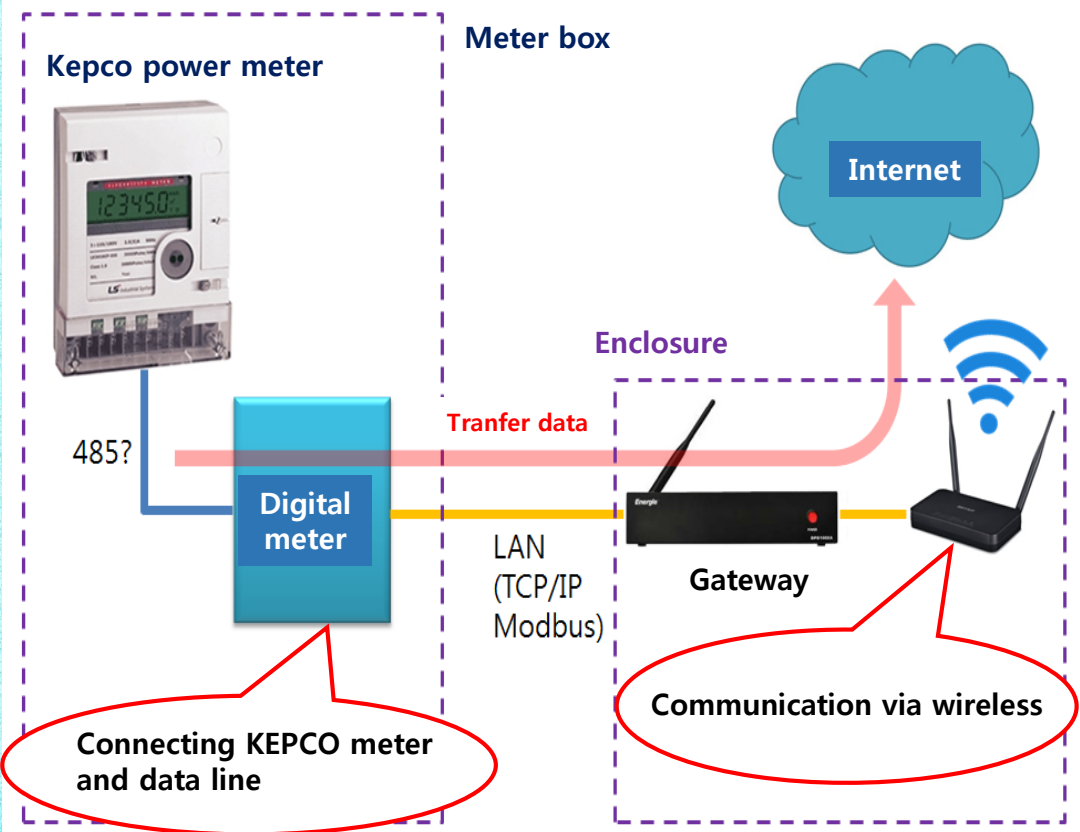
Operating Monitoring



## 2. Building DR Potential and system

5-minute data can be utilized in addition to power exchange market requirements

Diagram of Power-meter System





