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Which direction for South Korean electricity policy?

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요 약

South Korean policy makers have been sold a defective product. Seeking to address frightening long-term forecasts of electricity demand outpacing supply, the National Assembly adopted in 2000 a supply-side restructuring policy package that was in fact not well suited to address this particular problem in the best of circumstances, and especially poorly suited to the Korean situation of expensive imports of fuels. The imbalances that were forecast have increasingly come to pass, and current proposals to resume the restructuring package, which was halted in 2004, are likewise unlikely to provide much help for the actual problems at hand.

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This paper argues that in the special circumstances faced by Korea, the most urgent electricity sector reforms are on the demand side – in particular, real-time pricing for large customers and prices reflecting costs for the industrial sector – and that in this setting the supply-side focus on "vertical separation" and the creation of wholesale generation markets may be a costly distraction, in fact liable to make things worse rather than better.

Key Words : electricity, reform, restructuring, pricing
JEL Codes : L51, L94, L98, Q48

Ⅰ. Introduction

As the growth in demand for electricity in South Korea continues to outpace the growth in supply – as the supply reserve ratio continues to fall, and shortage and blackout concerns become regular news events – the debate on the future direction of electricity policy takes on an increased level of urgency.

In 2000, the National Assembly enacted reform legislation directing a supply-side restructuring process to begin the following year. The reforms were intended to encourage private investment in order to satisfy the sizable increases in demand that were being forecast, as well as to encourage competition in order to increase the efficiency of electricity sector operations. The overall restructuring model was basically a standard electricity sector reform package similar to others being discussed and adopted in many other countries around the world, consisting of the divestiture of generation assets from the vertically integrated monopoly KEPCO, the creation of competition

among privatized generation companies bidding into an hourly auction pool, and the introduction of retail competition, first among the largest users and eventually for the household sector as well. However, opposition to the restructuring process remained strong, especially among the labor unions, and in 2003 the program was suspended after the beginnings of the restructuring process but before any of the generation companies were actually privatized.[1)]

Thus reforms were begun but not completed, and the sector has ever since been trapped uncomfortably in medias res. The six newly created generation companies remain majority owned by the Korean government. User prices are regulated, including a detailed regime of required cross-subsidies, so that wholesale competition allocates production among generation companies as well as revenues between generation companies and KEPCO but does not directly affect downstream prices. Even the wholesale competition process remains tightly regulated, including separate power auctions and wholesale price ceilings for baseload (nuclear and coal) and mid-level and peak (natural gas and oil) electricity, as well as plant-specific capacity payments. In the meantime below-cost prices encourage excessive usage in the industrial and agriculture sectors and discourage entry by independent power producers, and generation reserves at times of peak demand become smaller and smaller. The longer-term problem remains unaddressed in fundamental ways.

Where to go from here? This paper begins with a discussion of the broader world experience in electricity sector restructuring and proceeds to examine the Korean restructuring plan and the current status of the Korean electricity industry in that context. It proceeds to argue that from the beginning, Korea may not have been a good candidate for the vertical separation model adopted

1) For discussions of the reforms and the reform process, see Kim and Petrov (2000); Byrne, et al. (2004); Kim and Kim (2008); Lee (2011); Hwang and Lee (2013); Kim, et al. (2013); and Nam (2013).

by many other countries, in part because a primary weakness of this model has been the poor incentives it provides for investment, while increased investment requirements were and are a primary driving force for electricity sector reforms in Korea, and in part because of the nature of the fuel mix used by Korean electricity generation (especially the absence of “cheap gas”).

We suggest that the special cost structure exhibited by the Korean electricity sector – low baseload costs, very high peakload costs – argues strongly for a path going forward that focuses on the demand side, and in particular on the apparently quite feasible task of providing incentives for a significant shifting of demand from peak to off-peak times. This would reduce the need for investment in generation, which is driven by peak levels of demand. Once that important step is in place, the focus may shift back to the supply side, where a more traditional structure seems more likely than vertical restructuring to result in increased investment and improved efficiency.

Ⅱ. Electricity Sector Reform: The Broader Context

For the past few decades, mainstream economists and market-oriented policy reformers have embraced a particular model for the restructuring of the old “natural monopoly” infrastructure sectors of their economies. Certain portions of these sectors would be opened up to private entry and competition, while those remaining portions with high fixed and sunk costs as well as strong network externalities would remain monopolies, either government-owned or privately owned and government-regulated. Thus privately owned electricity generation companies would compete to supply power into a monopoly transmission and

distribution grid; privately owned train operating companies would compete in transporting freight or passengers over a monopoly track and signaling grid; and so on.[2] Furthermore, in order to prevent anticompetitive discrimination by the grid operator against unaffiliated competitive suppliers, the grid operator would be prohibited from having its own operations in the competitive, "upstream" portion of the sector. This particular reform model was labeled "vertical separation", and it became the default model for restructuring network industries among economists and reformers, strongly and widely urged by international lending agencies like the World Bank.[3]

