

# Restructuring the Chinese Electricity Supply Sector: An assessment of the market pilot in Guangdong Province

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**Abstract** This paper examines power sector reform in China's largest province, Guangdong, following the publication of the No.9 document of the China State Council on 'Deepening Reform of the Power Sector' in March 2015. We look at the operation of the pilot wholesale power market in Guangdong in the light of international experience. We discuss how the power market pilot is working in Guangdong and the extent to which the current market design is in line with successful power markets we see elsewhere. We examine the evidence on whether the market reform has successfully brought new players into the electricity system in Guangdong. We consider the effects of the reform on the operational and investment decisions of firms in the sector. We conclude with several lessons for the Chinese government's ongoing power sector reform programme.

**Keywords** power market reform, international experience, Guangdong, China, industrial electricity price

**JEL Classification** L94

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# **Restructuring the Chinese Electricity Supply Sector: An assessment of the market pilot in Guangdong Province<sup>1</sup>**

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## *1. Introduction*

In March 2015 the No.9 document<sup>2</sup> was published by the China State Council and this began a new round of national electricity sector reforms in China. These reforms focus attention on reducing the price of electricity to industrial customers via the introduction of markets for wholesale power and the introduction of competition in the retailing of electricity<sup>3</sup>.

Guangdong province is the largest and most economically successful province in China. In 2016 Guangdong represents more than 25% of Chinese exports, 10.6% of Chinese GDP, 7.8% of the population (c.108m) and 9.5% of electricity consumption in China.<sup>4</sup> Guangdong has relatively high final electricity prices in China (for residential and most industrial and commercial customers) and is a net importer of power from other provinces<sup>5</sup>. It contains the Shenzhen special economic zone, which allows the introduction of new market measures not currently rolled out across China.

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<sup>2</sup> China State Council (2015). "Deepening Reform of the Power Sector, Document No. 9, March 21, 2015".

<sup>3</sup> China State Council (2015). See also China5e Research Centre (2016) and China Daily (2017), 'Nationwide electricity market reform expected by 2017', Retrieved from: <http://europe.chinadaily.com.cn/>

<sup>4</sup> These data are drawn from the website of National Bureau of Statistics (NBS) <http://www.stats.gov.cn/>.

<sup>5</sup> See Cheng (2016).

Guangdong has been leading the way within China on power market reform. The province is part of the region of the China Southern Grid, which has been a dynamic and innovative area of the national electricity system since its creation in 2002<sup>6</sup>. Even before the No.9 document was published an electricity market pilot project had begun in Shenzhen in 2014<sup>7</sup>. This consisted of the publication of separate electricity transmission and distribution charges and the introduction of monthly contract trading of electricity between certain generators and retail customers. In 2016, the Guangzhou Power Exchange was established to facilitate province wide trading of electricity<sup>8</sup>.

This paper seeks to document and analyse progress with the introduction of wholesale and retail power markets in Guangdong in the light of international experience. We will build on our earlier paper (Pollitt, Yang and Chen, 2017). This paper examined 14 aspects of power market reform in China (following Joskow, 2008, and Pollitt and Anaya, 2016) and made a number of recommendations of how power prices might be brought down for industrial consumers of electricity in the light of each of these aspects. In Pollitt, Yang and Chen (2017), we highlighted four key recommendations: (1) reform of dispatch of electricity power plants, so that these are dispatched on a least system cost basis; (2) reform of transmission and distribution charge regulation to ensure that network companies have an incentive to minimise cost; (3) rebalancing of electricity charges away from industrial customers to residential customers to better reflect underlying costs of service; and (4) reduction in the current over-investment in generation and networks to better reflect underlying system demand.

Well-functioning power markets are at the heart of delivering successful power market reform, as has been recognised by Stoft (2002). Appropriate competition between generators and retailers should in theory lead to the realisation of the key recommendations that we made in our earlier paper. Thus, our study of the reforms in Guangdong will focus on the

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<sup>6</sup> Chau et al. (2011). See also Wen (2017).

<sup>7</sup> China National Development and Reform Commission (2015). “国家发展改革委关于深圳市开展输配电价改革试点” 发改价格【2014】2379号 Retrieved from: [http://jgs.ndrc.gov.cn/zcfg/201411/t20141104\\_639639.html](http://jgs.ndrc.gov.cn/zcfg/201411/t20141104_639639.html)

<sup>8</sup> Guangzhou Power Exchange Center (2017). 《南方区域跨区跨省月度电力交易规则（试行）》，Retrieved from: <https://www.gzpec.cn/main/index.do>

following questions. What are the key achievements of recent power market reform in Guangdong to date? How has market piloting changed the traditional payment and power station dispatch systems? How have transmission and distribution charges been calculated and how are they being regulated? To what extent is the market pilot impacting on the current cross subsidies within the electricity system? How is the market pilot impacting on operational and investment decisions both within the generators and the network companies? What progress is being made in integrating interconnector flows into the electricity market? What progress is being made on creating a full set of electricity markets?

This paper aims to assess progress with reform, and what Guangdong is learning about how electricity market models need to be adapted for its own particular circumstances. A complete set of electricity markets can be easily stated, but in practice jurisdictions across the world have developed their own sets of electricity markets (for example, PJM in the US is different to the market in Great Britain). The paper highlights what the lessons from the market pilot experiences in Guangdong are for both the province itself and for the rest of China. The paper draws on the experience of Chinese stakeholders, to identify what are the key problems to be overcome in bringing about a successful electricity reform transition in the World's most significant electricity system. The paper offers some recommendations for next steps in the reform process at the provincial level and is intended to be a positive contribution to on-going debates about the detailed implementation of electricity sector reform in China and to be a platform for future discussion and informed input on the appropriateness of international reform experience in the Chinese context.

The rest of the paper is organized as follows. In Section 2, we begin with a discussion of the background to the reforms in Guangdong, including a discussion of the characteristics of the power system in Guangdong. Section 3 discusses how the power market pilot actually works in Guangdong and whether the current market design is in line with power markets we see elsewhere. Section 4 explores the extent to which power market reform has brought new players into the electricity system in Guangdong. Section 5 considers the effects of the reform on the operational and investment decisions of firms in the sector. In sections 3 to 5 we aim to provide some international context, as background to our analysis of the reform effects

observed to date. Section 6 offers some points for improvement in the light of the existing market design and its observed effects.

## 2. Background

### a. Guangdong within China

**Figure 1**  
**Map of Guangdong**



Source: [https://www.google.com.hk/search?newwindow=1&safe=strict&hl=zh-CN&tbm=isch&source=hp&biw=1280&bih=580&ei=JhM\\_Wr2ID4Ki0QSf97egAg&q=Guangdong+map&oq=Guangdong+map&gs\\_l=img.3...3260.5308.0.5834.5.5.0.0.0.0.89.241.3.3.0....0...1ac.1j4.64.img..2.2.167.0..0j0i30k1.0.lFwlxyuThfs#imgrc=EgKu\\_l1w56MVM:](https://www.google.com.hk/search?newwindow=1&safe=strict&hl=zh-CN&tbm=isch&source=hp&biw=1280&bih=580&ei=JhM_Wr2ID4Ki0QSf97egAg&q=Guangdong+map&oq=Guangdong+map&gs_l=img.3...3260.5308.0.5834.5.5.0.0.0.0.89.241.3.3.0....0...1ac.1j4.64.img..2.2.167.0..0j0i30k1.0.lFwlxyuThfs#imgrc=EgKu_l1w56MVM:)

Guangdong (see Figure 1 for a map) plays an important role in the development of policy for the whole of China<sup>9</sup>. It has been a leader in pro-market institutional developments, such as a clearer system of law and governance. Guangdong's capital is Guangzhou one of the largest in the world by population (at around 20 million only just less than Beijing), while its second

<sup>9</sup> Bui et al. (2002) and also Andrews-Speed (2013).

city, Shenzhen (population around 12 million), is also a global mega city. Shenzhen is opposite Hong Kong and a Special Economic Zone within China, which has grown from a market town of 30,000 in 1979<sup>10</sup>. Guangdong is located around the Pearl River Delta (or Greater Bay Area, which includes Guangzhou, Shenzhen, Macau and Hong Kong) through which much of the exports of the region flow. Shenzhen sits outside the remit of the provincial government of Guangdong and has its own regulatory institutions. Good examples of leadership in governance include Shenzhen's leading role the development of financial regulation and Guangzhou's hosting of one of China's three intellectual property courts<sup>11</sup>. Guangdong is politically significant for the whole of China, with many high ranking national officials in the Communist Party having spent time in provincial government in Guangdong.

Guangdong has introduced a carbon emissions pilot in 2012<sup>12</sup>. This was one of 2 provincial and 5 city pilots. The seven governments involved could decide on what sectors were included in the pilot. Only Guangdong has some auctioning of its allocation of permits. The Guangdong Emissions Exchange (GZX) trades three products: GDEAs, China CERs (Certified Emission Reductions) and provincial CERs<sup>13</sup>. 10% of allowances can come from provincial CERs and 30% of CERs can come from other provinces. Electricity, cement, petrochemicals and steel sectors were initially covered, with aviation and paper making added in 2016.<sup>14</sup> A national carbon market has recently been announced (December 2017) that will cover both electricity and heat sectors<sup>15</sup>. The price fell from 60 RMB in 2013 to 12 RMB in 2017, exhibiting similar problems to the EU ETS. There is an annual 20,000 tonnes threshold for participation. The national carbon market is expected to start around 30 RMB and increase to 200 RMB by 2030. There is an expectation of 3-5 years of overlap between pilots and national market, with no thought of linking. Lessons learned in Guangdong's carbon market pilot could be taken up in the design of the national market (see Wang et al., 2016)<sup>16</sup>. There is a big overlap between

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<sup>10</sup> See also Xinhua Finance (2015). Shenzhen given nod to pilot new power transmission, Available at: <http://en.xfafinance.com/html/Industries/Utilities/2015/40163.shtml>

<sup>11</sup> See Cohen, R. (2015).

<sup>12</sup> Cheng et al. (2016).

<sup>13</sup> Cheng et al. (2016). See also Liu, D. (2017). “电力市场、碳排放权市场和绿色证书市场的协调发展.” Electricity market, carbon market and green certificate mechanisms development, Industry perspective, China Electrical Equipment Industry, 2017.07.

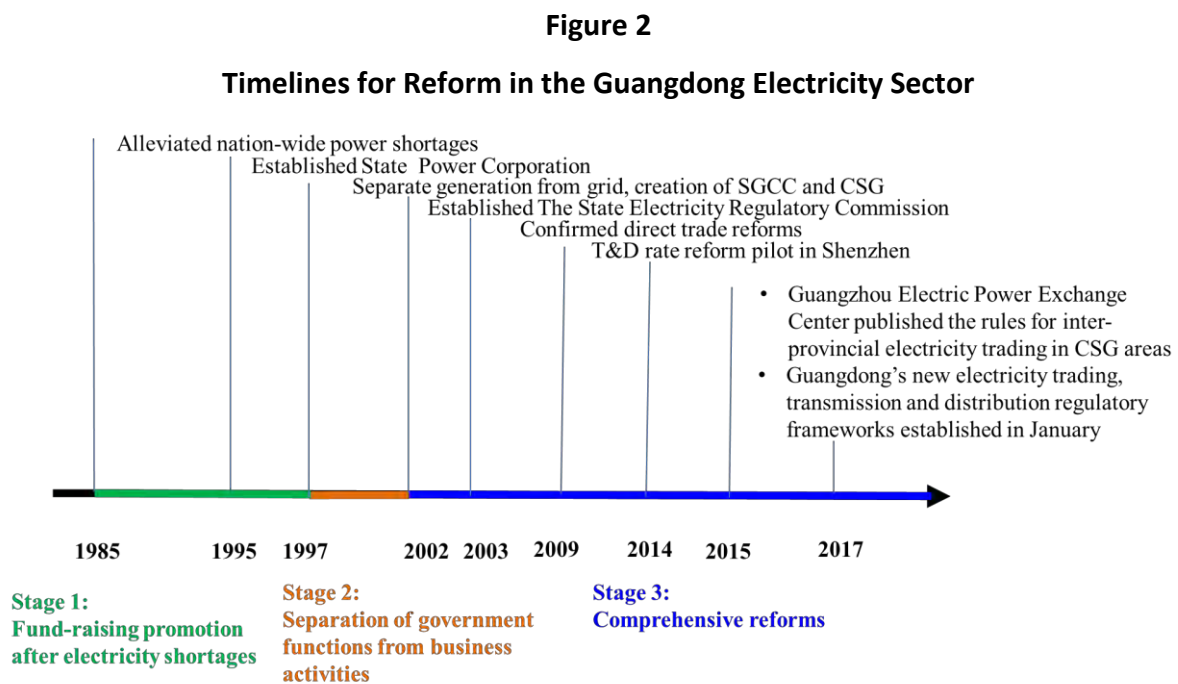
<sup>14</sup> See ICAP Status Report 2017.

<sup>15</sup> See Pike and Zhe (2017).

<sup>16</sup> Wang et al. (2016).

players in carbon allowances, electricity and renewables certificates markets. Analysis by Cheng et al. (2016) shows that a significant carbon price (of around \$10 per tonne of CO<sub>2</sub>) would reduce coal use for power generation in Guangdong significantly (and increase the use of natural gas). There are also likely to be significant air pollution co-benefits (see Cheng et al., 2016).

