



# TRACKING CHINA'S PROVINCIAL SPOT MARKET DESIGNS: 2019

Rocky Mountain Institute  
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## ABOUT ROCKY MOUNTAIN INSTITUTE

Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI has offices in the United States in Basalt and Boulder, Colorado; New York City; the San Francisco Bay Area; Washington, D.C.; and in Beijing, People's Republic of China.

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# 01 About This Report

# About This Report

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## Introduction:

Successful implementation of China's power market reform is critically important to accelerating China's use of efficient and renewable resources. Provinces are responsible for designing the details of these markets. The resulting market rules will greatly influence pilots' success or failure. Many different international and domestic organizations want to provide support to ensure that these markets are well-designed. Having up-to-date insights on how pilots are evolving, what has worked, and where there are struggles will better help organizations provide support to pilot provinces and allow other provinces to easily understand lessons learned and best practices.

## Purpose:

- Create a **living document** to track China's power market pilots, crowdsource further insights from peers, and coordinate international support for market design
- Provide a go-to repository for **progress updates** on pilots to help understand where provinces are at in their reforms and which local entities are steering those reforms
- Identify **prescient topics** market designers are inquiring about and provide recommendations to address
- Provide references for other researchers, embassies, and nongovernmental organizations (NGOs) to better hone programmatic efforts, align recommendations, and coordinate **outreach efforts**
- **Identify necessary programs** and work products to address gaps in current support for market design and improve broader provincial engagement

# Main Structure of This Report

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## 1 . National-level and reform overview

- China's power system structure and current market reform progress
- Stakeholder map highlighting regulation roles in reform and the organization providing support
- Snapshot on eight piloting provinces around basic demographic and electricity characteristics

## 2 . Province-level reform deep dives overview

- Snapshot of the province's electricity system, including key info on its generation fleet and market players
- Overview of progress to date on spot market design for each pilot province
- Detailed market reform progress and timeline
- Organization chart highlighting the key regulatory entities overseeing the reforms and their roles
- Discussion on concerns and recommendations for each province

*This document is up to date and accurate as of September 2019, to the best of RMI's knowledge.*





## 02 National-level Reform Overview

# Major Types of Electricity Markets in China

China has three primary types of markets in various states of deployment.

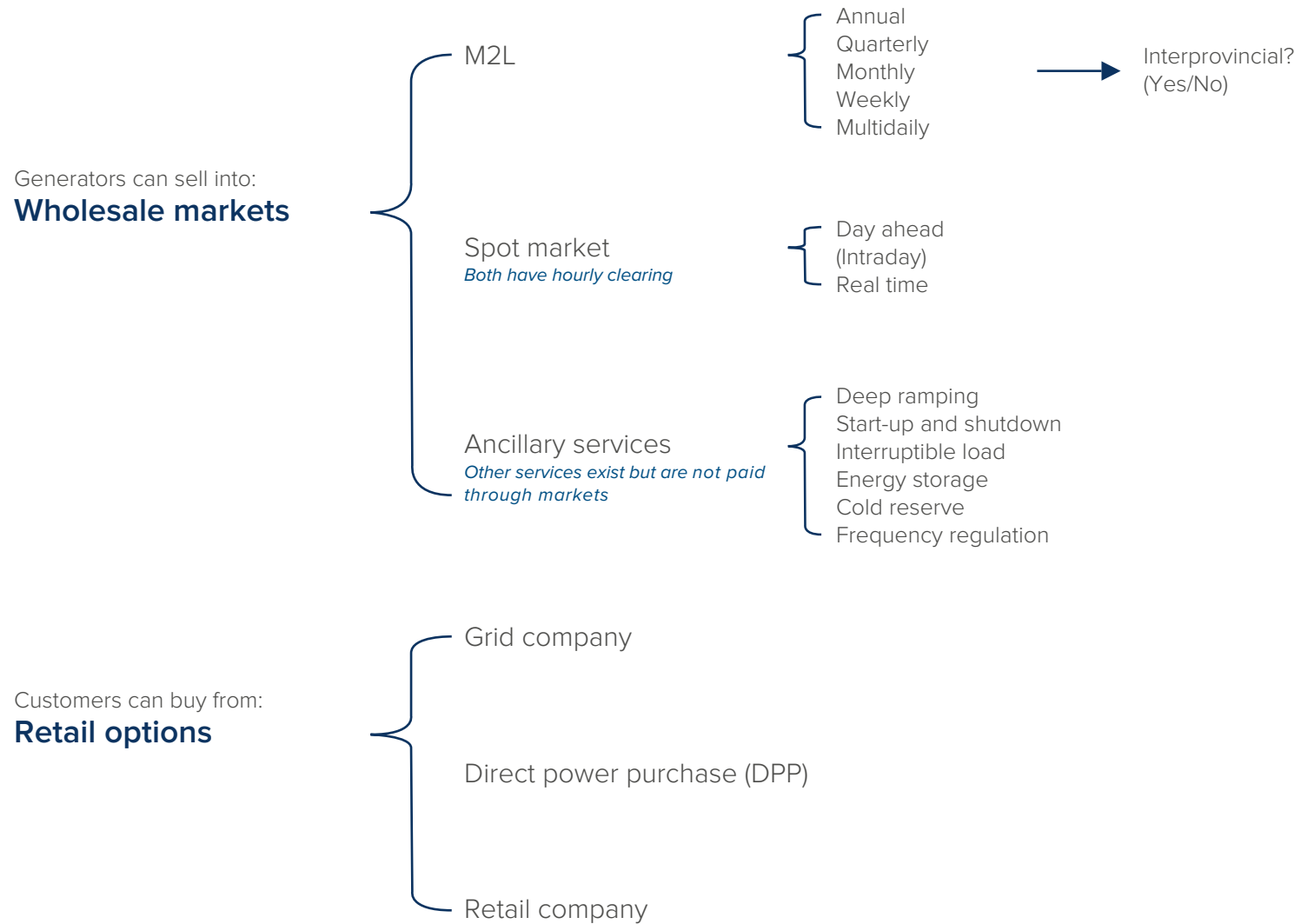
Market Type	Description	Deployment Status	Generator Participation	Retailer/User AccessType
Mid-to-long-term energy (M2L) markets	Trade bulk energy from the multiday, weekly, monthly, quarterly to annual timescales	Already operating in most provinces; the majority of trading activity is in annual and monthly markets	It varies a lot between provinces. Frequently, renewables, nuclear, and certain hydro resources are precluded from the market.	Certain large users are allowed to purchase depending on size, and certain regions allow retail companies to purchase energy. The means by which these actors participate in the market also varies substantially from province to province.
Energy spot markets	Trade energy on shorter timescales to manage real-time delivery of power	Eight provinces have been selected as pilot provinces. All are required to enter the trial operation before June 2019, and that goal has been achieved.		
Ancillary services markets	Identify the least-cost resources available to provide other services necessary to the safe operation of the power grid	Scattered deployment over the past two years; typically employed to address curtailment or other dispatch challenges in provinces		

\*M2L markets include several timescales, although monthly and annual transactions are the most common. In the following content, we mainly describe M2L markets by monthly and annual.



# Market Overview Schematic

Each provincial deep-dive section highlights which markets are being piloted and what types of generators and buyers can access each.



# Overview of China's M2L Energy Markets (中长期交易)

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M2L markets use **direct purchase contracts for bulk energy** to specify the volume and price of energy purchased from a generator by the grid, retailer, or large customer. They are signed through exchange centers on an annual or monthly basis. M2Ls are seen as the primary market reform to move away from state-set pricing and the guaranteed volumes system.

In China, these contracts are most commonly **physical contracts**, meaning they are dispatched according to a contracted schedule to meet the contracted volume. But where there are spot markets, contracts for differences (CfDs) are used. CfDs allow the dispatch to differ from the contract, and any generation bought or sold in the market is then settled up to match the prices and volumes signed in the contract.

An important distinction to be aware of is the difference between a contract schedule versus a physical schedule. **A physical schedule** refers to the process by which generators are told (or self-determine) when to operate in the following day(s). **A contract schedule** is used only for settlement. In some regions, generators can specify their physical schedule to meet their contract schedule (typically a net pool), and in other regions, the market clearing results determine physical scheduling, and the contract schedule is used just to settle CfDs (gross pool). In some regions where retailers and generators are not experienced at setting contract schedules or there is not enough grid information, they could use the typical/standard schedules provided by the grid company as their contract schedules (aka contract curves).

# Overview of China's M2L Energy Markets(中长期交易)

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M2L contracts can be signed with the grid operator (base volume contracts) or directly with customers or retailers (DPPs)

- Before deregulation, the government assigned each generator an annual generation volume to be paid at a state-set price to ensure cost recovery (known as the “equally dispatch rule”). During deregulation, guaranteed hours for those generators have been reduced and turned into contracts between generators and the grid company (**base volume contracts**). Those contracts are operated as physical contracts (self-scheduled outside of centralized spot-market dispatch) or financial contracts (treated as CfDs, then all generation is dispatched by the market).
- A **DPP** is any M2L purchased by customers or retailers, who pay the generator directly for energy and the grid company a regulated fee for using their grid. These are currently dispatched like all other energy, but as spot markets are implemented, DPPs may be required to submit a contract schedule and may also require physical schedules (could be generator or demand-side).

These contracts can be annual or monthly and can be determined in one of three ways:

- Bilateral arrangement: generators and buyers negotiate contracts and provide terms to power exchanges to execute the transactions
- Centralized auction: the power exchange organizes centralized bidding, where in demand and generation offer prices and volumes and the entire market is cleared at the same price for the volumes specified by the generators and buyers cleared
- Listing: remaining generation after auctions can post prices and volumes they are willing to generate at, and buyers can sign deals at those prices through the power exchanges

M2Ls are typically within a province, but some regions have allowed M2Ls to be assigned across provincial boundaries. We do not focus on interprovincial dispatch and markets in this document but do discuss how these modes of exchange influence spot market designs.

- **National special projects and interprovincial government-negotiated contract** are annually scheduled transfers between provinces, typically to support large dams or nuclear projects, and they must be adhered to regardless of various spot market pilots. The volumes and prices for these projects are determined through political negotiations between provinces and the national level.
- **Interprovincial DPPs** are typically between grid companies but are now open to certain industries in certain provinces. These DPPs are typically physically dispatched and are not subject to spot market pilots.
- National special projects, interprovincial government-negotiated contracts, and the base volume contract (government-prioritized generation) are usually determined and set in the November prior to the delivery year.

# Overview of China's Energy Spot Markets(电力现货市场)

Spot markets enable the exchange of energy on a day-ahead (DA) and real-time (RT) basis. They will be jointly operated by the exchange centers and dispatch centers within the grid company in that area. Most of these are provincial markets at the moment, but there are conversations on how to expand the geographic span of these markets for maximum efficacy. Spot markets are seen as the key to improving efficiency and reducing emissions in the power sector.

Although many pilots are taking different approaches, we lay out common design elements or choices below :

- **Gross vs. net pool:** Likely the central debate for market pilots, this focuses on who should schedule and dispatch
  - **Gross pool:** All scheduling and dispatch is determined by a central market operator based on bids submitted by generators; any bilateral contracts are CfDs
  - **Net pool:** Generators and buyers can schedule their own generation, and the spot market trades only for differences between the schedule and RT demand(net)
  - To date, pilot provinces have tended toward a gross pool model, but several include an intermediate step in the transition to gross pool markets that allows generators to physically schedule themselves in a net pool fashion
- **DA and RT markets:** These coexist in many provinces but may limit rebidding or have only one clearing step
  - Some pilots do not allow rebidding between DA and RT markets to simplify and minimize generators using situational awareness to manipulate bids
  - Some markets employ two-step clearing, in which generators are paid at the DA price for energy scheduled, then divergence is settled at the RT price  
Others plan to settle based on RT dispatch at DA prices.
- **Time resolution:** Most pilots are planning on clearing the market every 15 minutes, but not using subhourly prices
- **Locational resolution:** Many are not including Locational Marginal Price ( LMP) in their system in the initial phase due to minimal congestion and grid awareness today, but are building it into market algorithms and debating whether to use nodal or zonal
- **Generator participation:** Many pilots restrict market participation to certain generators in early phases
  - Renewables, except Gansu province, either price takers in the market, or excluded from the market as a regulatory must-take
  - CHP (at their minimum run rate), either price takers or excluded from the market as a regulatory must-run
  - Nuclear, mostly excluded in the market as a regulatory must-run

Beyond provincial pilots, there are two interprovincial spot markets:

- **Otherwise Curtailed Renewable Spot Market (OCRE-iSpot),** which allows renewables to offer in energy that will be curtailed during times of structural curtailment for other provinces to purchase. This is already operating and allows northwest provinces to sell excess energy to grid companies of interconnected provinces.
- **Interprovincial Market** is under discussion within the National Energy Administration (NEA). The plan is to allow available capacity to bid into the spot market for other provinces to use.



# Overview of Ancillary Services Markets (辅助服务)

Ancillary services (AS) markets typically operate in provinces where specific dispatch challenges exist and most commonly address renewable curtailment, with a few addressing capacity scarcity during peak hours. These markets do not look similar to other AS markets globally, even if called by the same name, because they evolved in the absence of spot markets. Their aim is to provide economic incentives to generators to shift their dispatch away from current schedules, in particular ramping below stated minimum output levels or ramping beyond levels typically required in previous dispatch protocols.

The below services are currently functional in some regions; we define them in the Chinese context and classify them similar to foreign definitions.

Purpose	Service	Description
Paying for forgone energy	Deep ramping	Pays thermal plants to ramp down below minimum output levels (varies in provinces; typically, greater than 50% of nameplate capacity) to incorporate more renewables. All generators are not ramping down pay for the service equally per MWh they are generating during the deep ramping period.
	Spinning reserve	Thermal, hydro, biomass, and nuclear plants operating below their agreed-upon dispatch to be available for ramping up for future peak demand (need to be able to fully ramp up within 10 minutes). Varies in defining what is considered “below ideal output.”
	“Cold” reserve	Pays generators to shut down for more than 72 hours to integrate renewables. Compensates the shutdown period with unit capacity daily rate. Assumes that plants lost specific generation revenue everyday that they need to make up.
Energy arbitrage	Interruptible load	Pays demand that can be ramped down (or up). Typically paid an availability price and a dispatching price. Dispatchable incremental demand is also included, especially electric heating, which gets discounted rates at specific times via bilateral contract with Grid.
	Energy storage	Storage charges during valley hours and discharges during peak hours. Prices and times are set because no RT wholesale prices exist. Similar to interruptible load, mainly to consume power during valleys, which gets discounted rates at specific times via bilateral contract with Grid.
Frequency regulation	Automated generation control (AGC)	Also known as regulation, generator output can be automatically adjusted by dispatchers to maintain system frequency. Generators are paid for installing this capability and allow the dispatcher to use it by (1) paying at unit-capacity rate for availability and response rate, (2) paying at unit-capacity rate for actual dispatched regulation range, or (3) paying at unit-generation rate for actual dispatched regulation power volume.
	Frequency modulation	Pay bonus for primary frequency modulation if plants contribute positively for frequency control (outside the complimentary range).
Reactive power control	Voltage control	Also known as voltage support, automated voltage control (AVC) pays generators to automatically adjust their reactive power to maintain the voltage on the grid. Paid at unit-generation rate for actual dispatched regulation power volume after reaching certain gratis response rate.
	Reactive regulation	Pays generators for reactive power control beyond the level required in grid codes. Paid at administratively set rates for the amount of reactive power control provided.
Other	Black start	Any resources able to restore power after a blackout without relying on the external transmission network are paid an administratively set fee.
	Start-up/shutdown	Pays plants for their start-ups and shutdowns (when shutdown for less than 72 hours). These are paid at prices agreed to out-of-market or pay-as-bid in some market, similar to uplift payments in other markets.

# Overview of General Market Designs in China: Ancillary Services

## Ancillary Services Markets By Province

	Guangdong	Shanxi	Gansu	Fujian	Shandong	West Inner Mongolia	Zhejiang	Sichuan	Northeast China
Deep ramping		✓	✓	✓	✓	✓	✓		✓
Spinning reserve									
Cold reserve			✓						✓
Interruptible load		✓	✓	✓	✓				✓
Energy storage		✓	✓	✓	✓				✓
AGC	✓	✓			✓	✓	✓	✓	
Frequency modulation									
AVC									
Reactive regulation									
Black start					✓		✓		
Start-up/shut-down		✓	✓	✓	✓				✓

## Notes

- Often these markets are being operated at the regional level (or are using consistent rules in the subsidiary provinces), because the regional dispatchers are the ones responsible for balancing across that area's synchronous grid.
- Northeast China is one of the longest operating regional AS markets (in operation since January 2017), where it was implemented to help reduce renewable curtailment. Its model has been copied elsewhere, although some elements will need to be adapted to harmonize with energy markets.
- West Inner Mongolia follows the *Central North Region Regulation Ancillary Services Market rules* (《华北电力调峰辅助服务市场运营规则（试运行版）》), which focus on regulation capacity (negative reserve/deep ramping) within and between provinces. No specific design for provincial AS market so far, but mentioned establishing an AS market in energy spot market development plan.
- Zhejiang follows the *Central East Region Regulation Ancillary Services Market rules* (《华东电力调峰辅助服务市场运营规则（试行）》), which focus on regulation capacity (negative reserve/deep ramping) between provinces. No specific design for a provincial AS market so far.
- Ningxia, Xinjiang, Chongqing, Jiangsu, Hunan, Central North region, Central East region, Northwest region, and the Northeast region also have an AS market, but they are not included here because they do not belong to the eight spot market pilots.
- Sichuan is calling for public comments on their AGC AS market design, but it is not currently being implemented.
- Jing-jin-ji and Anhui are calling for comments on their AS market rule.