The vertical separation model always had its skeptics. It was pointed out that the existing vertically integrated going concerns likely enjoyed economies of scope that would be lost by vertical separation, and that the "upstream" operations that were to be demonopolized and opened to entry might exhibit economies of scale and other characteristics that would make competition difficult to create and maintain.[4] In recent years, there has come to be a growing acceptance of the argument that a particular reform model – whether vertical separation or alternatives – may be appropriate to some sectors under some conditions but ineffective or even counterproductive in other sectors under other conditions.[5]

This has been as true in the electricity sector as in others. Arocena, et al. (2012) and Meyer (2012) find evidence of significant economies of scope in the electricity sector, with costs estimated to increase by 8 percent or more when generation is separated from transmission and distribution. Widespread experimentation with the vertical separation model in the electricity sector

2) Newbery (1999); Pittman (2003); Kessides (2004).
3) Brennan (1987); Joshi and Little (1996); Laffont (2004); Xu (2004); Pittman (2007a).
4) Joskow (1991); Pittman (2003); Thomas (2004).
5) Beato and Laffont (2002); World Bank (2002).

around the world has yielded mixed results. Just a few years ago, Hogan (2007) noted

> … the extensive discussion about the electricity restructuring glass as being half full or half empty. There have been impressive accomplishment s…. The qualitative evidence is sometimes dramatic…. However, all would agree that the glass is half empty, and it would be hard to justify all the costs and turmoil of the transition of electricity restructuring based on the results to date. (p. 5)

Earlier, Brennan (2001) had concluded that

> Whether we can ensure the consistency of competition with the central coordination necessary to maintain system reliability remains the most significant test restructuring has to pass. The list of flaws in the California experiment implies that we still cannot predict the outcome…. Perhaps … electricity will be the sector in which markets meet their match. (pp. 43-44)

Newbery (1999) was similarly measured in his conclusions:

> Creating a market in electricity generation is attractive providing it can be made adequately competitive, and that in turn will depend on the size of the market, the nature of scale economies (which will depend on fuel type) and the institutional design and oversight of that market.[6](p281)

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6) Furthermore, "An open, transparent single-price pool is the critical element in introducing competition into generation…. Efficiency requires that the correct signals on location, fuel-type, reliability, and degree of excess capacity are transmitted to generators, and this places a heavy burden on the design of access and use-of-system pricing of the transmission system." (p. 279)

Newbery's evaluation of the UK reforms was that they had been a success, but only following a costly period of successive deconcentration of the original duopoly, and even then only because of the ease of entry made possible by the availability of "cheap gas". Furthermore, the success of the program mainly took the form of increased efficiency in generation; the stubborn persistence of market power meant that few gains were passed along to final customers.[7)]

Surveys and overviews by Joskow (2008), Pollitt (2012), and Vagliasindi (2012) reach the similar conclusion that attempts to create electricity sector competition through vertical restructuring have had some success around the world, but only when conditions were just right, and frequently without much pass-through of benefits to users.

Ⅲ. Electricity Sector Reform in South Korea

As suggested above, the electricity restructuring plan approved by the Korean National Assembly in 2000 was very much of a piece with restructuring plans adopted by other countries and jurisdictions around that time. As one part of the broader program of South Korean corporate reforms urged by the International Monetary Fund and other international lenders (Joh and Kim, 2003; Lim, et al., 2003; Byrne, et al., 2004), the reform plan constituted the government's program both to attract private investment into the electricity system and to increase the efficiency of operations through a series of

7) Many in the UK remain unsatisfied with the results of reforms to date. See, e.g., Will Gant, "UK energy exchange to 'boost competition' if Labour wins next election," Policy and Regulatory Report (PaRR), December 3, 2013.

market-friendly reforms.

The South Korean electricity sector has some fairly distinctive features. The country's dramatic record of economic growth over the past few decades has led to ever increasing demand, with consumption levels increasing at a 4.9 percent compound rate over the five year period ending in 2012, to the point that annual consumption is now tenth highest in the world and twelfth highest per capita. But the country lacks domestic energy supplies, so that it also ranks second in the world in imports of liquefied natural gas (LNG) and third in imports of coal (as well as fifth in imports of crude oil).[8] The most recent (6th) "Basic Plan of Long-Term Electricity Supply and Demand" drafted by the Ministry of Trade, Industry and Energy forecasts demand growth at a 3.4 percent rate into the 2020's – revising the 3.1% estimate of the previous plan.[9]

The current fuel mix of South Korean electricity generation is 42 percent coal, 31 percent nuclear, 22 percent gas, 4 percent oil, and 1 percent hydro and renewable. (See Table 1.) In response to concerns regarding both energy security and global warming, the government has planned to increase the share of nuclear over the next 10 years, though the combination of a scandal regarding reactor safety certification in Korea and the Fukushima disaster in Japan has resulted in pressures to move in the opposite direction. Perhaps as a

8) KEPCO (2013) ("Our generation subsidiaries purchase substantially all of the fuel that they use (except for anthracite coal) from a limited number of suppliers outside Korea at prices determined in part by prevailing market prices in currencies other than Won."); U.S. Energy Information Administration, "South Korea – Analysis," http://www.eia.gov/countries/cab.cfm?fips=KS, accessed 8 August 2013.