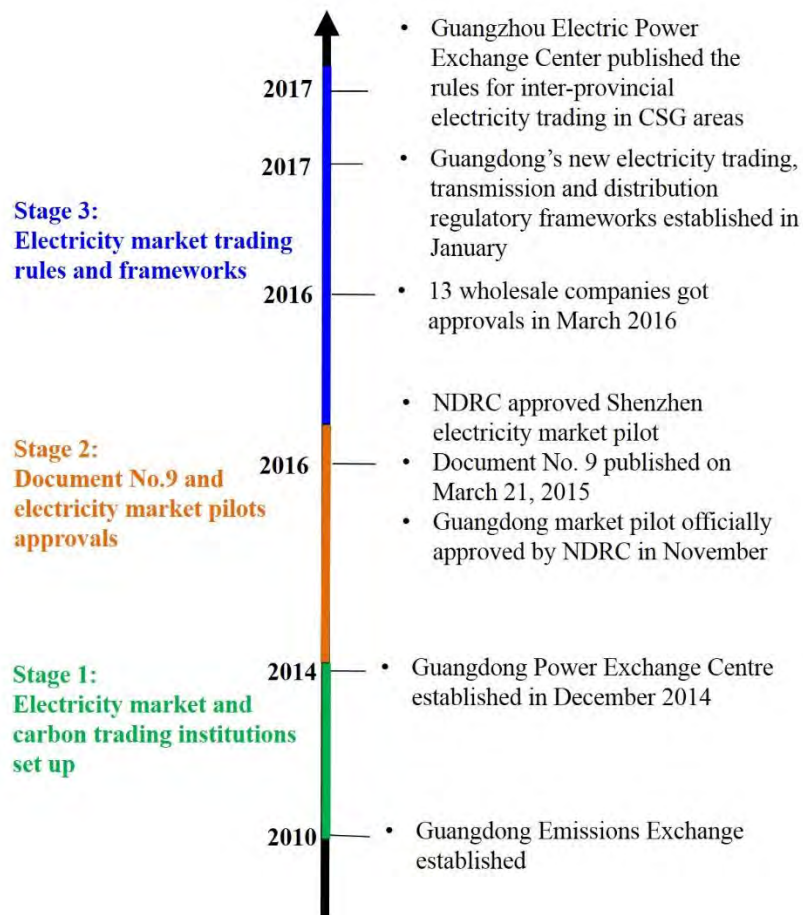
Guangdong is just one of the pilot power markets in China<sup>17</sup>. Other significant market pilots exist with differing degrees of coverage and discounts. Electricity prices are high in Guangdong due to lack of cheap gas, and longer distances for coal transportation, carbon prices will increase electricity prices more than elsewhere<sup>18</sup>. A timeline of significant recent power sector reform steps, relevant to Guangdong, is shown in Figure 2.



Source: Adapted from An Bo et al. (2015, p.6).

<sup>17</sup> See China5e Research Centre (2016); China National Development and Reform Commission (2015). “电力体制改革解读” Analysis of Electricity Institutional Reform, Remin Publisher, Beijing.

<sup>18</sup> Zhang (2017). See also Zhang and Xu (2017). “中国能源大省电力市场建设经验分析.” Electricity Market Construction Experience of Major Provinces of Energy in China. Electric Power, 2017, 50(4): 7-10.



Source: revised from Guangdong Power Exchange (2017b)

The retail market in Guangdong is being opened-up gradually, with the largest customers by voltage level being offered the chance to buy their power in the power market<sup>19</sup>. The process of registration for retailers and generators is the responsibility of the Economics and Information Commission (EIC) (see below). A monthly wholesale power market officially started trading in June 2016. As of August 2017, 310 retailers and 60 generators were registered in the market, of which 101 retailers were participating<sup>20</sup>.

b. The size of the electricity sector in Guangdong

The electricity sector in Guangdong is large, as shown in the Figure 3 below. Total production in 2014 was 380 TWh and capacity installed in 2014 was 91 GW (both larger than the UK in

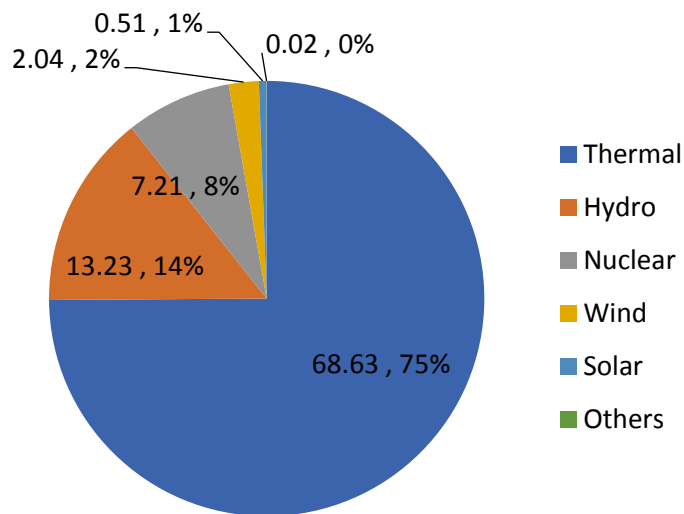
<sup>19</sup> See People's Government of Guangdong Province (2017). “广东电力市场交易基本规则（试行）” Retrieved from: [http://www.nea.gov.cn/2017-01/20/c\\_135999956.htm](http://www.nea.gov.cn/2017-01/20/c_135999956.htm)

<sup>20</sup> See Guangzhou Power Exchange Center (2017b).

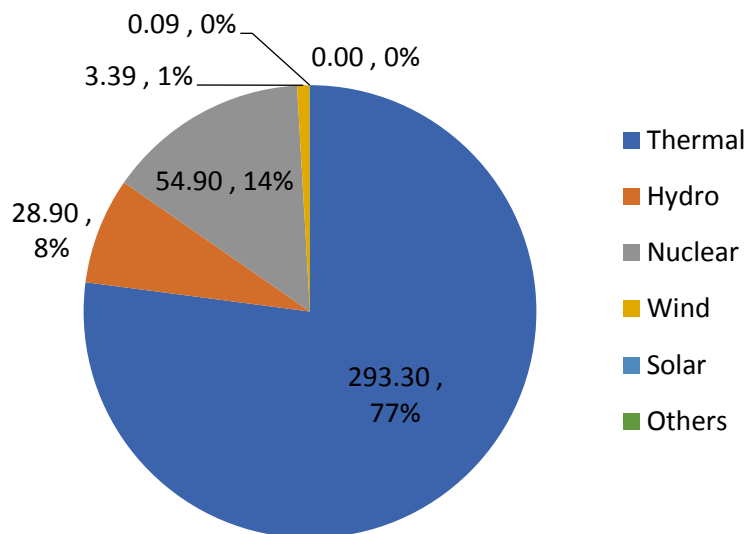


2016). Total demand in 2015 in 531 TWh and Guangdong was a significant importer of electricity from neighbouring provinces (particularly Yunnan).

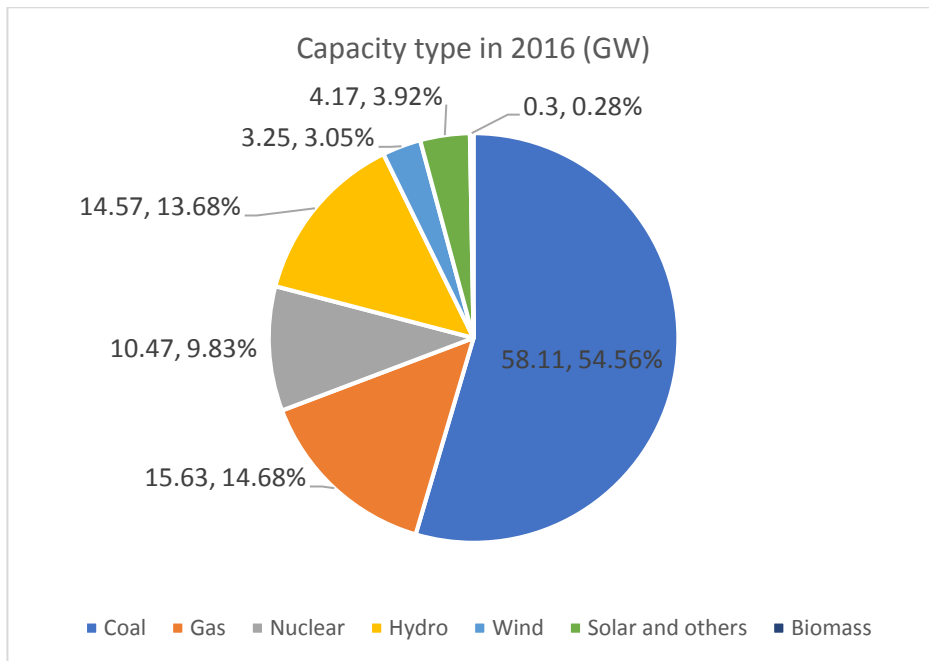
**Figure 3**  
**The size of the Guangdong electricity sector**  
 Capacity type in 2014 (GW)



Generation type in 2014 (TWh)

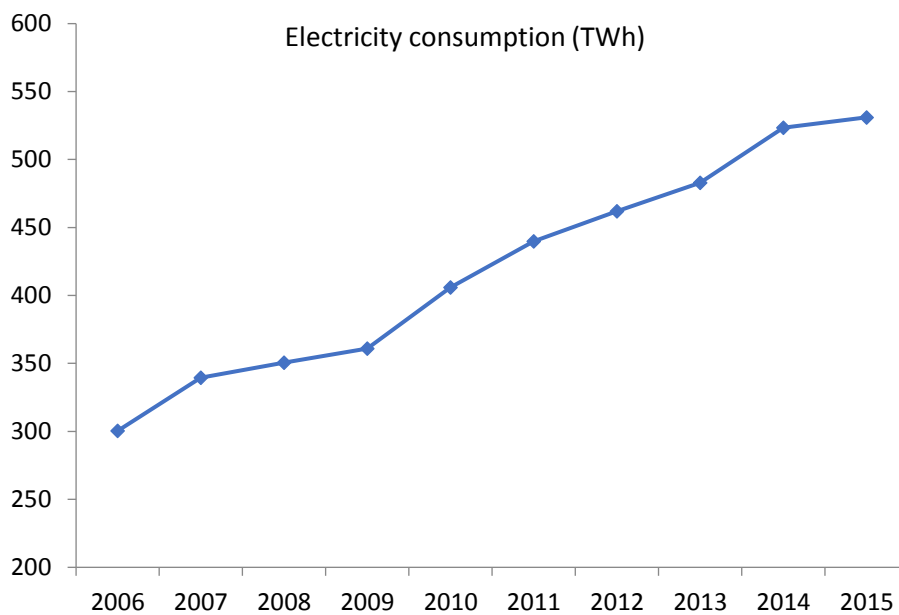


Source: China electricity statistics (2015)



Source: Guangdong Power Exchange Centre (2017)

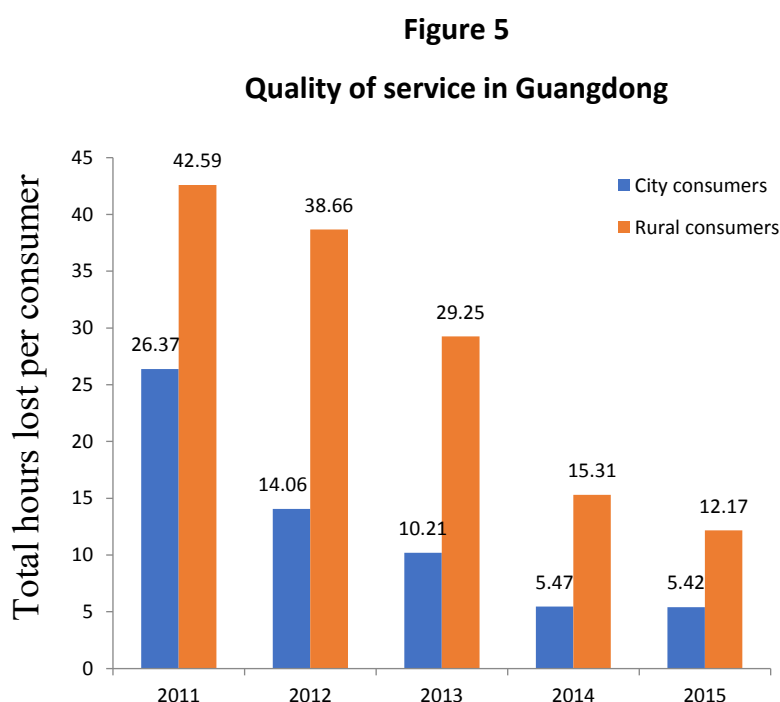
**Figure 4**  
**Electricity demand in Guangdong**



Source: Guangdong Government Statistics (2016)

<http://www.gdstats.gov.cn/tjnj/2016/directory/content.html?07-04>

Electricity demand in Guangdong has been growing rapidly (see Figure 4)<sup>21</sup>. Demand grew by 7.2% p.a. between 2006 and 2014. Demand growth slowed to 1.4% in 2015. The rate of construction of new power generation capacity was 10.15 GW in 2015 and 5.4 GW in 2016. The grid also continues to expand rapidly. 7274 km of new lines (of 220 kV and above) were added in 2015 and 4542 km of new lines were added in 2016.<sup>22</sup> The quality of service has been improving rapidly from a low base (see Figure 5), especially in the urban centres.



