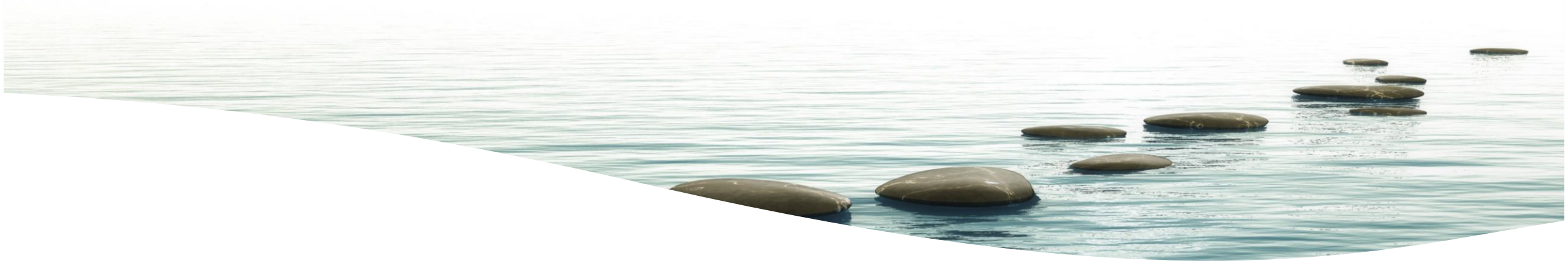

Facing the Challenges of a Greener Future

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DISCLAIMER

This draft document is developed to facilitate and stimulate discussion. It may not have been reviewed, and may have factual or other errors.

Agenda

1 Market Background

2 Key Challenges of the Wind and Solar Sector in China

- 2a Subsidy Payment Delay
- 2b (Lack of) Flexible Capacity
- 2c Wind and Solar Curtailment
- 2d Slow Progress of Market Mechanisms to Price CO2

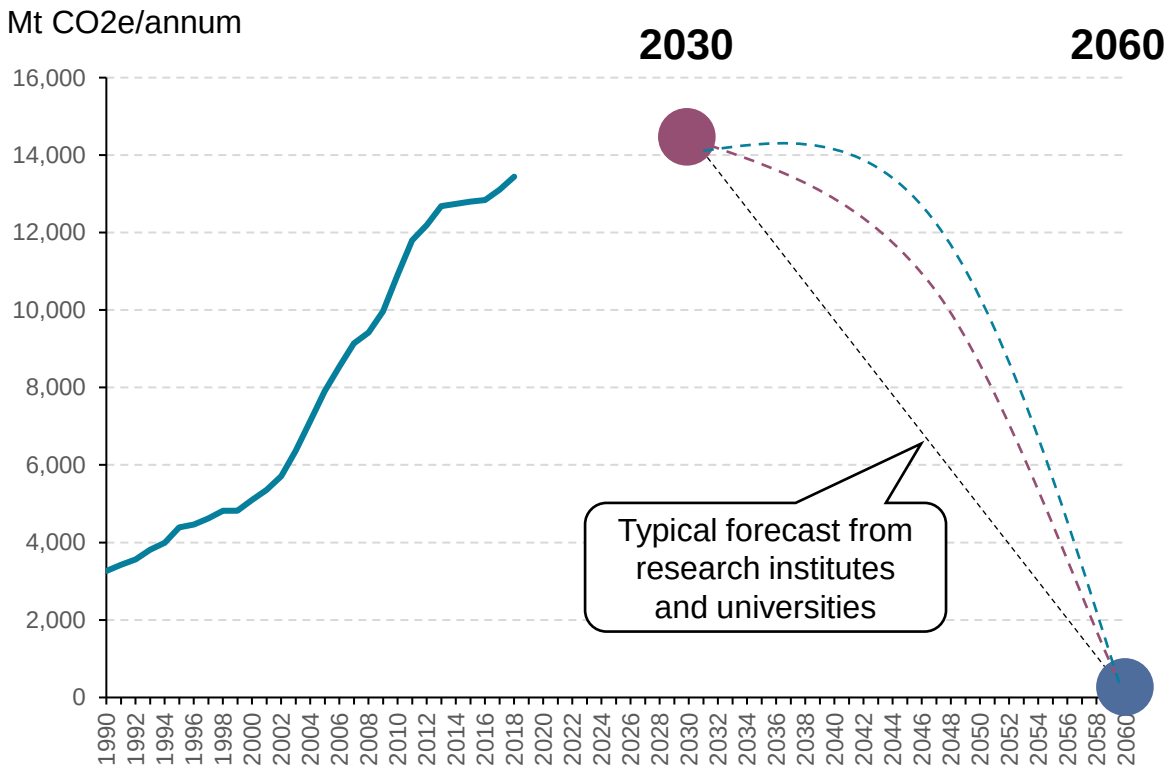
3 Summary

The 2060 carbon neutrality target sets the direction for de-carbonization in the long term, but it may not affect power sector much in near- and medium-term

- President Xi Jinping UN Address on Sep 22, 2020
  - CO2 emissions **peak before 2030** and **achieve carbon neutrality before 2060**
  - "….. achieve a green recovery of the world economy in the post-COVID era…."

- **Non-fossil fuel mix** targets in primary energy consumption in 2014 under COP 21 Paris Agreement
  - **2020: 15%** [Actual non-fossil fuel mix is 9.4% in 2010 and15.3% in 2019]
  - **2030: 20%**
  - Propose to **peak CO2 emission around 2030** and make efforts to peak earlier if possible.

CO2 Emission in China



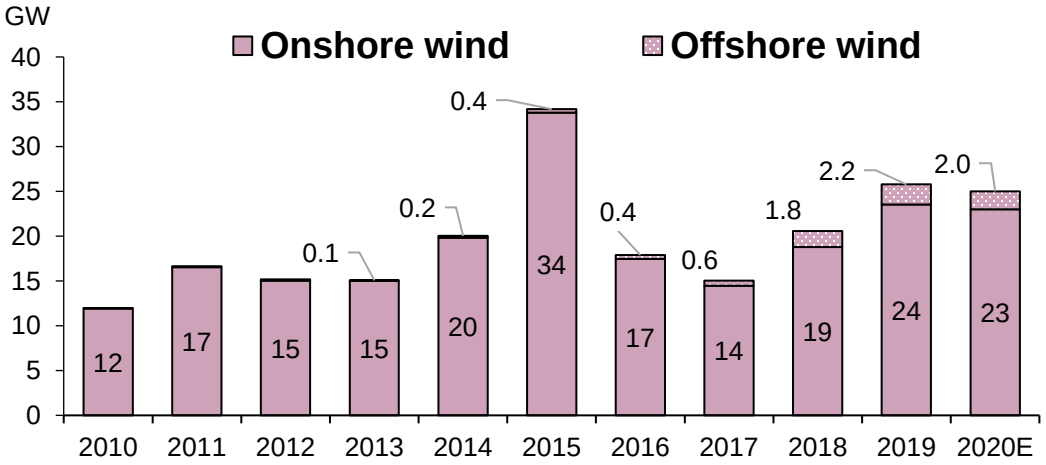
Source: Climate Action Tracker, WaterRock Energy Research and Analysis

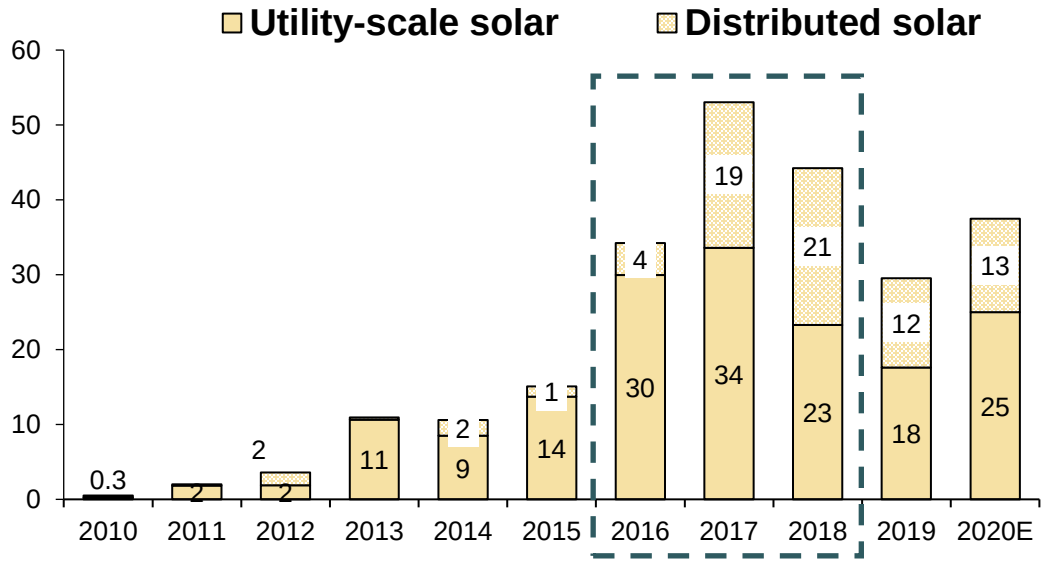
For 2030 target, new commitment is similar to what was announced in 2014.

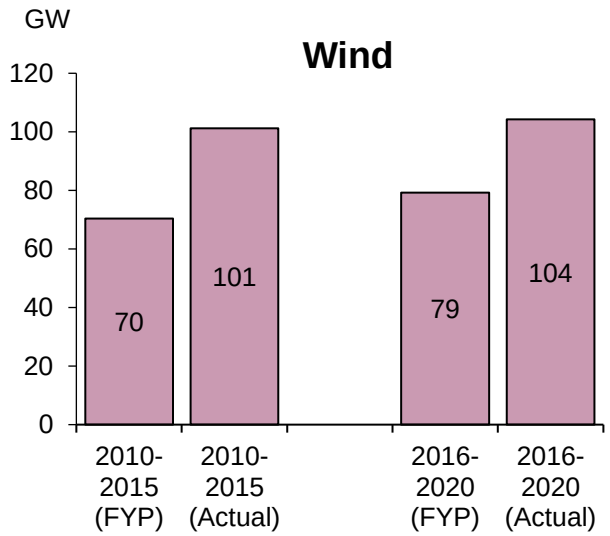
For 2060 target, it is 40 years away and there are many trajectories to achieve same aim in 2030-2040

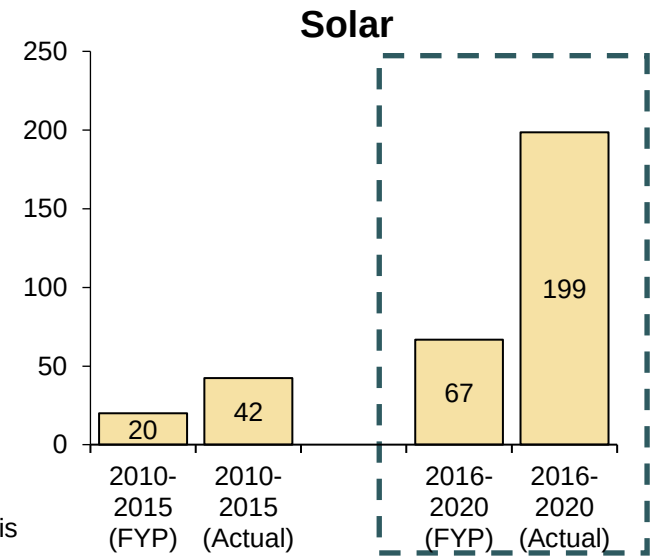
Market Background
Solar and wind capacity expansion have been consistently higher than government's plan, thanks to "promised" subsidies and rapid cost reduction

Wind and Solar Incremental Capacity Expansion, GW









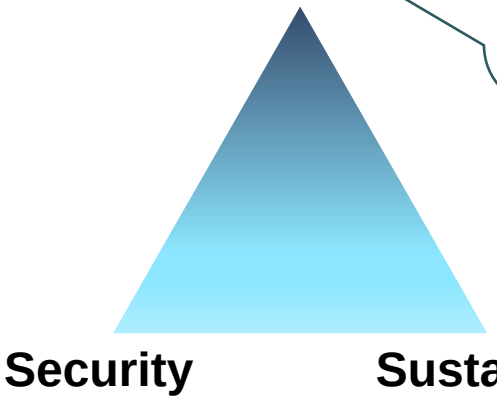
Source: National Energy Administration (NEA), WaterRock Energy Research and Analysis

- Wind and solar capacity expansion has been consistently higher than government's plan.
- Solar capacity expansion far exceeded government's expectation.
  - As the installation cost has declined faster than the feed-in tariff rate reduction, there was a solar rush in 2016-18.
- China has also built up an impressive value chain for solar manufacturing.
  - For example, more than 70% of solar panel is produced in China.

Market Background

The inability to reconcile cost and sustainability has led to several challenges for a greener future in China

Energy Trilemma



Central government has been primarily focused on reducing cost for end-users in recent years.

- General commercial/industrial tariff needs to be reduced by by 10% in 2018, 10% in 2019 and 5% in 2020.

- Solar and wind projects still need subsidies; more flexible capacity are also required to deal with increasing solar and wind penetration.
- Cost of power supply needs to increase if all are treated equitably.

