An Economical Analysis on the Installation of Photovoltaic Cell (PV) and Battery in the Residential Sector

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Purpose of This Study

- **Japanese Government has determined the new target of GHGs reduction to achieve 26% reduction from the 2013 level up to 2030 (in 2015).**
- **The GHGs emissions in 2017 recorded to the 8.4% down from the 2013 level (the 1.5% up from the 1990 level).**
- **In the long-run, the continuous increases in GHGs emission in the residential sector (offices and households) were largely influenced to the whole GHGs increases.**
- **In this study, we would like to analyze the effective uses of PV and battery in the residential sector under various capacity conditions and cost conditions.**
- **We also would like to discuss the future subjects of this important measure in the residential sector.**

Setting Basic Conditions for Economic Simulations in This Study

< Household sector >

- **Number of household: 1,000 households**
- **Size of PV on the roof: 4 kW Total: 4,000 kW**

< Commercial sector >

- **Total floor area: 25,000 m^2**
- **Installed place of PV: roof floor of building or Open space**

< Electricity Charge >

- **Household : Day 36.98 Yen/kWh, Intermediate 24.65 Yen/kWh**
  Midnight 13.00 Yen/kWh, Average: 24.33 Yen/kWh
- **Commercial: Day 19.28 Yen/kWh, Intermediate 14.83 Yen/kWh**
  Midnight 13.00 Yen/kWh, Average: 17.53 Yen/kWh

Installed Capacity Cases Treated in This Economics Simulation

Case (i): PV zero and battery zero (Base case)

Case (ii): PV zero and battery 20,000 kWh

Case (iii): PV 8,000 kW and battery zero

Case (iv): PV 8,000 kW and battery 20,000 kWh

(Net zero case: small purchased and small PV sold are almost balanced)

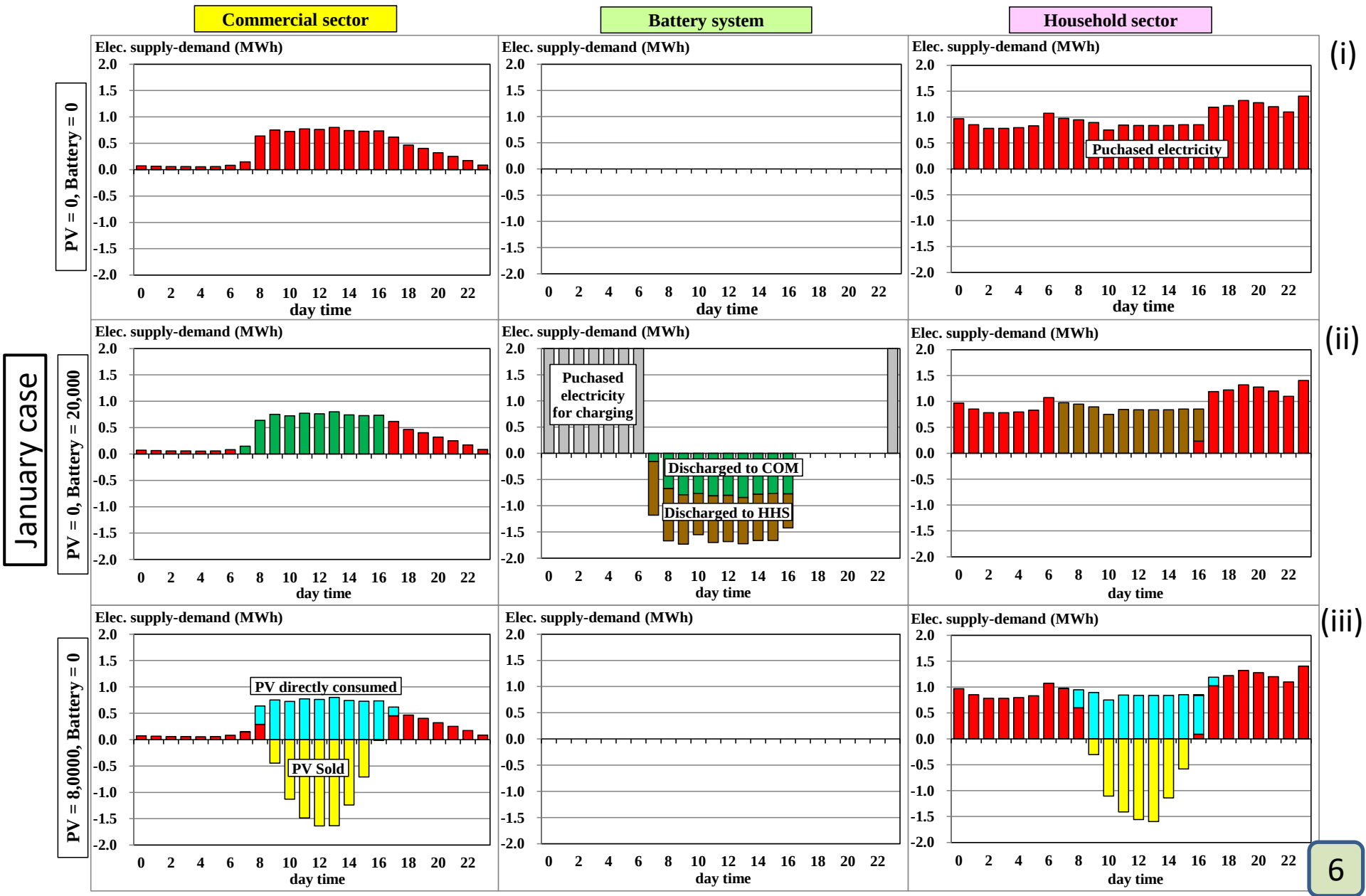
Case (v): PV 44,000 kW and battery zero

Case (vi): PV 44,000 kW and battery 20,000 kWh

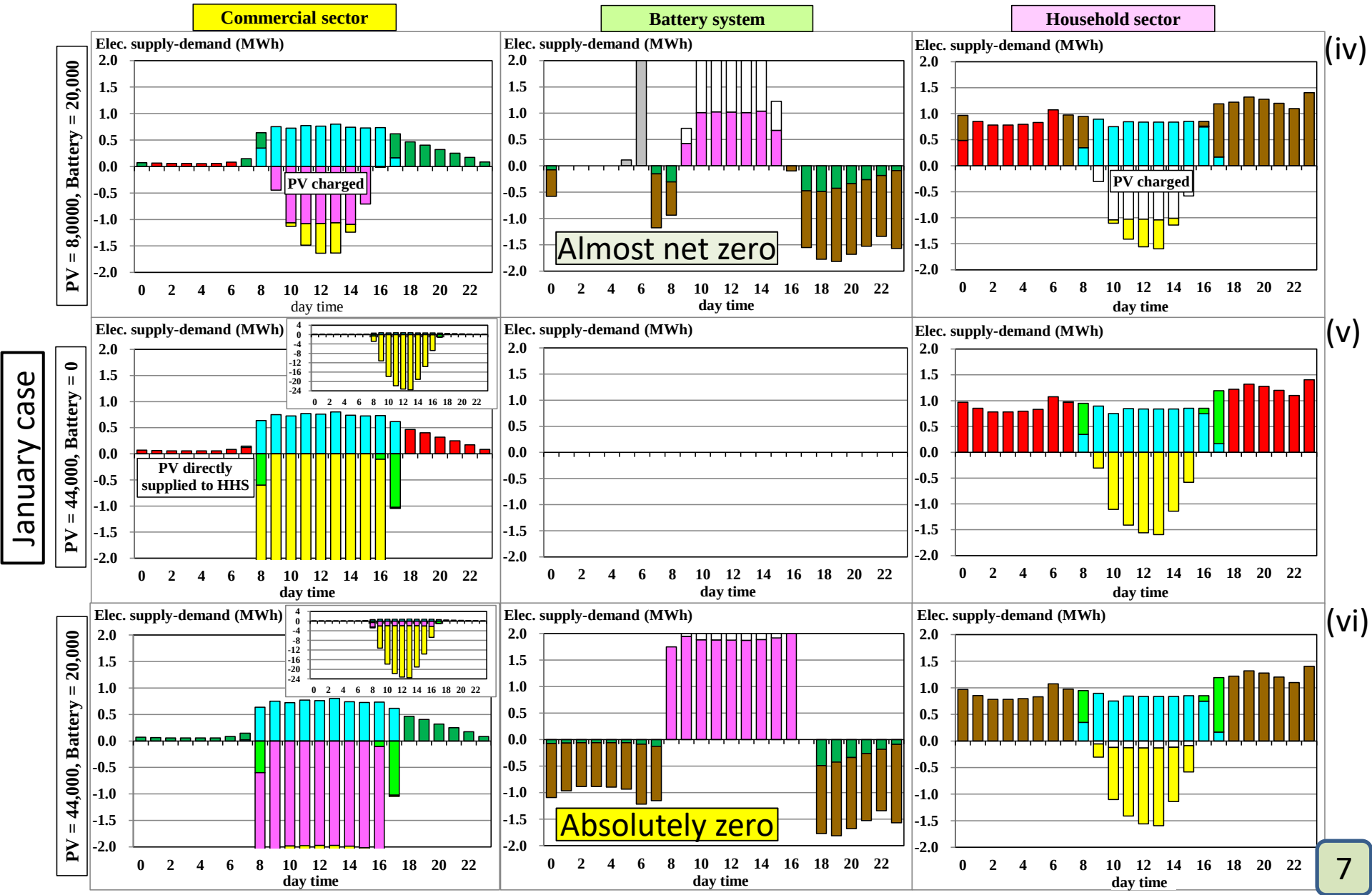
(Absolutely zero case: no purchased)

