

Electricity Market Challenges in Korea for Energy Transition

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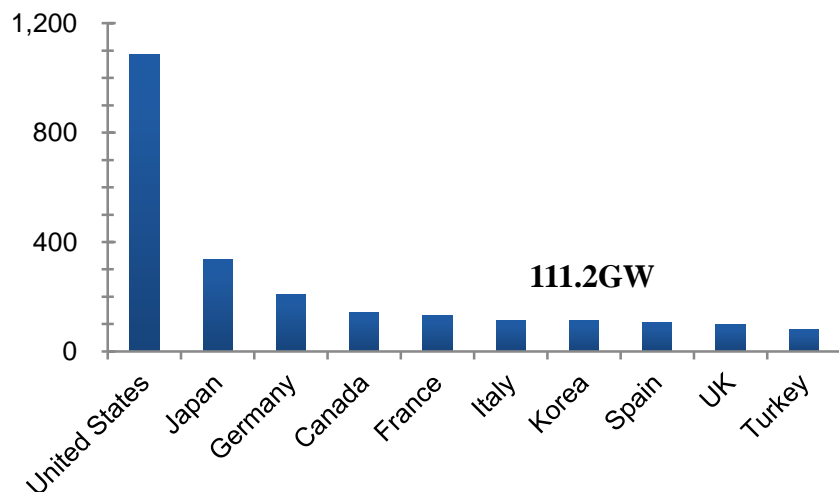
Electricity Market Overview



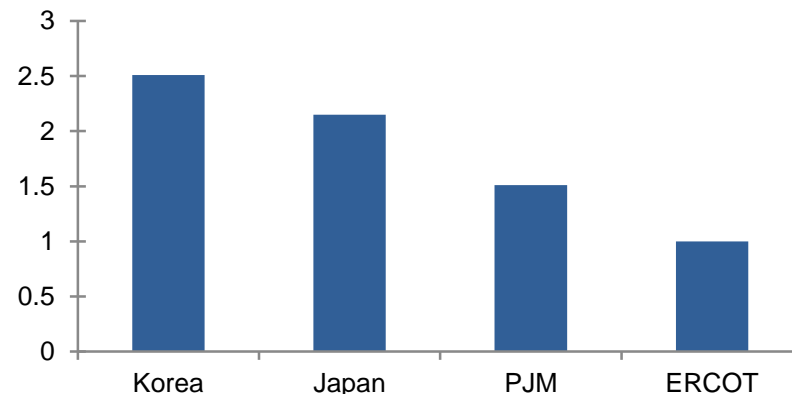
Overview of Korean Power System

- ▶ Islanded power system due to geopolitics
- ▶ Installed capacity was placed at 7th among OECD in 2016
- ▶ Densely populated network due to highly concentrated supply and demand

< Installed Capacity >



< Network Density >

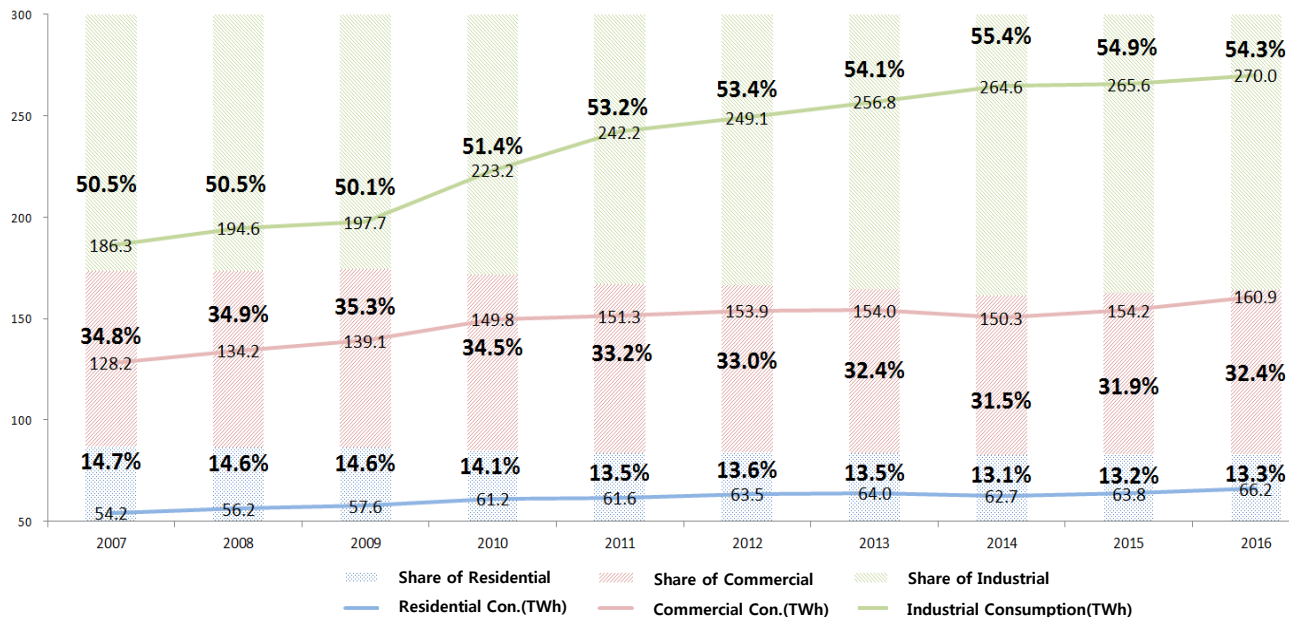


* Comparison of network density when ERCOT set to 1.

Demand Trends

- ▶ Demand has increased steadily, BUT recently increased slower than ever.
- ▶ Industrial consumption takes higher share of total demand than in other countries.
- ▶ Demand in Seoul metropolitan area takes about 40% of all national demand.