The inability to reconcile cost and sustainability has led to several challenges in the Chinese solar and wind sector

- **Delay in subsidy payment**
- **Lack of flexible capacity**
- **Wind and solar curtailment and**
- **Slow progress on CO2 pricing**

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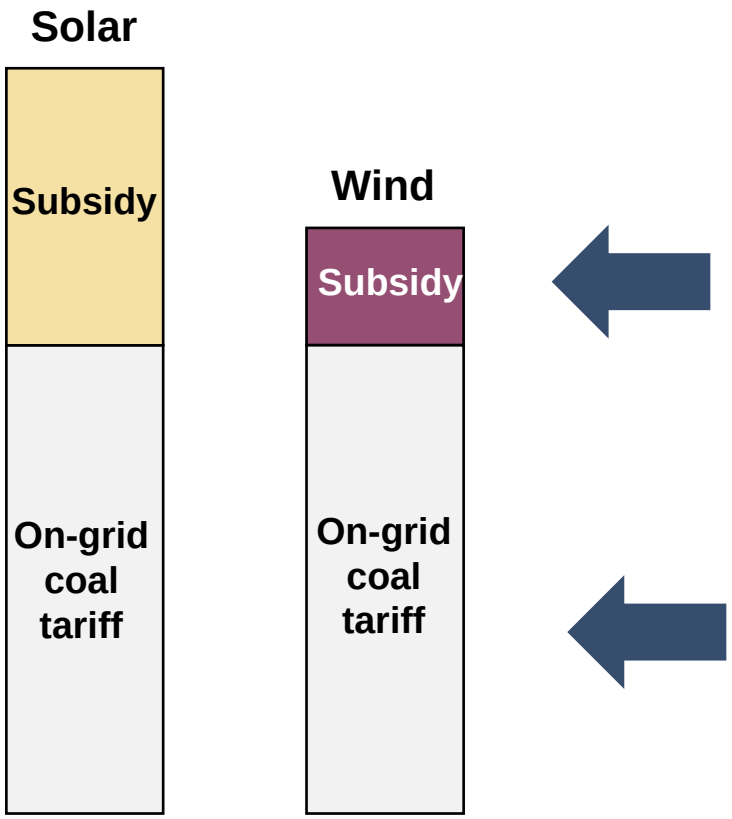
Issue (a): Subsidy Payment Delay

The subsidy component of the solar and wind farms are distributed to developers via the REDF, but it has delays of 3-5 years

Payment of FIT is split into two components



- **The subsidy component is paid from the Renewable Energy Development Fund (REDF), which is from the renewable surcharge on end-users*.**
- Fund from the REDF is paid to RE plants in "batches" based on their commissioning date.
  - A total of eight batches have been announced. The dispatch of the subsidy payment has been opaque and irregular. **Projects built after Feb 2016 have yet to receive their first payment.**

+

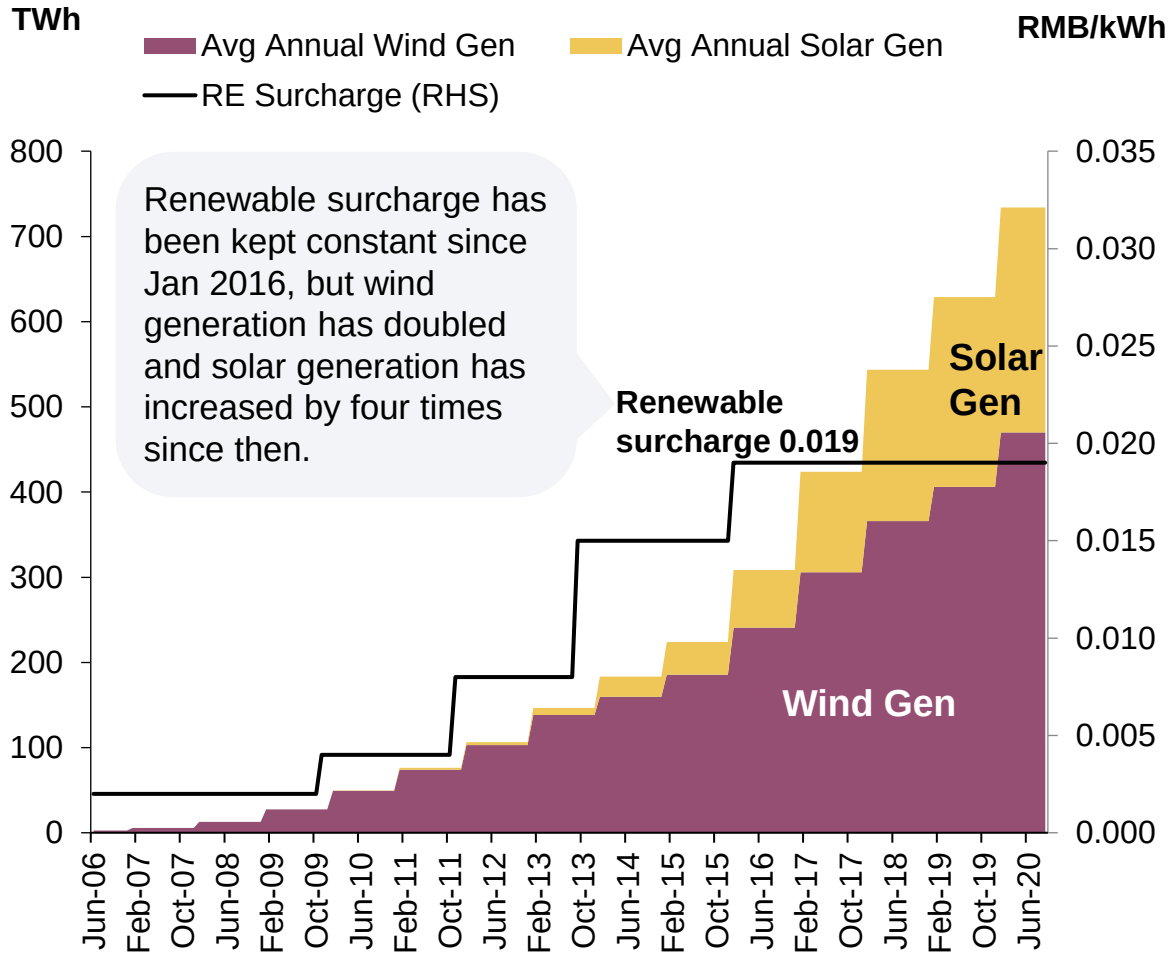
- On-grid coal tariff (including de-NOx and de-SOx) is paid by the grid companies each month, and there is no delay on the payment.
- The on-grid coal tariffs vary by provinces, ranging from 0.25-0.4 RMB/kWh.
- **For some provinces (like Yunnan), part of the generation volume is based on "market" tariff rather than on-grid coal tariff.**

Note: Since Jan 1, 2019, tax authority has become the new entity for collection of renewable charge. This could help to improve the collection rate.
Source: NEA, China Electric Council (CEC), WaterRock Energy Research and Analysis

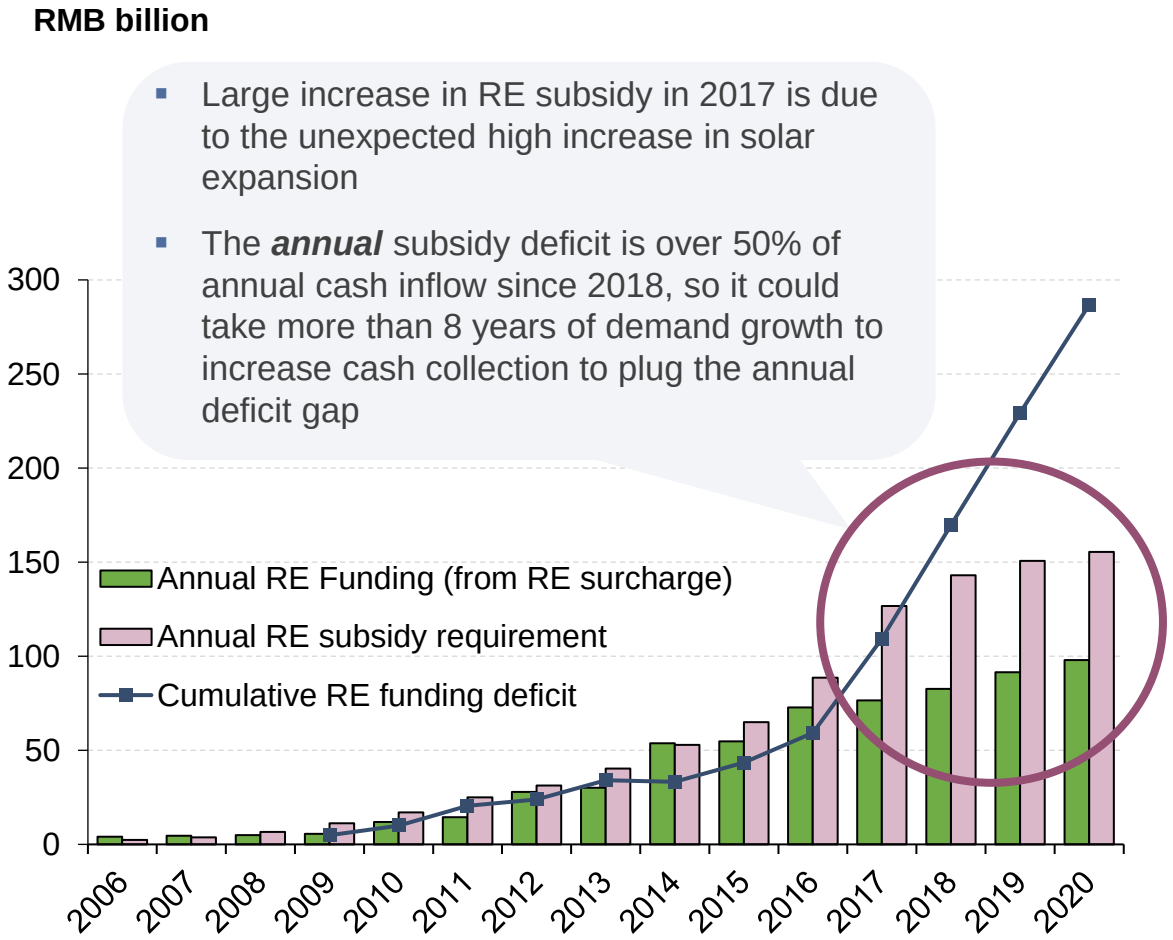
Issue (a): Subsidy Payment Delay

The subsidy deficit problem has been worsening in recent years, and the annual deficit has been more than 50% of annual cash inflow since 2018

Renewable Surcharge vs Solar + Wind Generation



Estimation of RE funding and Subsidy Requirement



Source: NEA, CEC, WaterRock Energy Research and Analysis

Issue (a): Subsidy Payment Delay

Government has been focusing on reducing subsidy payment for new projects and (to a less extent) existing projects to mitigate subsidy deficit issue

Aggressively reducing subsidy payment for new projects since 2018

- Since May 31, 2018, the government has become more aggressive on reducing feed-in-tariff for new solar projects (dubbed “531” policy). Competitive auction for new utility-scale solar and wind projects also become mandatory after June 2018 and Jan 2019.
- In 2019 and 2020, the Ministry of Finance adopted a new approach: the incremental RE subsidy should align with the increase in RE fund inflow (以收定支)*.
- All newly approved solar and onshore wind projects will be grid parity projects from 2021 onwards and new offshore wind projects will no longer get subsidies from the renewable fund from 2022 onwards.

Subsidy hour cap for existing projects

- The government encourages existing projects to switch to “grid-parity” projects.
- In October 2020, the Ministry of Finance (MoF), National Development and Reform Commission (NDRC) and National Energy Administration (NEA) jointly issued the “utilization hour cap for subsidy payment” policy [MoF (2020) No. 426].
  - The cumulative no. of hours eligible for subsidy payment for 20 years are capped at: Onshore wind, region I – 48,000, region II – 44,000, region III – 40,000, region IV – 36,000; offshore wind – 52,000; normal solar projects, region I – 32,000, region II – 26,000 and region III – 22,000. Thus, the annual average is 1800-2400 for onshore wind, 2600 for offshore wind and 1100-1600 for utility-scale solar.
- This cap will mainly affect the projects in Northeast China and Shanxi, which can reduce their expected subsidy payment by 5-15% [details are illustrated in the following slide]

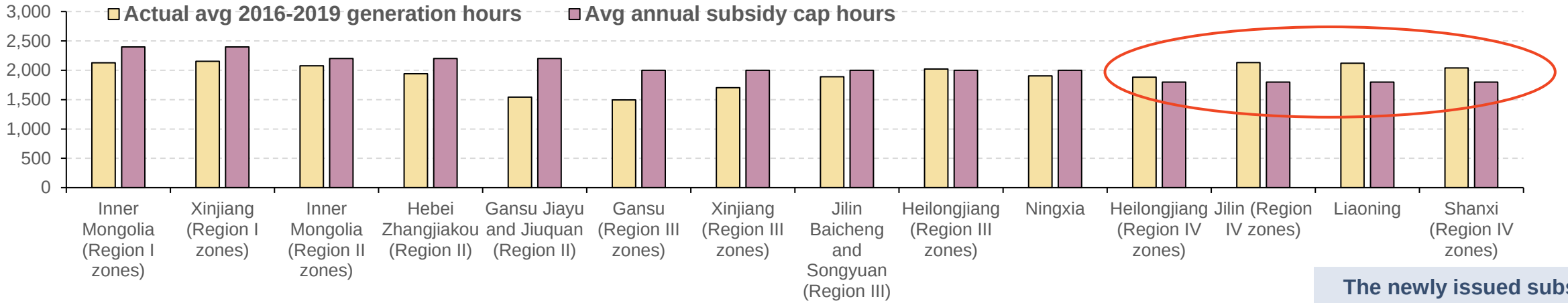
Note: *It uses a capping system for new utility-scale and distributed solar projects in 2019 and 2020. In 2019, total subsidy amount for new approved solar projects is 3 billion RMB [0.75 billion for household solar and the balance for other types of solar]. In 2020, total solar subsidy is capped at 1.5 billion RMB [0.5 billion RMB for household solar and 1 billion for other types of solar]. For onshore wind projects, it limits the availability of subsidies to new 2020 projects in provinces with installed capacity less than the planned capacity in the 13 5 FYP.

Source: WaterRock Energy Research and Analysis

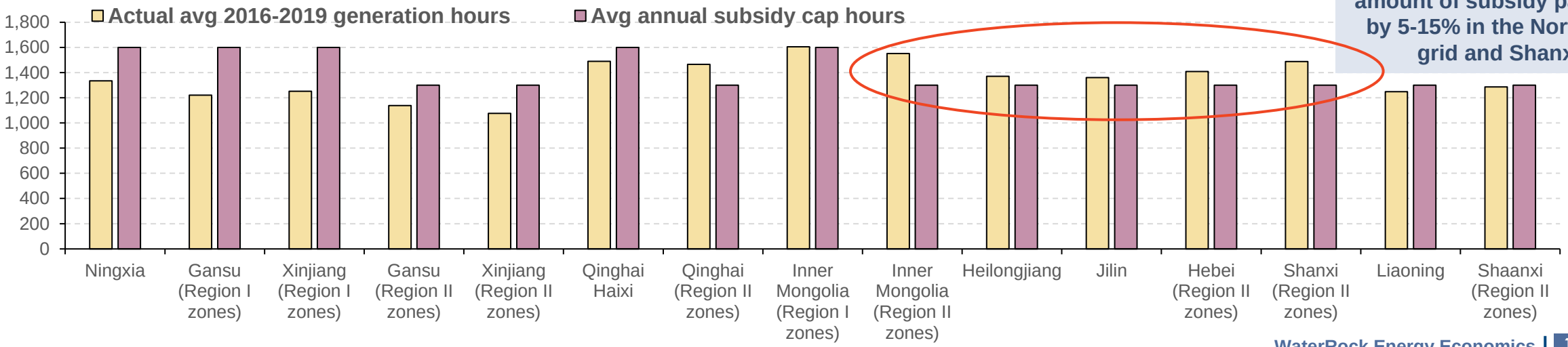
Issue (a): Subsidy Payment Delay

The newly issued subsidy cap policy can reduce expected subsidy payment by 5-15% for existing wind and solar projects in Northeast grid and Shanxi

Comparison of Different Types of Generations Hours for Onshore Wind Projects



Comparison of Different Types of Generations Hours for Solar Projects



The newly issued subsidy cap hours reduces total amount of subsidy payment by 5-15% in the Northeast grid and Shanxi

Source: NEA, WaterRock Energy Research and Analysis

Issue (a): Subsidy Payment Delay
There are no practical "easy" fixes to resolve the subsidy delay issue for existing RE projects

Increasing renewable surcharge
Unlikely in near-term

- There have been recurring calls to increase the renewable surcharge since 2017, but the government have consistently said that it is not going to increase the surcharge.
  - The most recent government statement is in an official letter from the Ministry of Finance (MoF) to the CEO of one of the state-owned power companies (Huadian) released publicly on Oct 10, 2020*. MoF mentioned that the time for increasing renewable surcharge is not right as the **central government intends to reduce taxes and power tariffs for the end-users.**

Bond issue by the grid companies
Diminishing possibility

- In Q3 2020, it was understood that the Chinese government is studying the possibility to ask the grid companies to issue bond to get upfront capital to help mitigate/resolve the subsidy delay issue. Nonetheless, there are practical implementation issues. We understand that this proposal is likely to be shelved.
- The government has officially mentioned that it encourages corporations to issue bond based on the subsidy "receivables" on their own.