Winter (Jan.), Summer (July), Intermediate (Oct.)

Changes in electricity supply pattern (1)



Changes in electricity supply pattern (2)

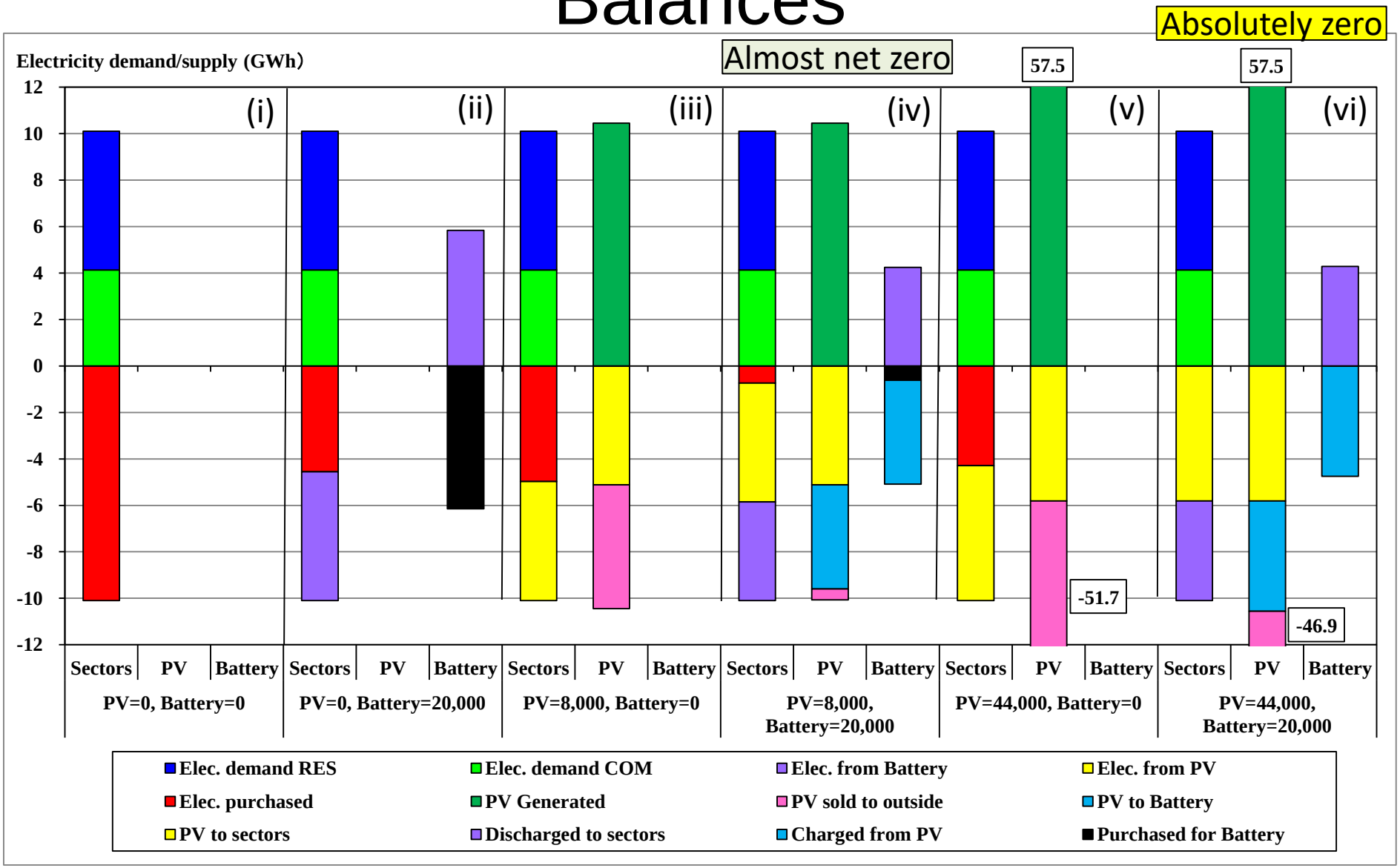


Specific Characters on Electricity Supply Pattern by Season

	Commercial	Household	Purchase $= \text{ or } \fallingdotseq 0$
Winter	↑ Daylight	↑ Whole day	Case (vi)
Summer	↑ Daylight	↑ Evening to midnight	Case (vi) and Case (iv)
Intermediate	↓ Daylight	↓ Whole day	Case (vi) and Case (iv)

- **PV plays a powerful role on covering the commercial and household daylight demand.**
- **But the household and commercial demand from evening to mid-night is covered especially by the combination of PV and battery.**

Case Changes in Annual Supply Demand Balances



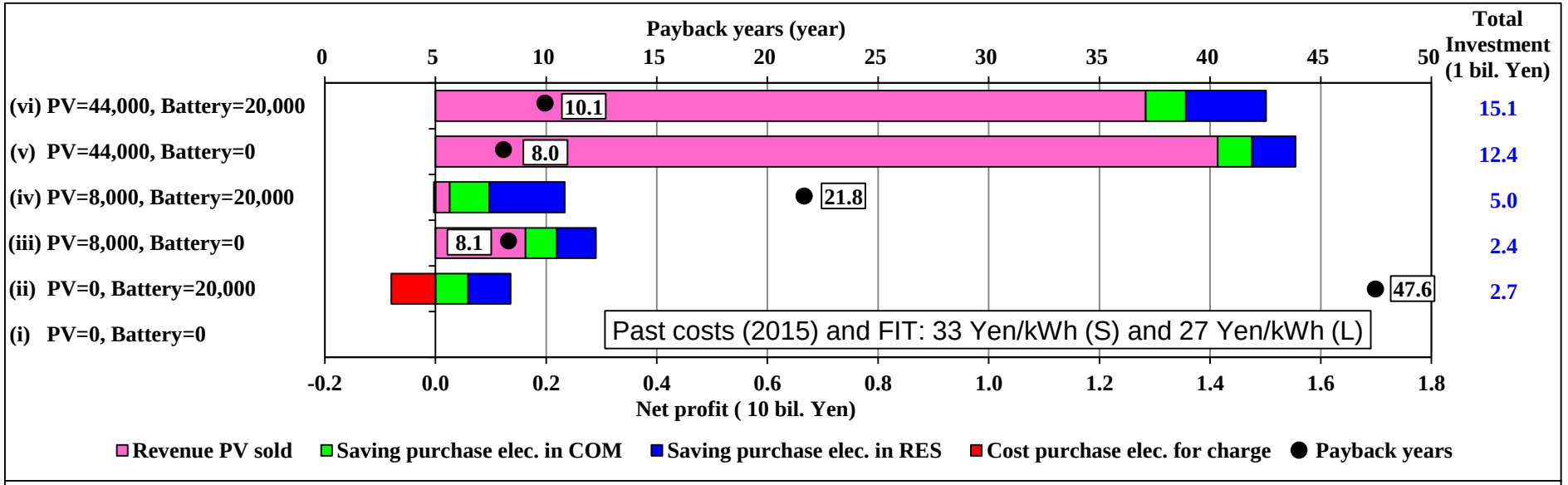
Purchased E remains in (ii),(iii), (v). Large surplus PV is sold in (V), (vi)