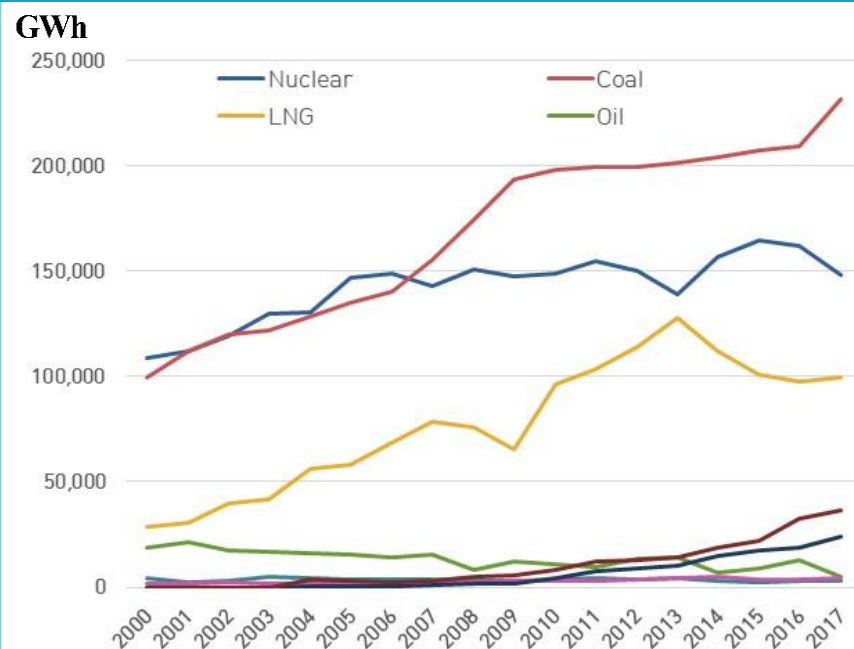
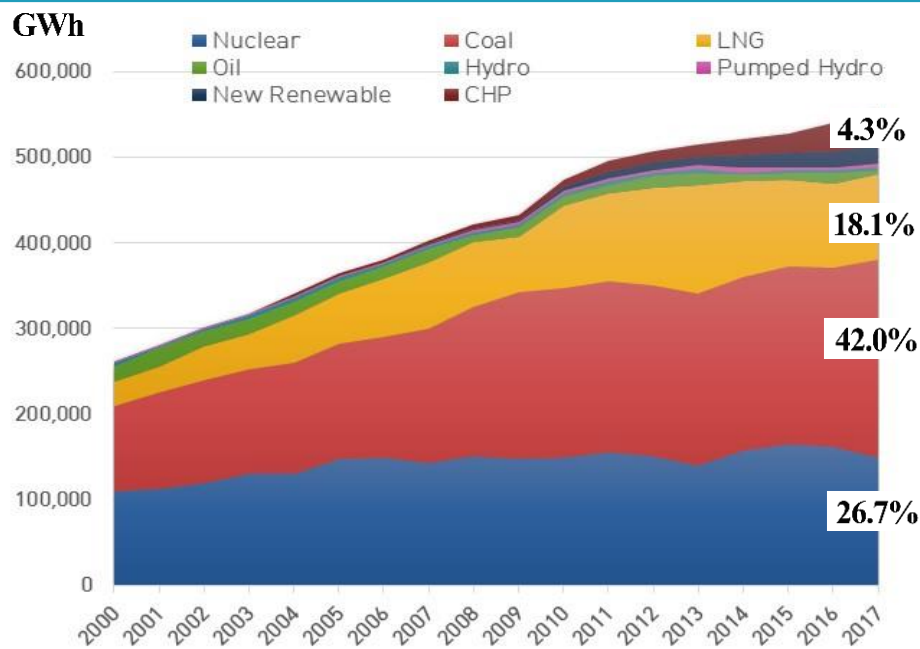
< Consumption by Sector >



Generation Trends

- ▶ Share of nuke has fallen though its generation has increased.
- ▶ Coal generation takes the highest share and has increased ever.
- ▶ Share of LNG has fallen since 2013, while that of renewables remains low, but is growing.