## Part 4

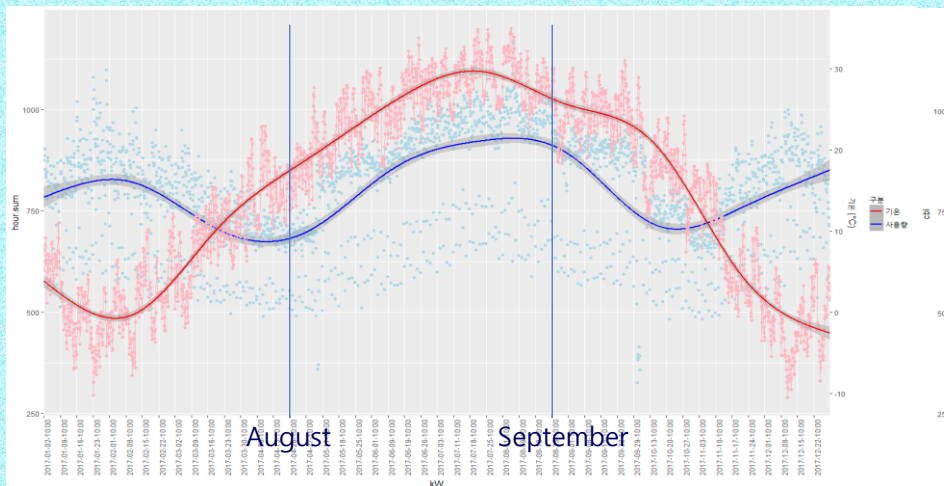
# Bldg. DR based on Big Data



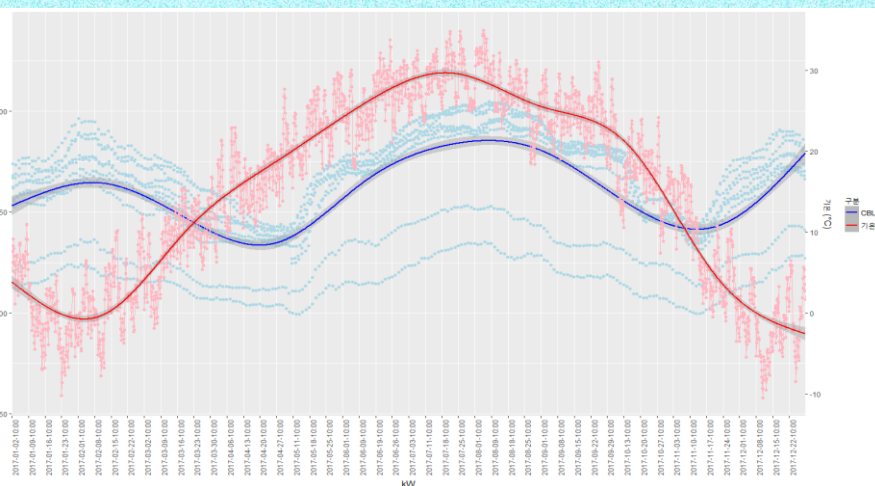
# 1. Building Data analysis

## 13,000kW (Capacity Power) Office Building in Seoul

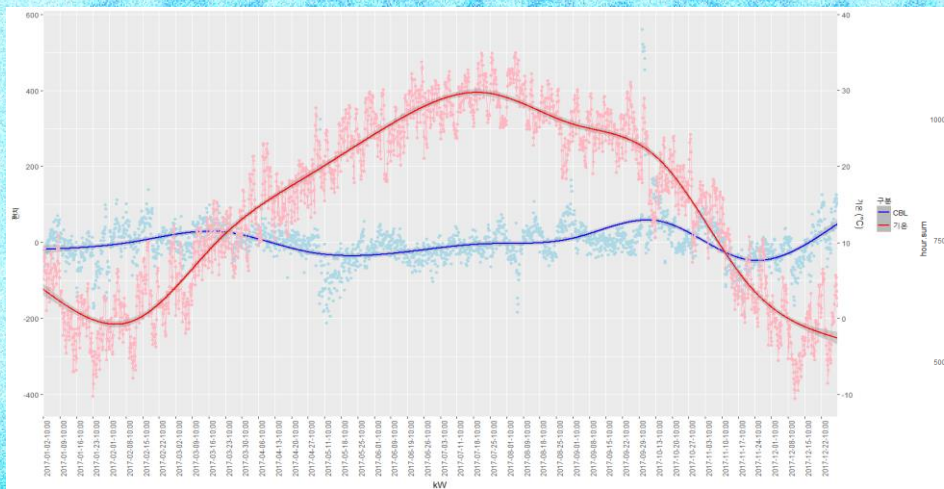