Other Potential Sources of Revenues
Mostly speculative

- In the medium term, the government may be able to shift fund collection from the national carbon market to the Renewable Energy Development Fund (REDF) to help plug the deficit.
- Some have called to shift tax or other surcharge collections of the RE generation to the REDF. MoF has officially said that this option is not feasible.

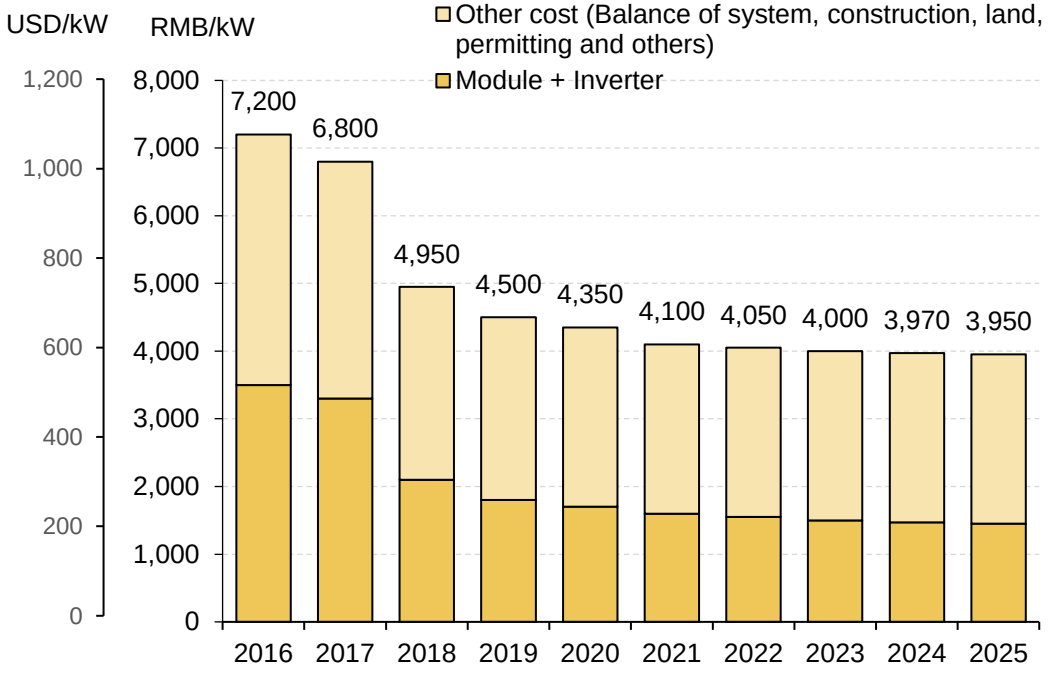
The subsidy delay issue poses cash flow challenges for existing investors, especially for private solar investors, and does reduce appetite for new capacity investment from private and foreign investors/lenders

Note: * The detailed letter can be sourced from website http://bgt.mof.gov.cn/zhuantilanmu/rdwyh/tianbanli/2020lh/2020fwgk/202010/t20201010_3601101.htm .
Source: WaterRock Energy Research and Analysis

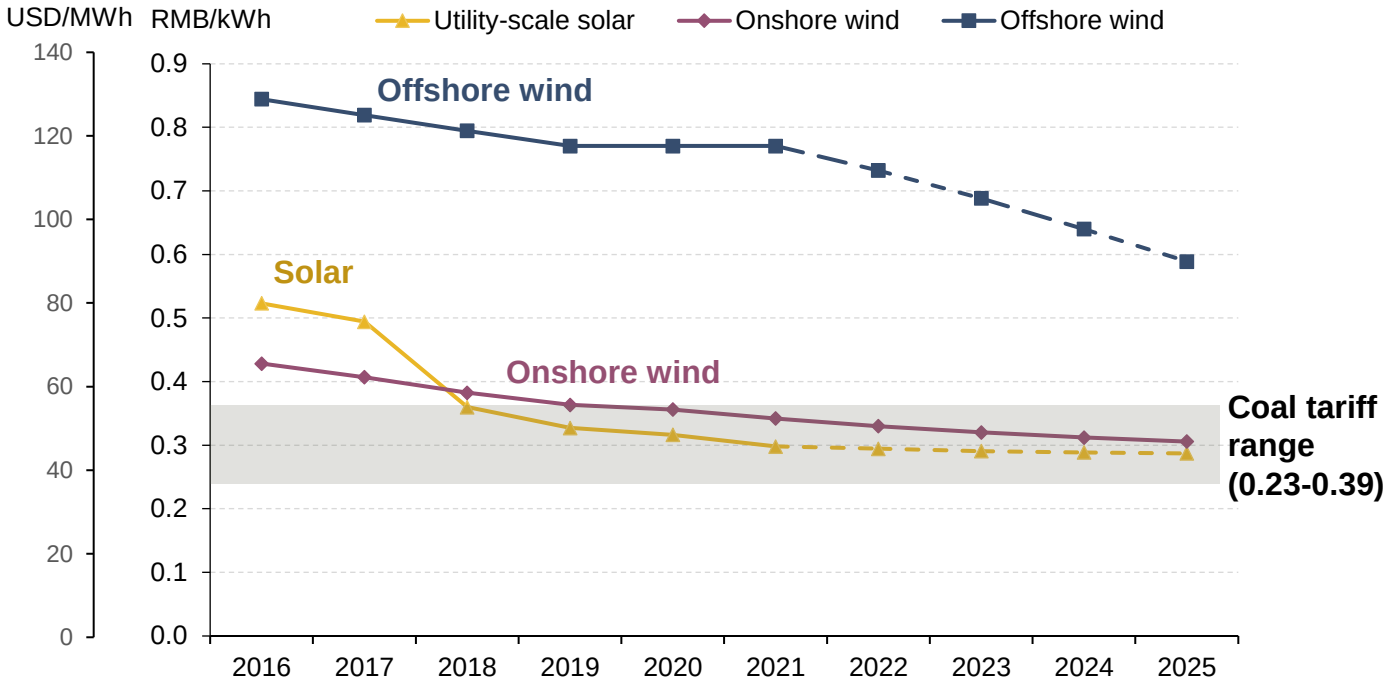
Issue (a): Subsidy Payment Delay

New onshore wind and solar capacity addition can be subsidy-free and will be mainly driven by economics

Overnight Capital cost of Solar
Reference Case



Levelized Cost of Energy (LCOE) of Different Technology (Ex-tax)



- Future onshore solar and wind capacity expansion will be mainly driven by economics as they could be more cost competitive than new coal projects. New offshore wind projects will still need local subsidies or "special" tariff from the local government.
  - For example, in 2020, total amount of approved "grid parity" projects is 33.1 GW for solar and 11.4 GW for onshore wind.
- **One key constraint of RE capacity expansion rate can be the grid's capability to accommodate wind and solar.**

Note: You can contact us for the key assumptions for the levelization cost calculation
Source: WaterRock Energy Research and Analysis

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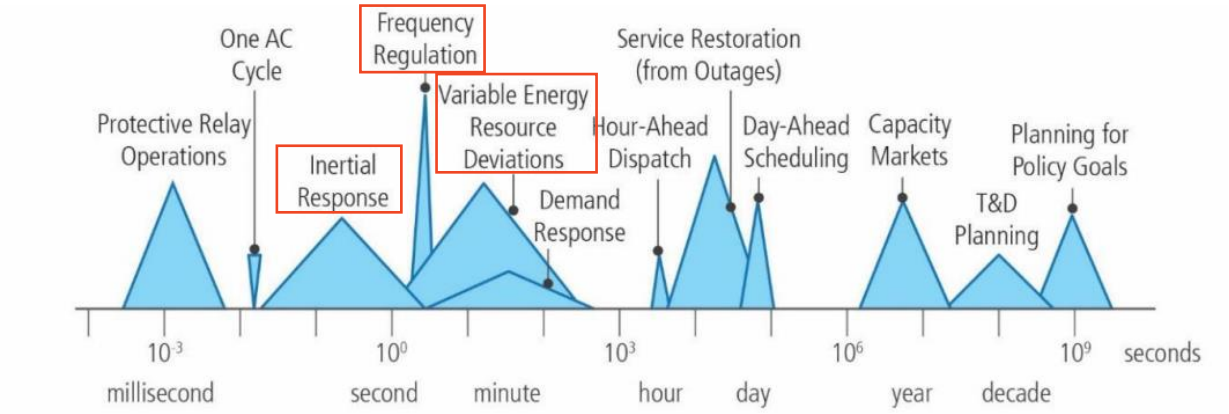
3 Summary

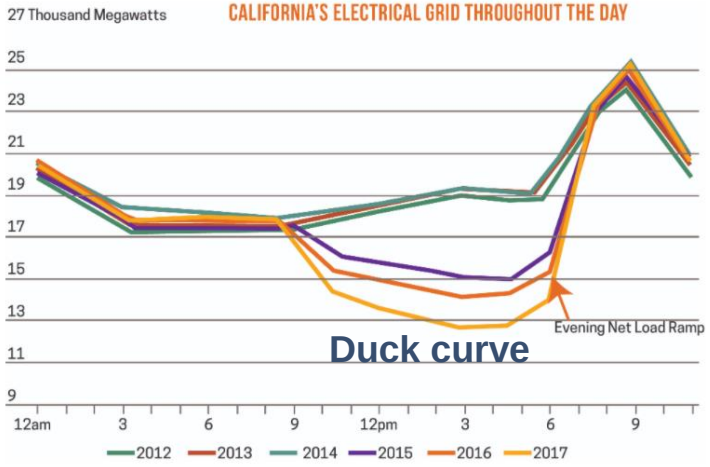
Issue (b): Lack of Flexible Capacity

There is a fundamental need for (much) more flexible capacity in order to accommodate more intermittent RE capacity

Power System Reliability Timescales



Net Load (excluding solar gen) in California ISO



Some provincial markets in China also start to have "duck curve" net load shape in high solar generation days

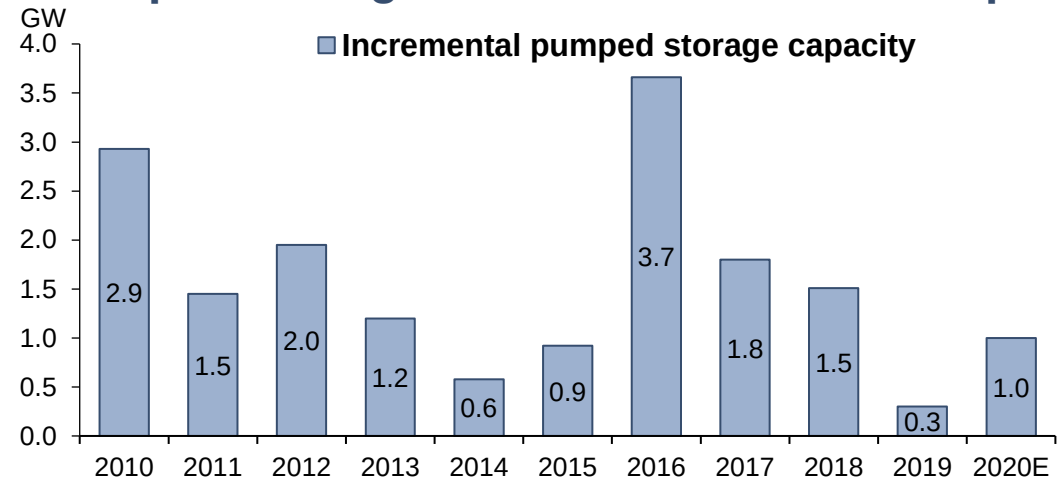
- Requirement of flexible capacity will increase rapidly as power system operators need to overcome multiple operational challenges to cater for higher solar and wind penetration:
  - **Higher requirement of frequency regulation** to cater for unpredictable solar and wind fluctuation over short time scales.
  - **Cycling**. The variable solar and wind generation forces other units to ramp up/down, turn on/off more frequently.
  - **Higher need for fast ramping** in late afternoon because of the duck curve phenomenon with rising solar penetration
  - **Higher reserve requirement** in the system as solar and wind displace conventional generation, leading to lower system inertia.

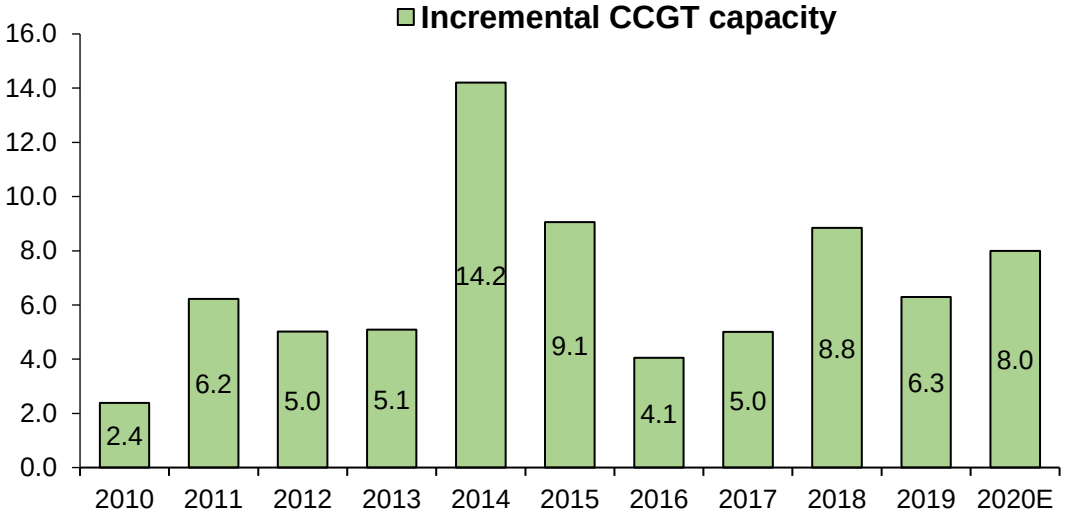
- In China, coal plants are being retrofitted to increase operational flexibility. But there are technical limitations – coal plants have slow ramp rate and are not well suited to do two-shift operation due to high start-up and shut-down cost.
- The best sources of flexible capacity to meet those increase requirement are energy storage facilities [battery or pumped storage] and gas plants.

