Some Strengths and Weaknesses of Electricity Industry Restructuring in Australia

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Abstract-- **Electricity industry restructuring is a complex, multi-disciplinary problem that requires a consistent approach to its engineering, economic, commercial and socio-political aspects to achieve a satisfactory outcome. Moreover, all aspects of the energy conversion chain, from primary energy forms to end-use energy services, should be consistently addressed so that options at all points in the energy conversion chain receive equal consideration, including fossil and renewable fuels and demand-side options and their associated external impacts. After discussing underlying principles and the conceptual model on which the Australian National Electricity Market design has been based, this paper reviews progress to date in electricity industry restructuring in Australia and discusses the challenges that lie ahead. It concludes that there have been significant achievements but that important issues remain to be addressed, and that the restructuring process, which commenced in the early 1990's, may require another decade to complete.**

Index Terms—**electricity industry restructuring.**

I. Introduction

Electricity industry restructuring is a protracted, fragile and complex process that requires consistent treatment of all steps in the energy conversion chain from primary energy forms to end-use energy services, consistent treatment of competing energy options such as end-use applications of natural gas and renewable energy, and recognition of important social and environmental externalities.

Careful attention must be paid to electricity market design and to industry structure – to achieve adequate competition in generation, retailing and, to the extent that they can be made contestable, network services. Compatible economic and technical regulation is required because there are important "common good" issues that competition cannot resolve. Compatible restructuring in gas and other competing energy forms is also required.

One implication of restructuring is that end-users should be assisted to manage price volatility for electricity despite it being traditionally regarded as an "essential good". Thus particular attention must be paid to metering, retail tariff design and support for end-user decision-making with respect to purchases of equipment and energy. Design of end-use equipment is also an important issue, particularly with regard to sensitivity with respect to supply availability and quality.

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II. Underlying Principles and Issues

The task of an electricity industry is to deliver end-use energy services, such as illumination, computing services and space conditioning, in a cost-effective manner considering external impacts as well as direct costs and benefits.

Given the lack of cost-effective storage of electrical energy, an electricity industry operates by maintaining a continuous flow of electrical energy from generators to end-use equipment. Generators, network elements and end-use equipment all contribute to this goal by operating in a mutually dependent manner.

The role of generators is to inject a flow of electrical energy into the network at their points of connection, while the role of the network is to carry the flow of electrical energy from generators to end-use equipment and the role of end-use equipment is to extract a flow of electrical energy from the network and convert it into end-use energy forms.

The flow of electrical energy in a network is fungible and cannot be traced from a specific generator to a specific end-user. The network operates as a shared entity and in doing so, provides a valuable physical aggregation function for the uncertain injection and off-take energy flows associated with the generators and end-use equipment connected to it. Thus if one generator fails, injections from the other operating generators will immediately rise to compensate for it. Similarly, the percentage variability of total demand is less than the percentage variability of individual end-use energy flows due to the smoothing effects of aggregation of uncertain processes that are not fully correlated.

As a result, generators, end-users and network service providers operate in a cooperative manner, sharing responsibility for availability and quality of supply (voltage magnitude, waveform purity and phase balance) as well as for supplying network losses.

The process of electricity industry restructuring involves introducing commercial interfaces into a previously vertically integrated supply industry, between generators, network service providers and end-users, with retailers often acting as intermediaries. The hypothesis is that restructuring will improve economic efficiency. However that will depend on the efficacy of the commercial interfaces and the development of a compatible policy and regulatory regime that can address the issues that cannot be resolved through competition.

In a restructured electricity industry, it is common to consider the flow of electrical energy integrated over a specific interval (e.g. 30 minutes) to be a tradable commodity.

However, that is an abstraction from the underlying reality of continuously varying energy flows and does not fully capture the short-term mutual dependencies between industry participants.

Because of this abstraction amongst other reasons, it has proved difficult to fully commercialize the risks associated with inadequate availability and quality of supply and the legal liability for unsatisfactory delivery of energy services remains vague.

This means that an important part of the high value that society attributes to continuity of end-use energy service delivery is not represented in commodity trading in electricity and is instead managed by centralized decision-making processes, mutual obligations and the network aggregation function. Thus in practice, commodity trading acts as a target-setting process for centrally managed industry operation.

Thus restructuring remains an uncomfortable mix of centralized decision-making (essentially traditional power system operation and planning, preferably extended to include end-use infrastructure) and decentralized, commercial decision-making in spot and derivative commodity markets.

