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Market Power and Electricity Market Reform in Northeast China

by

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The Northeast region of China has been used as a testing ground for creation of a functioning wholesale electric power market. We describe the ownership structure of the generation assets for those plants participating in the trial operation of the Northeast China Regional Electricity Market and also for the region as a whole and for each of the provinces making up the region. We calculate the 4-firm Concentration Ratio (CR4) and the Hirschman-Herfindahl Index (HHI). In general, we find that the current ownership structure is relatively concentrated. Arguably, this is a troublesome obstacle to instituting some form of competitive bidding in the wholesale power market, and this may be one factor in the poor outcome of the trial operation.

INTRODUCTION

Since the mid-1980s, the Chinese electricity industry has been undergoing a slow, but thoroughgoing reform and institutional transformation.[1] In 1985, the central government's monopoly on the development and ownership of generation was ended, so that various local governments, state-owned enterprises and even private investors including foreign investors could develop and own generating facilities. In 1997, the massive transmission and generation assets still held by the Ministry of Electric Power were removed from its control and put into a corporate structure, the State Power Corporation, with the objective of encouraging business style governance and

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[1] Sources for the following overview of the reform include Austin (2005) Xu (2006), Yeoh and Rajaraman (2004) and especially Zhang and Heller (2004) and International Energy Agency (2006).

management. A parallel corporate restructuring occurred for generation assets controlled by provincial and local government authorities.

In 2002, the State Power Corporation of China, which owned 90% of the nation's transmission assets and 46% of the nation's generation assets, was broken up. Two major transmission companies were organized on a geographic basis, with the State Grid Corporation of China and its regional and provincial subsidiaries running the system in the north, central and eastern regions, and the China Southern Power Grid Corporation and its regional and provincial subsidiaries running the system in 5 provinces in the south. The major generation assets were divided up to form 5 large gencos operating across regions, the Huaneng Group, the Datang Corporation, the HuaDian Corporation, the GuoDian Corporation and the China Power Investment Corporation. The State Electricity Regulatory Commission was created to oversee the industry, although the National Development and Reform Commission was tasked with managing the industry's contribution to the national economic goals and so remains involved with key strategic decisions about the industry's structure, including price policies.

In 2003, the government outlined its goal of developing regional wholesale power markets and the efficient exchange of power between regions (see State Electricity Regulatory Commission, 2003a). This was preceded by a set of small experiments with competitive bidding for power in 5 provinces and 1 city—Liaoning, Jilin, Heilongjing provinces together conducted one experiment, Zhejiang and Shandong provinces and the city of Shanghai each conducted separate experiments. These covered a very small portion of capacity in each territory, began with only simulated bidding in mid-2000, and were quickly suspended in 2001 when economic growth created power shortages

everywhere. The Northeast region was selected to pioneer the new system of regional markets, and trial operations began in 2004. The trial has had problems. Despite the significant publicity around the creation of these trial markets, it is not clear whether the trials will be followed up with actual implementation and whether these markets will soon take any meaningful role in matching supply and demand in any region.

One key question is whether the ownership of the generation assets in the Northeast region is sufficiently competitive to support market bidding for wholesale power—see Sun et al. (2003). Our paper addresses this issue. We describe the ownership structure of the generation assets for those plants participating in the trial operation of the Northeast China Regional Electricity Market and also for the region as a whole and for each of the provinces making up the region. We calculate the 4-firm Concentration Ratio (CR4) and the Hirschman-Herfindahl Index (HHI). In general, we find that the current ownership structure is relatively concentrated. Arguably, this is a troublesome obstacle to instituting some form of competitive bidding in the wholesale power market, and this may be one factor in the poor outcome of the trial operation.

2. THE NORTHEAST CHINA REGIONAL ELECTRICTY MARKET

For electric power purposes, the Northeast region of China encompasses the three provinces otherwise considered China's northeast region – Liaoning, Jilin and Heilongjiang – plus the eastern portion of the Inner Mongolia Autonomous Region, encompassing the Chifeng, Tongliao, Hinggan and Hulun Buir areas of the Region. This region is shown in Figure 1. This is the transmission territory covered by the Northeast China Grid Company, Ltd., a subsidiary of the State Grid Corporation. The first three provinces lie directly northeast of Beijing running from the northern edge of the Yellow

Sea and along the borders with North Korea and siberian Russia. At the southern tip of Liaoning is the major port of Dalian. Running directly northeast from there on a straight line are the three cities Shenyang, Changchun and Harbin, capitals of their respective provinces, Liaoning, Jilin and Heilongjian. On the western border of these three provinces is the eastern portion of Inner Mongolia. The full territory of Inner Mongolia has a wide east-west axis spanning much of the border with neighboring Mongolia and reaching north up to the border with siberian Russia. The eastern portion of Inner Mongolia that is incorporated in the Northeast grid starts north and east of Beijing and runs north from there. In the remainder of this paper we will refer to "four provinces" without qualification, understanding that the fourth is this eastern portion of the Inner Mongolia Autonomous Region.