9) B.H. Han and Daesung Kim, "Beneficiaries of 6th Basic Power Development Plan," Hyundai Securities, February 4, 2013 Issue Analysis, http://equity.co.kr/upfile/issue/2013/02/05/1360027999707.pdf; Sonal Patel, "South Korea Walks an Energy Tightrope," Power Magazine, 11/01/2013, http://www.powermag.com/south-korea-walks-an-energy-tightrope/?printmode=1; both accessed 9 March 2014.

result, the new "Basic Plan of Long-Term Electricity Supply and Demand" declined to forecast any new nuclear generation capacity beyond what had already been included in the previous version of the plan.[10)]

<Table 1> South Korean electricity generation by fuel (2008-2012)

	2008	2009	2010	2011	2012	% of 2012 Gross Generation [(1)]
			(in gigawatt hours, except percentages)			
Electricity generated by generation subsidiaries:						
Nuclear	150,958	147,771	148,596	154,723	150,327	29.8
Thermal:						
Coal	174,156	193,803	198,287	199,516	198,715	39.4
Oil	7,981	11,970	10,874	9,456	14,188	2.8
LNG	1,518	762	2,288	2,233	3,256	0.6
Total thermal	183,655	206,535	211,449	211,205	216,159	42.8
Internal combustion	503	697	731	821	692	0.1
Combined-cycle	55,909	47,580	70,081	71,668	75,733	15.0
Hydro	3,836	4,091	4,393	4,815	5,051	1.0
Wind	53	82	91	117	128	0.02
Solar and fuel cells	15	24	44	60	68	0.01
Total generation	394,929	406,780	435,384	443,409	448,158	88.8
Electricity generated from others:						
Thermal	25,699	25,274	37,197	42,240	54,720	10.8
Hydro and other renewable	1,727	1,550	2,079	11,244	2,023	0.4
Total generation (others)	27,426	26,824	39,276	53,484	56,743	11.2
Gross generation	422,355	433,604	474,660	496,893	504,863	100
Auxiliary use [(2)]	17,374	18,258	19,372	19,689	15,740	2.9
Pumped-storage [(3)]	3,243	3,713	3,663	4,257	4,789	0.9
Total net generation [(4)]	401,726	411,631	451,433	472,947	484,334	96.1
Transmission and distribution losses [(5)]	16,106	16,770	18,034	17,430	17,291	3.6

Notes:

(1) Unless otherwise indicated, percentages are based on gross generation.
(2) Auxiliary use represents electricity consumed by generation units in the course of generation.
(3) Pumped-storage represents electricity consumed during low demand periods in order to store water which is utilized to generate hydroelectric power during peak demand periods.
(4) Total net generation is gross generation minus auxiliary and pumped-storage use.
(5) Total transmission and distribution losses divided by total net generation.

Source: : KEPCO(2013)

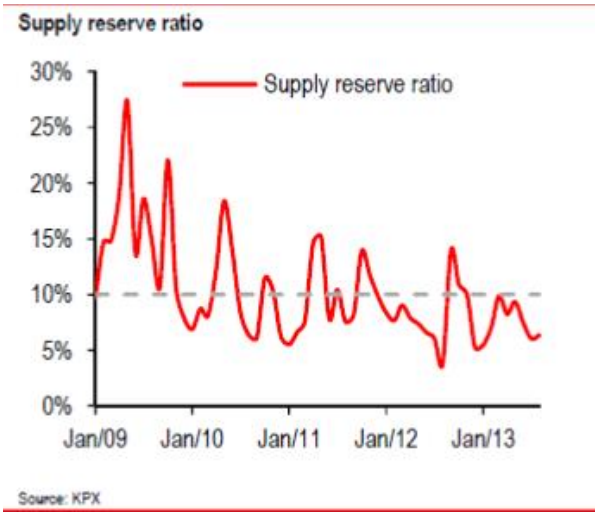
Electricity demand is highest in the Seoul area, while the bulk of generation assets are located in the South and East, resulting in chronic congestion for power flowing toward the capital on the long-distance transmission grid.

10) Kim, et al. (2013); Meeyoung Cho, "Stung by scandal, South Korea weighs up cost of curbing nuclear power," 29 October 2013, Reuters, http://www.interaksyon.com/article/73664/stung-by-scandal-south-korea-weighs-up-cost-of-curbing-nuclear-power; Jane Xie, "S. Korea may struggle to cut reliance on nuclear power – IAEA," 29 October, Reuters, http://in.reuters.com/article/2013/10/29/korea-iaea-idINL3N0IJ1D720131029; both accessed 5 March 2014; Patel, "South Korea Walks an Energy Tightrope,"*ibid*.

Attempts to build new high-capacity, long-distance power lines to relieve this congestion have foundered in the face of serious political opposition.

Recently the increased demand for electric heating has shifted the absolute demand peak from summer to winter, but demand spikes in both seasons have resulted in concerns about supply adequacy (Kim, et al., 2013). Figure 1 and Table 2 show the recent decline in supply reserve capacity, defined as the difference between the peak usage in a month or year, respectively, and the average available capacity at the time of such peak usage, expressed as a percentage of such peak usage.

