Integrating solar and storage technologies into Korea's energy landscape

Business models and policy implications

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1 **Korea Energy Market**
What are key drivers in promoting clean energy?

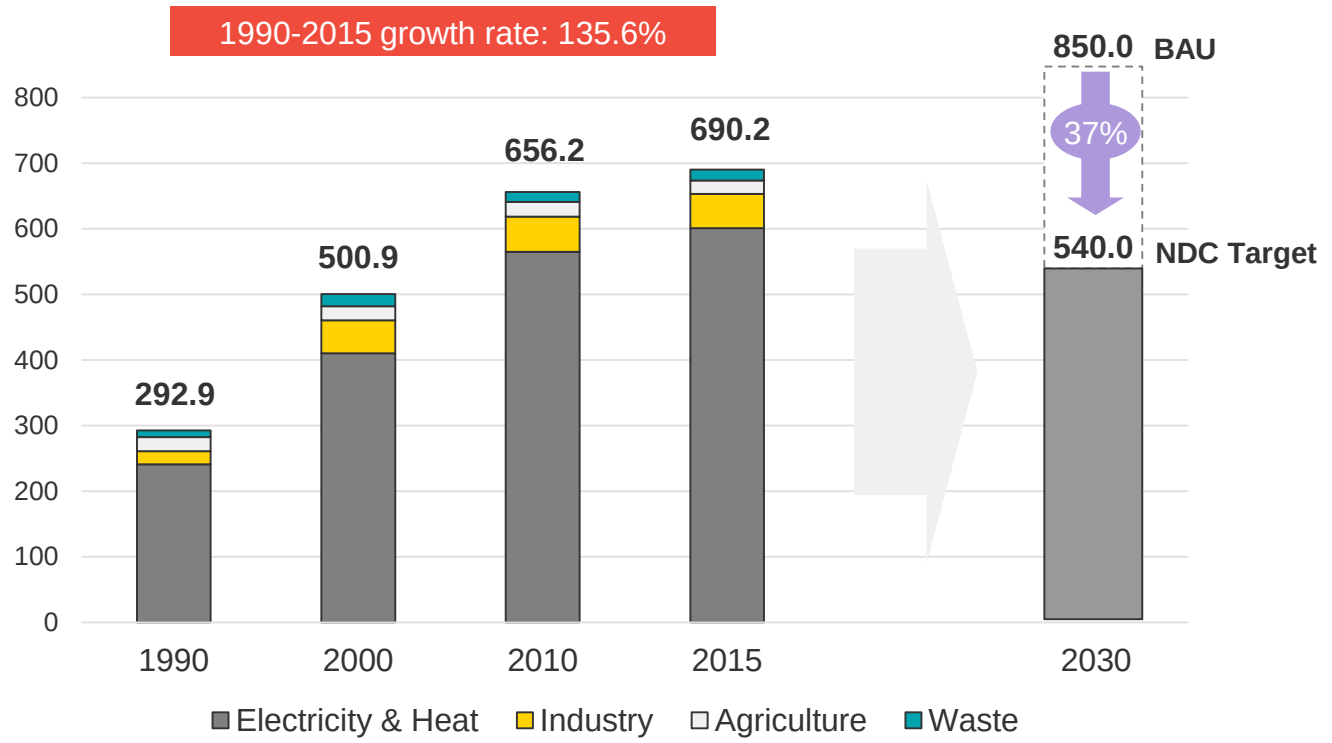
2 **Policies**
What policy instruments are there to achieve the national RE target 20% by 2030?

3 **Market Players**
How is the energy market structured and who are winning in the market?

4 **Business model**
What business model proliferates in the market and why?

Korea has seen significant growth trajectory in carbon emissions due to large manufacturing base

South Korea's GHG Emission Trends* and NDC Target



* Gross Emission, excepted LULUCF absorption

Source: National greenhouse gas inventory report of Korea(2017)

Local air pollution is threatening daily lives of citizen and calls for policy intervention toward clean energy

“total 130 of ultra fine dust and fine dust alarms issued In Korea 2017. 1Q”

Authorities announced package of measures to reduce fine dust emission by 30%, ~2022

Shut-down of coal power plants aged over 30yrs

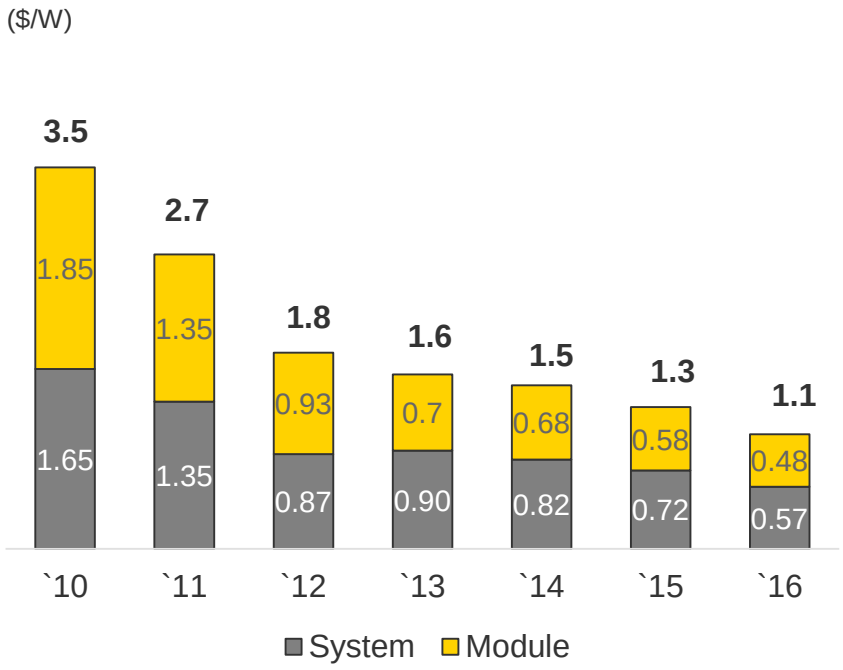
Early retirement of 77% aged diesel vehicles

Enhancement of emission standards for industrial sites

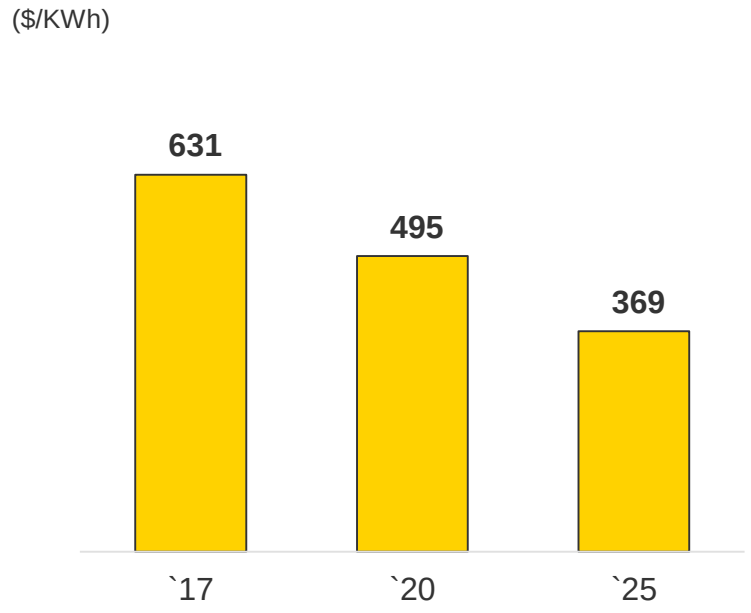
Source: Media research

Declining cost of technology is making clean energy more competitive compared to traditional energy technology

Solar PV module price trends



1MW ESS installment cost forecast



Source: Bloomberg New Energy Finance

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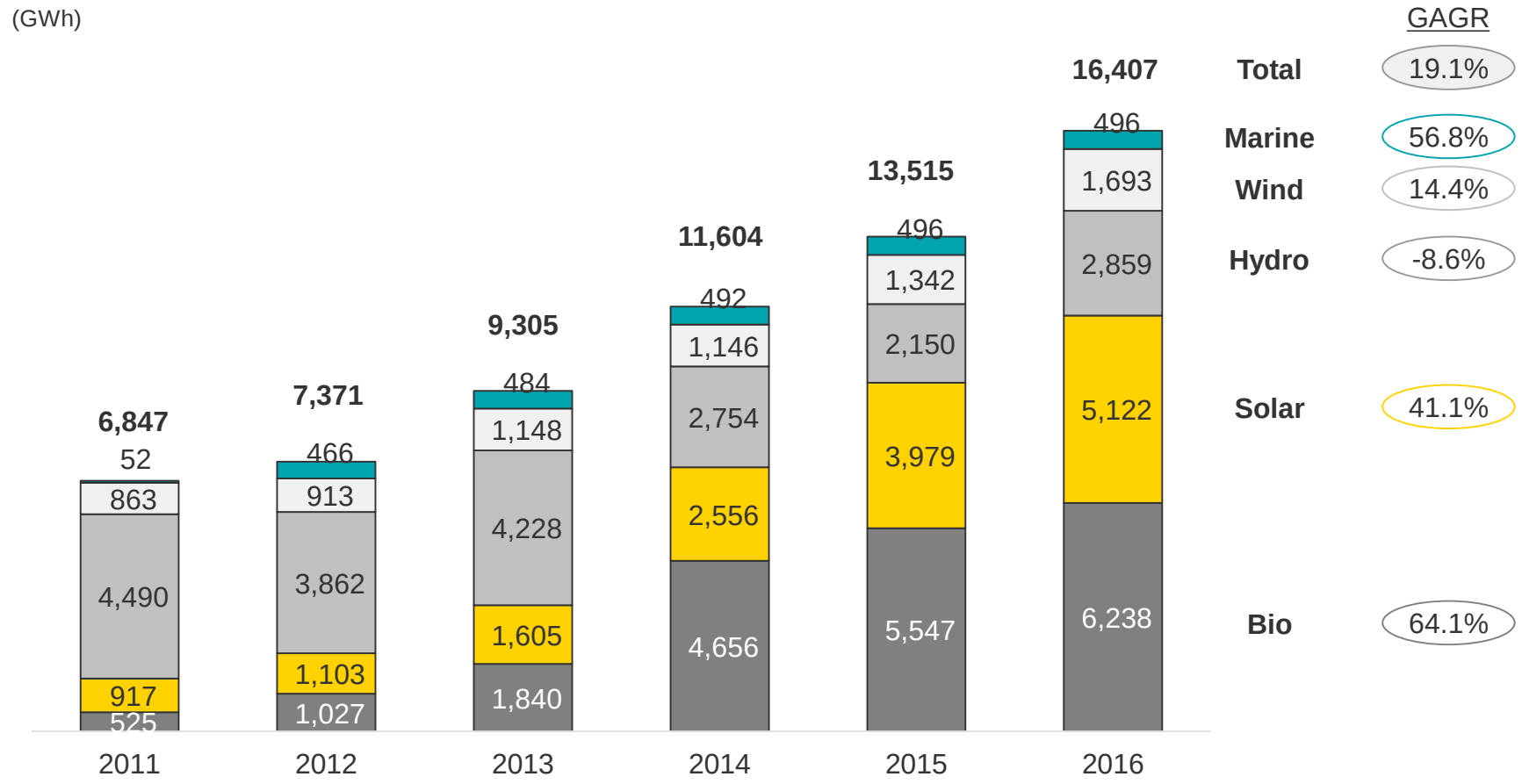
RE grew 19% annually for past 5 years, with significant increase in solar and biomass