< Generation Trends >

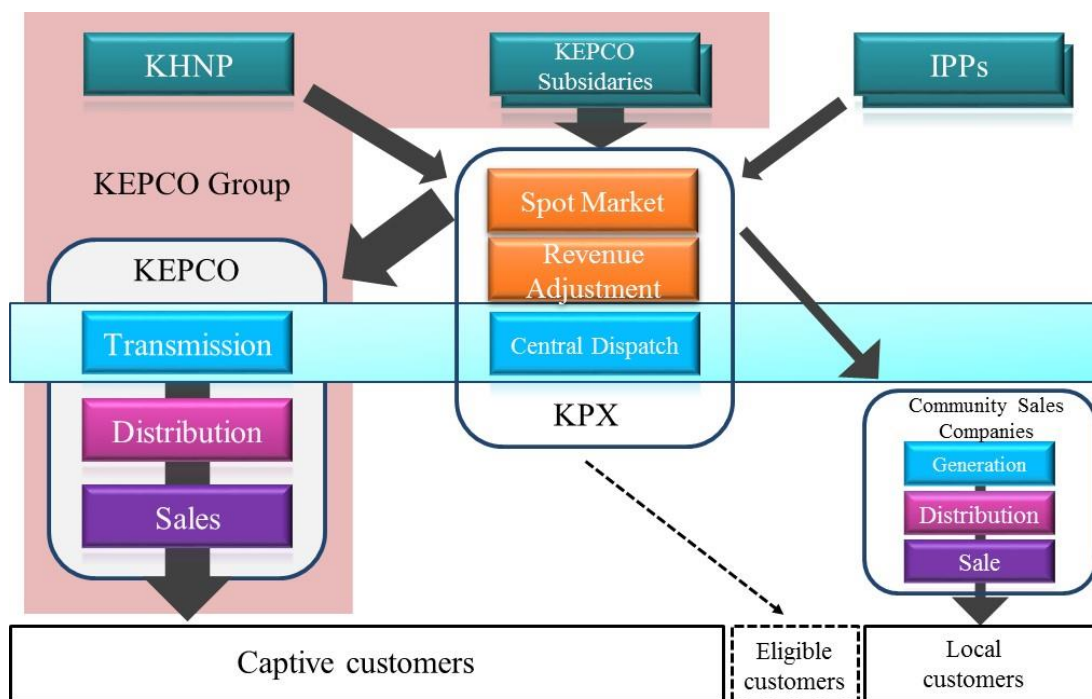


Market Structure

▶ Not a full competitive market \Rightarrow mainly generation competition

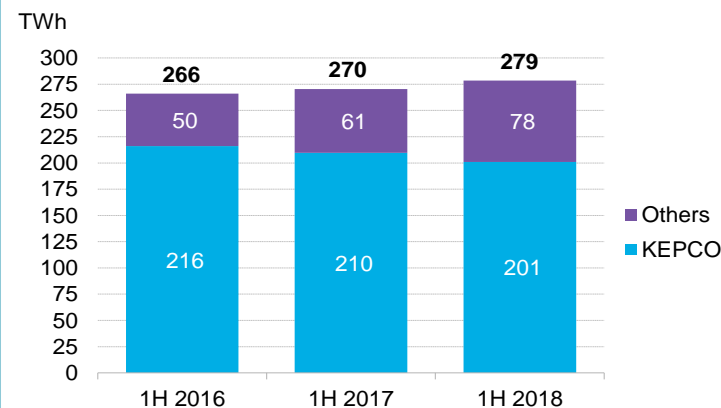
- KEPCO's 5 regional subsidiaries, Korea Hydro & Nuclear Power, independent power producers.
- KEPCO(Korea Electricity Power Corporation) is the monopsonist in the wholesale market.
- It owns both transmission and distribution networks.

< Market Structure >



< Generation by Ownership >

6 generation subsidiaries of KEPCO account for approximately 70~80% of total production.



Market Characteristics

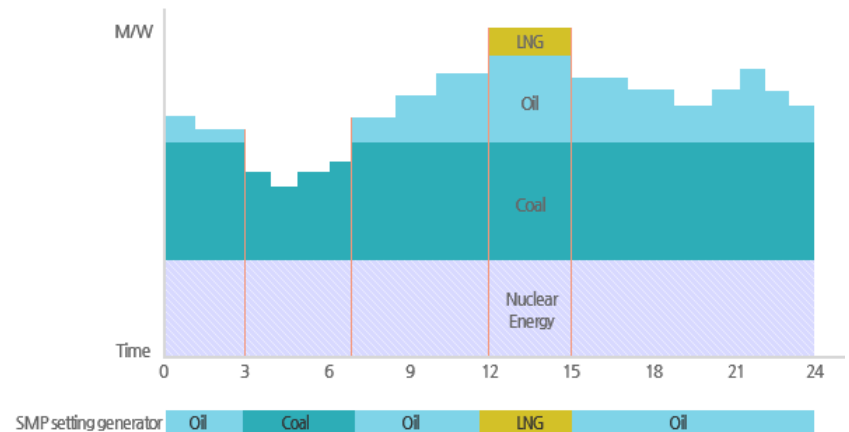
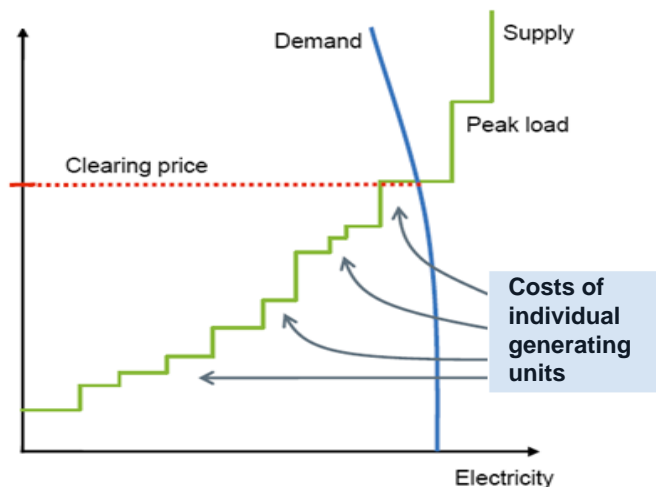
▶ Mandatory Pool Market

- Korea's electricity market is established on centralized and mandatory power pool
- All electricity must be traded over the pool
- KPX is a system and market operator

▶ Cost Based Pool \Rightarrow a mechanism of determining wholesale market price

- While generators submit ONLY quantity offers, the Committee determines each generator's cost in advance.
- Supply curve is made from the offered quantities and pre-approved costs.
- KPX ranks generating units based on their variable costs and dispatches them in a supposedly efficient manner.
- A uniform clearing price called SMP(system marginal price) is determined by the marginal generator's cost.