# Responsibility for Implementing Market Reforms

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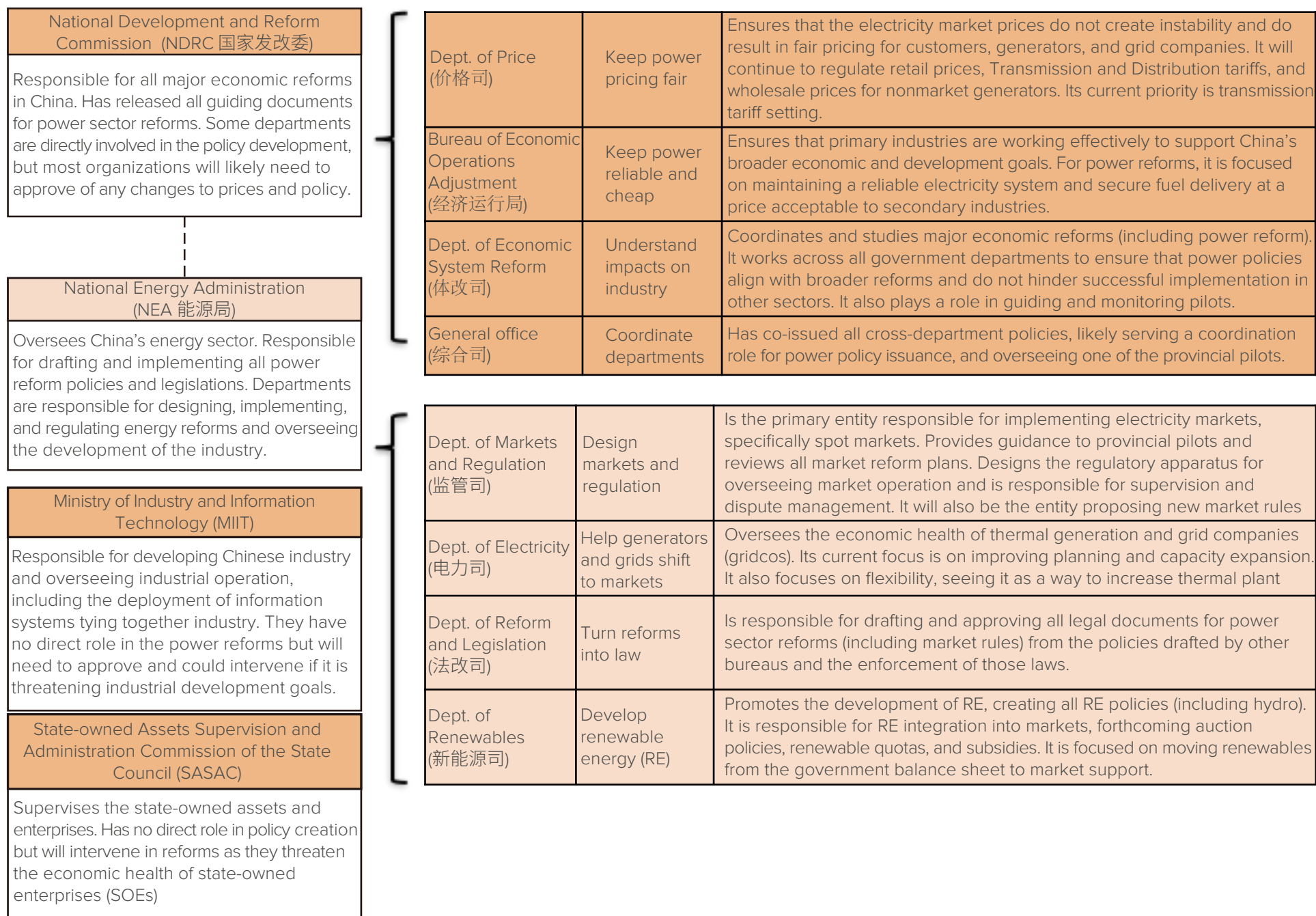
National-level policy provides guidelines for detailed provincial implementation.

The National Development and Reform Commission (NDRC) and the National Energy Agency (NEA) are the leading designers of China's power sector reform. It was deemed politically unfeasible to mandate that every province follow a standard market design, so the approach has been to provide framework policies to guide provincial market design efforts.

Within the NDRC and NEA are eight departments issuing policies regarding market reform, with market-related policies largely stemming from within NEA. Although each department does oversee specific topics (covered in the following org charts), there is not always definite role clarity (by design). Departments leading research on a given reform are often doing so because they have available capacity when the reform is requested, even if another division previously released policies on a related topic. This is particularly true at the provincial level, where there is even less capacity available to design reforms.

Given the shortage of regulator capacity, most provinces and national-level entities are relying heavily on the grid companies to design the specifics of power markets. Then regulators, with the assistance of government think tanks, universities, and some foreign organizations, approve or deny those plans. The specific structure of who designs, approves, and leads the reforms varies greatly in each province, and, where known, is described in those subsections.

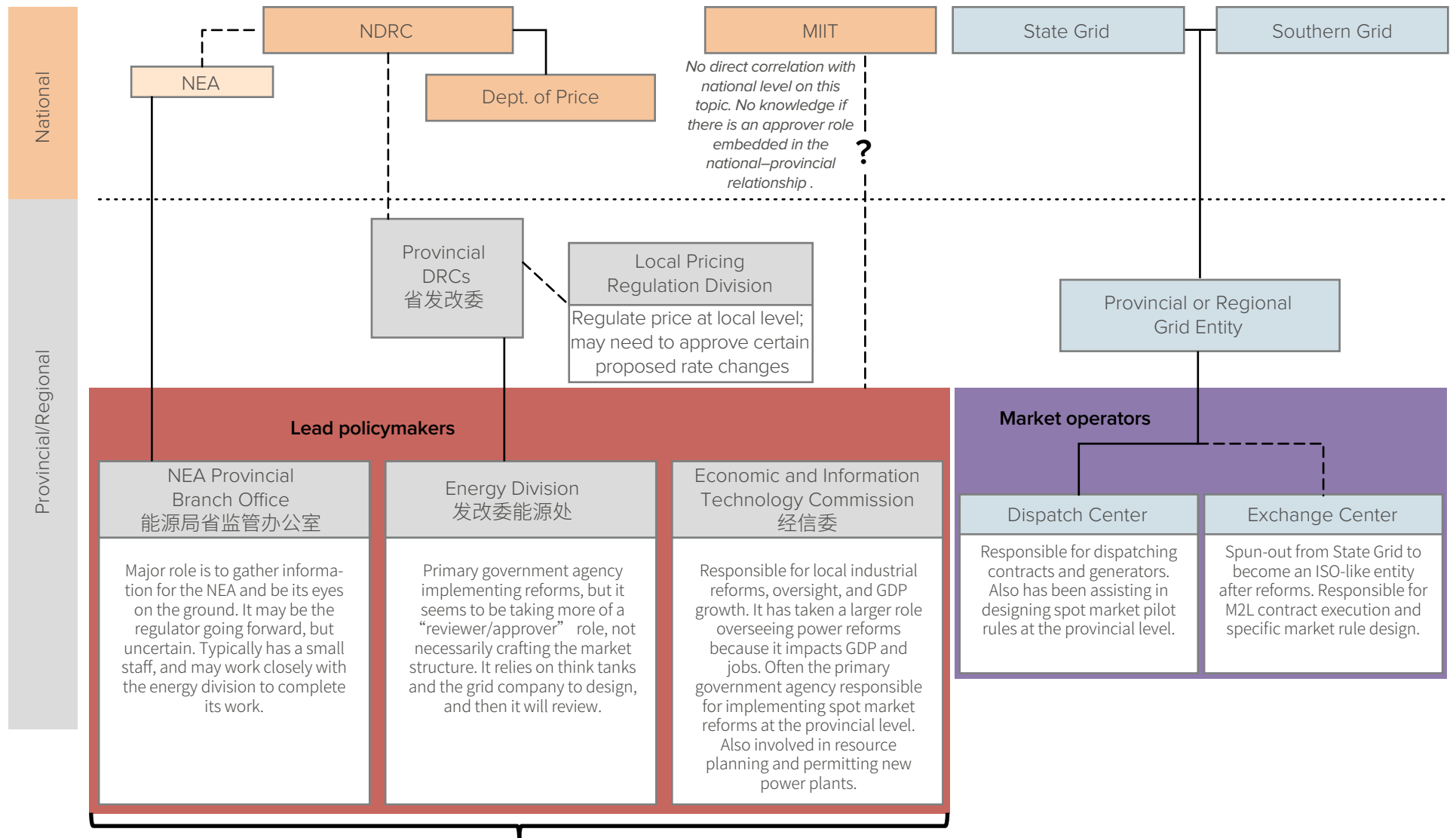
# Organizations Leading Power Reform (National)



----- Merely a hierarchical relationship; no oversight/approver role on this topic



# Organizations Leading Power Reform (Provincial)



These departments are the lead policymakers at the provincial level in charge of power market implementation, design, and approval. The roles of each and their relative importance differ drastically between provinces. In some, separate entities have been created to oversee power sector reform, pulling a team together from different government and industry entities.

----- Merely a hierarchical relationship; no oversight/approver role on this topic

# Organizations Leading Power Reform(National Think Tanks)

Parent Company	Think Tank	Role
China Energy Engineering Corporation	Electric Power Planning & Engineering Institute (EPPEI)	Advises on T&D reform and some on market design. Mostly national level. Independent think tank and for-profit company, but frequently conducts policy support research for the NEA and NDRC.
N/A	Tsinghua University	Advises on many market design policies nationally. Is deeply involved in some provincial pilots designing market plans.
	North China Electric University	
State Grid	State Grid Electric Research Institute (SGERI)	Subsidiary think tanks of State Grid focused on policy (SGERI) and technology (CEPRI). Provide research to national-level reforms, provide technical support to local pilots, and are involved in interprovincial reform market development.
	China Electric Power Research Institute (CEPRI)	
Southern Grid	China Southern Grid Electric Power Research Institute (CSG-EPRI)	Subsidiary think tank of Southern Grid largely responsible for all research supporting the creation of Southern Grid's pilot.

# NDRC-Approved Spot Market Pilot Provinces

The following is an overview of different pilots ongoing in China, including notes on where some leading spot market pilots are at and their sticking points. We will discuss in greater detail in the following sections.

**Gansu:** Spot market pilot with a plan announced, but problems with high curtailment and massive overcapacity will likely not be solved by internal markets alone. May unify with Xibei dispatch footprint for market implementation. Exporter.

**West Inner Mongolia:** Has fewer resources but potentially more autonomy to develop its reforms as a non-State Grid area. Abundant coal and RE resources. Exporter.

**Shanxi:** Spot market pilot with timeline established. Coal basin politics plus overcapacity could cause coal pricing distortions. Exporter.

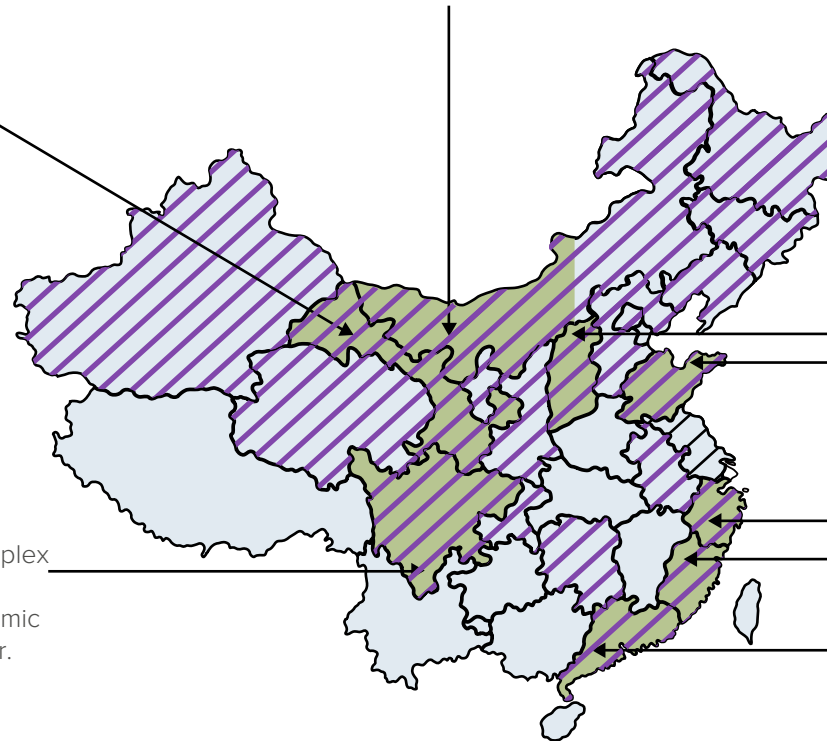
**Shandong:** The active M2L market may make the spot market transition easier. Captive generator response may be hard to predict. Importer.

**Zhejiang:** Leading spot market pilot province that hired PJM Technologies and CEPRI as its consulting team. Already designed the timeline and draft market rules. Market manipulation needs to be carefully managed due to single, strong market player. Importer

**Fujian:** Spot market pilot started but no information opens to public. Progressing on ancillary service market to address flexibility issue.

**Guangdong:** Southern Grid leading reform area, already far along in the process with a lot of implementation capacity. Pilot will likely expand to all of Southern Grid territory. Importer.

**Sichuan:** Stalled reforms due to complex hydro/export dispatch situation. Concerned with thermal plant economic health during runoff season. Exporter.



- Spot market pilots
- Ancillary services markets (AS Market)

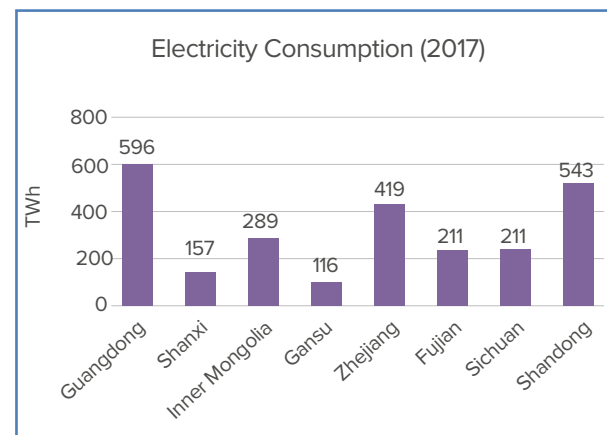
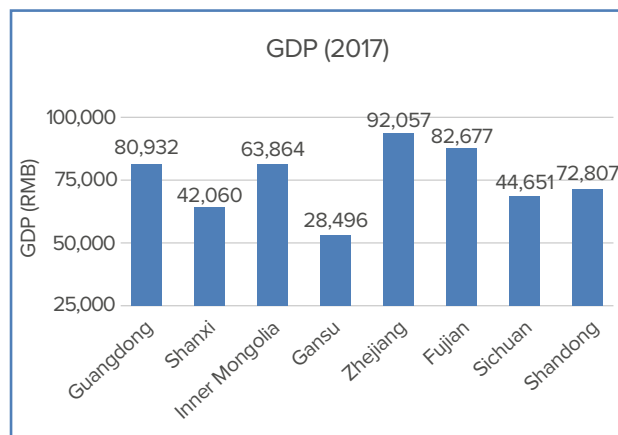
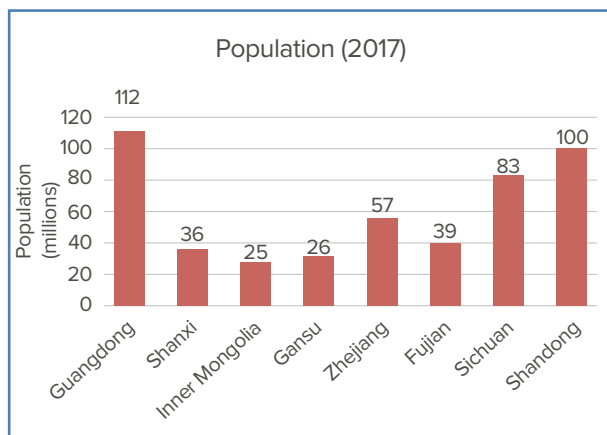
# Province-Level Spot Market Pilot Progress Snapshot

	<b>Spot Market Pilot Plan :</b> Document that explains the general market design and timeline for implementation, often in phases	<b>Spot Market Rules :</b> A package of documents that specify the detailed rules on bidding, settlement and monitoring, etc.	<b>Simulation test :</b> A “ <b>shadow market</b> ” phase of piloting when market participants submit bids and observe simulation results	<b>Operational test:</b> A phase of piloting when the market is operated and settled according to rules, but often limited in scope
<b>Guangdong</b>	Released	Released	September 2018	2 days every month since May 2019
<b>West Inner Mongolia</b>	Released	Released	June 2019	
<b>Shanxi</b>	Released	Released but not open to the public	December 2018	State Grid Company requires the subsidiaries of the six pilot provinces within its jurisdiction to start continuous settlement test since September 2019
<b>Gansu</b>	Released but not open to the public	Released but not open to the public	December 2018	
<b>Zhejiang</b>	Released but not open to the public	Released but not open to the public	May 2019	
<b>Sichuan</b>	Released	Released	June 2019	
<b>Shandong</b>	Released	Released	June 2019	
<b>Fujian</b>	Released but not open to the public	Not released	June 2019	

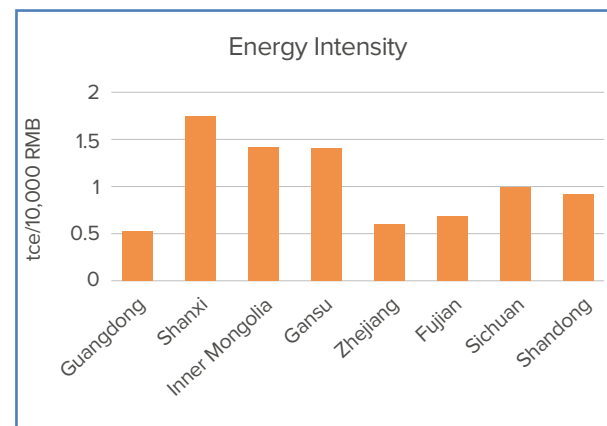
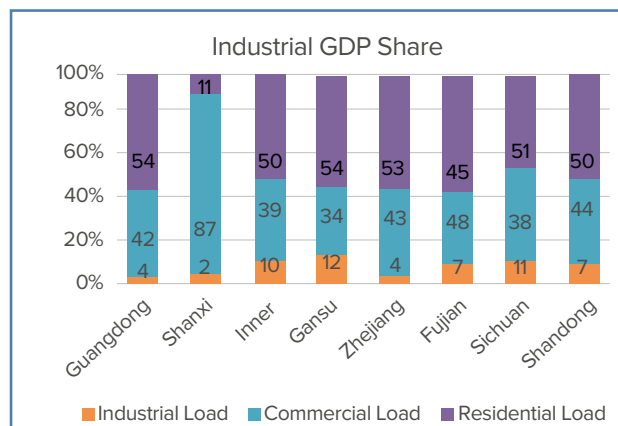
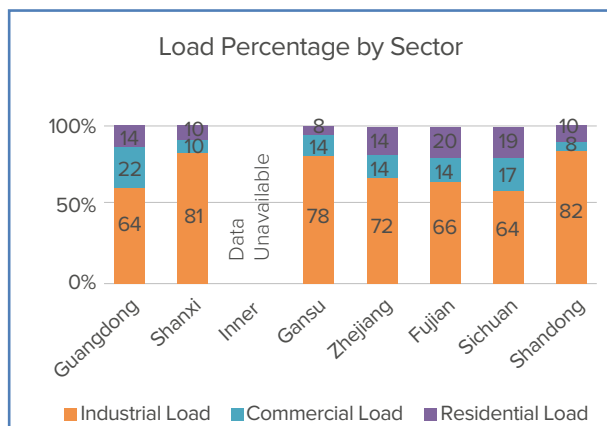


# Provincial Energy Use and Demographic Comparisons

The charts below provide basic information on provincial economic and power consumption statistics that provide useful context on the situation in those provinces



In general, Guangdong, Zhejiang, and Fujian are seen as economically developed provinces that will be most open to market-based reforms to continue making their power sector more efficient. Shandong and Sichuan are seen as provinces in transition, currently moving from heavy industry to more service-based economies. Gansu, Shanxi, and Mengxi (West Inner Mongolia) are seen as developing provinces, rich in natural resources, where the power sector plays a major role in the development of their economies.