The Northeast region encompasses a territory of 1,249 thousand kilometers square, a population of 120 million, and a GDP of ¥2,109 billion (Yuan) or ¥17,600 per capita. The region generated 238 terawatt hours of electricity in 2006, consuming 236 of them or 1,961 kwh per capita. Table 1 shows how these figures break down by province. Although Liaoning is the smallest province, it has the largest population and more than 40% of the GDP and generation and more than 50% of the electricity consumption. Eastern Inner Mongolia, while the largest territory in the region—approximately equal to that of Heilongjiang—has the smallest population and the lowest GDP per capita. The per capita GDP of Liaoning is nearly twice that of the eastern Inner Mongolian province. The provinces of Jilin and Heilongjiang appear very similar on a per capita basis, with Heilongjiang being slightly larger and more populous.The three provinces of Liaoning, Jilin and Heilongjiang all have a long history of investment in heavy industry, including

iron and steel. Heilongjiang, in particular, has significant oil and coal deposits and relies as well on timber production. Liaoning has in recent years enjoyed the benefit of a growing chemical industry. The eastern portion of Inner Mongolia is more rural and agricultural, although Inner Mongolia as a whole also enjoys major coal deposits and some significant related heavy industry. In the years following China's Reform and Opening, the region did not enjoy the same level of growth some other parts of China. However, in 2003 the country adopted a Northeast China Revitalization plan targeting economic growth there.

One of the goals of the reform of the electricity industry is integration of the transmission grid across provincial boundaries. Previously, the grid and the dispatch of generation functioned largely on a provincial basis. There was little exchange of power across provinces even when one province had a surplus of power and another a shortage (see China Daily, 2004). This was due both to inadquate transmission lines as well as to the rules and incentives for dispatch. Regional grids are intended to developing unified scheduling, management, accounting, and investment planning. The Northeast China Grid has been identified as a place to pioneer this effort (see State Electricity Regulatory Commission, 2003b). The region had in place a relatively good transmission system, and was one of the few to be experiencing a surplus in generating capacity. It had relatively comparable retail tariffs in the three provinces of Liaoning, Jialin and Heilongjiang, as well as comparable levels of economic development—see Zheng and Heller (2004), International Energy Agency (2006) and Yeoh and Rajaraman (2004). The grid is organized in three components: the South Grid, consisting of the province of Liaoning and the area of Chifeng in Inner Mongolia, the Central Grid, consisting of the province of

Jilin and the area of Tongliao and Hinggan in Inner Mongolia, and the North Grid, consisting of the province of Heilongjiang and the area of Hulun Buir in Inner Mongolia.

Development of the system of regional grids and improved connections across regions is also seen as a step in the process leading to competitive wholesale power markets. One of the state gencos explained to investors:

> The long-term objective for the electricity pricing reform is to establish a standardized and transparent tariff setting mechanism, classifying the electricity prices into the on-grid price, the transmission price, the distribution price and the end-user retail price, and to allow the on-grid prices and retail prices to be determined through market competition. The transmission and distribution prices are to be regulated by the government. (Huaneng Power International, 2005, p. 14)

The Northeast and the East grid regions were to begin this process. The Northeast China Regional Electricity Market began simulated operation in January of 2004 and trial operation in 2005—see the International Energy Agency (2006). Trading in the Northeast Market is conducted on the Northeast Power Exchange located in Shenyang, the capital of Liaoning province. The simulated and trial operation of the Northeast China Regional Energy Market involved the participation of 25 plants or installations.[2] Initially, a portion of each plant's normal volume of generation was assigned to be bid into the market, and later all of each plant's volume was assigned.[3] Bidding was either for monthly dispatch or for annual dispatch. The bidding would set an energy charge, with a separate capacity charge being set by other rules outside of the structures of the competitive market.

[2] Some reports refer to more than 20 "companies" or more than 20 "generators", perhaps suggesting a high level of competition. As we report in the next section, there are only 8 companies who own the 25 installations.

[3] Here again, though the terminology can be tricky. Where a given installation has multiple generators, only certain units were assigned to the competive market.

In the Northeast region the trial operations were suspended in early 2006, resumed in March 2006, and suspended again. The bidding results in 2006 were not used for actual settlements and the future operation of the market is under review (see Huaneng Power International, 2006). In the East region market, simulated operation began in 2005 and a pair of trial operations occurred in 2006 which involved actual settlements. A market has also been created in the South region with simulated operation in 2006. We have found little public data about the simulations or trial operations and little public discussion of what may be the nature and cause of any problems. In the following section we turn attention to the level of concentration in ownership of generation assets as one possible cause of the problems.

