Power Market Reform in China: Dividends, Market Impacts, and Transition Options

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Outline

- Background
- Research Questions
- Methods
- Results
- Sensitivity Analysis
- Conclusions

Background

- China is currently undergoing power sector reform
- Electricity market transition in China has the potential to further the country's environmental and economic aspirations
  - Stop excess investment in coal power
  - Reduce curtailment of solar/wind/hydro
  - Meet air quality and GHG targets
  - Increase efficiency of power system operation
- Guangdong power market reform
  - Focusing on the electricity wholesale market and promoting demand side management
  - Among the first batch of pilots to launch a real-time wholesale market in 2018
- Market reforms in China have started to run into political economy obstacles

Research Questions

Overarching:

- How can Guangdong (and China) best navigate the ***political economy*** of a transition to electricity markets?
- How can regulation and market design support the transition to a cleaner electricity system?

Specific

- How significant would the cost savings from market transition be, under different scenarios?
- How will markets affect consumers, different kinds of local generators, and importers?
- What might viable market transition strategies look like?

Methods: Approach

- Create a relatively simple model of the Guangdong electricity system, focusing on structural differences between generators
- Assume convergence to economic (marginal cost-based) dispatch with a single market clearing price
- Examine total cost impacts relative to a reference scenario and impacts on net revenues for different types of generators

Methods: Coal and Gas Generator Bins

Category	Size (Capacity)	Vintage	Installed Capacity (MW)	Average Net Heat Rate (gce/kWh)
Coal 1	> 1,000 MW	All	14,362	281 (44%)
Coal 2	600-1000 MW	2010-2017	6,887	301 (41%)
Coal 3		1980-2009	15,530	315 (39%)
Coal 4	300-600 MW	2000-2017	9,877	325 (38%)
Coal 5		1980-1999	6,283	337 (36%)
Coal 6	< 300 MW	All	6,981	350 (35%)
Coal Totals			**59,920**	**313 (39%)**
Gas 1			7,391	220 (56%)
Gas 2			4,703	275 (45%)
Gas 3			1,344	315 (39%)
Gas Totals			**13,438**	**256 (48%)**

Methods: Scenarios

Reference Scenario: Current planned operating hours

- Demand: Total electricity consumption in Guangdong was 561 TWh (2016); 28% import
- Supply: Installed capacity and annual operating hours for each type of generators

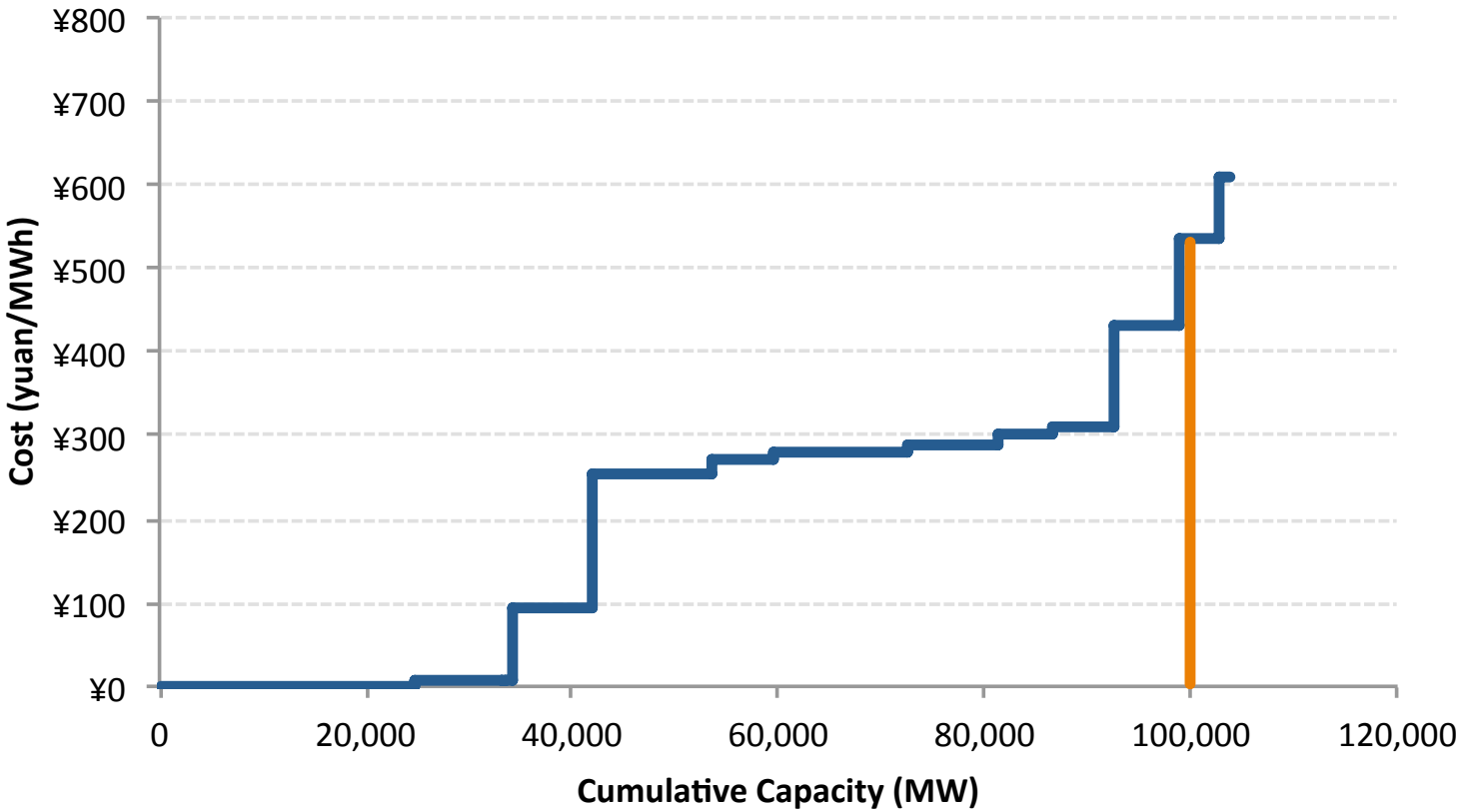
Generation Technology	Installed Capacity (MW)	Annual Operating Hours (hours/yr)
Coal	59,920	3,932
Natural gas	13,438	3,200
Hydropower	14,110	3,550
Wind	2,680	2,438
Solar	1,560	1,717
Nuclear	9,360	7,516

3 Market Scenarios：
least marginal cost dispatch

Scenario	Scarcity payment	Premium payment
Market only ("Market Only")	None	None
Low SPP payments ("Low SPP")	100 yuan/kW-yr, paid to all qualifying generators	Difference between energy market and scarcity revenues and current feed-in tariffs
High SPP payments ("High SPP")	400 yuan/kW-yr, paid to all within-province thermal generators	Difference between energy market revenues and current feed-in tariffs