The art of restructuring is to find an appropriate balance between centralized and decentralized decision-making. For example, one contentious issue in Australia is the extent to which network services can be made contestable through competition between providers of network services and distributed resources [1]. Another is the determination of flow constraints in the "hub and spoke" approximation to spot pricing that is used in the Australian National Electricity Market (NEM) [2]. A third is the treatment of "intermittent" generation with fluctuating power output (such as wind energy) [3, 4] and a fourth is the boundary between centralized management of reliability and security and decentralized commercial processes [5]. Issues such as these are testing the boundaries of our understanding of electricity industry restructuring.

One interpretation of these issues is that the centralized decision-making required to maintain the availability and quality of energy when traded as a commodity, is significant compared to the decentralized decision-making that can be coordinated by the commodity spot and derivative markets (for example, see [5]). This paper adopts a flow model for the industry that explicitly addresses the relationship between centralized and decentralized decision-making and incorporates the aggregation function of the network.

III. A Flow Model for th e Electricity Industry

The nodal auction model (NAM), which is described in [6] and [7], provides a flow model for electricity industry restructuring that internalizes the aggregation function of the network. An associated theoretical basis for inter-temporal pricing in the face of uncertainty, including consideration of pricing in the context of market power, appears in [8].

Implementation is based on four related procedures that address technical and commercial issues in a consistent fashion for various time projections from the present: centralized management of availability and quality of supply (QOS) by "ancillary services" (which can be partly commercialized), a forward-looking commodity "spot market" (actually a short-term forward market), a technical or operational forward market and a financial forward market (for commodity energy derivatives). Each incorporates a network model of appropriate detail.

These procedures operate as follows:

- Ancillary services manage QOS issues, and associated 'products' such as reactive power, by a mix of technical and commercial measures looking forward from the present instant of time. Ancillary services reject disturbances and track market-interval energy targets derived from the spot market. The spot market could also set nodal voltage targets if voltage-value functions were incorporated in spot market bids and offers [6].
- The forward-looking (nodal) spot market is implemented for commodity energy for the next spot market interval (eg half hour) using an approximate model for the electricity network, chosen to balance the conflicting demands of location accuracy, constraint representation and efficient management of location-related risks [6]. The spot market includes all (and only all) commercial agents in the physical industry - generators, unregulated network service providers (as permitted in the Australian NEM), large end-users and either small end-users directly or (less desirably) retailers acting as their representatives. Each market participant submits an offer or bid function to sell or buy commodity energy in the next spot market interval at a particular network node and potentially a voltage-value function. The bids and offer functions are processed simultaneously to derive a set of nodal prices that clear the spot market, taking network losses and operating constraints into account as well as the aggregation function of the network. This is done using a computer-based auction procedure [9] that has a network model embedded in its price setting algorithm.
- The (nodal) technical forward market operates as a series of trial nodal spot markets looking forward to the operation scheduling horizon (up to a week ahead depending on industry characteristics). This market has the same network model and participants as the spot market and operates according to the same procedures. A parallel process acquires ancillary service resources for those forward-looking aspects of QOS management that have not been addressed in spot market design. The technical forward market places forward performance obligations on market participants, network service providers, ancillary service providers, and industry operators.
- Financial forward markets, using spatially and temporally aggregated energy volumes (the aggregation is to maintain liquidity and to allow better quantification of risks) and a simplified network model (to represent network aggregation subject to key flow constraints), support derivative trading looking forward several years. These markets deal with coordination and risk sharing associated with tasks such as investment decision-making, maintenance scheduling, fuel purchasing, hydro scheduling and factory

production planning. Information on volumes of trade by location supports network service planning.

To be effective, this approach requires structural and regulatory protection against the exercise of market power, appropriate support for small decision makers, comparable restructuring in natural gas and other competing energy supply options, market compatible regulation of the stationary energy sector and policy formation to address the issues that competition cannot resolve.

IV. Implementation of Electricity Industry Restructuring in Australia

The Australian states of Queensland, New South Wales, Victoria and South Australia and the Australian Capital Territory share an inter-connected electricity network that extends for approximately 4000 km. This network, dubbed the National Electricity Grid, supplies about 85% of all electricity sold in Australia. With the anticipated construction of a DC link to Tasmania, this proportion will rise to over 90%.