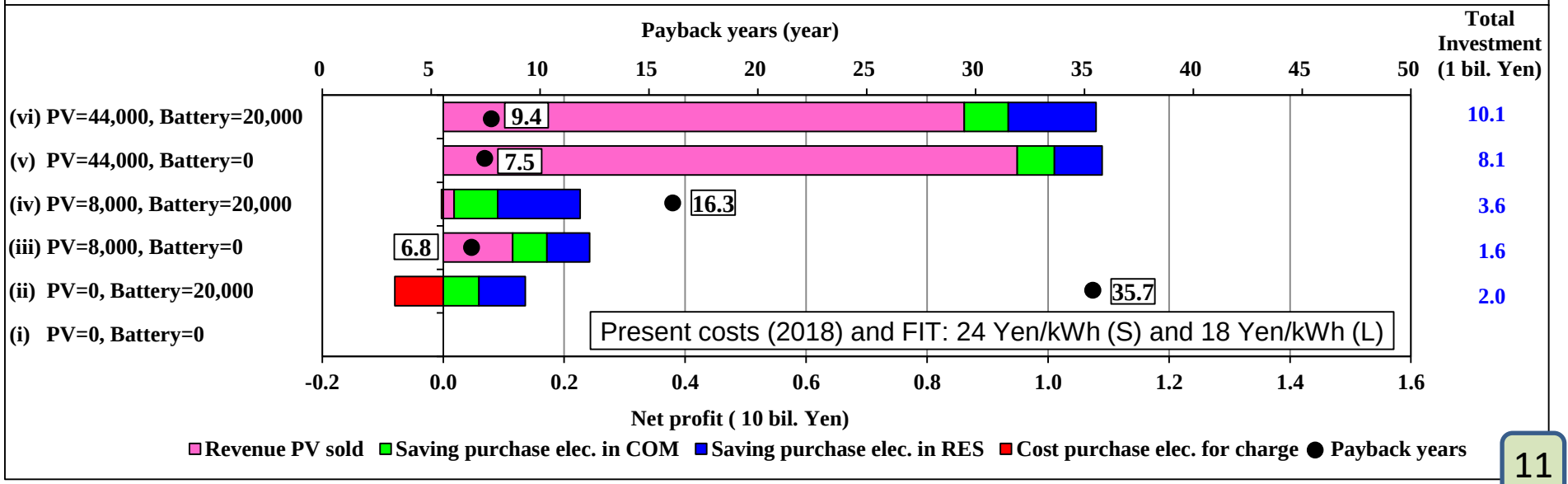
Recent Changes on Economic Conditions

	2015	2018 Present
Battery cost (Yen/kWh)	200,000	150,000
PV cost (Yen/kW) (Mega & large)	300,000	200,000
PV cost (Yen/kW) (Small)	350,000	250,000
FIT price (Yen/kWh) (PV Large, Commercial)	27	18
FIT price (Yen/kWh) (PV Small, Household)	33	24

Changes in payback years

-- Cost & FIT: Past (2015) and Present (2019) --





FIT Price Level Should be Considered from the Cost Competitiveness of PV

< Competitive Level of PV Cost >

Household Electricity Charge Level	:	24 Yen/kWh
Commercial Electricity Charge Level	:	14 Yen/kWh
Industrial Electricity Charge Level	:	10 Yen/kWh
Power Generation Full Cost Level	:	7 Yen/kWh
Power Generation Variable Cost Level	:	4 Yen/kWh

< Past Changes in PV FIT Price>

FY2012: Household 42 Yen/kWh, Commercial 40 Yen/kWh

FY2014: Household 37 Yen/kWh, Commercial 32 Yen/kWh

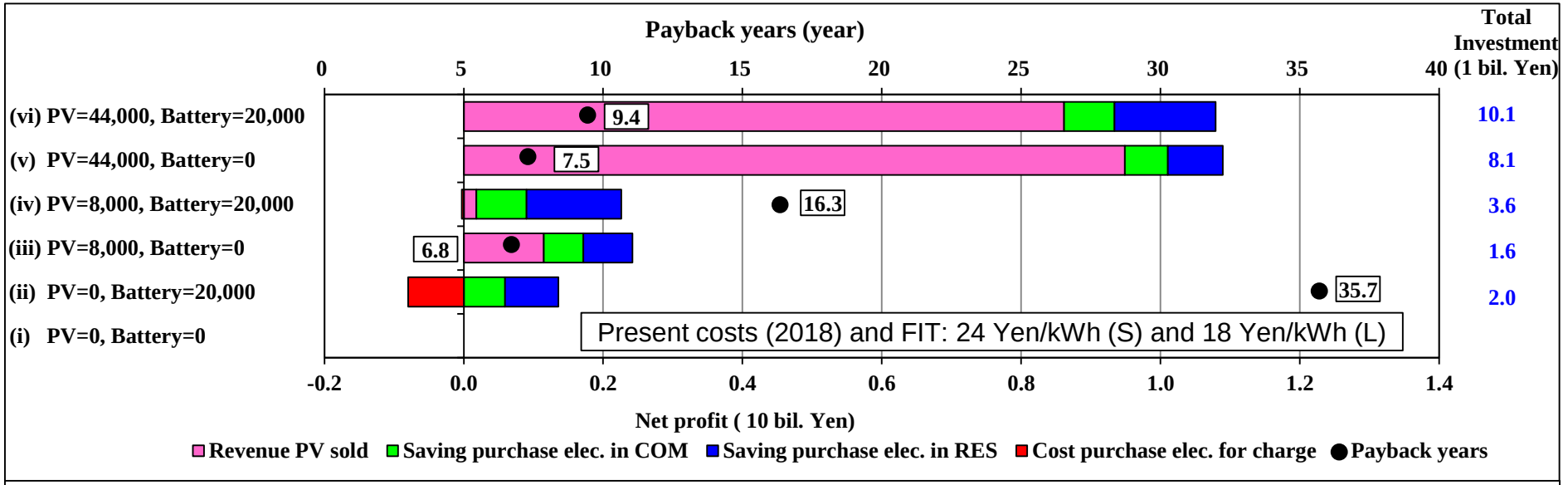
FY2016: Household 31 Yen/kWh, Commercial 24 Yen/kWh

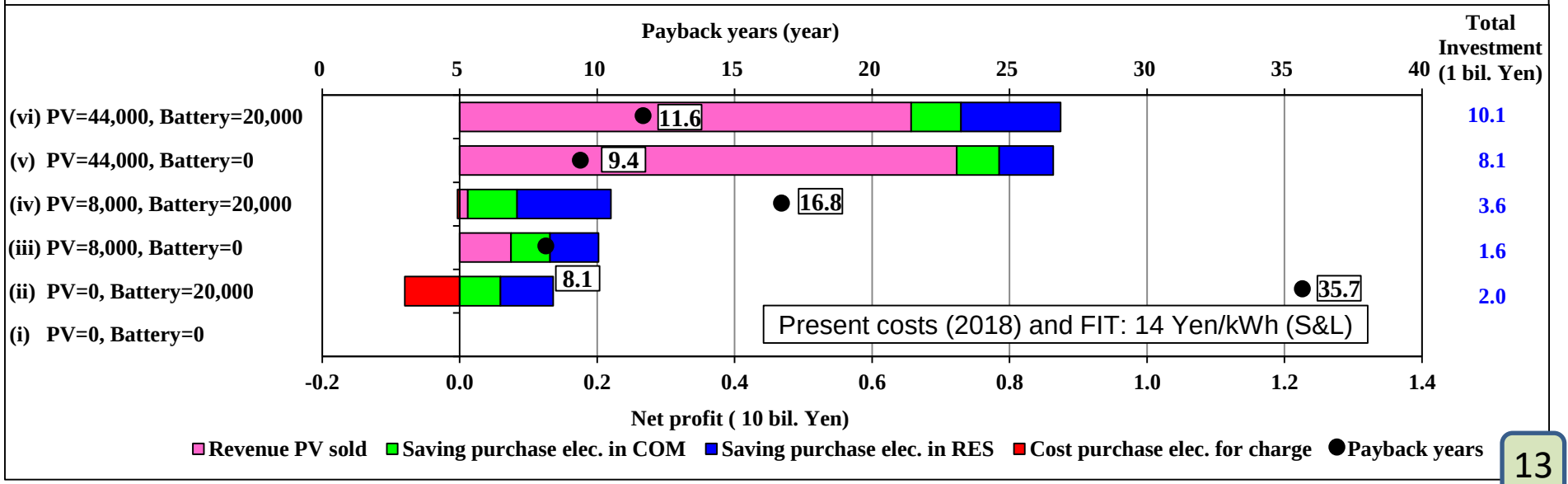
FY2017: Household 28 Yen/kWh, Commercial 21 Yen/kWh