Source: China Southern Grid (2016) <http://www.csg.cn/shzr/zrbg/>

Table 1 compares Guangdong’s electricity prices to those of Texas. This shows the major driver of reform: the high price of industrial electricity relative to international competitors, such as the US. The final industrial price in Guangdong is significantly higher than in Texas. Some of this differential is to do with the price of natural gas (the marginal fuel in Texas) for power generation in the US vs the price of coal (the marginal fuel in Guangdong) for power generation in Guangdong (around 25% of the 8.4 cents / kWh). Most of the gap however is

<sup>21</sup> See also Yang et al. (2017). “广东电力市场需求侧响应交易机制研究.” Research on Demand Response Trading Mechanism in Guangdong Electricity Market, Guangdong Electric Power, 30(5), 25-34.

<sup>22</sup> Across the whole of the China Southern Grid area grid investment amounted to 77.5 bn RMB in 2016.

not explained by cost differences between Texas and Guangdong. By contrast, the price of residential electricity in Guangdong is lower than the price of industrial electricity and is cheaper than the residential electricity in Texas.

**Table 1**  
**Electricity price and fuel input price differential with US**

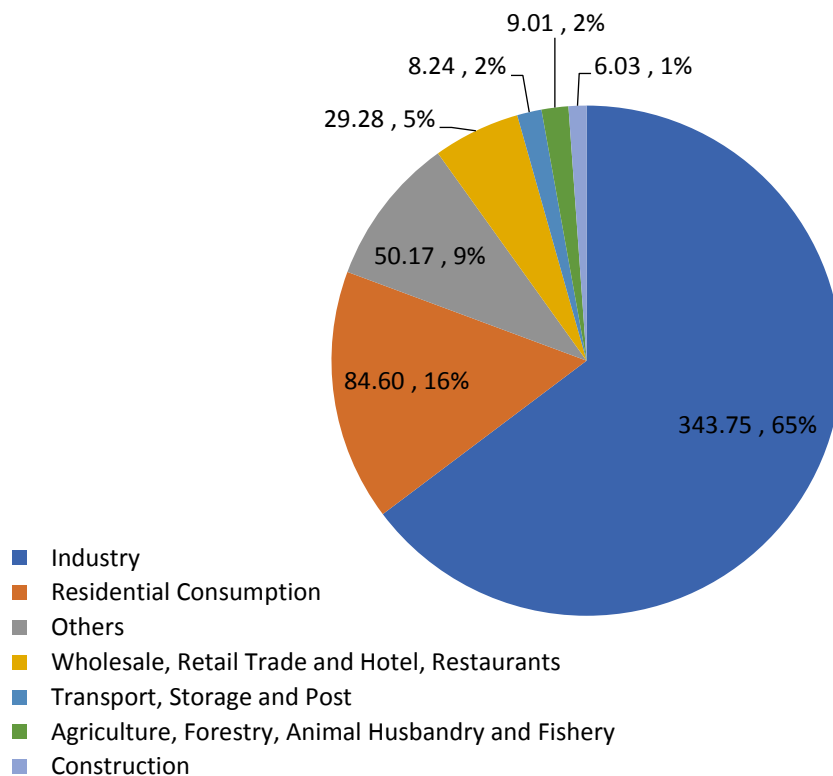
	<i>Industrial Electricity Price (US \$/kWh) In 2015</i>	<i>Coal price for generation (US \$/kWh)In 2015</i>	<i>Gas price for generation (US \$/kWh) In 2015</i>	<i>Residential Electricity Price (US \$/kWh)In 2015</i>
<b>Texas</b>	0.0554	0.0161	0.0094	0.1167
<b>Guangdong</b>	0.1394	0.0311	0.0884	0.1084
<b>Guangdong minus Texas</b>	0.0840 (152% higher)	0.0150	0.0790	-0.0083 (7% lower)

Sources: Fridley, David, Hongyou Lu, and Liu Xu. Key China Energy Statistics 2016. Berkeley, CA: Lawrence Berkeley National Laboratory, 2017 (p.28) ; Guangdong NDRC website: <http://www.sz.gov.cn/szzt2010/zdlyzl/sfxx/bz/jg/index.htm>; Zhang et al. (2013); EIA (2017); OECD energy price & taxes (pp.317-18); 1 USD = 6.2284 RMB.

Electricity demand (see Figure 6) in Guangdong is predominantly from industry (65%) with only a minority from residential consumers (16%). This is sharp contrast to developed countries, for example in Texas 37% of demand is from residential consumers and only 28% from industry in 2015.

**Figure 6**  
**Sources of electricity demand**

Source of electricity demand in 2015 (TWh)



Source: Guangdong Governmental Statistics (2016)

<http://www.gdstats.gov.cn/tjnj/2016/directory/content.html?07-04>

### 3. How the power market works

#### a. International context

Power markets have evolved gradually in many leading jurisdictions, such as the US and the UK. They have their origin in two fundamental ideas: 'merit order dispatch' and 'power pools'. Within monopoly generators such as EdF in France or the CEGB in England and Wales, power plants were dispatched in (merit) order of their marginal operating cost in order to meet system demand at any point in time<sup>23</sup>. System marginal cost was the marginal cost of an

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<sup>23</sup> See Chick (2007, pp.57-83) who discusses the history of marginal cost pricing in the electricity industries of Britain, France and the US.

additional MWh given the demand on the system at any time and represented the cost of the least expensive plant needed to supply the last MWh to meet demand. In the US, local integrated monopoly power utilities began to trade electricity across their territorial monopoly borders in order to mutually benefit from system savings arising from differences in their system marginal costs, with systems with lower marginal costs able to export power to those with higher marginal costs for mutual benefit. The trading platforms to allow this sort of trading were power pools, which eventually become the independent system operators we see today (such as PJM, MISO or ERCOT in the US).<sup>24</sup>

Power pools of this type were short run markets which guided plant operation over the hour or the half hour. The power market reforms of the 1990s saw a much deeper development of power markets with the breakup of the ownership of generation plants between multiple owners and the rise of new entrant generators. Wholesale power markets could now be used not just to trade power between systems but from all individual power plants. Power markets did not just cover short run (day ahead) markets but also contract markets for longer periods. Power markets have been extended from just energy to ancillary services, such as frequency regulation and capacity.

Stoft (2002) discusses what a full set of power markets looks like<sup>25</sup>. In the UK for instance, we observe bilateral energy contract markets (for monthly, annual and other periods) and short term energy balancing markets (down to one hour ahead of real time). We also see markets for ancillary services (e.g. for frequency and short term operating reserve). A capacity market, for longer term reserve capacity, has recently been introduced. These power markets are linked in the sense that changes in the supply and demand balance in one market has implications for the pricing in other power markets. Around the time of the earlier 2002 power market reform, which created China Southern Grid and the big five generators, Andrews-Speed et al. (2003) suggested a mandatory power pool for Guangdong<sup>26</sup>, followed

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<sup>24</sup> See for example, Hurlburt et al. (2017) who discuss lessons from MISO's experience for China.

<sup>25</sup> See Stoft (2002, pp.202-314) who discusses the complete set of energy markets and ancillary services markets.

<sup>26</sup> Andrews-Speed et al. (2003).

by a move to a regional power market. Zeng et al. (2004) discuss what a complete set of electricity markets looks like in the context of Guangdong<sup>27</sup>.

Power markets can be operated by the system operator or they can be operated by separate entities. In the US power markets tend to be operated by the independent system operator (which does not own any generation, retail or network assets). In Europe, a lot of wholesale power is traded across independent power exchanges, which are financial trading platforms, with limited ownership links to other parts of the electricity system (some still have transmission system operators as shareholders). Power exchanges have merged across Europe and are increasingly co-optimising their pricing algorithms to improve the efficiency of trading across a wide area. Thus, currently seven regional power exchanges coordinate their day-ahead pricing algorithms via a single trading platform (EUPHEMIA), so called 'market-coupling'<sup>28</sup>. This can give rise to a single day ahead price for wholesale energy across around 85% of the European Union's electricity in a given hour in the absence of any cross-border transmission constraints.

Efficient power market prices are about the extent to which prices reflect the underlying fundamentals of supply and demand over both the short and the long term and are a good guide to both short term operation and long-term investment. There are some excellent analyses of how the process of market extension has brought benefits in the short run. For example, ACER (2017) shows how the process of market-coupling has increased the percentage of the time in which power flows in the right direction (from low to high price areas)<sup>29</sup>, and Mansur and White (2012) show how market area extension by PJM has similarly improved pricing efficiency at its former borders<sup>30</sup>.

It is very important to say that in a power market every generator and every retailer that bids up to the market clearing price should be paid that price (in what should be a uniform price

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<sup>27</sup> Zeng et al. (2004). See also Bessembinder and Lemmon (2002).

<sup>28</sup> See APX et al. (2013) for a description of EUPHEMIA.

<sup>29</sup> Ibid.

<sup>30</sup> Mansur and White (2012).

auction)<sup>31</sup>. This is because they are equally valuable in matching supply and demand. Any other outcome would lead to incentives to game the bidding and would reduce the efficiency of the wholesale price determination process as a way of determining which supplies and demands should be matched in the market.

#### b. The power market in Guangdong

The wholesale power market is currently divided into 2 parts. The first is an annual bilateral negotiation once per year and this covers 80% of the traded electricity. In 2017, the annual traded quantity is 110 TWh, of which around 20 TWh is in the monthly market. This means that only 4% of total electricity demand (20% of 20%) is in the monthly market. There is a 20% limit on the market share of retailers in the monthly market, though no limits on retailer market shares in the annual market.

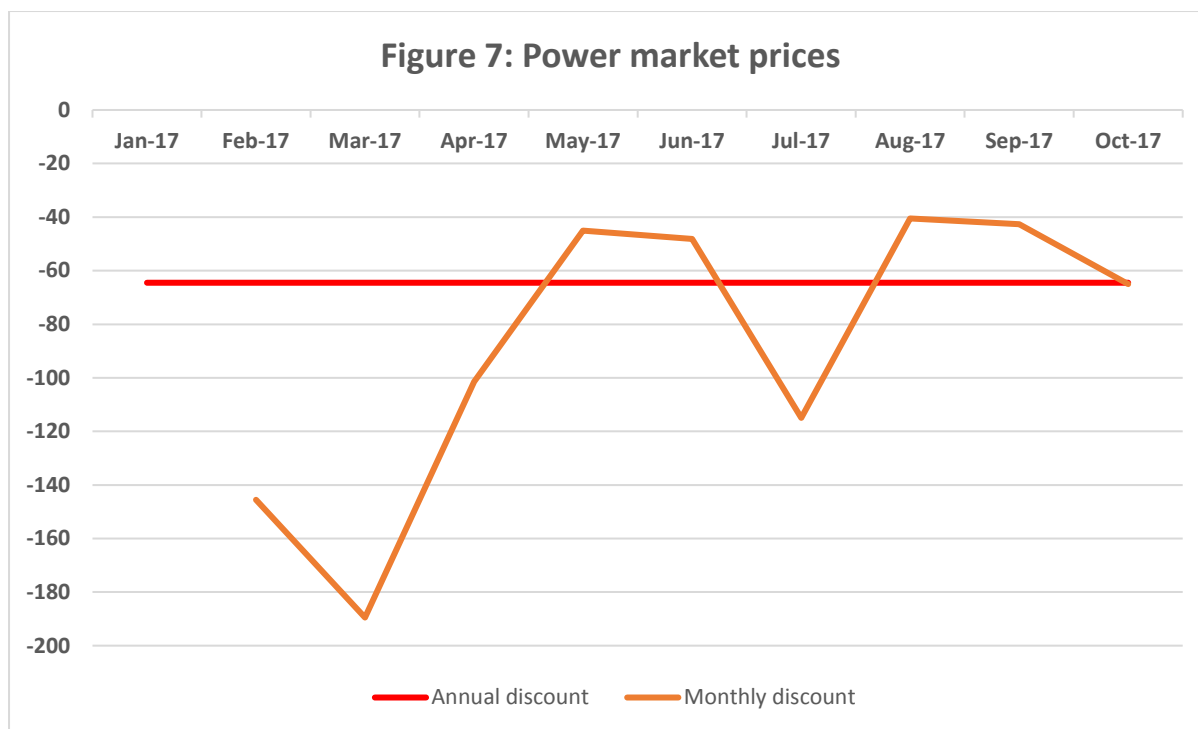
The current market price in the power market in Guangdong is actually a market determined discount on the regulated retail price<sup>32</sup>. The maximum discount is -500 basis points (1 point = 0.001Y per kWh). The market currently covers 4000 large users. A typical large user might be a large telecoms company or a metals factory. The annual market discount is around 64.5 basis points (0.0645 RMB / kWh), with the monthly discount fluctuating around this (see Figure 7). Prices already vary by time of day (peak-average-valley) by +/- 0.3 RMB / kWh. In 2018 the market will cover 180 TWh and all gas, nuclear, wind and hydro. Generators are paid a regulated price for their power by China Southern Grid (CSG) for all the power that they generate and supply to the grid. The power market determines a discount that generators are willing to accept on their regulated generation price.