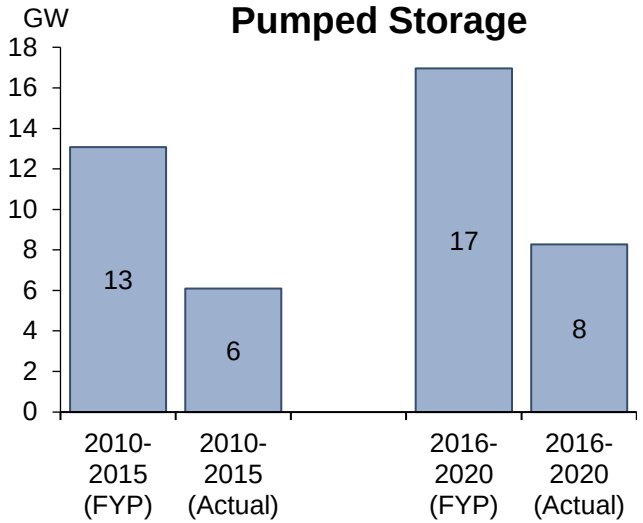
Source: US DOE, State Grid, WaterRock Energy Research and Analysis

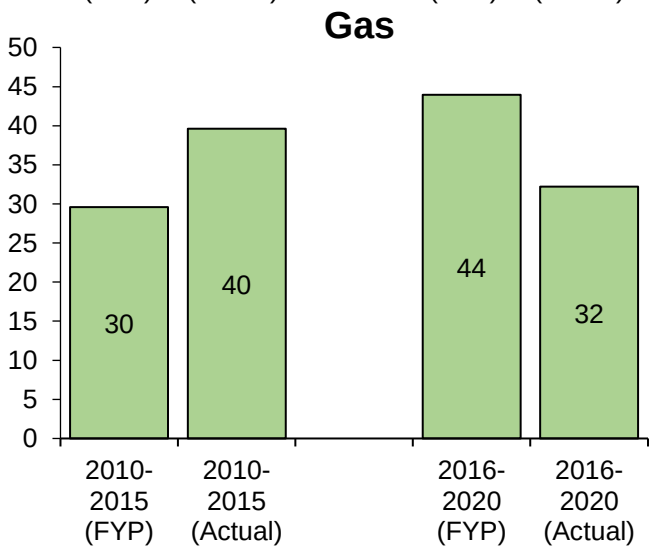
Issue (b): Lack of Flexible Capacity
But there have been under-investment in flexible capacity in the past decade due to rigid and low tariff setting

Pumped Storage and Gas Incremental Capacity Expansion, GW









Source: CEC, WaterRock Energy Research and Analysis

- Pumped storage plants are the most flexible capacity in the Chinese power system. Its expansion has been much slower than government's plan.
- Gas capacity can also operate much more flexibly than coal. In the past five years, gas capacity expansion is also slower than government's plan due to rigid on-grid gas tariff and gas availability.
- In general, **the tariff and market design do not align the "regulated price" and value of flexible capacity well**.
  - Tariff for flexible capacity is often too rigid and set too low.
  - No adequate pricing mechanisms to differentiate peak and off-peak periods.

Issue (b): Lack of Flexible Capacity

It will likely take a while before the Chinese regulators accept market designs that can provide strong market signal for flexible capacity

Best Market-based Practices in International Markets	Current Practices in China
1 **Strengthening real-time energy and ancillary service scarcity pricing in the competitive wholesale markets** [i.e. strengthen the mechanisms to allow prices to go very high in "system stress" conditions] • US ERCOT market has implemented an Operating Reserve Demand Curve (ORDC) since 2012; US PJM market is considering to implement a similar one for reserve market.	In the pilot wholesale market design in the seven provinces, there are no scarcity pricing regimes. The provincial governments also prefer "low price volatility" design, such as setting low price cap and relatively high price floor. This forces the market prices to settle at a narrow range. Such design reduces the true value of "flexibility" and reduces incentives for investors to build flexible capacity.
2 **Ancillary service market re-design by broadening and fine-tuning ancillary service products to increase possible ways to meet reliability objectives more efficiently** • Many jurisdictions considers to introduce fast frequency response product to incentivize the entry of battery. (e.g. in UK).	China is doing studies to re-design the ancillary service markets in different provinces. Prices are generally regulated to very low level; and cost is shared among different generators (including utility-scale solar and wind projects).
3 **Introduce/fine-tune capacity market** to maintain resource adequacy. More demand response and energy storage tend to enter in markets with capacity market design	Some provinces are considering to introduce capacity markets in the medium- and long-term. Several provinces give capacity payment and/or local subsidies for gas plants and demand response.

The incentive to efficiently operate and invest in flexible capacity is not strong in China

Source: WaterRock Energy Research and Analysis

Issue (b): Lack of Flexible Capacity

Battery Energy Storage System is well suited to deal with RE intermittency and improve grid flexibility

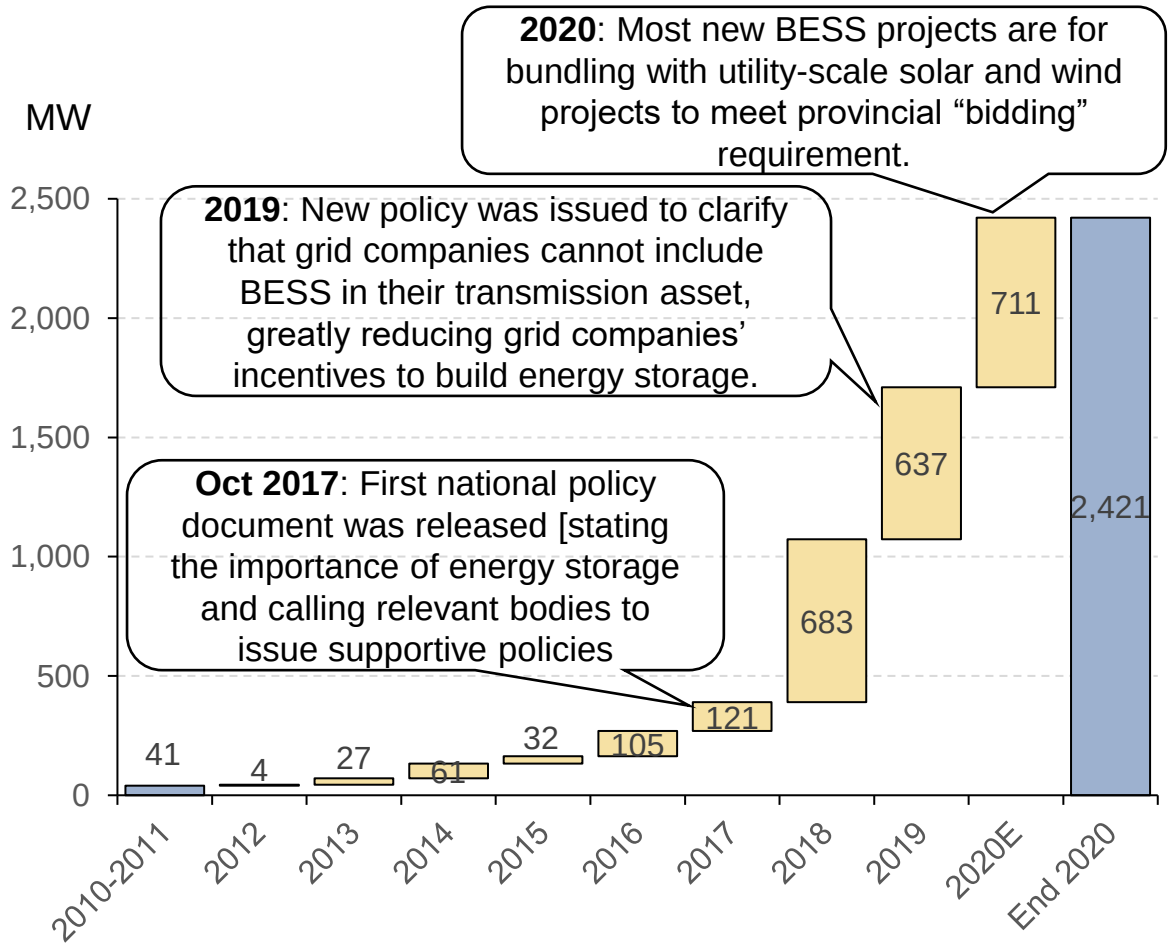
Value Streams of Battery Energy Storage System (BESS)

Battery Energy Storage System (BESS) can provide multiple value streams:

- Energy market values:
  - Energy price arbitrage
  - Avoided capacity investment for providing peaking energy
  - Reduce renewable curtailment.
- Ancillary service market values:
  - Fast response characteristics allow it to provide high quality ancillary services (such as frequency regulation etc).
- Utility infrastructure values:
  - Defer or avoid distribution and transmission infrastructure investment
  - Voltage support and improve power quality.

In China, market mechanisms for private investors to fully capture these values are yet to be set up

Capacity of BESS in China

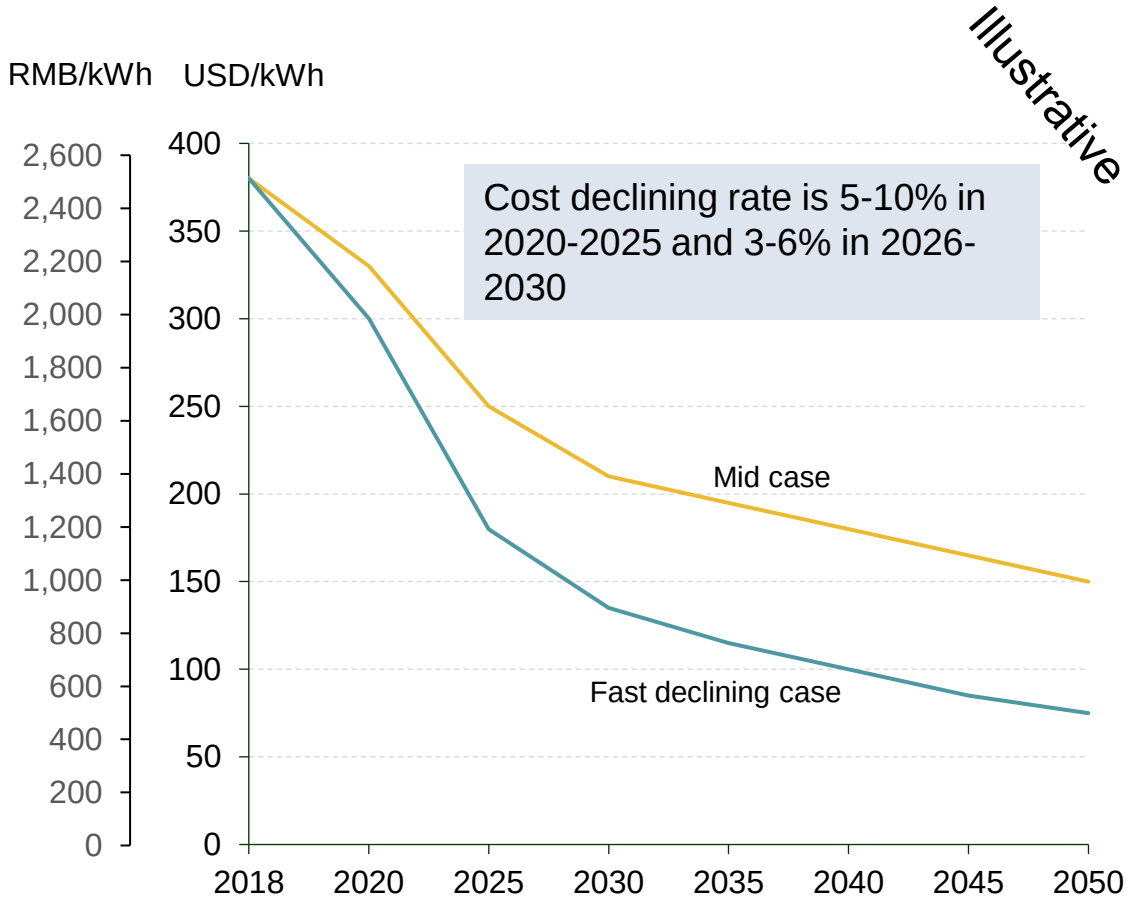


Source: China Energy Storage Alliance (CNESA), WaterRock Energy Research and Analysis

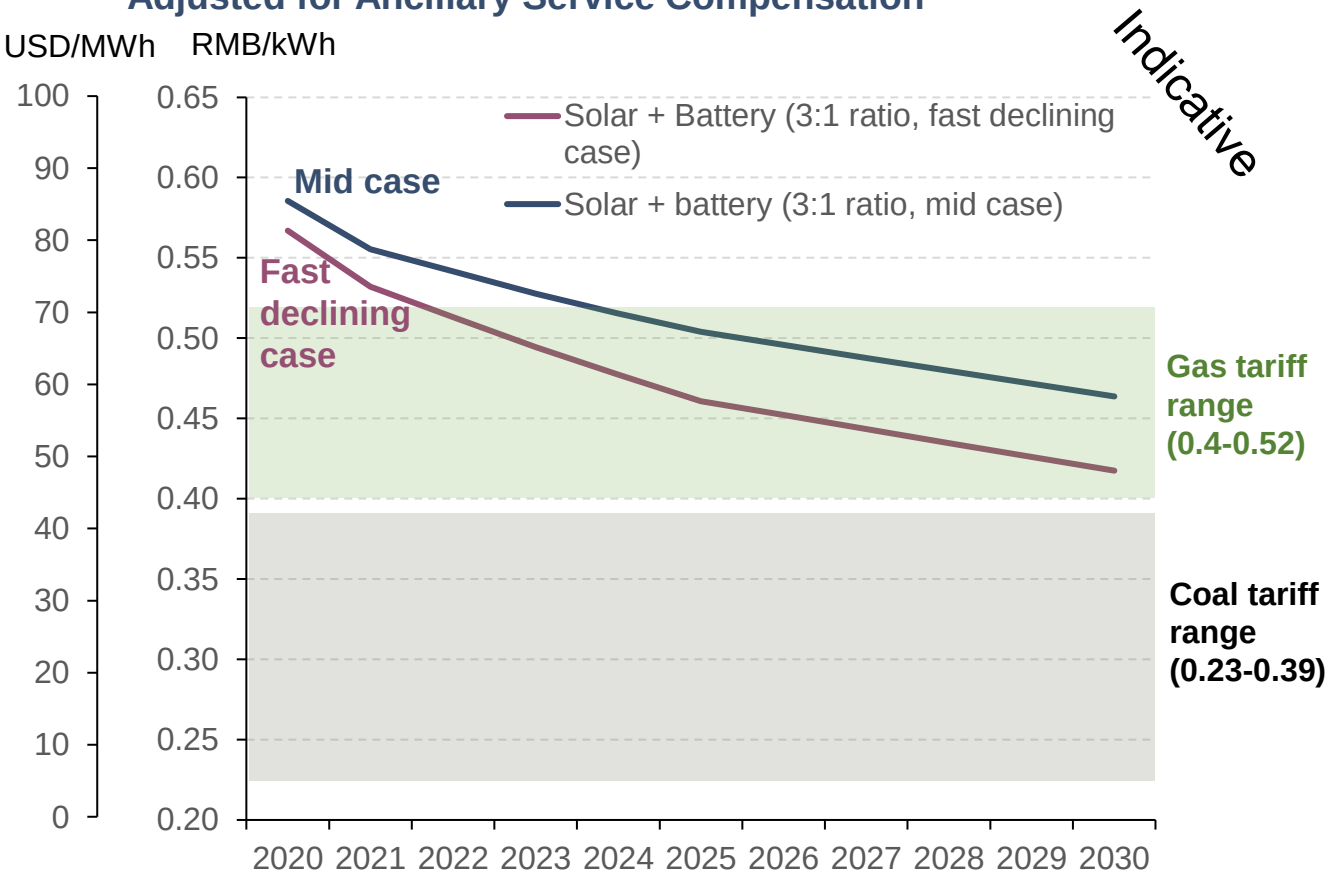
Issue (b): Lack of Flexible Capacity

With the declining cost of battery, large scale battery storage can provide as a viable economic option for mid-merit and peaking in the future

Capital Cost of Building 4-hour lithium ion Battery



Levelized Cost of Solar + Battery (3:1 Ratio)
Adjusted for Ancillary Service Compensation*



Note: Per kWh is a common unit used for energy storage. To convert it to per kW (same as the overnight capital cost for the thermal, solar and wind plants), one can simply multiply by its duration. In our case, we use 4-hour Lithium Ion Battery. So the per kW battery storage cost in 2018 is 380x4 = 1520 USD/kW.