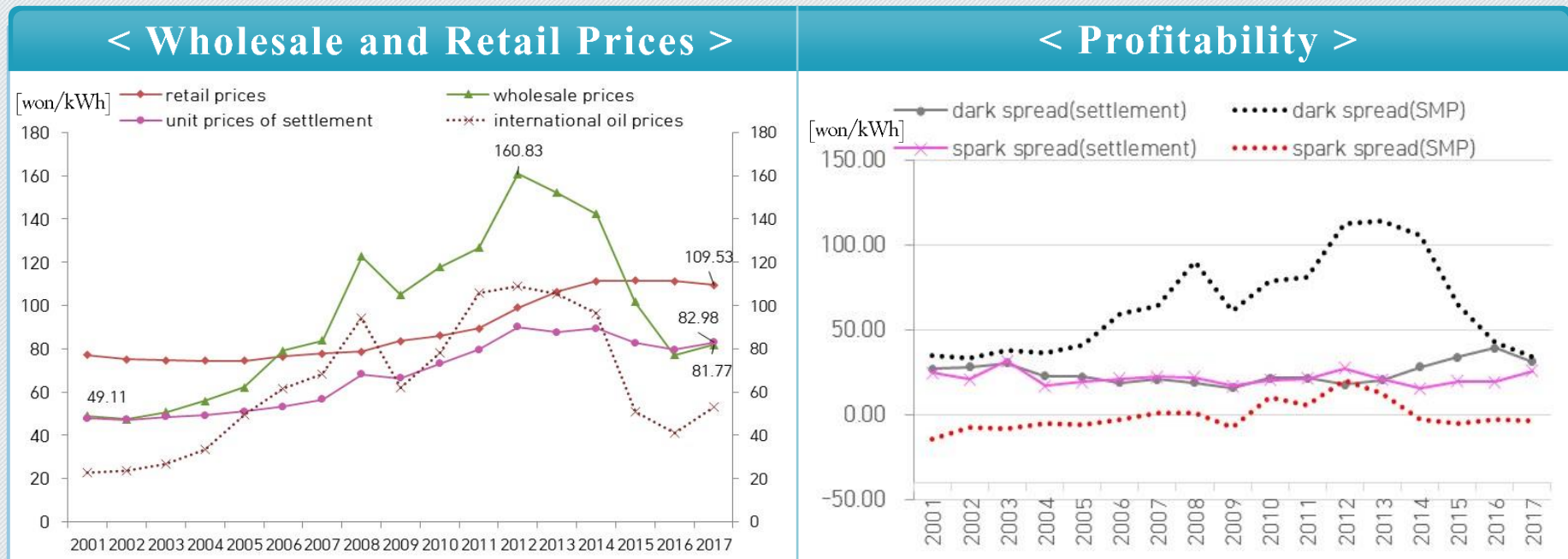
< Clearing Price in CBP >



Prices and Profitability

▶ Wholesale prices have plunged

- Recent new coal-fired generation makes wholesale prices down despite increasing oil prices.
- Peak-load generators have constantly been in deficit.



Note: The settlement prices are lower than the wholesale prices due to the following regulations:

- reduction of coal and nuclear generators' excessive profits
- revenue adjustment between KEPCO(monopsonist) and its subsidiaries due to inflexible retail tariff



Electricity Market Challenges

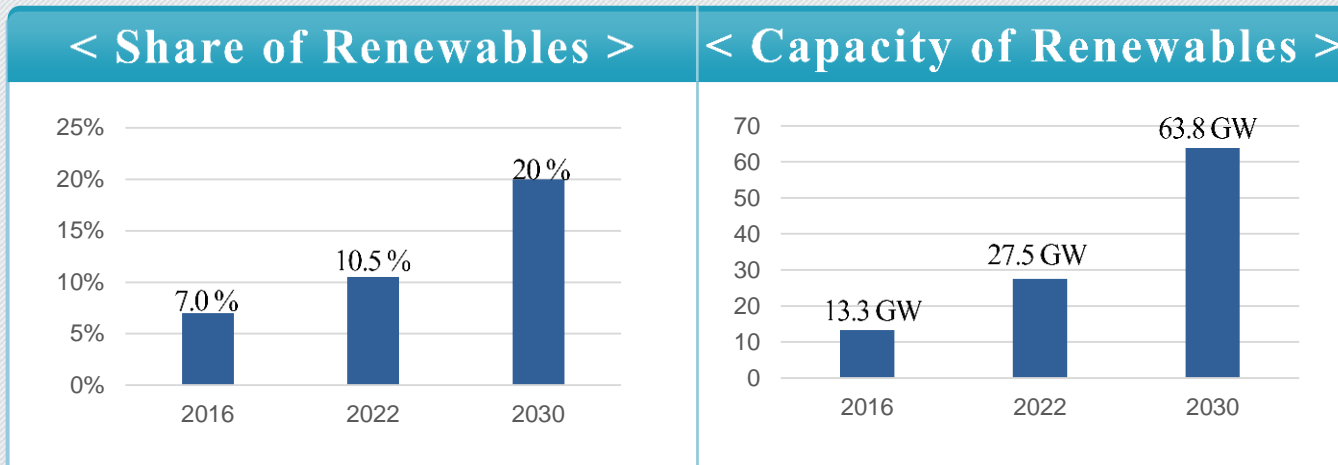
- II - 1 The Government's Plan for Energy Transition
- II - 2 Current Electricity Market & Challenges
- II - 3 Electricity Market Evolution



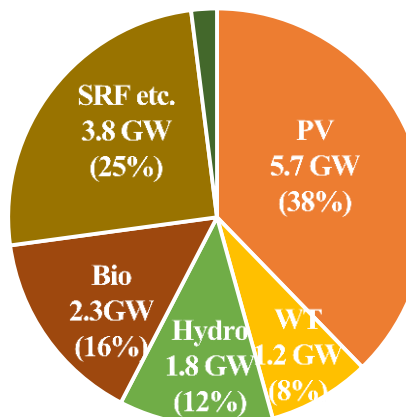
The Government's Plans for Energy Transition (1)

▶ Targeted share of renewable generation by 2030 is 20%.

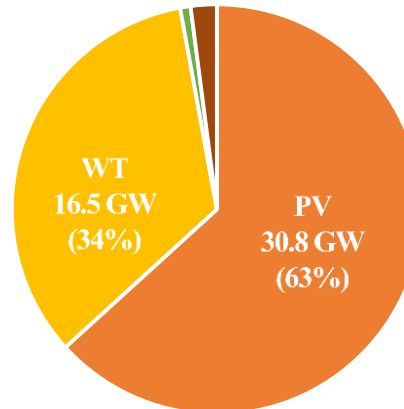
- It mainly consists of intermittent & variable energy resources like solar(63%) and wind (34%).