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<sup>31</sup> See Stoft (2002, pp.93-106) for a discussion of auction designs for electricity markets. He argues against using untested market designs. Stoft (2002, p.101) has a discussion of the limited circumstances under which pay-as-bid might be preferred to a single price auction in electricity. For a more detailed discussion of discriminatory price auctions vs single price auctions, see Krishna (2010, pp.173-184).

<sup>32</sup> Li and Shen (2016). Guangdong Electric Power Trading Center yesterday officially launched mainly act as a "matchmaker", Top News. See also South China Energy Regulatory Bureau of National Energy Administration of PRC China (2015). "广东省电力大用户与发电企业直接交易扩大试点工作方案" Retrieved from: <http://nfj.nea.gov.cn/adminContent/initViewContent.do?pk=zwgk1492>





Source: <http://mp.weixin.qq.com/s/CBdmpsVFppV1j2WskWnPNQ>

China Southern Grid uses the market prices in the power market to discount both price it charges to retail customers in the power market and the price it pays to generators in the power market, it also pays the agreed margins to retailers in the power market<sup>33</sup>. These payments are reflected in the following month's payments/bills. This avoids the need to separate out the transmission and distribution charges that CSG is charging. Separating out the distribution and transmission charges for all customers is quite difficult because of the implicit cross subsidies between different customer groups within the current retail charges of CSG. A particular issue in Guangdong is that Pearl River Delta region subsidises economic development other parts of Guangdong, through paying higher electricity charges. As of August 2017, Guangdong had not yet published its transmission and distribution charges, which need to be approved by the National Development and Reform Commission (NDRC)<sup>34</sup>.

<sup>33</sup> Regulatory Assistance Project (RAP) (2016). See also Sung (2017). “广东电力市场改革和售电策略探讨.” Guangdong electricity market reform and sale strategy, Mechanical and Electrical Information, 2017 June, 89-90.

<sup>34</sup> On 7 November 2017, China NDRC just published Guangdong's transmission and distribution charges for 2017-2019 《国家发展改革委关于广东电网 2017-2019 年输配电价的通知》(发改价格〔2017〕969 号) <http://shupeidian.bjx.com.cn/news/20171107/859803.shtml> See also China National Development and Reform Commission (2016). “国家发展改革委 国家能源局关于印发《电力中长期交易基本规则（暂行）》” 发改能源〔2016〕2784 号 Retrieved from: <http://www.ndrc.gov.cn/zcfb/zcfbtz/201701/W020170112319053238252.pdf> See also China National

However Shenzhen has published network charges because it has its own transmission and distribution grid which made it easier to calculate its underlying cost<sup>35</sup>.

All meters are currently owned by CSG. This reduces a substantial potential source of competition and benefit for customers. Customer/retailer ownership of meters would give incentives for better use of meter data and meter equipment. However it would also necessitate regulation of meter quality and connection to prevent fraud. CSG still dominant in the electricity supply industry in Guangdong, distributing 829.7 TWh in 2016 and having 473bn RMB (c. \$71bn)<sup>36</sup> of revenue. CSG is 95<sup>th</sup> in the Fortune 500. CSG is managing all of the payment risk in the sector because it collects all the revenue and distributes it to the market participants.

Another issue in Guangdong is unregistered generation<sup>37</sup>. This is self-generation which is being used to bypass the high grid and other charges that are levied on electricity from the grid. This generation is mainly from smaller dirty coal fired power plants.

The ultimate goal for power market reform is to open up all industrial and commercial users to competition. It might also be that residential customers could participate in the power market on a voluntary basis. Published grid charges are being recalculated every 3 years in line with NDRC pricing formula which includes a fixed price and an inflation adjustment. It is envisaged that a spot market will begin at the end of 2018<sup>38</sup>. There is currently (December 2017) no timeline for the introduction of a frequency regulation market. The spot market will likely be hourly day-ahead with 17% of energy in the spot market in phase 1. In phase 2 intra-day trading will be allowed. There is no market for demand side response. There is a general

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Development and Reform Commission (2017). “国家发展改革委关于印发《省级电网输配电价定价办法（试行）》”发改价格〔2016〕2711号 Retrieved from:

[http://www.ndrc.gov.cn/fzgggz/jgggl/zcfg/201701/t20170104\\_834333.html](http://www.ndrc.gov.cn/fzgggz/jgggl/zcfg/201701/t20170104_834333.html)

<sup>35</sup> See China National Development and Reform Commission (2015). “国家发展改革委关于深圳市开展输配电价改革试点”发改价格【2014】2379号 Retrieved from:

[http://jgs.ndrc.gov.cn/zcfg/201411/t20141104\\_639639.html](http://jgs.ndrc.gov.cn/zcfg/201411/t20141104_639639.html)

<sup>36</sup> At \$1 = 6.64 RMB.

<sup>37</sup> See China Electric Council (2017) 告别无序竞争 电力市场呼吁售电专业化时代

<http://www.cec.org.cn/xinwenpingxi/2017-10-30/174433.html>

<sup>38</sup> China National Development and Reform Commission (2017). “国家发展改革委关于印发《省级电网输配电价定价办法（试行）》”发改价格〔2016〕2711号 Retrieved from:

[http://www.ndrc.gov.cn/fzgggz/jgggl/zcfg/201701/t20170104\\_834333.html](http://www.ndrc.gov.cn/fzgggz/jgggl/zcfg/201701/t20170104_834333.html)

preference to develop a market which is closer to PJM than typical markets in Europe and some suggestion that experimentation with nodal pricing is possible<sup>39</sup>. We note that a spot market has been planned in China since at least 2008 and is yet to materialise<sup>40</sup>.

#### 4. *New players*

##### a. International Context

A striking impact of power market reform in many leading jurisdictions is the proliferation of companies actively involved in the trading of electricity (in the widest sense). The creation of wholesale markets is premised on the creation of a separate supply and demand side in the wholesale market. Generators are on the supply side and retailers are on the demand side. For wholesale markets to function efficiently there needs to be multiple generators and multiple retailers. It is not enough for there to be one large generator selling to one large retailer. Thus, in the US and Europe we have seen generation and retail opened up to competition.

Large industrial and commercial customers have been allowed to shop around for a retailer/supplier (or indeed are free to set up a retail/trading company directly). Similarly, generators have been able to enter the retail market i.e. to directly acquire final customers for their electricity. Some of the retail companies have been set up by third parties new to the electricity industry, often with experience in gas, telecoms or financial markets. The most successful of these third-party entrants have been those from the gas industry (e.g. British Gas in the UK is the largest new entrant into the electricity sector, with half of all the customers who switched from their incumbent supplier switching to British Gas, or GdF-Suez

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<sup>39</sup> Tung and Huang (2017). “美国 PJM 电力市场及对广东电力改革的启示” Experiences in PJM Market in the United States: A Good Reference for the Power Market Reform in Guangdong Power Grid, Yunnan Electric Power, 2017, 45(1). See also Zhang et al. (2015), “售电侧市场放开国际经验及其启示” International Experience and Lessons in Power Sales Side Market Liberalization, State Grid Energy Research Institute. Retrieved from: [http://www.aeps-info.com/aeps/ch/reader/create\\_pdf.aspx?file\\_no=20151128001&flag=1&journal\\_id=aeps&year\\_id=2016](http://www.aeps-info.com/aeps/ch/reader/create_pdf.aspx?file_no=20151128001&flag=1&journal_id=aeps&year_id=2016)

<sup>40</sup> Please see the latest progress of spot market pilots in China at [http://www.nea.gov.cn/2017-09/05/c\\_136585412.htm](http://www.nea.gov.cn/2017-09/05/c_136585412.htm) See also Tsai et al. (2017). “英国电改专家怎么看待中国电改，给了什么建议？——专访剑桥大学能源政策研究所副所长迈克尔·波利特教授” Interview with Professor Michael Pollitt, Energy Observer, Retrieved from: <http://www.eothinker.com/eo/show.php?itemid=569>

who have been very successful in entering the industrial and commercial electricity markets in Northern Europe).

In the UK there has been a proliferation of generators and retailers who participate in wholesale power markets. Immediately prior to the power market reform in 1990 there were 14 retail area monopolies in Great Britain (i.e. 1 retailer per customer). There were 2 regional generation companies. The 1990 reform created a market with 6 generators (the CEGB was effectively separated into 4 parts) and 14 former area monopoly retailers. The former gas retail monopoly for Great Britain (British Gas) immediately entered the retail market, as did the 4 former CEGB generators seeking to acquire final customers directly. New generators could also enter both generation and retail, as could stand alone retailers. In 2017 there are 149 licensed generators and 68 industrial and commercial retailers in the UK wholesale power market<sup>41</sup> and market had very low generator and retailer concentration.

Generators and retailers are exposed to significant market risks that need to be managed. Generators have both fixed and variable costs that need to be covered by their sales revenue. Likewise retailers mostly sell power at fixed prices for a year to their customers, with a guarantee to supply of all of their demand. This exposes both parties to significant potential financial risks. A sharp rise in wholesale power prices could bankrupt retailers, a sharp fall in wholesale prices could bankrupt generators. This encourages both parties to hedge their positions with longer term fixed price contracts (for 1-2 years) for most of their generation/sales. This limits their financial exposure to short term wholesale prices. This happens regardless of what percentage of power is actually traded in short term markets. In PJM in the US generators have to trade all of their power in a compulsory day-ahead market, while in Great Britain generators trade only around 5% of their power in the near real time balancing market. In Great Britain cases the degree of bilateral contracting (direct contracts between buyers and sellers) is of the order of 90% of all traded contracts.<sup>42</sup>

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<sup>41</sup> See Ofgem (2017).

<sup>42</sup> See Ofgem (2016) which reports that most power that is traded in Great Britain is traded in OTC (over the counter) contracts, not via power exchanges.

Retailers and generators participate directly in power markets in Europe and North America. Retailers also have to manage their own billing and collection systems. They have to pay relevant government taxes and charges on power, network charges and wholesale costs. Non-payment or miss-billing is a serious issue, because retail margins (i.e. the difference between all their external costs and the revenue they receive are small, of the order 5-10% of total revenue). Retail companies have been bankrupted by poor data management and billing (e.g. Independent Energy in the UK in 2000<sup>43</sup>). Generators exposed to low wholesale prices have also been bankrupted (e.g. British Energy<sup>44</sup> and TXU Europe<sup>45</sup> in 2002 in the UK).

Another set of new players in deregulated electricity markets are energy service companies who seek to manage the energy costs of electricity customers. These companies can have a range of business models including owning electricity assets and selling power at a fixed price (rather like a conventional generator) or seeking to manage electricity costs through better metering and finding the best market price<sup>46</sup>. Energy service companies are often IT based enterprises that focus on aggregating demands across their customers and seeking the best price for their customer base and then sharing cost savings with them. They would mostly not be exposed to full market price risk in the same way as a conventional retailer, but essentially receive a fee for service.

Power market reform is not just about wholesale markets, it is also about the introduction of incentive regulation of power networks.<sup>47</sup> Pressure to cut costs across the electricity industry – in both generation and networks – creates pressure to competitively outsource supply contracts for the creation and operation of new generation and network assets.<sup>48</sup> This creates or widens procurement markets. Existing companies often divest their construction

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<sup>43</sup> See M. Harrison, 'Independent Energy collapses with customers still owing £119m in bills', *The Independent*, 8 September 2000. Available at:

<http://www.independent.co.uk/news/business/news/independent-energy-collapses-with-customers-still-owing-pound119m-in-bills-699827.html>

<sup>44</sup> See Taylor (2007).

<sup>45</sup> See M. Harrison, 'Generators exposed after collapse of TXU Europe' *The Independent*, 20 November 2000. Available at:

<http://www.independent.co.uk/news/business/news/generators-exposed-after-collapse-of-txu-europe-128536.html>

<sup>46</sup> For a discussion in a European context see Marino et al. (2011).

<sup>47</sup> See Jamasb and Pollitt (2007).

