Costs of electricity deregulation

C.K. Woo[a,b], M. King[b,*], A. Tishler[c], L.C.H. Chow[b,d]

[a] Energy and Environmental Economics, Inc., 353 Sacramento Street, Suite 1700, San Francisco, California 94111, USA

[b] Hong Kong Energy Studies Centre, Hong Kong Baptist University, Hong Kong

[c] Faculty of Management, Tel Aviv University, Tel Aviv 69978, Israel

[d] Department of Geography, Hong Kong Baptist University, Hong Kong

Abstract

The last decade has witnessed efforts throughout the world to deregulate the electricity industry, with varied results. While there have been a few qualified success stories, many challenges of deregulation have come to light. These challenges can lead to negative, even disastrous, outcomes. Based on a comprehensive literature review, this paper catalogues problems experienced in various deregulation efforts, and considers the application of the lessons learned from this history to Israel, which is considering deregulation. Failings of deregulation are found to center around the following problems: high set-up cost; complicated market design; inevitable spot price volatility; market power abuse; inefficient investment; difficulty in reducing generation cost; dysfunctional input markets; stranded cost; unequal distribution of benefits. We find that many of these problems are exacerbated by the particular circumstances faced by Israel, and advise any country or region considering deregulation to carefully consider these obstacles to success.

[*] Corresponding author: Tel.: +1-415-391-5100; fax: +1-415-391-6500
E-mail address: mikeking@ethree.com (Michael King).

1. Introduction

This paper reviews potential problems of electricity deregulation and their ensuing costs. This paper is not about how to develop a market reform proposal. That topic is addressed elsewhere [1-9]. Rather, this paper canvasses recent literature on electricity deregulation to document the problems that have arisen in countries that have undertaken deregulation. To illustrate the application of the lessons derived from this review, we discuss the implications of our findings for Israel, a country that is considering deregulating its electricity sector.

Throughout this paper, we use the term "deregulation", "market reform" or "market restructure" interchangeably to mean implementation of a market design that transforms an electric sector dominated by regulated integrated utilities into one that relies on competition to deliver generation and retail services.

[INSERT FIGURE 1 HERE]

Figure 1 portrays a generic model of restructured markets [10]. In this model, customers can choose to buy electricity directly from wholesale generation markets (which are the pool and the bilateral market), or through load-serving entities (LSE) such as distribution companies and retailers that procure from wholesale generation markets to meet their load obligations. Buyers and sellers may manage electricity spot price risk using hedge instruments (e.g., forward contracts) traded in a financial market. Though not shown in Figure 1, a transmission company operates the grid and offers open and comparable access to all market participants (e.g., UK). Alternatively, an independent system operator (ISO) leases transmission facilities from transmission owners to perform the same functions (e.g., California, New England, New York, PJM, Texas, Alberta, and Ontario).

Detailed in the next section, the key findings of this paper are:

- The cost of setting up and operating an ISO is substantial.
- Electricity deregulation is complicated, and transforming a regulated monopoly into a market that relies on competition to supply wholesale power and retail services is difficult.
- A complicated market design invites gaming by traders and retailers.
- Electricity spot prices are highly volatile.
- Market power abuse is common in deregulated generation markets.
- Electricity deregulation causes inefficient generation and transmission investment.
- Deregulation can jeopardize reliability.
- Deregulation does not always reduce generation cost.
- Dysfunctional input markets preclude an efficient market for generation.
- Deregulation often creates stranded cost/debt.
- The net benefits of electricity deregulation, if any, are unevenly distributed among residential users, industrial users, and electricity suppliers.

Table 1 presents a list of critical questions to be addressed prior to electricity deregulation [10-14]. The list is both a result of deregulation problems observed in the past and a checklist for how to help avoid such problems in the future.

[INSERT TABLE 1 HERE]

Sadly, many governments in the world did not fully address the questions in Table 1 before implementing deregulation. We hope Section 2 of this paper will raise awareness of the complexity of these questions and the magnitude of associated problems for countries now considering deregulation.†

† Since deregulation has already occurred or stopped in North America, South America and Europe, such countries are mainly in Asia (e.g., China, Hong Kong, Taiwan, South Korea, and India) and Africa (e.g., Malawi, Tanzania, Uganda and Zimbabwe).

2. Costs of electricity deregulation

For clarity and easy exposition, the presentation of each finding uses the following format: (a) a description of the problem; and (b) real-world examples of the problem and, where available, associated costs.

2.1. The cost of setting up and operating an independent system operator (ISO) is substantial.

2.1.1. Description

A common element of electricity deregulation is an ISO responsible for reliable grid operation via efficient dispatch and congestion management, provision of open and comparable access, and transmission tariff design and administration [1-5]. Though seldom discussed, the cost of setting up and operating an ISO is substantial.

2.1.2. Real-world examples

<u>Setup costs: Ontario</u>

The Ontario reform created the following new organizations:

- Ontario Power Generation (OPG), a government-owned company that inherited the generation assets of Ontario Hydro, the formerly government-owned integrated utility.
- Hydro One, a government-owned company that inherited Ontario Hydro's transmission assets.
- Independent Market Operator (IMO), a non-profit corporation responsible for operating the grid and wholesale spot markets.
- Ontario Electricity Financial Corporation (OEFC), a government-owned company responsible for Ontario Hydro's debt not assigned to OPG.

Based on discussions with a number of Ontario Executives involved in the Ontario restructuring, the direct cost of setting up Ontario's IMO was C$300M (C$1 = US$0.73 as of June 18, 2004). In addition, the one-time costs incurred by OPG were C$100M, Hydro One C$125M, and local distribution companies C$600M, bringing the total to well over C$1B. These costs were due to investment in hardware and software, organizational change, and operational systems changes triggered by the Ontario market reform.

Operation costs: ISO in North America

The annual expenses of the ISO in North America are substantial:

- Ontario: C$212M in 2002 and C$133M in 2001 [15].
- California: US$198M in 2002 [16].
- Midwest: US$119M in 2003 [17].
- New England: US$103M in 2003 and US$64M in 2002 [18].
- New York: US$116M in 2003 and US$97M in 2002 [19].
- PJM: US$247M in 2003, US$255M in 2002, and US$123M in 2001 [20].

One may argue workload savings in the post-reform transmission and local distribution companies (LDCs) partially offset these operational costs. However, this argument is dubious because these post-reform companies (e.g., PG&E, SCE, and SDGE in California) continue to perform similar functions previously done by the integrated utility (e.g., making load forecasts, assessing supply, preparing and submitting schedules, and procuring power).

2.2. Electricity deregulation is complicated, and transforming a regulated monopoly into a market that relies on competition to supply wholesale power and retail services is difficult.

2.2.1. Description

Recognizing the difficult transition in the U.S., Joskow [5, p.12] opines: "[i]n the U.S., electricity sector restructuring and competition initiatives got off on the wrong foot in many parts of the country at least in part because policymakers and many of their advisors underestimated the nature and magnitude of the technical and institutional challenges associated with successfully introducing competitive wholesale and retail markets and the uncertainties associated with how best to respond to these challenges. … The experts did not, and in many cases still do not, agree on how best to proceed with these structural and institutional reforms. … This in turn resulted in numerous political compromises over restructuring and market design issues and the mixing and matching of pieces of alternative restructuring models that did not fit very well together."

2.2.2. Real-world examples

<u>Ontario</u>

Trebilcock and Hrab [21] attribute Ontario's capacity shortage to insufficient investment, inter-regional transmission constraints, and nuclear plants' prolonged outage. Private investors were reluctant to invest in Ontario because of the delay in market opening, uncertainty in final rules governing the market, and the dominance of OPG. As well, the government's market power mitigation agreement (MPMA) required OPG to rebate electricity consumers when the spot market prices exceeded C$38/MWh. The MPMA reduced the demand for forward contracts and increased the demand in the electricity spot market, thus raising spot price volatility in the province. As shown in Section 2.4 below, excessive price volatility can have disastrous consequences.