3. GENERATION ASSETS AND OWNERSHIP CONCENTRATION

Our analysis of the generation ownership structure in the Northeast China Regional Electricity Market is based on a number of sources. We began with the *Comprehensive Statistical Data and Materials 2006* published by the Development and Planning Department of the State Grid Corporation of China.[4] Underlying this document is a complete listing of power plants or installations in the region, their capacity, generation, fuel type, ownership and other information. The document reports summary information along a number of different dimensions. It also individually lists installations with a capacity of 6 MW or more, showing their capacity and generation and location by province, but not the fuel type or ownership. However, often the name of the plant makes the fuel type clear. Alternatively, we found the plant on the web and identified its fuel

[4] The document is in Chinese and the original title is given in the list of references.

type or determined it from other information. For information on ownership of the individual installations, we turn first to the *Annual Report on Electricity Regulation of Northeast China* for 2006, published by the Northeast China Burea of the State Electricity Regulatory Commission of China.[5] Part 5 of this report lists the large thermal plants owned by each of the five major gencos. This corresponds to 34 installations with 17,151 MW of capacity, or 36% of our sample of plants with capacity greater than 6 MW. No other owners are listed individually. To determine the ownership of the remaining plants, we search the web using the plant name. In many cases we can find an owner for the plant: 218 installations with 27,487 MW of capacity, or 58%. Where we cannot, we treat the plant as if it is independently owned: the remaining 126 installations with individual capacity above 6 MW, accounting for 2,841 MW in total or 6%. Failure to have identified the true owner of some plants will bias our results slightly towards a lower measure of concentration.

The *Annual Report on Electricity Regulation of Northeast China* for 2006 also identifies for us which installations—indeed, which units of the installations—participated in the simulation and trial operation of the Northeast China Regional Electricity Market.

The Northeast region has a total of 47,880 MW of generation capacity produced in 578 installation.[6] The regional breakdown of the capacity, shown in Figure 2, is 38% in Liaoning, 23% in Jiling, 28% in Heilongjiang, and 10% in eastern Inner Mongolia.

[5] The document is in Chinese and the original title is given in the list of references.

[6] The document shows 582 installations. We identify two listed installations that show zero generation capacity and which we assume are under construction. The remaining discrepancy of two is, we believe, due to double counting within the original document.

The average capacity of an installation is 83 MW, but the distribution of installation sizes is very skewed. There are 11 installations with a capacity of greater than 1,000 MW, although an installation can consist of several units. These large installations represent 31% of capacity in the region. There are 18 installations with a capacity between 1,000 and 500 MW, representing 26% of capacity. Another 58 installations have a capacity between 500 and 100 MW, representing 28% of capacity. There are 491 installations with a capacity less than 100 MW, a good many of which are smaller than 6 MW. These 491 small installations provide 15% of capacity. Figure 3 shows this profile for the region as a whole and for the four provinces, individually. The only notable provincial distinctions are that Jilin has a smaller fraction of installations greater than 1,000 MW, while eastern Inner Mongolia has fully 50% of its capacity in such very large installations and a much smaller share of capacity, in small installations of less than 100 MW—7% for eastern Inner Mongolia versus 15% for the region as a whole.

Fully 85% of the Megawatt capacity is thermal power. These are overwhelmingly coal-fired units, although the documents do not provide a further breakdown between coal, oil and gas fired thermal plants. Most of the remaining capacity, 13%, is hydro power, and 2% of capacity is wind power. There are currrently no nuclear plants in the Northeast region, although construction began in 2007 on a plant in Liaoning province which is scheduled to come on line in 2012. Figure 4 shows this profile for the region as a whole and for the four provinces, individually. Liaoning and Heilongjiang are even more dependent on thermal installations, while Jilin has fully 35% of its capacity hydropowered.

Some 14% of the capacity is in installations built for self-generation, so that only the remaining 86% is sold. This is shown in Figure 5. The portion of capacity used for self-generation is as low as 9% in eastern Inner Mongolia and rises to 20% in Heilongjiang.

Much of the capacity is in units providing combined heat and power. Of the 378 plants with capacity greater than 6 MW, 200 of them are listed as units with at least some, if not all, capacity for heating. The total MW dedicated to heating is 18,424 MW of 47,478 MW, or 33%.

Five of the six largest capacity owners are the gencos assigned the generation assets of the former State Power Corporation in 2002. The remaining member of that club is the State Grid Corporation that was also assigned some of these generation assets. As shown in Figure 6, the Datang Corporation has 9% of the assets, the GuoDian corporation has another 9%, the HuaDian Corporation has 14%, the Huaneng Corporation has 11%, the China Power Investment Corporation has 12%. The State Grid Corporation has 13% of the assets, consisting 75% of hydro power and 25% of one large thermal station in eastern Inner Mongolia. The remaining 33% of capacity is divided among other companies. We have been unable to identify any company outside of the 5 gencos and the State Grid Corporation that owns more than 2% of capacity. Figure 6 also shows this ownership breakdown by province. There are some marked differences with the regional profile, since certain gencos are absent from certain provinces and have a very large presence in other provinces. Liaoning is notable for the large percentage of power not owned by the 5 gencos nor by the State Grid—fully 53%. Jilin and eastern Inner Mongolia have the most capacity in the hands of these 6 corporations, 86% and 87%,

respectively. In Jilin, with its large hydropower resources, the State Grid has 31% of the capacity. The State Grid also has 30% of the capacity in eastern Inner Mongolian due to the one very large thermal installation it owns which is Yuanbaoshan.