<sup>48</sup> See Lohmann (2001).

businesses and seek to run tenders for new business. For example, many of the distribution companies in Europe sold their construction and IT businesses and sought to run more tender processes for the supply of services<sup>49</sup>.

b. New energy market players in Guangdong

**Figure 8**

**Generator and Retailer market shares in Guangdong in 2017**

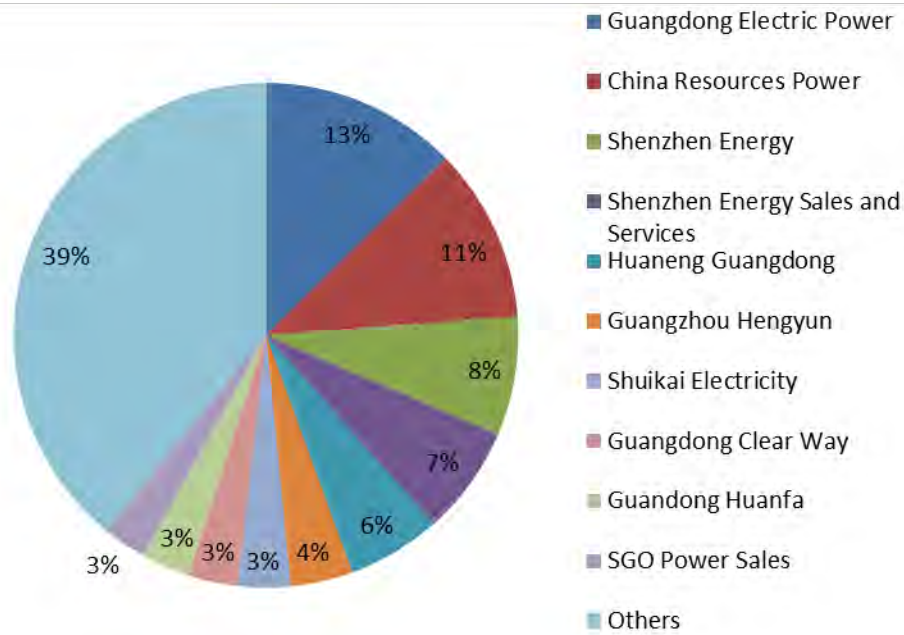
**A. Generator Capacity Shares**



Source: <http://mp.weixin.qq.com/s/CBdmPsVFppV1j2WskWnPNQ>

**B. Retailer Market Shares**

<sup>49</sup> See Hermann and Pond (2012).



Source: [http://www.sohu.com/a/213958006\\_679911](http://www.sohu.com/a/213958006_679911)

Figure 8A shows the generator market share in Guangdong among all generation. Figure 8B shows the market shares in the liberalised power market. The wholesale market in Guangdong is attracting new players into the market. Of the 13 largest retailers, 3 are privately owned and 10 publicly owned<sup>50</sup>. For example, the privately owned Shenzhen Energy Sales and Services Company (SESS) is a new entrant formed (30 January 2015) soon after the market pilot was announced<sup>51</sup>. The firm does energy retailing, energy and power contract management, software, renewable energy projects, building incremental grid and power management research. It focuses on big data and IT management, with a management team drawn from both the electricity and IT sectors. It was the first company to be granted a retail permit. At the centre of its operation is a retail management platform, it has a retail market share of around 10% in the wholesale power market. It can offer a number of value added services to its retail customers including: power system emergency response, technical consultancy, preventative testing, engineering management, price monitoring, load control, accurate measurement in real time etc. Many of these services are currently included in the market discount, but eventually SESS may be able to charge separately for some of them. In

<sup>50</sup> See Wen (2017). Sung (2017). “广东电力市场改革和售电策略探讨.” Guangdong electricity market reform and sale strategy, Mechanical and Electrical Information, 2017 June, 89-90.

<sup>51</sup> See the official website of SESS 深圳市深电能售电有限公司 (in Chinese) available at: <http://www.sz-sess.com/index>.

the future retailers will be able to add value through data mining and focusing on smart energy and smart grids rather than asset heavy solutions. Data mining will allow different consumers in the same sector to be compared to each other, in order to offer better energy efficiency advice. Other market participants include established generation companies, such as China Resources Power (a large conglomerate) who established their CRP Sales company in November 2015, they offer energy and efficiency management services and professional equipment and repair services<sup>52</sup>. Retailers are interested in competition in connections, whereby they compete with CSG for network extensions. This is because the profit margin on a grid extension is currently substantially more per TWh than in generation.

There are currently three major types of retail contracts that retailers seek to sign with electricity customers<sup>53</sup>. First, minimum discount contracts, where the retailer guarantees a fixed discount on the regulated price and then keeps anything above this that they can save in the wholesale market. Second, sharing contracts where 80-90-95% of the market discount goes to the customers and the retailers keep the rest. Third, combination contracts which combine minimum discounts with sharing. Imbalance charges are imposed if retailers over or under use power relative to their contracted position in the power market. Retailers are incentivised to match supply and demand as they must keep their total imbalance within +/- 2% of their contracted amount. There are strong incentives to match supply and demand. Imbalance charges for retailers are set at +/-5% of the power market price. Some retailers share imbalance risk with their customers, others absorb it up to a point. Retailers can offer value added services through energy efficiency advice and investment. Some retailers are demonstrating very high levels of accuracy in matching their contractual position to their actual monthly demand (i.e. +/-3% per individual contract), others are very inaccurate (i.e. +/- 30%). Retailers are not able to trade between themselves but generators can do this from June 2017.

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<sup>52</sup> See the official website of China Resource Power (华润电力) available at: <http://www.cr-power.com/en/>

<sup>53</sup> People's Government of Guangdong Province (2017). "广东电力市场交易基本规则（试行）" Retrieved from: [http://www.nea.gov.cn/2017-01/20/c\\_135999956.htm](http://www.nea.gov.cn/2017-01/20/c_135999956.htm); People's Government of Guangdong Province (2017). "广东电力市场建设实施方案", Retrieved from: <http://dp.meizhou.gov.cn/show/index/630/15611>; See also Shu et al. (2016).



An important objective of power market reform in China is to prepare for the internationalisation of the Chinese power sector. The maturing of the Chinese power system will inevitably mean a reduction in the demand for power equipment within China, with consequences for the productive capacity of the power system. One strategic response to this, in line with the 'One-Belt One-Road' policy is that supply chain companies within China will need to seek new markets abroad<sup>54</sup>. It further suggests the benefit of spinning out separate companies from existing ones to create more nimble companies better able to bid for contracts in a competitive environment (perhaps, against other Chinese companies). A good example of this is Guangdong Electric Power Design Institute Co. Ltd of China Energy Engineering Group (GEDI) which is an engineering and project contracting company, responsible for delivering power projects<sup>55</sup>. It was formally separated from China Southern Grid in 2017. GEDI now has around 40% of its business outside China.

## 5. *Effects on Dispatch*

### a. International Experience

The creation of wide area wholesale markets can effect prices in two ways.

First, by exposing the existing prices to challenge it can mean that generators and retailers are forced to set prices which more accurately reflect supply and demand conditions. Thus if there is actually too much generation relative to demand at the initial prices, prices should fall as generators and retailers are forced to reduce prices to bring supply and demand back into balance. This could be as simple as showing up the fact that the previous regulated prices for generation and retail were too high. Thus markets reduce rents (or monopoly power) in the electricity sector (i.e. improve allocative efficiency). Such an effect can be seen in both shorter run (day ahead) and longer term (monthly) wholesale markets. However it is

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<sup>54</sup> China National Development and Reform Commission and National Energy Administration (2016), " 电力发展“十三五”规划（2016-2020年）” NDRC, NEA: Electricity Sector Development under 13th Five-Year Plan (2016-2020), 25 December, 2016, Retrieved from: <http://www.sdpc.gov.cn/zcfb/zcfbghwb/201612/P020161222570036010274.pdf>.

<sup>55</sup> See the official website of Guangdong Electric Power Design Institute Co. Ltd (广东电力设计院) available at: <http://www.cccme.org.cn/shop/cccme8977/index.aspx>

important to say that prices might initially be too low relative to supply and demand conditions, as a result of regulation forcing retailers/generators to charge too little. In this case the introduction of a wholesale market will (correctly) raise the price of electricity.<sup>56</sup>

Second, a wholesale market should bring about an increase the efficiency of production. This is because whatever the previous system of allocating power between different power plants there are now stronger incentives to allocate power to the least cost power plants first<sup>57</sup>. Wholesale markets cause plants to make bids related to costs and to only run if they are part of the least cost group of plants that can meet system demand. Extension of the market across previously non-integrated areas causes competition between plants on the basis of price bids, where the lower price bid plants will be dispatched first. Because being dispatched now depends on the competitiveness of the price bid in the market, individual plants have strong incentives to cut costs in order to remain competitive. This is especially true of similar plants which are in the price setting part of the generation bid curve. Here, slightly higher costs can be the difference between winning a contract in the wholesale market or not, and in longer run make the difference being viable or being shut down. Thus markets should incentivise plants to minimise costs (i.e. improve productive efficiency). In turn this gives rise to only invest in power plants which are least cost and which have a positive net present value (NPV) given expected future market prices. This effect of the introduction of wholesale markets would seem to require short term markets (normally, day ahead), as it is in efficient real time operation that potential dispatch savings relative to current operation are likely to be realised. Once again it is important to say that if prices are initially too low relative to the competitive level, a wholesale market will raise them and cause all plants to be paid more and bring forth more generation from higher cost plants.

The impact of wholesale power markets on underlying efficiency of operation and investment in power generation is a function of prices being allowed to affect the actual dispatch of power plants. In European markets such as Great Britain, exposure to wholesale market prices

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<sup>56</sup> See Pollitt (2004) for a discussion of the case of Chile where wholesale electricity market prices have been fluctuating up and down (driven by water scarcity) since 1982. Parades (2003) discusses the links between price fluctuations and performance in the case of Chilean public services.

<sup>57</sup> See Newbery and Pollitt (1997) for an analysis of the impact of the introduction of a wholesale power market in England and Wales on operational and investment efficiency.

gives generators an incentive to self-dispatch only their least cost mix of plants. In US markets price bids are used to determine which plants are dispatched by the system operator on the basis of day-ahead price bids, in centrally dispatch systems. In both cases actual dispatch and price bids are closely related. Indeed, in both these types of markets the underlying price bids directly determine the dispatch decisions. Arguments continue as to whether central dispatch or self-dispatch algorithms are to be preferred. Central dispatch economises on the need for individual generation companies to self-optimize and predict what else might be running on the system. Self-dispatch ensures that all information on the firm's costs and contractual position is taken into account in determining whether it wants to run particular plants, regardless of the payment rules of the market. The Competition and Markets Authority in the UK recently concluded<sup>58</sup> that GB's self-dispatch system and the typical central dispatch system in the US were equally efficient.

Across Europe and North America market extension has been very important for both allocative and productive efficiency. The efficient use of interconnector capacity between European countries has been a way that production has been reallocated between countries to reduce total system costs, while in PJM market extension has also reallocated production within previously separately dispatched areas. This effectively increases competition within separate markets and ensures that the least cost plants are dispatched across the whole market area.<sup>59</sup>

#### b. Effects on dispatch in Guangdong

There have been substantial impacts on the financial returns to coal fired power generation in Guangdong as a result of the recent power market reform. Ng (2016) predicts returns to fall from 9% in 2016 to 5% by 2018<sup>60</sup>. China Light and Power (CLP) have already announced a sharp drop in profits in their generation business in southern China, as a result of power market reform.<sup>61</sup>

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<sup>58</sup> CMA (2016, pp.183-188).

<sup>59</sup> See Mansur and White (2012) for an analysis of benefits of market extension in PJM.

<sup>60</sup> Ng, E. (2016).

<sup>61</sup> See China Light and Power Group (CLP) (2016).

Across the CSG area there are 4 levels of dispatch<sup>62</sup>: (1) the CSG level, which includes West to East interconnection; (2) provincial grid; (3) city level (including Guangzhou and Shenzhen); and (4) county level, which includes distributed generation (e.g. small hydro). All coal, some gas CHP and all nuclear are subject to provincial level dispatch in Guangdong.

Dispatch decisions by the system operator are not directly influenced by wholesale market contracts. These are still occurring according to the dispatch rules which applied before the advent of market trading, i.e. on an allocated running hours basis. This is different from other power markets where prices in the power market should influence which plants physically run. Generators do know their contractual position in the power market and hence can in theory signal to the system operator that they are either available or not available accordingly. This knowledge also allows generators to trade power between themselves. There have been some coal savings as a result of sharper incentives to align supply and demand (in which case it is better to run cheaper coal fired power plant).

Dispatch may be reformed<sup>63</sup>. Two models being tested: an auxiliary test where the plant needs to follow instructions as to whether it is to run; and the declaration of plant availability in 5 days time. There are no plans to implement self-dispatch as an answer as to how to incorporate information about underlying contractual position into the power market.

Interprovincial trading of electricity is conducted via two trading centres in Guangzhou and Beijing<sup>64</sup>. There is a toll fee for power that is transmitted from Yunnan into Guangdong of 0.45/0.35 RMB per kWh (this is very high in relation to the prices paid to generators in Guangdong)<sup>65</sup>. Guangdong imports 1/3 of its power from Yunnan. The amount of trading between Yunnan and Guangdong is subject to negotiation and while it would seem to be

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<sup>62</sup> See China Southern Power Grid (CSPG) (2016), Corporate social responsibility report 2016. Retrieved from: <http://www.csg.cn/>. See also Wang et al. (2006).

<sup>63</sup> See Ho et al. (2017).

<sup>64</sup> Zhang et al. (2014).

<sup>65</sup> The 2017 figures for payments to generators in Guangdong are: coal - 0.4505 RMB/kWh (source: <http://news.bjx.com.cn/html/20170418/820743.shtml>); gas - 0.745 RMB/kWh, (source: <http://shoudian.bjx.com.cn/news/20171010/854086.shtml>); Wind -0.61 RMB/kWh (source: <http://news.bjx.com.cn/html/20151215/691707-2.shtml>); and solar - 0.85 RMB /kWh (source: <http://news.bjx.com.cn/html/20161227/799707.shtml>).

mutually beneficial, there are winners and losers within each province. In Yunnan coal generators will likely see revenues decline (due to competition with coal fired generation in Guangdong) and market customers will likely pay higher prices, while in Guangdong all generators will likely be worse off, while customers are likely better off. Yunnan has a spot market, but it is 95% hydro and not likely to be fully integrated with Guangdong soon<sup>66</sup>.