<Figure 1> KEPCO supply reseve ratio



Source: Lee, et al. (2013)

<Table 2> KEPCO supply reserve ratio

2008	2009	2010	2011	2012
9.1%	7.9%	6.2%	5.5%	5.2%

Source: KEPCO(2013)

Some of Korea's gas generation capacity is in combined heat and power (CHP) plants, mostly in the Seoul area. Korea has no international electricity supply connections at this point, and is unlikely to have any so long as tensions with North Korea remain high. Discussions of an undersea transmission line between Japan and South Korea or an undersea natural gas pipeline between Irkutsk and South Korea, via China or otherwise, have apparently led to no concrete plans as yet.[11)]

Prices paid by residential, commercial, and educational customers have traditionally been set by government regulation at levels at or above their costs of service, while prices paid by industrial and agricultural customers have been set below cost. Within the residential sector, the uniform rate structure arguably results in urban households cross-subsidizing rural households. By world standards, industrial customers account for an unusually large share, and residential customers an unusually small share, of electricity demand (OECD, 2000; Lee, 2003, 2011; see Table 3).

<Table 3> South Korean electricity consumption by sector(2008-2012)

	2008 (GWh)	YoY growth (%)	2009 (GWh)	YoY growth (%)	2010 (GWh)	YoY growth (%)	2011 (GWh)	YoY growth (%)	2012 (GWh)	YoY growth (%)	% of Total 2012
Residential	57,878	3.9	59,426	2.7	63,200	6.3	63,524	0.5	65,484	3.1	14.0
Commercial	86,827	5.6	89,619	3.2	97,410	8.7	99,504	2.1	101,593	2.1	21.8
Educational	5,783	9.0	6,465	11.8	7,453	15.3	7,568	1.5	7,860	3.9	1.7
Industrial	203,475	4.4	207,216	1.8	232,672	12.3	251,491	8.1	258,102	2.6	55.3
Agricultural	8,869	8.0	9,671	9.0	10,654	10.2	11,232	5.4	12,776	13.8	2.7
Street lighting	2,847	1.9	2,954	3.8	3,081	4.3	3,145	2.1	3,158	0.4	0.7
Overnight Power	19,391	(0.4)	19,122	(1.4)	19,690	3.0	18,606	(5.5)	17,620	(5.3)	3.8
Total	385,070	4.5	394,475	2.4	434,160	10.1	455,070	4.8	466,593	2.5	100.0

Source: KEPCO(2013)

11) OECD (2000); Cho, et al. (2007); Zelenovskaya (2011); IEA (2012). Russian president Vladimir Putin recently revived the possibility of building a natural gas pipeline between Irkutsk and South Korea: "The pipeline from Sakhalin could go to Vladivostok, then the branch would continue into South Korea through North Korea or via the ocean." "Putin Urges Investors to Join Rail Projects," Moscow Times, 8 October 2013.

The reform plan adopted by the government at the end of 2000 consisted of three “phases” (Kim and Petrov, 2000; Lee, 2003; Cho, et al., 2007; Yeom, 2010; KEPCO, 2013; Kim, et al., 2013):

- ○ Phase I: Generation Competition, 2001-2003. KEPCO generation assets would be divided into six companies – five primarily thermal, the sixth primarily nuclear – and separated from KEPCO, while KEPCO retained control of transmission and distribution assets. Entry of independent power producers (IPP’s) would be permitted. The resulting generation companies would compete to sell power into an hourly auction pool operated by the new Korea Power Exchange (KPX), with KEPCO acting as a “single buyer”. The auction pool would initially be a “cost-based pool” (CBP); that is, the generation companies would be required to bid at their variable cost of operations, as determined by the Cost Estimation Committee of KPX every month. Later in this phase the CBP was to be replaced by a more market-oriented “price-based pool” (PBP), with generation company bid prices substantially deregulated.
- ○ Phase II: Wholesale Competition, 2004-2008. KEPCO distribution assets were to be spun off into regional distribution companies. Large customers would be permitted to contract directly with generation companies for electricity supply, with KEPCO and the distribution companies required to transmit and distribute such power at regulated rates. A true wholesale market would be created, with supply-side bids facing demand-side bids from both large customers and individual distribution companies. In addition, this Phase would see privatization of the five thermal generation companies.

○ Phase III: Retail Competition, 2009- . Choice of supplier would be extended to even the smallest customers, and the regional distribution companies would be privatized. At this point, retail tariffs would be deregulated (Lee, 2011).

In the event, most of the Phase I reforms were implemented, but the restructuring process was halted abruptly in 2004, in response to anti-reform political pressures. The forces resisting reforms were led by organized labor (especially the Korean National Electrical Workers Union), whose members were concerned about possible job losses from privatization, as well as other civic and political organizations, especially those opposed to increased control by foreign capital and/or the chaebols (Lee, 2003; Byrne, et al., 2004; Hwang, et al., 2013). The abrupt interruption of reforms left the generation companies separate from KEPCO but still government-owned, and since then the electricity sector of the country has languished in an increasingly awkward position. In particular:

○ Generation companies continue to be required by KTX to bid into the auction pool on the basis of their variable costs, with the equilibrium wholesale price determined by the cost of the marginal generation company at the level of power demanded. In order to prevent baseload plants – which by definition are characterized by high fixed costs and low marginal costs – from earning excess profits from this CBP, KPX is required to hold two distinct auctions, with separate auction-determined wholesale prices for baseload plants, on the one hand, and mid-level and peakload plants, on the other. But then, in order to allow plant owners to make up their fixed

costs – traditionally covered by a mark-up over variable cost that is prohibited under this regulatory regime – a complex regime of capacity payments is administered, with higher payments for baseload plants.