Hong Kong

Lam [22] proposes a reform program, calling for price cap regulation for the existing generation and competitive procurement from IPPs to serve load growth or when existing plants retire and power contracts expire. Retail access will occur gradually, with 25% of total end-use load in 2009, 50% in 2014, and 100% by 2019. "By that time, there would be at least four players in the generation market and the market share of any company should not be more than 30%" [22, p.853]. Lam's proposal is not supported by empirical evidence of projected net benefits. As well, Hong Kong has not developed regulations that will limit market concentration in the electric sector. Even if such regulation is developed, four equally-sized firms can exert market power in an oligopolistic electricity market, as seen in other parts of the world [10]. Finally, integrating Hong Kong with the fast growing and electricity-hungry China is risky because it can compromise Hong Kong's service reliability, a likely result of China's insatiable power import.

U.S.

Market reform at the state level has completely stopped in the U.S. "[N]o state has passed restructuring legislation since June 2000, when the California crisis was just taking shape. … After the summer of 2000 and into early 2001, state activity shifted predominantly to states backing away from restructuring" [23, pp.28-29].

2.3. A complicated market design invites gaming by traders and retailers.

2.3.1. Description

A complicated market design like California's invites gaming by traders who gain at the expense of consumers. Under the single market clearing price (MCP) rule, a trader could simply make supply bids into the California Power Exchange's (PX) day-ahead market using the "hockey stick" pricing strategy described by Hurlbut, Rogas and Oren [24]. Even if the PX did not select such supply bids, the trader would have a second chance in the CAISO's hour-ahead market [14]. The example below shows how Enron successfully gamed the California markets [25].

A less known defect of the California design is retailers gaming the frozen rates that were projected to exceed the PX price forecast. The expected positive difference between the frozen rates an investor-owned utility (e.g., PG&E) and the actual PX price was the projected competition transition charge (CTC) collected by the investor-owned utility for the purpose of stranded cost recovery [26]. The second example explains this strategy.

2.3.2. Real-world examples

<u>Enron</u>

"The state of California sued Enron Corp. and several subsidiaries … for allegedly manipulating market prices during the state's energy crisis and costing Californians billions of dollars. … The suit, the first filed against Enron by the state's top law enforcement officer, accuses the company, among other things, of deliberately causing congestion along transmission lines, then reaping revenue for taking action to relieve the bogus congestion. The company also allegedly misrepresented out-of-market energy sales so it could sell power back to the state at a higher price" [27].

Enron's strategies were named to portray their essence:

- "Fat Boy". This strategy was based on the fact that the CAISO hour-ahead market price often exceeded the PX day-ahead market price. Hence, selling generation into the CAISO hour-ahead market would be more profitable than the PX day-ahead market. The per MWH profit was the price difference between the two markets. To make this profit, Enron would, for example, submit a presumably balanced schedule of 1000 MW of generation and load with the CAISO, even though the actual load is only 600 MW. This intentional over-scheduling of load thus earned the name "fat boy". The excess generation of 400 MW (= 1000 MW generation – 600 MW load) generation would then receive the higher CAISO market price, rather then the lower PX market price.
- "Death Star". Enron would submit energy schedules to the CAISO as import/export transactions. But those transactions were in fact linked to other transactions outside the CAISO's control area, forming a closed loop. Although there was no physical power flow under these circular schedules, the import/export transactions appeared to have created "counter-flow" on the CAISO's scheduling records, thus earning congestion payment from the CAISO.
- "Get Shorty". Enron would sell capacity in the CAISO's day-ahead market and buy the same capacity in the CAISO's hour-ahead market. This strategy was profitable when the day-ahead price was systematically above the hour-ahead market price.

- "Ricochet". Enron would export power outside the CAISO's control area and then resell the same power as import to the CAISO, thus circumventing the CAISO's price cap, which only applied to in-state power.

Retailers

The strategy described herein is based on the first author's participation in 2004 as an expert witness in a contract dispute between a retailer and a large chip manufacturer. Assembly Bill 1890, passed in 1996, shaped electricity deregulation in California. It imposed a rate freeze at the 1996 level that was scheduled to end no later than April 2002, upon the full recovery of stranded costs. The LDC's bundled service rates were expected to drop by 2-3 cents per kWh at this time. Anticipating this rate decrease, a retailer marketed a long-term fixed price contract to a poorly-informed electricity end-user. The contract was to last beyond 2002. To win the end-user's business, the contract's fixed price was slightly below the LDC's frozen rate level. To meet the end-user's electricity requirement, the retailer would simply resell the LDC's bundled service. The fixed price contract would have been highly profitable if the unfrozen rate had dropped as expected after the end of the rate freeze. However, this strategy did not work because the LDC's bundled service rate did not fall, see Section 2.4 below. The end result was costly litigation between the retailer and the customer, as the retailer withdrew from the service contract once it had become unprofitable. This example illustrates the pitfall of a complicated market design that permits gaming by retailers.

2.4. Electricity spot prices are highly volatile.

2.4.1. Description

Electricity cannot be economically stored and must be generated and delivered in real time to perfectly balance supply and demand that can fluctuate randomly. Since hourly market demand is highly price-insensitive, a supply shift along a demand curve can produce a large price swing. As well, a demand increase at times of capacity shortage can effect a large price spike. To be sure, price volatility can be managed using hedging instruments [28-30]. Unfortunately, liquid markets for a full spectrum of products (e.g., futures, forward, options, and swaps) with differing term (e.g., 3-month vs. 5-year), shape (e.g., flat block vs. time-varying MW), and size (e.g., large vs. small) do not currently exist in the U.S. or anywhere else. As a result, least-cost procurement of such products requires benchmarking their price reasonableness [31, 32] and competitive auctions [33, 34]. Such auctions have higher transaction costs than trading of standardized financial contracts (e.g., NYMEX electricity and natural gas futures).

2.4.2. Real-world examples

<u>Alberta</u>

The average power pool price in Alberta was under C$20/MWH in 1996, gradually rose to around C$40/MWH in 1999, then exploded to over C$130/MWH in 2000 [35, p.24]. In 2001, the Alberta Government spent C$2 billion in monthly rebates at C$40 per retail customer to help reduce their bills [21].

Ontario

According to Trebilcock and Hrab [21], when the market opened in May 2002, the wholesale average price was C$30/MWH. It then rose to C$37/MWH in June, C$62/MWH in July, C$69/MWH in August, and C$83/MWH in September. The high summer price led to enactment of Ontario's Electricity Pricing, Conservation and Supply Act on December 9, 2002. The Act froze the rate at $43/MWH for small users with consumption less than 150 MWH per year. In March 2003, the frozen rate extended to medium users with annual consumption less than 250 MWH. Implementing the frozen rate caused the OEFC to issue C$730 million in debt to finance the difference between the wholesale price and the frozen rate.

Regional deregulated markets in North America, Europe, Australia and New Zealand

Half-hourly and hourly price data from 14 deregulated markets show that prices can be unpredictable and volatile. "The fact that electricity is not storable also leads to high hourly variations in price in deregulated markets. Unlike other commodities, it is not unusual for electrical power to show both a significant daily variation in price and large variations in average price (AP) between days" [36, p.658].

Singapore

The spot market in Singapore was formed in 1998 as the Singapore Electricity Pool (SEP), which evolved to the National Electricity Market of Singapore in January 2003 [37]. The mean price in 2003 is S$92/MWH (S$1 = US$0.58 as of June 18, 2004), with most half-hourly prices lying between S$70/MWH to S$130/MWH. However, the price reached the S$4500/MWH limit in 3 trading periods out of 17,520 trading periods in the year.