Electricity quantity Temperature



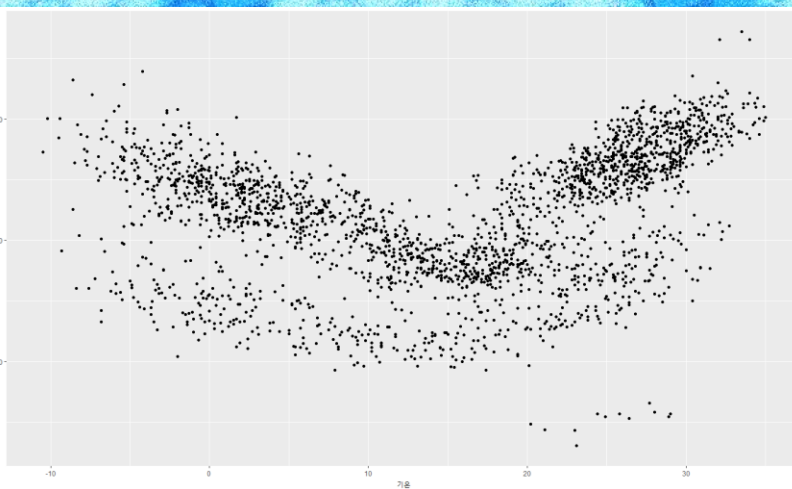
CBL(Customer Load Baseline) Temperature



Electricity quantity – CBL Temperature



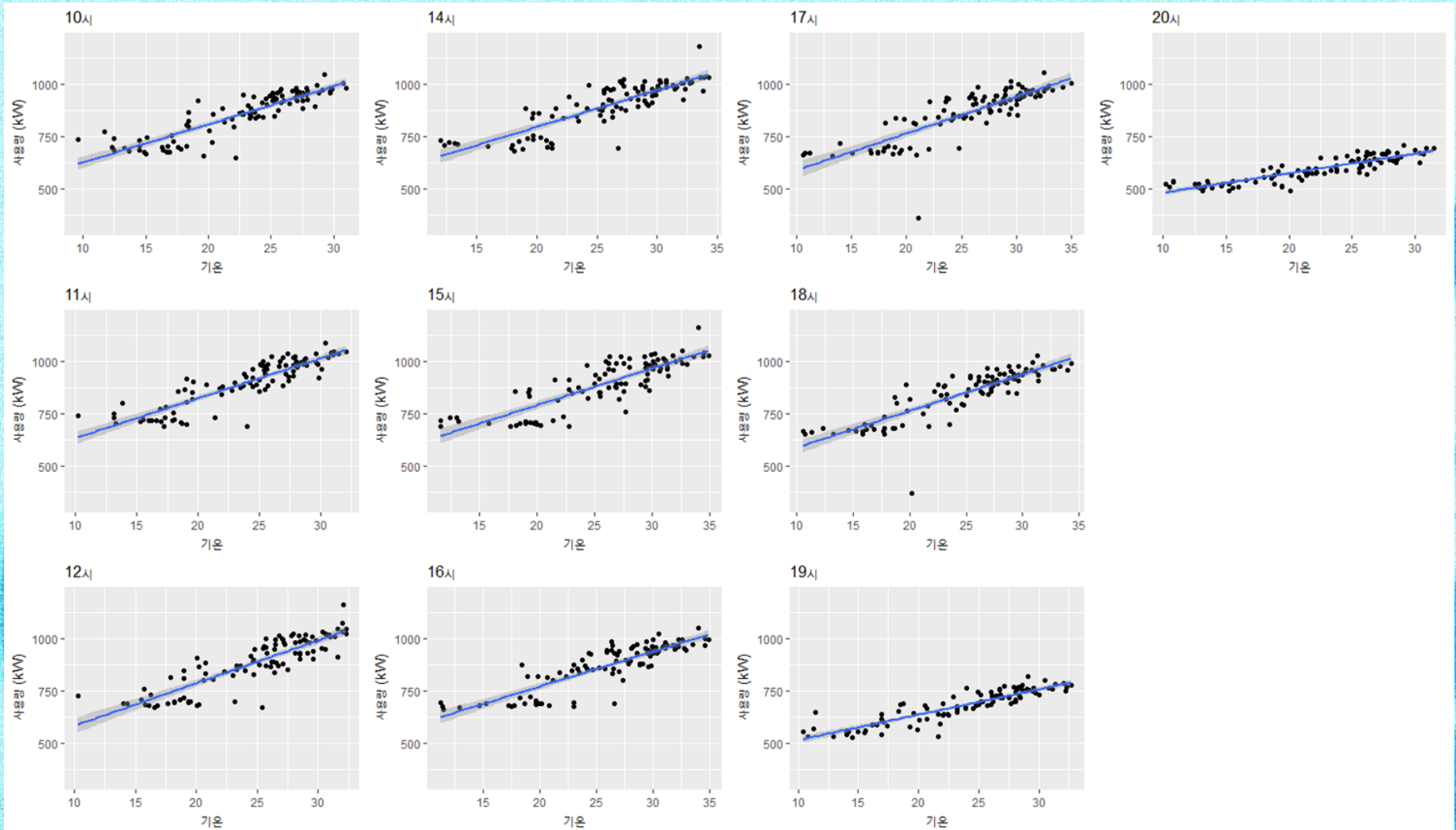
Y : Electricity quantity, X : Temperature