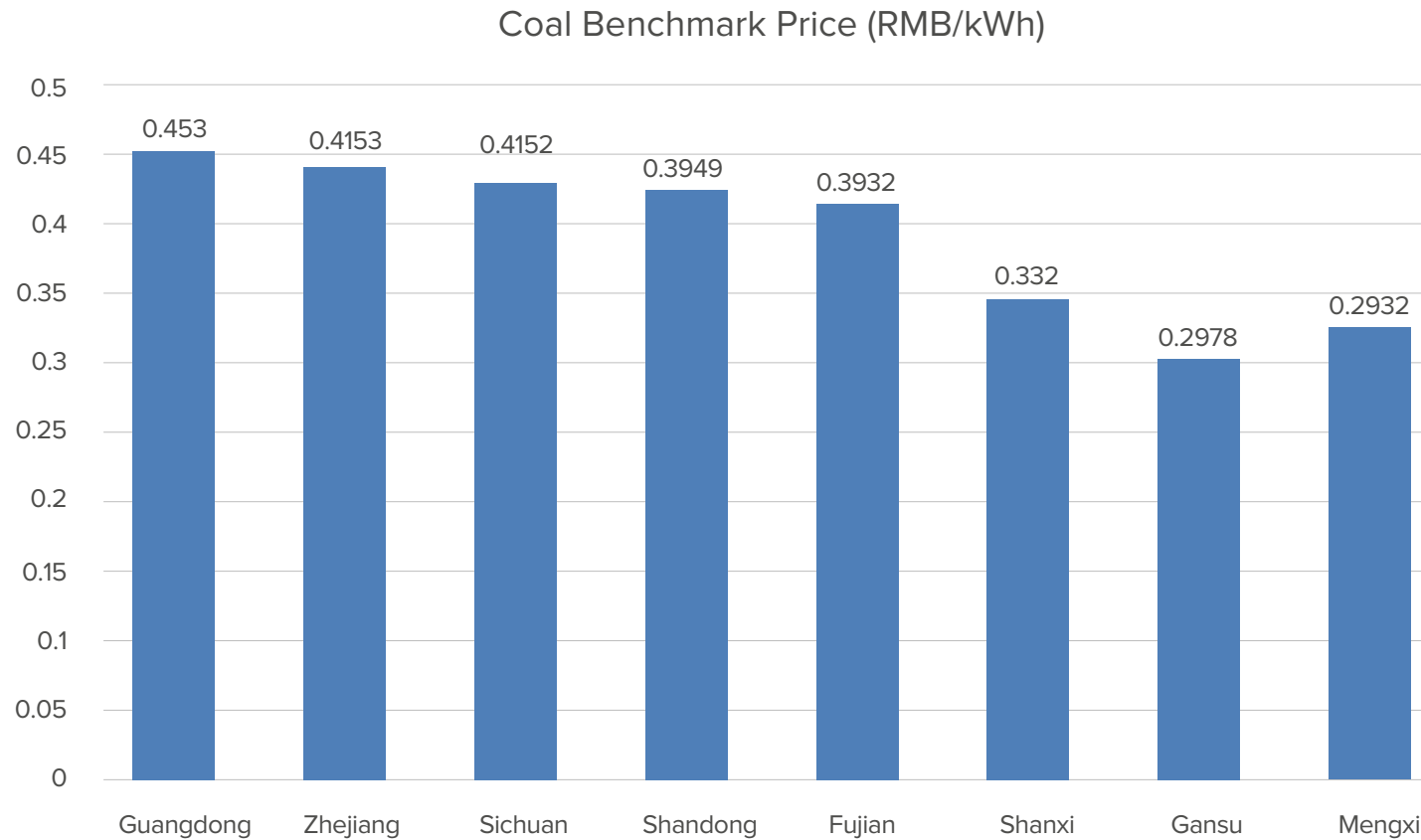
Provinces with a high share of industry load and the highest energy intensity are more sensitive to electricity price and are expected to move rapidly to the M2L market looking forward, lowering their energy cost. At the same time, they could be more conservative on spot market reform concerning price fluctuations that might be introduced.

\*China defines primary industry as agriculture, secondary industry as manufacture and heavy industries, and tertiary industry as commercial services. Unlike the United States, China counts mining industry as secondary industry.

\*\* tce stands for ton of standard coal equivalent

# Provincial Benchmark Price Comparison

The benchmark price is a government-set price that generators would be paid before the markets.



The coal benchmark price is set for local plants to recover their costs, so it is basically correlated with local coal reserves and cost.



## 03 Provincial-level Reform Deep Dives

# Provincial Deep Dives

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- For each of the spot market provinces, we will provide:
  - An overview of the province's electricity system composition
  - High-level summary of market rules
  - Detailed information on market rules
  - A timeline for the pilot rollout
  - Initial market price and operation data and information (if available)
  - Local stakeholder map
  - Potential challenges with the market design
  - Recommended approaches to manage challenges
- When reading through these summaries, some things to note are:
  - If you see that certain sections are missing, it's because the data likely doesn't exist or has not been made public
  - We have sequenced provinces in order of most information available to least
  - There are certain details that we could not include in this document, but if you or your associates are engaging in that province, please get in touch with RMI and we would be happy to provide additional information as needed



# Takeaways Across All Provinces

- There is no universal market design applied across all provinces. Each province faces different sets of challenges, technical and political, and has designed its market accordingly.
- Many of the questions and challenges that provinces have are on similar topics, and they are looking to different international models to understand how to manage in their local situation.

These include:

- Renewable integration into markets
- Market monitoring to avoid manipulation and measure market efficiency
- How best to procure resource adequacy and better integrate with the AS market
- Future-ready design that considers demand-side and Distributed Energy Resource (DER) services
- Management of imports and exports and integration with their markets
- How to coordinate with interprovincial markets
- Improvements to reserve setting
- Driving generators to be more flexible in their dispatch
- Transition mechanisms to move toward a more comprehensive market
- Managing stranded assets



# Guangdong

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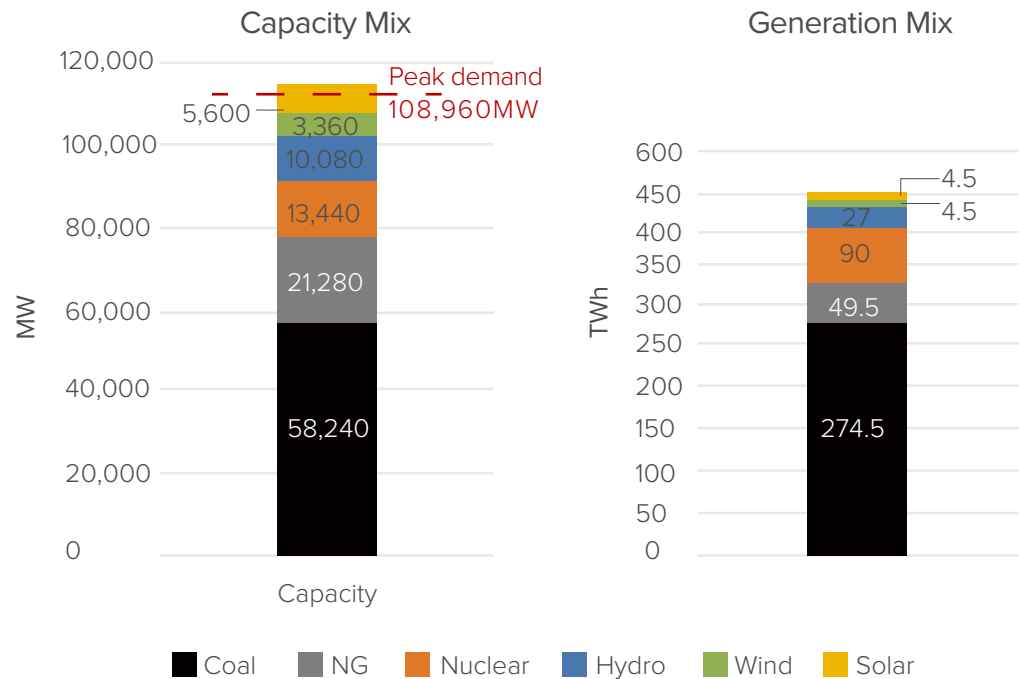
- Province profile
- Spot market pilot overview
- Decision-making structure
- Challenges and further considerations



# Guangdong: Electricity System Composition

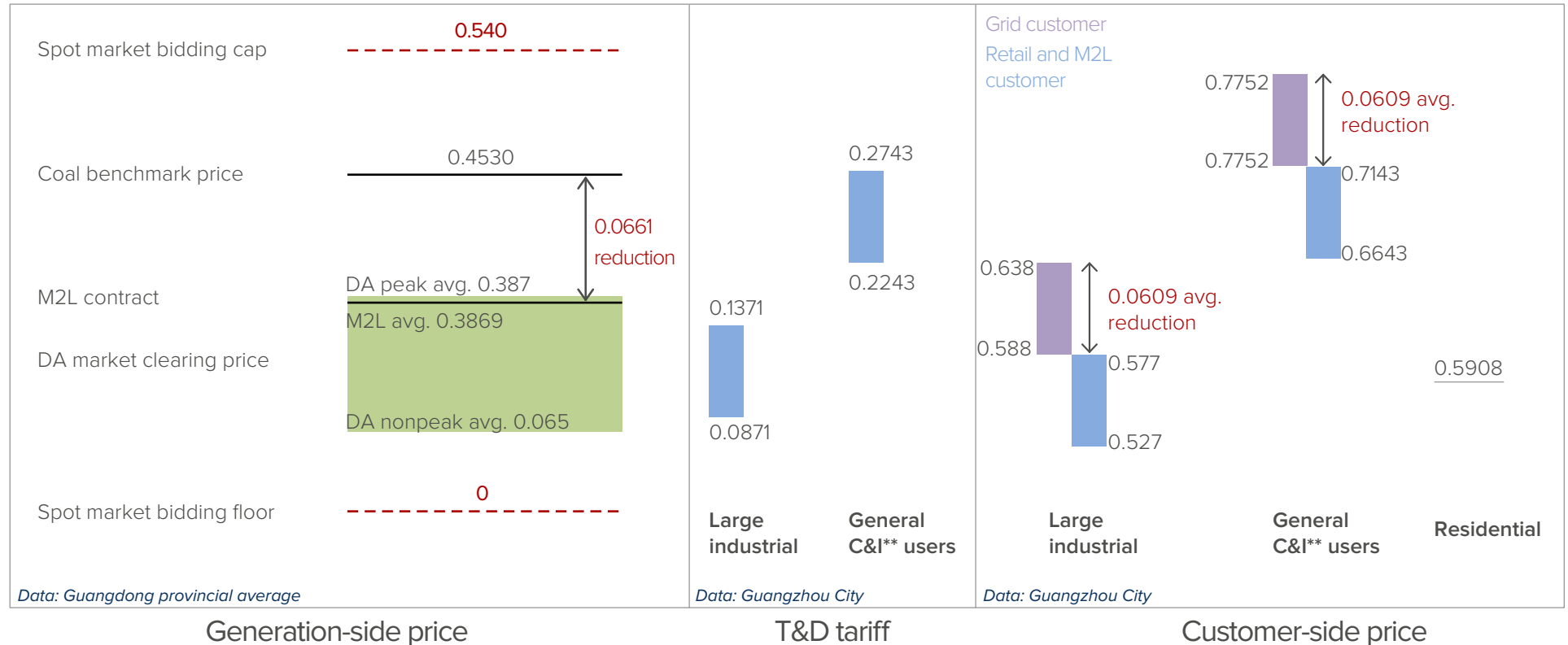
## Province Overview:

- Guangdong is the province furthest along in power reforms, with a high percentage of demand open to retail and the longest functioning spot market pilot (since September 2018).
- Guangdong has a reputation for piloting market reforms and is more open than other regions in terms of selecting market design choices and process transparency.
- Reserve margin is tight compared to the rest of China, and in summer peak hours, the system might experience shortages. This is encouraging further construction or greater imports, especially as air conditioning demand grows in the region.
- Guangdong is reliant on energy imports from other provinces (about one-third of the demand) and is the main receiving province for hydro power from Yunnan. The transmission scale is the key factor deciding the hydro curtailment rate in Yunnan.
- Guangdong has a concentrated load distribution that leads to serious congestion. This is the main reason Guangdong was pushed to try LMP at the beginning of its spot market pilot.
- It is estimated that roughly 60% of the generation is set with government contract (base volume contract) and only 40% is exposed to spot market.



# Price Comparison in Guangdong

\*All numbers are in RMB/kWh



- The T&D and retail price from Guangzhou are shown here to demonstrate a rough range in prices, given significant variance between cities, customer classes, and time of use pricing.  
T&D tariffs apply only to M2L contract customers.
- The grid customer price (government set) was decreased three times in 2018, by 0.0806 RMB/kWh in total. At the same time, the T&D tariff also decreased. These prices are likely to be reduced further by another 10%, according to the prime minister's new announcement.
- For M2L contracts, the customer price reduction is less than wholesale price reductions because (1) retailers keep some savings as their service fee and (2) some savings are used to paid the deviation penalty.
- The price difference between the M2L contract price and the grid customer price kept decreasing in the past 12 months.

• \*The data was updated in April 2019.  
• \*\* C&I refers to Commercial and Industrial

# Guangdong Market Overview

Guangdong’s spot market applies the gross pool model, and the first phase just requires thermal generators to participate.

Spot Market	Structure	DA and RT market (1-hour interval settlement)
	Participation	Most thermal generators participate (Type B*); represents approximately 70% of Guangdong’s total capacity. Exempt: Renewables, reliability must-run, thermal, nuclear, and hydro (Type A*); exempt generators follow prior dispatch method.** Imports and exports follow current contracts and dispatch schedule (occupies 30%).
	Bidding	<ul style="list-style-type: none"> <li>Generators bid volume and price; demand-side bids only volume.</li> <li>No rebidding is allowed or needed for the RT market.</li> </ul>
	Payment	Generators are paid out at LMP (both in RT and DA—about 200 nodes). Customers buy at a weighted average price of all LMPs.
M2L Contracts	Government Planned or Prioritized Generation	Converted into base load contracts that are: <ul style="list-style-type: none"> <li>Physical for Type A generators</li> <li>Financial for Type B generators</li> </ul> The settlement contract curves are assigned by dispatch center.
	Customer Direct Purchase	All financial contracts; only Type B generators can participate. Participants can submit their own curve or select typical standard curve.
Ancillary Services Market		Market compensated: AGC/frequency control
Settlement		M2Ls are paid according to their settlement schedule at the contract price. Any differences between M2L settlement curve and DA are settled at the DA price. Any difference between DA schedule and RT are paid out at the RT price. Most generation volume is governed under M2Ls, therefore little revenue risk exists from market participation.

- \*Type A generators are reliability must-run, renewables, nuclear, and hydro plants. Type B generators are most thermal generators.
- \*\*Prior dispatch is annual generation volumes fulfilled through daily scheduling.



# Guangdong: Market Design Overview

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## Spot market

- Adopts a “**gross pool**” model, although only some generations participate in the market.
- Operates DA and RT markets, with two-step settlements. The DA volumes and prices are paid out, and any differences in RT are paid out at the RT price. Generators submit bids every day for the DA market. Bids remain valid for the whole day; no rebidding is allowed or needed for the RT market.
- The first phase is a one-sided market: no demand bids are allowed, only generators bid in capacity and price, and the market is cleared to meet all demand. Later, customers can submit demand bids (demand-side response) to the spot market, but no date is set.
- Generators are paid at LMP prices, but customers pay an average price of all LMPs (a work-around for not having Financial Transmission Rights (FTRs)).

## M2L Contracts

- All nondispatchable generators continue to receive current guaranteed hours at state-set prices and follow current dispatch protocols (usually must-run or must-take).
- All M2L contracts with Type B generators are dispatched by the market and settled using CfDs, whether base volume contracts with the grid or DPPs with customers. No physical scheduling is permitted for Type B generators (e.g., all dispatch and scheduling decisions are made by the market or dispatchers).
- To settle the CfDs, a settlement curve must be provided for each DPP or base volume contract. When the DPP is signed, generators and customers agree on a curve to be submitted. The grid company provides sample curves if customers and generators can't determine a curve. Base volume contracts' settlement curve is adjusted based on their previous year's dispatch result.

## Ancillary services market

- Guangdong's AS market currently includes only AGC/frequency control. It uses centralized bidding and single clearing price mechanisms to compensate different generators for providing capacity for frequency regulation. Bidding caps/floors ensure that bids are between 6 and 15 RMB/MW.
- The remaining ancillary services remain compensated using the current prices and mechanism.