○ Retail electricity prices remain tightly regulated by KOREC, the electricity sector regulator, on an overall rate-of-return basis, with cross-subsidies from residential and commercial users to industrial and agricultural users and between classes of residential users enforced as part of broader industrial policy. The government has announced a gradual phasing out of the regime of cross-subsidies, but this has yet to take place. According to the most recent rate schedule, a grain farmer pays a variable ("energy") charge of 20.6 won/kWh, while a residential user pays a variable charge of 57.3 won/kWh for the lowest block of usage (1-100kWh), a rate that increases to 670.6 won/kWh for the highest block (501+kWh).[12)]

○ With demand growth continually pressing up against supply constraints, the "marginal system price" is more and more often set by expensive peak-load gas generation plants rather than the cheaper baseload nuclear and coal plants (Kim, et al., 2013; Nam, 2013). This means that wholesale prices are highly volatile. It also means that regulated retail prices are less and less reflective of costs, and KEPCO has been operating at a deficit for the past two years, for three of the past six, and overall for the period 2008-2012 (KEPCO, 2013; see Table 4). Of course this in turn exacerbates the long-standing problem of the lack of sufficient investment in new capacity.

12) "Rate Schedule for Electric Service, Effective as of January 1, 2012," http://cyber.kepco.co.kr/kepco/EN/F/htmlView/ENFBHP00101.do?menuCd=EN060201,accessed 1August2013. See also IEA (2012), Table 9, p. 87.

○ With continuing uncertainty regarding the long-term direction of reforms combined with continued rate regulation, the level of market entry by independent power producers (IPP's) has been disappointing, and the private sector has not yet accounted for as much as twelve percent of total electricity generated (KEPCO, 2013; see Table 1, "Electricity generated by others").

<Table 4> KEPCO Operating Income by Category

(million won)

	2007	2008	2009	2010	2011	2012
Power generation	2,190,447	571,520	1,926,392	3,359,795	2,230,933	2,675,175
Transmission and distribution	381,700	(3,659,202)	(568,697)	(1,312,517)	(3,555,876)	(5,309,607)
Other	220,234,	267,224	411,622	367,710	395,952	460,476
Adjustment	29,294	22,385	(54,495)	(155,068)	(91,464)	(126,267)
Operating income (loss)	2,821,675	(2,798,073)	1,714,822	2,259,920	(1,020,455)	(2,300,323)

Source: KEPCO

In 2010, faced with warnings of impending electricity shortages, the Korean government asked the Korea Development Institute for a recommendation for how to proceed from the current in-between reform position. The resulting study (KDI, 2010) recommended proceeding mostly along the original reform path, and this recommendation has been echoed recently by others (IEA, 2012; Kim, et al., 2013; Nam, 2013). But is this really the best choice going forward?

Ⅳ. A Flawed Idea from the Start?

There are plenty of reasons to question whether the widely adopted vertical separation model of electricity sector restructuring was a good idea for Korea in the first place.[13)]

Even in the broader worldwide debate concerning the reform of network industries, it has come to be accepted that while vertical separation may in some cases be successful in creating a competitive upstream sector that improves overall efficiency of operations, it is not ideally suited for settings in which a primary desired reform outcome is increased investment in the infrastructure network (Buehler, et al., 2004; Xu, 2004). Indeed one traditional argument against old fashioned rate-of-return regulation of vertically integrated "natural monopolies" was its alleged incentives for network over-capitalization – the Averch-Johnson-Wellisz effect (Kahn, 1970). Vertical separation tends to focus the attention of reformers and regulators on the details of the operation of competition in the upstream market – the level of the chain of production where the greatest changes are taking place – rather than the incentives for investment at either the upstream or the grid level.

In the electricity sector in particular, vertical separation complicates the coordination required to insure an optimal mix of investment in new

13) The author is not the first observer to note this. Cf. Kim, et al. (2013), describing a hearing at the National Assembly in 2000: "Some experts argued that the restructuring plan had been hastily drawn, simply copying foreign models without regard to the national differences."

transmission capacity and in new generation capacity, including the location of the new generation (Newbery, 1999; H`ffler and Wambach, 2013). Capacity payments and "capacity markets" are designed in part to compensate for this problem, but they are quite imperfect instruments, and at some point one must ask how complex a restructured system can be and still qualify as "deregulation" (Oren, 2000; Brennan, 2008). Since a primary driver of electricity sector reform in South Korea was concerns over whether investments in both generation and grid capacity could keep up with rapidly increasing demand, the reform model chosen may have been doomed from the start.