FY2018: Household 24 Yen/kWh, Commercial 18 Yen/kWh

Case simulation on payback years (1)

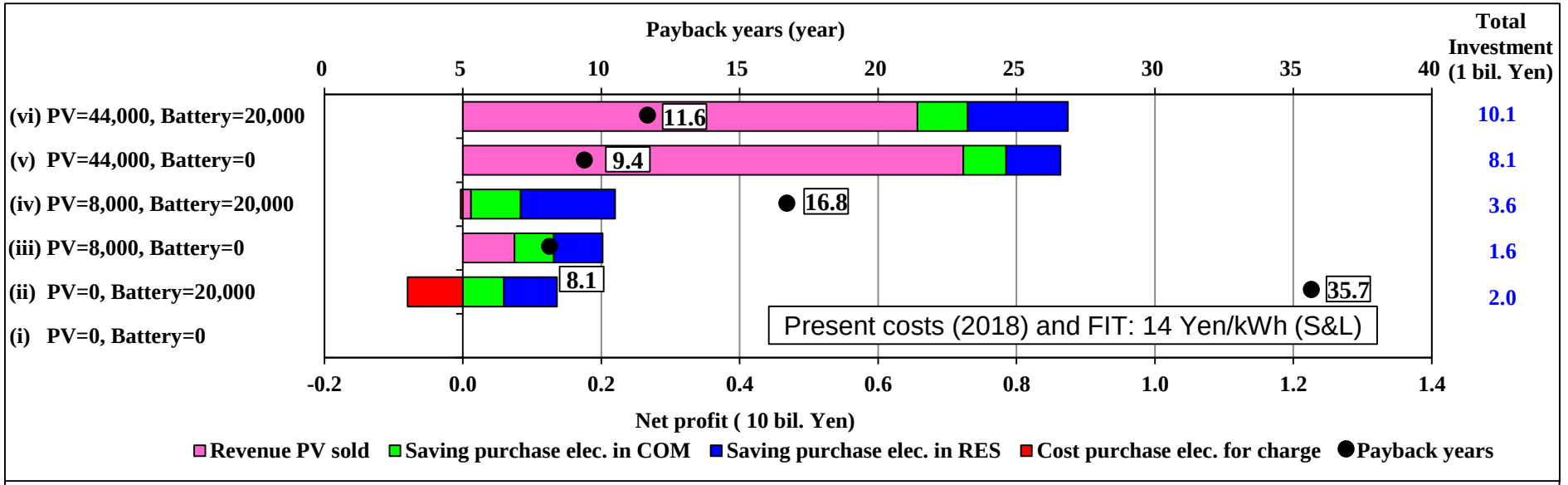
-- Present cost, FIT: 24 Yen (S), 18 Yen (S) → 14 Yen (S&L) --

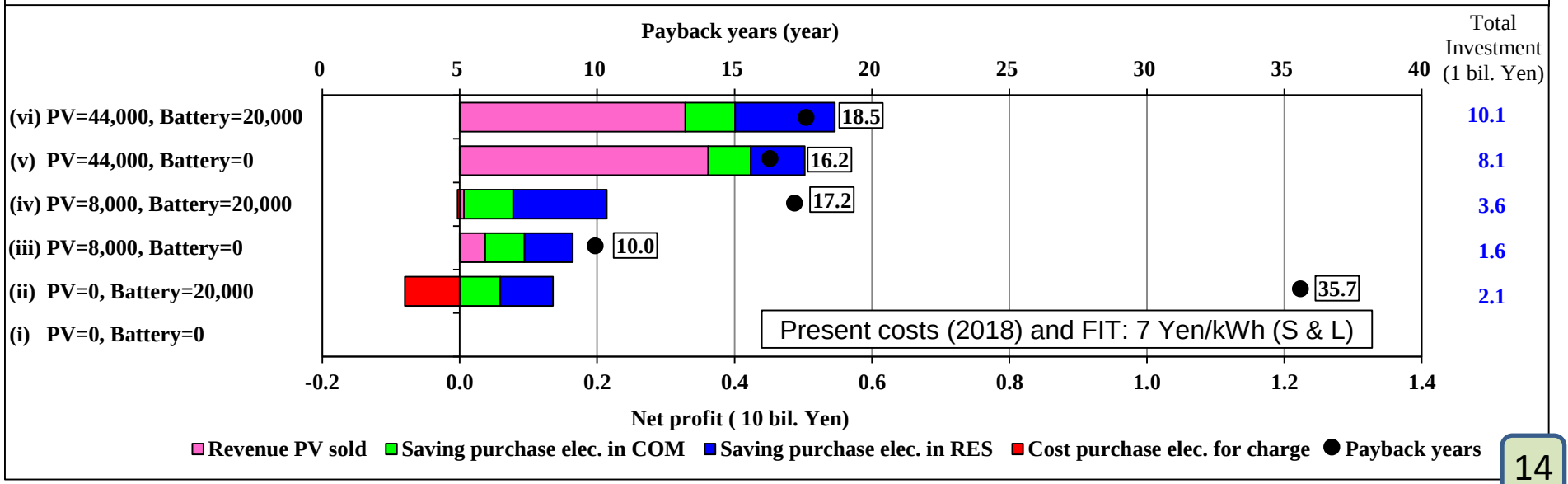




Case simulation on payback years (2)

-- Present cost, FIT: 14 Yen (S&L) → 7 Yen (S&L) --





Future Reduction of PV and Battery Cost

< Present PV and battery cost >

Small size (Household) : 250,000 Yen/kW
Large size & Mega Solar : 200,000 Yen/kW
Battery : 150,000 Yen/kWh

< Intermediate cost down >

Small size (Household) : 180,000 Yen/kW
Large size & Mega Solar : 150,000 Yen/kW (EU present level)
Battery : 75,000 Yen/kWh