South Korea's renewable generation trends by source *

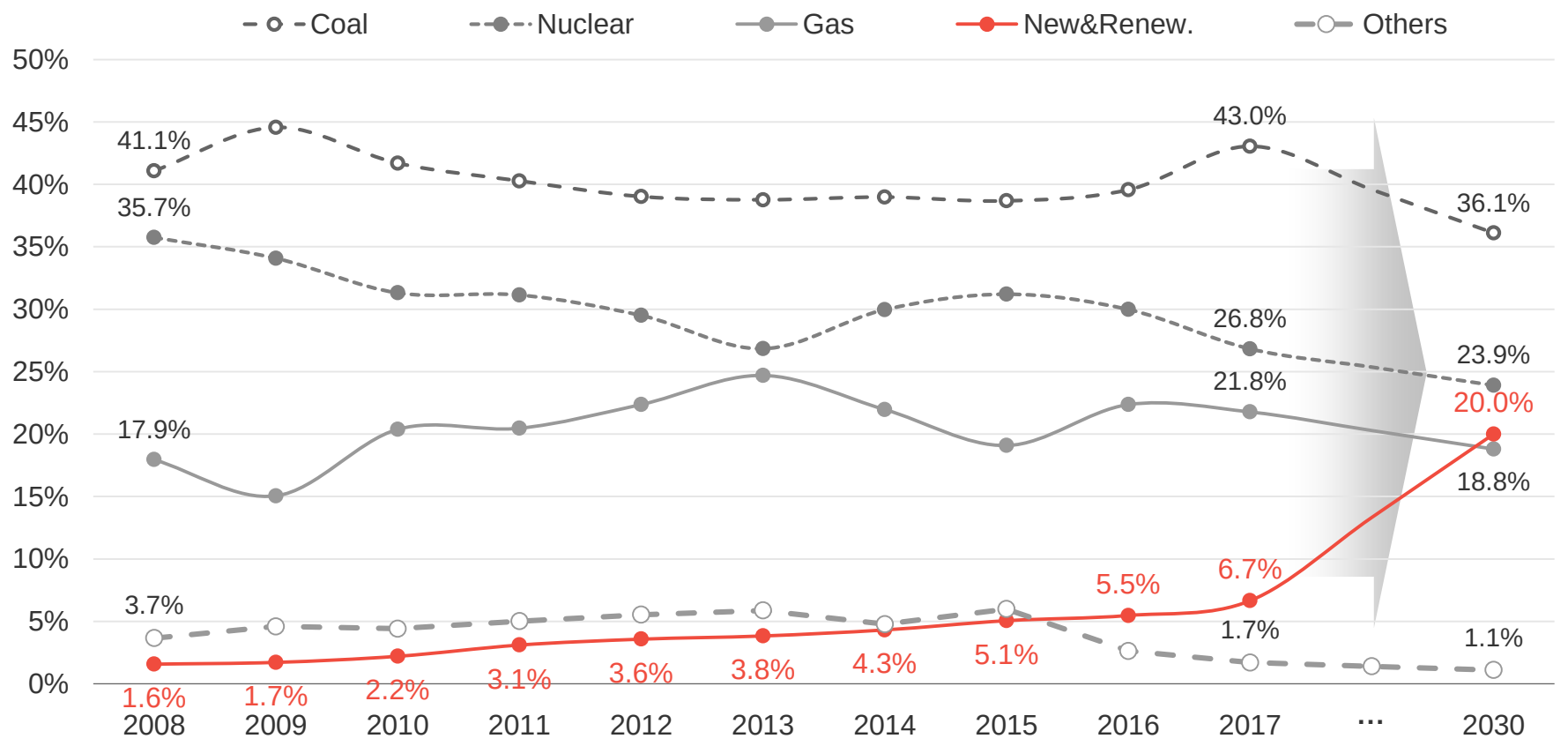


* Excluding Waste generation

Source: KEPCO statistics

While RE accounts for only 7% of total electricity generation in Korea, the new administration's 'Renewable Energy 3020' has put ambitious target to increase RE share to 20% by 2030

South Korea's Generation mix



* Others: Oil and group energy

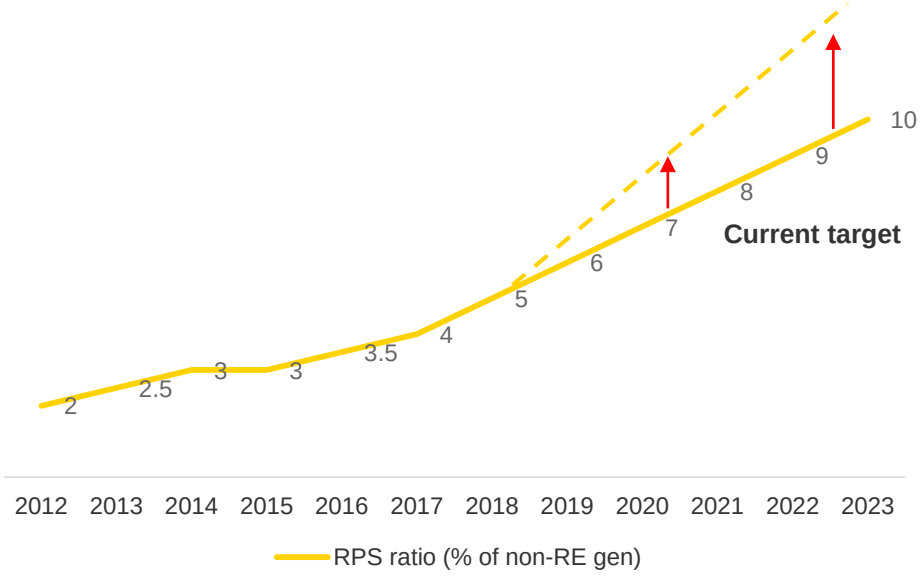
Source: KEPCO statistics

RPS is the main policy tool that helps RE projects become economically competitive by providing market-based incentive

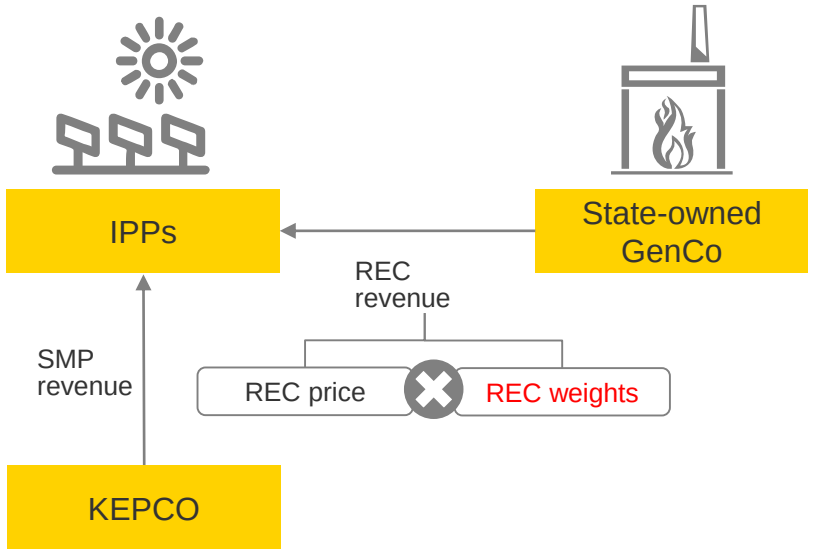
South Korea's RPS Scheme (2017 revised)

- Power companies with over 500MW of installed capacity must increase their renewable energy mix to a level set by government
- RE mix is defined as the proportion of renewable electricity generation in the total non-renewable electricity generation
- Currently the government is working to increase existing RPS target to achieve 'Renewable Energy 3020' plan

RPS ratio (% of non-RE gen)



RPS mechanism



Source: Korea Energy Agency

REC weight is set to provide strong incentive for small-scale solar and hybrid application with energy storage

REC weight for solar PV

Installation type	Details	REC weights
Install on general site	Under 100kW	1.2
	100kW – under 3,000kW	1.0
	Over 3,000kW	0.7
Install in existing facility (ex. existing buildings)	Under 3,000kW	1.5
	3,000kw and over	1.0
Floating system Installed on water		1.5
On-site generation connected to grid		1.0
Solar + ESS	effective in `16, `17	5.0

REC weight for other renewables

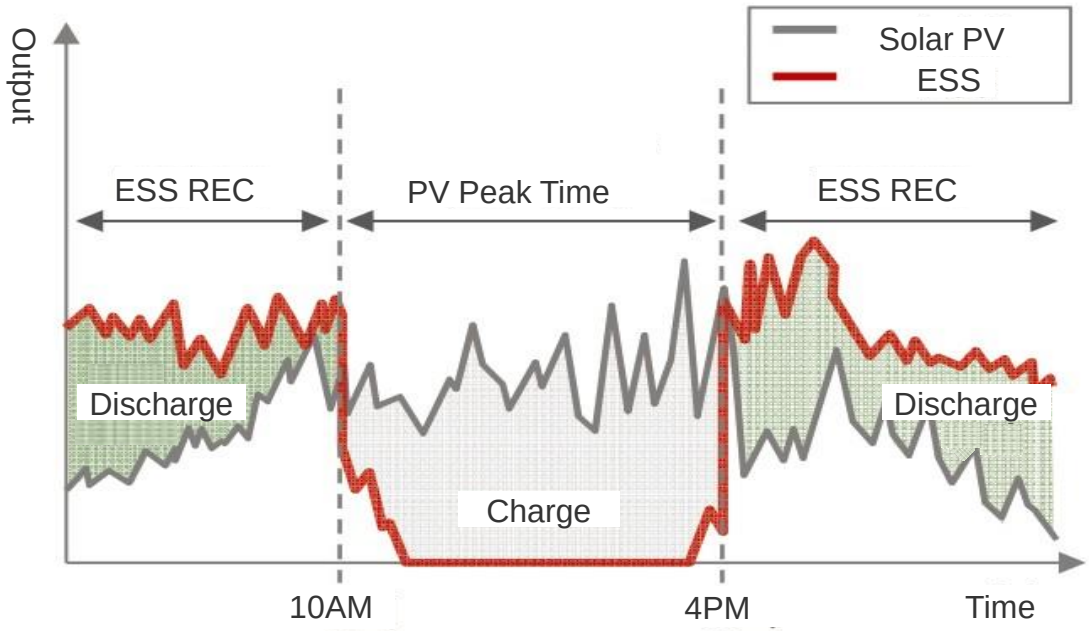
Installation type	Details	REC weights
IGCC, By-product gas		0.25
Waste, Land fill gas		0.5
Hydro, On-shore wind, RDF, Waste Gasification, Marine tidal (with embankment), on-site generation connected to grid		1.0
Wood biomass, Off-shore wind(~5km of connection distance), Hydrothermal		1.5
Fuel cell, Ocean energy		2.0
Off-shore wind (over 5km of connection distance), Geothermal, Marine tidal (without embankment)	Fixed	2.0
	Variable	1.0-2.5
Wind + ESS	`15	5.5
	`16	5.0
	`17	4.5

Source: Korea Energy Agency

For PV+ESS, charging during PV peak time will earn the highest REC weight and also eliminate rapid power/voltage swing

REC weight 5.0 granted to solar PV + ESS

- REC 5.0 applies to all electricity discharged from solar PV+ESS during off-peak time (peak time: 10AM-4PM)
- Effective from 2017 (to be adjusted after 2018 July)



Expectation

- ❖ Optimize connection capacity during PV peak hours
- ❖ Create $400million of new ESS market (800 MWh)
- ❖ $300million of Investment Deferral (20MW)