When the trial operation of the Northeast China Regional Electricity Market was begun, a specific subset of the region's power plants were selected to participate. Participation was limited to thermal plants with individual unit capacity greater than 100 MW and excluding those used for combined heat and power or for self-generation. In certain cases, some of the units at a given installation were selected to participate, but not the other units. Table 2 shows this list of plants, their capacity and their owners. We can identify units meeting these criteria that, nevertheless, were not participants in the trial operation. Moreover, some of the units that did participate appear to be combined heat and power units.[7] The total capacity of participating plants was 20,260 Megawatts from 25 different installations. Table 3 shows the 4-firm Concentration Ratio (CR4) and the Hirschman-Herfindahl Index (HHI) calculated for the trial Regional Market. The level of concentration is high enough to be a point of concern. The 4-firm Concentration Ratio is 76%. The HHI is 1,759 which is within the region normally labeled 'moderately concentrated', although it is approaching the 1800 cutoff demarcating high concentration.

Table 3 also shows the 4 firm Concentration Ratio and the Hirschman-Herfindahl Index calculated for the Northeast Region as a whole. The CR4 is 50% while the HHI is 770, indicating a low level of concentration. Contrasting these figures with those for the trial operation of the Regional Market gives a sense of whether the high concentration in

[7] For example, the Mudanjiang No. 2 thermal station in Heilongjiang province is a participant, although 400 MW of 1,020 MW is heating. Also in this category are the Qitaihe No. 1 and the Jiamusi thermal stations in Heilongjiang, and the Hunjiang and Huichun thermal stations in Jilin.

the trial operation is due to the selection of plants for participation or is inherent in the regionwide ownership structure. This contrast suggests there is potential for competition that was not taken advantage of in designing the trial market structure. Table 3 also shows the CR4 and HHI when calculated excluding self-generation, since arguably these units would be less readily incorporated into a competitive market. Excluding self-generation moves the regionwide HHI from 770 to 1,035, i.e., from below the 1,000 cutoff level to just above it and so into the 'moderately concentrated' range.

Table 3 also shows the provincial breakdown of these measures of market concentration. This is important insofar as transmission problems may create pockets of generation with greater market power. In three of the four provinces, the HHI is greater than 1800, indicating a high level of concentration. Only in the province of Liaoning is the HHI below 1000, indicating a low level of concentration. Removing units employed for self-generation does not change the picture with respect to these cutoffs, although it does raise the measures of concentration in the three provinces of Jilin, Heilongjiang and eastern Inner Mongolia dramatically.

It may be instructive to compare these concentration measures in the Northeast China Regional Electricity Market with measures for other electricity markets around the world. Several of the independent system operators in the US have a market monitor who calculates and reports these figures for their systems.[8] ISO-New England runs the system covering the six New England states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut. It reports an HHI of 700. The New York

[8] ISO New England Inc. (2007), New York State Department of Public Service (2006), PJM Interconnection (2007) and Independent Market Monitor for the Midwest ISO (2007).

System Operator reports an HHI for the three regions of the system: the HHI for Upstate New York was 1,028, for New York City was 1,843 and for Long Island was 6,317. The high level of concentration in the two latter regions justify extra measures to prevent exploitation of market power. The largest of the ISOs is PJM, which covers New Jersey, Delaware, Maryland, West Virginia, much of Pennsylvania Virginia and Ohio, and parts of North Carolina, Indiana, Michigan and Illinois. They report an HHI of 1,256 which is moderately concentrated.[9] The Midwest ISO, which covers the remaining portions of Ohio, Indiana, Michigan and Illinois, plus Wisconsin, Iowa, Minnesota, Nebraska, North Dakota and parts of Missouri, South Dakota and Montana, as well as the Canadian province of Manitoba, reports an overall HHI of 567, and breaks this down by 4 sub-territories with HHIs ranging from 1,529 up to 2,813.

In Europe, measures of concentration are typically calculated for markets organized according to national boundaries. A recent report by Matthes, Grashof and Gores (2007) shows diverse situations.[10] In the England and Wales the HHI had fallen to 616 by 2005, a level markedly below 1,000. In Scandinavia, the level is 974. In the Portugal and Spain the level is 1,271. Taking France together with Belgium, the

[9] Caution and care need to be exercised in comparing these HHIs across different countries or reporting territories. As always, the proper calculation of the HHI most crucially depends on a proper identification of the market. In our calculations, we have measured the HHI based on generation capacity and have included all generators within a given region. However, we also made the additional calculation excluding self-generation. The PJM figure is based on energy figures, not simply capacity, and in this sense is not directly comparable. PJM also further refines its figures by calculating an HHI according to the segment of supply provided, be it base load, intermediate, or peaking plants. The intermediate and the peak load segments of the supply curve are markedly more concentrated, with HHIs of 2,664 and 4,157, respectively, on average. The ISO NE figure, however, is based on generating capacity. But our figures for capacity in the Northeast China Region may more liberally include units that were not actually available, while the ISO NE figure is based on units made available for generation.