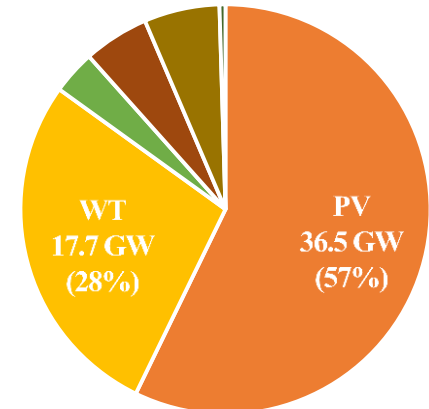
< '17(15.1GW) >



< Projected Installed Capacity(48.7GW) >



< '30(63.8GW) >



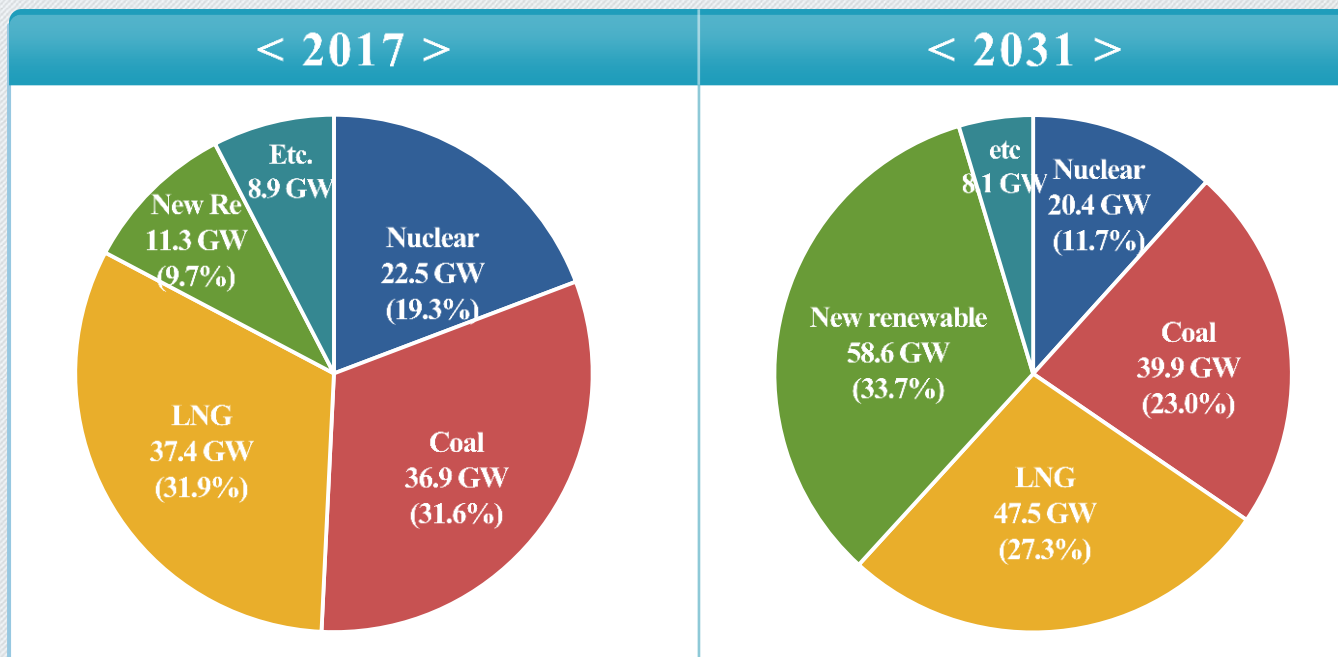
The Government's Plans for Energy Transition (2)

▶ (Share of coal ↓) retirement of aged coal-fired gen., switching from coal to LNG

- 3 aged coal-fired generators were retired in 2017, 7 generators(2.8GW) will be retired by 2022
- The government considers to switch 6 planned coal-fired generators(2.1GW) to gas-fired generators

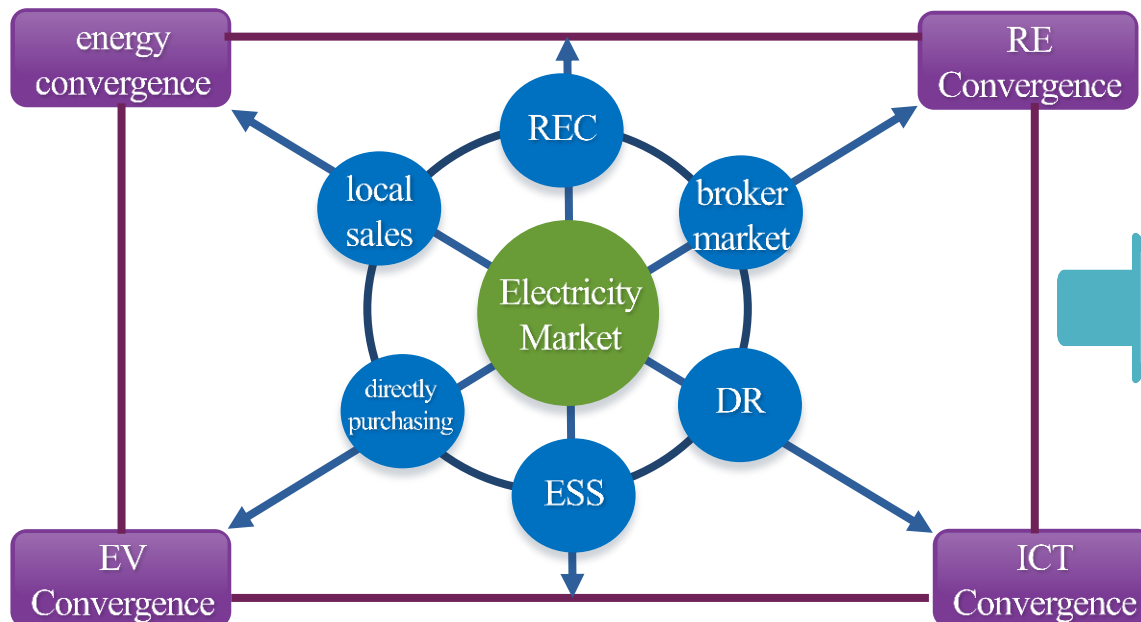
▶ (Share of nuclear ↓) cancellation of construction plan, no life-extension of aged generators

- The government considers to cancel construction plan for 6 planned nuclear generators(8.8GW), and
- Retire 11 aged nuclear power plants(9.13GW) by 2031



Current Market Status & Challenges (1)

- Current market in synergy with ICT seems to result in diversified markets & products.
 - Community sales companies, REC market, demand response market and ESS's participation in electricity market
 - Electric car charging business, plan for introducing aggregator of distributed resources
- Current market design for conventional generators is not enough to accommodate changes.
 - Electricity prices based on unconstrained scheduling* can not induce appropriate responses from resources.
 - * unconstrained scheduling: generation scheduling without considering operational constraints of power system
 - Electricity prices do not necessarily reflect the characteristics of renewables in real time(only day-ahead market)



- Prices reflect intermittency of renewables?
- Prices are expected to increase new flexible resources for backing up renewables?