## Retail participation

- To participate in wholesale markets, major users and retail companies need to provide DA load forecast and submit a time-based demand curve. These curves are not used for settlement at this point (e.g., RT settlement for misforecasting is not allocated to each retail entity) but are used to help improve their forecasting and improve and compare to dispatcher forecasts. There is, however, an administrative penalty for misforecasting assessed to DPP and retail customers if they are more than 2% off for their contract volume on a monthly or annual basis (depending on contract term).
- For customers participating in the retail market, the government-set retail price no longer applies. If the contract between the customer and its chosen retailer lapses, the gridco becomes the default provider and will charge 1.2 to 2 times the regulated residential rate until the customer selects its next retailer.

## Regulation

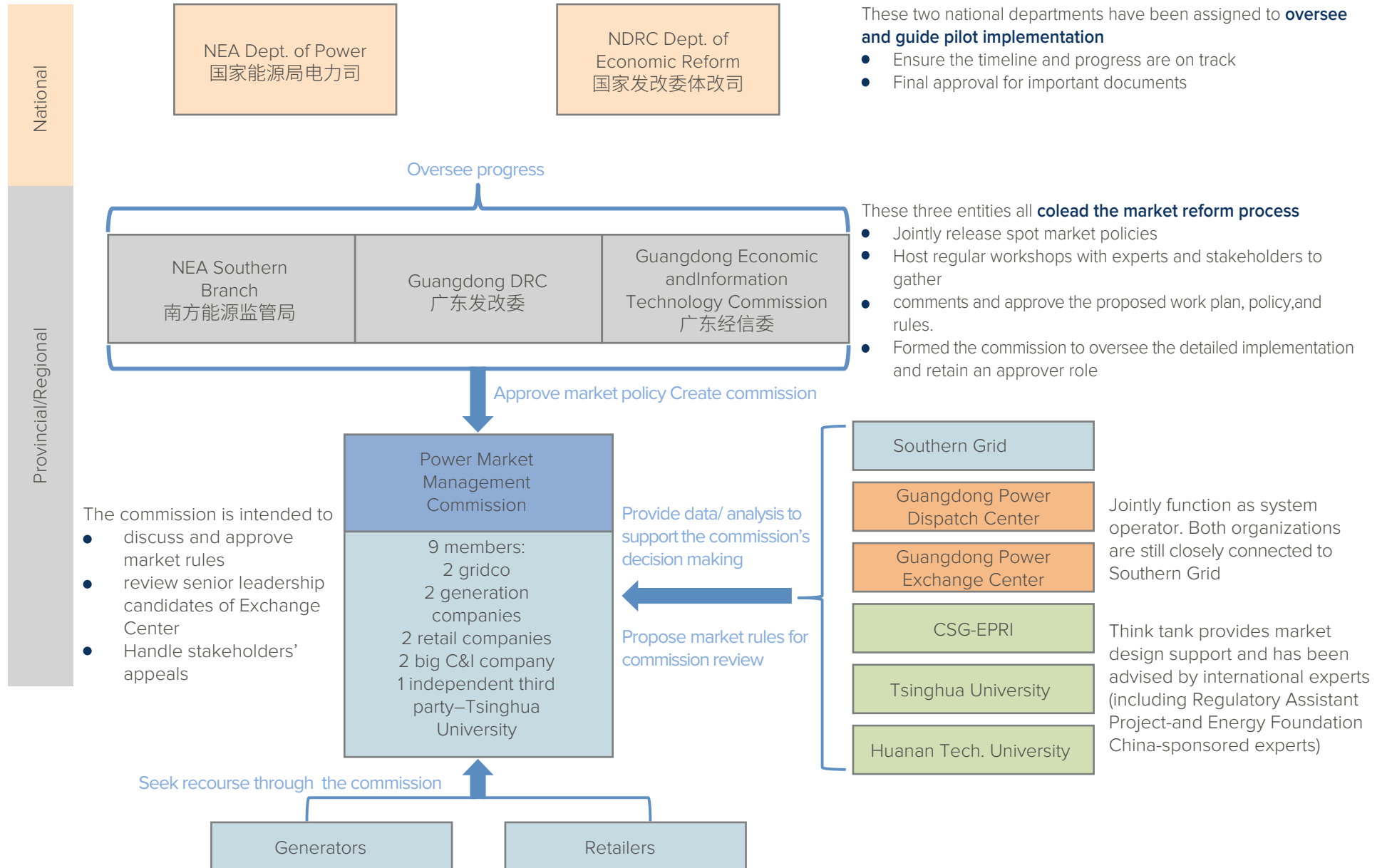
- The dispatch center and power exchange center jointly operate the market during the early phase, and it is uncertain if they will also monitor the market. They may also have the authority to intervene in the market if manipulation is detected. An independent commission has been formed that may handle recourse for market participants.
- The exchange center has established the spot market platform that enables participants to bid, trade, and access necessary clearing results and market data.
- Limited information on market monitoring is available, and only a few publications of pilot data and performance are out.

# Guangdong: Implementation Timeline



- Phase 1 (September 2018–December 2019): Pilot Phase.** Objectives are to operate the market and refine the market design based on outcomes.
  - AS and spot market will operate independently
  - At the end of 2018, generators to submit load and cost curve, while customers submit only the load
  - At the end of 2019, both generators and customers will bid in load and cost curve
  - No results currently published
- Phase 2 (2020–): Expand the Pilot.** Eliminate pilot protections, integrate spot and AS market, diversify market products (focus on financial products), and explore regional market.
  - Gradually reduce and eliminate government-guaranteed hours
  - Explore capacity market, DR, and RE transaction mechanisms
  - Explore expanding the pilot to the entire Southern Grid area as a unified market footprint

# Guangdong: Stakeholder Map



# Guangdong: Concerns and Recommendations

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Guangdong's market design has the right fundamentals, but being the first means Guangdong does not have other pilots to learn from. It should focus on creating the right monitoring and governance structure so market participants, regulators, and third parties can identify challenges and the right recourse, while not adjusting too quickly to anomalies that may just be a bump on the road to implementation.

- **Minimal concerns with underlying market design:** Guangdong has given a lot of thought to the design of their market rules and has brought in many consultants to aid the effort. Even if certain design elements are problematic from an international market perspective (e.g., too low of price caps, lack of demand-side participation in the first phase), these are sensible approaches in the risk-averse context of these pilots, and considering many other portions of China's economy are still tightly regulated. Even exempting some generators from market participation has few complications in Guangdong because these are low-marginal-cost units that will inevitably be cleared first and will not shift the market greatly when they join.
- **Set up robust market monitoring:** Market monitoring will be key evaluation on market health that should be conducted by an independent third-party market monitor, in addition to dispatch and exchange centers that are operated by the gridco. Otherwise, this could perpetuate problems where lack of visibility into dispatch decisions builds mistrust with market participants and doesn't provide clear feedback on how generators need to become more flexible or efficient to compete.
- **Set clear guidelines for when and how market rules should be amended.** Regulators ought not to be overly responsive to outcomes in the market: they are sufficiently hedged in their market design already, and single instances are not that problematic. Changing too quickly can result in further complications and deteriorate participant trust. Setting up a governance structure and periodic terms for reevaluation and revision will make the process less erratic. Developing a near-term rule change process, with a standard evaluation approach that relies on modeling to evaluate the impacts on other stakeholders is key, as is stakeholder involvement (although the latter may not be central at this early stage).
- **Increase accuracy and consistency during test operation:** Guangdong selected several consecutive days in a month to conduct market settlement, which results in a substantial price difference between the real settlement day and the simulated settlement day. Guangdong could consider randomly choosing settlement days so that market participation is consistent during nonsettlement days.
- **Build the case for regional markets:** Guangdong, depending on pilot success, has an opportunity to move directly to interprovincial markets. It could conduct an analysis to make the economic case for each province to join with Guangdong to help overcome potential resistance.

## Useful international experience:

- Should capacity payment be given to generators? If so, what are the restrictions and detailed rules?
- How could the reference price for generators be better set, and when should mitigation mechanisms be used?
- How could the market be established in such a way to allow and reward more DER participation and services in the future?



# Shanxi

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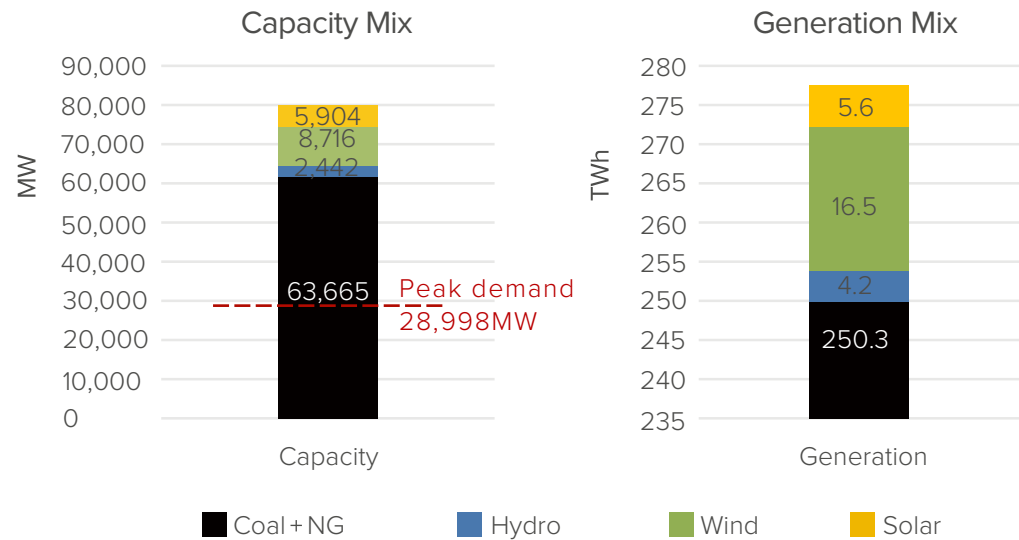
- Province profile
- Spot market pilot overview
- Decision-making structure
- Challenges and further considerations



# Shanxi: Electricity System Composition

## Province Overview:

- Shanxi is an important hub grid, connecting many of the outer provinces to the Northern demand centers in Beijing and Tianjin. Many interprovincial power transfers are scheduled in and out of Shanxi, making provincial dispatchers' jobs harder given that these import/export schedules are very inflexible.
- Shanxi has more installed capacity in the north (mine-mouth plants and wind farms), whereas the central and southern regions have the majority of the demand. There are frequently transmission constraints, and market designers are considering how to deal with this problem without overcomplicating the market design.
- Shanxi has a large share of Combined Heat and Power (CHP) for heating in the winter. A lot of people live in rural areas, so a significant amount of this heating is still from on-site, stand-alone coal boilers. There is a push to move them to natural gas, to electrify, or, where possible, to connect them to larger CHP plants.
- Shanxi has a growing amount of wind energy, which is facing some curtailment. It has targets to reduce curtailment rates in the coming years to avoid restrictions on building new renewable capacity.
- Shanxi is the first and only province to be fined for market manipulation during the recent power reforms. NDRC fined 23 generators a total of 70 million RMB for colluding their bids into the M2L market; therefore, this is a prevalent concern among market designers.





# Shanxi Market Overview

Shanxi's spot market applies a gross pool model and requires only thermal generators to participate (government planned hours are exempt).

<b>Spot Market</b>	Structure	DA and RT market (15-minute interval)
	Participation	Most thermal generators participate. Exempt: Renewables, reliability must-run, thermal, and nuclear. Exempt generators follow the prior dispatch method. Renewables will submit their forecast and be prioritized in dispatch. Imports and exports follow current contracts and dispatch schedule.
	Bidding	<ul style="list-style-type: none"> <li>• Generation side bids in volume and price; demand side bids only in volume.</li> <li>• No rebidding is allowed or needed for the RT market.</li> </ul>
	Payment	Adopts zonal pricing for both generators and customers.
<b>M2L Contracts</b>	Government Planned or Prioritized Generation	Turned to base volume contracts and the daily scheduling is assigned and physically executed.
	Customer Direct Purchase	Financial contract. Participants can use self-determined curves or standard grid company curves.
<b>Ancillary Services Market</b>		Market: AGC/frequency control, deep ramping.
<b>Settlement</b>		The M2L contract is paid out at the contract price, any differences in DA are settled at the DA price, and any differences in RT are paid out at the RT price.

\*The zonal price in this document means a single price applied to the whole province or the designated zone.

# Shanxi: Market Design Overview

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Provincial markets govern only some generation. Bulk interprovincial exchanges are scheduled first, then provincial demand is met, and any remaining generation can participate in short-timescale regional markets

- First, all bulk interprovincial transactions are contracted and scheduled on an annual or monthly basis. These scheduled exports/imports are scheduled and dispatched separate from the provincial market.
- Next, generation not meeting interprovincial exports participates in the provincial M2L market and spot market to meet all provincial demand.
- Finally, any remaining generation not purchased in the above markets can participate in the interprovincial spot market (only RE at the moment) and regional deep ramping market (AS market).

## M2L Contracts

- Government guaranteed hours are turned into contracts with the grid (called base volume contracts) with the same price and volume, and they must be physically dispatched. For the first 20 days or so of the month, all generators are centrally dispatched according to market bids. At that point, dispatchers check to ensure that base volume contracts are on track to be completely fulfilled by the end of the month. If not, dispatchers will manually schedule these generators to fulfill their base volume contracts by the end of the month. If for some reason they cannot fulfill their volume by the end of the month, these generators will receive more dispatch in the following month to compensate.
- All current DPP contracts will be financially executed and dispatched according to the central market clearing.
- Gradually, all contracts will change to financial contracts, so we expect that grid companies will be allowed to renegotiate volumes and prices for the base volume contracts at that point.

## Spot market

- Employs a gross pool model, but the export volume, base volume contracts, must-run (mainly CHP), and RE are excluded from the market in the early phases. Generators bid available volume and price on an hourly basis, while the demand side offers only the volume needed each hour (referred to as a one-sided market).
- RE will submit their forecasted output into the DA market and receive priority dispatch (regulatory must-take). The volume is paid at the government set price or contract price. Any divergence from the forecast in the RT market is paid at the RT market price.
- The system will be designed to calculate LMP but will be implemented only if congestion is a major challenge.

## Ancillary Services Market

- AGC frequency control markets use centralized bidding and a single clearing price mechanism to procure AGC frequency control service. The bidding range is 12–20 RMB/MW.
- A regulation market exists to help integrate renewables. It contains products for deep ramping, start-up and shutdown, and consumer-side resources like energy storage and interruptible loads.
- Deep ramping markets pay thermal plants to ramp down below their minimum run to incorporate more wind. All generators not ramped down during deep-ramping periods pay for ramp-down, with costs spread evenly across each MWh they are generating during that time period.
- North China has an established interprovincial deep-ramping market, but Shanxi is not included according to the temporary rule.
- Shanxi is also actively researching a market mechanisms for black start and AVC. They're hiring third-party research entities and looking to international market design experience.
- Other ancillary services markets (like spinning and nonspinning reserve) will be considered after the initial spot market pilot and would also be centrally procured and co-optimized with spot market dispatch.

# Shanxi: Implementation Timeline



Shanxi started test operation of a spot market in January 2019, but no results have been publicly released. Shanxi's timeline has not provided specific dates, and it discusses implementation only in terms of short-term and long-term phases.

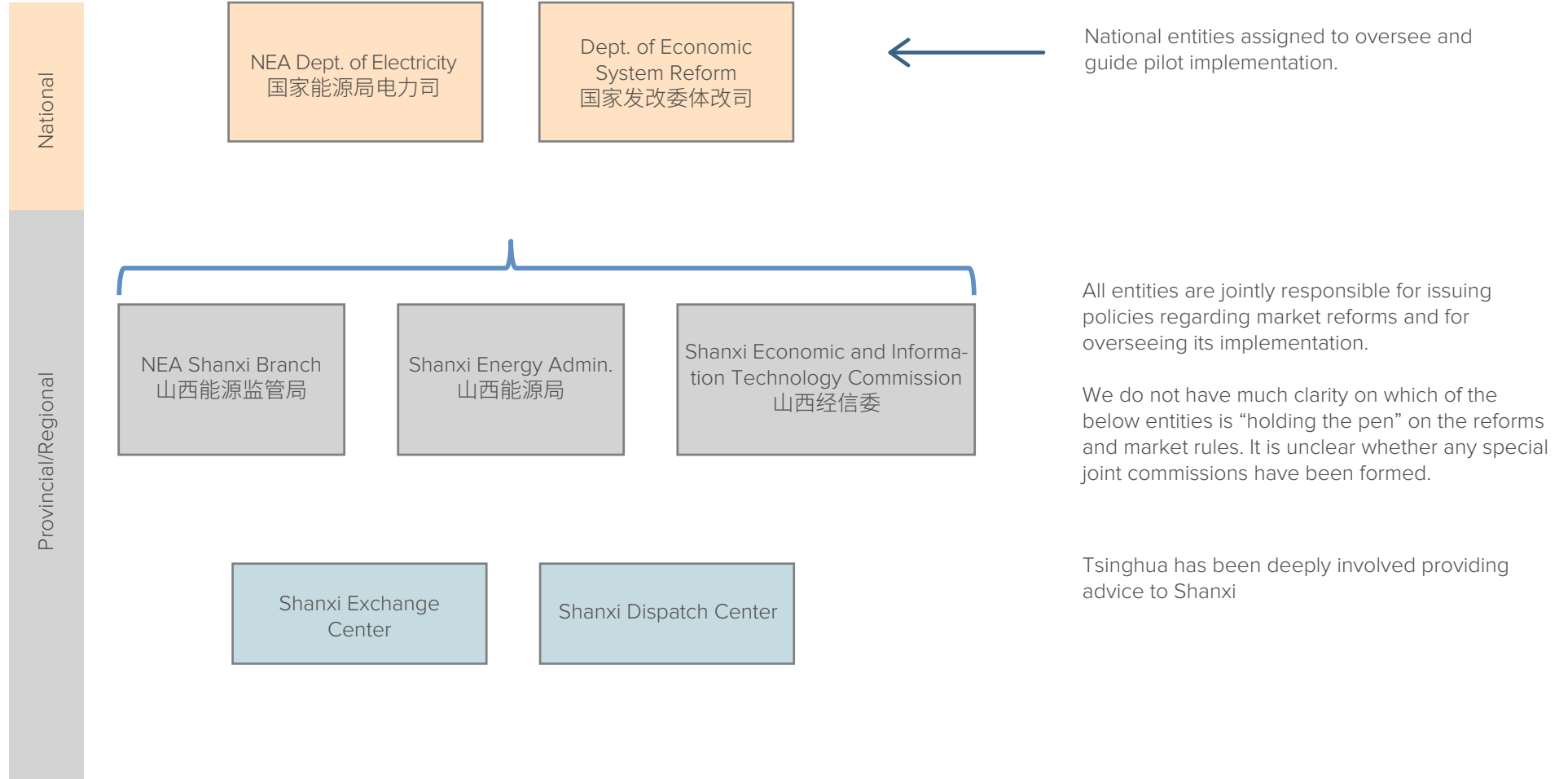
- **Short term**

- Government hours are prioritized and guaranteed by still being physically executed.
- Renewables participate as regulatory must-take. They provide their forecast and will be integrated up to technical limits and paid at the government set price.
- One-sided market; demand does not currently bid into the market.
- Deep ramping markets pay for thermal plants' generating under their minimum run rate to support RE integration.