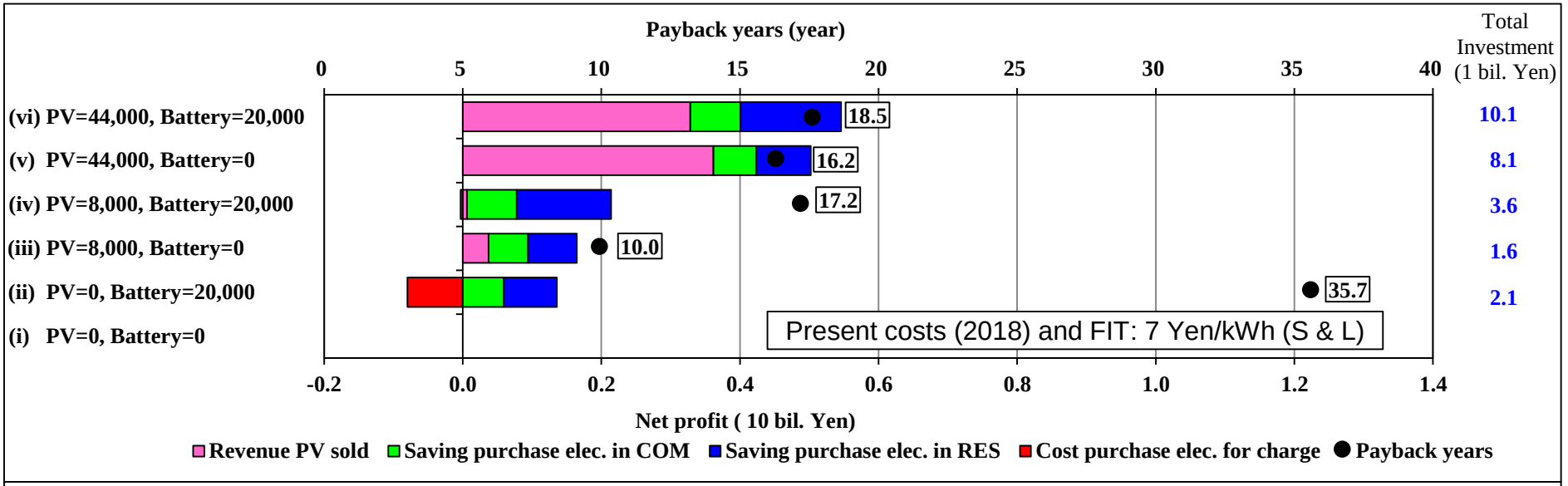
< Expected future cost down >

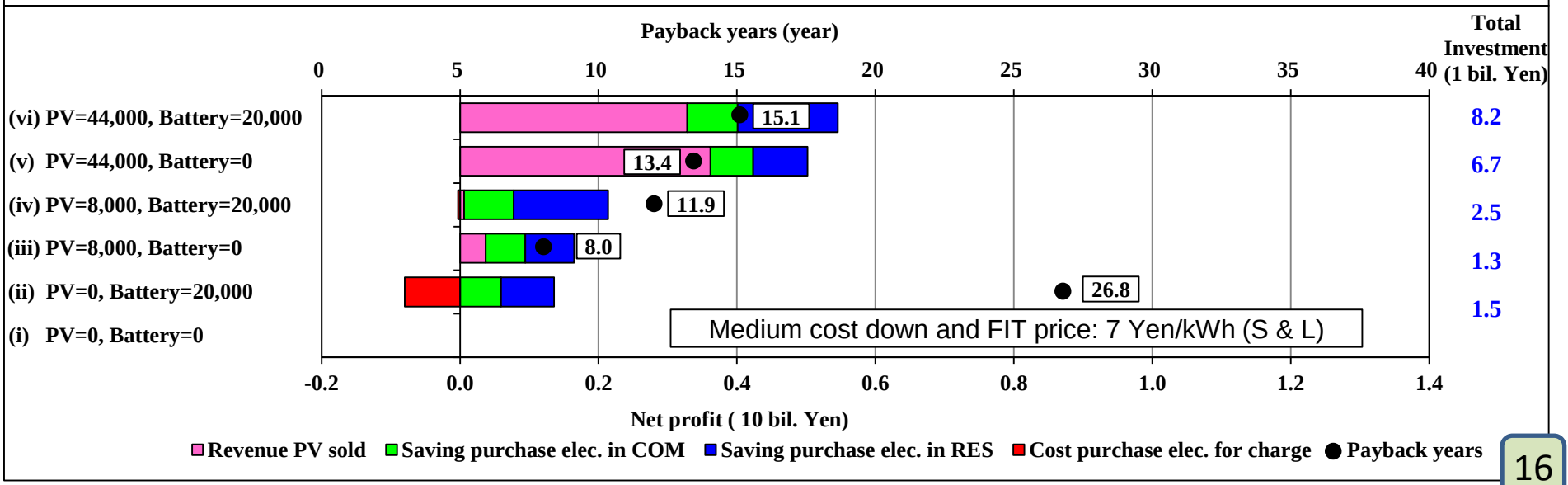
Small size (Household) : 100,000 Yen/kW
Large size & Mega Solar : 100,000 Yen/kW (IRENA expectation)
Battery : 30,000 Yen/kWh (US present level)

(Source) Shibata [2017], Agency of Resources and Energy [2017]

Case simulation on payback years (3)

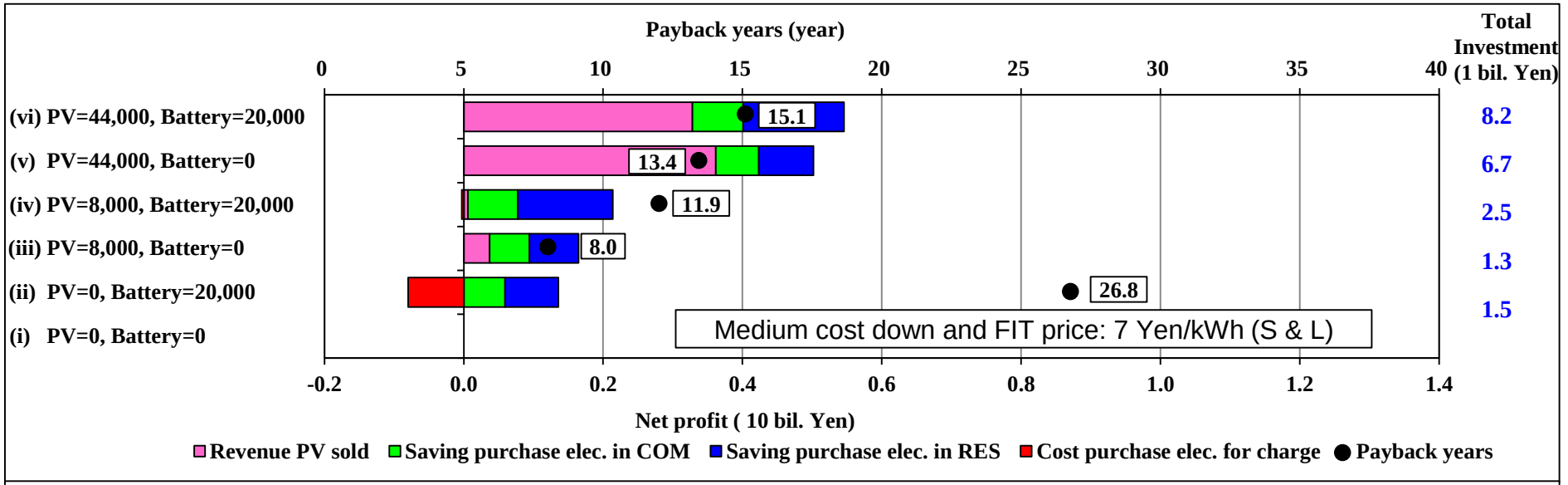
-- Present cost →Medium cost down, FIT: 7 Yen (S&L) --

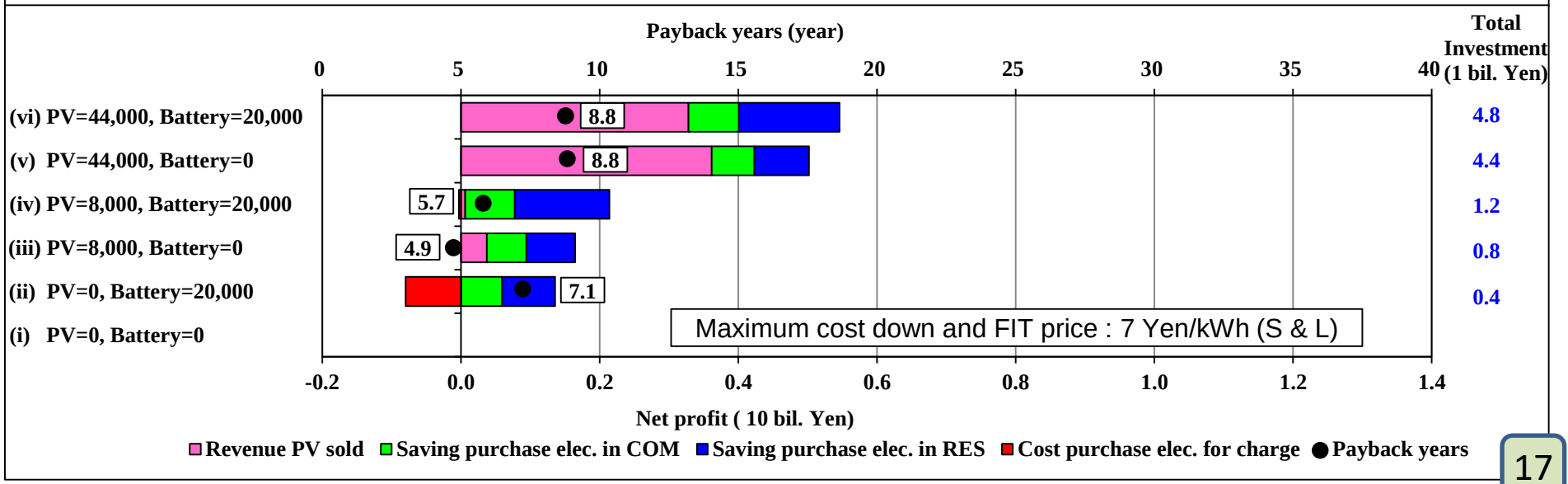




Case simulation on payback years (3)