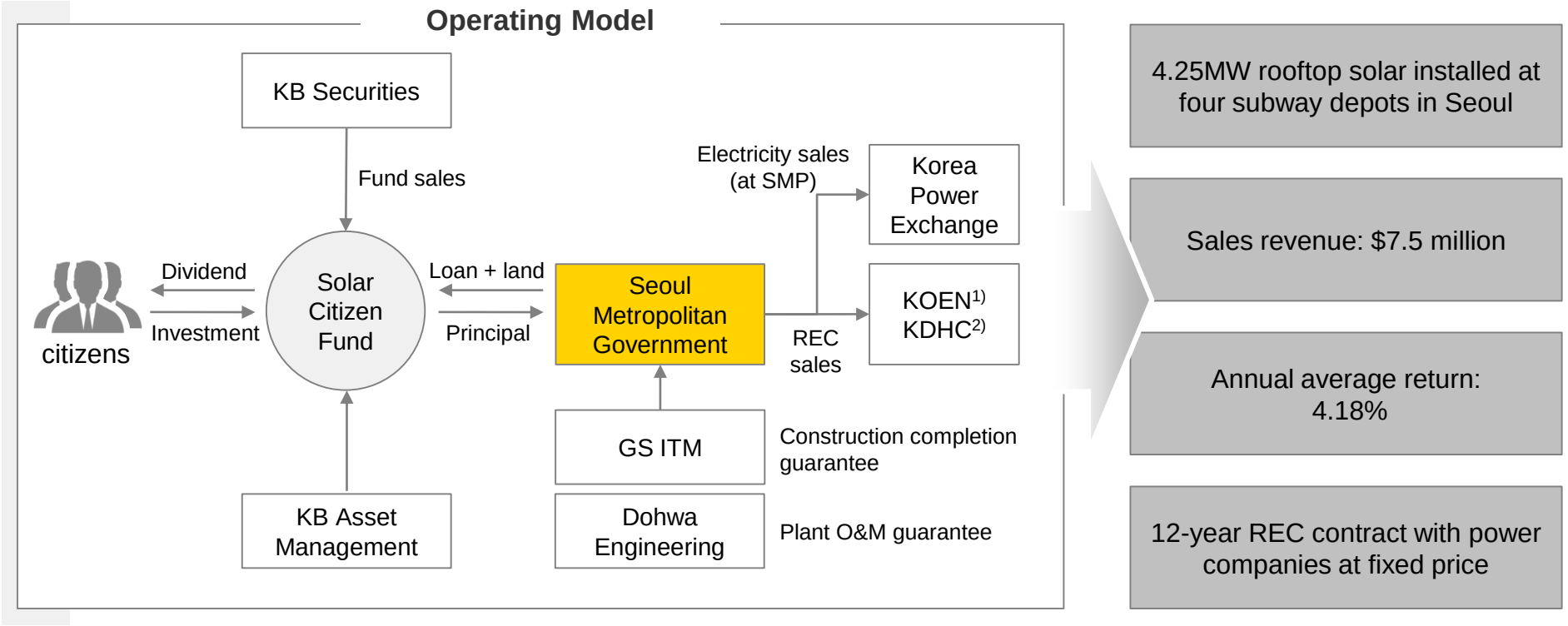
Challenge

- ❖ Peak demand during day-time in summer season
- ❖ Efficiency loss during conversion

Source: Industry data

Government can design funding mechanism to scale-up the investment and create public awareness on RE

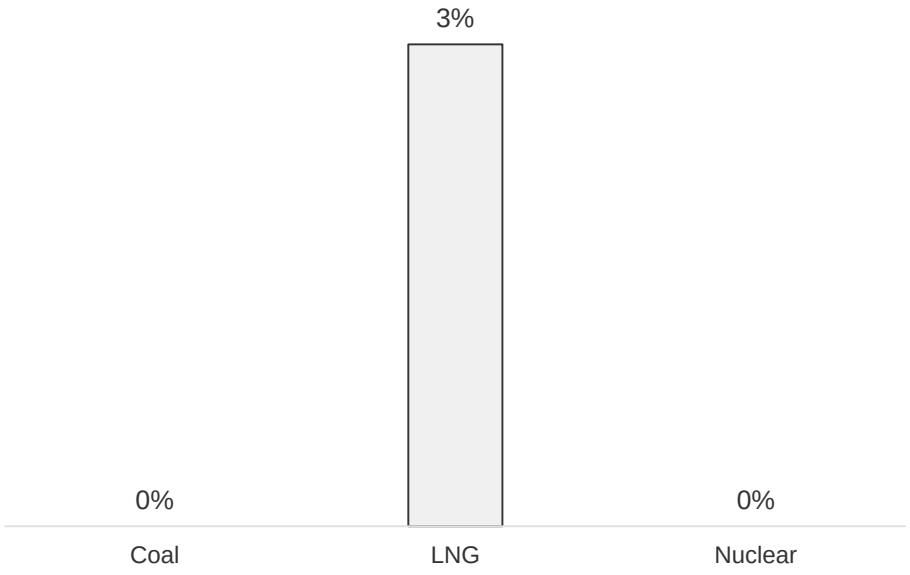
Korea's citizen fund for solar projects : Seoul Metropolitan Government case



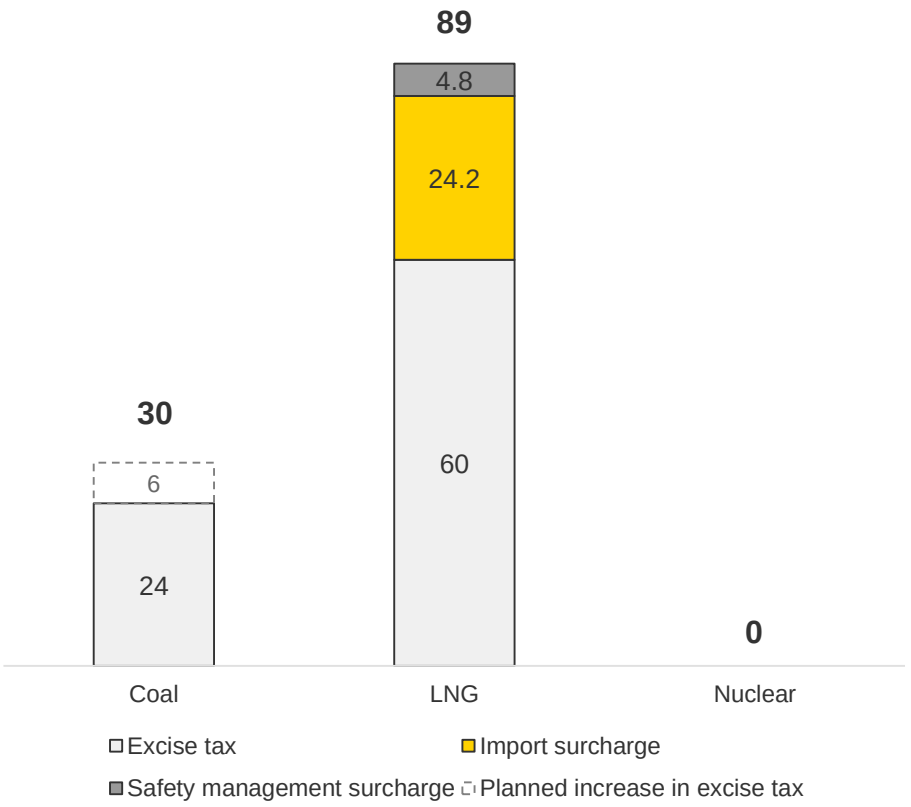
- 1) KOEN: Korea South-East Power
- 2) KDHC: Korea District Heating Corporation

However, tax and duty structure across different technology are not currently consistent with the new administration's policy direction

Basic duty rate (%)

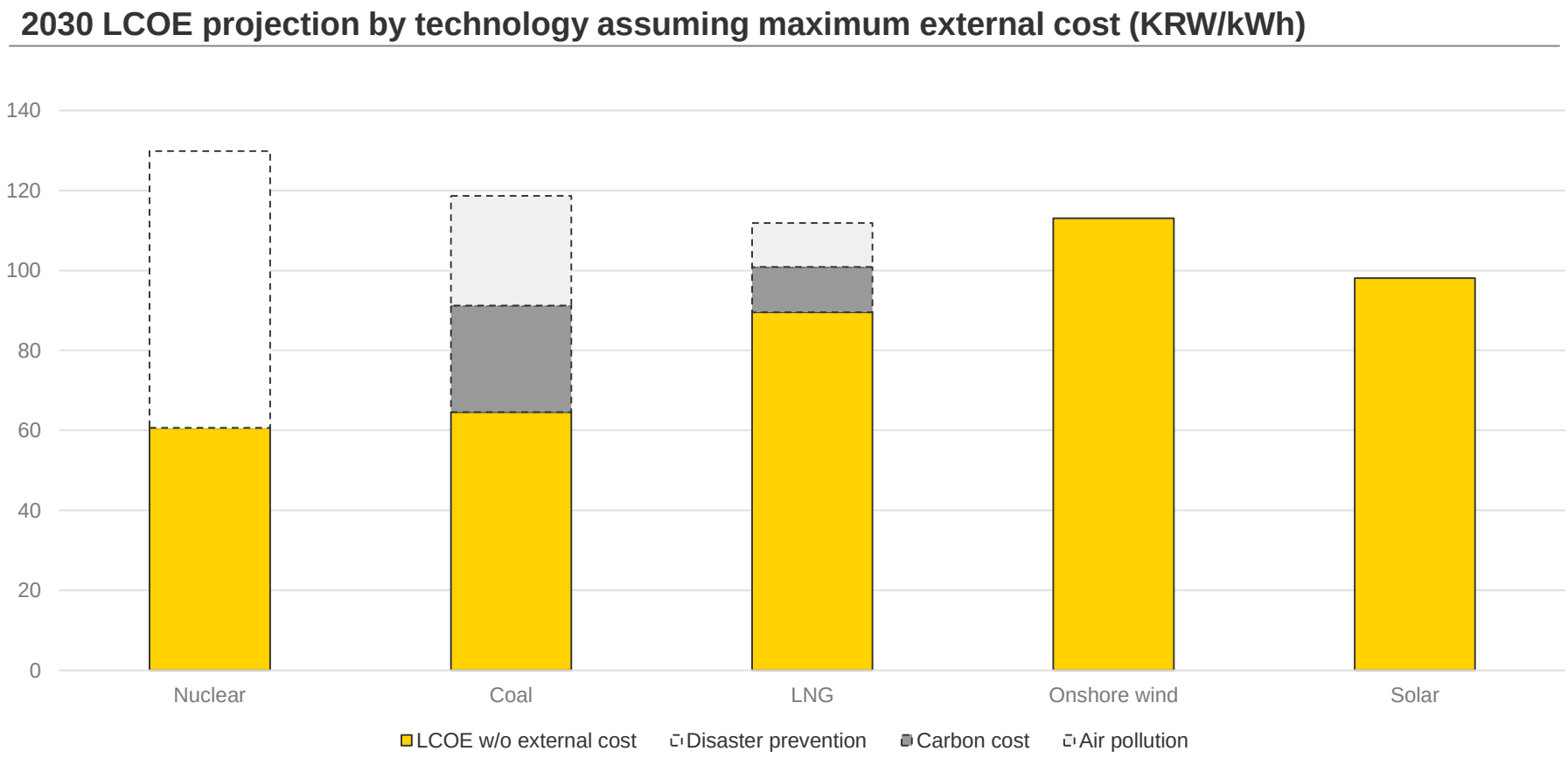


Tax rate (KRW/kg)