## 6. Key points for improvement

### a. Discussion of overall impressions of reform

One striking thing is the lack of transparency of the final retail price in different areas of Guangdong. Retailers are unaware of the final prices that their customers actually pay<sup>67</sup>. This is because this is still the responsibility of CSG. There is substantial variation in final retail prices for the same type of customer across Guangdong with six major pricing zones<sup>68</sup> (originally there were 71) from the point of view of CSG. County level final prices are different, particularly between the Pearl River Delta (PRD) and non-PRD areas where different taxes and subsidies apply. There are 21 municipalities in Guangdong and 19 different prices for electricity. Final prices can vary from 0.1 to 0.2 RMB per kWh on the basis of transmission and distribution charges alone between price areas<sup>69</sup>. Final prices are made up of guideline generation prices, utilisation charges, cross subsidy charges and transmission and distribution charges, in addition to any market discount.

The monopoly transmission and distribution charges is significant in overall reform effects. As Pollitt et al. (2017) discuss the introduction of incentive regulation has been a large source of the overall impact of electricity reform on final prices. In January 2017 the NDRC required all

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<sup>66</sup> See Guangzhou Power Exchange Center (2017). 《南方区域跨区跨省月度电力交易规则（试行）》， Retrieved from: <https://www.gzpec.cn/main/index.do>. See also Meng, T. Li, C. & Chang, T. (2016). “未来广东电力市场下实时调度规则思考” Guangdong Science & Technology, 2016, 25(16).

<sup>67</sup> See Shu et al. (2016). “基于优化理论市场化的日前电力市场机制设计” Day ahead Electricity Market Design Based on Market Interpretation of Optimization Theory, Automation of Electric Power Systems. Vol. 40, No. 2.

<sup>68</sup> Five pricing zones across Guangdong in addition to Shenzhen.

<sup>69</sup> See National Energy Administration China's official announcement on 13 November 2017 “广东各价区输配电度电价最低-5.16分/千瓦时” Retrieved from: [http://www.nea.gov.cn/2017-11/13/c\\_136749039.htm](http://www.nea.gov.cn/2017-11/13/c_136749039.htm).

provinces to publish separate electricity network charges<sup>70</sup>. Guangdong's NDRC office published its charges in November 2017, fixed in nominal terms for the three years 2017-2019<sup>71</sup>. This office also announced a reduction in the regulated transmission and distribution charges in January 2018 of 0.0233 RMB per kWh for all customers<sup>72</sup>. Adding this to a discount of -0.0645 RMB / kWh in the power market, industrial customers participating in the power market will see reductions of up to -0.0878 RMB / kWh (before payment of the retailer cost). This is equivalent to \$0.0141 / kWh or 10% of the 2015 industrial electricity price (in Table 1 above).

Three agencies are responsible for regulation of the power sector in Guangdong.<sup>73</sup> The Electric Power section of the Economics and Information Commission (EIC) of the Guangdong Development and Reform Commission (DRC) is responsible for the market and licensing of market participants. The Pricing Section of the DRC is responsible for the calculation of T+D charges. The South China Energy Supervision Bureau (part of the NEA) is responsible for some of the monitoring. All three bodies are responsible for monitoring of how competitive the market is. There would seem to be a lack of clear responsibility for monitoring competition in the power market between different branches of government and there is currently legal dispute as to whether China's Anti-monopoly Act – i.e. general competition law - applies to the power sector<sup>74</sup>. An independent regulatory agency at the provincial level should be responsible for market participant licensing, market design changes, the setting of regulated

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<sup>70</sup> See NDRC's official announcement on 22 December 2016 publishing NDRC Price Reform Document 2016 No. 2711 “省级电网输配电价定价办法（试行）” Retrieved from:

[http://www.ndrc.gov.cn/gzdt/201701/t20170104\\_834330.html](http://www.ndrc.gov.cn/gzdt/201701/t20170104_834330.html)

<sup>71</sup> See NDRC Guangdong office's Price Reform Document 2017 No. 498 “广东省发展改革委关于调整销售电价等有关问题的通知” Retrieved from:

<http://www.gzns.gov.cn/zwxgk/zdlyxxgk/jghsf/201707/P020170726493877075556.pdf>.

<sup>72</sup> See NDRC Guangdong office's Price Reform Document 2017 No. 498 “广东省发展改革委关于调整销售电价等有关问题的通知” Retrieved from:

<http://www.gzns.gov.cn/zwxgk/zdlyxxgk/jghsf/201707/P020170726493877075556.pdf>.

<sup>73</sup> See People's Government of Guangdong Province (2017). “广东电力市场监管实施办法（试行）” Retrieved from: [http://www.nea.gov.cn/2017-01/20/c\\_135999956.htm](http://www.nea.gov.cn/2017-01/20/c_135999956.htm). See also Sun and Su (2017). China, The Energy Regulation and Markets Review (Edition 6), Edited by David L Schwartz, Law Business Research for a discussion of the government institutions overseeing the energy sector.

<sup>74</sup> The first legal case regarding the applicability of the Act to the power sector appeared in Shanxi in June 2017, when the regulator applied the Act to several generators. This is being challenged by the generators who are challenging whether the Act can apply given that there is not a fully competitive electricity market. See <http://finance.sina.com.cn/roll/2017-08-08/doc-ifyitapp2997520.shtml>; [http://news.xinhuanet.com/2017-06/06/c\\_1121092318.htm](http://news.xinhuanet.com/2017-06/06/c_1121092318.htm); and

<https://hk.saowen.com/a/ba4f85af87d5d5a78c9572a60e62b11de7ac497c60818c08dad5a55649576c81>.

network charges and the monitoring of competition. This would have the distinct advantage of pooling administrative resources and experience and in developing regulatory competence on the part of the authorities. Pollitt et al. (2017) discuss the importance of independent regulation in the international experience of power sector reform and apply this specifically to China. Li and Yu (2017) discuss legal reforms to the supervision system for the power sector which would promote reform<sup>75</sup> in a Chinese context.

The introduction of new retailers into the power system has had three positive effects. First, it has improved understanding of the nature of the electricity product and customers have been made more conscious of pricing and energy management. Second, the government has gained an understanding of what it means to move from an administered price to a market price. Third, retailers have improved service quality to customers relative to CSG.

The ownership of generation in Guangdong is concentrated with the largest company (Yudean) having around 35% market share of capacity, with the next largest firm having 20%. Yudean is affiliated with the China Huaneng Group (a national big 5 generator)<sup>76</sup>, but is significantly concentrated within the CSG area. This is true not only of total capacity, but also in terms of peak generation. This suggests there may be some value in swapping assets between state owned generators to create more competition in bidding.

The current power market only covers 20% of demand. This is 30% of in-province generation though it is higher for coal fired power plants in Guangdong (perhaps 40%). The marginal cost of power in the power market can be less than the marginal fossil fuel cost of production. This is because of start-up, shut-down and part-loading costs. For a given coal fired power plant, failure to sell to power in the power market might require reduced power output. If this raises remaining marginal fuel costs (due to part-loading) or requires an expensive shut down of a plant/start-up cost of another plant, then a bid below marginal fuel cost would be optimal.

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<sup>75</sup> Li and Yu (2017).

<sup>76</sup> Yudean is 24% owned by China Huaneng Group and 76% by the People's Government of Guangdong Province (see <http://www.gdyd.com/site/yudean/gsjj/index.html>).

A significant problem is that there is too much demand relative to supply in the partly liberalised market<sup>77</sup>. This results in retailers simply bidding the regulated price of power with a slight discount on the final amount of energy that they want to purchase in order to reduce the market price (due to the price determination process, explained below). The monthly supply and demand curves do not actually cross, see for example the figure for February and March 2017, illustrated in Figure 9.<sup>78</sup>

**Figure 9**  
Initial market clearing result of monthly future market  
in Guangzhou Power Exchange Center



Source: E-Power (2016) and Zhang (2017)

<https://www.linkedin.com/pulse/china-power-market-too-young-irrational-huiting-zhang/>

The price that is paid is determined by a formula which calculates the share of the savings attributable to winning bidders in the auction. This is not an efficient uniform price auction such as we see in most wholesale electricity markets around the world. The calculation in Guangdong is done by calculating the theoretical savings in both the demand bids and supply offers relative to the undiscounted price (i.e. areas of gross consumer surplus and producer surplus). The sum of these two areas is then used to calculate a system discount charge.<sup>79</sup> This is then apportioned 50-50 to the demand and supply side. The demand receiving total

<sup>77</sup> See also Yang et al. (2017). “广东电力市场需求侧响应交易机制研究.” Research on Demand Response Trading Mechanism in Guangdong Electricity Market, Guangdong Electric Power, 30(5), 25-34. Pang, P. (2016). “电力市场化改革背景下电力需求响应机制与支撑技术.” Electric Power Demand Response Mechanism and Support Technology Under Electric Power Market Reform, Guangdong Electric Power.

<sup>78</sup> See Zhang (2017) for a commentary on this figure.

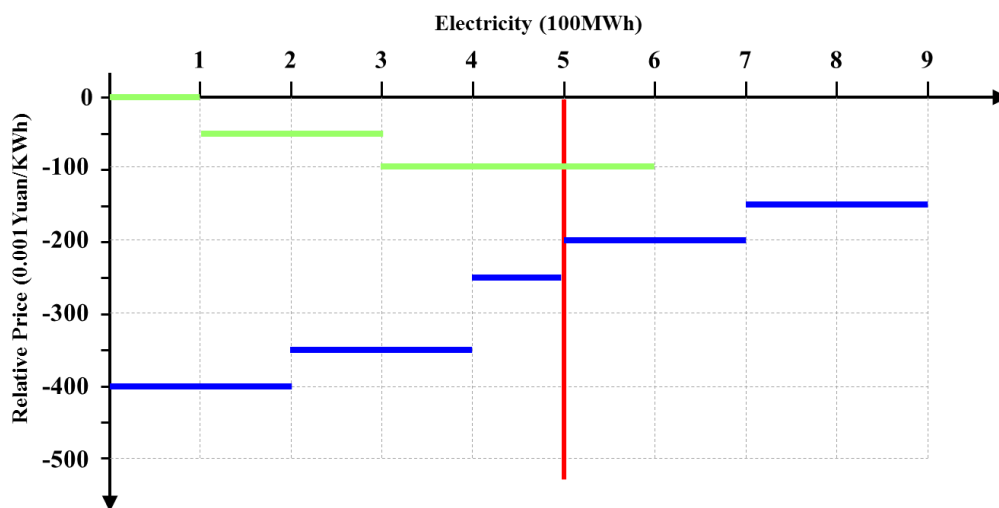
<sup>79</sup> With thanks to Phil Chen for explaining this in a note: ‘Clearing mechanism of Guangdong Power Market in 2016’.



savings equal to half the area, and the supply receiving prices lower than the regulated price by half the amount of the system discount charge. This ensures that the total discount is matched on the demand and supply side. The savings for demand are apportioned in proportion to their relative absolute discounts. Lower prices for generators are apportioned in proportion to the relative absolute discounts. An example of how the calculation works is shown in the panels of Figure 10.

**Figure 10**  
**Illustrative market clearing and price determination**

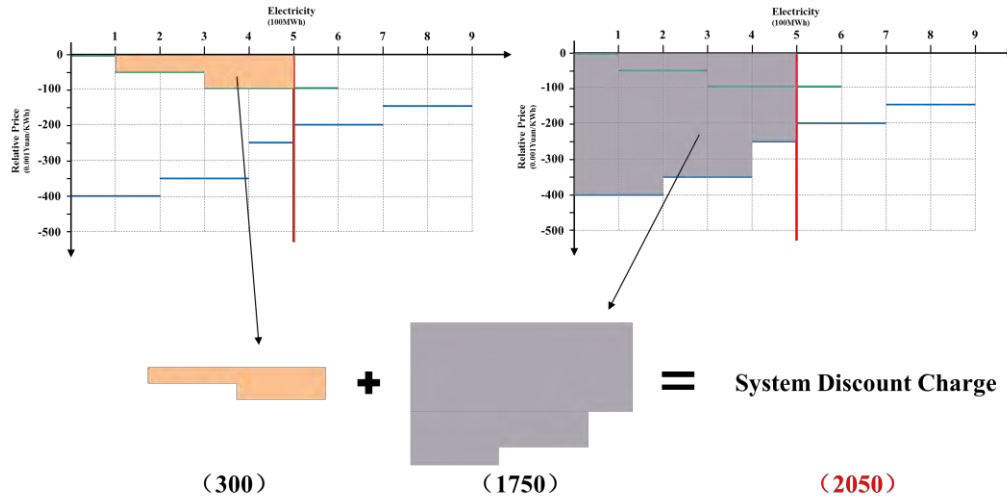
**A. Retailer (green) bids and Generator (blue) offers, with maximum trading volume (red)**



Source: Jing, Z., Chen, Z., and Zhu, J. (2018).