New Zealand

"The 2001 hydro situation and increased demand caused [the electricity price] index values to rise to levels five to ten times higher than previous levels. … The 2003 hydro situation caused the index to rise to levels similar to those seen in 2001"[38, p.15]. The 7-day rolling average of half-hourly electricity prices around July 1, 2001 was over NZ$350/MWH (NZ$1 = US$0.66 as of July 7, 2004) and around July 1, 2003 over NZ$300/MWH.

2.5. Market power abuse is common in deregulated generation markets.

2.5.1. Description

Market power is a seller's ability to raise market price by (a) economic withholding whereby the seller's offer price exceeds its marginal cost [39] or (b) physical withholding whereby the seller withholds some capacity to raise the price of output from its remaining capacity [40,41]. It is a primary cause for the California electricity crisis in May 2000 to April 2001 [42-47]. Market power increases when transmission constraints create load pockets [48,49] or when regulatory actions limit forward trading and demand response [50-52].

2.5.2. Real-world examples

California

The cost of market power abuse on consumers was substantial. "In summer of 2000, wholesale electricity expenditures were $8.98 billion up from $2.04 billion in summer 1999. We find that … 59 percent of this increase [was due] to market power" [44, p.1376].

PJM and New York

Based on the percent of hours in a year during which pivotal firms can disrupt the grid by withholding supply, Blumsack, Perekhodtsev, and Lave [53] detect significant market power in PJM and New York.

Texas

When a wholesale market operates as a pool with a single MCP determined by the interaction of an aggregate supply curve and a price-inelastic demand curve, a supplier can profit from a "hockey stick" pricing strategy [24]. In an actual instance, a supplier made price offers at marginal cost for most of its capacity. For the few remaining MW, however, the seller made extremely high price offers. In a capacity shortage, the ISO dispatched these few MW, resulting in a MCP of US$990/MWH for all of the seller's capacity.

Alberta

In a 2000 report, the Market Surveillance Administrator of the Alberta Power Pool expressed concerns of market power abuse [54]. Such a concern is justified by three incidences of power price manipulation [55].

Australia

"There is insufficient generator competition to allow Australia's gross system to work as intended, [resulting in] too many periods of excessive generator market power and pool price volatility" [56, p.6].

UK

The British pool exhibited price behavior consistent with market power abuse by the two dominant generators [57,58]. However, prices fell in 1998, possibly due to the regulatory threat embodied in the introduction of the New Electricity Trading Arrangement [59].

Germany

"Germany arranged deregulation in 1998 when its new energy law became effective. As a consequence, the first German power exchange in Leipzig started operation in June 2000" [60, p.1]. Increased market concentration due to mergers of eight into four power companies enabled market power abuse. "[T]here is strong evidence of market power in the second period from September 2001 to June 2003; on average, prices are nearly 50% above estimated costs. Mostly, these price differences lie in periods of high demand … [with] prices … 77% higher than [estimated] costs" [60, p.18].

Austria

"But very soon [after full market liberalization in October 2001] electricity prices for small customers will start to increase continuously, mainly because prices are no longer regulated and because of increasing generation prices in Central Europe due to the merger mania and the increased exertion of market power" [61, p.238]. The exit by foreign companies consolidates the European oligopoly [62].

Europe

Cross-border transmission constraints prevent market integration that can dilute market power. "A single European market with six or seven comparably sized companies might not raise competition concerns if there were adequate transmission capacity across the continent.

This is far from the case, as existing interconnection was primarily designed for improved reliability within a structure that aimed at national self-reliance. Despite the substantial variation in wholesale prices across the Union, wholesale trade is only eight percent of all electricity generated in the European Union. The competitiveness of cross-border trade is further compromised when some generation companies (particularly in Germany) own half of the interconnection. Further, some generation companies on one side of the border have bought generation and supply companies on the other side of the border, while legacy long-term interconnection contracts further restrict access by other suppliers" [63, pp.2-3].

2.6. Electricity deregulation causes inefficient generation and transmission investment.

2.6.1. Description

Deregulation decentralizes generation investment. While it shifts the investment risk from consumers to investors, it also creates uncertainties on the returns on and of investment. This increases the cost of capital and discourages generation investment. Uncertainties can extend to transmission and distribution investment. A case in point is the U.S. where there is on-going debate on issues like regional transmission organizations, standard market design, and incentives for and cost recovery of T&D investment. The ensuing outcome is alarming, as summarized by the National Council of Energy Policy in the U.S.:

> "Electric-industry restructuring has derailed. The massive blackout of August 14, 2003 certainly was not needed to underscore the point, but it adds urgency to the effort to find solutions. … Indeed, investment in all categories of electricity infrastructure is down significantly" [64, p.3].

2.6.2. Real-world examples

Generation investment and debt downgrades: U.S.

"Since 1998, electricity markets in the U.S. have completed the entire cycle from bust to boom and back to bust again. … Those merchant generators who successfully brought projects on line were then faced with market prices that fell far short of their expectations. …. This contributed to the bankruptcy of Enron and led to the downgrading of numerous developers. Eight of the largest U.S. merchant generating companies (not including Enron) suffered an average of seven debt downgrades *each* between 2001 and 2003. In 2001, the *lowest* rating among these eight firms was BB+; by 2003, the *highest* rating of the eight had dropped to B+" [65, pp.33-34]. The rating trend extends to the natural gas sector [66, p.I-6]. The debt downgrades shook investor confidence, which was already weakened by Enron's untruthful financial reports and eventual bankruptcy [67]. This dries up credit available at a cost that can rationalize investment by merchant generators. "No one should expect that unsecured lenders will increase their exposures, particularly since so many banks have maneuvered themselves ahead into secured lending positions during the last 12 months" [68, p.49].

Generation investment and long-term contracts: U.S.

"In theory, competitive electricity markets can provide incentives for efficient investment in generating capacity. We show that if consumers and investors are risk averse, investment is efficient only if investors in generating capacity can sign long-term contracts with consumers. Otherwise the uncovered price risk increases financing costs, reduces equilibrium investment levels, distorts technology choice towards less capital-intensive generation and reduces consumer utility. We observe insufficient levels of long-term contracts in existing markets, possibly because retail companies are not credible counter-parties if their final customers can switch easily" [69, p.1].

A corollary is that "[w]ith the retreat of the merchant power sector due to financial and market constraints, more utilities are turning to affiliates to contract long-term generation to meet forecast load growth. That has led to a growing number of cases before the Federal Energy Regulatory Commission (FERC) in which independent generators question whether the utility has given improper preferential treatment to its affiliate" [32, p.1]. If generation investment can only be supported through affiliate transactions, deregulation has failed to foster independent power production. Subject to regulatory review, generation investment by an integrated utility is, by and large, equivalent to an affiliate transaction.

A substantive policy question thus arises: if generation investment must occur to keep the lights on, can an economy, with high confidence, rely on decentralized decision making by merchant generators? The U.S. experience suggests that the answer is "no".

<u>Transmission planning and investment: U.S.</u>

Electricity restructuring often divests the formerly integrated utility into generation companies, a transmission company, and LDCs. While necessary to mitigate vertical market power in the post-reform world, the disconnection of generation and transmission eliminates the economies of joint planning and coordination [70]. Moreover, a transmission company operating under price cap regulation does not have the incentive to build because a lumpy investment harms the company's earnings when the new capacity is not fully used. The disincentive strengthens if the transmission company's revenue depends on congestion cost [71].