[10] This report highlights another area of caution for analysis of the HHIs across different countries since it takes care to incorporate additional information about control of a plant exercised through contractual arrangement and not through direct ownership. Our analysis of ownership in China does not incorporate any additional measures of control through contract or other means.

Netherlands and Luxembourg yields an HHI above 4,513 which is obviously a very high level of concentration. In Germany, the HHI of 1,374 is in the moderately concentrated region. In Italy together with Austria and Switzerland, the HHI is 1,024. Interestingly, the report examines the possible creation of a market across national boundaries, encompassing all of the continental countries listed above. They report an HHI of 1,410 for this theoretical regionwide market.

5. CONCLUSIONS

Calculation of the HHI for the provinces of the Northeast China Regional Electricity Market show that in each of the provinces the HHI is very high. Only in the region as a whole is the HHI in the low range. This is largely attributable to a large number of small owners of power in Liaoning, including many self-generators. This suggests that the level of ownership concentration in generating capacity may be a potential obstacle to the efficient functioning of a competitive wholesale power market within each province. The low HHI for the region as a whole is only meaningful if sufficient investment in transmission is made to assure that there is no congestion between provinces. This obstacle could be tackled a number of ways, from a direct change in the level of concentration, to the development of appropriate regulations and controls to mitigate the impact of the market power. This paper does not address the effectiveness of these options.

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Table 1
Provincial Breakdown of Key Regional Statistics, 2006

	Territory		Population		GDP			Electricity Generation		Electricity Consumption		
	(thousand km sq)		(million)		(billion Yuan)		per capita (Yuan)	(Terawatt hours)		(Terawatt hours)		per capita (kwh)
	[a]	[b]	[c]	[d]	[e]	[f]	[g]	[h]	[I]	[j]	[k]	[l]
[1] Northeast Region	1,249		120		2,109		17,600	238		236		1,961
[2] Liaoning	146	12%	43	36%	926	44%	21,700	101	42%	123	52%	2,876
[3] Jilin	187	15%	27	23%	425	20%	15,600	46	19%	41	18%	1,515
[4] Heilongjiang	454	36%	38	32%	622	29%	16,300	65	27%	60	25%	1,562
[5] E. Inner Mongolia	462	37%	12	10%	136	6%	11,400	27	11%	12	5%	986

Table 2
Participants in the Trial Operation of the Northeast China Regional Electricity Market

	Owner [a]	Name [b]	Units [c]	Province [d]	Capacity in MW Installation [e]	Capacity in MW Company [f]	Market Share Installation [g]	Market Share Company [h]
[1]	Datang	Changshan	6 - 8	Jilin	405		2%	
[2]	Datang	Huichun	1 - 2	Jilin	200		1%	
[3]	Datang	Qitaihe	1 - 2	Heilongjiang	700		3%	
[4]	Datang	Liangzihe	3	Heilongjiang	100		0%	
						1,405		7%
[5]	GuoDian	Shuangliao	1 - 3	Jilin	1,200		6%	
[6]	GuoDian	Shuangyashan	1 - 3	Heilongjiang	830		4%	
[7]	GuoDian	Chaoyang	1 - 2	Liaoning	400		2%	
						2,430		12%
[8]	HuaDian	Fuer	1 - 6	Heilongjiang	1,200		6%	
[9]	HuaDian	Jiamusi	11 - 14	Heilongjiang	400		2%	
[10]	HuaDian	Hasan	1 - 4	Heilongjiang	1,600		8%	
[11]	HuaDian	Muer	1 - 7	Heilongjiang	1,020		5%	
[12]	HuaDian	Tieling	1 - 4	Liaoning	1,200		6%	
						5,420		27%
[13]	Huaneng	Dalianwan	1 - 4	Liaoning	1,400		7%	
[14]	Huaneng	Yingkou	1 - 2	Liaoning	600		3%	
[15]	Huaneng	Dandong	1 - 2	Liaoning	700		3%	
[16]	Huaneng	Yimin	1 - 2	Inner Mongolia	1,000		5%	
[17]	Huaneng	Hegang	1 - 2	Heilongjiang	600		3%	
[18]	Huaneng	Xinhua	3 - 5	Heilongjiang	400		2%	
						4,700		23%
[19]	CPIC	Hunjiang	5 - 6 & 9	Jilin	605		3%	
[20]	CPIC	Tongliao	1 - 4	Inner Mongolia	800		4%	
[21]	CPIC	Fuxin	8 - 9	Liaoning	200		1%	
[22]	CPIC	Qinghe	1 - 8	Liaoning	1,200		6%	
[23]	CPIC	Suizhong	1 - 2	Liaoning	1,600		8%	
						4,405		22%
[24]	State Grid	Yuanbaoshan	1 - 3	Inner Mongolia	1,500	1,500	7%	7%
[25]	Independent	Nenggang	14 - 15	Liaoning	400	400	2%	2%
	Total				20,260		100%	