# 1. Building Data analysis

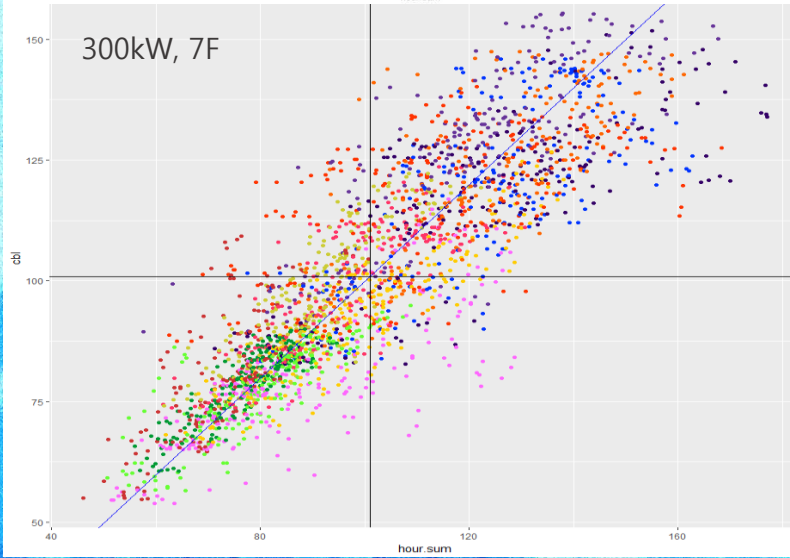
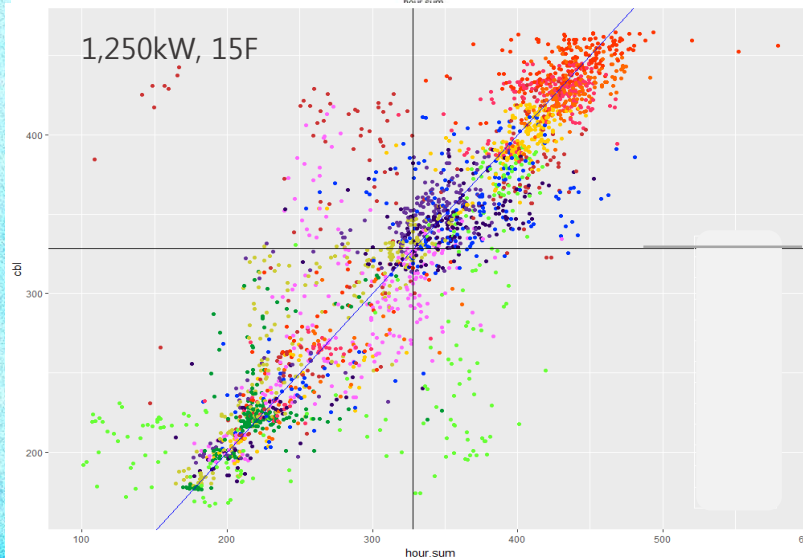
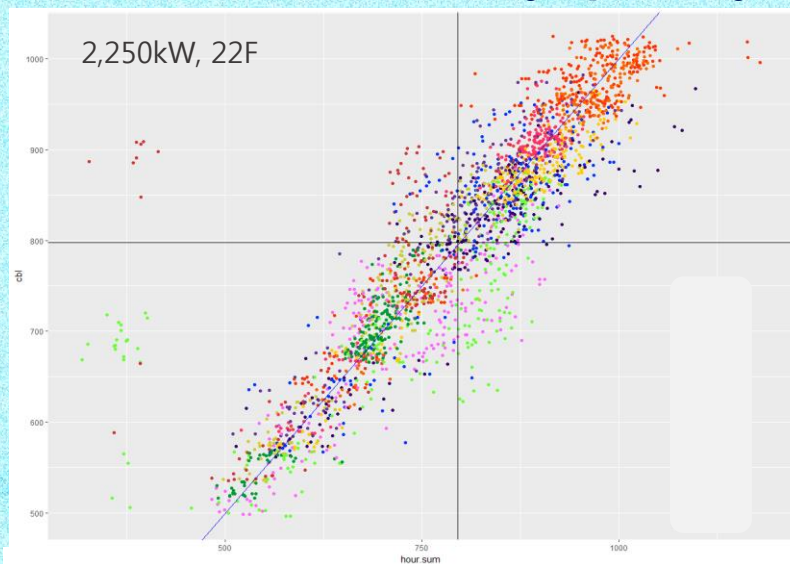
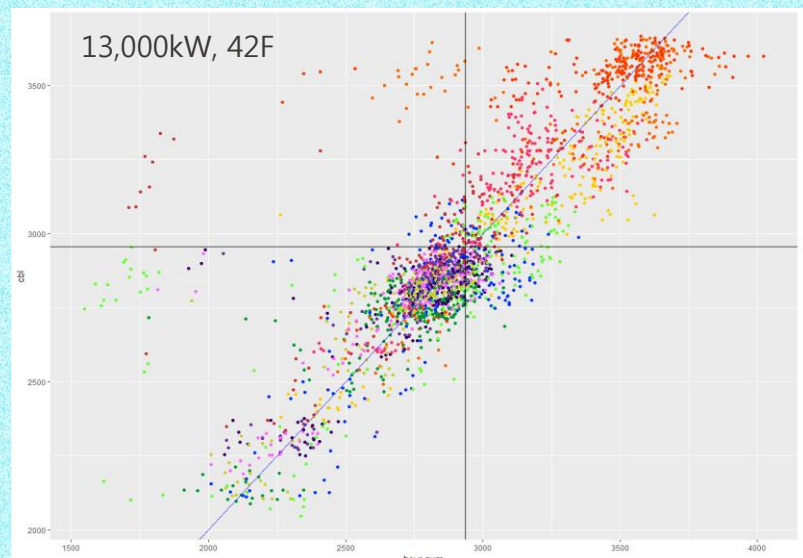
## Correlation between Electricity quantity and Temperature, hourly (April~August, 2017)