More specifically, the world experience has also shown that electricity markets exhibit multiple characteristics that make them different from other markets and that make the creation of workable competition a challenge in the best of circumstances.

To begin with, the demand for electricity is generally quite price-inelastic. Electricity is an essential input for a variety of industrial, commercial, and residential uses, and its cost tends to be a small part of the cost of the larger activity in which it plays a part. Both of these characteristics suggest inelastic demand by the Hicks-Marshall "rules of derived demand" (Kennan, 1998). In addition, the majority of electricity customers do not receive real-time pricing information, so that they are unable to respond to timely price signals even if in fact they are close to the margin of switching their electricity usage to another time period (or switching from electricity to another energy source). Furthermore, electricity is essentially non-storable – with certain exceptions such as batteries and pumped hydro storage – so that consumers can generally not stockpile supplies at times of lower prices.

To make matters worse for the smooth operation of markets, the supply of electricity is under some conditions quite price-inelastic as well. Nuclear and

coal-fired plants are slow and expensive to ramp up and down as well as relatively inflexible in output levels. Hydro plants are dependent on the weather as well as subject to multiple constraints on their operational flexibility because of environmental considerations as well as agricultural demands for irrigation. What supply elasticity there is in wholesale markets tends to come from smaller and more flexible plants powered by natural gas and oil – though the latter are generally being phased out for both economic and environmental reasons. As overall system capacity levels are approached, more and more expensive peaking plants are called into operation, and the supply curve may turn up sharply.

Under circumstances of very inelastic demand and supply, market power may be much easier (and more lucrative) to exercise than in more "normal" market settings, with the result that wholesale electricity generation markets that appear to be structurally competitive using the standard tools of industrial economics may in fact be subject to the exercise of significant market power – one of the lessons of the California restructuring experiment (Borenstein, et al., 1999; Joskow, 2001). And there are two other characteristics of electricity markets that favor the exercise of market power:

- ○ The same suppliers confront each other in the same auctions that are operated (for example) 24 times a day, 7 days a week, 365 days a year. The "repeat game" nature of these competitive interactions may render a collusive outcome achievable by competitors without the need for explicit communication (Fabra and Toro, 2005).
- ○ Generation companies with diversified portfolios will in many situations find one or more of their plants "marginal" while others are "inframarginal". Shutting down a marginal plant for maintenance has little effect on firm profits by definition, but if that act raises

the equilibrium price, all inframarginal plants benefit (Lee, 2003; Wolak and McRae, 2009).[14)]

In retrospect, South Korea was probably not a good candidate for overcoming this formidable set of hurdles to the creation of workably competitive electricity markets. One primary reason was (and remains) the composition of current and likely future generation plants. As noted above, the current fuel mix of South Korean generation is 42 percent coal, 31 percent nuclear, 22 percent gas, 4 percent oil, and 1 percent hydro and renewable, with plans to increase the share of nuclear over the next 10 years. Neither nuclear nor coal generation plants exhibit much flexibility in operation: they are expensive to turn on and off and not very flexible regarding output levels. Indeed, this is why these plants are invariably used as baseload plants. As noted by Newbery (1999, quoted above), countries that have succeeded in creating wholesale generation markets have typically done so by taking advantage of abundant and inexpensive supplies of natural gas. But South Korean supplies of natural gas are neither abundant nor inexpensive; rather, South Korean gas-fired plants operated almost entirely using expensive imported liquefied natural gas (LNG).

Moreover, something like 6 of the 22 percent of generation powered by gas reportedly comes from combined heat and power (CHP) plants, mostly supplying high-rise apartment buildings in the Seuol-Incheon area with district

14) Other issues that complicate attempts to create workable competition in electricity markets include a) the high ratio of fixed to variable costs for baseload plants (so that firms that bid into auctions, especially under CBP regimes, have difficulty covering their total costs), b) the accompanying high investment requirements to meet needs for expanding capacity, c) environmental restrictions on the siting of new generation and transmission facilities, and d) the frequent desire of policy makers to insure some minimum level of electricity supplies for even the poorest citizens.

heating and selling electricity into the KPX power pool, and the government is encouraging expansion of CHP capacity.[15] CHP plants must supply heat continuously during the cold winter months; they do not switch on and off in response to price signals for wholesale electricity. Thus as in Russia (Pittman, 2007b), gas-powered plants in South Korea are likely to provide much less flexibility in wholesale generation markets in winter than their share of capacity might suggest. Similarly, there are no plans or prospects for significant increases in hydro generation.[16]

All of this means that a supply curve for wholesale electricity in South Korea would typically be shaped not as the gradually upward sloping curve of textbooks but more as a reverse L-shape: low and nearly horizontal in times of low demand, with a discontinuous jump to much higher levels in times of high demand. (The same is true, by the way, of China; see Pittman and Zhang, 2010.) Thus in a freely operating wholesale market, price movements would tend to be quite volatile between peak and off-peak times.[17]

In other countries, one way to address this problem would be to improve

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15) See, for example, "CHP/DHC Country Scorecard: Republic of Korea," Paris: International CHP/DHC Collaborative, International Energy Agency(2009), http://www.iea.org/media/files/chp/profiles/Korea.pdf, and "South Korea targets CHP expansion," Cogeneration and On-Site Power Production, 11:5, January 10, 2010, http://www.cospp.com/articles/print/volume-11/issue-5/features/south-korea-targets-chp-expansion.html, both accessed 19 November 2013. The 6 percent figure is calculated as follows: The Cogeneration and On-Site Power Production article reports that 8 percent of Korean electricity is generated in CHP plants, and that natural gas powers about 75 percent of the output of the primary CHP enterprise, the publicly owned Korea District Heating Corporation.