- **Long term**

- All contracts become financial contracts and are dispatched by the market
- Shanxi will consider adding capacity markets to support bringing in new capacity if market prices don't align with central planning targets (specifically for RE)
- Plan to introduce FTRs, options, futures, and RE credits trading in the future
- Demand bids will be allowed to integrate demand response (treated as a demand resource, not a generator)
- Will add spinning reserves and other AS markets that are co-optimized with energy spot markets

# Shanxi: Spot Market Decision Makers



# Shanxi: Discussion and Recommendations

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Shanxi's market design gets close to creating a pilot that fully reflects what dispatch and prices might be in a full market, but Shanxi's focus on maintaining base amounts of physical dispatch hinders cost and emissions reductions potential and could limit renewable curtailment reduction and increasing thermal flexibility.

- **Move away from the physical dispatch of base volume hours:** Although the approach of trying to integrate these base volumes with market dispatch as much as possible is a good step, physically fulfilling the base volume contract still introduces substantial inefficiency and leads to suboptimal dispatch. Maintaining the physical dispatch for base volume contract is a compromised and transitional design considering participants' resistance and the potential political risk, but in the longer term, two pathways could help in moving away from physical scheduling: shifting base volume contracts to DPPs or financializing the base volume contracts. Financialization seems the more probable route because generators have been unwilling to move to the DPP market in the past for fear of losing the government revenue guarantee.
- **Incorporate CHP into markets:** Shanxi has sizable amounts of CHP, which is not subject to market dispatch at its minimum run rate. Although there has been pressure for minimum run rates to reach a certain standard (approximately 50% of nameplate capacity), the current market design does not use spot markets to improve flexibility: by excluding a large portion of their generation from market dispatch, generators are not subjected to financial pressure to ramp down below their minimum run rate (especially CHP). By continuing to pay for ramp-down in AS markets, it perpetuates the idea that thermal generation needs to be paid for any divergence from today's base load dispatch.
- **Better coordinate exports with provincial spot market:** As approximately one-third of Shanxi's generation in 2018 was exported to other provinces, a better coordination between exports with spot market is critical for dispatch optimization. Instead of limiting the exporting with specific generators, treating exporting contracts as a normal load added to the spot market and clearing it with most economic generators could improve the system's efficiency.

## Useful international experience:

- How can Shanxi encourage thermal generators to improve flexibility?
- How can ancillary services be marketized, and which services are the priority?



An aerial night photograph of a large industrial complex, likely a steel mill or refinery. The scene is illuminated by various lights, including bright white lights from buildings and a large, intense orange and red glow from a central area, possibly a furnace or a large fire. The complex features numerous large cylindrical tanks, rectangular buildings, and intricate piping systems. The overall atmosphere is one of intense industrial activity.

# West Inner Mongolia(Mengxi)

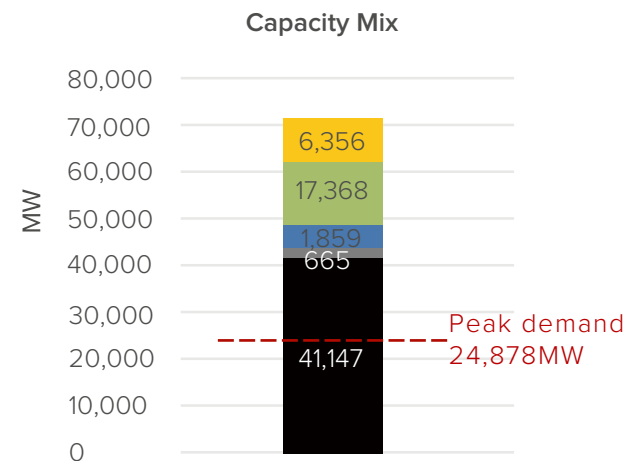
- Province profile
- Spot market pilot overview
- Decision-making structure
- Challenges and further considerations



# Mengxi: Electricity System Composition

## Province Overview:

- West Inner Mongolia is the only pilot that is not at the provincial scale. This is because it has its own grid company and the only local grid that remains independent from the State Grid and China Southern Grid. Their service territory covers about 70% of Inner Mongolia's GDP and industry.
- Inner Mongolia is a province with rich generation resources, especially coal and wind, but it has relatively less load. Since the territory is relatively narrow and long, there are many long lines connecting distant generation and load, which leads to transmission congestion.
- Of the thermal plants in Mengxi, 17% are captive plants, which are not dispatched by the grid and therefore do not provide flexibility to the system. Furthermore, 51% of the thermal plants are CHP plants, which are scheduled to meet their heat supply obligation. Those issues undermine system flexibility and impede renewable integration. Inner Mongolia has one of the highest wind curtailment rates in China at 10.3%.
- Mengxi is a power-exporting system with two 500 KV transmission lines connected to State Grid North China grid. Even though their power price is competitive, the limited transmission capacity and competition between grids prevent other provinces from accessing their cheap power and help reduce curtailment.
- Mengxi was the earliest provincial bilateral market in China and has been selected as a spot market pilot since it has more autonomy in its decision-making. However, conflicts with industrial and urban heating policy and less coordination between other regions have led to a relatively conservative market design.



■ Coal ■ NG ■ Hydro ■ Wind ■ Solar

Source: 《蒙西电力现货市场建设试点方案》; <https://baijiahao.baidu.com/s?id=1623529117004346440&wfr=spider&for=pc>

\*The overall profile data is for the entirety of Inner Mongolia, not just the western region.

# Mengxi Market Overview

West Inner Mongolia's spot market applies a net pool model that allows generation rights trading between thermal and renewables.

<b>Spot Market</b>	Structure	DA + intraday + RT (15-minute interval)
	Participation	Thermal, renewables, pumped hydro storage, and interruptible loads can all participate
	Bidding	Generation side bid the volume and price they would like to adjust from the M2L contract schedule
	Payment	Adopt zonal price for both generators and customers
<b>M2L Contracts</b>	Government Planned or Prioritized Generation	Turned to base volume contract and the daily scheduling is assigned and physically executed
	Customer Direct Purchase	Physical contract
<b>Ancillary Services Market</b>		Market: AGC/frequency control
<b>Settlement</b>		The M2L contract is paid out at contract price, any differences in DA are settled at the DA price, and any differences in intraday are paid out at the intraday price

# Mengxi: Market Design and Implementation Timeline



- **Phase 1 (July 2019–2020)**

**M2L Contracts:** The government base volume and DPP contracts remain unchanged from current practice and are still physically executed.

- Encourages DPP participants to submit their own curves
- Allows generators to trade their contract to other generators (generation rights trading)
- The dispatch center would break down both government and DPP contracts to daily scheduling in DA based on demand, RE forecasting, and the constraints

**Spot Market:**

- Mengxi's spot market is formed by the DA, intraday, and RT markets and operates in a net pool style, wherein most of the bilateral contracts are physically dispatched and the spot market is mainly for short time period adjustment and generation rights trading. All three markets allow generation-side bidding.
- The DA market allows thermal plants, RE, hydropump storage, and adjustable load to bid the price and volume they would like to adjust based on their contract scheduling. Load forecasting is still managed by grid.
- The intraday market helps balance the demand forecast changes. This market is continuing clearing and forms the time-based price. The volume difference from each clearing is settled by the price at the time.

Ancillary Services Market: Market for ancillary services, specifically AGC, reserve, and ramping service, are under consideration by Mengxi.

**Ancillary Services Market:**

Market for ancillary services, specifically AGC, reserve, and ramping service, are under consideration by Mengxi.

- **Phase 2 (2021–long term)**

**M2L Contracts:** Remove all government guarantee contracts.

- Not specified whether the DPPs are financially executed or not

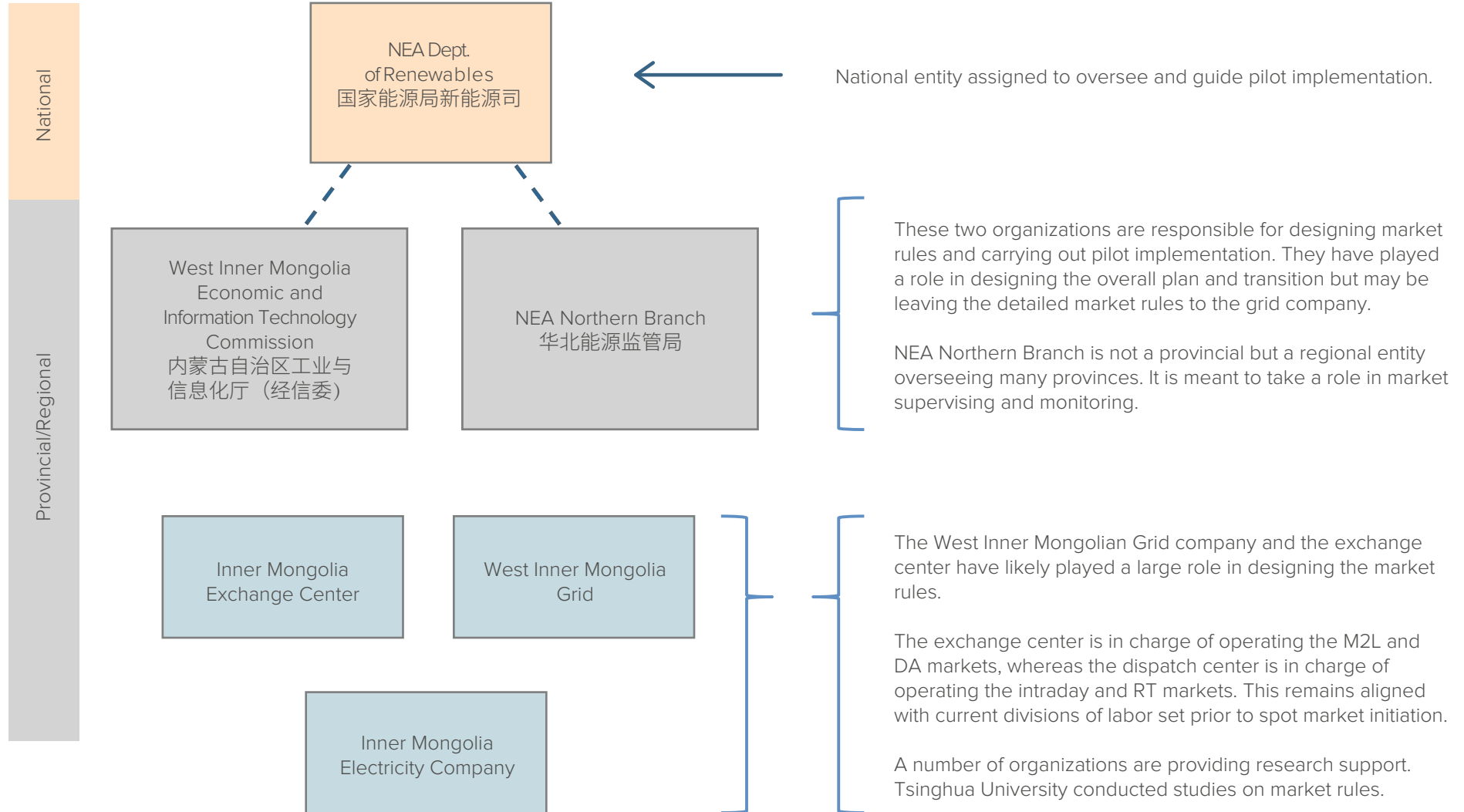
**Spot Market:** Establish DA + intraday + RT market structure.

- Generators submit cost curve, start-up and shutdown costs, idle cost, and constraints, which are used to determine the DA dispatch schedule and price (more like gross pool)
- Demand side can also bid in
- The intraday and RT markets are cleared during every dispatch period to settle forecast deviation
- Renewables are fully included into spot markets and are paid at market prices

**Ancillary Services Market:**

- Co-optimize the AS market with the spot market
- Allow demand-side resources like DR and storage to participate in the AS market
- Add AVC, reactive regulation, and black start service to the market

# Mengxi: Spot Market Decision Makers



# Mengxi: Concerns and Recommendations

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By allowing physical scheduling of DPP and base volume contracts, Mengxi may face less flexibility and suboptimal dispatch, exacerbating current curtailment, inefficiencies, and transmission constraints. Mengxi should find ways to encourage more active spot market trading.

- **Physically scheduled contract is a compromise for stakeholders.** Mengxi's market is the only "net pool" model, and it was chosen based on historic divisions between the roles for scheduling transactions and dispatch and managing generator concerns that many plants would be very rarely dispatched if otherwise. It is unlikely that Mengxi will reconsider this design, despite substantial risks that a physical scheduled contract could minimize cost savings potential and lead to many transmission constraints.
- **Find an efficient solution to minimize suboptimal scheduling:** Physical scheduling of M2L contracts and base volume contracts and the voluntary bidding in the DA market for scheduling adjustment are likely to result in suboptimal dispatch, because generators may be motivated to maintain current dispatch levels to not reveal they are less efficient than competitors for fear of regulatory shutdown. This could mean that gencos still may not trade in the spot market even when cheaper energy is available. At the same time, Mengxi has several binding transmission constraints that may result in frequent dispatch center redispatch. Mengxi could consider a more efficient mechanism to drive full participation in the spot market and high efficiency redispatch, which would:
  - Require all plants to submit the price points at which they are willing to buy or sell power, then allow the dispatch/exchange centers to automatically make these swaps and scheduling changes when economically feasible.
  - Monitor how one generator's scheduling decisions may prevent other market players from accessing least-cost generators (they are confirmed sequentially at the moment). Also observe for scheduling behavior that may be intentional to prevent competition from signing deals or intentionally creating situations where generators could successfully clear higher priced bids in the spot market.
  - Provide clear protocols on how renewable integration necessitates rescheduling, otherwise generators may not ramp down to integrate RE or wait until they get paid much more in deep ramping markets for integrating RE.
  - Evaluate market performance and quantify how much cost efficiency is lost through self-scheduling as opposed to idealized dispatch.

## Useful international experience:

- Regulation experience on how to set a structure that can balance interest between different stakeholders and improve efficiency from the current situation.



# Gansu

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- Province profile
- Spot market pilot overview
- Decision-making structure
- Challenges and further considerations

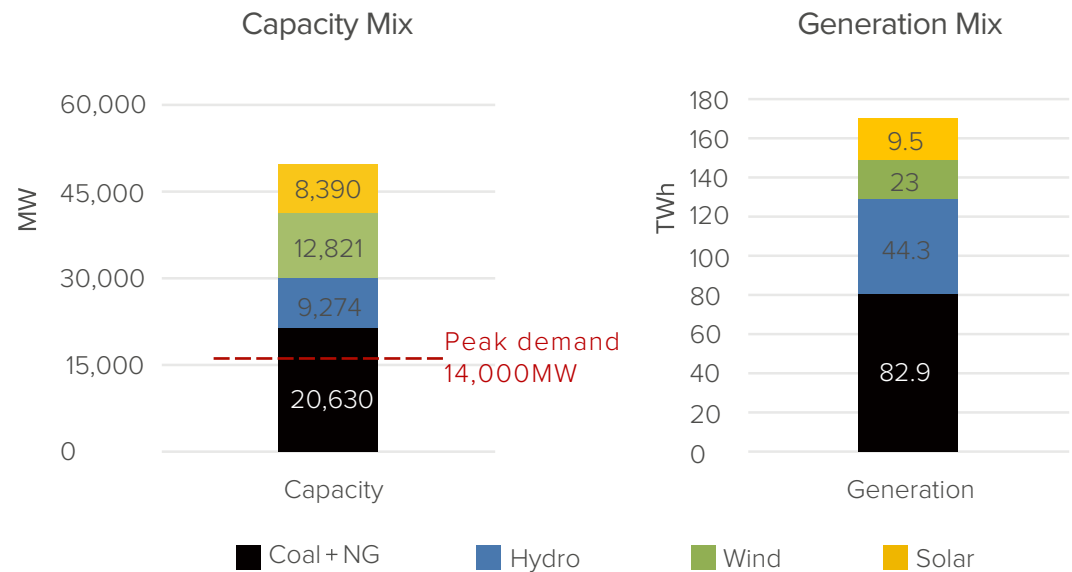




# Gansu: Electricity System Composition

## Province Overview:

- Among the pilot provinces, Gansu has the smallest population (26 million in 2018), the lowest GDP, and is the least urbanized. It has abundant wind and solar resources and the highest renewable share in terms of capacity nationwide, but it experiences the most severe curtailment as well.
- Gansu has made large efforts to reduce renewable curtailment in recent years and has been able to do so through large-scale interprovincial transactions—exporting electricity to 19 provinces, mainly through seven large interprovincial transmission lines, of which half of their carrying capacity is carved out for renewable generation (usually bundled with thermal generation).
- In Gansu, high-energy-consuming enterprises account for more than 30% of electricity consumption. These consumers are highly price sensitive, have interruptible features, and respond to price signals quickly. These attributes, and an influential share of consumption, lay a favorable foundation for power market construction.
- Gansu uses a variety of market approaches to curb renewable curtailment. These include generation right trading, energy storage, and deep ramping ancillary services.