Current Market Status & Challenges (2)

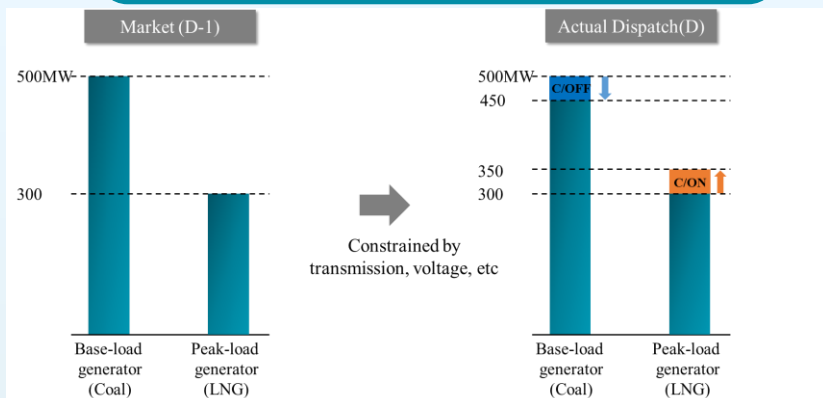
► Unconstrained day-ahead prices (absence of real-time prices) \Rightarrow peak-load generators' disadvantages

- Base-load generators are compensated for opportunity cost with constrained-off payment
- Peak-load generators lose revenue opportunity for backing up other generators

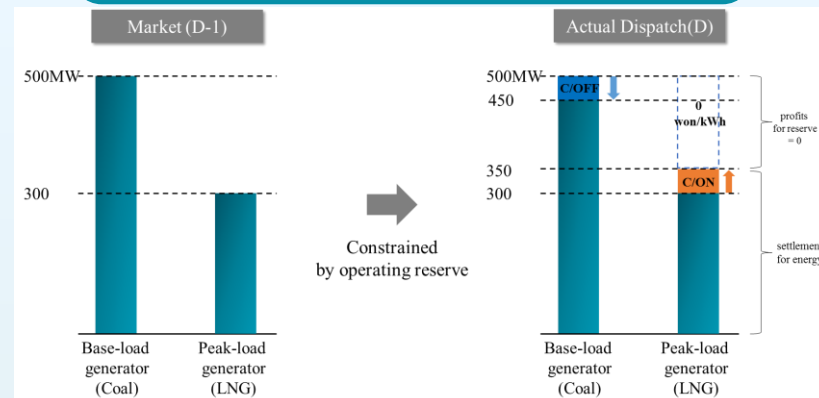
► No market for flexibility \Rightarrow barrier to inducing flexible resources (peak generator, DR, ESS, GT)

- Base-load generators are compensated properly for their supply of reserves.
- Peak-load generators are not compensated though they can deliver flexibility.

Constrained on & off



Settlement for reserves

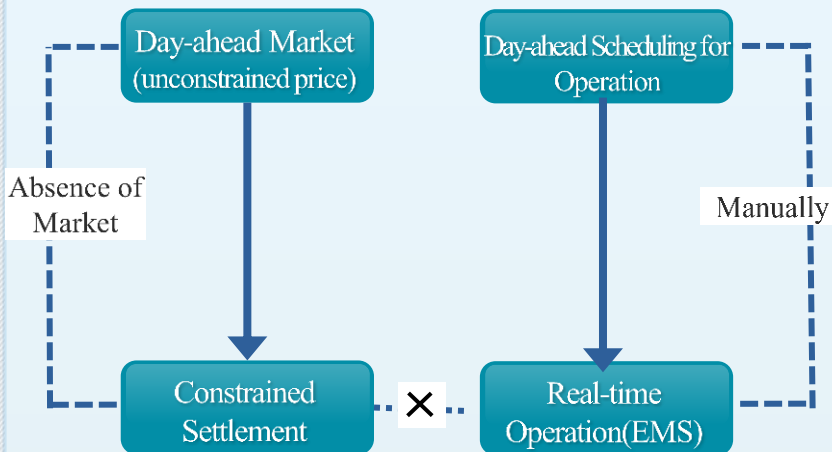


Market Evolution - Stage 1

- Electricity trading platform evolution(strengthening price signals)
 - Introducing intra-day and real-time markets to treat variability with price function.
 - Strengthening compensation for flexible resources in intra-day and real-time markets.
 - Adopting constrained prices in order to reflect operational constraints in power system.

As-Is

- Unconstrained pricing
 - Undervaluation of flexible resources(ESS, LNG, PHS)
 - Market prices in disharmony with operational constraints
- Balancing by KPX's discretion in real-time
 - Limited trading opportunities