16) As noted by KEPCO in a recent regulatory filing: "Existing hydroelectric power units have exploited most of the water resources in the Republic available for commercially viable hydroelectric power generation. Consequently, we expect that no new major hydroelectric power plants will be built in the foreseeable future" (KEPCO, 2013).

17) Ahn and Niemeyer (2007) provide a graphic illustration in their Figure 1, as do Kim, et al. (2013) in their Figure 22.7.

long distance international transmission capacity, thus increasing the size of the geographic market to bring in more potential suppliers and smooth out price movements by calling forth supplies at times of peak demand. Unfortunately, South Korea's location, along with the nature of its relations with North Korea, renders international electricity supplies quite unlikely for the foreseeable future. As noted above, there have been discussions of an undersea transmission line between South Korea and Japan (OECD, 2000), but no action appears to be forthcoming at present. In any case Japan is as highly dependent on energy imports as South Korea, and with its similar geographic position its times of peak demand would likely be similar to those of South Korea, so the benefits of such a transmission line in terms of demand-smoothing are not clear.[18] In the longer term, a natural gas pipeline from Russia may be the more promising source of relief, but, as noted above, this option faces its own difficulties.

In sum, the urgent requirement for increased generation capacity, along with the specific nature of generation capacity and the lack of raw energy resources, likely rendered South Korea a poor fit for an electricity sector reform plan based on vertical separation from the start. Empirical studies using sophisticated modeling by Ahn and Niemeyer (2007) and Bunn, et al. (2010) demonstrate the ability of generation firms in the Korean electricity sector as structured by the reforms to increase prices by behaving strategically either individually or as a group. The country's current status in medias res contributes to the problems of the sector but is probably less important in this regard than the weaknesses in the original reform strategy. In that case, what are the most promising steps to take now?

18) As Jacottet (2012) notes, "Interconnections are particularly useful when two countries have diverging characteristics."

Ⅴ. Moving Forward: Demand-Side Measures, Restructuring But Not(Necessarily) Competition

There is no disputing the importance of the goals of electricity sector reform in South Korea – most immediately the ominously low supply reserve ratios at times of peak demand, but in the longer run certainly including the desirability of encouraging investment and increasing efficiency. The question is whether means other than vertical restructuring might be more effective – as well as less expensive and disruptive – at achieving them.

It seems clear that the highest priorities going forward should be on the demand rather than the supply side: to improve the price signals sent to customers in order to shave peak consumption, as peak consumption both a) drives capacity requirements and the shortages and blackouts associated with peak demands impose severe costs economy-wide and b) is directly responsible for the increasing prevalence of high and volatile wholesale prices.

An important first step would be as rapidly as possible to move more customers to real-time pricing. As it is, there is some generalized time-of-day pricing, but this is unconnected to real-time wholesale price signals. Encouragingly, there are the beginnings of an attempt to establish a country-wide “smart grid” following the enactment of the Smart Grid Act in 2011; one important advantage of smart grids is that they may enable real-time pricing.[19)]

19) Kim, et al., 2013; Sonal Patel, “South Korea Walks an Energy Tightrope,” fn. 9 above.

As noted above, in the particular circumstances of the Korean electric power sector, moving demand from peak to baseload generation reduces costs dramatically. Also as noted above, industrial users account for 55 of Korean electricity consumption (Table 3). This is important because the world experience thus far is that industrial users of electricity exhibit significant demand responses to peak-load electricity prices, with a combination of shifting demand to off-peak periods (the majority of the response), substituting other inputs for electricity, and simple conservation (Boisvert, et al., 2004; Borenstein, 2005; Taylor, et al., 2005). Real-time pricing at the household level is of course more difficult and expensive to implement, but there is evidence of demand response to peak-load prices here as well – though in this case the reduction in peak demand is apparently mostly the result of simple conservation, such as lower usage of lighting and air conditioning (Faruqui and Sergici, 2010; Joskow, 2012).

A second and related step would be to end the system of cross-subsidies by which industrial and agricultural users pay less for their electricity than the cost of serving them. There is nothing wrong with adding different mark-ups over cost to different classes of customers – "differential pricing" – as a "second best" policy option for the recovery of high fixed costs; this is common practice in network industries around the world.[20] But the efficient form of this practice involves differential positive mark-ups over marginal cost, not negative mark-ups.