Source: NREL, Cole, Wesley, and A. Will Frazier. 2019. Cost Projections for Utility-Scale Battery Storage. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-73222. https://www.nrel.gov/docs/fy19osti/73222.pdf.

*Note: We assume that ancillary service compensation can pay for 50% of the battery cost.

Source: WaterRock Energy Research and Analysis

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- 2d Slow Progress of Market Mechanisms to Price CO2

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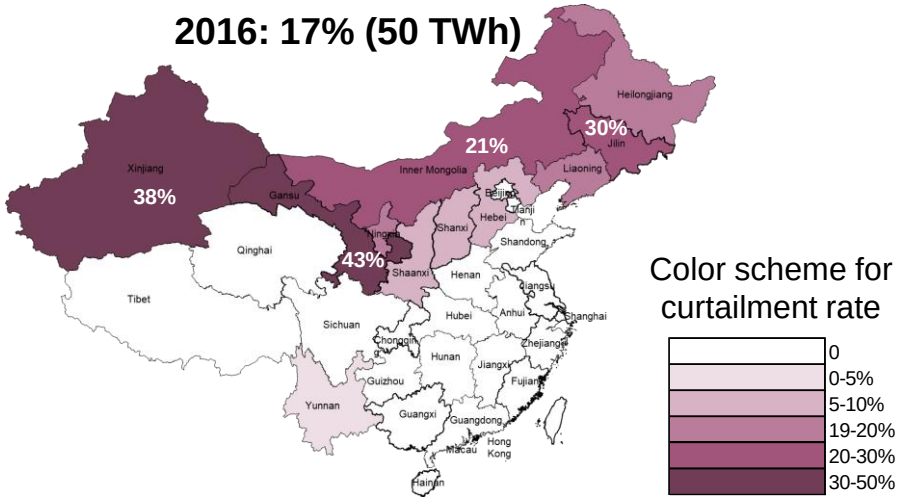
Issue (c): Renewable Curtailment

Curtailment rates have been reducing since 2017, but provinces in Northwest still experience relatively high curtailment rates

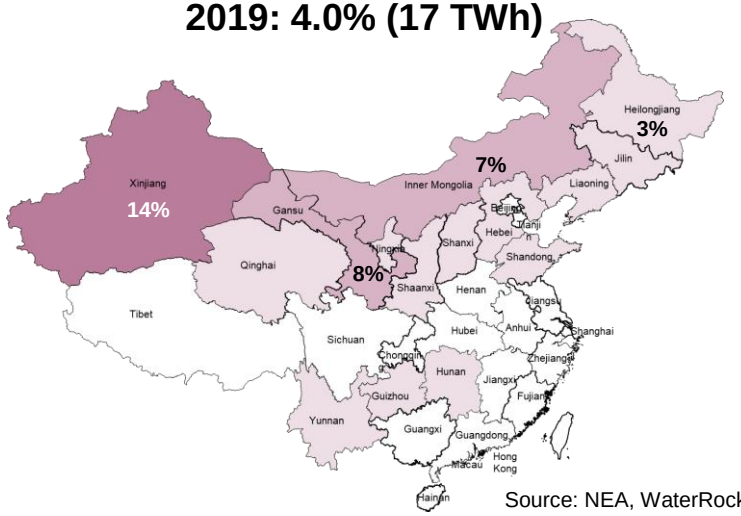
Wind Curtailment Heat Map
[Mainly in the "Three North" Regions]

2016: 17% (50 TWh)

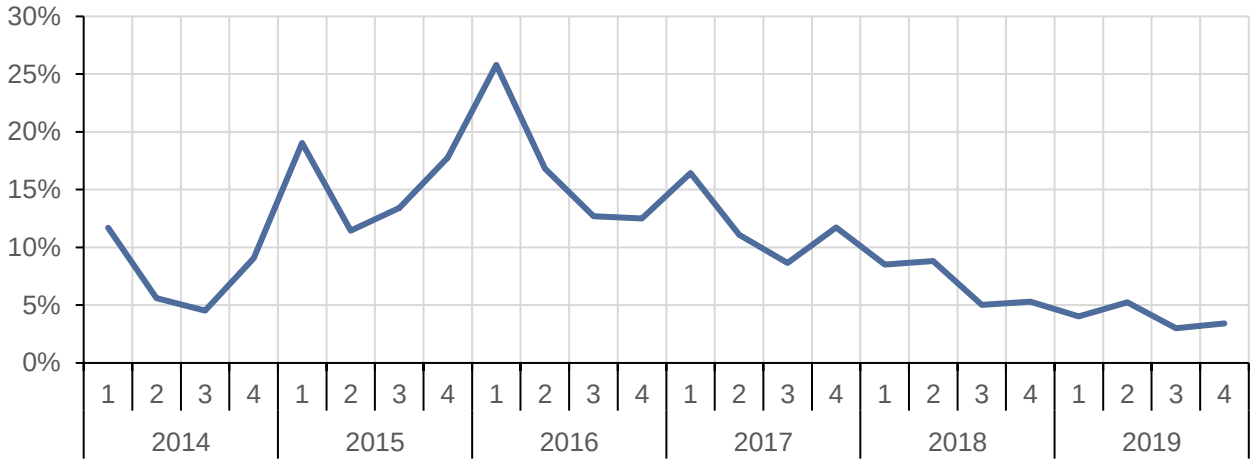


Color scheme for curtailment rate

2019: 4.0% (17 TWh)



Quarterly Wind Curtailment [National Average]



- Curtailment rates are generally the highest during winter season (Q1) because of the need to run combined coal heat and power plants to supply heat, reducing the room to offtake more wind and solar generation.
- Up to now, high solar curtailment (>5%) happen in Northwest region (i.e. Gansu and Xinjiang). This is mainly because of greater generation resource dispersion and better alignment between peak generation and consumption periods (e.g. daytime, summer).

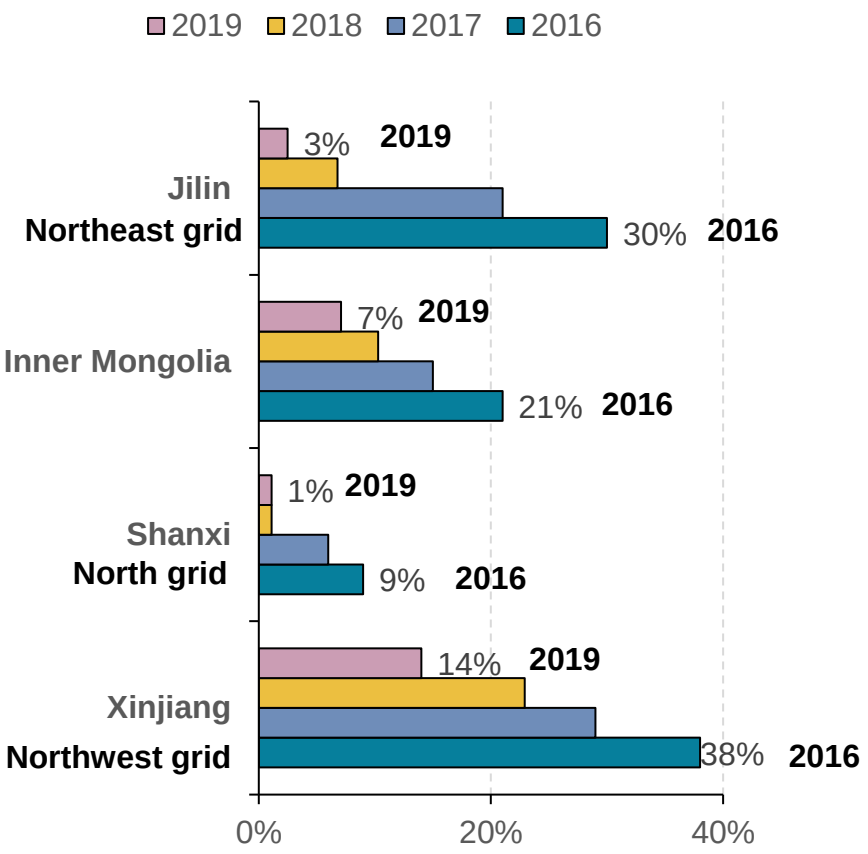
Source: NEA, WaterRock Energy Research and Analysis

Issue (c): Renewable Curtailment

High demand growth in 2017-19 is the primary reason for reduction in wind and solar curtailment in the three "North" regions in China

Key Reasons Leading to RE Curtailment	Actions/Market Development
Over-supplied in the local system **Material improvement**	▪ **National alert system to slow/stop new capacity addition** if curtailment rates increase from previous years or more than 5% ▪ **High demand growth in 2017-2019** ▪ **Commissioning of Ultra-high Voltage (UHV) lines** helps to export more power out of the surplus regions.
Rigid dispatch protocol **Some improvement**	▪ In Northeast grid, the government has introduced more co-sharing of resources to provide ancillary services ▪ There are also plans to have more efficient inter-provincial dispatch in Northwest grid ▪ Economic dispatch will be eventually adopted for provinces with wholesale competitive spot market.
Lack of flexible capacity **No improvement**	▪ The grid companies have plans to build pumped storage and battery energy storage projects. But progress has been slow because there is no clear mechanism for them to recover cost of their investment.

Historical Wind Curtailment Rate

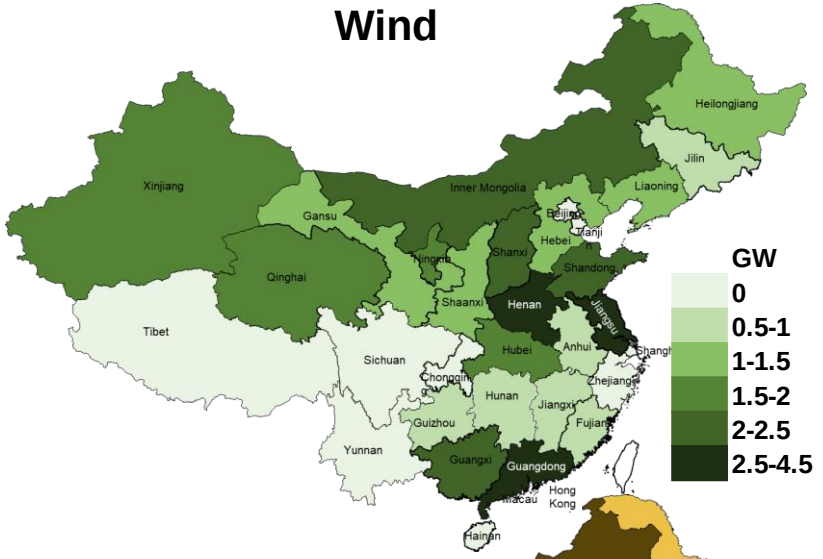


Source: NEA, WaterRock Energy research and analysis

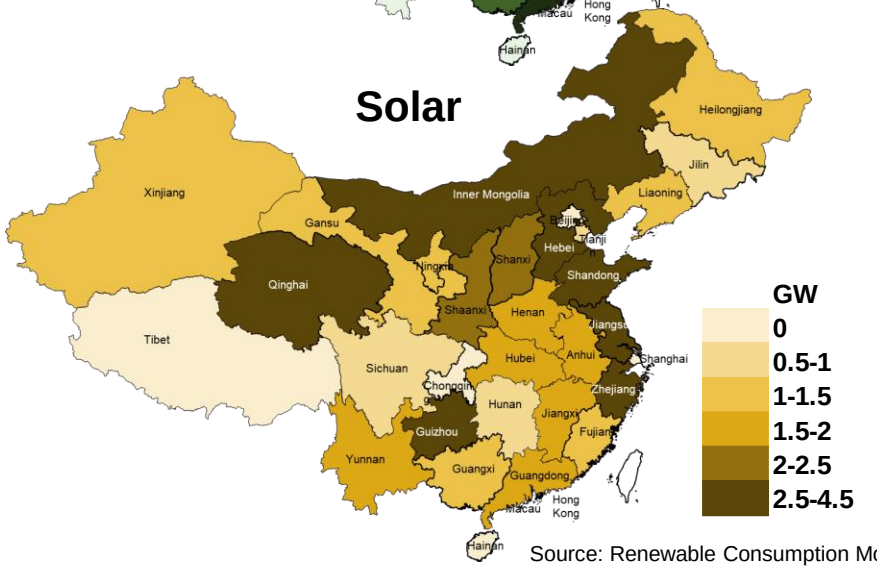
Issue (c): Renewable Curtailment

Capability of the grid to offtake more wind and solar has become a primary determining factor for the rate of solar and wind capacity expansion