Source: The 8th basic plan of long-term electricity supply and demand

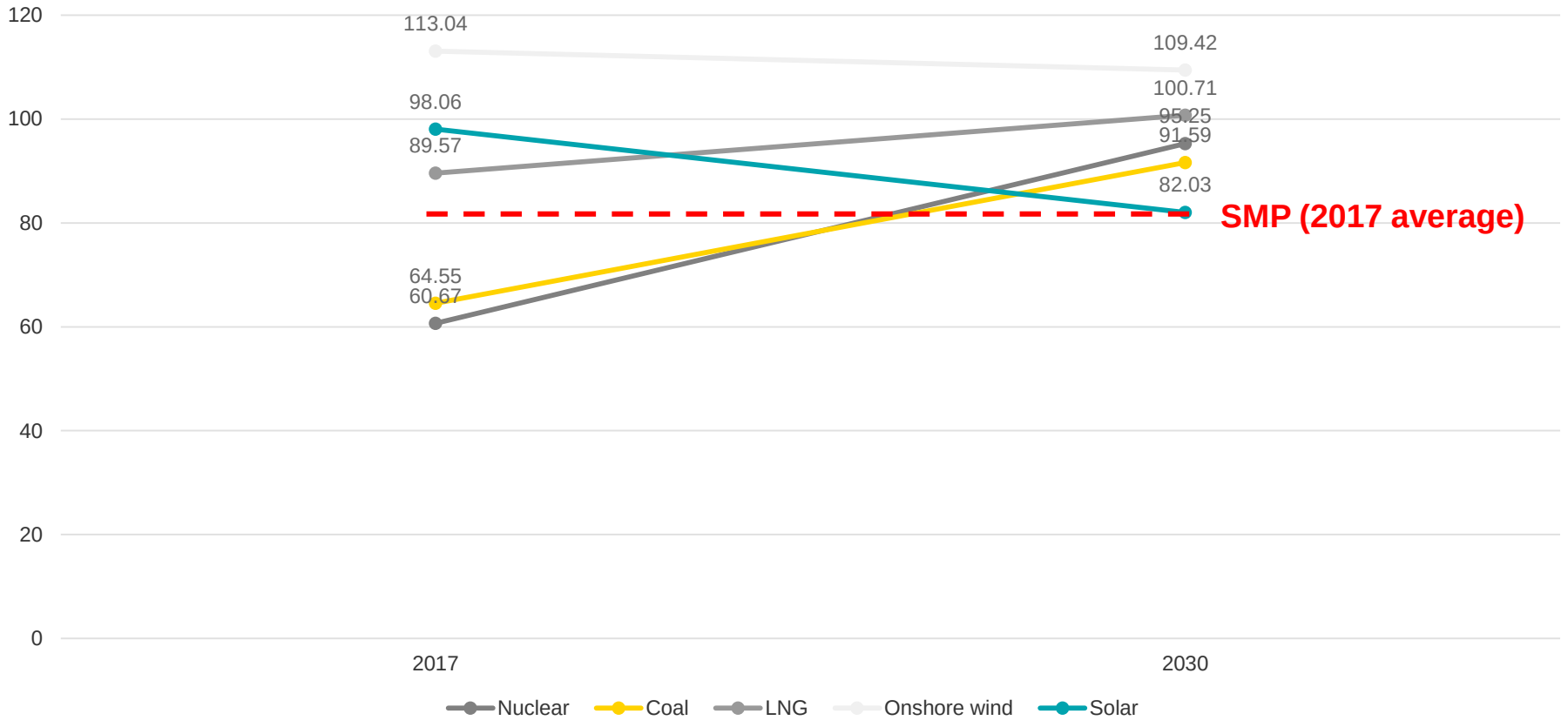
The government is considering using LCOE from next energy planning because LCOE reflects external cost and helps make unbiased investment decision on future energy mix



Source: Energy & Climate Policy Institute

LCOE comparison by each technology indicates that solar will become more cost-competitive and reach grid-party by 2030, whereas fossil fuel will no longer be profitable due to their associated external cost

2030 LCOE projection by technology assuming 50% external cost (KRW/kWh)



Source: Energy & Climate Policy Institute

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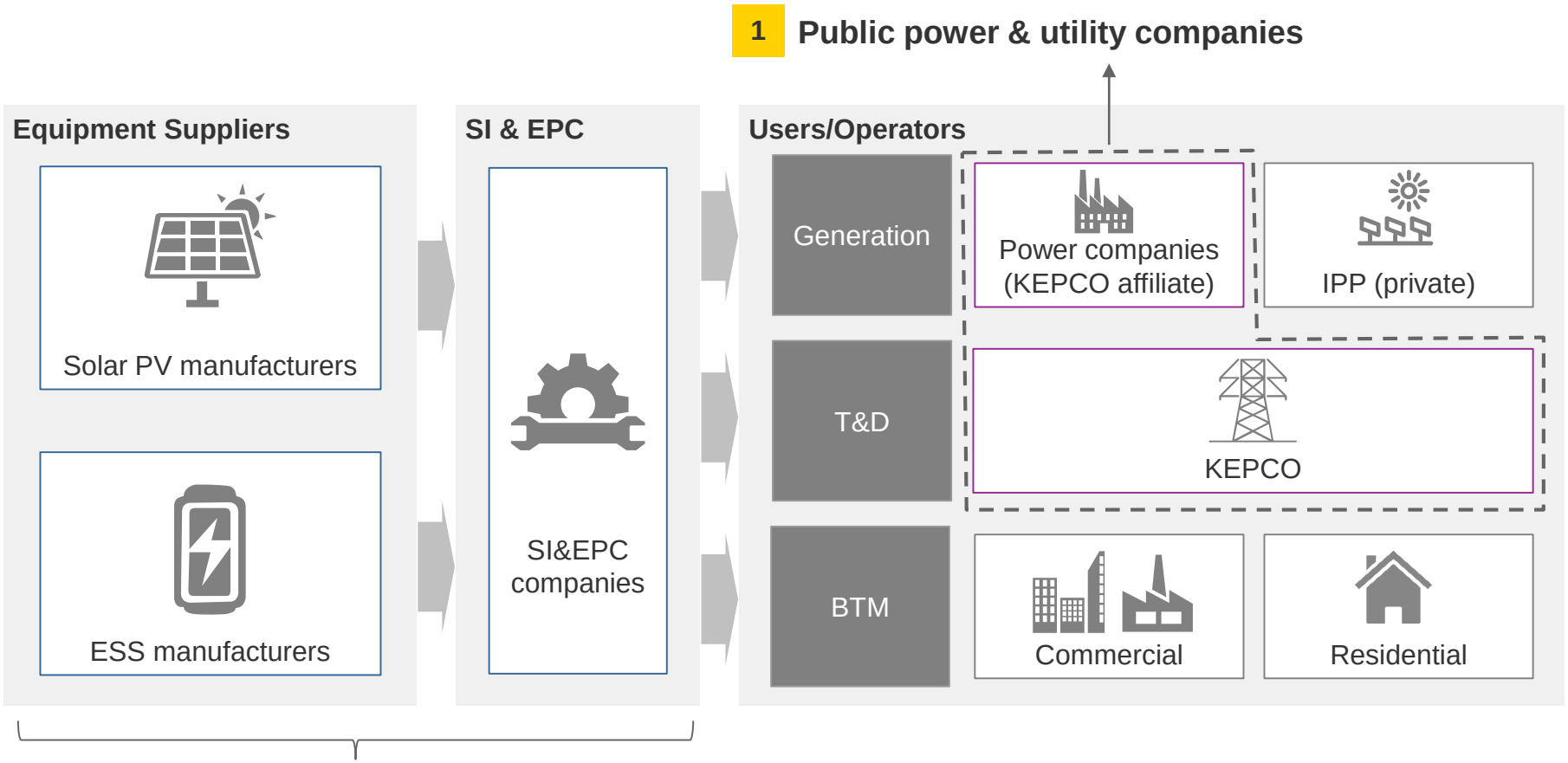
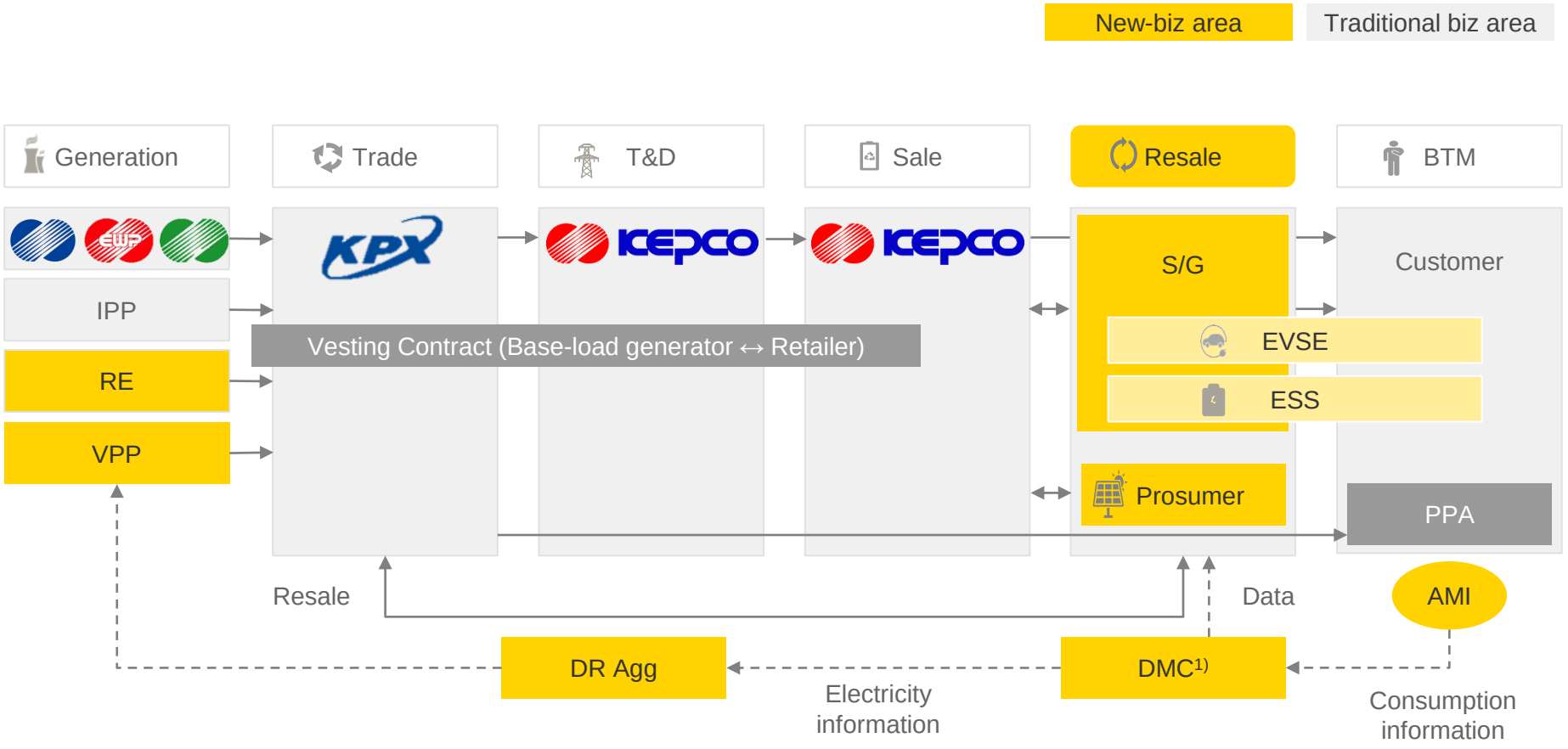
Korea energy market is largely dominated by the state-owned utility KEPCO and its 6 affiliate power companies



KEPCO and power companies are exploring new biz opportunities in downstream due to increasing RE penetration



1) DMC: Data Management Center

KEPCO deployed the world's largest FR-ESS on its own grid for grid stability and operational cost saving

Engineering by KEPCO

Equipment supply

PCS	Battery
LG CNS, HYOSUNG, LSIS, WOOJIN Industrial Systems Co., Ltd.	LG Chem, SAMSUNG SDI, Kokam Great Power for Everyone
· · · 32 companies	· · · 14 companies