-- Medium cost down → Max cost down, FIT: 7 Yen (S&L) --

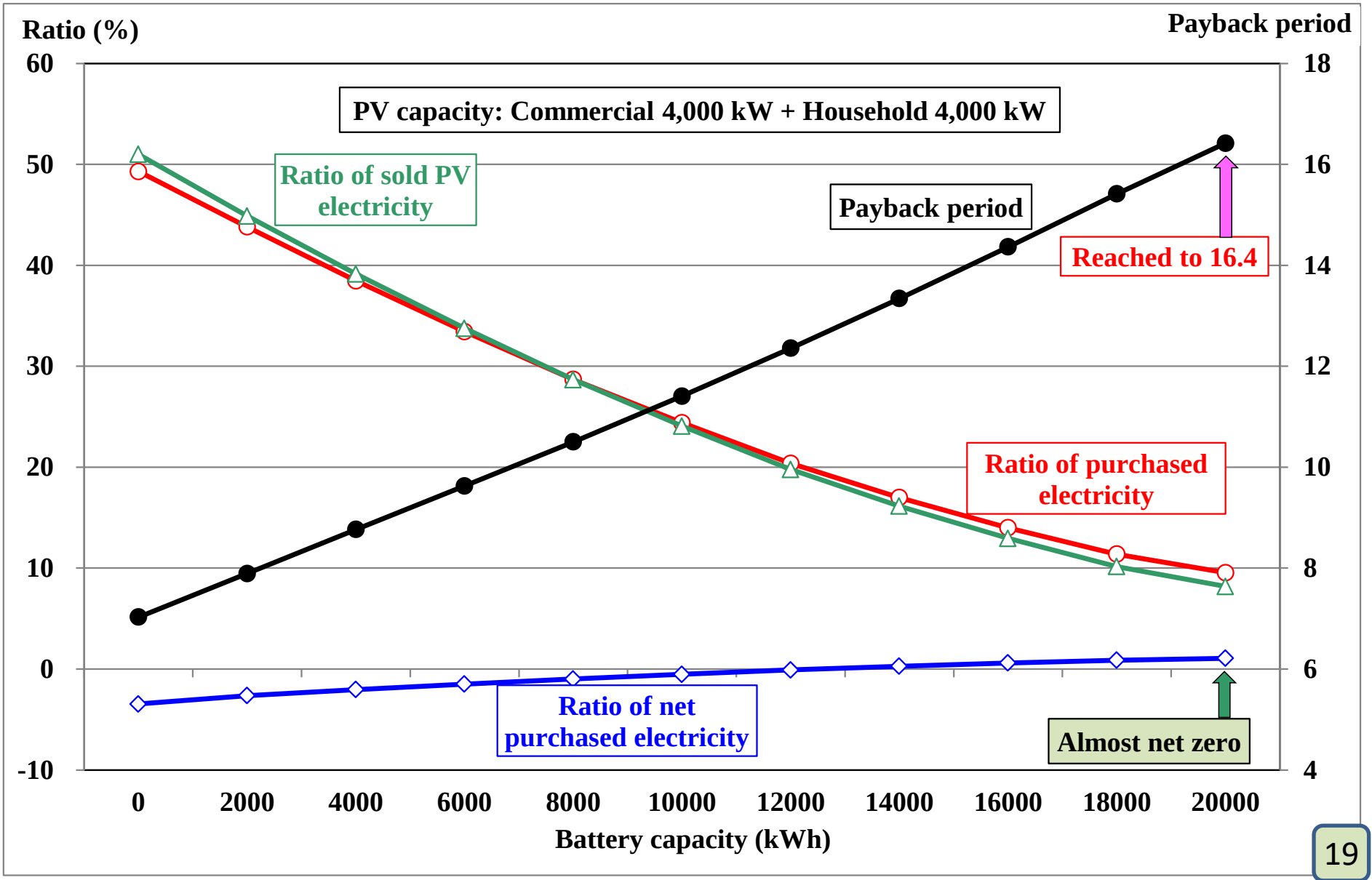




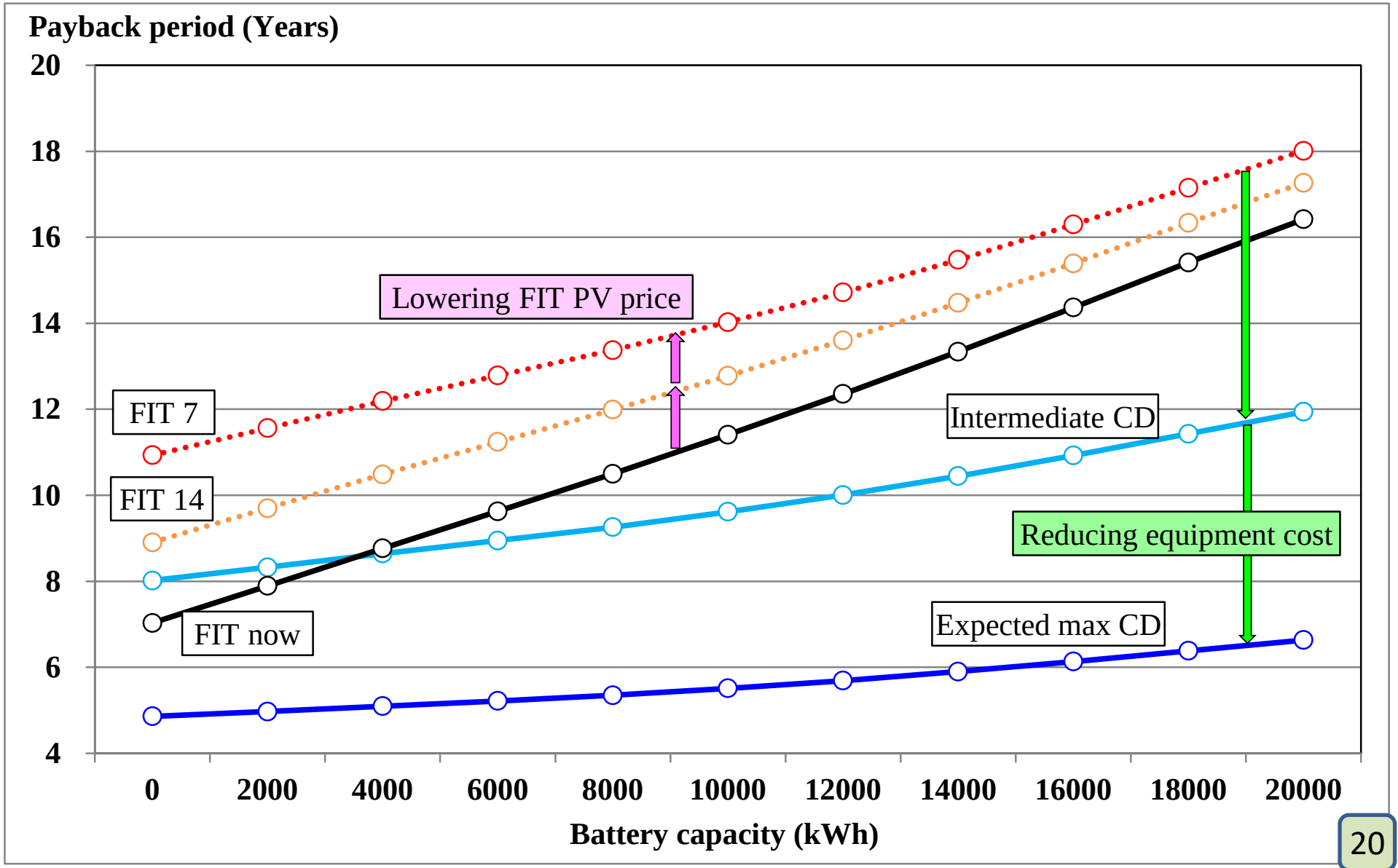
Summary of Analysis on FIT and Cost Down

- **Though the PV FIT price was lowered from 2015 to 2019, the economics was improved because of cost down.**
- **If the PV FIT price is reduced to the target of 7 Yen/kWh, the economics will worsen under the present cost condition.**
- **The further cost down of PV and battery will be required to keep the preferable economics.**
- **Even though the PV FIT price is reduced to 7 Yen/kWh, the reasonable economics will be kept if the PV cost is reduced to 100,000 Yen/kW (one half) and the battery cost is reduced to 30,000 Yen/kWh (one fifth).**
- **The cost down will play a crucial role for the effective use of PV and battery in the residential sector.**