# 1. Building Data analysis

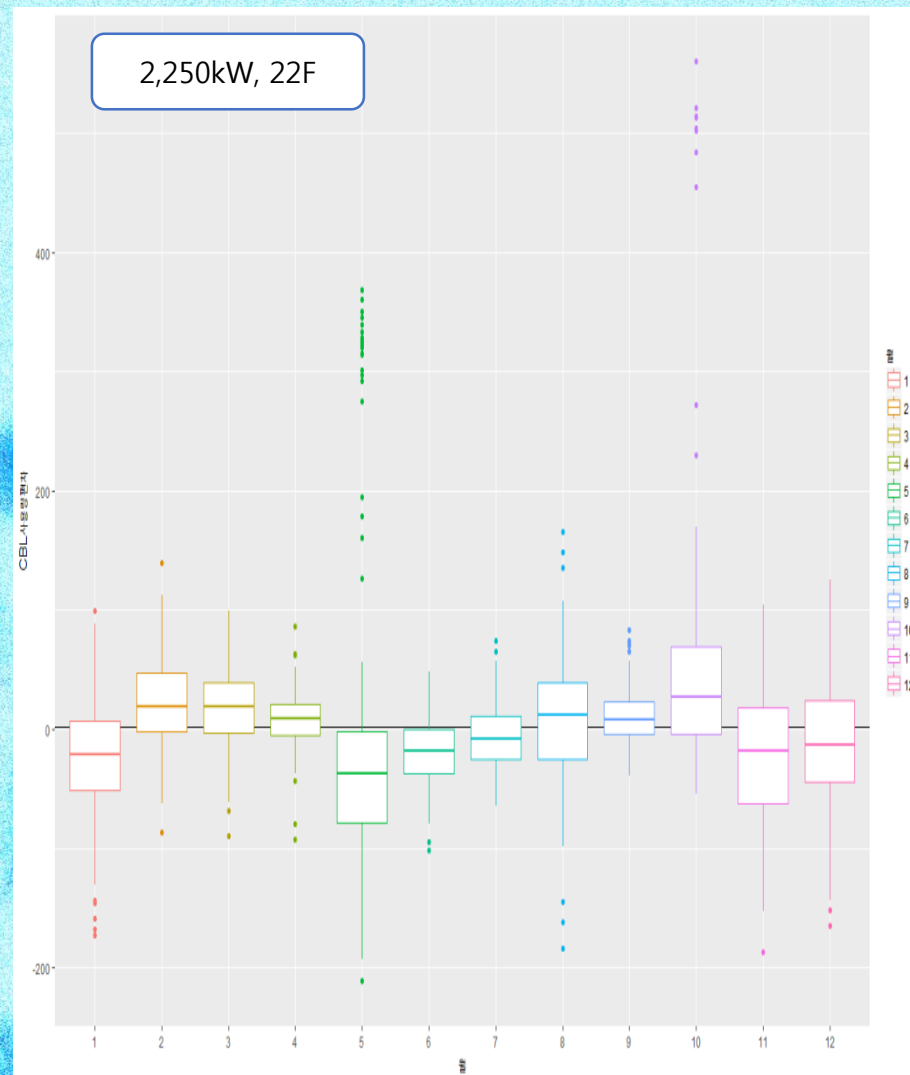
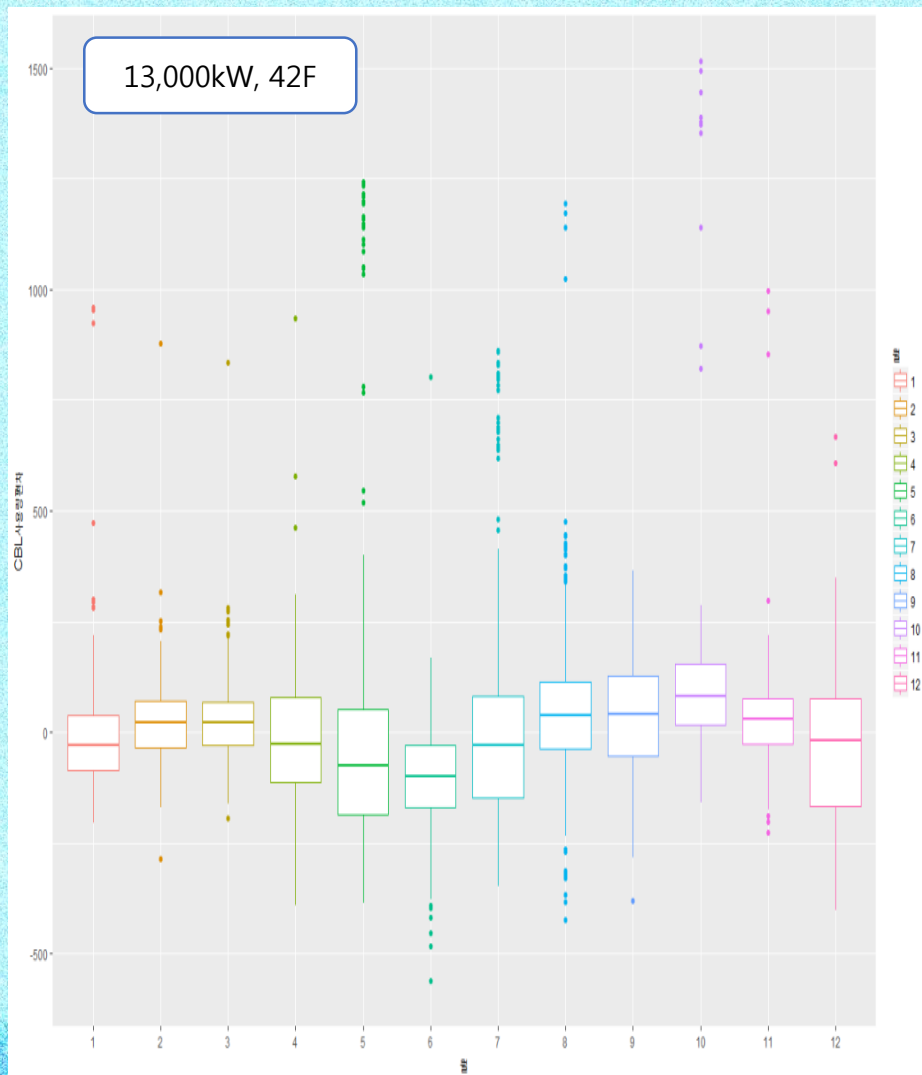
## Correlation between Customer baseline load and Electricity quantity (2017)