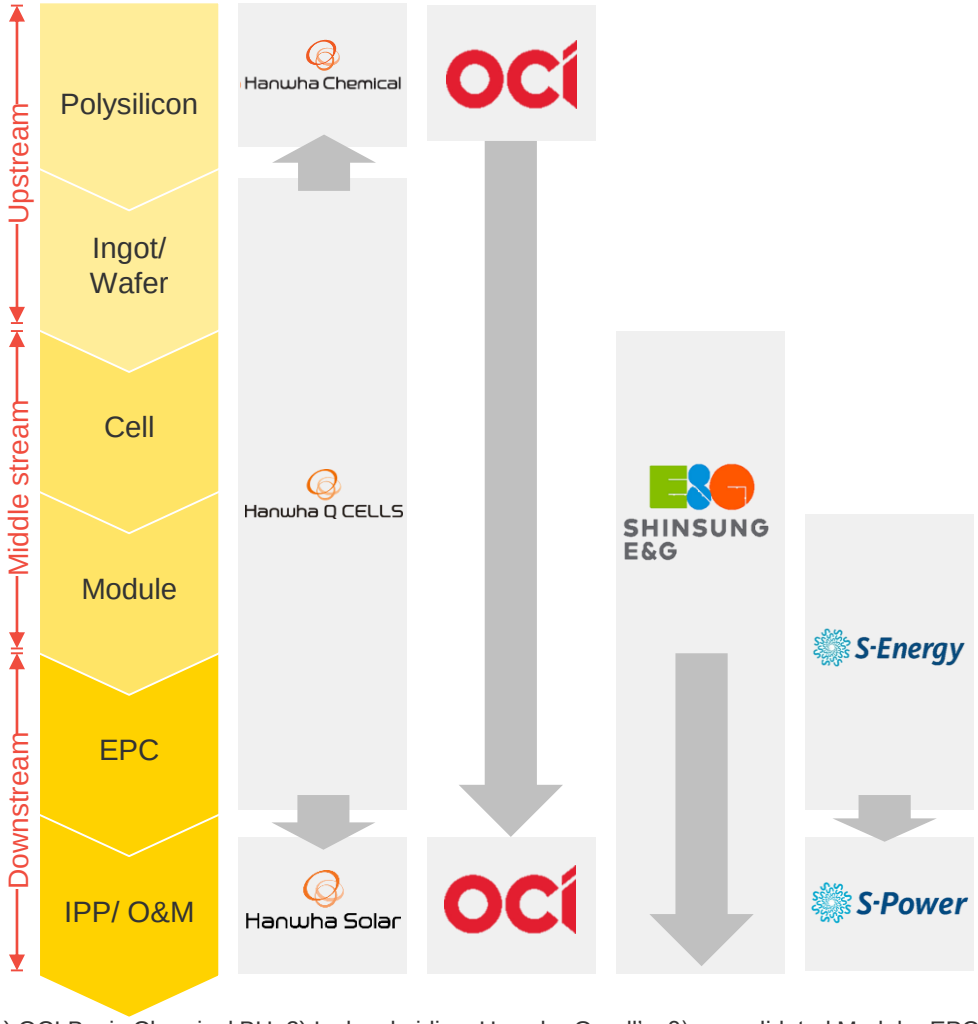
Installed capacity (2015 - 2017)	376MW
Operation cost saving	Annual $ 400 million
Payback period	0.5 years

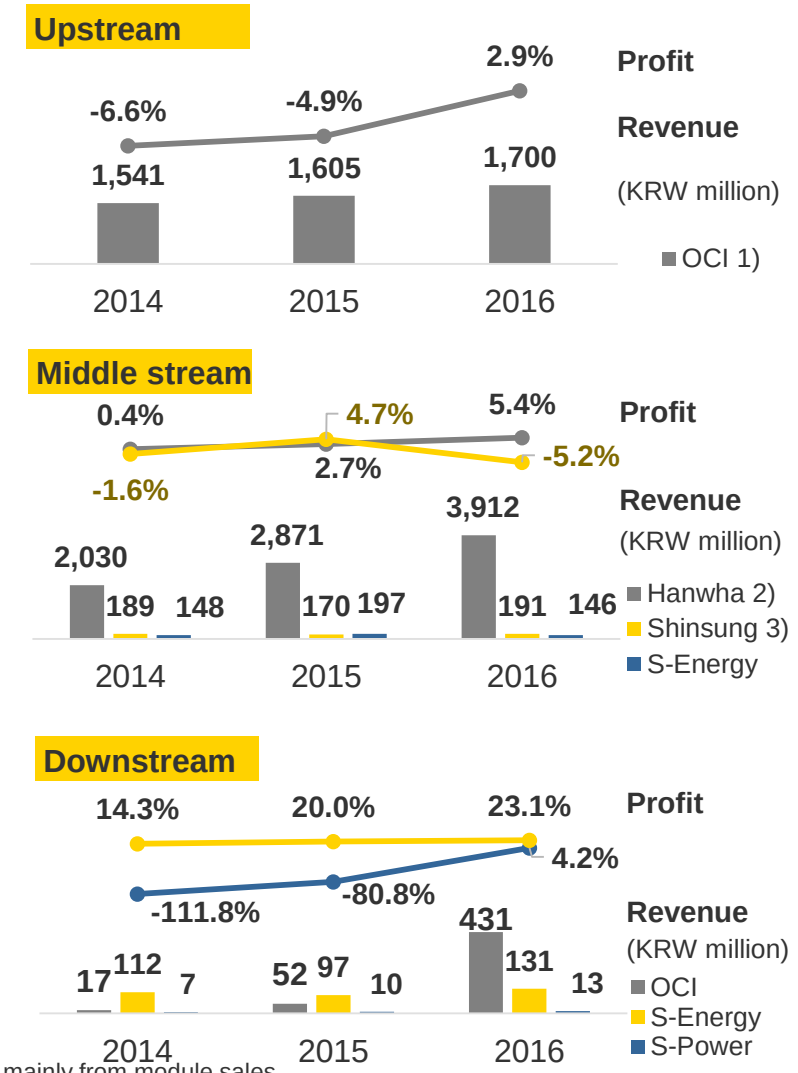
Industry activation

- Market demand creation
- Technology Improvement
- Business track record

Source: KEPCO; Media research

For solar value-chain, major conglomerates are expanding vertically to win in cost-driven market

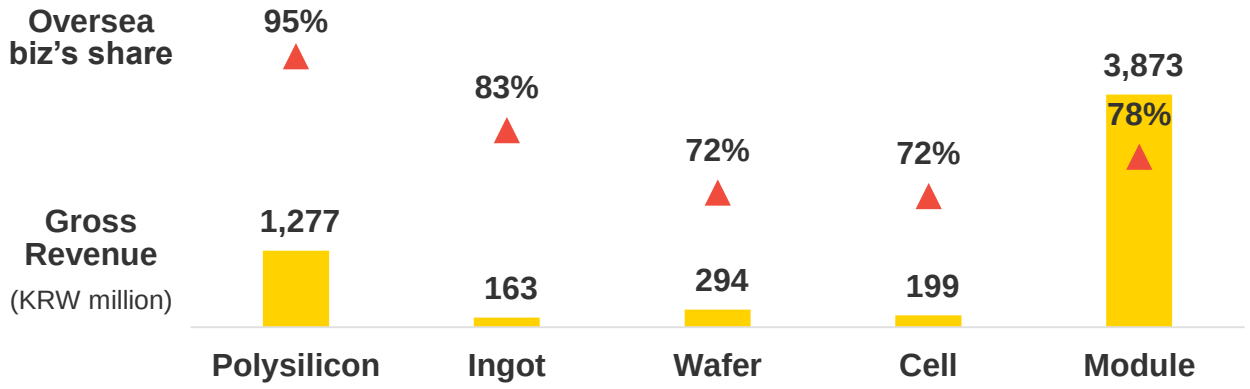




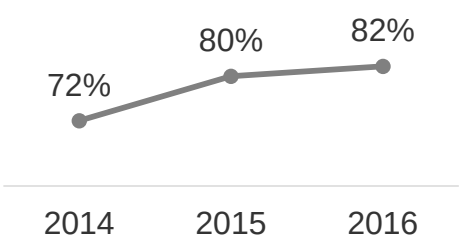
1) OCI Basic Chemical BU; 2) Incl. subsidiary Hanwha Q-cell's; 3) consolidated Module~EPC~O&M, mainly from module sales
Source: Company data

Solar PV manufacturers are increasing their production capa and sales in overseas market to gain economies of scale

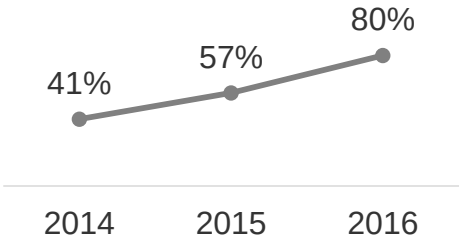
2016 South Korea solar PV industry revenue by category



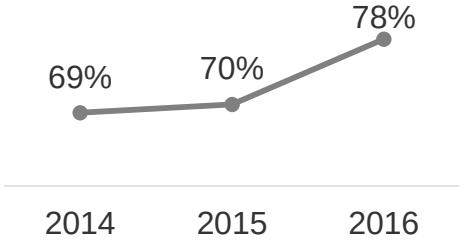
OCI (Basic Chemical)



Shinsung E&G (Cell & Module)

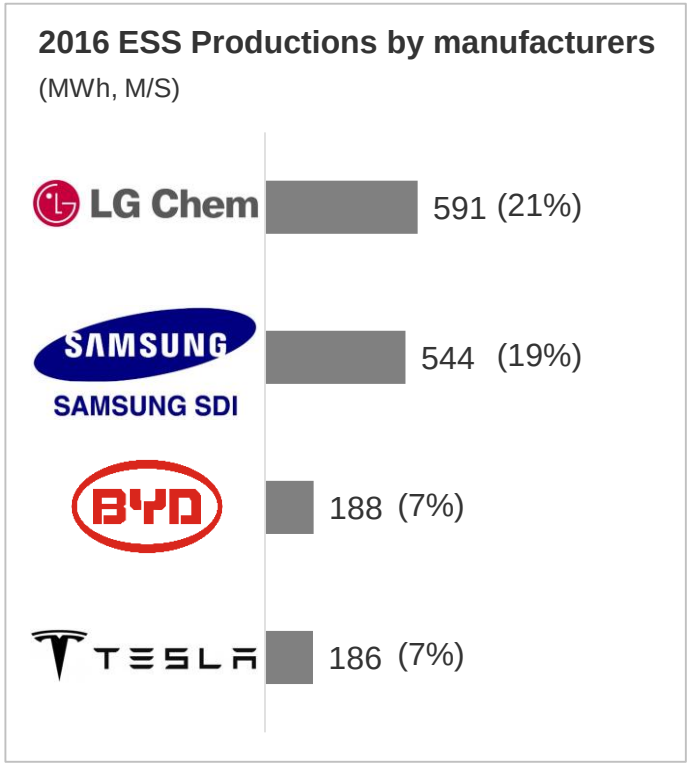


S-Energy (Module)