Transmission investment and market expansion: Nordic Power Pool

Market expansion has reduced market power in the Nordic Power Pool [72,73]. However, "[w]hen a free market opens up, the cross-border power flow tends to increase if the international power exchange had previously limited to optimizing marginal production. The capacity between Norway and Sweden has already fallen short at times, resulting in a difference in system price between the two countries. *A shortcoming of the Nordic market (as in most other power markets) is that there are no clearly defined rules prescribing when network expansions have to be built by the grid companies and how they should be financed*" [74, p.4 *emphasis added*].

Merchant transmission investment in Australia

Delegating transmission investment to merchants has failed. "How far can merchant transmission sensibly replace or supplement investment by a regulated transmission company? Proponents suggest that merchant transmission could play a significant role and that only where there are market failures should regulators look to rate-based projects. Skeptics tend to see market failure as overwhelming in this area. It is also suggested that experience with merchant interconnectors in Australia has not been successful and has delayed investment in efficient regulated interconnectors. … *Australian experience with regulated and merchant transmission lines has certainly been characterised by controversies, litigation and delayed investment in regulated transmission*" [75, p.1 *emphasis added*].

2.7. Deregulation can jeopardize reliability.

2.7.1. Description

A regulated integrated utility is often accused of over-investment under the rate of return regulation. However, such investment yields high reliability. Deregulation can jeopardize reliability in the following ways:

- Under-investment. Deregulation reduces investment in the electricity sector, therefore harming reliability, see Section 2.6.
- Capacity withholding. Market power abuse compromises reliability, see Section 2.5.
- Transmission constraint. A system designed for operation by an integrated utility is not suited to accommodate wholesale trading that requires transmission expansion across trading regions, see Section 2.6.
- Complexity. Grid operation by an integrated utility is done under centralized command-and-control with almost perfect information. Operation by an ISO is through decentralized scheduling by market participants, resulting in more uncertainties and less control.

2.7.2. Real-world examples

U.S. and Europe

The 2003 blackouts underscore the weakness of the inter-regional grid that cannot support large volume trading. "Increased liberalization of [the] electricity supply industry has resulted in a significant increase in inter-area (or cross-border) trades which often are not properly accounted for when assessing system security" [76, p.1].

Europe

In 2002, a prominent deregulation economist in UK expressed concern over reliability deterioration in Europe. "At present, the margin of spare capacity is adequate in Europe (although it has been falling fast in response to lower prices and capacity withdrawals). … Member countries are right to worry that liberalised markets may reduce future quality and safety unless active steps are taken to avoid under-investment. *Private owners benefit from high prices, which in electricity markets require either market power or low reserve margins*" [28, pp.19-20 *emphasis added*].

Italy

Italy has a capacity shortage problem. "[T]he total available capacity is 55,250 MW. Such capacity must meet peak demand (currently running above 52,000 MW) plus a reserve margin for unexpected events and/or errors in demand forecasts" [77, pp.54-55]. Under deregulation, a market-based solution is an incentive-compatible capacity payment scheme. However, it is not known if and when such a scheme will induce sufficient investment that can timely bring capacity on line to resolve the imminent shortage.

California

Generation capacity shortage, market power abuse, transmission congestion, and the CAISO's computation error caused an unprecedented number of rotating blackouts during the crisis [14,40,41,78].

2.8. Deregulation does not always reduce generation cost.

2.8.1. Description

An argument supporting electricity deregulation is that competition and privatization can improve the sector's cost performance, which in turn lowers the price for electricity. However, an econometric analysis of price data from 19 OECD countries indicates that "the unbundling of generation and the introduction of a wholesale spot market did not necessarily lower the price, and may possibly have resulted in a higher price" [79, p.830]. While costs have fallen in Europe [80] and Australia [81], largely because the formerly integrated utilities were highly inefficient, the examples below will show that empirical evidence for this argument is at best mixed.

2.8.2. Real-world examples

<u>Operation cost vs. capital cost: U.S.</u>

Wolfram [82] reports that restructuring improves the efficiency of electricity generation by reducing the number of employees and non-fuel expense per MW of capacity. However, restructuring also increases the cost of capital, see Section 2.6 above. Hence, the net effect is likely an increase in the all-in cost of new generation because the financing cost increase will likely dwarf the variable O&M cost saving.

<u>Capacity obligation: PJM and California</u>

A commonly cited inefficiency of an integrated utility is the excess capacity built under the allowed rate of return regulation [83]. Deregulation presumably will reduce the excess capacity. For reliability reasons, however, PJM obligates LSEs to purchase sufficient capacity to cover their peak load plus a reserve margin [84]. The absence of a capacity obligation contributed to the California electricity crisis; and as a result, a 15% reserve requirement, less than the CAISO's desired 17%, will be imposed on LSEs [85]. Prior to deregulation, PG&E's reserve margin target, developed in 1991, was 16% [86]. Thus, we question the need for, and ability of, deregulation to reduce excess capacity when such capacity does not exist in the first place.

<u>Operation cost: Hong Kong</u>

The two privately owned integrated utilities in Hong Kong secure financing and procure equipment and fuel from the competitive world markets. A 25+% reserve margin provides excellent reliability required by the highly developed economy and is used for profitable (non-firm) energy export to China. Thus, the only major source of cost savings is local variable O&M. To improve earnings, however, both companies cut their O&M cost substantially in the late 1990s. Hence, deregulation will not improve generation efficiency.

2.9. Dysfunctional input markets preclude an efficient market for generation.

2.9.1. Description

Even if electricity deregulation can yield a competitive generation market with many price-taking sellers, its success in delivering low and stable prices is unlikely in the presence of dysfunctional input markets (e.g., natural gas and gas pipeline).

2.9.2. Real-world examples

<u>Natural gas: Western U.S.</u>

The North American natural gas market is large and integrated [87-89]. Because it intertwines with the electricity market in the Western U.S. [90,91], its dysfunction in 2000-2001 adversely impacted the western electricity markets. Examples of market dysfunction include wash trading (i.e., a trader making rapid buy and sell orders to artificially increase trading volume and market price), misreporting transactions and prices, and transport capacity withholding by El Paso. The resulting price increase was US$5-US$7/MMBTU [13,87,92]. At a conservative heat rate of 7,000 BTU per kWh, this gas market dysfunction raised the California electricity price by as much as US$50/MWH.

Since this price increase affected all spot electricity purchases heavily used by load-serving entities (LSE) like PG&E and SCE to meet their load obligations, its effect was financially disastrous. To be fair, the gas price increase could have a similar effect on the wholesale spot electricity price faced by an integrated utility. However, an integrated electricity utility typically owns enough generation resources, not all of which are fueled by natural gas, to be almost self-sufficient and is therefore much less affected by the same spot electricity price increase.

Emissions permit: California

Preliminary empirical evidence suggests that during the California electricity crisis, some generators bid up the emission permit prices in Southern California, so as to raise the market clearing price for the entire state [93].

2.10. Deregulation often creates stranded cost/debt.

2.10.1. Description

Recovery of stranded cost is critical to the financial health of an incumbent utility that has, with regulatory approval, made the investment affected by deregulation [94]. Stranded cost is the decline in value of affected assets. It is typically related to generation assets because market reform often aims to introduce competition in the generation segment of the electric sector. It arises because the pre-reform regulated rate, based on average embedded (or accounting) cost pricing, exceeds the post-reform generation market price.

2.10.2. Real-world examples

<u>U.S.</u>

Stranded cost recovery is a critical element in reform proposals in the U.S. "Both federal and state regulators in the U.S. permit stranded cost recovery. Explicitly, Order 888 issued in 1996 by the Federal Energy Regulatory Commission, which promotes wholesale market competition via open and comparable access to transmission, affirms '…our preliminary determination that the recovery of legitimate, prudent and verifiable stranded costs should be allowed' (p.451). Market reform legislation at the state level espouses a similar view" [26].