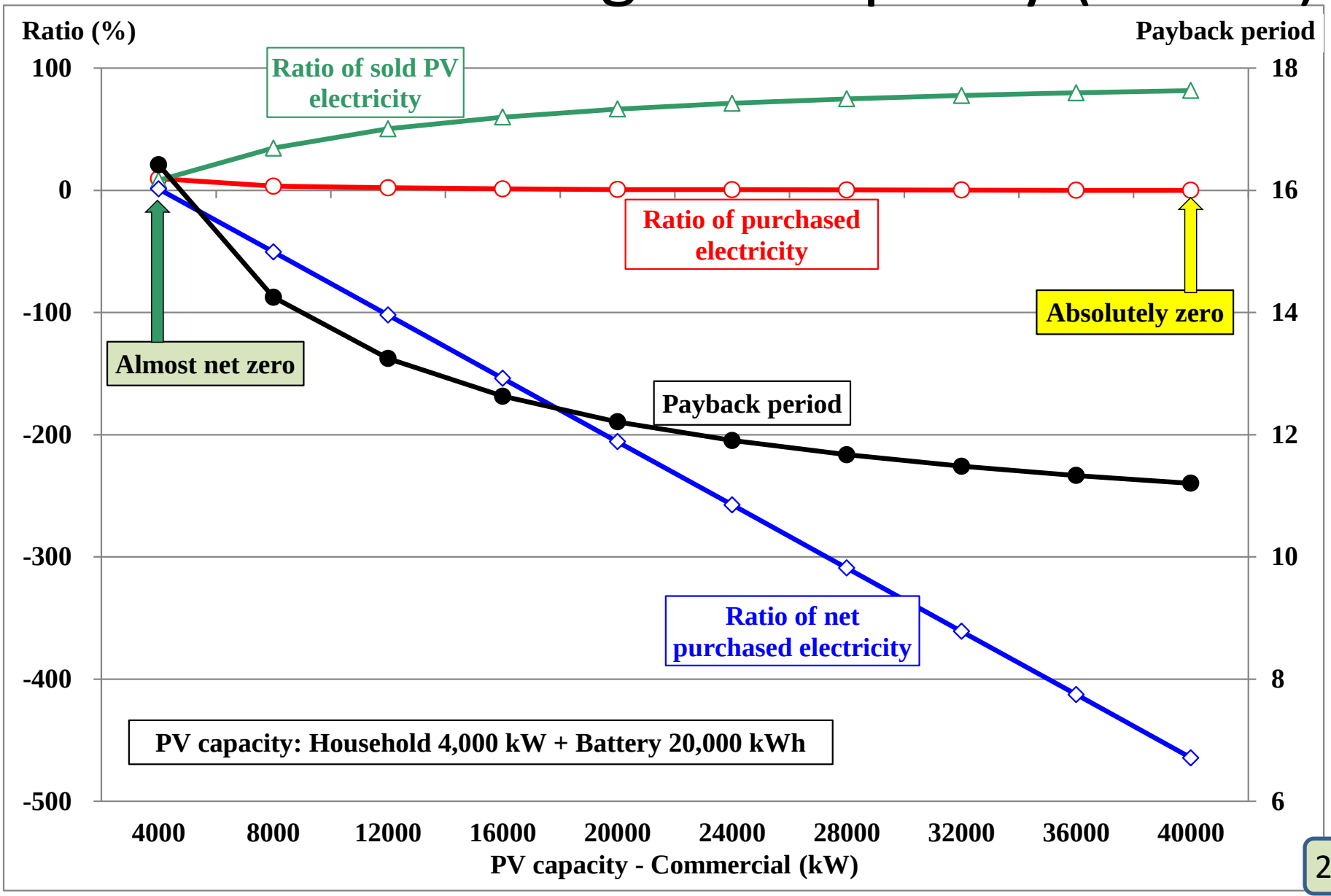
Economics and performance changes by the increase on battery capacity (Case X)



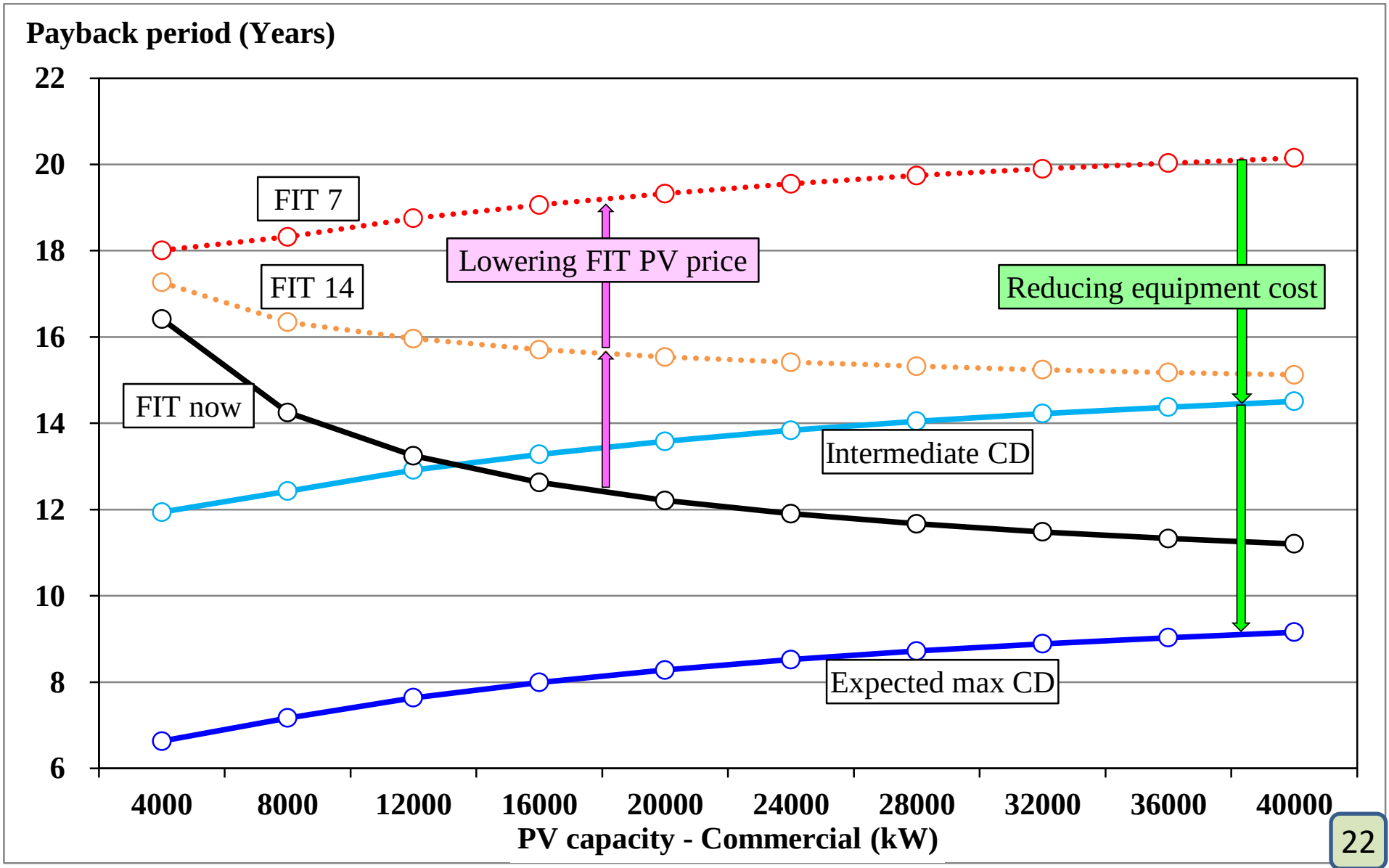
Payback Period Changes by Lowering FIT and Cost Reduction in Case X