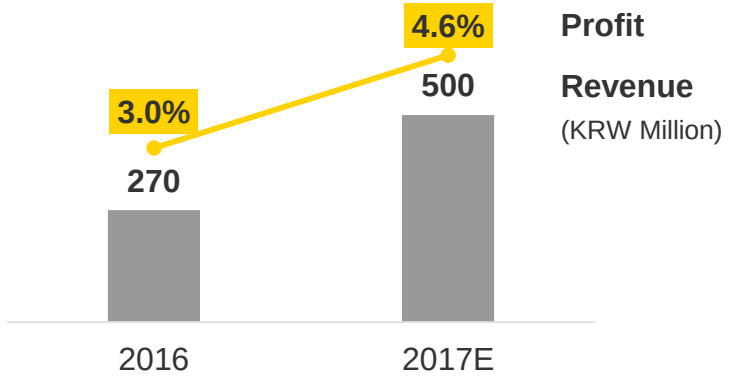


Source: Korea Energy Agency; Company data

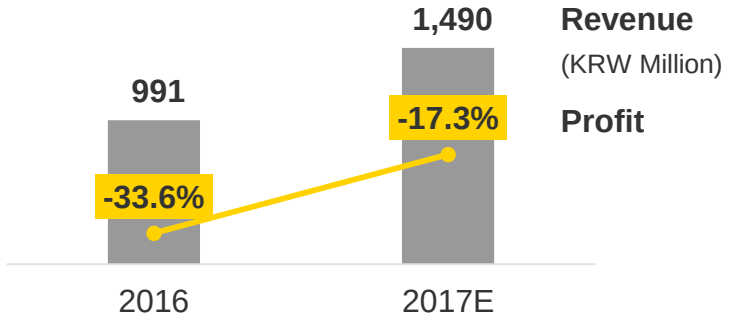
Korea has leading lithium-ion battery manufacturers and they are starting to make a profit



LG ESS Battery biz



SAMSUNG Medium-large battery biz (EV+ESS)



- EV sector accounts for a large portion of the rev.
- ESS sector turned around in 2016, cutting losses in EV sector

Source: Company data; Media research

Heavy electronic/IT companies perform as SI and/or EPC in ESS market

ESS SI & EPC players

Electronic Equipment	LS IS, HYOSUNG
IT	LG CNS, POSCO ICT, LG Electronics
Heavy industry	HYUNDAI HEAVY INDUSTRIES CO.,LTD., DOOSAN Heavy Industries & Construction

- SI or EPC players in private sector develops oversea business on their own or in cooperation with public utilities

Hokkaido PV+ESS power plant

KEPCO
- Project development
- Investment (80%)

Energy Product (local partner)
- Project development
- Investment (20%)

LS
- EPC
- O&M

Source: Media research; EY Analysis

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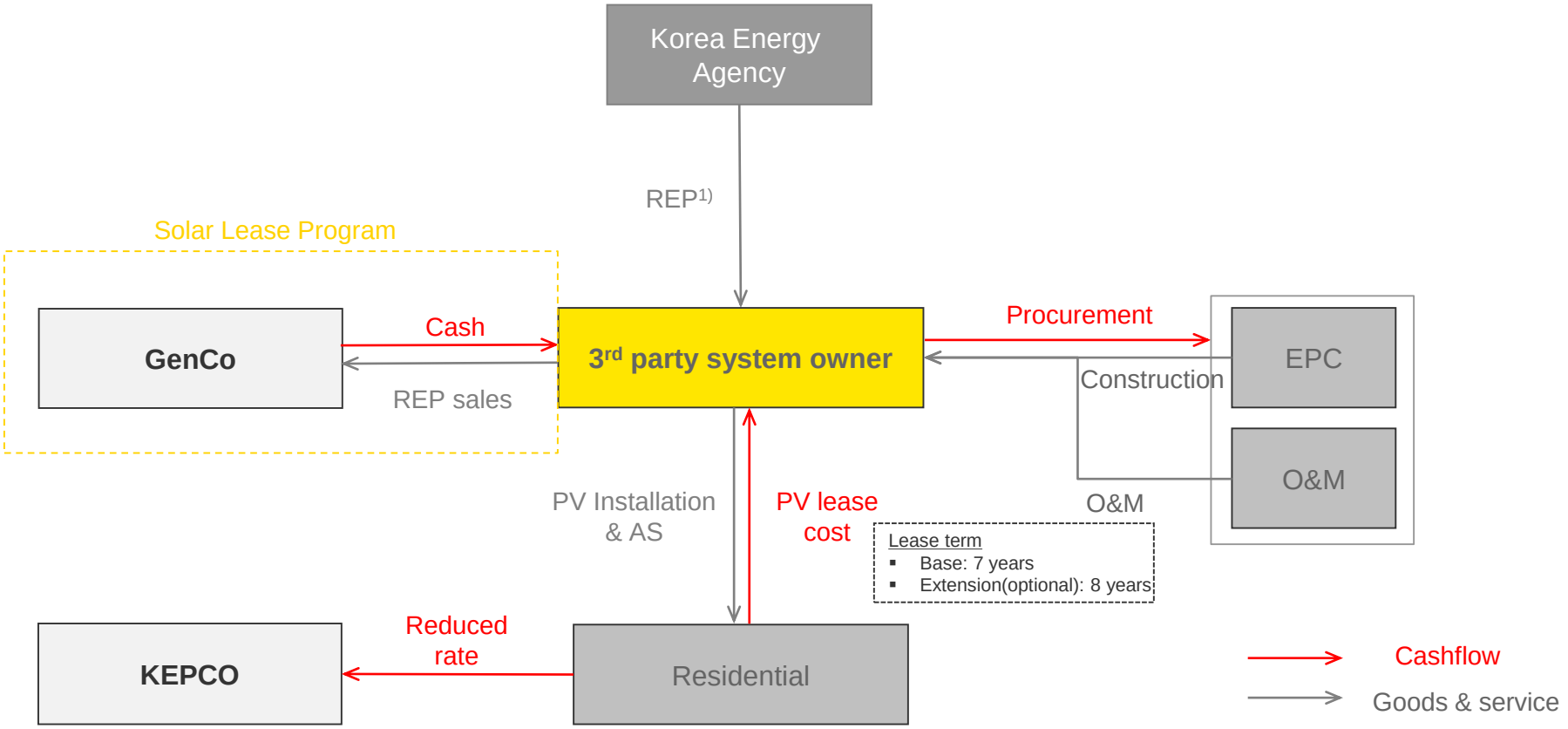
Model 1: Third-party ownership (residential)

Third-party ownership enables system owner to build PV on residential customer premise and get monthly lease payment

Third-party owned model

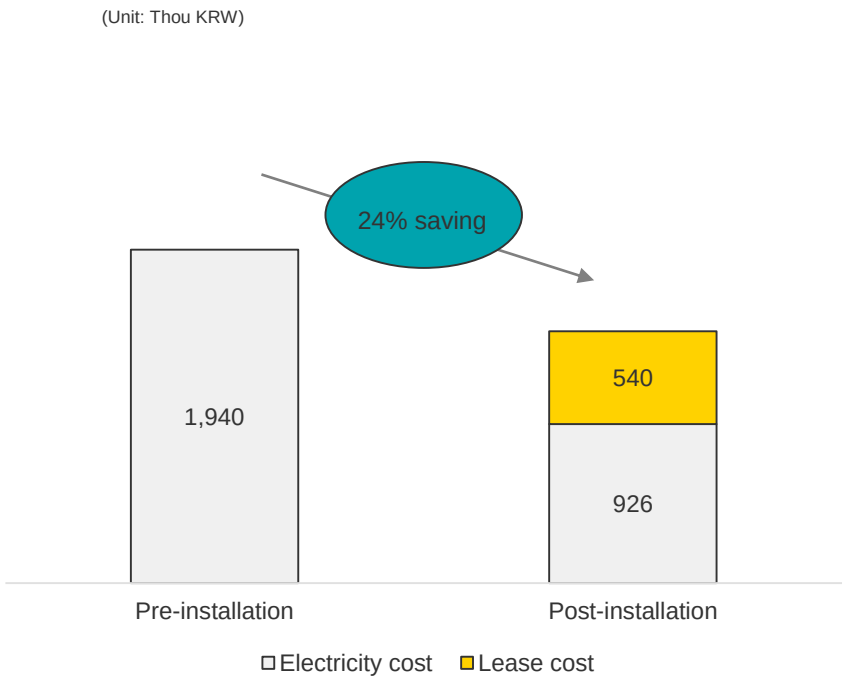


1) Renewable Energy Point: eligible for single house under 3kW @234 KRW / kWh based on 2017 solar lease program

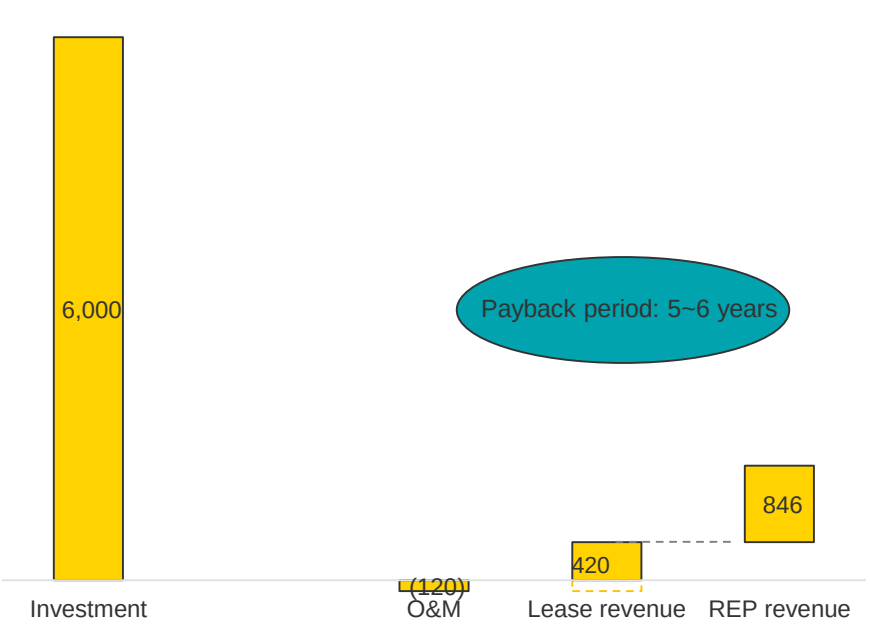
Model 1: Third-party ownership (residential)

Solar lease program is on track to achieve its goal of installing PV in 1 million houses due to the program's economic benefit

Consumer cost (annual)[1)]



System owner cost/revenue (annual)

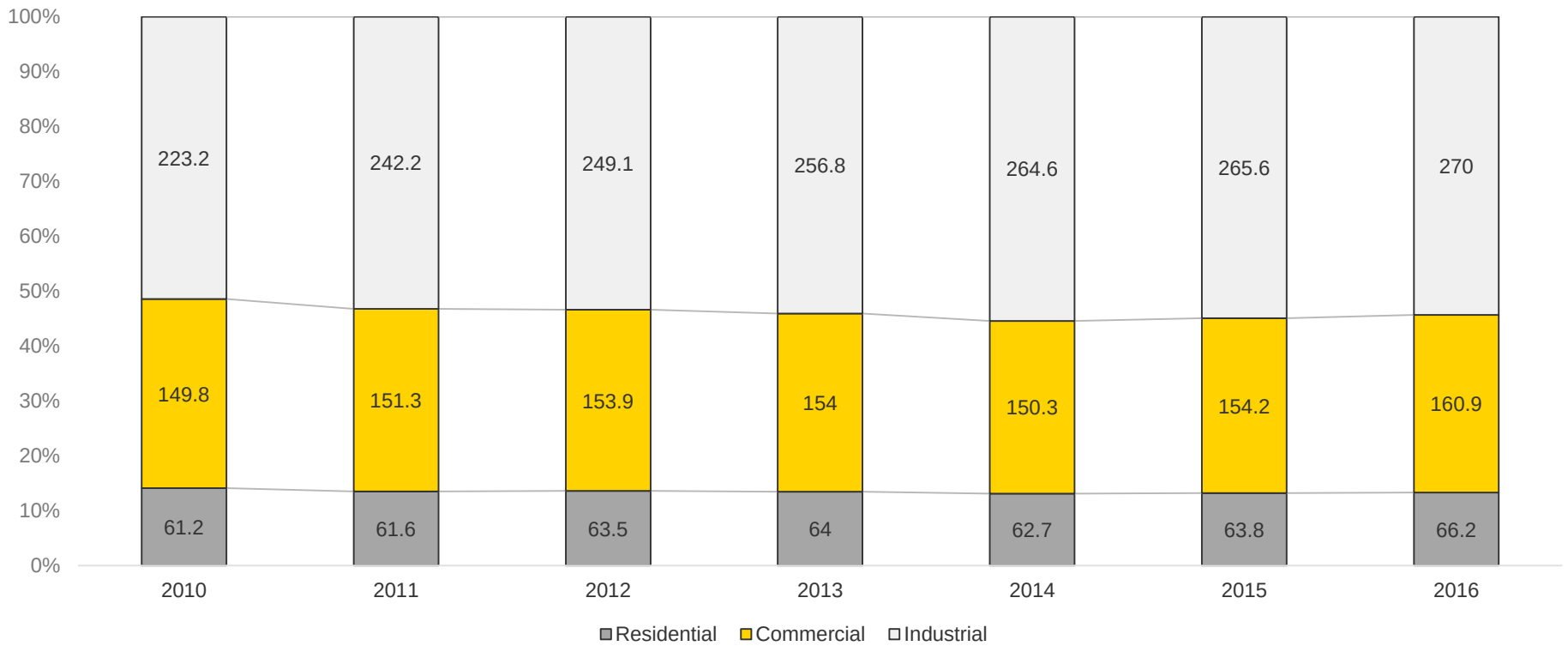


[1)] 3kW single house; maximum least cost assumed based on 2017 solar lease program