<u>Ontario</u>

Stranded cost recovery complicates the market reform in Ontario. Based on discussions with a number of Ontario Executives involved in the Ontario market reform, the key element of the Ontario reform proposal was that the $38/MWH price cap in the MPMA is high enough so that OPG can service and retire the debt inherited from Ontario Hydro. The OEFC absorbs the residual stranded debt.

2.11. The net benefits of electricity deregulation, if any, are unevenly distributed among residential users, industrial users, and electricity suppliers.

2.11.1. Description

Prior to implementing a particular market reform proposal, a cost-benefit analysis is necessary to determine the net benefits and the resulting income redistribution [7,9]. While the net benefits may be positive, theoretical and pragmatic considerations suggest that the bulk of the benefits should go to consumers, not producers. This is because producers, especially those that are foreign-owned, may receive little weight in the computation of net social benefit, the weighted sum of the change in consumer surplus and the change in producer surplus. However, the benefits of deregulation typically accrue more to producers than consumers. As documented below, consumers can actually lose as a result of deregulation.

2.11.2. Real-world examples

<u>Brazil</u>

Mota (95, Table 5) reports the efficiency gains from restructuring and privatization for the base case scenario may range from $7.2B Real (1 Real = US$0.32 as of June 18, 2004) at a 15% discount rate to 10.2B Real at a 9% discount rate. However, producers' gain is twice to thrice the consumers'. Finally, such gains are suspect because "[i]t is difficult to avoid concluding that the Brazilian electricity sector experience over the last decade was really about government accounting. Privatization was all about maximizing revenues in the short run, not optimizing the power sector in the long run.... Privatization transferred capital and liabilities, but did so without liberalization, without market development, and without improving overall efficiency" [96].

Victoria, Australia

As in Brazil, market reform in Victoria did not focus on economic efficiency and projected net benefits. "In Victoria, the entire industry has been privatized ostensibly to attain economically efficient outcomes, but in reality to retire state debt" [81, p.1098].

UK

The UK reform took place in 1990, following privatization of other industries (e.g., petroleum, natural gas and telecommunication). The objectives of the UK reform included generation of revenue for the Treasury, reduction of the power of the mineworkers union, and elimination of the protected British coal market [97]. Newbery [7, p.240] reports the distribution of gains and losses (as a present value based on a 6% discount rate): (a) consumers - loss of £1.3B (£1 = US$1.84 as of June 18, 2004), (b) government - gain of £1.2B, and (c) producers: gain of £9.7B. Hence, the UK reform produced a net gain, but at the expense of consumers.

3. Conclusion

We should, of course, acknowledge claims of successful deregulation in the UK [98], Norway/Sweden [72] and PJM [99]. Nevertheless, the task of electricity deregulation is rife with challenges and pitfalls, as demonstrated by Section 2 of this paper. Even the aforementioned "successful" markets have not been immune to sometimes severe problems (e.g., market power concerns in the UK and PJM, see Section 2.5; under-investment, see Section 2.6; and £1.3B in losses to consumers in the UK, see Section 2.11). Many of the markets where problems have occurred enjoyed circumstances favorable to deregulation (e.g., interconnection with neighboring markets, local fuel availability, easy market entry by IPPs, and adequate capacity prior to reform). Given that even under these favorable circumstances outcomes have been mixed at best, any country or region considering deregulation should proceed with extreme caution.

3.1. Market reform challenges in Israel

To illustrate the problems with deregulation documented in this paper, we consider their application to Israel, which is currently considering deregulation of its electricity sector. Deregulation, complicated in any environment, is only made more difficult by the particular challenges faced by Israel (e.g., isolated state, small market size, heavy reliance on imported fuels, and country-specific investment risk).

Israel can be expected to face particular challenges in many of the problems outlined in this paper:

- Rapid demand growth. Israel's projected gross domestic product (GDP) growth of 4-5% per year requires substantial and continuous investment in its electric sector [8]. The examples herein demonstrate that deregulation may not lead to adequate investment that can support Israel's economic growth.
- Small market size. Market power abuse by a few dominant generators should be a major concern. Unlike Norway, market expansion via interconnection with neighboring countries is not an option for Israel. However, a policy that creates too many local generators with fierce price competition can make the industry financially unsustainable, see Section 2.6. This problem could lead to the likely failure of deregulation in Israel [100].
- Stranded cost/debt. IEC's debt-equity ratio was about 3 in December 31, 2003 and return on equity (ROE) was about 2%, much lower than the 10-12% average ROE authorized by state regulators of privately owned utilities in the U.S. [101]. If privatization is part of deregulation in Israel, two unattractive scenarios emerge:

1. No price liberalization so that the post-reform price will stay near the currently low level. To achieve the ROE range in the U.S., few investors would pay much for IEC's assets, resulting in large write-offs.
2. Price liberalization so that the post-reform price can rise to a level that yields 10+% ROE. The price increase will help attract investors and improve the market value of IEC's assets, obviating the large write-offs. But the post-reform price increases will raise the bills of electricity consumers.

Since an asset's value mirrors the present value of future cash flows [102], the scenarios show that privatization cannot achieve the twin goals of maintaining asset value and keeping rates low.

- Natural gas supply. Given that Israel will increasingly depend on combined cycle gas turbines (CCGT) in the future, dysfunctional input market risk is real. As some observers have noted, "there can be no free market in electricity if the gas pipelines are monopolized" [13, p.34]. And, as others have pointed out, "[i]f California's electricity crisis could cause shock waves in a market as mature and liquid as the North American natural-gas market, less developed markets would surely be even more vulnerable" [90, p.20].
- Few generation cost savings. Deregulation may not be effective in reducing generation costs in Israel. IEC secures financing and procures equipment and fuel from competitive world markets. Hence, the main source of potential cost saving is local variable O&M. When compared to other means to reduce cost (e.g., contract negotiation to curb wage increase), deregulation is a blunt and risky instrument.

The net effect of the conditions outlined above is that, under the best of circumstances, deregulation can be expected to provide only very modest real cost savings to Israel. In fact, an ex ante cost-benefit analysis of deregulation in Israel found that "flawless implementation of the government's plan may yield a small net benefit … , which can be easily wiped out by a less-than-perfect transition to privatization and competition" [9, p.25].

3.2. Post-reform price volatility and its implications

Suppose market reform, albeit its challenges, occurs in Israel. As elsewhere, short-term price spikes and price volatility will be unavoidable by-products of deregulation. This inevitable price volatility has significant implications for Israel or any country / region considering deregulation, beyond the effects on generation investment and cost of capital already described in Section 2.6 above. These implications are described below:

- **Market power problems resulting from the need for rate stability**. Most consumers prefer price stability [103]. As a result, post-reform LDC's are unlikely to implement mandatory real-time pricing for all consumers, with the hourly rates tracking the hourly electricity spot prices. Thus, the post-reform market demand cannot react to wholesale market price movements. This raises the generators' market power in the spot market, as discussed in Section 2.5.
- **Financial impact of government intervention after price spikes**. This impact manifests in two ways. First, it substantially increases government spending (e.g., the Alberta Government's C$2 billion spending in monthly rebates) and debt (e.g., OEFC's issuance of C$730 million debt to finance the difference between the wholesale price and the frozen rate). Second, it has long-term effect on retail rates. For example, the California state government incurred over US$11 billion of new debt because of its electricity spot purchases in the months immediately after the Governor's January 17, 2001 proclamation declaring a crisis [104]. The government also signed long-term contracts at an average price of

$86/MWH sufficient to meet 95+% of the total load of the three regulated utility distribution companies (UDCs) (i.e., PG&E, SCE and SDGE) in the next 10 years [105]. To retire the government debt and pay for the contract cost, the CPUC imposed surcharges on customers of the regulated UDCs [104,106-108].