There are no good policy arguments for encouraging more energy use by South Korean manufacturers and farms. Indeed South Korea's industrial sector is by any standard strong and productive; the country is not well served by

20) Newbery (1999); Laffont and Tirole (2000). Indeed, to cite one example, it is U.S. government policy to encourage differential pricing to rail freight shippers for precisely this reason (Pittman, 2010).

subsidies for its use of electricity or, for that matter, railways (Pittman and Choi, 2013). If supporting the agricultural sector is considered desirable public policy – a situation familiar to other market economies – there is no good argument for seeking the necessary funds from the pockets of other electricity users (and investors), as opposed to general tax revenues, or for using incentives for inefficient input choices as the instrument. The removal of these required cross-subsidies would have the political advantage of benefitting the household sector of the economy, even if and as industry and agriculture interests object.

These two steps by themselves should reduce demand, especially at peak times, and thus reduce both cost volatility and the need for additional investment in generation capacity. However, future economic and population growth are likely to require additional capacity. What policies are most likely to support this?

Continuing down the original reform road with minor midcourse corrections, as urged by IAD (2012), Kim, et al. (2013), Nam (2013), and other reformers, has some appeal. To begin with, privatization of generation assets – and perhaps of transmission and distribution assets, further down the road – would likely improve incentives for efficient operation. However, this is a difficult political issue in South Korea, and the recent corruption scandal regarding nuclear power generation has certainly made things worse.[21] Also, to make this strategy effective in actually creating workably competitive markets would seem to require, per the Newbery (1999) analysis discussed above, increased natural gas supplies (perhaps, as discussed, from Irkutsk) as well as moving from a CBP to a PBP (to insure returns to investors) and the introduction of nodal

21) The politics of privatization make reform difficult in Korean railways as well – see Pittman and Choi (2013).

transmission prices (to better reflect real costs, to use market signals for the location of new generation plants, and to insure returns to transmission investors if transmission is privatized; Green, 2007).

Even with these steps, the question remains whether an electricity system based on vertical separation provides adequate incentives for investment in new generation and transmission capacity. Ahn and Niemeyer (2007), for example, find the current model consistent with increased future investment in the Korean generation sector – but only because the exercise of market power by incumbent generators is expected to increase prices high enough to do so. If one continues and refines the regime of capacity payments to address this issue, the overall plan of organization becomes quite complex and increasingly distant from free market principles. Are there alternatives?

As noted above, a virtue of the old fashioned system of rate-of-return regulation of monopolies – including vertically integrated monopolies – was and is the support of investments. Indeed in the modern economics literature, rate-of-return regulation has been shown to be one end of the spectrum of the "power" of regulatory incentives. "High-powered" incentive schemes such as market-determined prices or price caps provide strong incentives for firms to operate efficiently, but society must be prepared for the firms either to earn very high profits if they succeed or to incur losses if they fail. "Low-powered" incentive schemes such as rate-of-return regulation or cost-plus contracts provide poor incentives for efficiency and may even encourage over-capitalization, but they encourage investment and likely reduce the returns to rent-seeking and regulatory capture (Laffont and Tirole, 2000; Burns, et al., 2006).

Keeping all these factors in mind, the rather old-fashioned arrangement of vertically integrated regional electricity firms has some attractiveness in the current South Korean context. Vertically integrated electricity providers have

good incentives to collect the necessary information to make efficient internal decisions regarding questions like nodal transmission pricing and the optimal mix of expanding generation capacity vis-à-vis transmission capacity. (Of course the quality of the incentives would improve if these providers were privatized as well.) They likewise make the complex decisions of which generation plants to dispatch at which times internally rather than through a complex rule-based procedure organized by a system operator. Indeed all of this is reflected in the econometric findings of significant economies of vertical integration in the electricity sector noted above (Arocena, et al. 2012; Meyer, 2012).

Such firms could be reorganized from the current five thermal generation companies to allow for regional transmission and distribution monopolies, and could be subject to yardstick regulation to provide some degree of incentive "power" while still encouraging investment. Two or three such firms might transmit power to Seoul from different directions – for example, some combination of the LNG plants in the Northwest, the coal plants in Dangjin and Taean, and the nuclear plants in Youngkwan and the East – competing for that business, while others served demand centers further south and east. On the distribution side, the econometric findings of Salvanes and Tjøtta (1998), Arocena, et al. (2012), and Jamasb, et al. (2012) all suggest that distribution firms covering one-third or one-half of South Korean territory would be large enough to exhaust most available economies of scale in distribution.

Clearly there is much work to be done going forward to construct the best institutional arrangement for KEPCO and the rest of the South Korean electricity sector to meet the needs of the future economy, and the scenario that we have just presented is only one of many possibilities. The principal point here is that returning to the original three-stage plan adopted almost fifteen years ago is only one of many possible avenues going forward, and not

obviously the best, either, especially in the near term. First of all, the lower hanging fruit is on the demand side, not the supply side – under current circumstances, any policy reform that results in peak-shaving is likely to offer much higher and faster returns than reforms that focus on supply-side restructuring. Second, even on the supply side, the special circumstances faced by Korea mean that vertical separation and the creation of wholesale markets are unlikely to lead to real generation competition and thus to dramatic increases in efficiency and investment. As Hogan (2001) emphasizes, “Markets are means, not ends.”

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