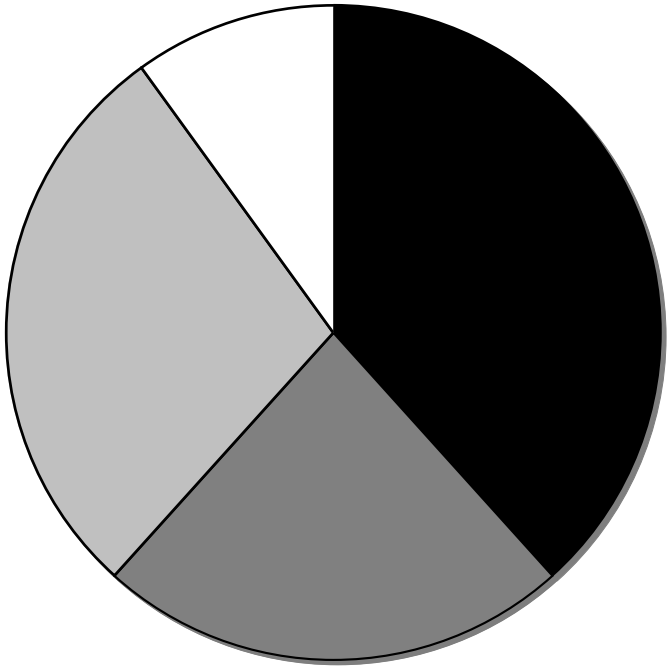
Table 3
Measures of Concentration in the Northeast China Regional Electricity Market

	All Facilities		Excluding Self-Generation	
	CR4 [a]	HHI [b]	CR4 [c]	HHI [d]
[1] Trial Regional Market	76%	1,759		
[2] Northeast Region	50%	770	58%	1,035
[3] Liaoning	44%	580	51%	803
[4] Jilin	83%	1,925	89%	2,202
[5] Heilongjiang	67%	1,837	84%	2,850
[6] E. Inner Mongolia	87%	2,495	96%	2,952

Note: We have no ownership data for the 1% of MW capacity in plants below 6MW in size. In calculating the HHI we add zero to the HHI calculation for these plants. We also cannot match the self-generation capacity total with individual plants. To make this calculation, we assume that all of the self-generation is from units owned by companies other than the 5 gencos or the State Grid