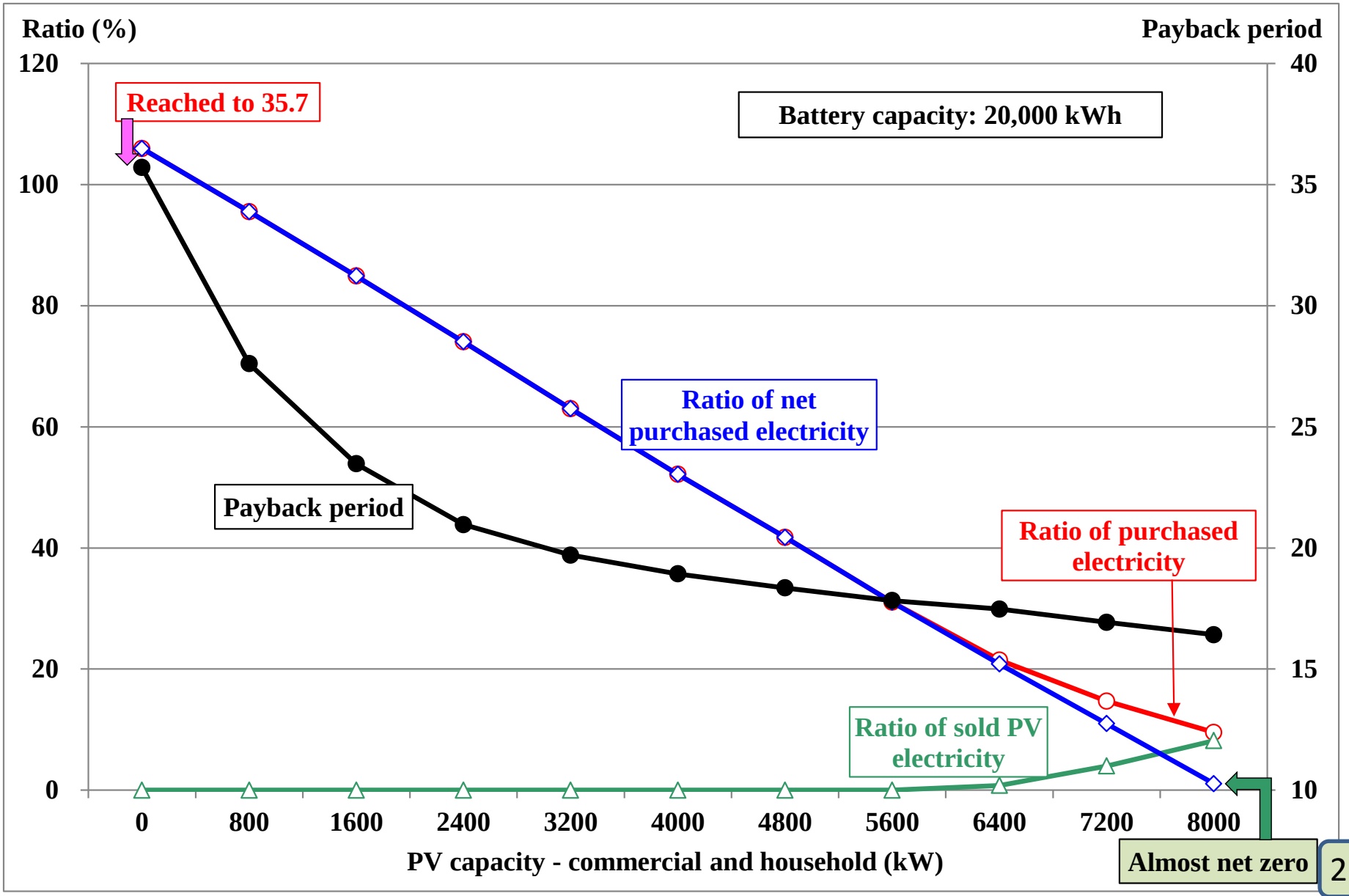
Economics and performance changes by the increase on mega PV capacity (Case Y)



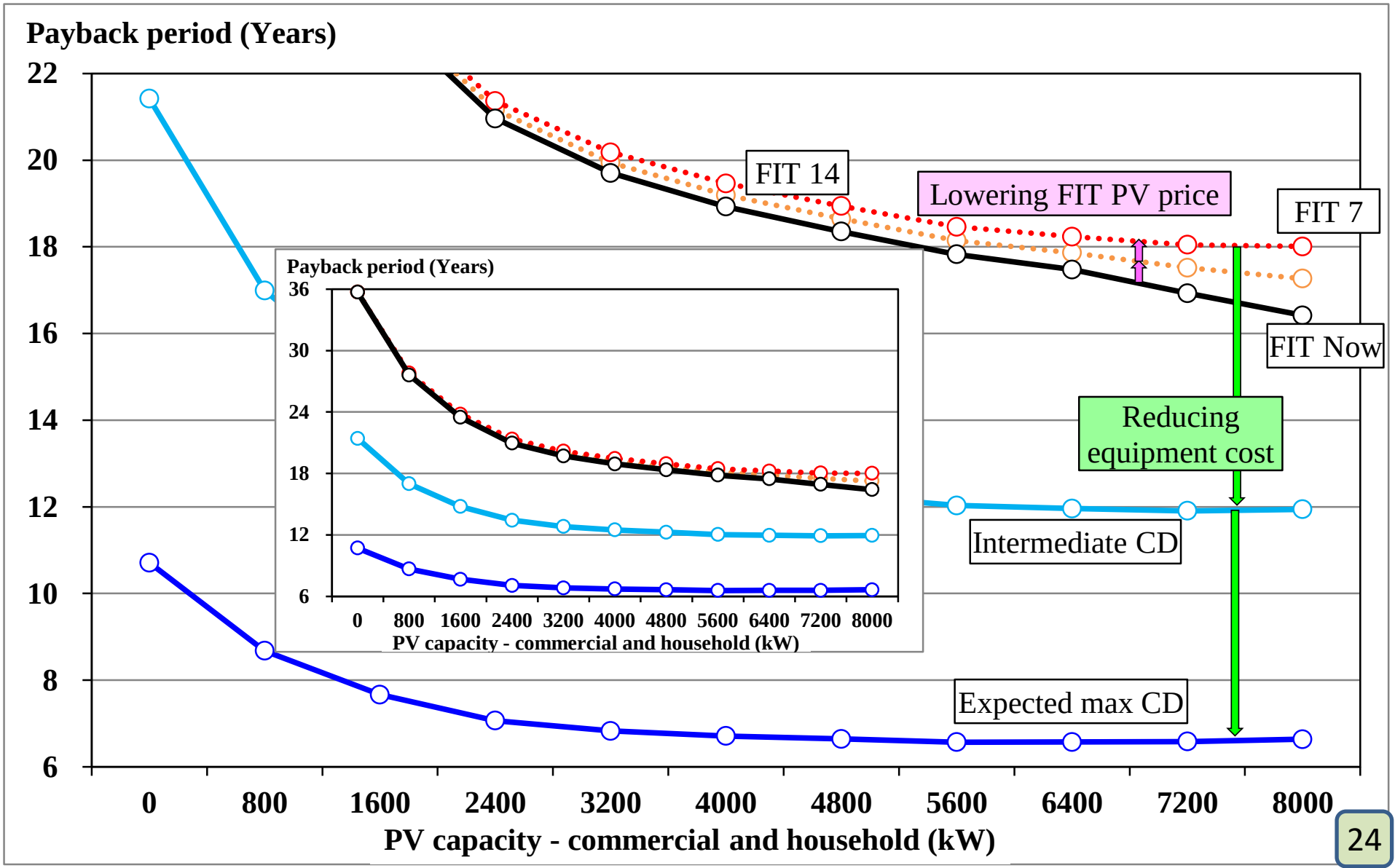
Payback Period Changes by Lowering FIT and Cost Reduction in Case Y



Economics and performance changes by the PV increase (Battery: 20,000 kWh, Case Z)



Payback Period Changes by Lowering FIT and Cost Reduction in Case Z



Concluding Remarks

- **For the installation of PV and battery in the residential sector, the cost reduction will be required essentially.**
- **Of these, the cost reduction of battery would play a important role on the effective uses of PV and battery to reduce electricity purchased from outside.**
- **Thus, the infiltration of cheaper battery will be anticipated eagerly.**
- **The past preferable PV FIT price makes large distortion (Huge PV expansion for the electricity sales) to the decision making of investment.**
- **The recent revision of FIT by Japanese Government is reasonable for the healthy expansion of PV and battery (purchased electricity reduction) in the residential sector.**

Thank you very much for
your kind attentions !!

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