- **Higher procurement costs**. The seller of a forward contract absorbs the spot price risk of the spot market and therefore demands a risk premium up to 10% of the expected spot price to compensate its risk taking [29,30,109]. This raises the LDC's procurement cost. In contrast, a regulated integrated utility may only have to manage the fuel price risk, which is much smaller than the electricity price risk.
- **Litigation surrounding recovery of procurement cost**. To mitigate market power and manage procurement cost risk, a LDC may enter into forward contracts to reduce the amount of market purchases exposed to spot price volatility [110,111]. Should the forward contract price turn out to be much more than the spot price in the contract's delivery period, however, the LDC's recovery of procurement cost could become litigious [105].
- **Forward price effect of retail competition**. "An electricity retailer facing competition will be limited in its ability to pass on the costs of long-term contracts, should the spot price fall below the price in those contracts. This will reduce the optimal level of contracting for a risk-averse retailer, relative to a regulated incumbent that is allowed to pass on a yardstick measure of actual costs in the wholesale markets. Generators will enter the annual market with fewer forward sales when there is a competitive retail market. The fewer long-term sales the generators have made, the more willing are they to raise the annual price" [112, p.18].

3.3. Final remark

This paper has catalogued deregulation challenges faced throughout the world. Given the magnitude of these problems, we understand the lament of a senior economist of the National Regulatory Research Institute of the U.S.: "As someone who early on was a strong supporter of restructuring, I now seriously question whether at this time we are capable of doing it right." [113, p.13]. Importantly, "[t]he costs of inadequate electricity capacity are much, much greater than the costs of extra electricity capacity" [114]. Therefore, it is our hope that countries or regions considering deregulation will seriously contemplate the obstacles to successful deregulation documented in this paper.

References

[1] Wilson R. Architecture of power markets. Econometrica 2002;70(4):1299-1340.

[2] Chao H-P, Wilson, R. Multi-dimensional procurement auctions for power reserves: robust incentive-compatible scoring and settlement rules. Journal of Regulatory Economics 2002;22(2):161-183.

[3] Hunt S. Making Competition Work in Electricity. New York: Wiley, 2002.

[4] Stoft S. Power System Economics. New York: IEEE Press, 2002.

[5] Joskow PL. The Difficult Transition to Competitive Electricity Markets in the U.S. AEI-Brookings Joint Center for Regulatory Studies, Washington DC; 2003.

[6] Littlechild S. Electricity: regulatory development around the world. The Beesley Lectures on Regulation Series XI, London, UK; 2001.

[7] Newbery DM. Privatization, Restructuring, and Regulation of Network Utilities. Cambridge: MIT Press; 1999.

[8] Tishler A, Woo CK, Lloyd D. Reforming Israel's electric sector. Energy Policy 2002;30(4):347-353.

[9] Tishler A, Newman J, Spekterman I, Woo, CK. Cost-benefit analysis of reforming Israel's electricity industry. Energy Policy, 2004;(forthcoming).

[10] Woo CK, Lloyd D, Tishler A. Electricity market reform failures: UK, Norway, Alberta and California. Energy Policy 2003;31(11):1103-1115.

[11] Besant-Jones JE, Tenenbaum BW. The California Power Crisis: Lessons for Developing Countries. Washington DC: World Bank, 2001.

[12] Lee WW. U.S. lessons for energy industry restructuring: based on natural gas and California electricity incidences. Energy Policy 2004;32(2):237-259.

[13] Navarro P, Shames M. Electricity deregulation: lessons learned from California. Energy Law Journal 2003; 24(1):33-88.

[14] Woo CK. What went wrong in California's electricity market? Energy 2001;26(8):747-758.

[15] IMO. Financial Statements 2003; 2004. See www.theimo.com.

[16] CAISO. 2002 Annual Report. California Independent System Operator, Folsom, California; 2003.

[17] Midwest Independent Transmission System Operator. Financial Statements: December 31, 2003 and 2002; 2004. See www.midwestiso.org.

[18] ISO New England. Financial Statements for the years ended December 31, 2003 and 2002; 2004. See www.iso-ne.com.

[19] New York ISO. 2003 Annual Report; 2004. See www.nysio.com.

[20] PJM. 2003 PJM Annual Report; 2004. See www.pjm.com.

[21] Trebilcock MJ, Hrab R. Electricity restructuring: a comparative review. Working Paper, Department of Law, University of Toronto, Toronto, Ontario, Canada; 2004.

[22] Lam PL. Hong Kong's electricity market beyond 2008. Energy Policy 2004;32:851-854.

[23] Rose K. The state of retail electricity markets in the U.S. Electricity Journal 2004;17(1):26-36.

[24] Hurlbut D, Rogas K, Oren S. Protecting the market from "hockey stick" pricing: how the Public Utility Commission of Texas is dealing with potential price gouging. Electricity Journal 2004;17(3):26-33.

[25] CAISO. Supplemental Analysis of Trading and Scheduling Strategies Described in Enron Memos. California Independent System Operator, Folsom, California; 2003.

[26] Woo CK, Lloyd D, Karimov R, Tishler A. Stranded cost recovery in electricity market reforms in the U.S. Energy 2003;28(1):1-14.

[27] Veiga A. State AG takes on Enron. San Francisco Examiner, June 18, 2004.

[28] Newbery DM. Liberalising electricity markets. Paper presented at the 25th IAEE International Conference, Aberdeen, Scotland; June 28, 2002.

[29] Woo CK, Horowitz I, Hoang K. Cross hedging and value at risk: wholesale electricity forward contracts. Advances in Investment Analysis and Portfolio Management 2001;8: 283-301.

[30] Woo CK, Horowitz I, Hoang K. Cross hedging and forward-contract pricing of electricity. Energy Economics 2001;23:1-15.

[31] Woo CK, Olson A, Orans R. Benchmarking the price reasonableness of an electricity tolling agreement. Electricity Journal 2004;17(5):65-75.

[32] Orans R, Woo CK, Clayton W. Benchmarking the price reasonableness of a long-term electricity contract. Energy Law Journal 2004;(forthcoming).

[33] Woo CK, Lloyd D, Borden M, Warrington R, Baskette C. A robust Internet-based auction to procure electricity forwards. Energy 2004;29(1):1-11.

[34] Lloyd D, Woo, CK, Borden M, Warrington R, Baskette C. Competitive procurement and internet-based auction: electricity capacity option. Electricity Journal 2004;17(4):74-78.

[35] NEB. Canadian Electricity: Trends and Issues. National Energy Board, Calgary, Alberta, Canada; 2001.

[36] Li Y, Flynn, PC. Deregulated power prices: comparison of diurnal patterns. Energy Policy 2004; 32:657-672.

[37] NEMS. Wholesale Electricity Market Report, National Electricity Market of Singapore; 2004.

[38] NZEM. 2003 Annual Report, New Zealand Electricity Market, 2004. See www.nzelectricity.co.nz/C2wholesale.htm.

[39] Borenstein S. The trouble with electricity markets: understanding California's restructuring disaster. Journal of Economic Perspectives 2002;16(1):191-211.

[40] CPUC. Wholesale Generator Investigation Report. California Public Utilities Commission, San Francisco, California; 2002.

[41] CPUC. Supplement to the California Public Utilities Commission Staff's Wholesale Generator Investigation Report. California Public Utilities Commission, San Francisco, California; 2003.

[42] Wolak FA. Diagnosing the California electricity crisis. Electricity Journal 2003;16(7):11-37.

[43] Wolak FA. Measuring unilateral market power in wholesale electricity markets: the California market. American Economic Review 2003;93(2):425-430.