# Gansu Market Overview

Gansu will build a one-sided market; both the base volume and DPP contracts will be financialized and dispatched in the spot market for settlement, including RE.

Spot Market	Structure	DA + RT market (15 minutes)
	Participation	Thermal generators and renewable generators (wind and solar) are required to participate but the reliability must-run thermal generation is exempt Hydro generators don't participate and do act as price taker.
	Bidding	<ul style="list-style-type: none"> <li>• Generation-side only</li> <li>• Thermal generators and renewable generators both need to bid volume and price in spot market</li> <li>• Allows renewables to rebid in RT market; thermal generators cannot rebid</li> </ul>
	Payment	Both generators and customers are paid out at zonal prices
M2L Contracts	Government Planned or Prioritized Generation	Executed financially
	Customer Direct Purchase	DPPs are financialized. Generators are paid based on their settlement curve, but for customers, all demand covered under DPPs is simply paid at the contract price regardless of their demand curve, and any extra is paid at the grid price.
Ancillary Services Market		Market: Provincial/Northwest deep ramping market
Settlement		The M2L contract is paid out at contract price, any differences in DA are settled at the DA price, and any differences in RT are paid out at the RT price

# Gansu: Market Design Overview

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## Spot market

- Adopts a “gross pool” model and operates DA and RT markets. Bids remain valid for the whole day; renewables are allowed to rebid for the RT market.
- The first phase is a one-sided market: customers don’t participate. Only generators bid in volume and price, and the market is cleared to meet all demand.
- Generators are paid at zonal prices, which are calculated based on LMP prices. Customers pay the original price.

## M2L markets

- All M2L contracts are dispatched by the market and settled using CfDs, regardless of whether they are base volume contracts with the grid or DPPs with customers.
- To settle the CfDs, a settlement curve is required to be provided for each DPP or base volume contract in the future. At present, the curve typically is assigned by the dispatch center or exchange center based on historic demand or generation. The assigned curves are designed to best match the renewable output to hedge the risk of their exposure to the fluctuated spot market price. In the future, this needs to be assigned when the contract is signed.

## Ancillary services market

- Gansu’s AS market currently includes only the deep ramping market. It uses centralized bidding and single clearing price mechanisms to compensate different generators for providing deep ramping.
- The remaining ancillary services will continue being compensated at the current prices and mechanisms. Gansu is currently exploring marketizing other ancillary services.

## Retail participation

- Users do not participate in the spot market. Users participate only in the M2L market, and all other demand is paid at the grid customer price (government-set retail price).

# Gansu: Implementation Timeline

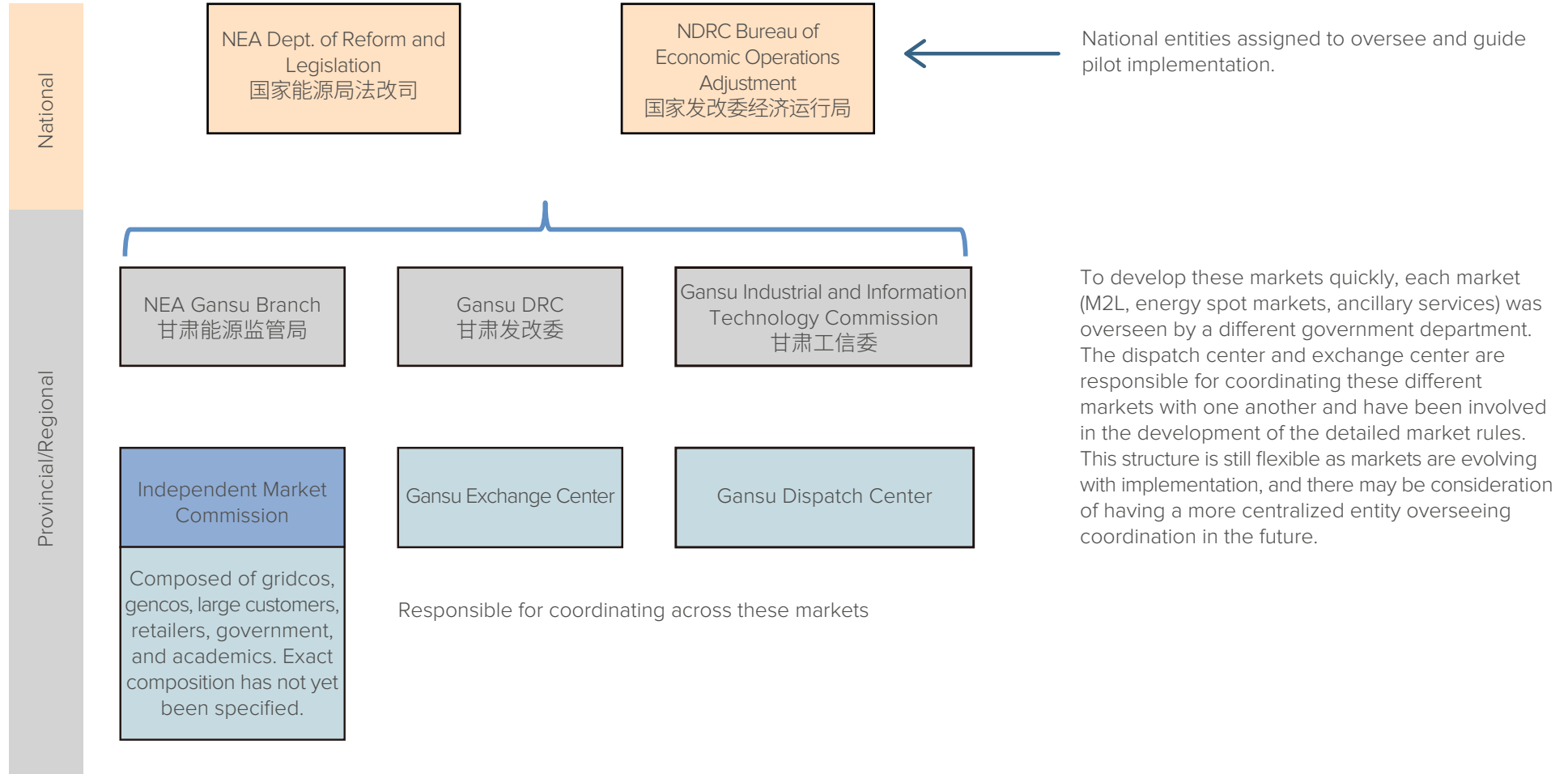
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Gansu generally took a centralized model and focuses on how to deal with renewable integration.

- **Short term (2018–2020)**
  - Establish DA and RT market
  - Generation-side gross pool market and gradually eliminate government planned generation
  - Market includes reference prices—bidding cap and floor
- **Long term (after 2020)**
  - All generation should be included into market optimization
  - Ancillary services markets and spot markets will be co-optimized
  - Find ways to enable customer-side participation
  - Explore LMP

# Gansu: Spot Market Decision Makers



# Gansu: Discussion and Recommendations

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Gansu's markets have been designed to maximize renewable integration and encourage exports, but reliability standards need to be revised to fully enable market dispatch to address these challenges.

- **Maximizing renewable integration:** Gansu is the only market that allows RE to bid prices and set clearing prices (other provinces' RE just provides forecasts), and it allows rebidding in the RT market to maximize integration. These market mechanisms alone may not be able to reduce curtailment if the current ways of scheduling generators for reliability continue to crowd renewables out of the dispatch order. Gansu should look to address the conservative setting of:
  - **Operating reserves:** Gansu should revise its operating reserve setting to reflect the amount of renewables integrated in the system at different times instead of adopting a fixed volume across the day. Gansu could consider forecasting error penalties or quantify how much curtailment has been caused by bad forecasting to motivate generators to better perform forecasting.
- **Managing the market price collapse due to overcapacity:** Gansu is reliant on exports, and low prices will be essential to encourage exports. But if low prices persist for too long, especially the M2L market prices, it may cause generators to resist market reforms and may pressure regulators to intervene in the market. Gansu can set criteria that would trigger an intervention and agree on a governance structure that would determine the right intervention that would not undermine the market.
- **Fulfill interprovincial volumes with spot market dispatch:** Most of Gansu's interprovincial export volumes are determined annually and must be physically dispatched. These often are fulfilled by assigning specific thermal plants to provide minimum firming, and then renewables are integrated up to a certain point. This scheduling approach could limit renewable integration and could actually make scheduling in the market more challenging by having certain generators scheduled to be on and crowding out other, more economic generators. This demand should just be met using market dispatch and could use financial contracts to manage any plants affected by this change in dispatch.

## Useful international experience:

- Integrating RE into the market, including what contracts to use to help support continued growth in RE
- Improving RE forecasting and setting reserve requirements to accommodate for high-RE periods
- Conducting more flexible market-based dispatch and evaluating appropriate thermal flexibility set points



# Zhejiang

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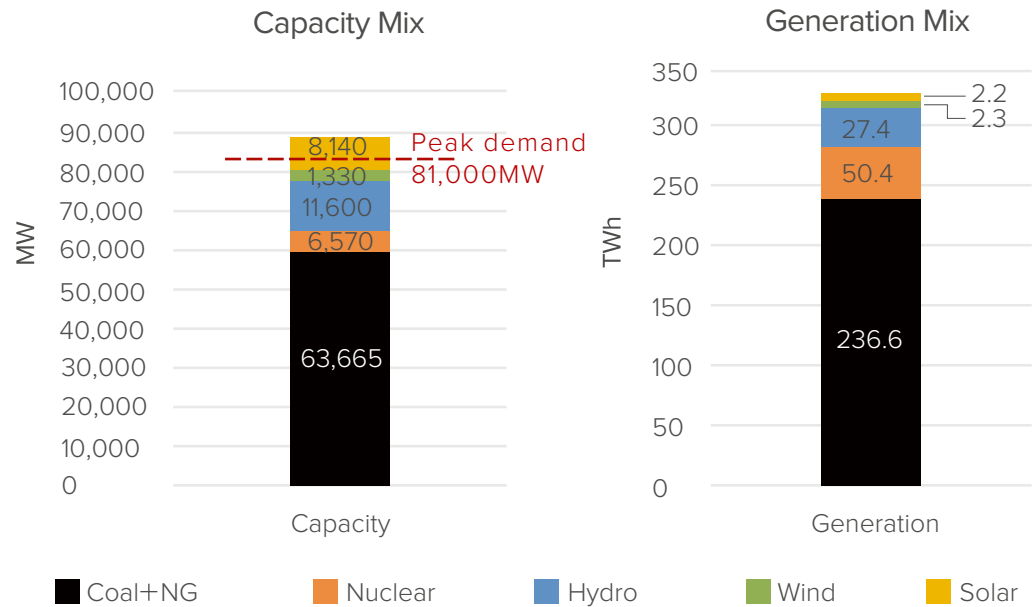
- Province profile
- Spot market pilot overview
- Decision-making structure
- Challenges and further considerations



# Zhejiang: Electricity System Composition

## Province Overview:

- Zhejiang is a power-importing province with 135.4 TWh of imports in 2018 (roughly one-third their demand). About 50% of interprovincial transactions, mainly nuclear and hydro, are nationally planned by the central government. The rest are negotiated between Zhejiang's government and exporting provinces, including Sichuan, Fujian, Ningxia, and Anhui.
- Zhejiang Energy Group (Zhe Neng) is the largest local generation company and owns more than 70% of generation assets in the province. With such a concentration of market power, avoiding market manipulation is a key focus for its market design.
- Zhejiang was one of the pilots in the last round of power market reform. It completed power market system reform (bidding on the generation side) in January 2000 to alleviate oversupply of power supply. But in 2003, Zhejiang was back in a power shortage, and bidding on the generation side was leading to very high prices, so the power market came to an end. This experience has influenced Zhejiang to favor a pure market model and hire international consultants to design the market.
- Zhejiang's government heavily favors distributed solar installation and provides strong government subsidies. It has the largest distributed solar installed capacity in China.



# Zhejiang Market Overview

Zhejiang's spot market applies the gross pool model for all provincially dispatched nonrenewable generators.

Spot Market	Structure	DA + RT market (15-minute interval)
	Participation	Other than the imported and exported generation and renewables (which occupy 30% to approximately 35%), all provincially dispatched generators are required to participate in the spot market, but non-hydro RE are represented by a gridco.
	Bidding	<ul style="list-style-type: none"> <li>• All nonrenewable provincial dispatched generators are required to bid into the DA market</li> <li>• Renewables get prioritized in the market</li> <li>• Grid-to-grid transactions are physically dispatched based on preagreed schedules, according to prior dispatch protocol</li> <li>• Generators-to-grid interprovincial generation is paid as a price taker in the spot market, but the schedule is set monthly or annually, not by the market</li> <li>• Demand side can bid in DA market</li> </ul>
	Payment	Generator are paid at LMPs; customers buy at the weighted average price. FTRs are applied for congestion surplus sharing.
M2L Contracts	Government Planned or Prioritized Generation	Turned to base volume contracts and the daily scheduling is assigned and physically executed.
	Customer Direct Purchase	Financial contract. Participants can use self-determined curves or standard grid company curves.
Ancillary Services Market		Market: AGC, spinning reserve, nonspinning reserve Contract payment: black start, reactive regulation
Settlement		M2L contracts are paid out at contract price, any differences in DA are settled at the DA price, and any differences in RT are paid out at the RT price

# Zhejiang: Market Overview (Mid-2019)

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## Spot market

- The wholesale side applies LMP for each node, and the demand side uses the weighted average of LMPs as the price.
- The clearing is in a 15-minute interval, which would shorten to 5 minutes in the final phases. However, the settlement uses 30-minute average price.
- The scheduling and price of imported generation is determined by the regional and national dispatch centers, except the imported contract that signed with individual generators located in other province, which would be treated as a price taker in Zhejiang's spot market.
- Zhejiang is also exploring the use of FTRs in allocating the congestion surplus coming from LMP. Zhejiang may not auction off FTRs in the early phases, but rather allocate congestion surplus revenue to each market participant by MWh consumed.

## M2L markets

- All bilateral contracts with customers or retailers become financial and used just for settlement.
- Government-authorized contracts (e.g., guaranteed hours, base volume contract) are financial contracts with the grid. The price and volume is set by the government instead of the M2L market, and the dispatch is conducted by least-cost market dispatch.

## Ancillary services market

- Procuring reserves will be co-optimized with the energy spot market
- The reactive power control and black start are contracted with specific generators on an annual basis
- Deep ramping will be cancelled when the spot market operation begins, because spot market dispatch should cancel the need for deep ramping dispatch

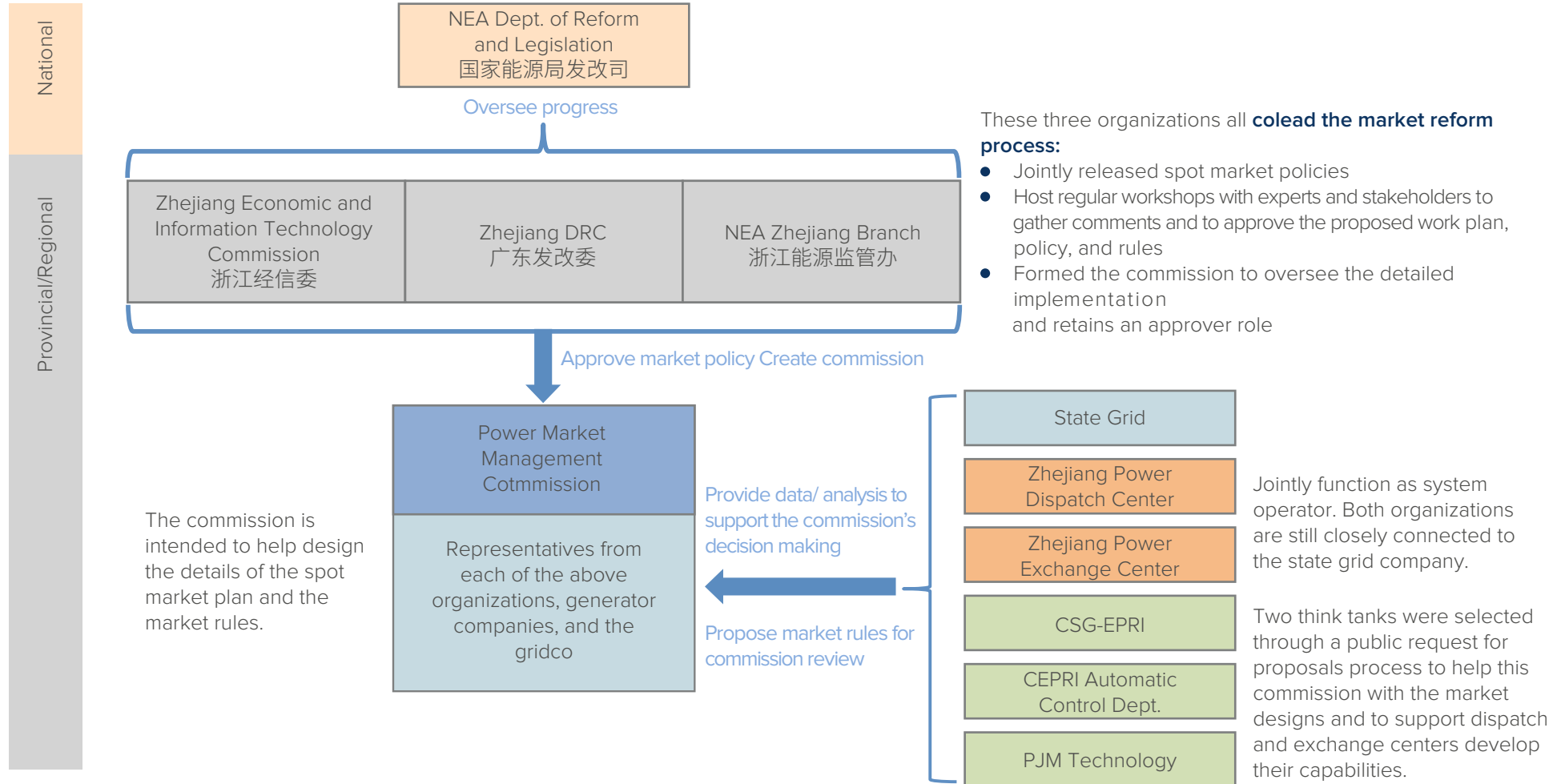


# Zhejiang: Implementation Timeline



- **Near-term (before June 2019):** Establish “bilateral + spot” market structure and prepare participants for spot market. Avoid price volatility to ensure smooth transition into market, while aiming to reduce price by introducing competitions.
  - RE (except hydro) does not directly participate in markets in the current stage. It has the priority to be dispatched first, and it acts as a price taker in the spot market, but all RE is still covered by base volume contracts to ensure that the full benchmark price is paid (+ subsidy).
  - Establish power market systems and simulation operation.
- **Mid-term (July 2019–2022)**
  - Broaden participation and gradually open up retail competition
  - Encourage RE participation in the market and explore demand-side participation
  - Allow financial institutions to issue derivatives based on the markets
- **Long-term (2022–)**
  - All generators must participate in the wholesale market, and customers can freely choose their service provider
  - FTRs are created to manage congestion and develop other financial products
  - Explore capacity market to ensure longer-term resource adequacy
  - Explore ways for demand response and energy efficiency to compete in the market, both for energy and any emerging capacity payments

# Zhejiang: Stakeholder Map



# Zhejiang: Discussion and Recommendation

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Zhejiang's market design fundamentals are solid, but the presence of a single provincial genco with a majority of generation, a high reliance on imported energy, and a capacity payment to natural gas plants may conflict with the objectives of the market design adopted.