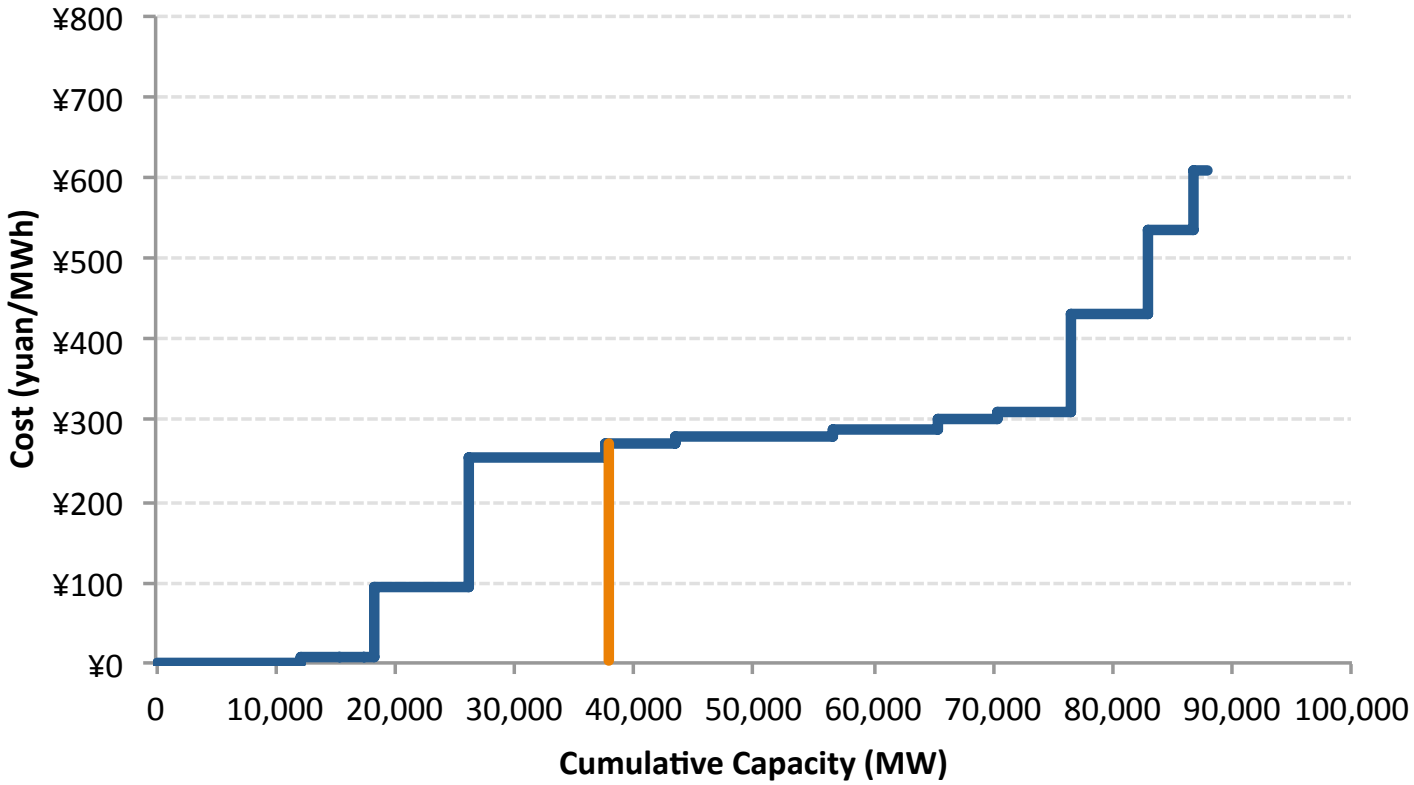
Market simulation– supply and demand for an hour

Supply-Demand Curve Illustration of Hourly Dispatch in the Stack Model, for Hour Ending 16:00 on July 1 (high load day)



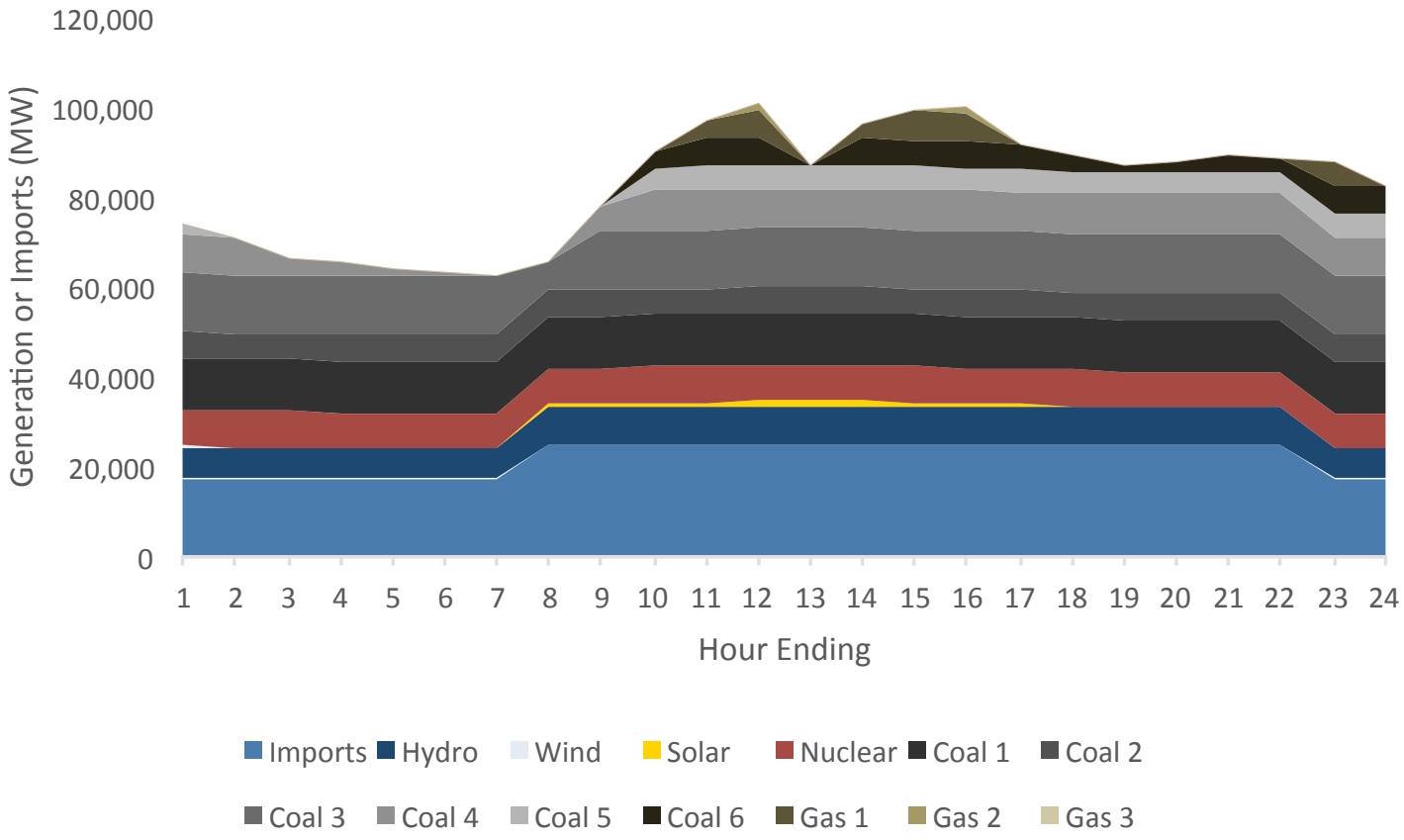
Market simulation– supply and demand for an hour

Supply-Demand Curve Illustration of Hourly Dispatch in the Stack Model, for Hour Ending 16:00 on Feb. 1 (low load day)



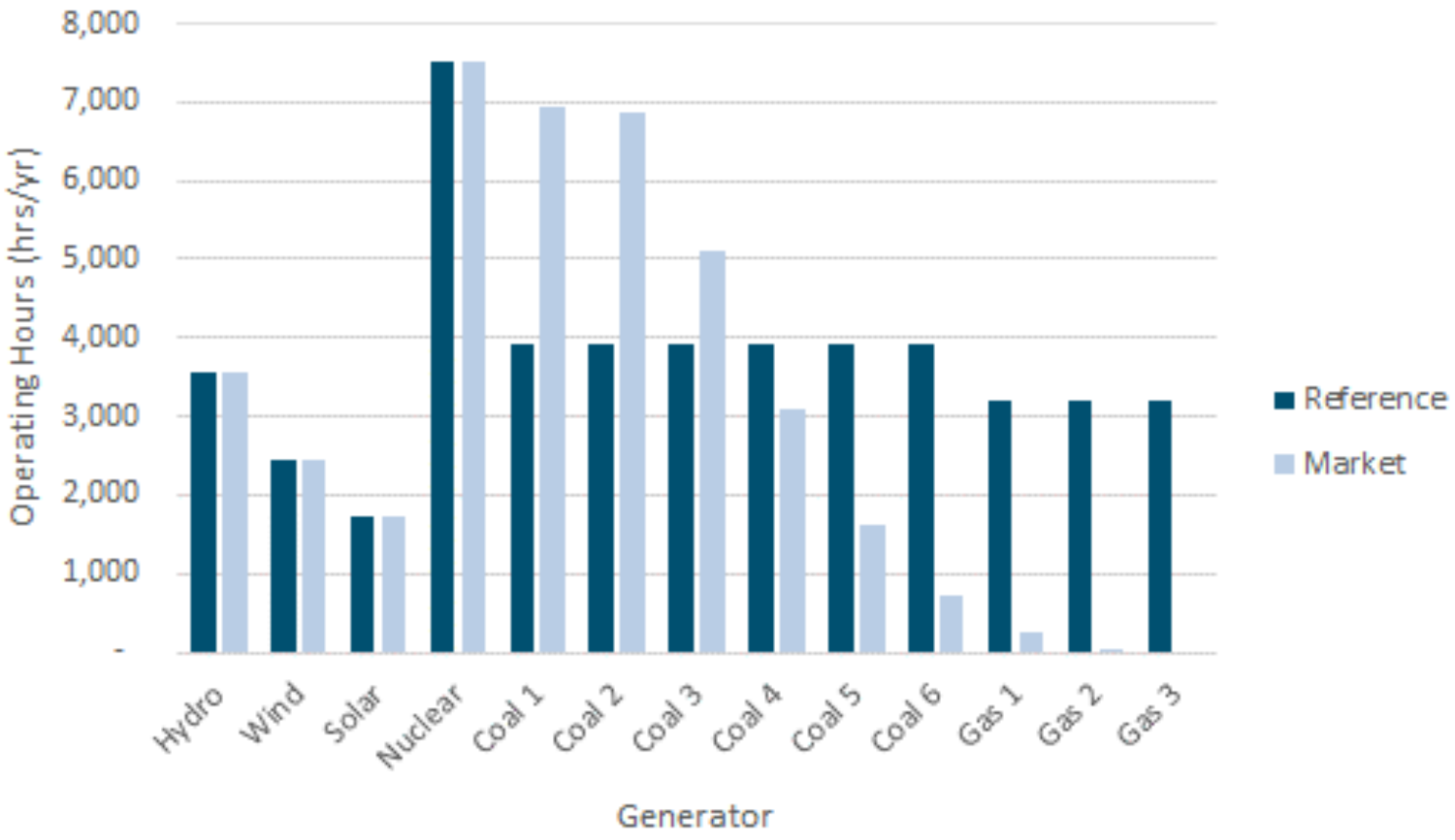
Market simulation– generator dispatch in one day