[44] Borenstein S, Bushnell JB, Wolak FA. Measuring market inefficiencies in California's restructured wholesale electricity market. American Economic Review 2002; 92:1376-1405.

[45] Joskow PL, Kahn E. A quantitative analysis of pricing behavior in California's wholesale electricity market during Summer 2000. Energy Journal 2002; 23(4):1-35.

[46] Jurewitz JL. California electricity debacle: a guided tour. Electricity Journal 2002;15(4):10-29.

[47] Hildebrandt E. Further Analysis of the Exercise and Cost Impacts of Market Power in California's Wholesale Energy Market. California Independent System Operator, Folsom, California; 2001.

[48] Joskow PL, Tirole J. Transmission rights and market power on electric power networks. Rand Journal of Economics 2000;31(3): 450-487.

[49] Borenstein S, Bushnell JB, Stoft S. The competitive effects of transmission capacity in a deregulated electricity industry market. Rand Journal of Economics 2000;31:294-325.

[50] GAO. Restructured Electricity Markets: California Market Designed Enabled Exercise of Market Power. U.S. General Accounting Office, Washington DC; 2002.

[51] Faruqui A, Chao, H-P, Niemeyer V, Platt J, Stahlkopf K. Analyzing California's power crisis. Energy Journal 2001;22(4):29-52.

[52] Bushnell J. California's electricity crisis: a market apart? Energy Policy 2004; 32:1045-1052.

[53] Blumsack S, Perekhodtsev D, Lave LB. Market power in deregulated wholesale markets: issues in measurement and the cost of mitigation. Electricity Journal 2002;15(9):11-24.

[54] Daniel T, Doucet JA, Plourde A. Electricity industry restructuring: the Alberta Experience. Working Paper, School of Business, University of Alberta, Edmonton, Alberta, Canada; 2003.

[55] Avery B. Power prices manipulated in three cases: Alberta Power Pool probe concludes. Edmonton Journal, May 29, 2002.

[56] Australia. Towards A Truly National and Efficient Energy Market. Canberra, New South Wales, Commonwealth of Australia; 2002.

[57] Wolfram CD. Measuring duopoly power in the British electricity spot market. American Economic Review 1999;89:805-826.

[58] Green R. Failing electricity markets: should we shoot the pools? Utility Policy 2003;11:155-167.

[59] Evans J, Green R. Why did British electricity prices fall after 1998? CMI Working Paper 26, Department of Applied Economics, University of Cambridge, UK; 2003.

[60] Müsgens F. Market power in the German wholesale electricity market. EWI Working Paper Nr.04.03, Institute of Energy Economics, University of Cologne; 2004.

[61] Haas R, Auer H, Orasch W. The implementation of the EU directive for electricity in Austria: a new era for the Austrian electricity supply industry. In: Glachant J-M., Finon, D, editor. Competition in European Electricity Markets. Northhampton, Massachusetts: Edward Elgar; 2003. p. 217-240.

[62] Stanfield J. Competition lost. Public Utilities Fortnightly 2003;141(3):18-26.

[63] Newbery DM. Mitigating market power in electricity networks. Paper presented at the conference Towards a European Market of Electricity: What have we Learnt from Recent Lessons? Spot Market Design, Derivatives and Regulation, organized by the SSPA Italian Advanced School of Public Administration; June 24-25, 2002.

[64] NCEP. Reviving the Electricity Sector. National Commission on Energy Policy, Washington DC; 2003.

[65] Parkinson TW. Market price risks of merchant generation. Electricity Journal 2004;17(4):33-48.

[66] Rose K. 2003 Performance Review of Electric Power Markets. Institute of Public Utilities, Michigan State University, East Lansing, Michigan; 2003.

[67] Healy PM, Palepu KG. The fall of Enron. Journal of Economic Perspectives 2003;17(2):3-26.

[68] Rigby P. Energy merchant debt prospects: when "worst-case" scenarios become the "base-case". Electricity Journal 2004;17(1):37-50.

[69] Neuhoff K, De Vries L. Insufficient incentives for investment in electricity generation. CMI Working Paper, Department of Applied Economics, University of Cambridge, UK; 2004.

[70] Scott A. Between a rock and a hard place: transmission planning and expansion. Electricity Journal 2004;17(2):78-82.

[71] Glanchant J-M, Pignon V. Nordic electricity congestion's arrangement as a model for Europe: physical constraints or operators' opportunity. CMI Working Paper 20, Department of Applied Economics, University of Cambridge, UK; 2002.

[72] Amundsen ES, Bergman L. The deregulated electricity markets in Norway and Sweden: a tentative assessment. In: Glachant J-M, Finon D., editors. Competition in European Electricity Markets. Northhampton, Massachusetts: Edward Elgar, 2003. p.110-132.

[73] Bergman L, Brunekreeft G, Doyle C, vod der Fehr N-H, Newbery DM, Pollitt M, Regibeau P. A European Market for Electricity? Center for Economic Policy Research, London, UK; 1999.

[74] Carlsson L. International power trade – The Nordic Power Pool. Viewpoint, Note No. 171, Washington, DC: World Bank, 1999.

[75] Littlechild S. Regulated and merchant interconnectors in Australia: SNI and Murrylink revisited. CMI Working Paper 37, Department of Applied Economics, University of Cambridge, UK; 2004.

[76] Bialek J.W. Recent blackouts in U.S. and continental Europe: is liberalization to blame? CMI Working Paper 34, Department of Applied Economics, University of Cambridge, UK; 2004.

[77] Fraser H, Passo FL. Developing a capacity payment mechanism in Italy. Electricity Journal 2003;16(9):54-58.

[78] Kahn M, Lynch L. California's Electricity Supply Options and Challenges. Report to the Governor, California Public Utilities Commission, San Francisco, California; 2000.

[79] Hattori T, Tsutsui M. Economic impact of regulatory reforms in the electricity supply industry: a panel data analysis for OECD countries. Energy Policy 2004;32:823-832.

[80] Glachant J-M, Finon D (Ed.). Competition in European Electricity Markets. Northhampton, Massachusetts: Edward Elgar, 2003.

[81] Sharma P. The multi-dimensionality of electricity reform – an Australian perspective. Energy Policy 2003;31:1093-1102.

[82] Wolfram CD. The efficiency of electricity generation in the U.S. after restructuring. WP 111, Center for the Study of Energy Markets, University of California, Berkeley, California; 2003.

[83] Averch H, Johnson LL. Behavior of the firm under regulatory constraint. American Economic Review 1962;52:1053-1069.

[84] Bowring JE, Gramlich RE. The role of capacity obligations in a restructured Pennsylvania-New Jersey-Maryland electricity market. Electricity Journal 2000;13(9):57-67.

[85] CPUC. Order Instituting Rulemaking to Establish Policies and Cost Recovery Mechanisms for Generation Procurement and Renewable Resource Development: Interim Opinion. California Public Utilities Commission, San Francisco, California; 2004.

[86] Keane DM, Woo CK. Using customer outage costs to plan generation reliability. Energy 1992;17(9):823-827.

[87] Woo CK, Olson A, Horowitz I. Market efficiency, cross hedging and price forecasts: California's natural-gas markets. Working Paper, Energy and Environmental Economics, Inc., San Francisco, California; 2004.

[88] King M, Cuc M. Price convergence in North American natural gas spot markets," Energy Journal 1996;17:17-42.

[89] NEB. Price Convergence in North American Natural Gas Markets. National Energy Board, Calgary, Alberta, Canada; 1995.

[90] Olson A, Woo CK, Horowitz I. Bi-directional causality in California's electricity and natural-gas markets. Working Paper, Energy and Environmental Economics, Inc., San Francisco, California; 2004.