- **Few concerns with underlying market design:** Zhejiang's energy market design was supported by PJM; accordingly, its energy markets are similar, but do not borrow from PJM's more controversial elements (e.g., reliability/capacity payments, out-of-market scheduling). The major concern with Zhejiang's market is not the design but setting up appropriate regulation. Zhejiang is likely to set many precedents, both in terms of regulation and models for integrating with interprovincial exchange, and there is hope that Zhejiang will become increasingly open about its approaches to allow other provinces to borrow its best practices (to date, it has been very closed-door).
- **Mitigating market power and implementing checks and balances:** Zhejiang has two large players that are dominating market design, operation, and participation: Zheneng, the largest generator company, which operates more than 60% of the generation in the market, and the provincial state grid subsidiary, which is the only shareholder in the exchange center. Both present a challenge for stakeholder engagement, transparency, and fair access to the markets. Zhejiang has installed an independent Power Market Management Commission to set up monitoring, regulation, and transparency protocols. These processes should give an outsized voice to smaller players to counterbalance the major players; otherwise, stakeholders could lose confidence in the market with insufficient visibility into the market's fairness. If challenges persist with potential manipulation, Zhejiang may consider using cost-based bids.
- **Managing risks with imports:** Zhejiang imports about 30% of its energy and has little control over the dispatch volumes and scheduling, which are usually set at the national level. This has caused two problems for Zhejiang: (1) It requires a large portion of Zhejiang's dispatchable fleet to be scheduled on to act as contingency reserves, and (2) Zhejiang needs to retrofit plants or install new NG to provide flexibility when nonadjustable imports dominate the generation stack and don't align with large intraday ramps. Zhejiang's market rules aim to influence import schedules by making them price-takers, thereby incentivizing importers to revise their schedules according to expected prices. But this applies only to generators with direct contracts with the Zhejiang grid company, and it represents a very small portion of total imports. Zhejiang does not have the means to influence nationally planned imports.
- **Managing NG nonmarket payments:** NG is paid a capacity payment to cover some of these costs in the current rules. Zhejiang should evaluate if this capacity payment is necessary and identify which plants are critical to the system and still need support, instead of compensating the whole fleet of NG plants. In the long term, this will cause market distortion that Zhejiang will need to manage, and it may drive other resources, like coal, to seek capacity credits.

## Useful international experience:

- How to manage imports from nonmarket regions such that they are coordinated with least-cost dispatch
- How to manage structural congestion without the complexity of FTRs in the early phases



# Sichuan

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- Province profile
- Spot market pilot overview
- Decision-making structure
- Challenges and further considerations

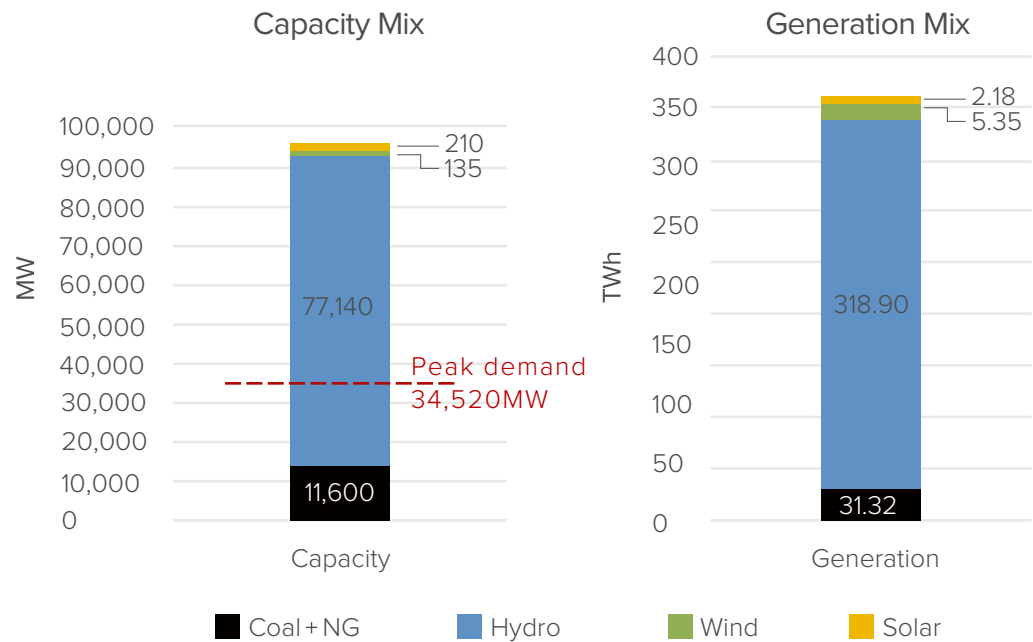




# Sichuan: Electricity System Composition

## Province Overview:

- Sichuan is the biggest electricity-exporting province in China, with eight HVAC lines and four HVDC lines connecting Tibet, Central China, East China, and the Northwest grid, which provide a total of 30 GW of transmission capacity. About one-third of the annual generation in Sichuan is sold to other provinces.
- Sichuan has one of the most complicated provincial grid structures and operation paradigms in China, with the longest total line distance and the most substations. Due to historical precedent, Sichuan also has many local grid companies that own and operate parts of the grid, while the state grid still services most customers. Currently, 60% of generators are dispatched at the provincial level, 22% at the national level, 15% by local gridcos, and 3% are regional, which makes creating a central operated market challenging.
- Sichuan has serious hydro curtailment in the rainy season and has very little hydro generation available in the dry season. That means that even when faced with an overcapacity issue, coal plants are necessary for winter generation. These coal plants are often scheduled to run for reliability in the rainy season, and to help cover their costs—and because they can't be shut off—this leads in part to the curtailment of hydro.
- To help consume hydro power, Sichuan set a special low-power price for the rainy season to encourage extra consumption during that time frame.
- Sichuan's DPP is open to most customers and offers hydro power contract to selected large customers with a lower price.



# Sichuan Market Overview

Sichuan's spot market applies a gross pool model and is basically seasonal; only hydro participates during runoff season, and only thermal plants in the non-hydro-curtailed season.

Spot Market	Structure	DA + RT market (15-minute interval)
	Participation	<ul style="list-style-type: none"> <li>• Generation that is exempt from the market pilot still follows the old dispatch method (assign annual generation and daily scheduling):               <ul style="list-style-type: none"> <li>- Imports and exports</li> <li>- NG plants</li> <li>- Renewables</li> <li>- Government guarantee/base volume contract volumes</li> <li>- Reliability must-runs (includes heating)</li> </ul> </li> <li>• Only hydro plants participate in the spot market during the hydro-curtailed season, and only thermal plants participate in the non-hydro-curtailed season</li> </ul>
	Bidding	Generation side only The bidding cap is 316.8 CNY/MWh in the hydro-curtailed season and 441.3 CNY/MWh in the non-hydro-curtailed season
	Payment	Zonal price
M2L Contracts	Government Planned or Prioritized Generation	Turned to base volume contract, and the daily scheduling is assigned and physically executed
	Customer Direct Purchase	Financial contract
Ancillary Services Market		Market: AGC, thermal spinning reserves
Settlement		The M2L contract is paid out at the contract price, any differences in DA are settled at the DA price, and any differences in RT are paid out at the RT price

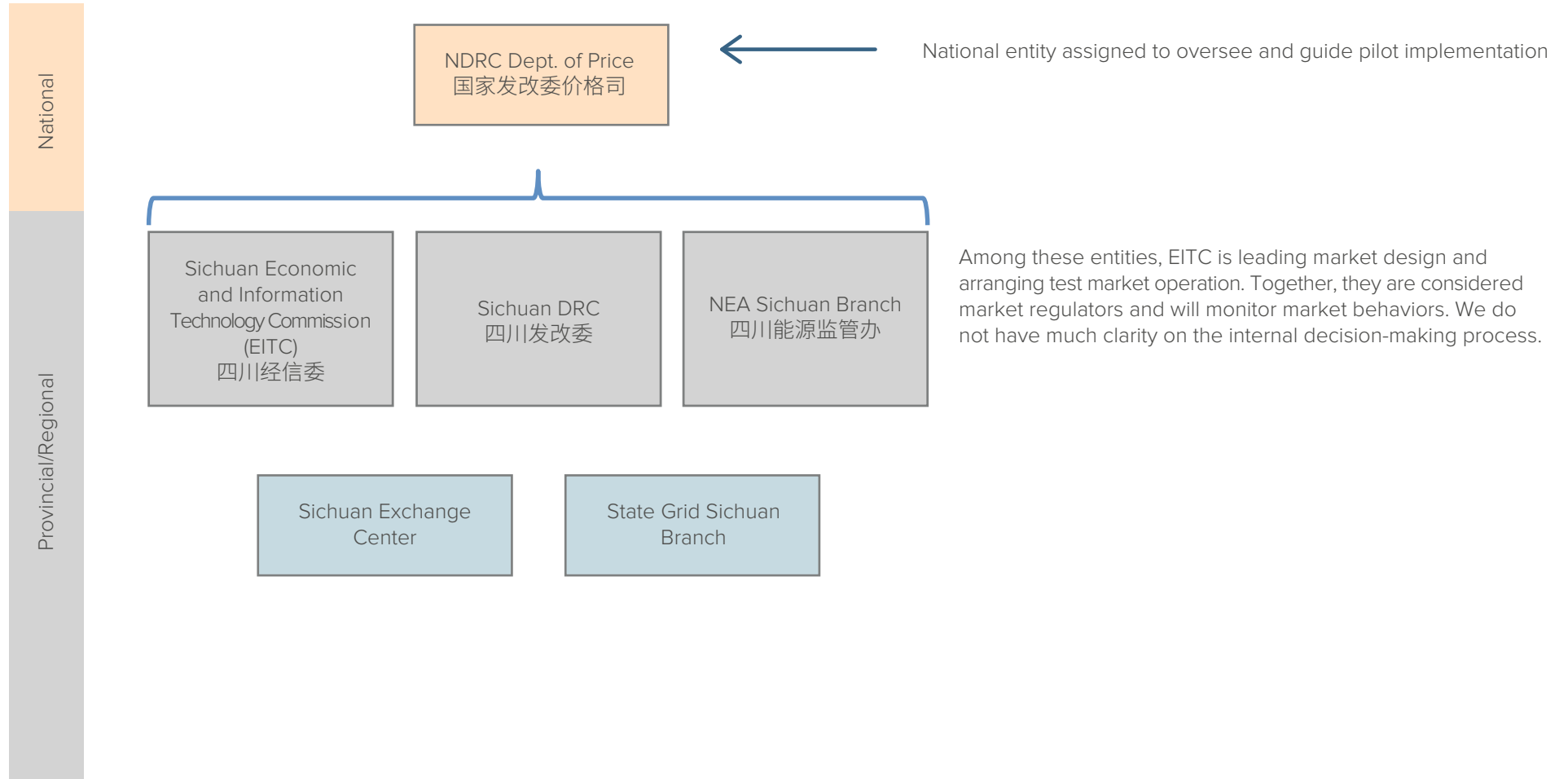
# Sichuan: Implementation Timeline

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- **Near-term (2019–2023):** Establish “bilateral + spot” market structure in State Grid Sichuan grid territory and prepare participants for spot market. Avoid price volatility to ensure smooth transition into market, while aiming to reduce price by introducing competitions.
  - Only hydro plants participate in the spot market during the hydro-curtailed season, and only thermal plants participate in the non-curtailed season
  - Only the generation side can bid in the spot market
  - Establish AS market for reserves and AGC
- **Mid-term (2024–2028)**
  - Allow demand side to bid into the spot market
  - Establish rules for RE to participate in the spot market
- **Long-term (2029–)**
  - Create FTRs to manage congestion and develop other financial products
  - Allow financial institutions to issue derivatives based on the markets

# Sichuan: Spot Market Decision Makers





# Sichuan: Discussion and Recommendations

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Sichuan's market design is trying to balance reducing hydro curtailment while guaranteeing minimum revenues for thermal plants that run only in the dry season.

- **Current market design may not address the core issues Sichuan is trying to solve.** Sichuan's design is a compromise in the face of resistance to move all generators into the market. The market design focuses on the two major challenges: hydro curtailment and insufficient coal revenues. The vision seems to be for base contracts to keep these plants running enough during the wet season to cover base costs, and then the market during the dry season will be used to prioritize the dispatch of thermal generators above their minimal run rates. The volume of generation submitted to the market is very minimal, likely intended to avoid plants critical during the dry season from facing a revenue gap.
- **Reduce unnecessary thermal operation during the wet season.** During runoff season, thermal plants should not be run to alleviate revenue adequacy concerns, but only for reliability. The level of thermal power necessary for adequate reserves needs to be reevaluated to make room for more hydro integration.
- **Eliminate undercompensated coal or find the right means to compensate.** The base volume contracts are set very high, leaving very little optimization of dispatch in the dry season (only 2–5% of thermal dispatch will be market based). If these generators are genuinely needed, market-based dispatch will use all generators enough during this time frame, but it will save costs by prioritizing the least cost. If some plants are needed only for a few days, then relying on other provinces to provide that excess capacity would be a far cheaper option.
- **Interconnect with other provinces' balancing area.** Sichuan has a lot to gain and little to lose by increasing its connectivity with other provinces. During periods of excess, low prices will incentivize neighbors to import (especially hydro), and during unexpected shortfalls, high spot market prices will incentivize generators from other regions to export to Sichuan to get higher returns. This would be best enabled by Sichuan joining in to participate in any of the curtailed renewables markets or the regional deep ramping pilots.
- **Manage transmission rights-of-way in a centralized manner.** A centralized model, if politically possible, would benefit Sichuan because it could help manage the multiple right-of-way issues with the many gridcos. If left decentralized, it could cause many complications in the scheduling process and out-of-market redispatch that could be opaque and more focused on local protectionism.

## Useful international experience:

- Interprovincial transactions that can help address the hydro curtailment issue during the rainy season
- The right compensation mechanism for thermal plants that are critical in the winter
- Coordination between the state and local grids so customers can trade freely ignored grid ownership

# Shandong

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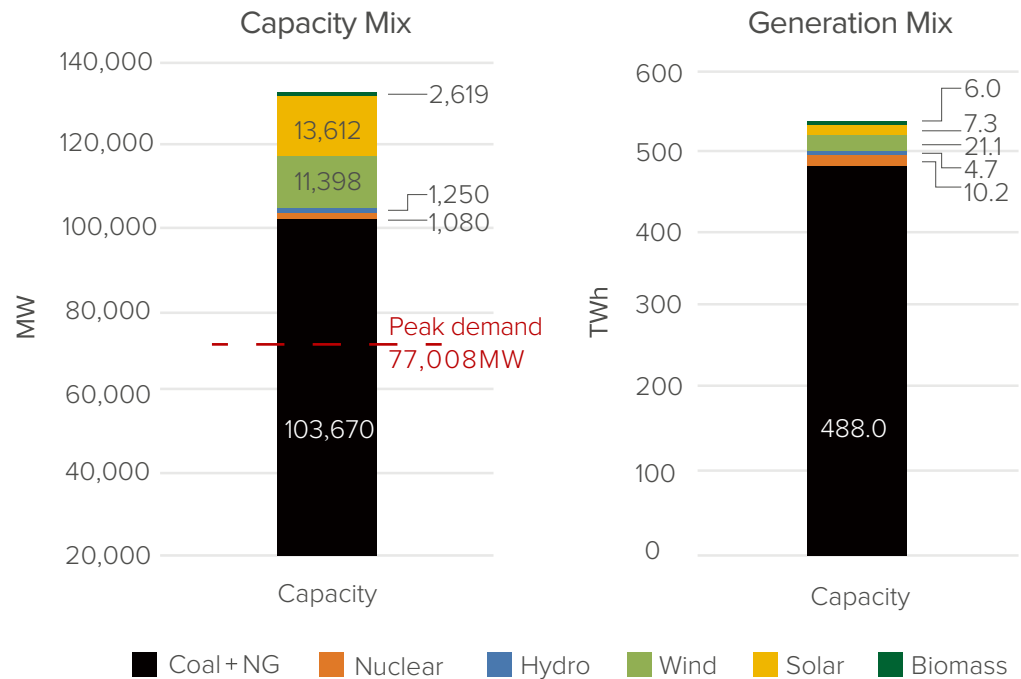
- Province profile
- Spot market pilot overview
- Decision-making structure
- Challenges and further considerations



# Shandong: Electricity System Composition

## Province Overview:

- Shandong relies heavily on coal for power and heat provision (about 78%, well above national average), despite having the highest installed capacity for solar and biomass and the fifth-highest for wind in the nation (as of 2018).
- Shandong has aggressive targets to reduce its coal consumption, and it views power imports as a major strategy to reduce its coal dependency:
  - As of January 2019, four HVDC and four HVAC lines are connected to Shandong with a total of 23,000 MW importing transmission capacity, which are expected to be 30,000 MW by the end of 2020.
  - The total imported power supply is more than 20% of Shandong's loads.
  - Most of the imports are from renewables across the Ningxia–Shandong DC line, the Inner Mongolia–Shandong HVDC line, and from Hebei across AC interconnects.
- Shandong has opened its retail market to most industrial customers and retailers. Shandong is also the only province so far that allows retail companies to participate in interprovincial transactions.
- Shandong has about 600 CHP units, among which 300 are industry-owned plants. The captive plants take one-third of the total installed capacity in Shandong. Only some of these can be dispatched by the provincial gridcos. Shandong has mandated the closure of many of the small and inefficient captive plants, but many stay open to provide heat and keep local jobs. The high percentage of undispachable captive plants limits flexibility and can pose security of supply risks if plants choose not to generate during peak load hours.