Illustration of Generator "Stacking" and Marginal Unit Cost Over the Course of a Day, for July 1 (high load day)



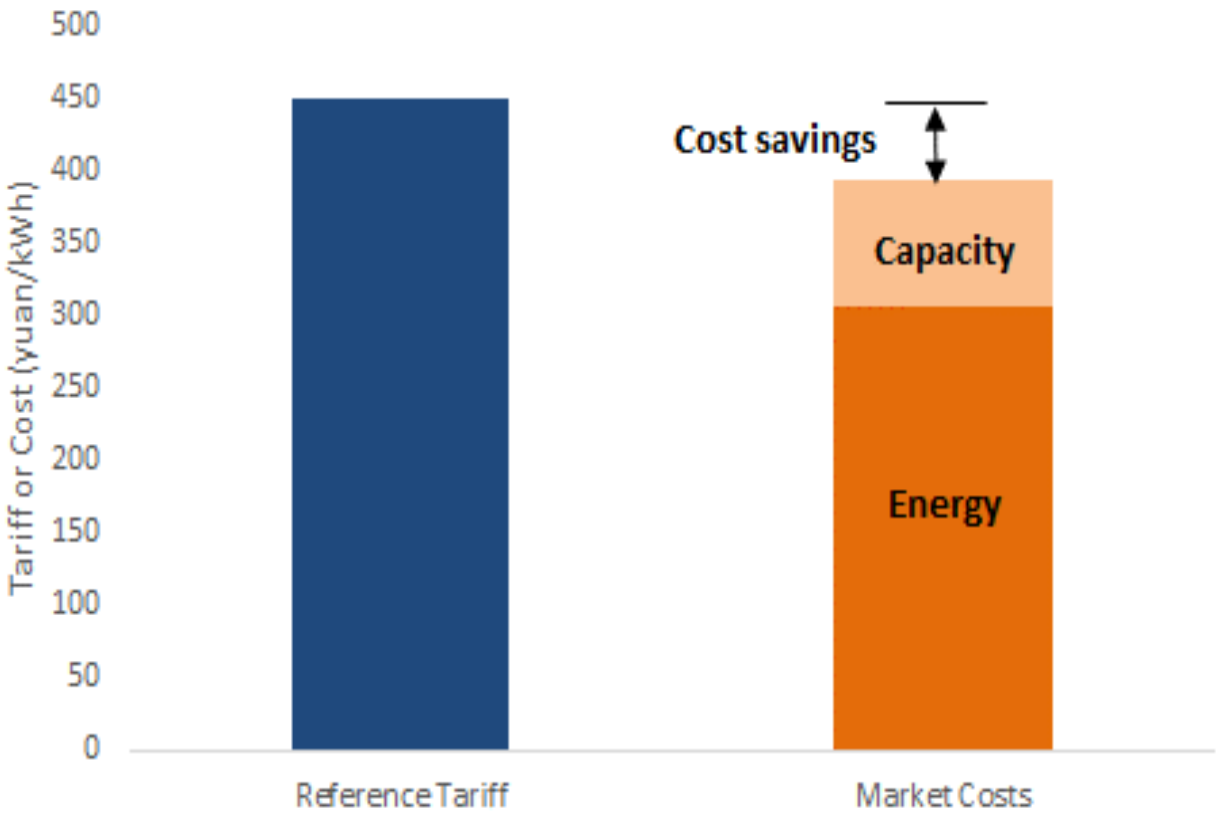
Results: Impact of market transition on generator type

Annual Operating Hours in the Reference and Market Scenarios, by Generator Type



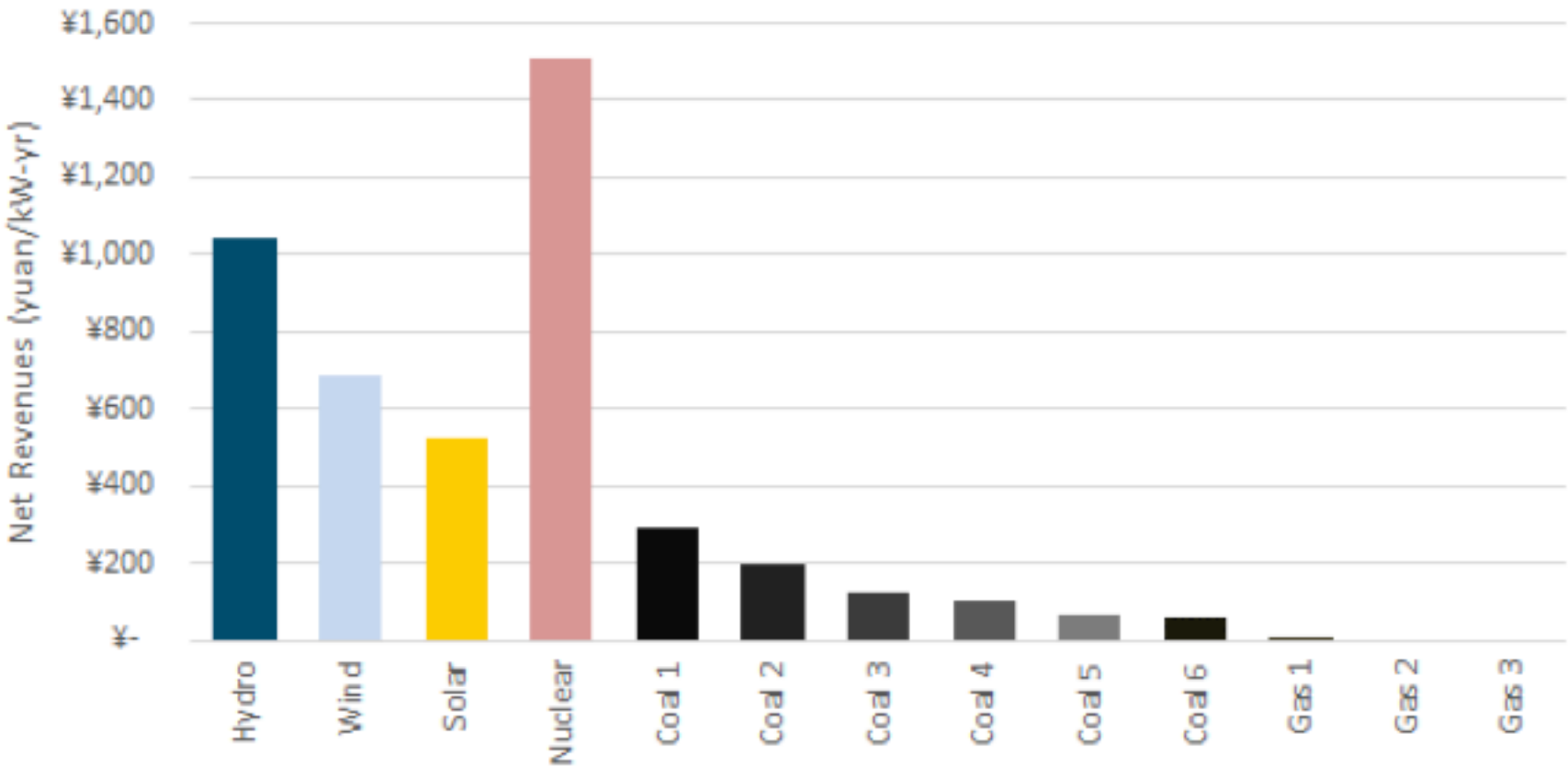
Results

Cost Savings for Coal Generation in the Market Scenario (High SPP), Relative to an Average Reference Tariff