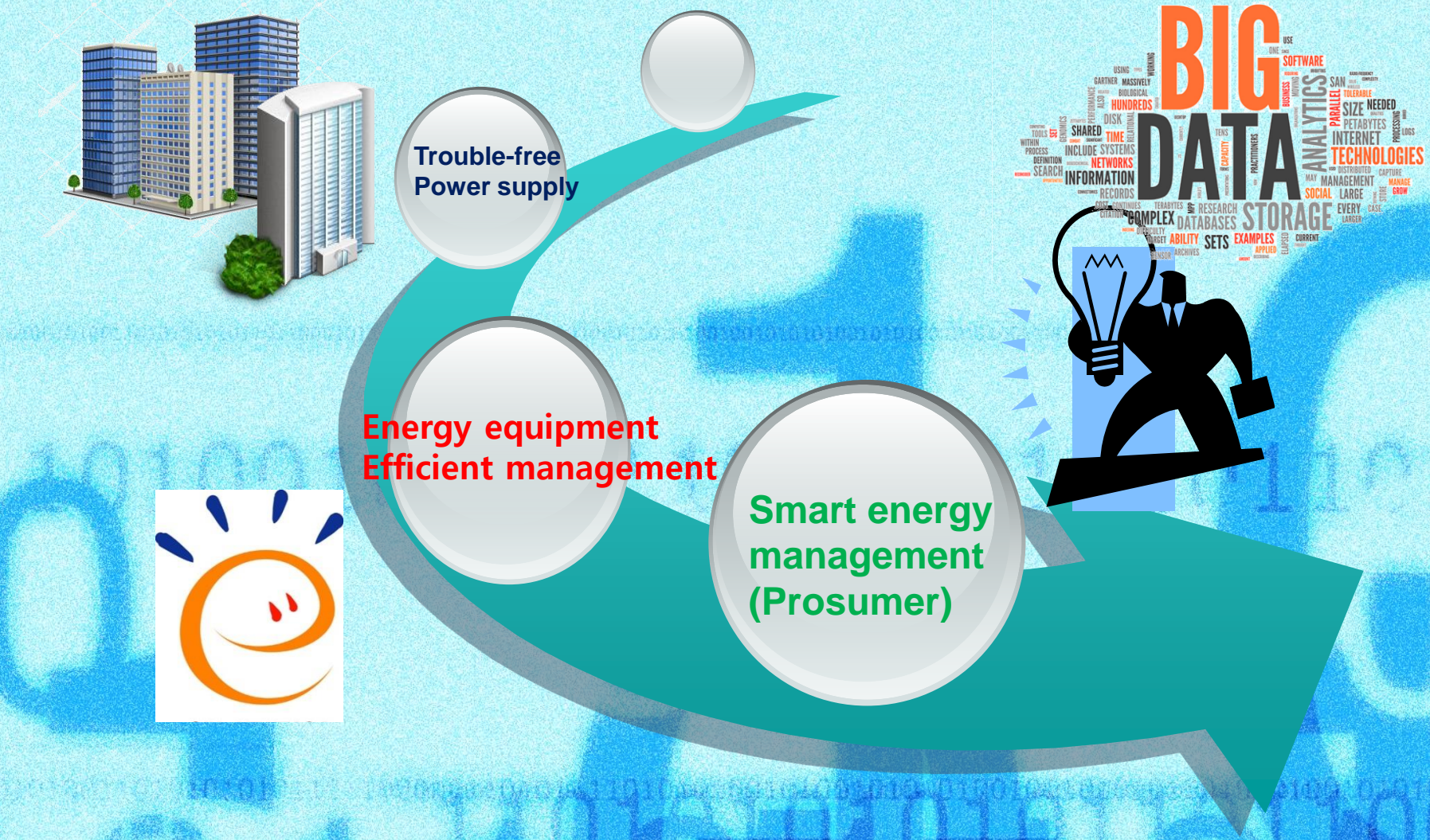
# 1. Building Data analysis

## Monthly Distrubution of CBL-Electricity quantity in two office Buinding





## ◆ Change of the Energy Management Needs





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# Thank You