Thus, in panel A we have three retailers and three generators, who win in the auction. For instance, the least price generator bids to supply 2 units at price of -400. The market clearing price should be -200 and all the retailers in the market should pay this.

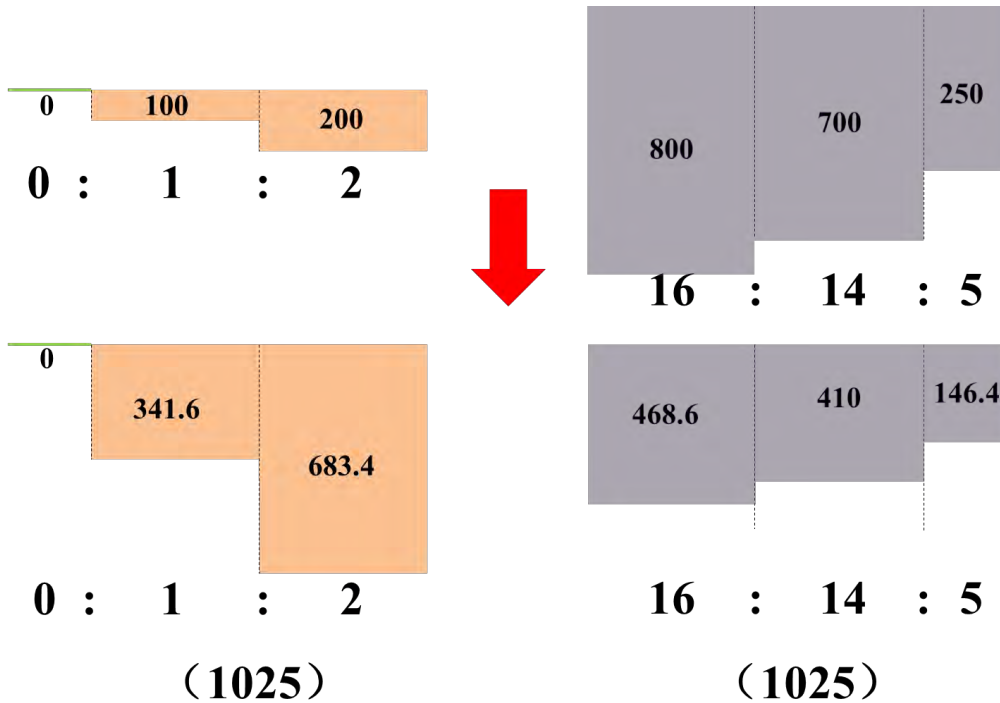
### B. Calculation of System Discount Charge



Source: Jing, Z., Chen, Z., and Zhu, J. (2018).

In panel B the gross consumer surplus is in orange (300) and the gross producer surplus is in purple (1750). These are summed to give the system discount charge (2050).

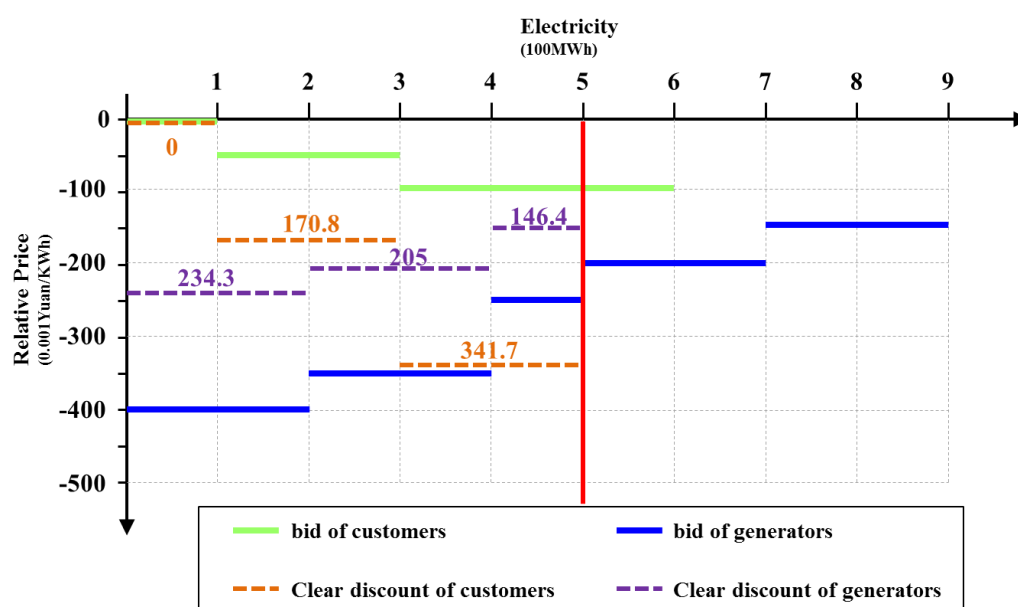
### C. Allocation of System Discount Charge to winning bidders



Source: Jing, Z., Chen, Z., and Zhu, J. (2018).

In panel C the total system discount charge is then divided equally between the winning retailers and the winning generators in proportion to their gross consumer and producer surpluses. For example, the second lowest bidding retailer bid for a consumer surplus of 100, which was 1/3 of the total winning surplus (= 100/300) and hence receives a discount of 1/3 of 1025 = 341.6 (the retailer allocation of the system discount charge).

#### D. Calculation of final prices paid to winning retailers and generators



Source: Jing, Z., Chen, Z., and Zhu, J. (2018).

In panel D, the allocated system benefit charges, are converted into prices to be paid and received. These prices are calculated by dividing the allocated system benefit charges by the number of units demanded or supplied by the winning bidders. In this case the second lowest bidding retailer pays a discounted price of -170.7 (341.6 divided by 2 units).

The final result shows that generators receive more than they bid, while retailers pay less than they bid. Importantly intra-marginal bidders affect the outcomes in the market, because what the retailer bidding -50 (call them R2) and the generators bidding -400 and -350 (call them G1 and G2) can influence the final prices, even though they are intra-marginal.

Thus if R2 had bid -100. This would have changed all of the final prices paid and received, and paid less themselves. Similarly, if G1 had bid -350, this would have changed all of the final prices paid and received, and received more themselves. We show the calculations in the Appendix. This should not happen in a well-designed auction<sup>80</sup>. This encourages bidders to game demand bids down and supply bids up, rather than encouraging truthful bidding. This does give the retail bidders an incentive to manipulate their retail bid in the way that appears to be happening in Figure 9.

A better solution is to realise that the market has surplus supply and that the market clearing price is where the fixed quantity to be sold crosses the supply curve (-300 in this case). That is the price at which generators are willing to supply the whole market. Yunnan also does not use a uniform market clearing price in its auction<sup>81</sup>. Instead the highest demand bid and the lowest supply bid are matched and the average of the two is taken and this is the price paid by the demand bidder to the supply bidder<sup>82</sup>. This encourages demands to shave their bids down and suppliers have an incentive to shave their bids up.

Market reform in Guangdong should have implications for neighbouring provinces. Yunnan has very low retail prices for power<sup>83</sup>. A fully functioning power market which included Yunnan and Guangdong would involve hydro generators in Yunnan getting much higher wholesale prices for their power. There are substantial benefits for trading power between other southern provinces in China (e.g. Yunnan and Guizhou, see Zhang et al., 2014)<sup>84</sup>. This would bid up the wholesale price in the Yunnan power market and potentially increase prices for retail customers in Yunnan. One solution to this would be to identify a 'hydro benefit', which would be taxed from hydro producers in Yunnan and used to reduce transmission and distribution charges in Yunnan for connected customers in the province. This was the solution that was implemented in the UK for electricity customers in the North of Scotland following

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<sup>80</sup> On suggestions for good auction design see Klemperer (2002) and Ausubel and Crampton (2011).

<sup>81</sup> Feng (2016). “从云南方案看新电改隐患” Yunnan local pilot and Challenges for China's recent power sector reform, China Energy, Retrieved from: [http://www.cnenergy.org/yw/zc/201602/t20160205\\_270260.html](http://www.cnenergy.org/yw/zc/201602/t20160205_270260.html).

<sup>82</sup> See Zhang (2017). See also Tung and Huang (2017). “美国 PJM 电力市场及对广东电力改革的启示” Experiences in PJM Market in the United States: A Good Reference for the Power Market Reform in Guangdong Power Grid, Yunnan Electric Power, 2017, 45(1).

<sup>83</sup> See Feng (2016).

<sup>84</sup> Zhang et al. (2014).

market liberalisation in 1990, continuing a pre-liberalisation benefit from local hydro production.<sup>85</sup> This would maintain efficient price signals while ensuring that Yunnan customers did not lose out from the negative re-distributional effects of market reform. Cross-provincial trading should make use of supply and demand curves for the whole region across which trading is occurring and not be based on arbitrary restrictions on traded quantities, unrelated to available capacity<sup>86</sup>. A particular problem is the conflict between the desire for such trading from the central government – who can see its merits – and the individual provinces for whom there will be winners (i.e. electricity customers in Guangdong and electricity generators in Yunnan) and losers (i.e. electricity generators in Guangdong and electricity consumers in Yunnan).

b. Recommendations for furthering reform:

1. There is a need to acknowledge value of assets in generation will go down with the introduction of a market which reduces prices. If necessary there should be a reallocation of assets between state owned generators to increase competition and spread the value loss. It would also be possible to introduce a competitive transition charge<sup>87</sup> on consumers which would collect some of their savings and use them to compensate the generators for losses of asset value directly.
2. In Guangdong, there is a need to move to a day-ahead market for all generation and to integrate this with dispatch. Partial monthly contract markets have successfully encouraged the creation of a new set of market actors – retailers – but they are not generating a proper set of price signals for operation and investment. A complete day ahead market implies that is difficult to avoid a big-bang day for trading. This big-bang day approach was the one experienced in the UK and US wholesale power markets<sup>88</sup>.

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<sup>85</sup> See DECC (2015, p.9).

<sup>86</sup> Guangzhou Power Exchange Center (2017). 《南方区域跨区跨省月度电力交易规则（试行）》，Retrieved from: <https://www.gzpec.cn/main/index.do>

<sup>87</sup> For a discussion in the context of California, see <https://www.eia.gov/electricity/policies/legislation/california/assemblybill.html>

<sup>88</sup> See FERC (2004) for a discussion of this in the context of setting up an independent system operator in the US. Henney (1994) presents the background to the establishment of the power pool in Great Britain on 1 April 1990.

Long term contracts between generators and customers can be used to hedge financial positions.

3. It would seem sensible to experiment more fully in one province. A genuine market pilot needs a full set of wholesale electricity markets applied to all generation and demand. A full set of electricity markets should include both markets for energy (yearly, monthly, day-ahead and intra-day) and for ancillary services (particularly frequency and short term operating reserve). This is not the case in any existing pilot, including in Guangdong. Guangdong is a good candidate for a comprehensive pilot because of its initially high electricity prices and relatively small electricity sector within its GDP. Continuing the Texas analogy we introduced at the beginning, Texas has gone further with power market reform than any other state in the US<sup>89</sup>. The result has been low prices and high renewables penetration.
4. The probability of reversal of power market reform in China seems higher than in many other jurisdictions due to the lack of progress over a 5-year time period and the lack of legislative underpinning of the reform itself. The reform is based on a ruling from the State Council (No.9 of March 2015) which does not have legal force and can be quietly abandoned.<sup>90</sup> This suggests that there needs to be a sense of urgency in reform lacking due to the longer political cycle in China (10+ years) of one Presidency. In the UK, the 1987 General Election set a 5 year maximum (and effectively 4 year) timetable for power sector reform (which was largely complete by 1991)<sup>91</sup>. This argues in favour of experimentation to create a workable plan at the provincial level first AND THEN setting an ambitious time table for reform more generally.

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<sup>89</sup> See Adib et al. (2013) for a discussion.

<sup>90</sup> Document No.9 is a policy document, not a law. Some local governments say that sometimes they do not know whether they should just follow policy documents and ignore the content of current Electricity Act (1996). There is therefore an urgent need to revise the current legal frameworks for China's electric industry in line with the policy goals of the No.9 document. See China Electric Council <http://news.bjx.com.cn/html/20161129/792530.shtml>

<sup>91</sup> See Henney (1994 and 2011) for a discussion of the reform process in the UK.

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## Appendix: How changing infra-marginal bids changes the auction results

What if R2 (the second and third units of retail demand) had bid -100, instead of -50. Panels A1 to D1 change and the R2 receives a bigger discount. See Figures A1 to D1 for the calculations. R2's discount was originally -170.8, it is now -268.8. All other prices are changed.