Figure 1
Territory of the Northeast China Regional Electricity Market

Figure 2
Generation Capacity by Province



Liaoning

Jilin

Heilongjiang

e. Inner Mongolia

Figure 3
Generation Capacity by Installation Size

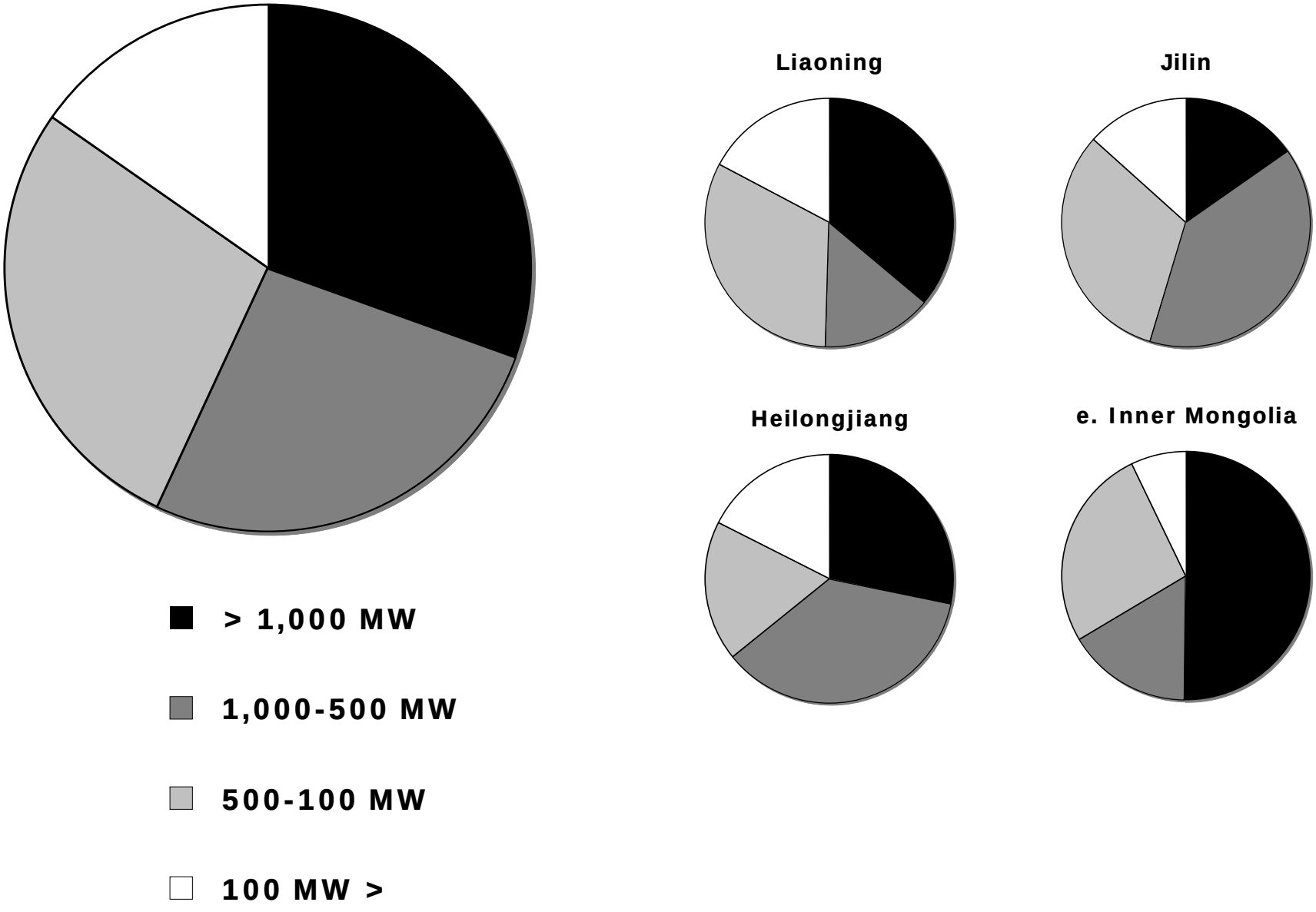


Figure 4
Generation Capacity by Fuel Type

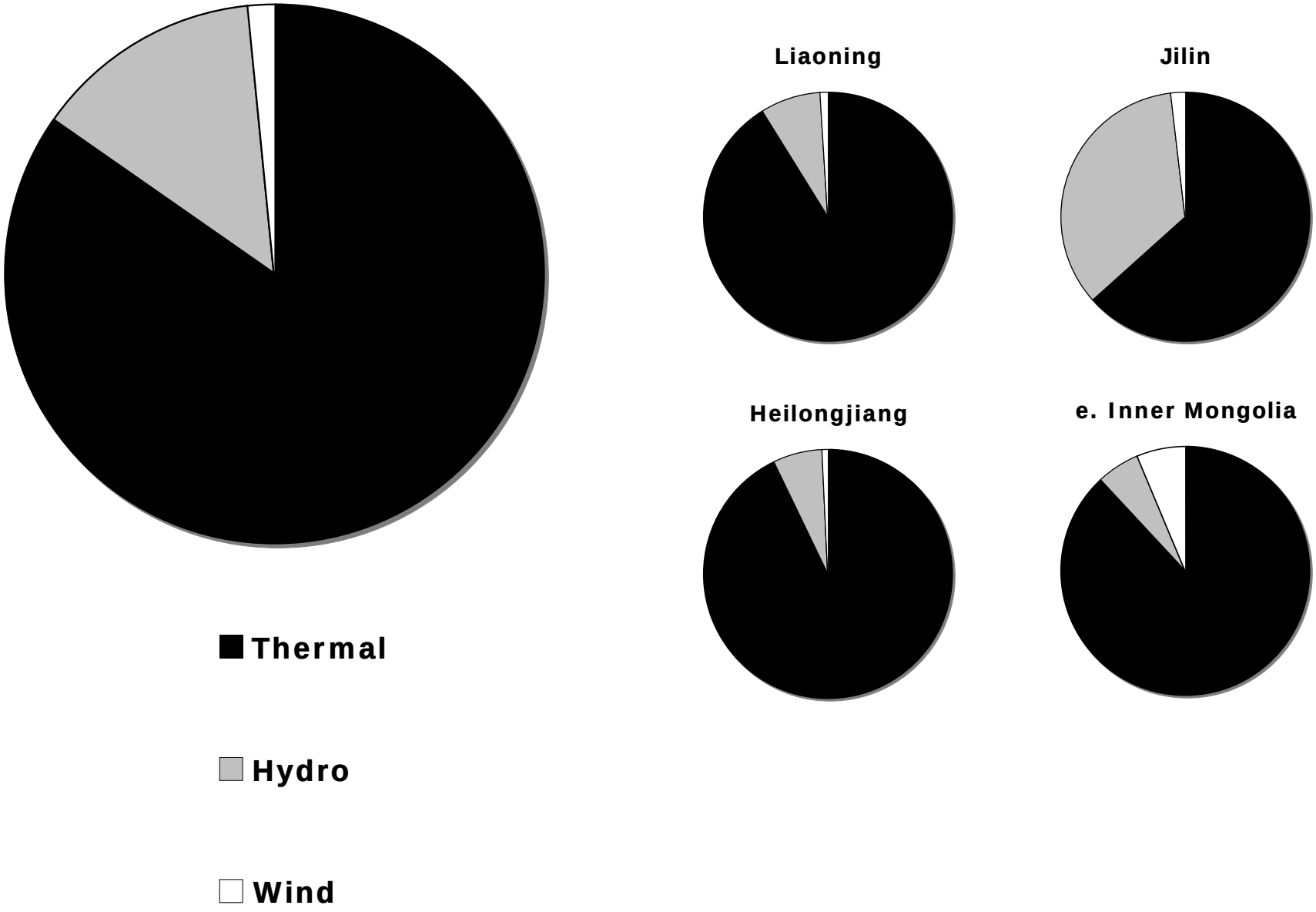


Figure 5
Generation Capacity by Outlet

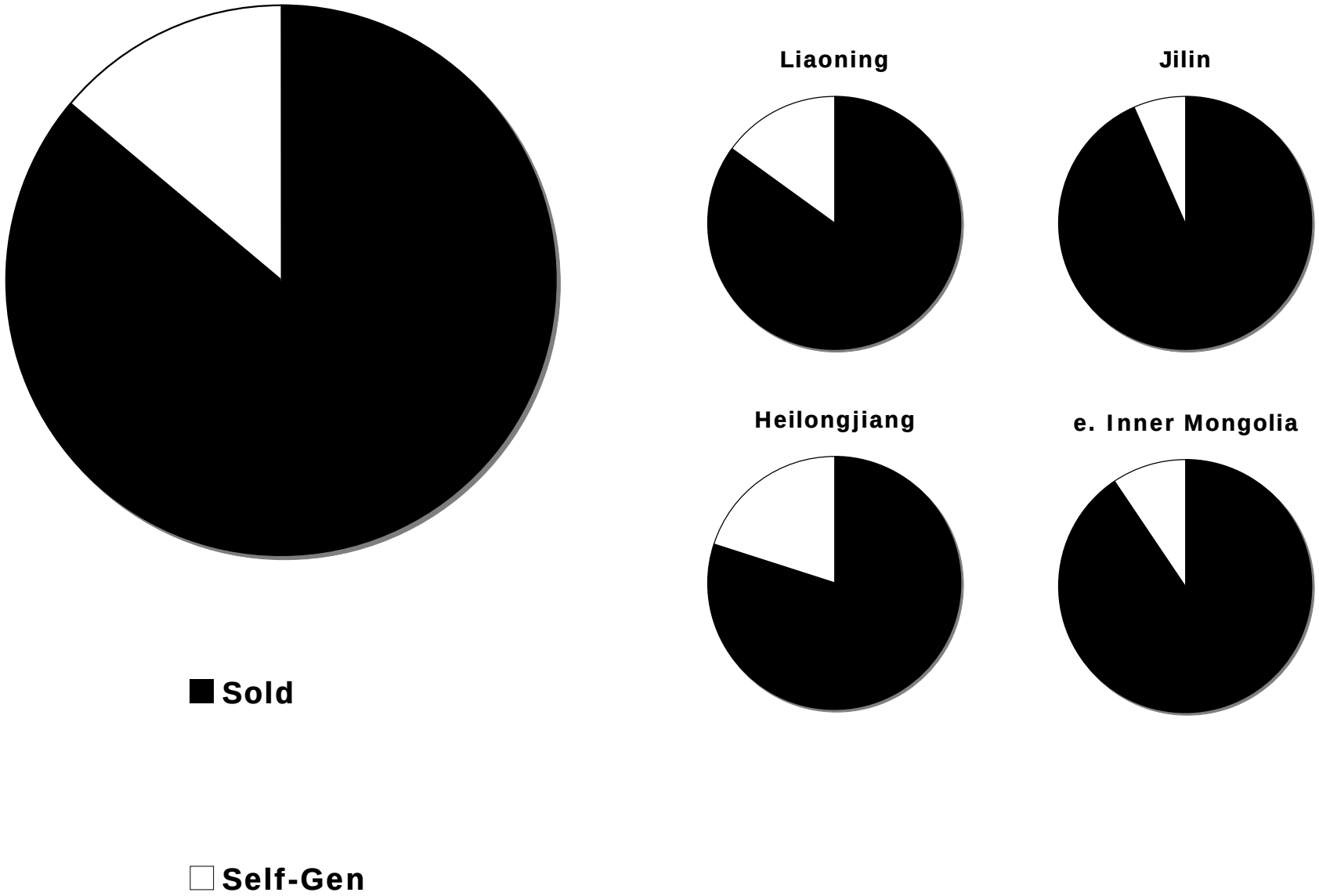


Figure 6
Generation Capacity by Ownership