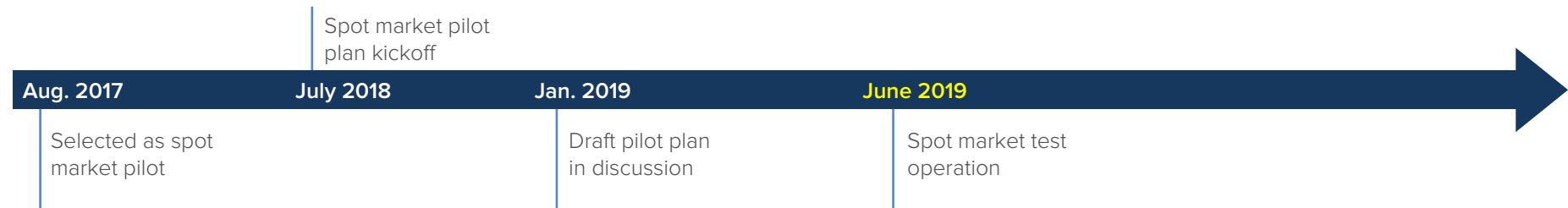
# Shandong Market Overview

Shandong's spot market applies the gross pool model for thermal generators.

Spot Market	Structure	DA + RT market (15 minutes)
	Participation	Thermal generators are required to participate. Renewables and captive plants do not participate in the market in the early stage (occupies 8%). Import generation doesn't participate (occupies 15%).
	Bidding	<ul style="list-style-type: none"> <li>Generators bid volume and price; demand side only bids volume.</li> <li>No rebidding is allowed or needed for the RT market.</li> </ul>
	Payment	Will use LMP; unclear if demand will buy at LMP or averages
M2L Contracts	Government Planned or Prioritized Generation	Turned to financial base volume contract and the settlement curve is assigned by the dispatch center
	Customer Direct Purchase	The contracts are financialized
Ancillary Services Market		Market: AGC/frequency control, deep ramping
Settlement		M2Ls are paid out at the contract price, any differences in DA are settled at the DA price, and any differences in RT are settled at RT price



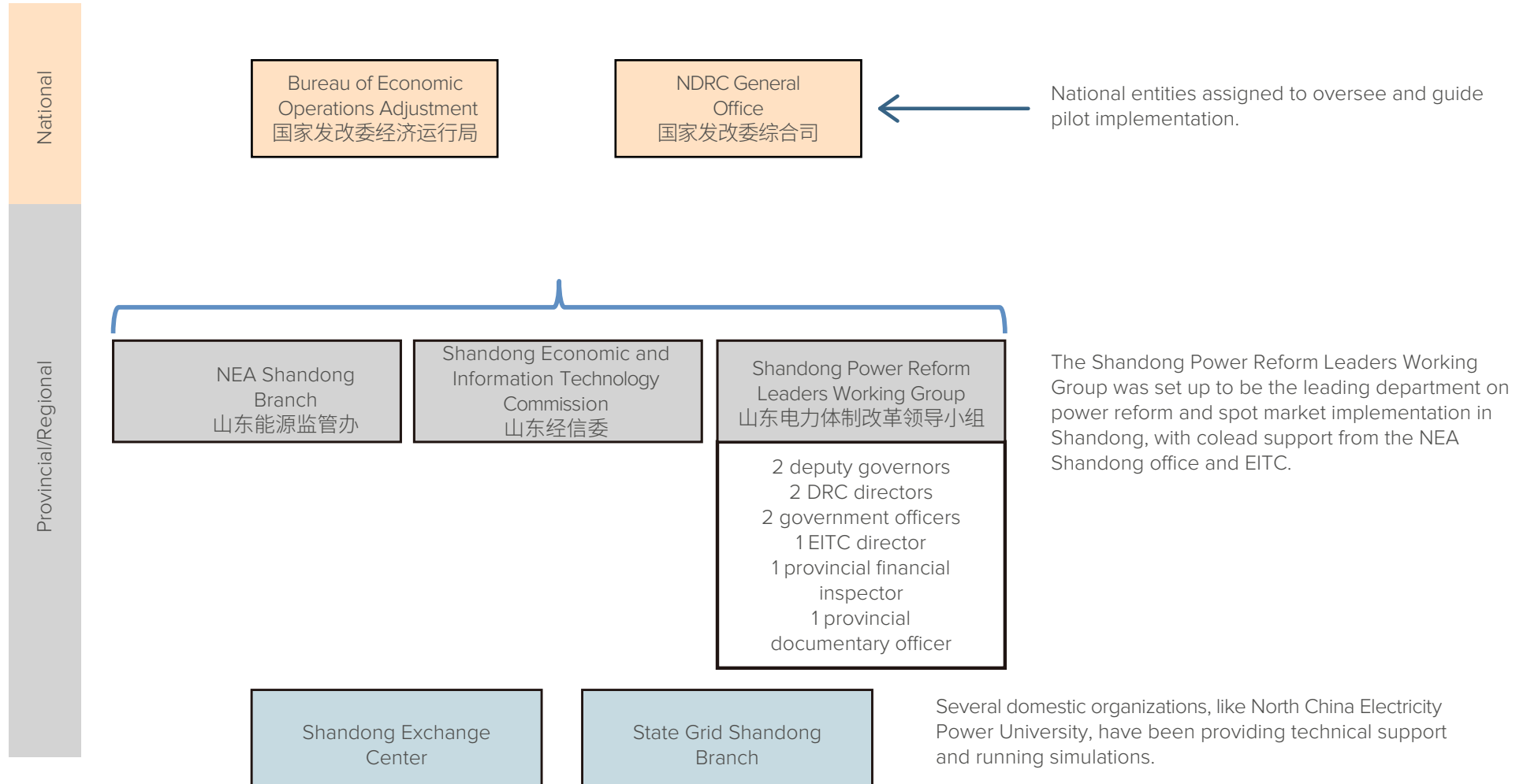
# Shandong: Implementation Timeline



- **Near-term (before June 2019):** Establish “bilateral + spot” market structure and prepare participants for spot market. Avoid price volatility to ensure a smooth transition into the market while aiming to reduce the price by introducing competitions.
  - Renewables, nuclear, and captive plants do not participate in markets in this early stage
  - Only the generation side bids into the market and gets paid at LMP
- **Mid-term (July 2019–2021)**
  - Include RE, provincial dispatched captive plants, and local plants into the spot market
  - Expand the ancillary services market for more products and explore co-optimization with the spot market
  - Establish a retail platform that allows customers to switch their retailers and access to load and price data
- **Long-term (2022–)**
  - FTRs are created to manage congestion and develop other financial products
  - Explore capacity market to ensure longer-term resource adequacy



# Shandong: Spot Market Decision Makers



# Shandong: Discussion and Recommendations

Shandong's underlying market design is solid, but integrating captive power plants and CHP into the market is critical for reliable operation at least cost and managing the growing challenge of solar integration.

- **Integrating captive plant dispatch and retirement into power sector operation.** The operation of Shandong's many captive power plants is not coordinated with dispatchers, who in many cases are unaware of their operating schedules. Captive generation plants need to be better integrated into the market to appropriately conduct least cost dispatch and to set operating reserve requirements. At a minimum, grid operators should require captive plants to submit (and adhere to) schedules, especially as dynamic prices are expected to drive self-owned generators to modulate their output according to market prices. These generators can also participate as demand-side resources and be paid for their availability and their ability to provide reserves.
- **Managing increasing flexibility needs.** Shandong has rapidly increasing flexibility needs to integrate growing levels of solar, which is hindered by a large amount of CHP and a growing volume of imports.
  - **CHP** should put more pressure on market dispatch. CHPs submit their minimum run rate when heating and have the priority to clear as price-taker. There may be risk of CHP manipulating the minimum run rate. CHP should be fully included in the spot market to improve flexibility in a competitive way. This will put competitive pressure on generators to ramp down below their minimum run rate and integrate solar, without having to pay excess in the deep-ramping market to have them ramp down.
  - **Interprovincial.** Shandong should explore using Zhejiang's model of having generator-to-grid imports be price takers in the market to manage integration, although the volume of imports which are these deals is unknown and may be small.
  - **Solar photovoltaic intraday ramps** can be managed by factoring in the increased flexibility needs for thermal ramp rates in scheduling of operating reserves. By factoring flexibility into dispatch decisions and compensating operating reserves for forgone energy revenues (not a common practice in China currently), this will naturally create a dispatch priority for flexible units. Demonstrating how this increased flexibility increases dispatch and revenues (see Gansu's discussion and recommendations on p.53) can drive plants to reevaluate their true ramping capability and offer more flexibility into the market without retrofit.

## Useful international experience:

- Incentive mechanisms for encouraging captive plants to respond to the system needs and provide necessary flexibility
- Ways to improve coordination between the provincial and interprovincial markets to receive more flexible imports from other provinces
- The mechanisms to help retire inefficient and high-polluted coal captive plants

# Fujian

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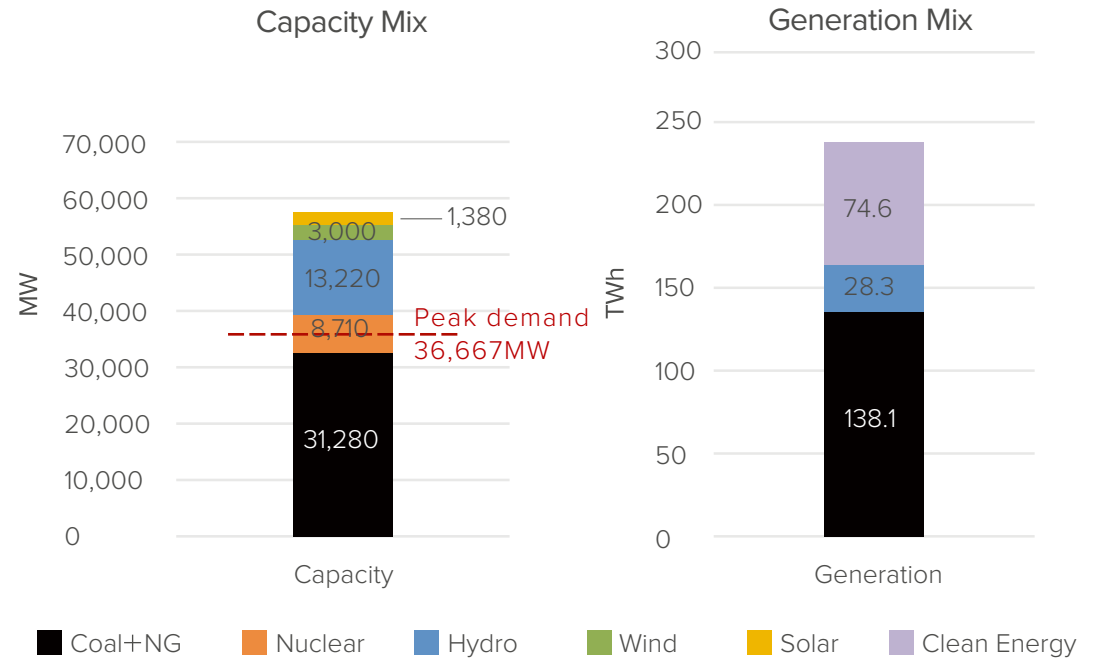
- Province profile
- Spot market pilot overview
- Decision-making structure



# Fujian: Electricity System Composition

## Province Overview:

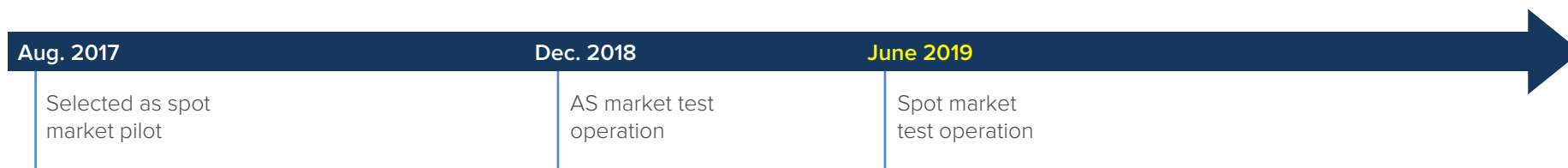
- Fujian is self-reliant for its power provision and has a diverse mix of renewables, hydro, thermal, and nuclear. Fujian has increasingly exported its energy (exported 17.6 TWh in 2018, mainly to Zhejiang), and plans to continue as wind and nuclear capacity grows.
  - The province set ambitious goals to develop wind power, especially offshore, aiming for 2,000 MW installed capacity by 2020. Wind developments in Fujian have some of the highest capacity factors in all of China.
  - As planned, 8.71 GW nuclear plants will come online by the end of 2020, driving some of the exports. Nuclear capacity factors are low because benchmark prices are higher than coal, so dispatchers don't fully utilize their capacity.
  - In the end of 2018, the government formulated a plan to phase out coal generators of less than 30 MW that are not up to the standard of environment protection, energy consumption, etc.
- Fujian's higher-than-average needs for intraday and interseason flexibility have driven it to be an early adopter of AS markets.
  - The intraday peak/valley ratio continues to increase (approximately 1,100 MW difference in 2017), forcing dispatchers to ramp thermal plants below their stated minimum run rates to keep units on, then ramping up quickly to meet the peak, which drives up cost.
  - With substantial hydro and nuclear, huge seasonal output changes require large thermal capacity in reserve for the dry season. This also leads to thermal generators not being able to make adequate revenue.
  - Fujian encourages all types of generations and load-shifting/shredding to participate in the AS market, hoping to improve system flexibility.





# Fujian: Implementation Timeline

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- **Spot market**

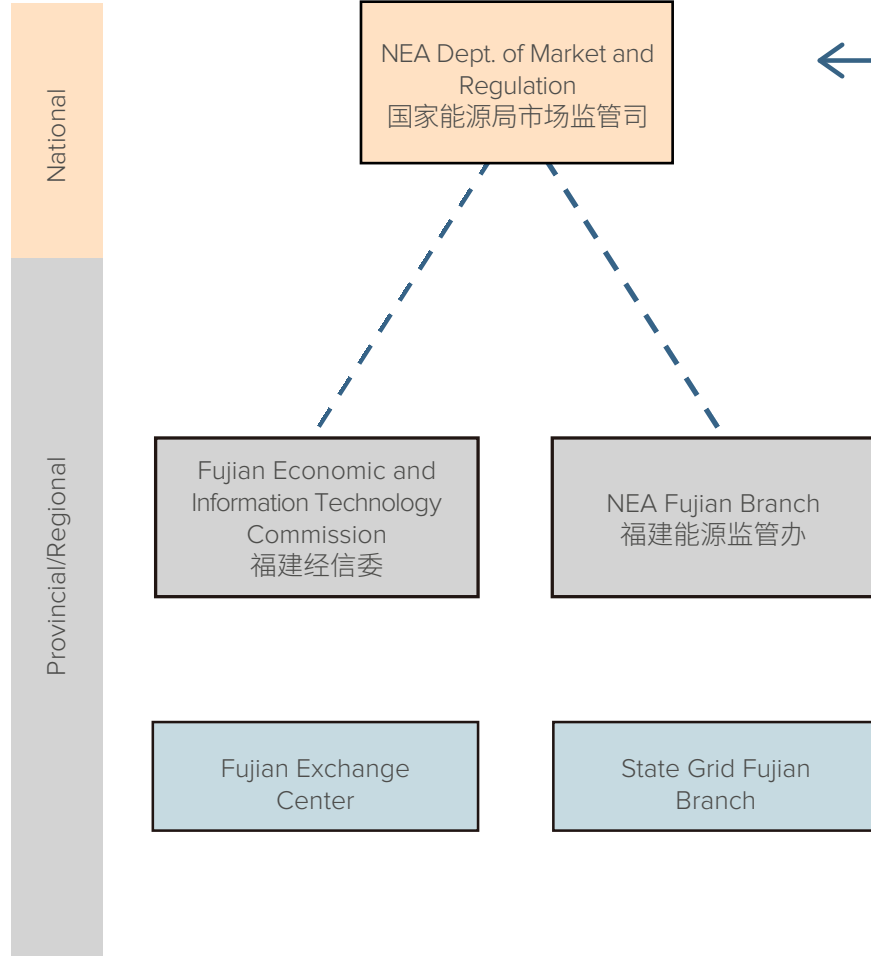
- Fujian has been very closed-door on its spot market plans to date, and no documents have been publicly released. We suspect that draft spot market pilot plans and market rules exist and are being kept within pilot participants during the simulation phase underway as of June 2019, although this simulation may not extend to market participants. It is also very likely that Fujian is taking a phased approach, with a focus on integrating with the AS market pilot.

- **Ancillary services market**

- Coal and nuclear generators are allowed to participate in the deep ramping market and get compensated when their generation is below a certain output level. The compensation cost are shared by all coal, nuclear, and renewable generators.
- Coal and hydro generators are allowed to participate in start-up and shutdown ramping markets.
- Demand-side consumers with interruptive load and storage are also allowed to participate in the ramping market.



# Fujian: Spot Market Decision Makers



National entities assigned to oversee and guide pilot implementation.

These entities are jointly responsible for designing market rules and carrying out pilot implementation. We do not have much clarity on which of the below entities are “holding the pen” on the reforms and market rules, but we have heard that EITC is particularly influential in these reforms. We know that the exchange center is involved in market reforms, but we do not know what aspects or to what extent.

North China Electric Power University has been deeply involved in providing advice and research support to Fujian.



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