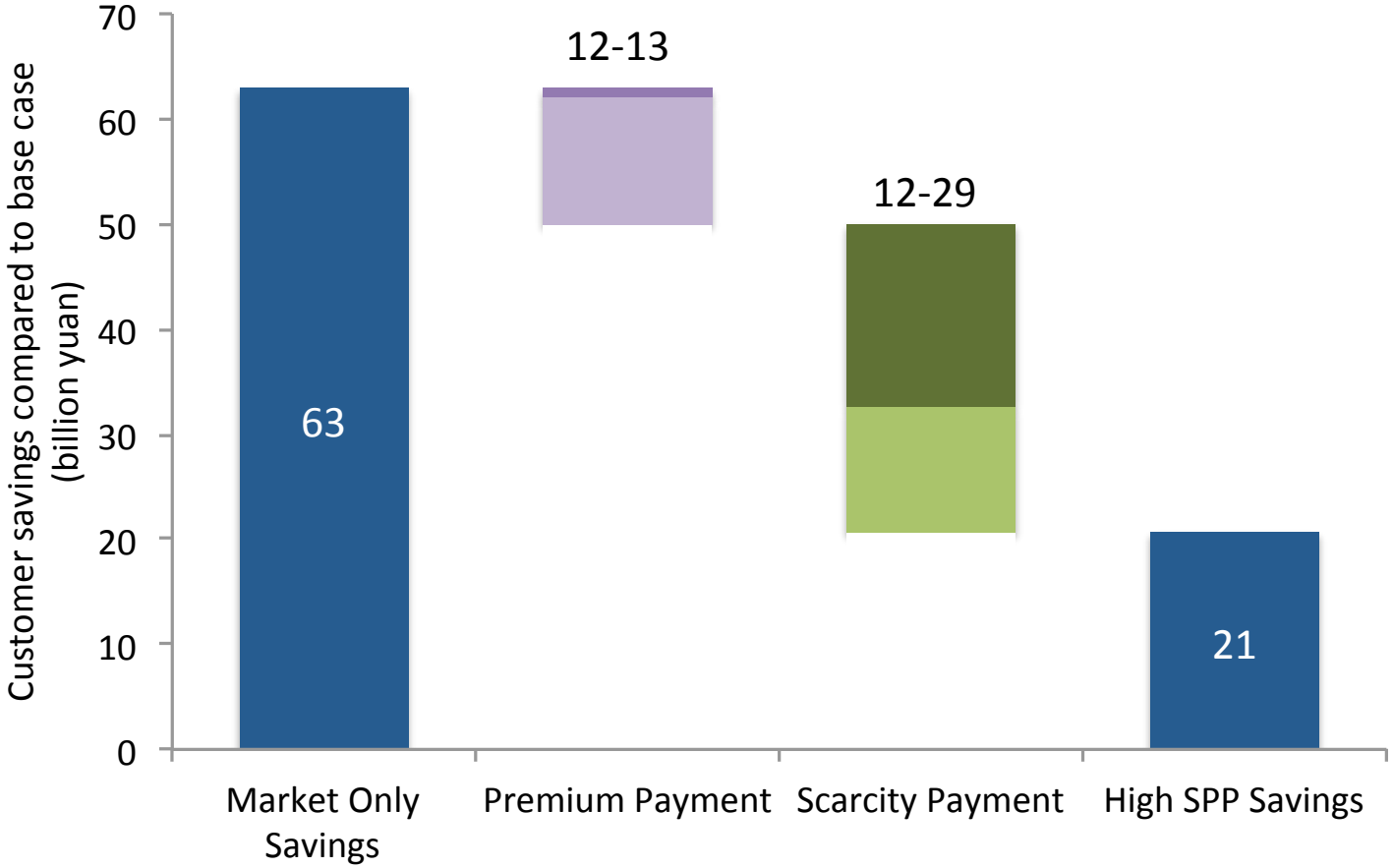


Results: More net revenue for efficient generators

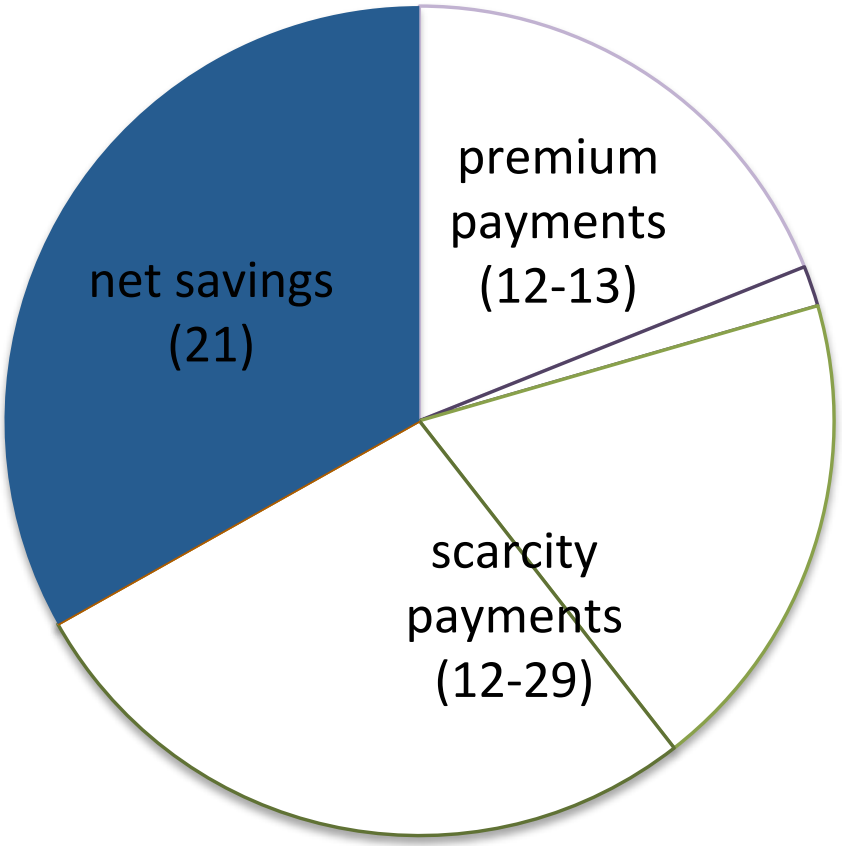
Net Market Revenues for Each Generation Type



Results: Cost Savings Vary



Transition towards market yield large cost savings for the society, but savings shrinks with additional payments