[91] Krapels E. Was gas to blame? exploring the cause of California's high prices. Public Utilities Fortnightly 2001;139(4):28-36.

[92] FERC. Final Report on Price Manipulation in Western Markets. Docket No.PA02-02-000, Federal Energy Regulatory Commission, Washington, DC; 2003.

[93] Kolstad J, Wolak F. Using environmental emission permit prices to raise electricity prices: evidence from the California electricity market. WP 113, Center for the Study of Energy Markets, University of California, Berkeley, California; 2003.

[94] Sidak JG, Spulber DF. Deregulation Takings and Regulatory Contract. New York: Cambridge University Press, 1998.

[95] Mota RL. The restructuring and privatization of electricity distribution and supply business in Brazil: a social cost-benefit analysis. CMI Working Paper 16, Department of Applied Economics, University of Cambridge, UK; 2003.

[96] Brown AC. The privatization of Brazil's electricity industry: sector reform or reinstatement of the Government's balance sheet. Working paper, John F. Kennedy School of Government, Harvard University, Cambridge, Massachusetts; 2002.

[97] Surrey J (Ed.). The British Electricity Experiment. London, UK: Earthscan, 1996.

[98] Newbery DM. Issues and options for restructuring electricity supply industries. CMI Working Paper 1, Department of Applied Economics, University of Cambridge, UK; 2002.

[99] Sutherland RJ. Estimating the benefits of restructuring electricity markets: an application to the PJM region. Center for the Advancement of Energy Markets, 2003. See www.caem.com.

[100] Tishler A, Woo CK. Likely failure of electricity deregulation: explanation with application to Israel. Working Paper, Faculty of Management, Tel Aviv University, Israel; 2004.

[101] Cross PS. Return on equity: a survey of recent PUC rulings. Public Utilities Fortnightly 2003;141(21):33-36.

[102] Elton EJ, Gruber MJ. Modern Portfolio Analysis and Investment Analysis. New York: Wiley, 1995.

[103] Alexander BR. Managing Default Service to Provide Consumer Benefits in Restructured States: Avoiding Short-Term Price Volatility. National Center for Appropriate Technology, Butte, Montana; 2003.

[104] CPUC. Decision Adopting Methodology for Setting Charges to Recover Bond-Related Costs Incurred by the Department of Water Resources. Decision 02-10-063, California Public Utilities Commission, San Francisco, California; 2002.

[105] Woo CK, Lloyd D, Clayton W. Did a local distribution company procure prudently during the California electricity crisis? Energy Policy 2004;(forthcoming).

[106] CPUC. Order Instituting Rulemaking Regarding the Implementation of the Suspension of Direct Access Pursuant to Assembly Bill 1X and Decision 01-09-060. Decision 02-11-022, California Public Utilities Commission, San Francisco, California; 2002.

[107] CPUC. Interim Opinion Regarding Emergency Requests for Rate Increases. Decision 01-01-018, California Public Utilities Commission, San Francisco, California; 2001.

[108] CPUC. Interim Opinion Regarding Proposed Rate Increases. Decision 01-03-082, California Public Utilities Commission, San Francisco, California; 2001.

[109] Longstaff FA, Wang AW. Electricity forward prices: a high-frequency empirical analysis. Journal of Finance 2004;59(4):1877-1900.

[110] Woo CK, Karimov R, Horowitz I. Managing electricity procurement cost and risk by a local distribution company. Energy Policy 2004;32(5):635-645.

[111] Woo CK, Horowitz I, Horii B, Karimov R. The efficient frontier for spot and forward purchases: an application to electricity. Journal of the Operational Research Society 2004;(forthcoming).

[112] Green R. Retail competition and electricity contracts. Department of Applied Economics, CMI Working Paper 33, University of Cambridge, UK; 2003.

[113] Costello K. The shocking truth about restructuring of the U.S. electricity industry. Electricity Journal 2003;16(5):11-19.

[114] Watts PC. Heresy? the case against deregulation of electricity generation. Electricity Journal 2001;14(4):19-24.

Table 1: Critical questions to be addressed prior to electricity deregulation

Question	Remarks
Will there be adequate capacity after the reform?	Adequate capacity provides the reserve required for reliable service and mitigates market power.
Will many price-taking sellers compete for sales to many buyers?	A few dominant sellers can abuse their market power to raise prices. However, too many sellers can result in fierce price competition, rendering the industry financially unstable.
Will efficient investment occur?	Deregulation replaces centralized planning and investment with decentralized decision-making driven by market prices; which is the superior decision process remains unknown.
Will there be sufficient transmission available under open access?	Transmission congestion limits trading that would have caused electricity to flow from low-cost areas to high-cost areas. As well, it creates load pockets and exacerbates market power.
Will the input markets be competitive?	A dysfunctional input market can compromise the economic performance of a wholesale generation market.
Will there be active forward trading?	Forward trading facilitates market power mitigation, price discovery and risk management.
Will electricity end-users see and respond to wholesale price changes?	Demand response reduces market power and improves reliability. However, electricity consumers, especially households, prefer rate stability and do not exhibit large sensitivity to hourly price variations.
Will the market rules prevent gaming and market power abuse?	A complicated design without strong rules invites gaming and market power abuse.
Will stranded cost be large?	Recovery of large stranded cost complicates the transition to competition.
Will transaction costs be small?	Large transaction costs dissipate potential benefits from deregulation.
Will the post-reform spot price be stable?	High and volatile prices can doom a market reform.
Will deregulation harm reliability?	Centralized planning and investment in developed countries have yielded highly reliable service, which may not be the case under decentralized decision-making.
Will deregulation adversely affect income distribution?	Even if deregulation can produce positive net benefits, electricity producers are likely to receive the benefits, while households and business customers will pay higher prices.
Will there be commitment to deregulation?	If voters and politicians would reverse deregulation after price spikes, it should not have occurred in the first place.
Will electricity consumers be better off than the status quo?	Deregulation should be based on a careful cost-benefit analysis, not an ideological belief in competition.
Can the projected benefits of deregulation be obtained via other means?	Deregulation is not the only mechanism to improve the performance of an electric sector. Performance based regulation is a less risky alternative.
If deregulation fails, can it be reversed?	Deregulation often entails divestiture of the integrated utility's assets. Once done, it is almost impossible to put the pieces back together again.

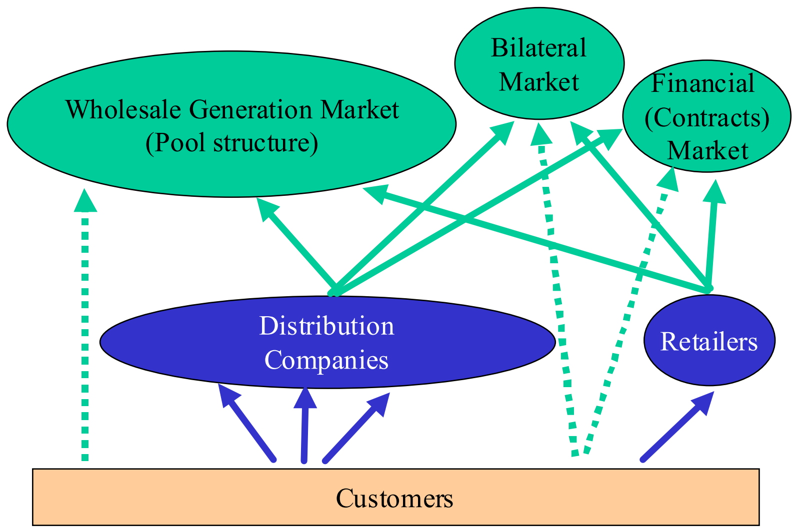

Figure 1: Generic model of the restructured electricity markets