Model 1: Third-party ownership (C&I)

Industrial sector accounts for over half of total electricity consumption, and thus energy storage will have bigger impact on reducing the bill

Annual electricity consumption by sector (2010-2016)

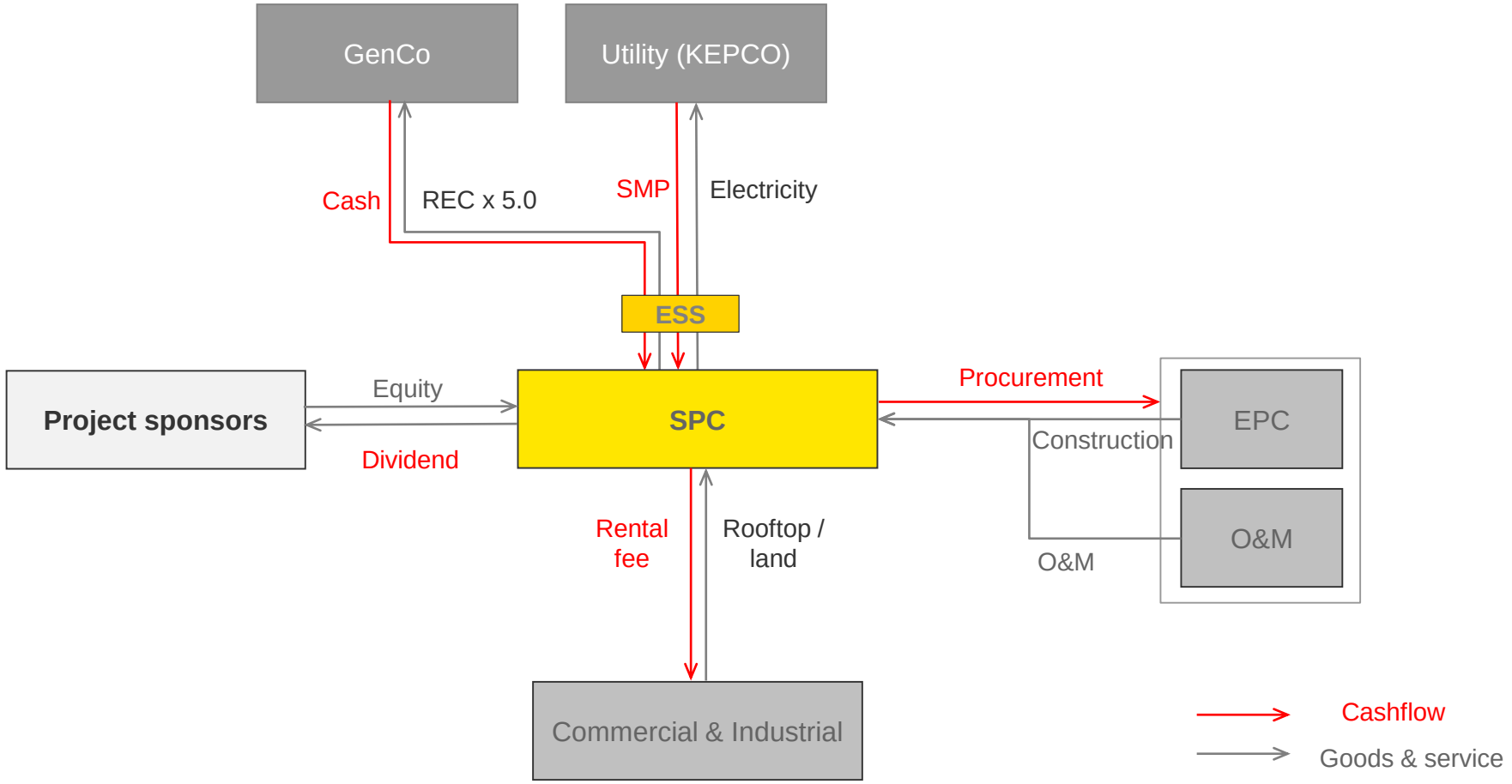


Source: Korea Energy Agency

Model 1: Third-party ownership (C&I)

For C&I, hybrid application of PV + energy storage has become popular as the customer can offset their electricity bill with REC

Third-party owned model



[1] Source: News Clipping

Model 1: Third-party ownership (C&I)

Wastewater treatment facility provides project developers sufficient space to install PV and earn high REC weight, while allowing provincial government to create new source of steady income

Wastewater treatment facility (Gwangmyeong)

- Project sponsor: KD power, Q1 solar
- Project size: 1.8 MW
- Rental contract: 10 years
- Rental fee: 30,000 KRW / kW (approx. USD 50k / year)

Wastewater treatment facility (Seonam/Joongrang)

- Project sponsor: Hanwha Q Cell
- Project size: solar 3.6MW
- Rental contract: 10 years

Model 1: Third-party ownership (C&I)

Companies also use their own property as marketing tool to showcase their technology

LS-IS Busan Office (PV+ESS)

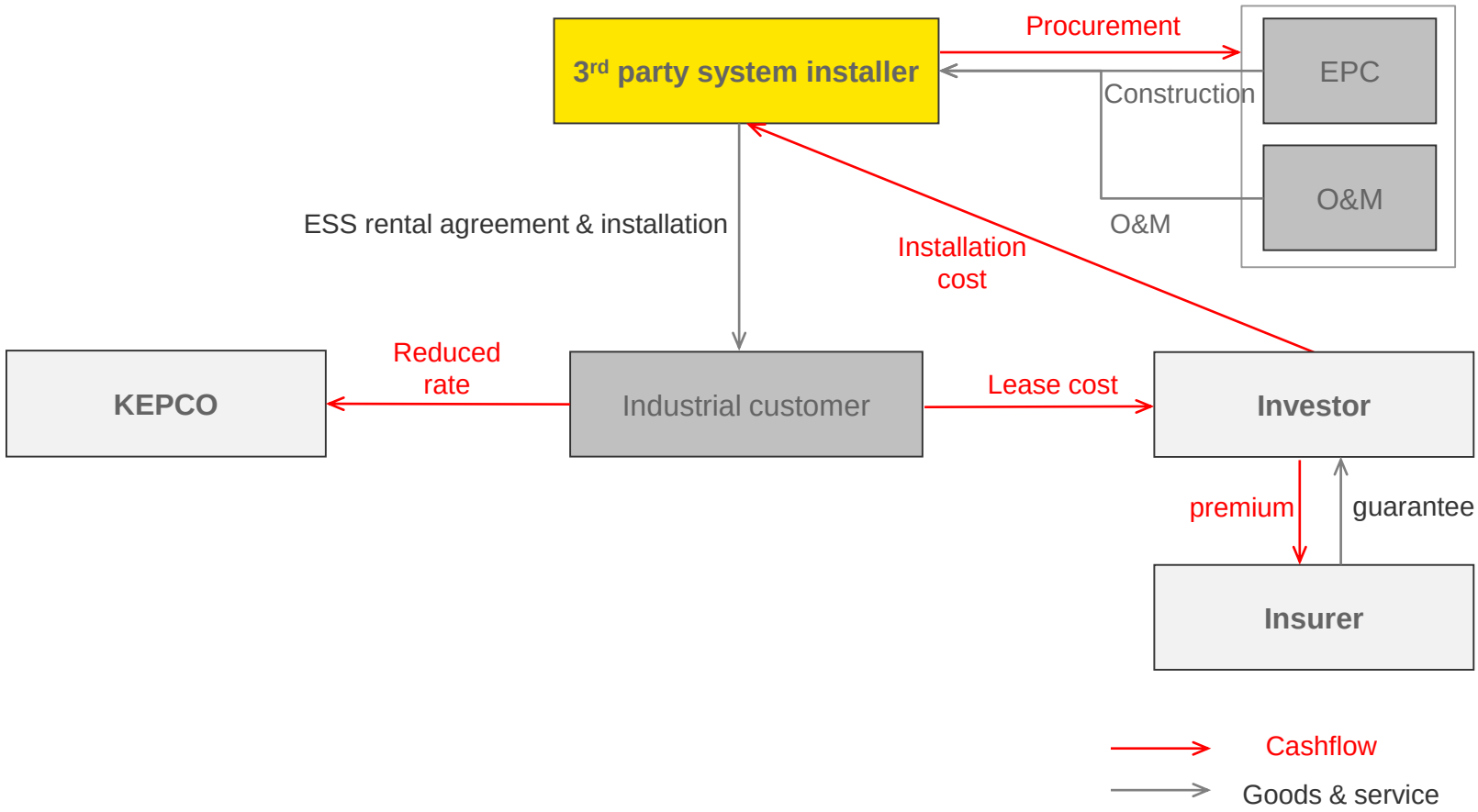
- System: PV 1MW, PCS 1MW, Battery 3MWh (USD 4 million)
- Construction period: Sep - Dec 2017
- Target revenue: USD 600k from SMP + REC sales

Source: Korea Energy Agency

Model 2: Customer ownership

Similar to automotive lease model, customer ownership model eliminates customer's burden of paying upfront cost and transfers the asset ownership to the customer once the term expires

Customer owned model



Model 2: Customer ownership

ESS has different applications from power generation to end customers and thus have multiple business model in accordance with its application

	Application	Purpose	Benefit
Generation	Capacity firming	Maintain the intermittent power output from RE at a firm level for a period of time	Smooth the output and control ramp rate (MW/min) to eliminate rapid voltage and power swings on the electrical grid
	Load levelling	Store power at off-peak and delivering it at on-peak	Reduce the load on less economical peak-generating facilities
	Frequency regulation	ESS is charged or discharged in response to an increase or decrease in grid frequency	Improve power quality
	Spinning reserve	Provide seconds-scale reserve to respond to generation or transmission outage	Eliminate the need to have back-up generators
T&D	Voltage support	Protect loads against sharp drop of voltage in grid	Maintain voltages within the acceptable range
	T&D deferral	Maintain adequate T&D capacity to serve load requirement	Defer the need for the upgrade
BTM	Peak shaving	Reduce peak demand	Avoid installations of additional capacity
	Energy arbitrage	Charge at off-peak, discharge at on-peak	Save on electricity bills