2020 New Wind and Solar Capacity Cap



	2020 New Wind Cap (GW)
North	6.65
Northeast	4.10
Northwest	6.50
East	5.75
Central	5.95
South	6.20
Total	**35.15**



	2020 New Solar Cap (GW)
North	12.95
Northeast	3.80
Northwest	8.75
East	9.05
Central	6.50
South	7.40
Total	**48.45**

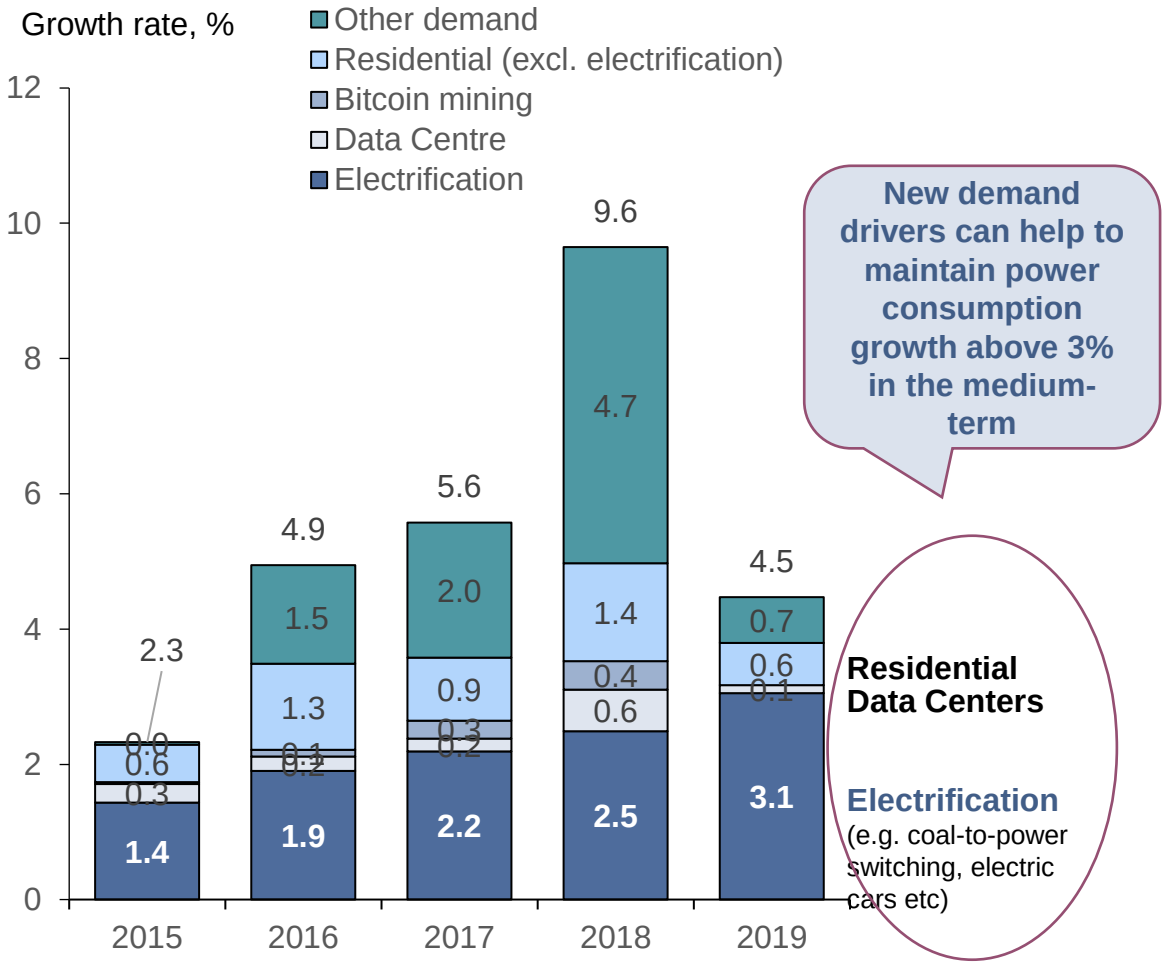
Source: Renewable Consumption Monitoring and Forecast Centre (NEA), WaterRock Energy Research and Analysis

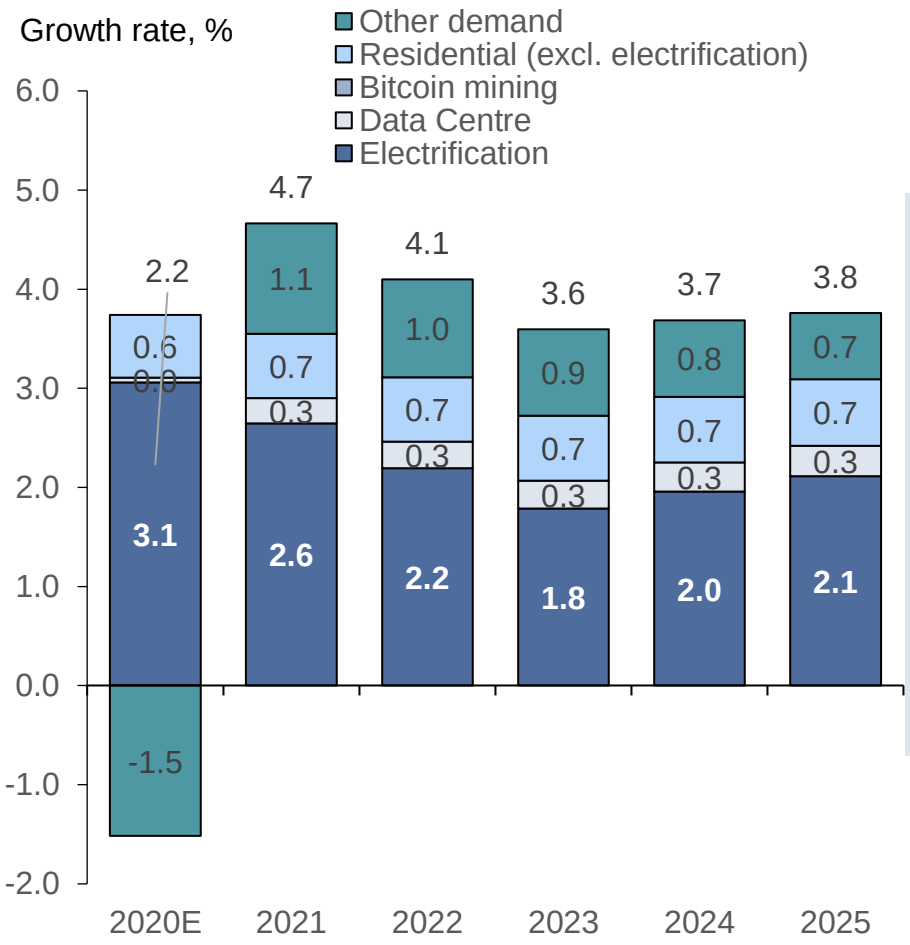
- Since 2019, the grid companies are tasked to work with China Electric Power Planning and Engineering Institute (EPPEI) and NEA to determine the upper limit for new wind and solar capacity expansion for each province in China.
  - This is to ensure curtailment rate does not rebound.
- In 2020, they set the upper limit at 36.65 GW for wind and 48.45 GW for solar.
- Key drivers for the upper limit in each province are:
  - The rate of expansion of flexible capacity – unlikely to be fast in the near-term.
  - The future demand growth: likely to be 3-5% each year
  - Expansion of ultra-high voltage lines: pace has picked up recently
- The actual capacity expansion will be increasingly limited by **availability of land,** especially for utility-scale solar and onshore wind projects near load centers.

Issue (c): Renewable Curtailment

New demand drivers from electrification, data centres and residential sector will likely lead to moderately high load growth in the next five years (3-5%)

China Power Demand Growth Rate by Sectors





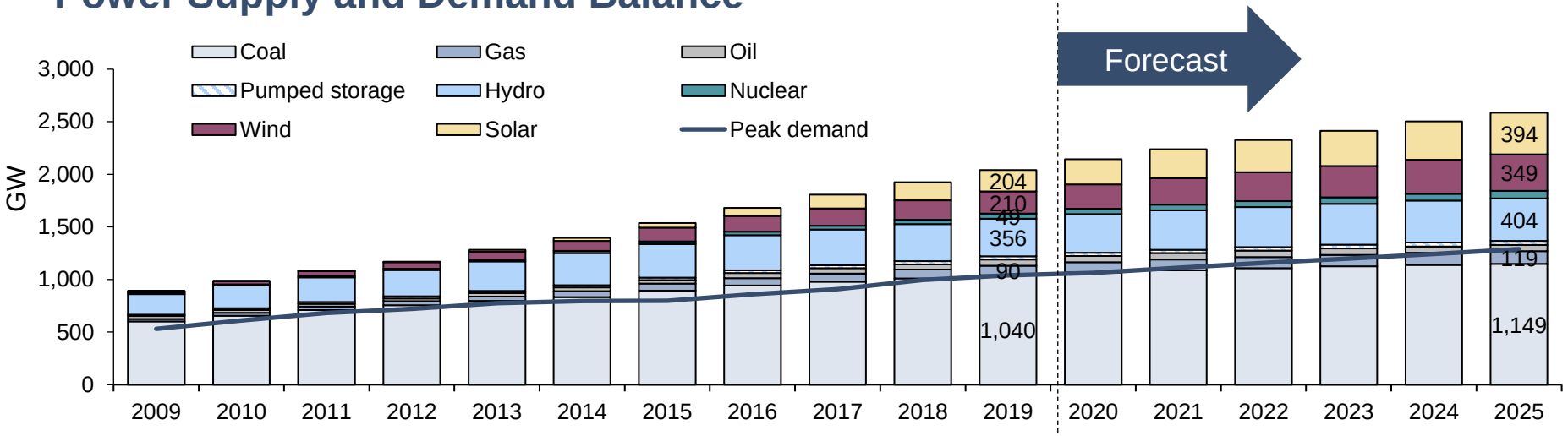
Electrification, digitalization of the economy (5G, big data etc) and rising household income are the new structural drivers for power consumption growth

Source: State Grids, MIIT, Various news clips, research paper and WaterRock Energy analysis

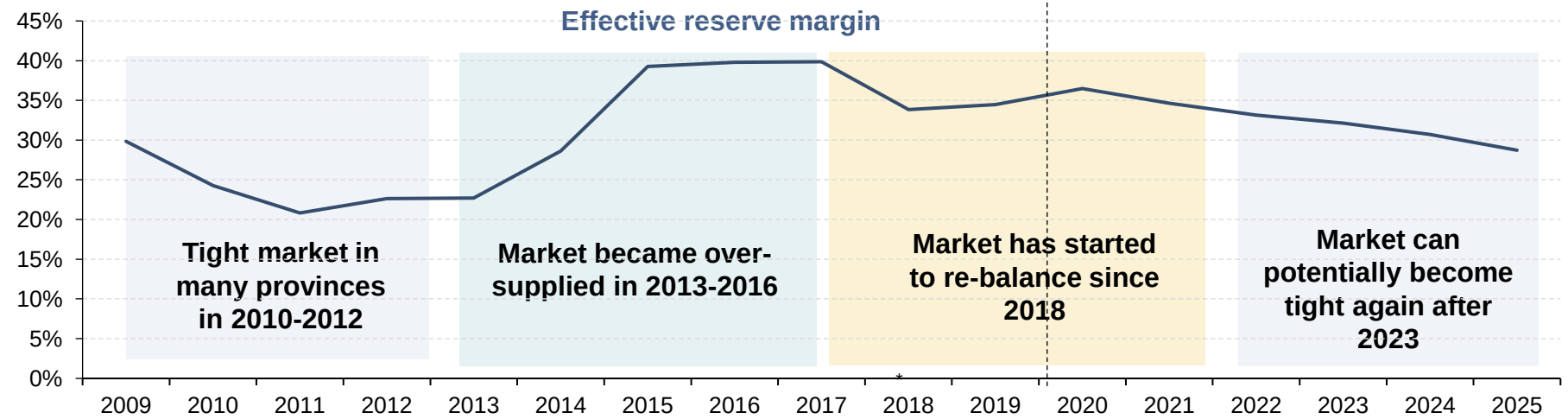
Issue (c): Renewable Curtailment

With relatively strong demand growth, the Chinese power market has re-balanced since 2018 and could potentially become tight again after 2023

Power Supply and Demand Balance



Effective reserve margin



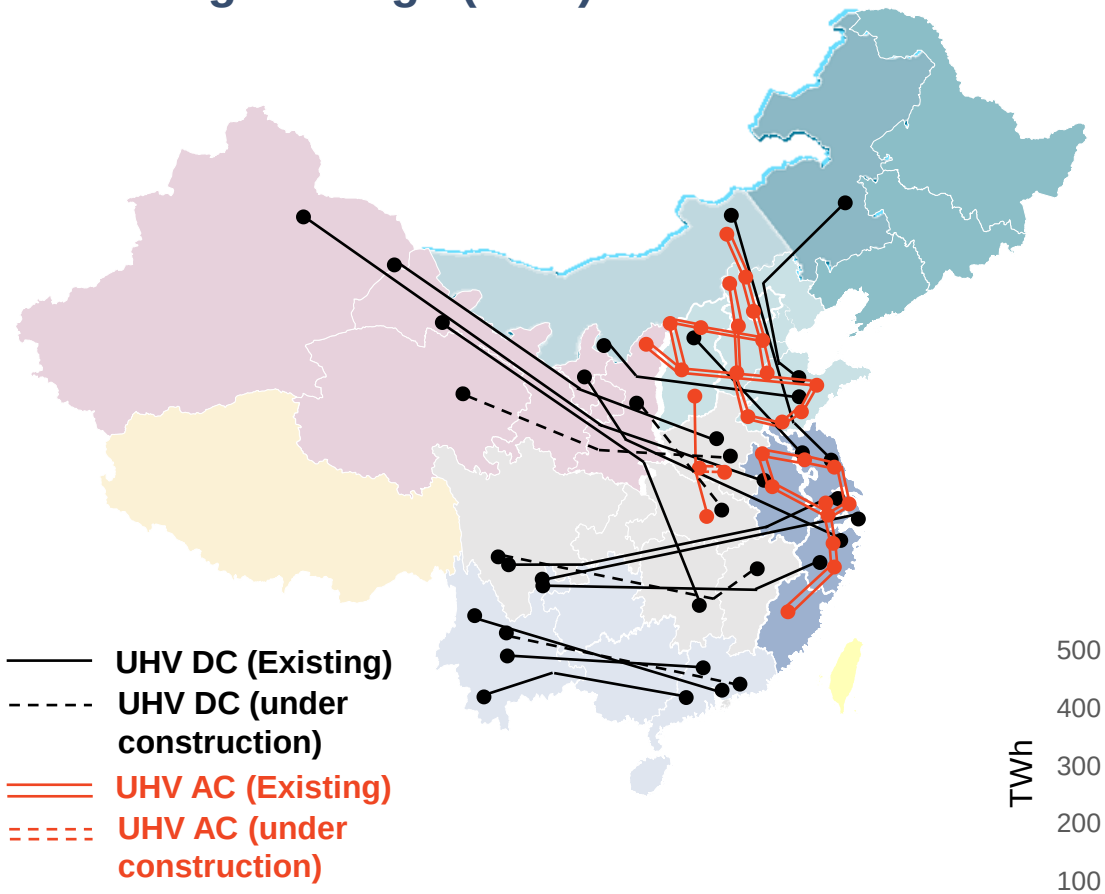
- As the market fundamental improves, the risk of renewable curtailment is reduced. Grid companies will be also able to accommodate more new wind and solar capacity.
- Our reference case for average annual wind and solar capacity expansion
  - Wind: around 20 GW for onshore wind, around 4 GW for offshore wind.
  - Solar: 30-50 GW each year.

Note: Effective reserve margin calculation takes into consideration of availability factor of different types of capacity during peak hours (Thermal – 90%, Hydro – 40%, wind – 24% and solar – 30%).
Source: CEC, NEA and WaterRock Energy Research and Analysis

Issue (c): RE Curtailment

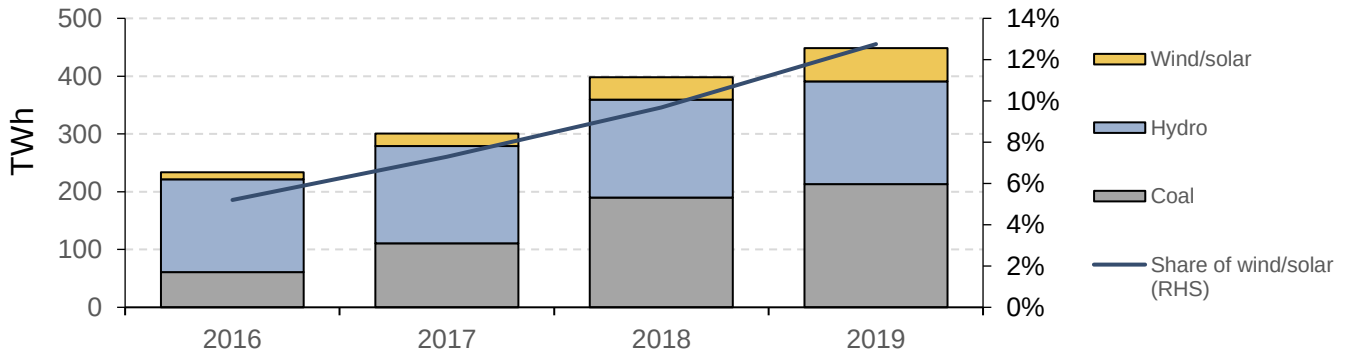
State Grid accelerates building a third round of UHV projects, which can help inland provinces to reduce curtailment and build new capacity for export

Ultra-high voltage (UHV) AC and DC lines



UHV DC Lines	UHV AC Lines
State Grid ▪ 11 UHV DC lines with total transfer capacity of ~96 GW are operating. 5 more will be built in the next few years [3 are under construction and 2 would be approved] **China Southern Grid** ▪ 3 operating UHV lines and one UHV line under construction for exporting hydro-power from Yunnan to Guangdong.	**State Grid** ▪ 12 UHV AC lines. 2 UHV AC loops have been built in East and North China, enabling more integrated power flows within the two regional grids. ▪ Only one existing UHV AC line cut across regions. Several other proposed UHV lines cut across regional grids are not approved because of safety concerns.