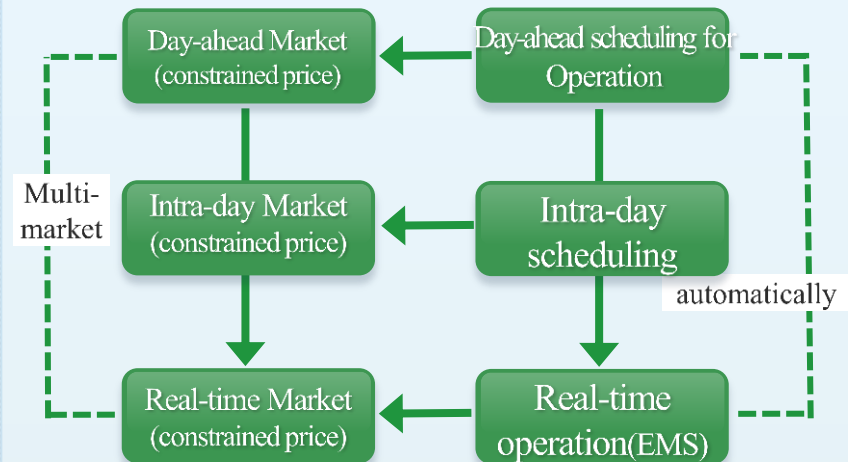


Strengthening
price signals

Trading
platform
evolution

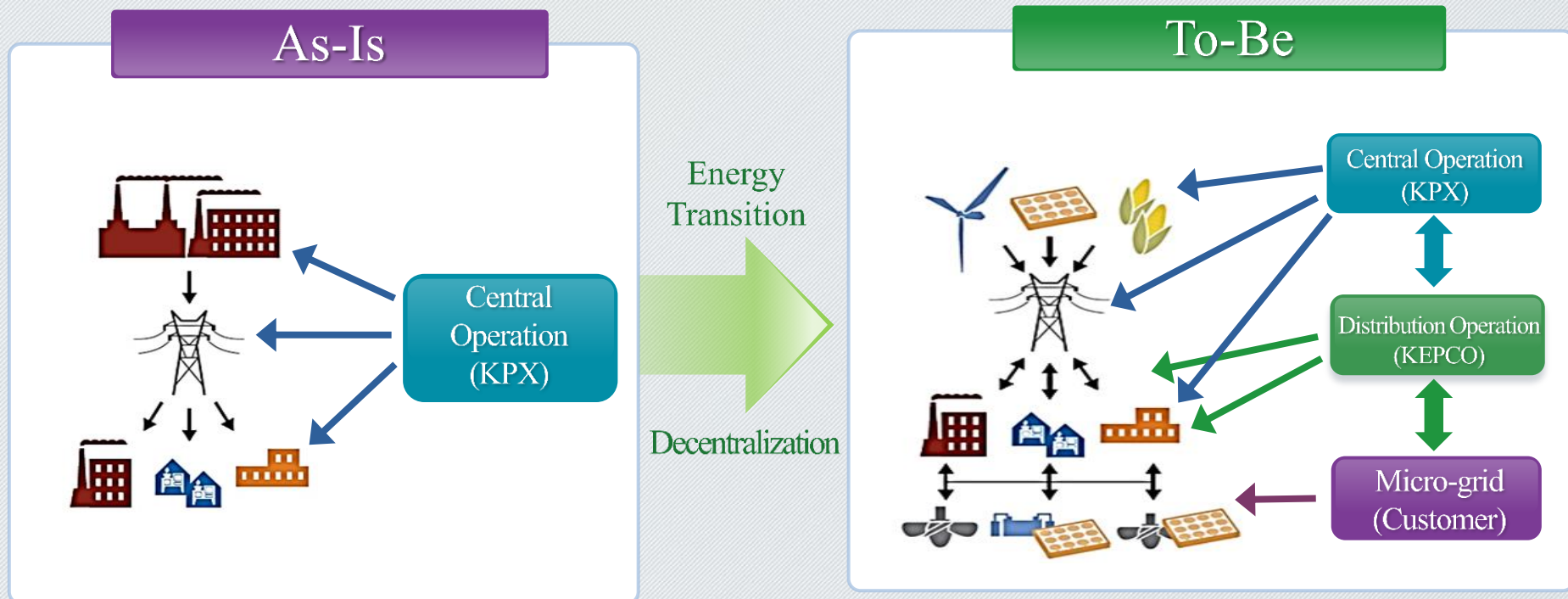
To-Be

- Constrained pricing
 - Proper valuation for flexible resources(ESS, LNG, PHS)
 - Harmonize market prices with operational constraints
- Balancing by market prices
 - Resources respond to prices in real-time



Market Evolution - Stage 2

- ▶ Centralized energy platform \Rightarrow Decentralized renewable energy platform
 - Generation \leftrightarrow Transmission \leftrightarrow Distribution \leftrightarrow Consumption : Two-way flow of electricity and information
 - Central Dispatch(Transmission) \leftrightarrow Distribution \leftrightarrow Micro-grid : Two-way control protocol
- ▶ Challenges for decentralized energy trading and control platform
 - (Market operation) consistency of wholesale and retail market, forecasting capabilities for load, renewables
 - (System operation) voltage control and reactive power optimization, digital transmission/distribution operation
 - Coordination of ISO/TSO(KPX), DSO(KEPCO) and new market players





Action Plans for Energy Transition

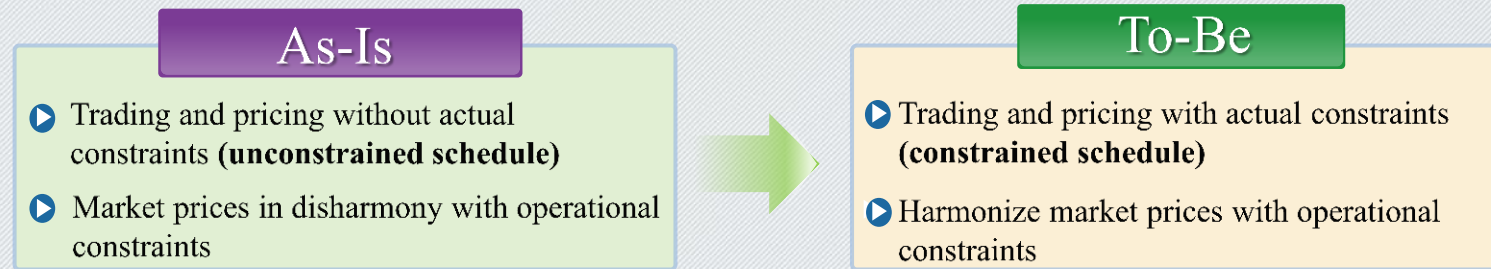
- III- 1 Pricing with Constraints Considered
- III- 2 More Diversified Markets and Products
- III- 3 Multi-staged Scheduling