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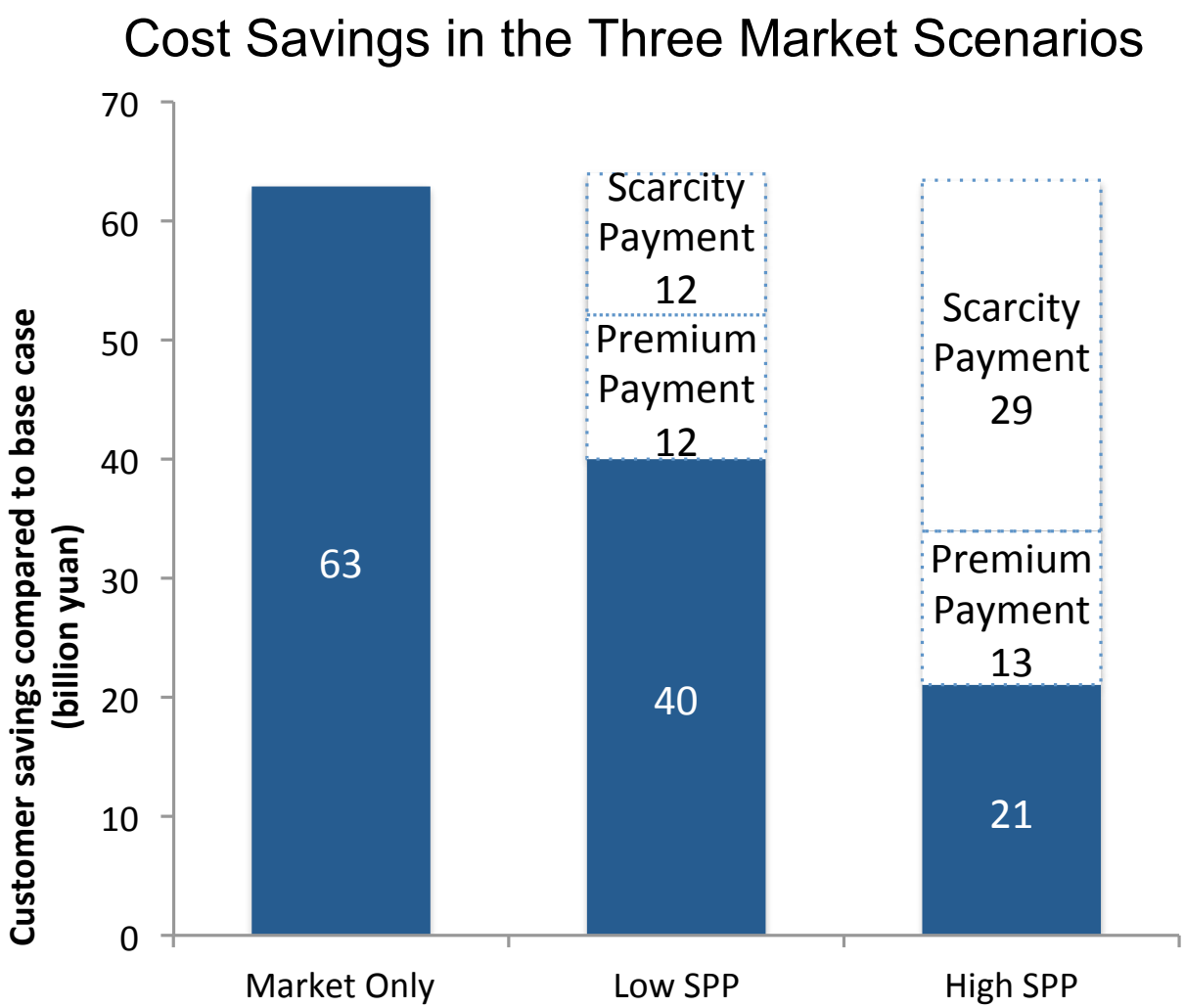
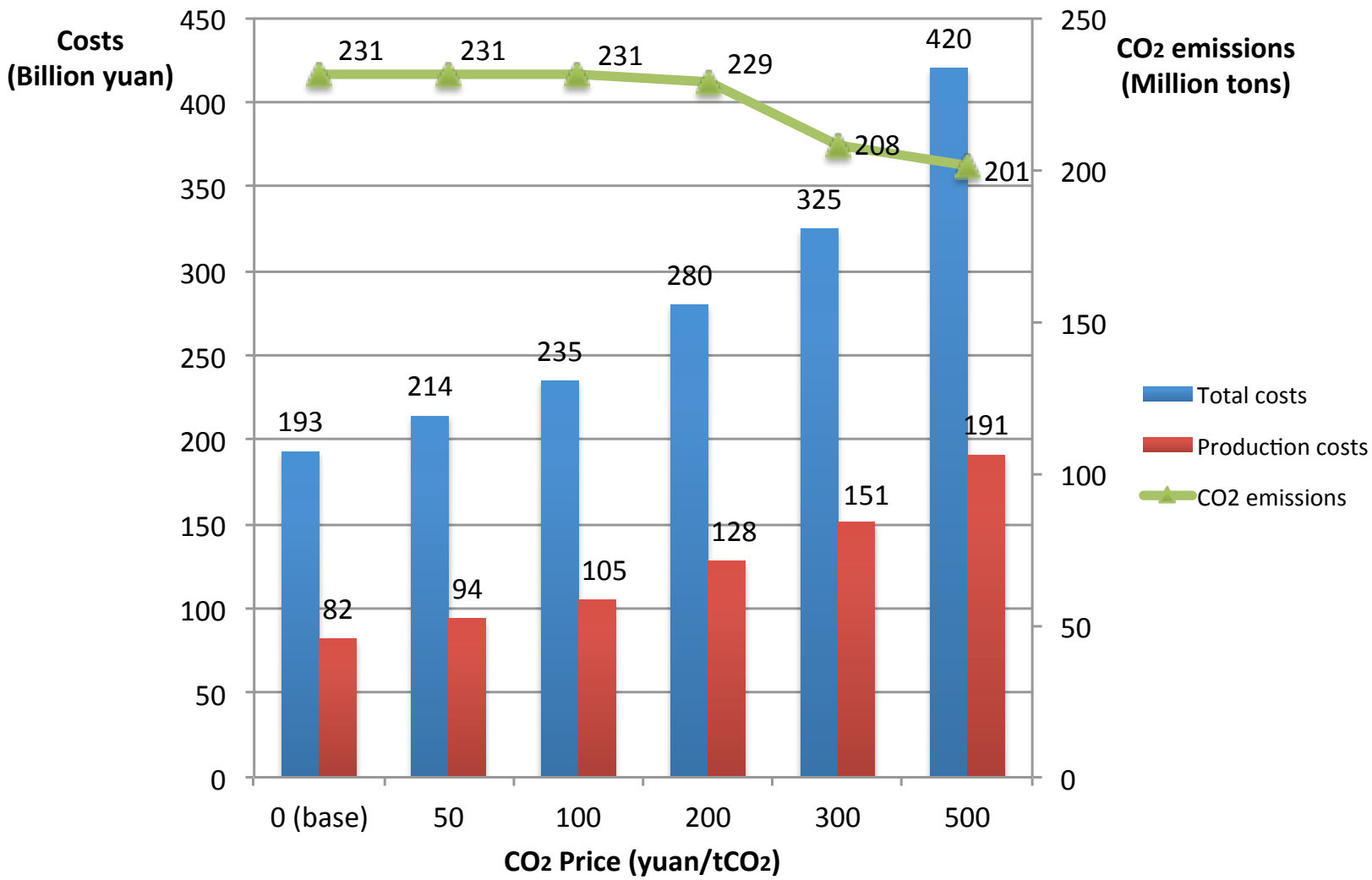
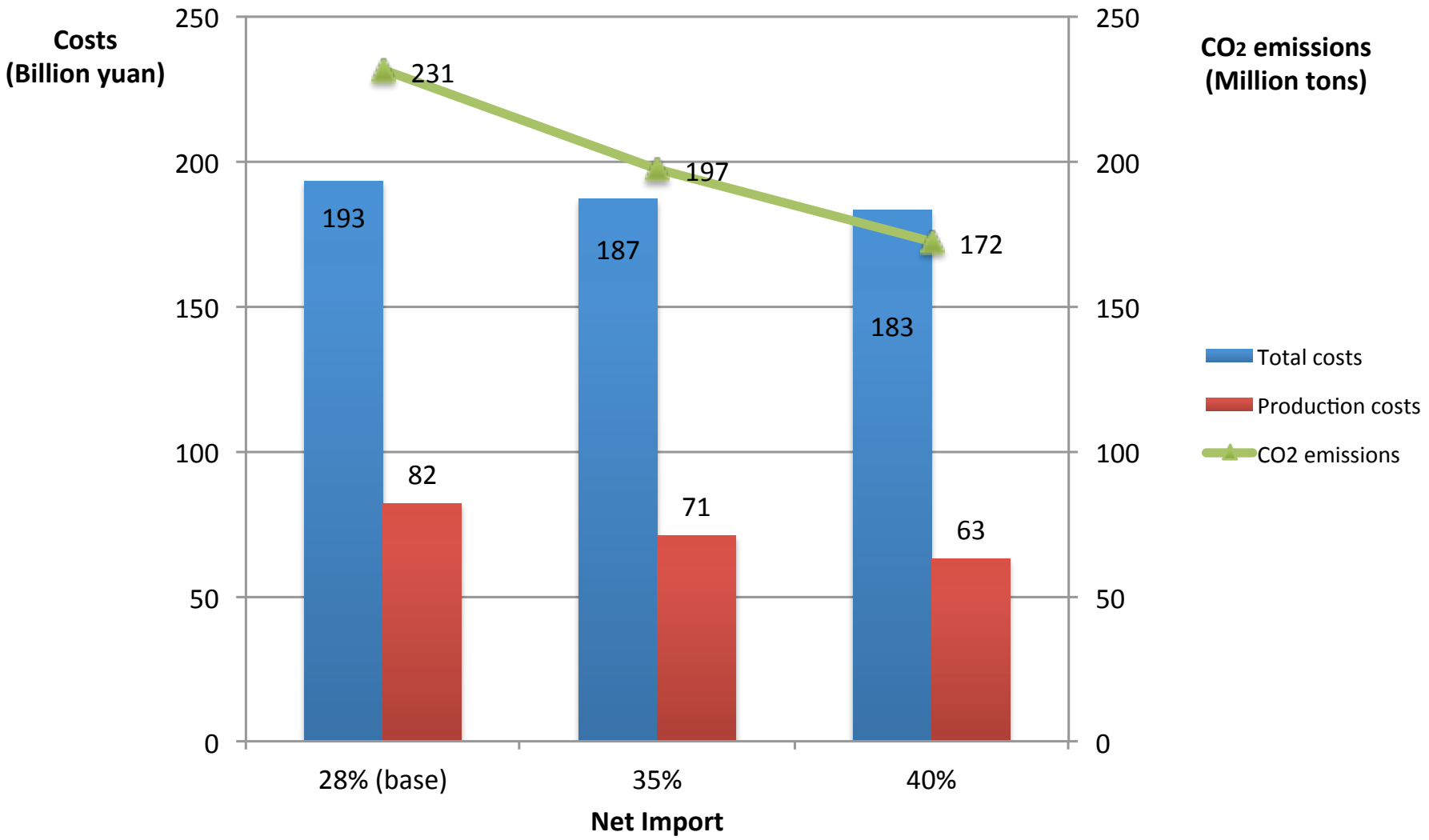