Total Power Transfer across UHV Lines



Note: In Feb 2020, State Grid has announced to start constructing several UHV lines. In mid Sep 2018, NEA announced that it would approve 6 more UHV DC lines and 2 UHV AC line in Q4 2018 and 2019。They are Qinghai to Henan (under construction), Shaanxi North to Hubei (under construction), Zhangbei in Hebei to Xiong'An in Hebei UHV AC (Completed), Yazhong to Jiangxi (under construction), Nanyang-Jinmeng-Changsha UHV AC line (approved). Baihetang to Jiangsu (approved in Nov 2020) and Baihetang to Zhejiang UHV DC

Source: State Grid, WaterRock Energy Research and Analysis

Agenda

1 Market Background

2 Key Challenges of the Wind and Solar Sector in China

- 2a Subsidy Payment Delay
- 2b (Lack of) Grid Flexibility
- 2c Wind and Solar Curtailment
- 2d Slow Progress of Market Mechanisms to Price CO2

3 Summary

Issue (d): Market Mechanisms to Price CO2

Policies to price carbon are still in progress, although new solar and wind projects need to wait longer to fully capture the values of being "carbon-free"

National Carbon Market

- On Oct 28, 2020, the Ministry of Ecology and Environment (MEE) published a public consultation draft of the National Carbon Emission Trading Mechanism (ETS).
- In the draft, it is stated that carbon allowance will be "free" in the initial stage, and cost will be gradually introduced at later stage. This means that the impact on coal and renewables will be very limited, at least in the near term.

Green certificate trading

- Government has set up the process to determine renewable portfolio standard.
  - Nonetheless, setting of the provincial renewable portfolio standard is a negotiated process, and most provinces can meet the renewable portfolio standard with its own planned renewable investment.
- Green certificate trading is still voluntary, and trading volume is negligible.

Renewable Corporate PPAs

- More global and domestic large corporations in China are seeking to sign renewable corporate PPAs.
  - For example, Longi and Jinko have joined RE100, and they are relocating manufacturing plants to hydro provinces like Sichuan and Yunnan.
- Regulation on corporate PPAs vary by provinces and many provinces are yet to set up clear regulations for long term corporate PPA.

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3 Summary

Summary
Overall environment for the solar and wind sector is improving even though there are still challenges.

- The power sector will transition to a greener future with the 2060 carbon neutrality target.
  - The focus on reducing cost/tariff for end-users in the near-term have limited policy options to address key challenges, but the government will still ensure the financial health of the sector in the near-term and could be supportive for RE development in the medium- and long-term.
  - It will seek to facilitate the development of leading technologies along the solar and wind value chain.

- There are several key challenges in the solar and wind generation sector. And the challenges also create new opportunities.
  - **Subsidy payment delay** issue will likely get worse in the coming years.
    - As some private investors face cash flow issues, there could be opportunities for equity investment in good long-term assets.
    - New onshore wind and solar projects are "subsidy free" and economical. Project location will be critical for risk assessment due to different market fundamental and policies at provincial level.
  - **Lack of flexible capacity**. Investment in flexible capacity (pumped storage and gas capacity) lags government's plan, but the need for flexibility is increasing. This can become the primary constraining factor for rapid solar and wind capacity expansion.
    - Even though market mechanisms are yet to be set up, local opportunities to invest in battery energy storage will increase with declining cost.
    - Other opportunities for dealing with RE intermittency, such as demand response and control technologies/equipment, will also increase over time.
  - **Renewable curtailment** rates have reduced and will likely decrease further with improving market fundamental. Nonetheless, provinces in Northwest China still face relatively high curtailment rates.
  - **Slow progress of carbon pricing initiatives** (like national carbon market and green certificate trading) limit upside potential for solar and wind projects in the near term. But they will be eventually implemented, providing good upside for solar and wind projects in long term.

- Electrification, new data centres, residential demand growth and digitalization of the economy will help to drive demand growth at 3-5%. Market fundamental has been improving in most provinces in China, and this does create a good environment for more wind and solar investment.

Thanks and Contact

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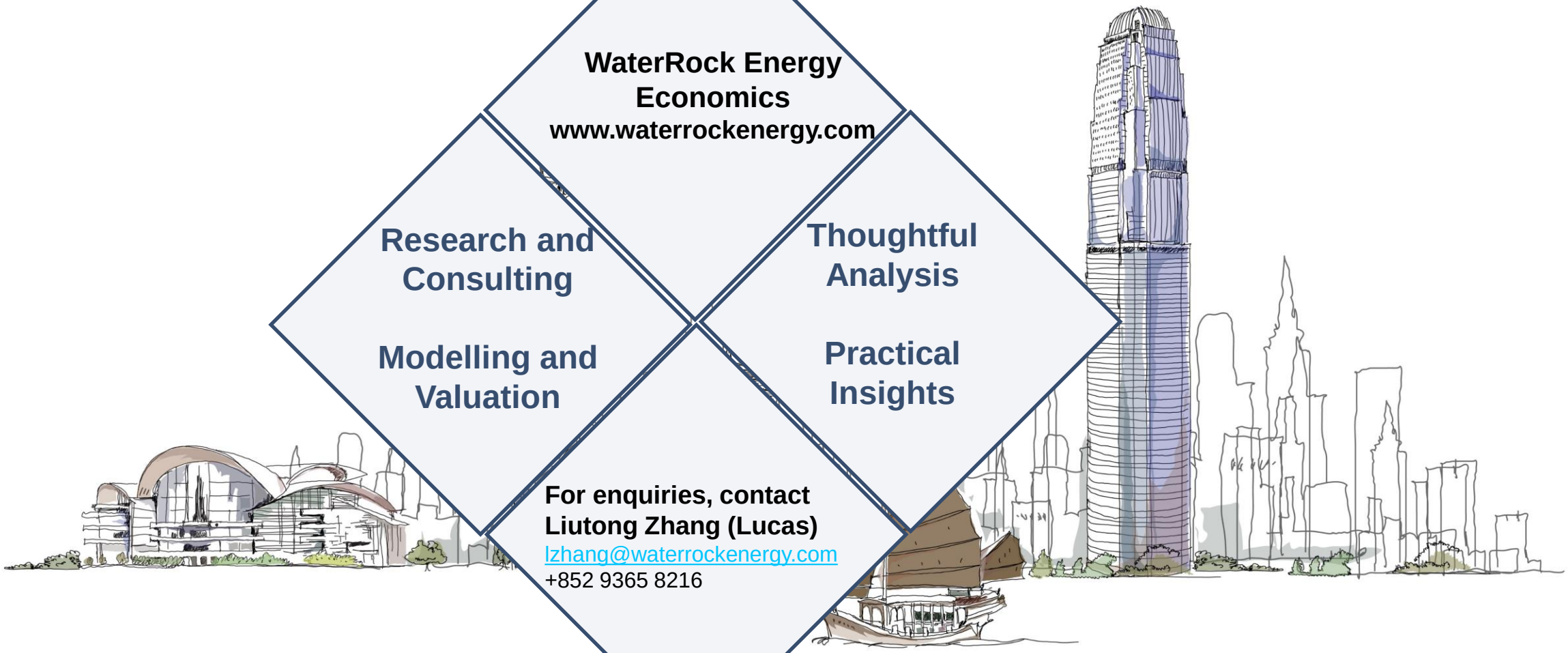

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Liutong has over 12 years' experience of providing advisory services on the power and gas market in China and ASEAN electricity markets.

He has in-depth knowledge in greater China region, including forecasting of solar and wind curtailment and power tariffs, asset valuation and evaluation of opportunities/risks of investing in renewables and gas infrastructure in mainland China, Hong Kong and Taiwan.

He has also been extensively involved in the market design of a Forward Capacity Market in Singapore since early 2019. In the Philippines, he was invited to present to the Philippines' Energy Committee of the Senate and Philippines' House of Representatives on the role of natural gas and economics of building new LNG terminals in early 2020.

He holds a Bachelor of Chemical Engineering with first class honours from the National University of Singapore (NUS). He is fluent in English and Mandarin.

Appendix

Subsidy Delay Issue
Key determining factors on the priority of subsidy payment are the commissioning date of the projects and type of the projects

Batch-wise Quota System for Projects in 2012-2019

	Quota announcement date	Commissioning Date
1st	12 Jun 2012	N.A
2nd	21 Sep 2012	N.A
3rd	20 Dec 2012	N.A
4th	26 Feb 2013	N.A
5th	21 Aug 2014	Bef Aug 13
6th	24 Aug 2016	Aug 13 – Feb 15
7th	11 June 2018	Mar 15 – end Feb 2016
8th	Jan 2020	Mar 2016 – Dec 2019 for wind, solar under front-run program and 2019 competitive bidding program March 2016 – July 2017 for normal solar projects.

- China used to have a batch-wise quota system to dispatch subsidies to the wind and solar projects.
  - The plants commissioning in earlier date have higher priority.
  - Under the regulation, the fund is supposed to be distributed to the eligible plants on a quarterly basis. However, the exact implementation process is opaque and fund distribution time-line is not predictable [although they try to distribute to eligible plants at least once every year].
- In early 2020, it announced that it is going to change the fund distribution process, but it remains uncertain how the new process will work.
  - One possibility is that RE cash inflow may be distributed to all the eligible RE plants, and they all only get a fraction of their total subsidy; or
  - the dispatch of fund remains largely the same (i.e. the plants built in earlier years have higher priority).

Note:* based on government announcement http://www.gov.cn/zhengce/zhengceku/2020-03/23/content_5494490.htm

Source: WaterRock Energy Research and Analysis

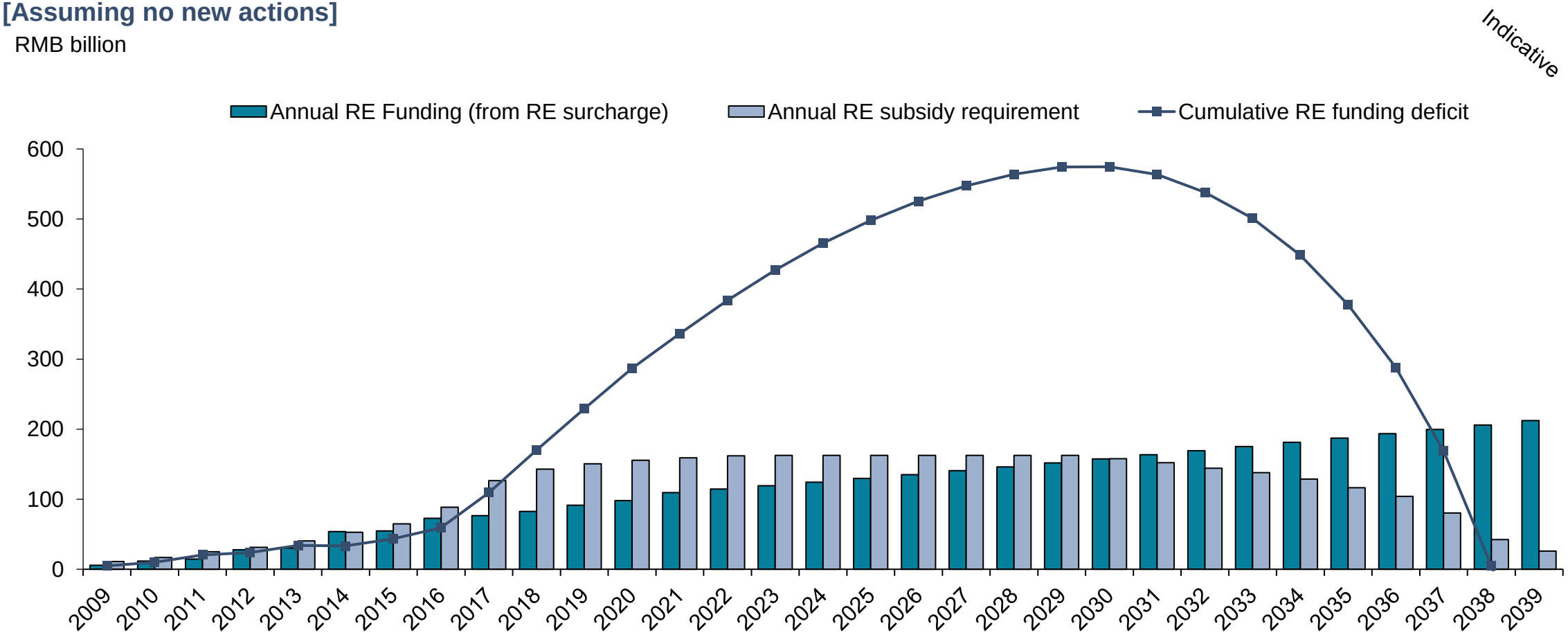
Subsidy delay issue

Without any actions, the subsidy delay issue will become worse in medium-term as renewables deficit will only decline quickly around 2030

Forecast of RE Subsidy Deficit

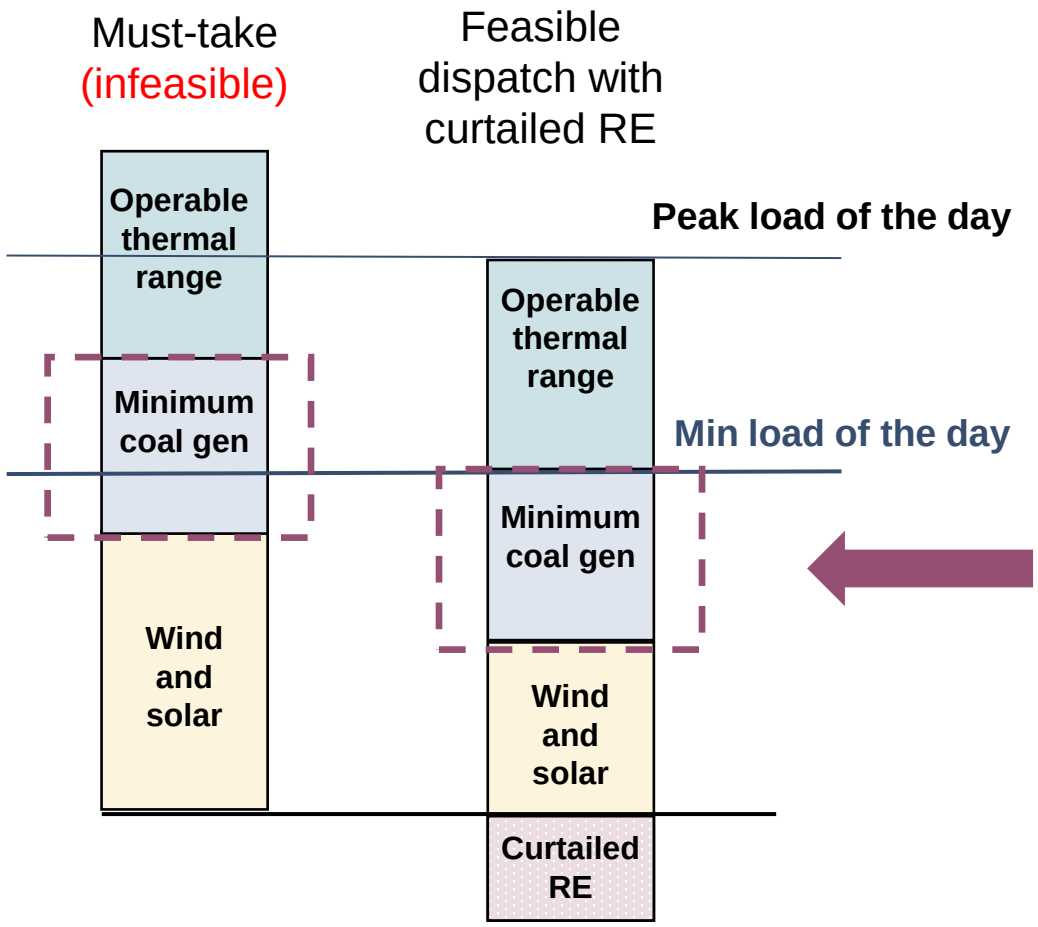
[Assuming no new actions]

RMB billion



Renewable Curtailment

Fundamental reasons for the RE curtailment is over-supplied in the local system, the lack of flexible capacity and rigid dispatch protocol



The NEA's Rules identify three typical constraints under which a Dispatch Organization (DO) may curtail renewable output:

1. system security constraints;
2. insufficient load following capacity; and
3. system emergencies.