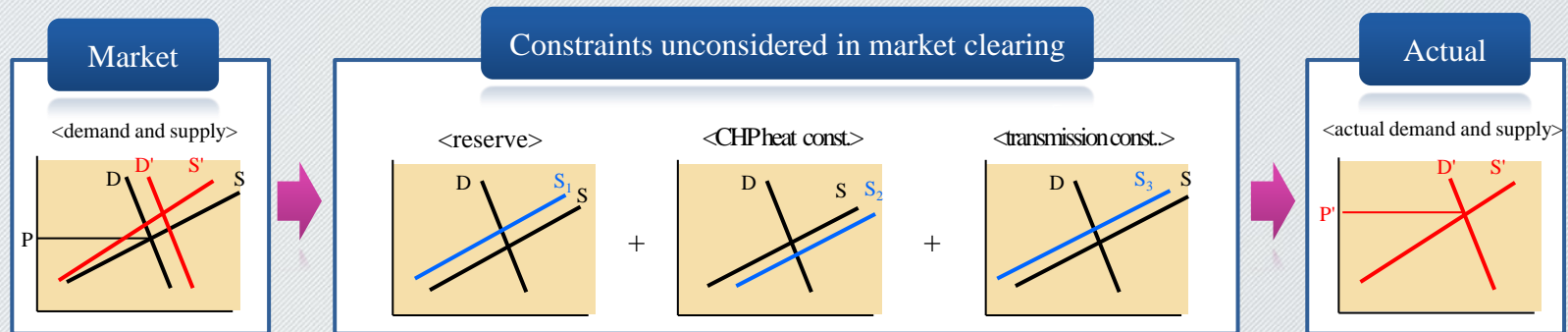
1. Pricing with Constraints Considered

▶ Pricing based on constrained* schedule

- Determining wholesale prices with considering various operational constraints
 - ※ constraints : CHP's heat, operating reserve, transmission constraints, etc.



Unconstrained schedules keep down wholesale prices



2. More Diversified Markets and Products

▶ (Multi-settlement) Introducing intra-day and real-time markets

- Energy and reserve will be traded in day-ahead, intra-day and real-time markets

▶ (Reserves market) Reserve pricing by co-optimizing energy and reserve

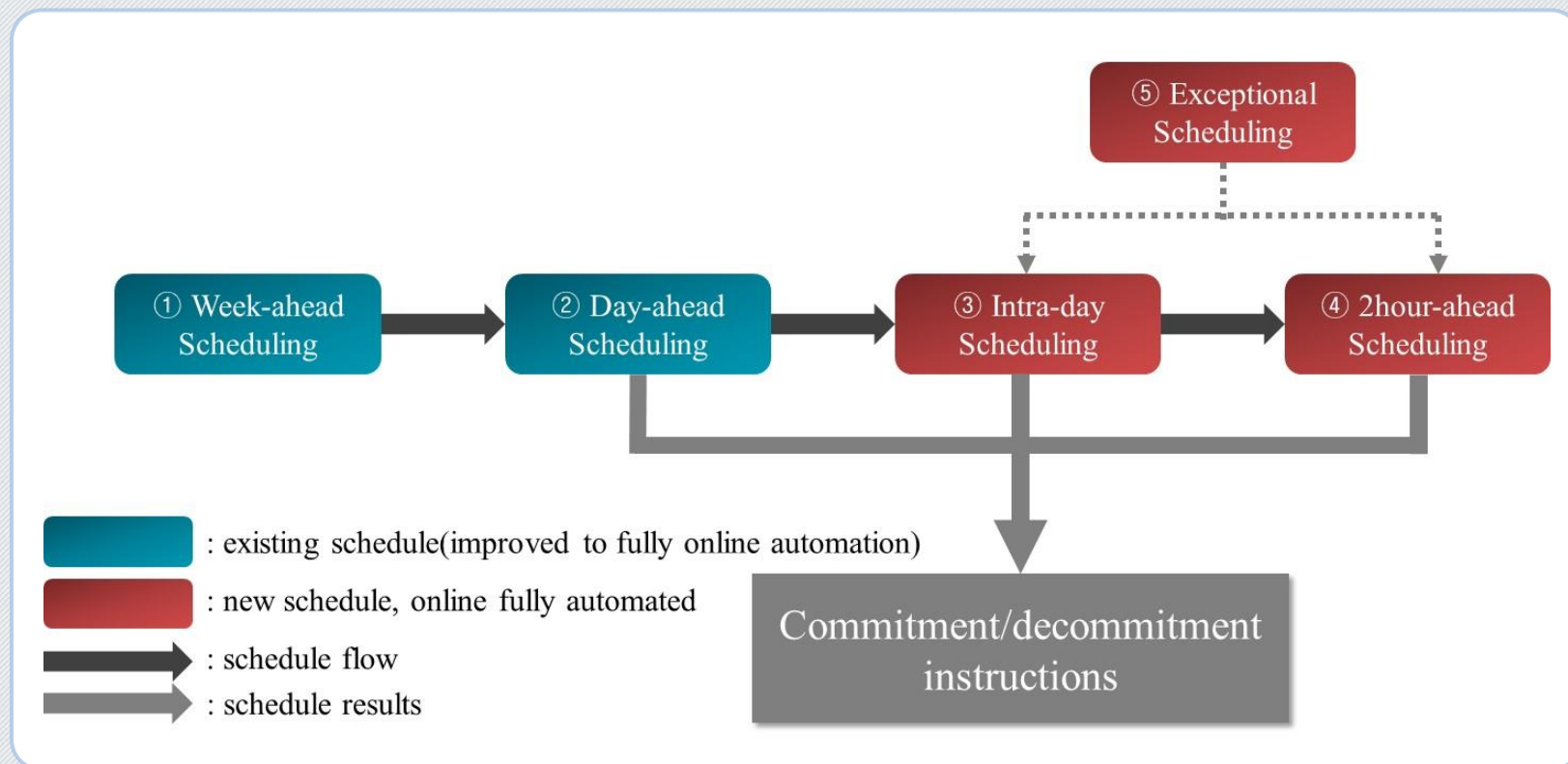
- Determining energy and reserve prices from co-optimization of energy and reserve

		As-Is			To-Be		
		Day-ahead	Intra-day	2 hour-ahead	Day-ahead	Intra-day	2 hour-ahead
Market	Gate Closure	1 day ahead	-	-	1 day ahead	4 hour ahead	2 hour ahead
	Trading Interval	1 hour	-	-	1 hour	15 min	15 min
Products	Energy	○	X	X	○	○	○
	Reserves	X	X	X	○	○	○

3. Multi-staged Scheduling

► Multi-stages for generation scheduling

- Multi-laid generation scheduling in order to repeatedly reflect actual condition changes
 - ※ multi-stages : week-ahead, day-ahead, intra-day, 2 hour-ahead schedules



Thank you