Sensitivity Analysis: CO_2 Prices



* Sensitivity analysis was based on the Low SPP scenario

Sensitivity Analysis: Net Imports



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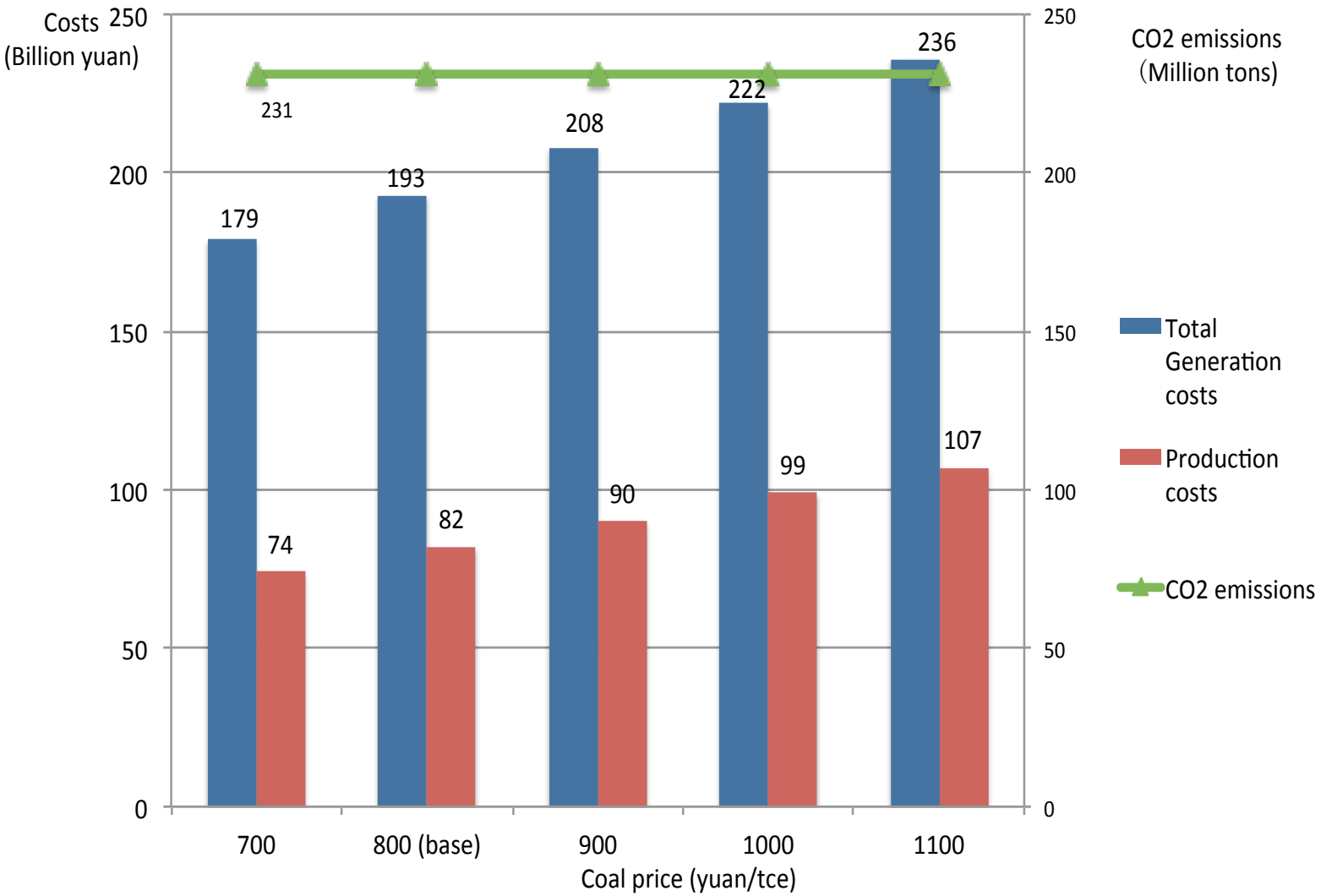
Sensitivity Analysis: Coal Price



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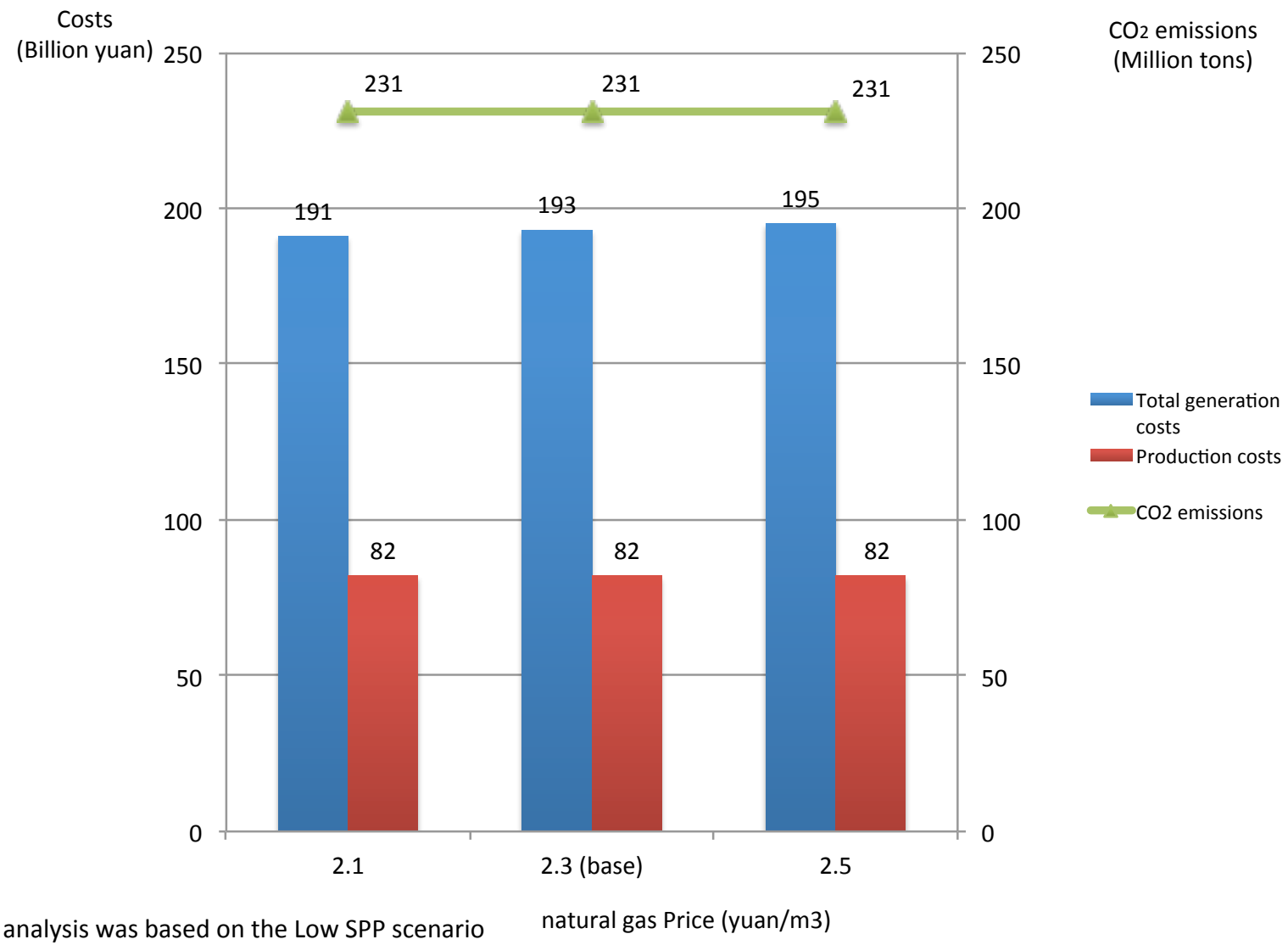
Sensitivity Analysis: Natural Gas Price