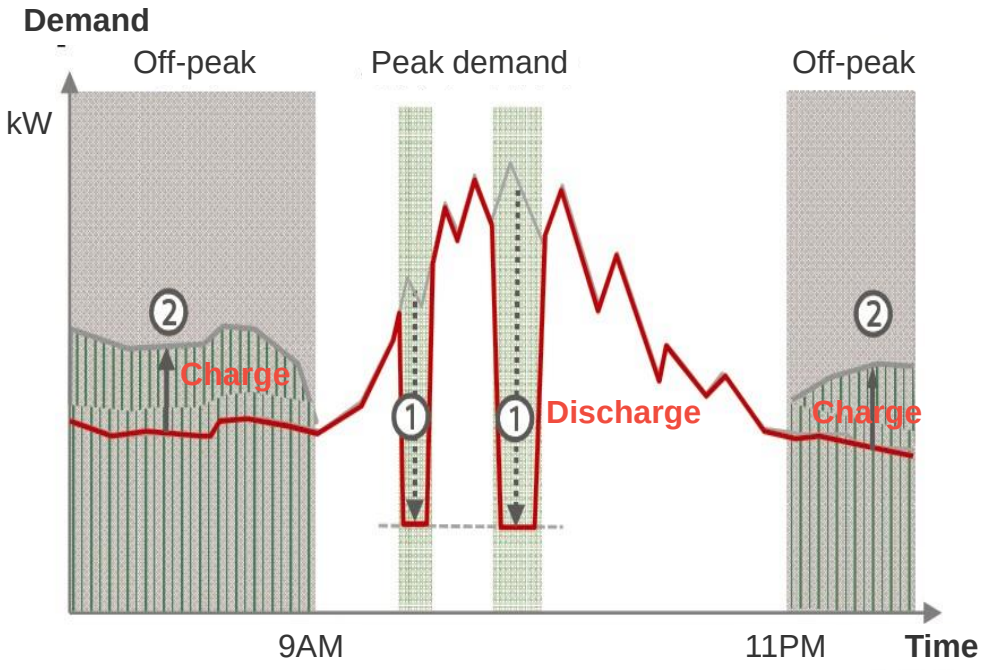
Model 2: Customer ownership

The government's temporary ESS rate discount program boosted customer-owned ESS as peak shaving is heavily compensated

Overview of ESS rate discount program

- Special electricity rates apply to ESSs deployed in general, industrial and educational buildings
- Effective 2017 – 2020

Daily load pattern with ESS peak shaving



ESS rate discount program

① **Base rate discount for peak shaving**

Peak reduced (kW) × Base rate (KRW/kW) × 300% × Weight by capa

② **Discount for off-peak time charge**

Charging consumption (kWh) × Consumption rate (KRW/kWh) × 50% × Weight by capa

Weight by installed capacity

ESS capa. compared to contracted capa	Weights
10% and over	X 1.2
5% ~ less 10%	X 1.0
Less 5%	X 0.8

Source: Industry data

Model 2: Customer ownership

Large-scale ESS is being deployed as investment payback period is reduced to 3-4 years

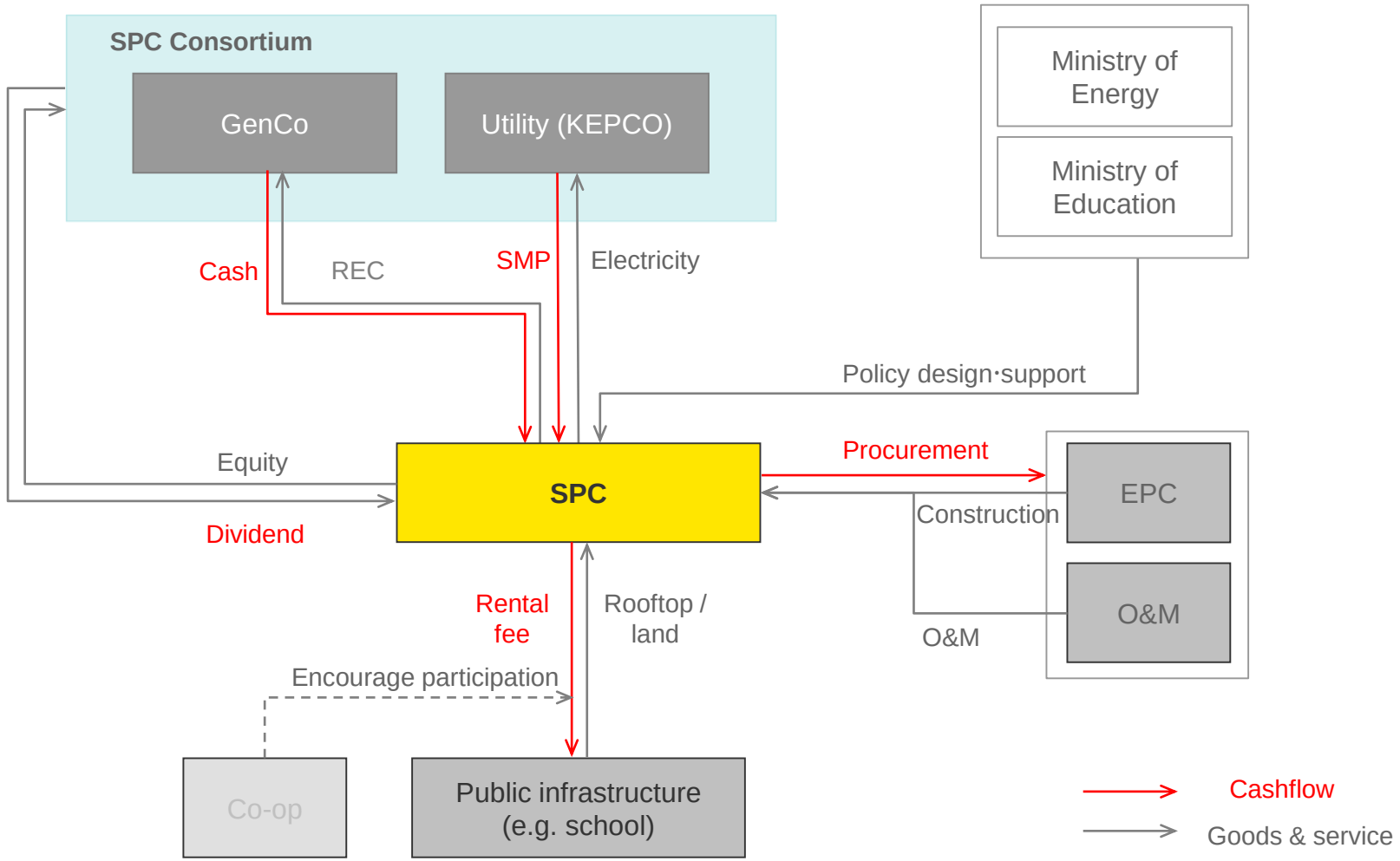
Hyundai heavy industries (Ulsan)

- Project sponsor: Korea Energy Agency, KEPCO energy solution, Hyundai commercial
- Configuration: Battery 51.5MWh, PCS 24MW
- Project financials
  - Total investment: $24 million
  - Expected annual saving: $8 million (~'20), $5 million ('21~)
- Commission date: Nov 2017 (total 20 years)
- Operation strategy: 10% peak-shaving, ESS rate discount program

Model 3: Utility ownership

Utility firm builds and owns PV through SPC and sell power to the grid as intra-company transaction

Utility-owned model (school solar)



Model 3: Utility ownership

As utility-ownership model, KEPCO launched school solar program to install 250MW in 2,500 schools by 2020

<KEPCO-Daejon education authority MOU signing ceremony, 2016>

<Solar PV installed on school rooftop>

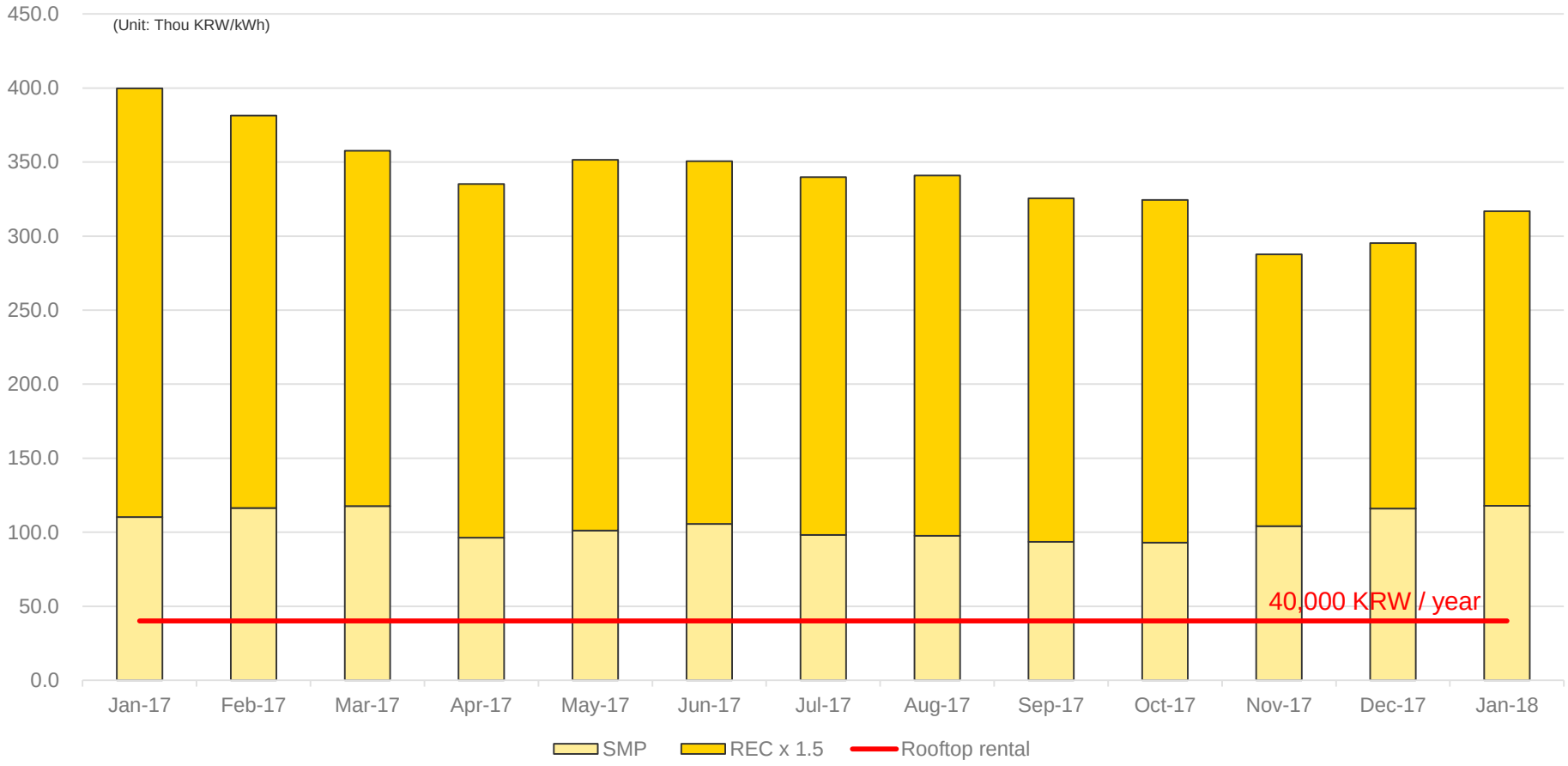
- Project sponsor: SPC(KEPCO / 6 Power Companies)
- Investment cost: $550 million
- Project size: 250MW (2,500 out of 11,446 schools)
- PPA contract: 20 years

1) Source: News Clipping

Model 3: Utility ownership

Utility firm has set fixed KW-based price for renting school rooftop, enabling project economics indifferent from installation location

Rooftop solar PV revenue simulation for school solar program[1)]



[1)] SMP and REC price based on spot price

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