When the DO curtails RE output, it is required to provide the amount of output curtailed, the reason for curtailment, and the situation under which curtailment occurred.

The quantity of **minimum coal gen** has material impact on renewable curtailment, and it is driven by:

- Whether the coal plants need to provide **heating requirement**
- Amount of **flexible resources** to provide ancillary services (such as ramping and regulating reserves) to ensure power system reliability
- Amount of **unpredictable resources** (such as solar and wind) that could increase ancillary service demand
- Capability to **share resources** (such as pumped storage plants) across different provinces.

Source: WaterRock Energy research and analysis

Renewable Curtailment (Impact of COVID-19)

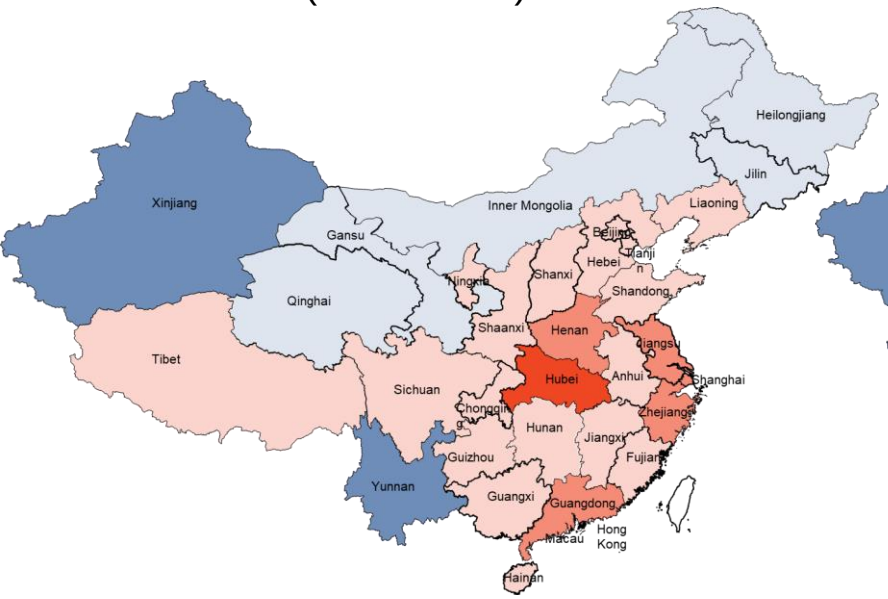
In Q2 2020, Power demand growth have returned to positive in most provinces as China manages to contain COVID-19

% Change of Power Demand in 2020 vs 2019

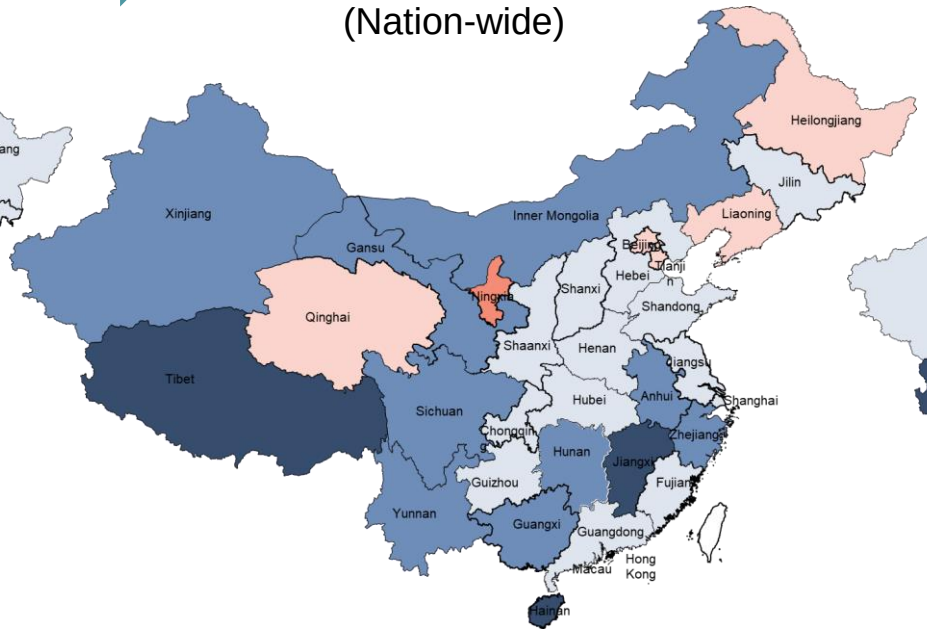
Demand change

- <-25%
- minus 10% - minus 25%
- 0 - minus 10%
- 0-5%
- 5-10%
- >10%

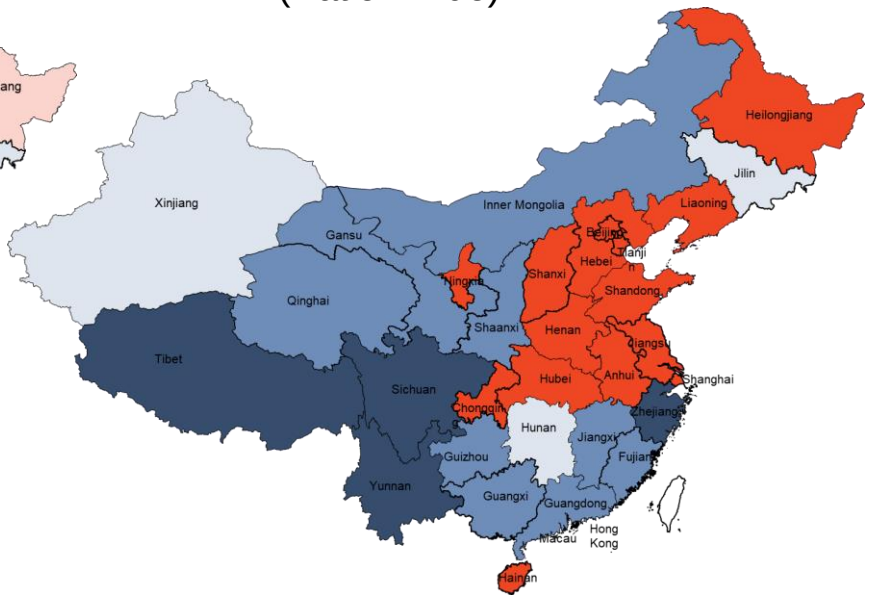
Q1 2020 vs Q1 2019: -6.5%
(Nation-wide)



Q2 2020 vs Q2 2019: 3%
(Nation-wide)



Q3 2020 vs Q3 2019: 6%
(Nation-wide)



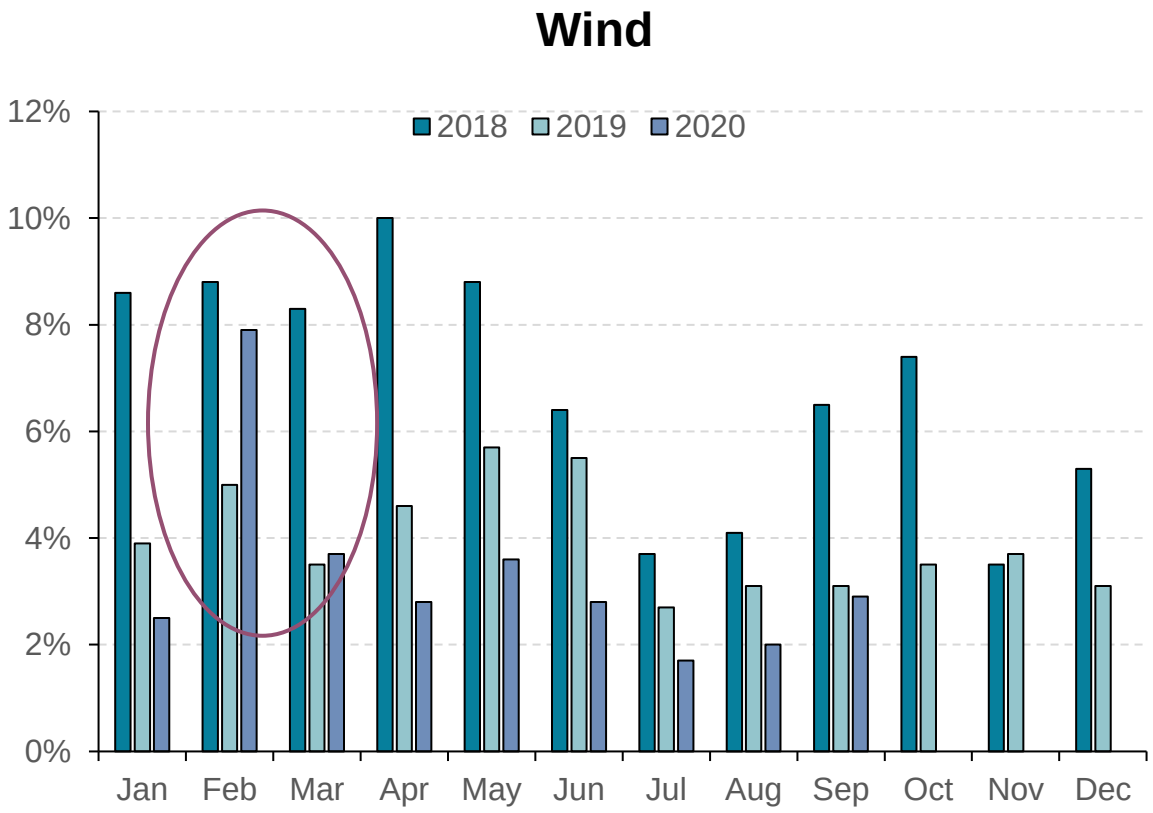
In Jan-Sep 2020, demand is up by 1.3% year-on-year in China

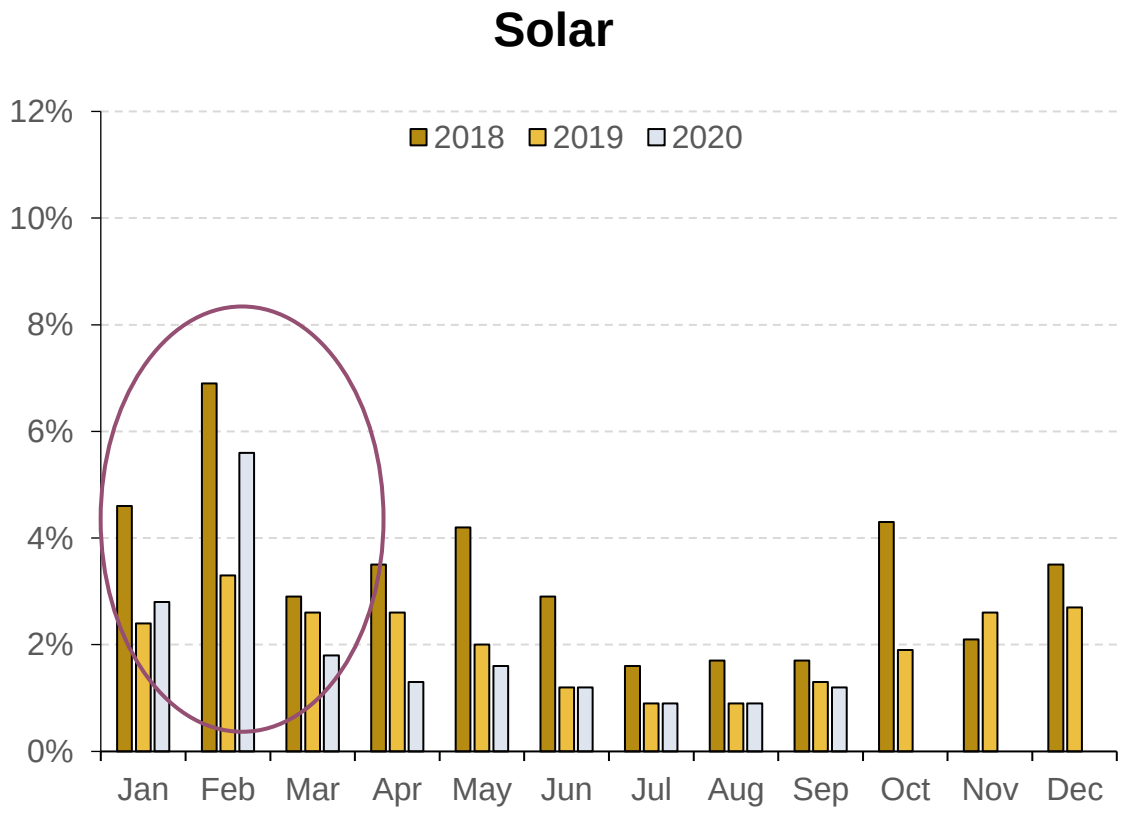
Source: CEC, WaterRock Energy estimates

Renewable Curtailment (Impact of COVID-19)

The drastic demand drop during the lock-down period in Feb-March does lead to a slight temporary rebound in curtailment rate.

Wind and Solar Curtailment Rate





Source: NEA, WaterRock Energy Research and Analysis