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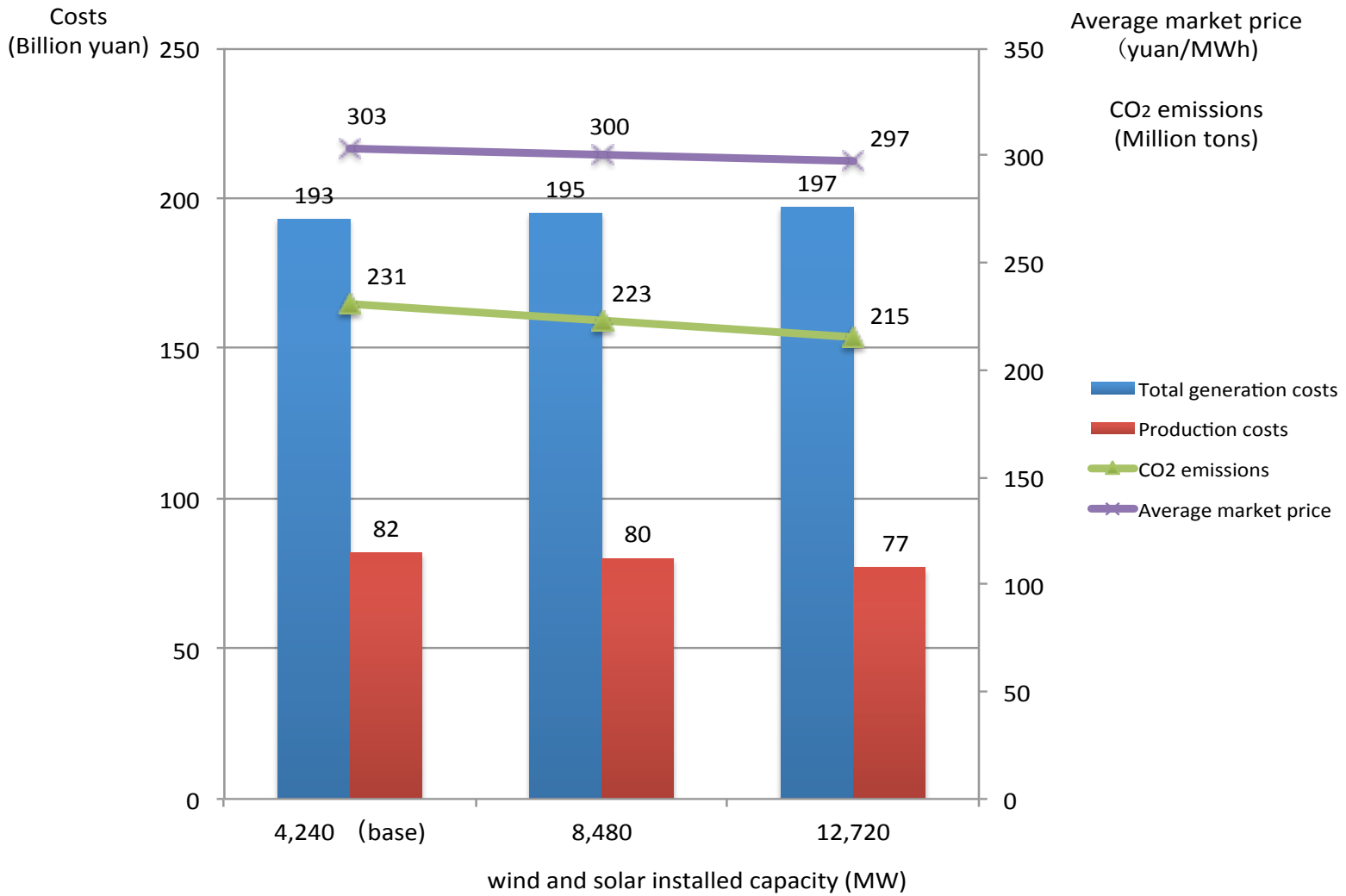
Sensitivity Analysis: Wind and Solar Capacity



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Conclusions

- Significant potential gains (RMB 21-63 Billion) from implementing electricity markets in Guangdong (and China)
  - The extent of these gains depends on how much in savings must be paid out as premiums to clean generation and paid to generators in the form of scarcity payments
  - Even with these payments, significant savings are likely to remain
- Factors influencing savings:
  - The most important factor influencing savings is likely imports (of hydro from Yunnan), which has significant implications for market design
  - Fuel prices will also matter
  - CO_2 pricing is likely to be an expensive strategy for reducing CO_2 emissions in Guangdong in the short run

Conclusions: Impacts on Different Generator Types

- Key ways to address net revenue impacts on generators:
  - Some form of side payment is politically and economically necessary
  - Need to think of how to enable demand-side resources to participate in providing reliability services
- Orienting these payments around a product, such as reliability (capacity), is likely to lead to lower overall costs
- Issues in the U.S. electricity industry over the past decade are likely to emerge in China
  - For example: the financial viability of nuclear power in markets; the role of demand response
  - China can prevent these issues by anticipating them

Conclusions: What's Next?

- The most important benefit of economic dispatch: Providing an overall economic framework for investments in generation, transmission, and demand-side resources (needs further analysis)
- Least-cost operation influences both the level and composition of generation investment, and should guide investment in transmission planning
  - Coal investment and generation: market prices are too low to support new investment in coal and gas generation
  - Hydro, wind, solar, and nuclear generation: likely continue to be policy driven, but market prices can shape both the level and composition of new investment (e.g., the balance between wind and solar generation).
  - Market prices play an important role in guiding new investments in storage
- U.S. experience: the largest long-term benefits of electricity market reform are in rationalizing investment costs

Thank You!