Figure A1: Retailer (green) bids and Generator (blue) offers, with maximum trading volume (red)

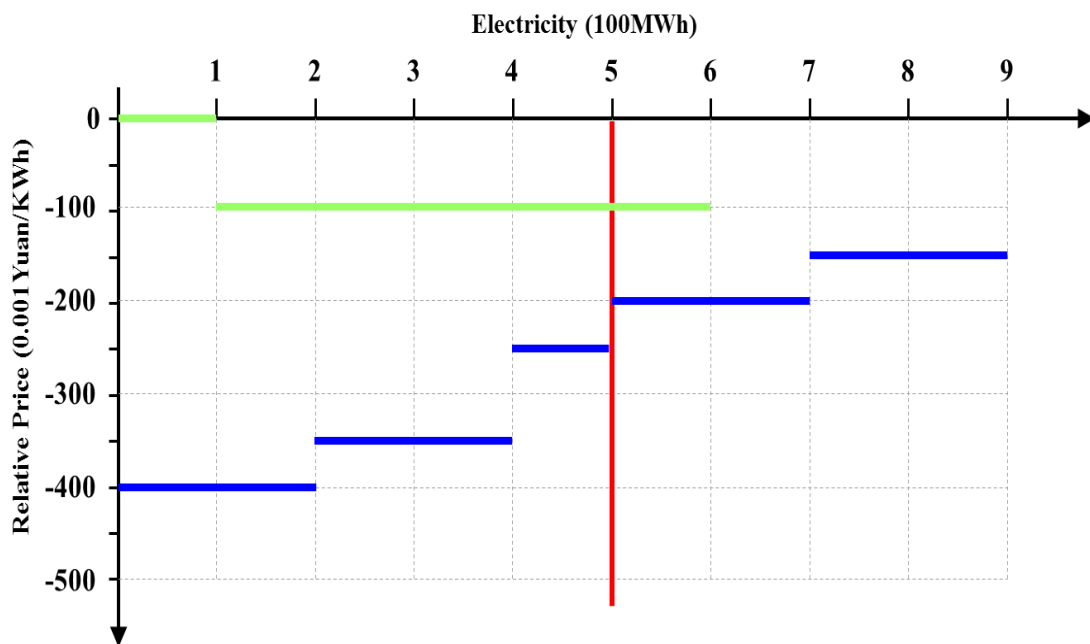


Figure B1: Calculation of System Discount Charge

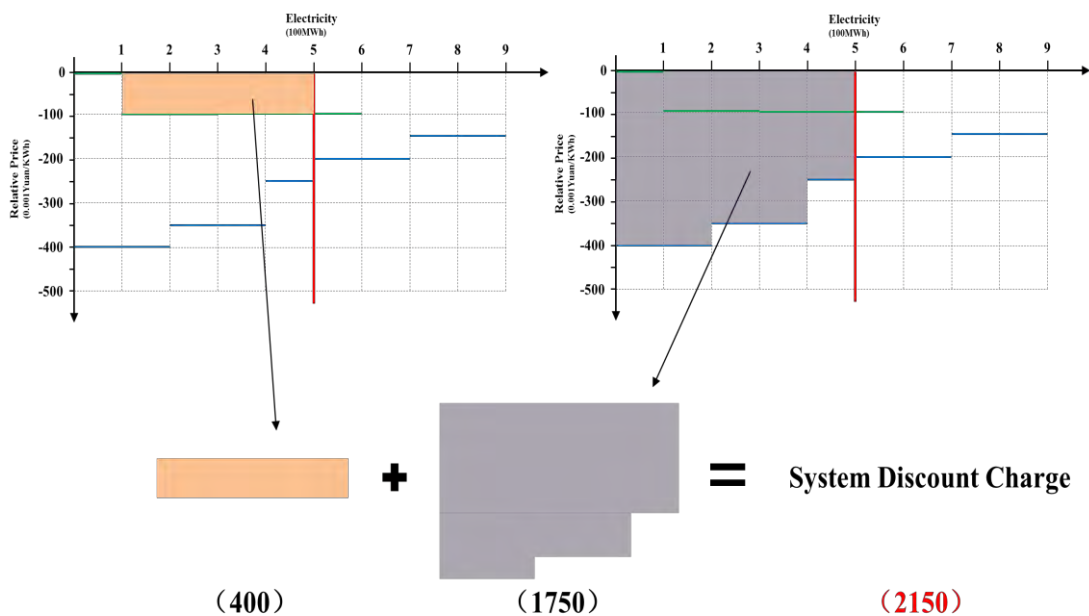




Figure C1: Allocation of System Discount Charge to winning bidders

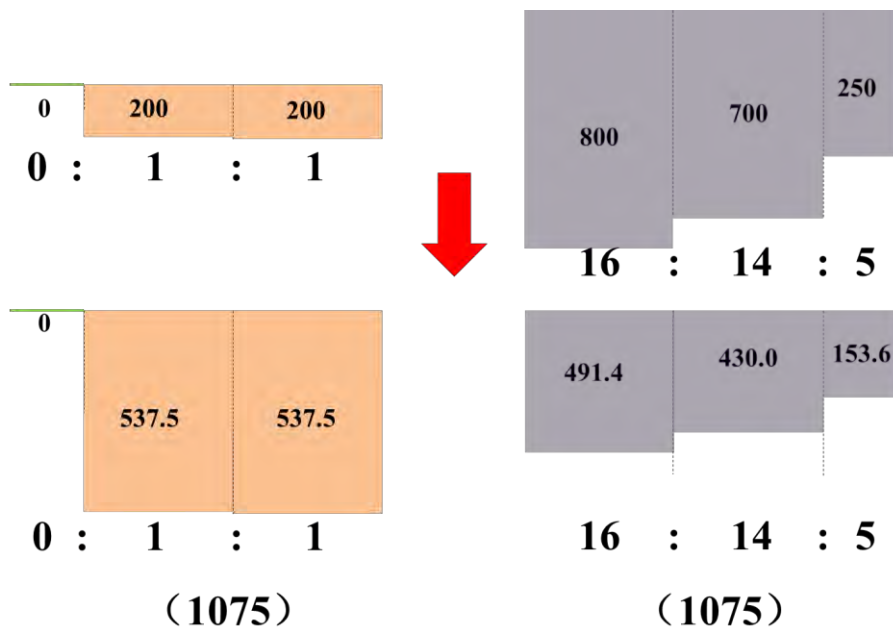
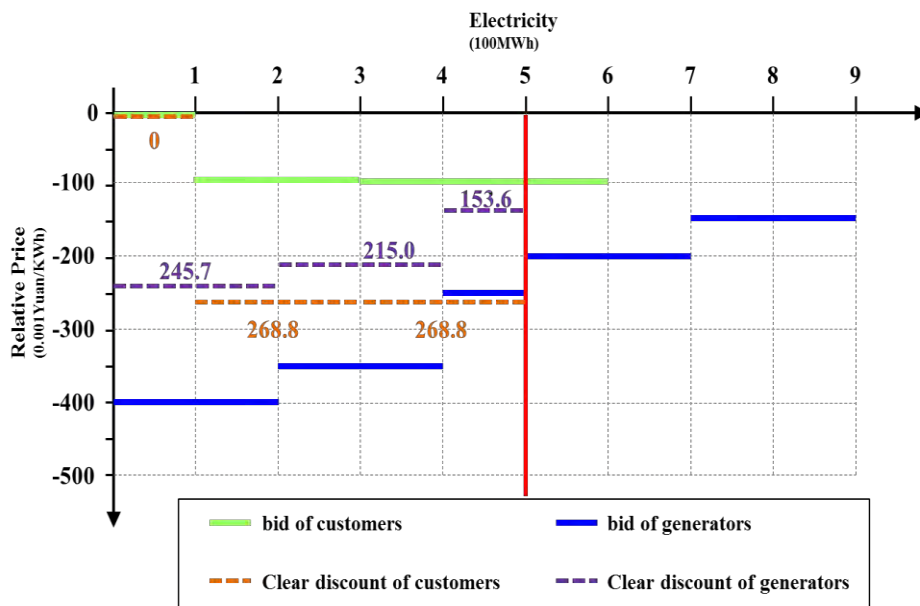


Figure D1: Calculation of final prices paid to winning retailers and generators



if G1 (the two cheapest units of generation) had bid -350, rather than -400 then they would end up receiving higher payments. Figures A2 to D2 show the calculations. G1's original payment was a discount of -234.3, it now becomes -206.8. Note all other final prices are changed.

Figure A2: Retailer (green) bids and Generator (blue) offers, with maximum trading volume (red)

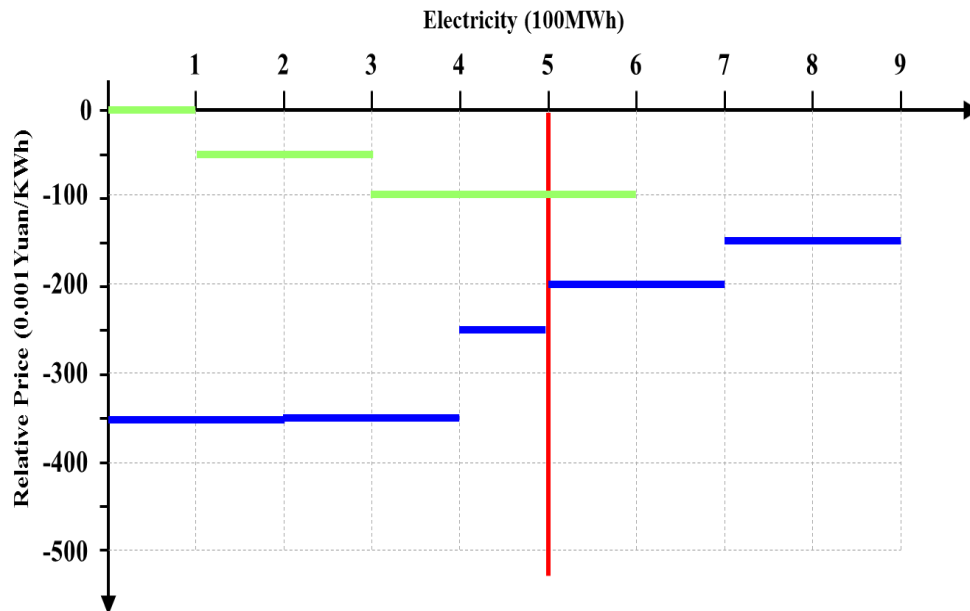


Figure B2: Calculation of System Discount Charge

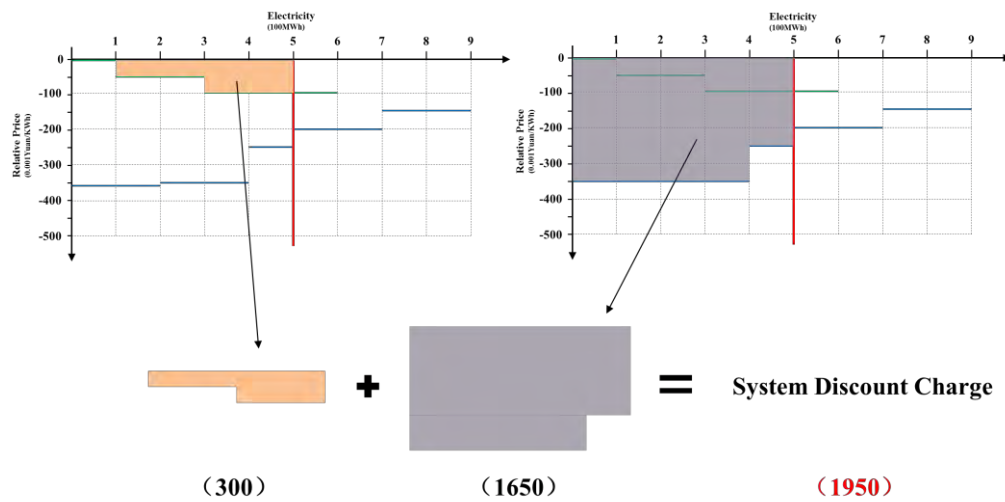


Figure C2: Allocation of System Discount Charge to winning bidders

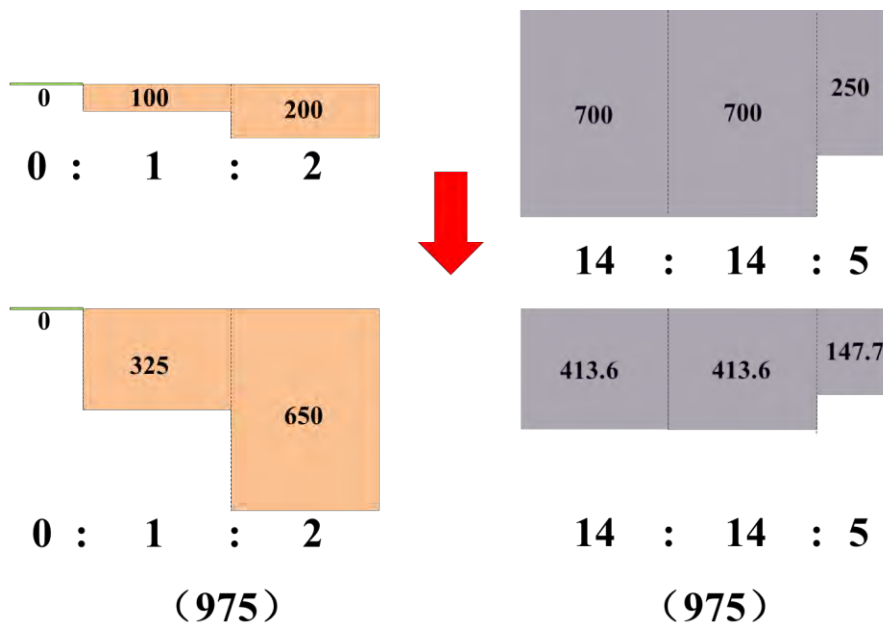


Figure D2: Calculation of final prices paid to winning retailers and generators