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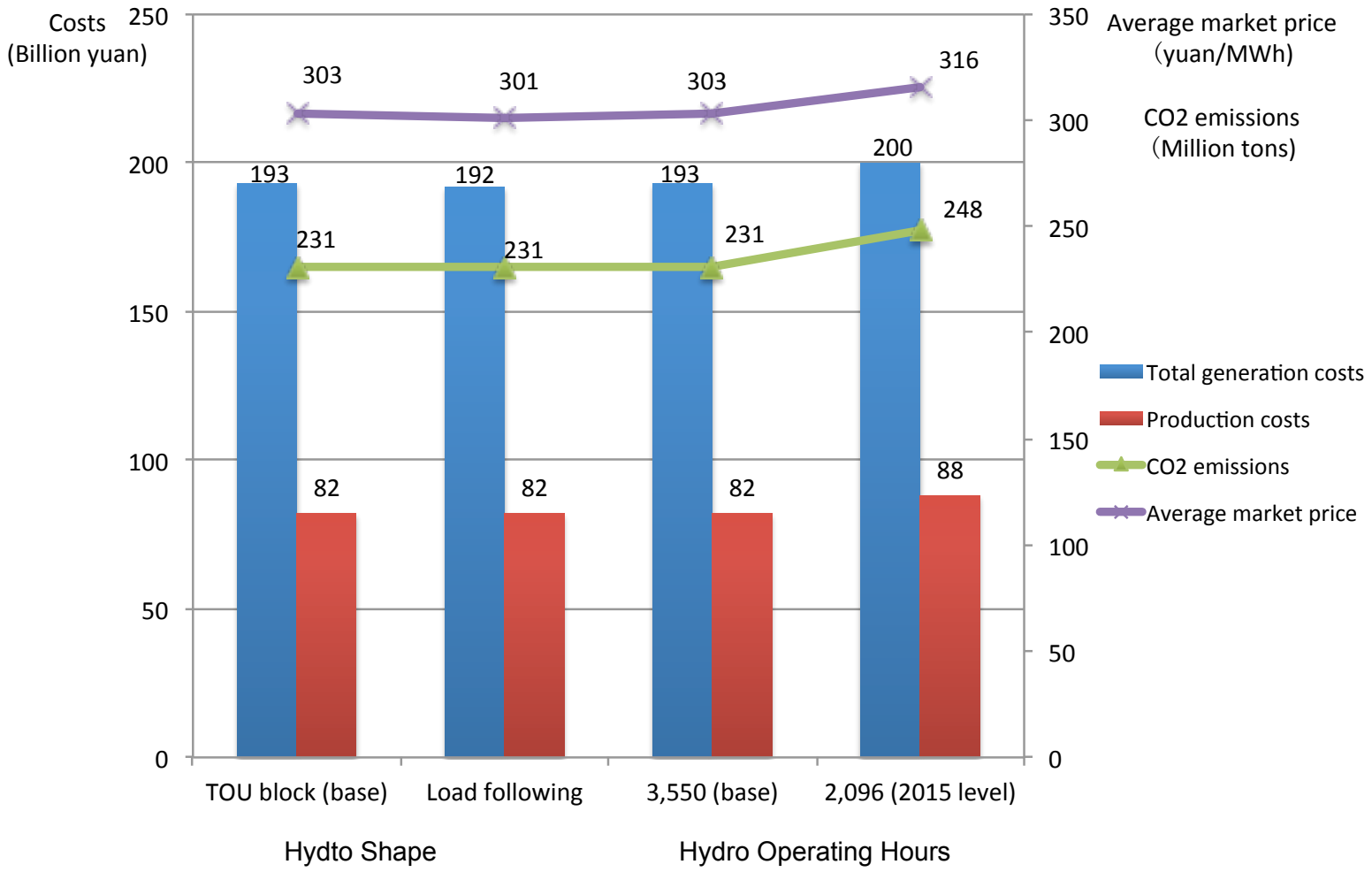
Backup slides

Sensitivity analysis – hydro output



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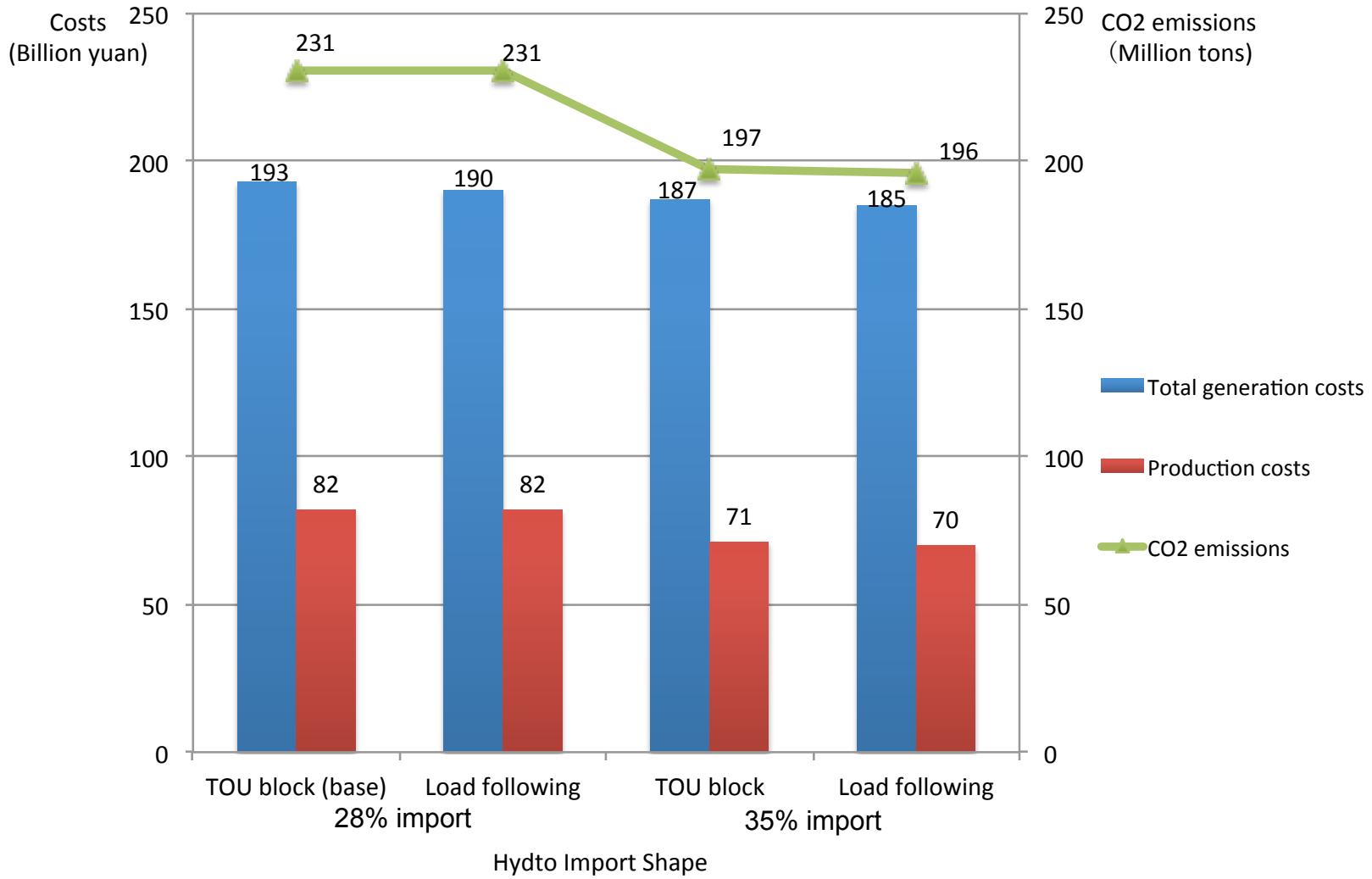
Sensitivity Analysis – import shape



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PLEXOS Scenarios Simulated

Name of the Scenario	Conventional (GW)	Wind (GW)	Solar (GW)	Battery Storage
BAU	Coal = ~60 GW Nuclear = ~9GW Gas = ~14GW Hydro = ~14GW Imports per 2016	2.7	1.6	0
RPS_50		25	55	0
RPS_100		75	150	0
RPS_100 Storage_200		75	150	50 GW * 4 Hours
RPS_100 Storage_400		75	150	100 GW * 4 Hours
Solar_100		2.7	250	0
Solar_100 Storage_200		2.7	250	50 GW * 4 Hours
Solar_100 Storage_400		2.7	250	100 GW * 4 Hours
Wind_100		178	1.6	0
Wind_100 Storage_200		178	1.6	50 GW * 4 Hours
Wind_100 Storage_400		178	1.6	100 GW * 4 Hours

PLEXOS annual energy generation for key scenarios (TWh/yr)

	BAU	RPS_50	RPS_100	RPS_100 Storage_200
Coal	269	165	132	65
Gas	0.3	1.6	6.3	6.8
Nuclear	77	65	42	35
Hydro	49	36	18	26
Solar PV	2.7	83	110	166
Wind	6.5	53	96	115
Batteries (Net)	0.0	0.0	0.0	-9.5
Imports	157	157	157	157
Total	**562**	**562**	**562**	**562**