The National Electricity Code [10] defines the implementation of electricity restructuring for this electricity industry, apart from the decisions taken by State governments with respect to disaggregation of the previously state-owned electricity supply authorities and timetables for the introduction of retail competition. The implementation adopts many of the features of the Nodal Auction Model:

- Dispatchable generators, market network service providers (trading between market regions) and end-users (if they so wish) submit offer or bid functions (initially one day ahead) into five-minute spot and ancillary services markets. The spot market sets forward-looking five-minute dispatch prices that are then averaged to thirty-minute prices for the purpose of clearing the market. The price-setting process is at present a linear program that incorporates a regional representation of network losses and thermal and security flow constraints, and implements a hub-and-spoke approximation to nodal pricing. Price projections are made up to one day ahead. The five-minute ancillary service markets set prices for frequency regulation services and contingency management.
- Derivative markets are left to participants to organize apart from auctions of inter-regional settlement residues, which arise when there are flow constraints between market regions.
- The National Electricity Code Administrator (NECA) and the National Electricity Market Management Company (NEMMCO) operate a detailed process for determining and implementing a system reliability and security framework within which the market operates [5]. Projections of supply demand balance are made up to 10 years ahead. The intent of this process is to guide the market towards outcomes that are acceptable in both the short and long term.
- Although the National Electricity Code supports competition in the provision of network services between market regions, regulated network service providers provide most transmission and distribution network services.
- Some states have retained regulated tariffs for small end-users. Others have introduced retail competition for all end-users but have retained some form of regulatory oversight or market intervention [1].
- Environmental regulation is largely dealt with at State level and has yet to systematically target climate change emissions. However there is a Federal “Mandatory Renewable Energy Target” scheme for electricity retailers and climate change emission credit schemes in Queensland and New South Wales.

V. Key achievements of Electricity Restructuring in Australia

Key achievements of electricity industry restructuring in Australia include the implementation of a hybrid 5/30 minute wholesale spot market (the National Electricity Market or NEM) that efficiently dispatches generation under most circumstances across a network that extends over 4000 km; competition for the provision of interconnectors between market regions; and a compatible market in “renewable energy certificates” that provides some recognition of climate change externalities.

Fig. 1 shows running average spot prices at regional reference nodes since market inception [11]. After an initial transition period, these prices have exhibited a seasonal pattern, with high prices occurring more frequently in summer and winter peak load periods. Differences between regional reference prices arise when the market representation of inter-regional flows becomes constrained.

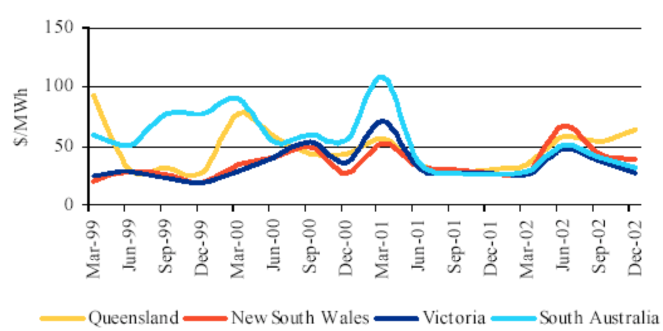

Fig. 1. Running average regional reference spot (30 minute) prices since the inception of the Australian National Electricity Market [11].

Fig. 2 shows forward contract prices for flat annual contracts since market inception [11]. These show a converging trend towards “new entrant” prices in all regions. However, it seems likely that some cycling between under and over capacity will be an ongoing feature of the industry, and thus oscillations in forward prices are likely to continue to emerge in near-term forward prices. A total of 4,400 MW of capacity was commissioned in the first 3.5 years of market operation [5] primarily in market regions that were relatively short of capacity.

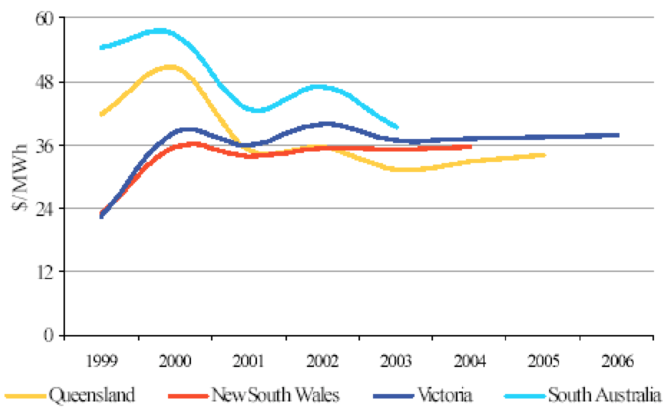

Fig. 2. Forward contract prices for flat annual contracts since the inception of the Australian National Electricity Market [11].

The underlying 30-minute spot prices can be very volatile. Fig. 3 shows spot price duration curves for the South Australian region of the market, which has the worst load factor of all the market regions [11]. Uncertainty in the fraction of time spent at high prices is reflected in uncertainty in the annual average price. Important underlying drivers are weather-related uncertainty in peak demand and uncertainty in generator and network availability at times of peak demand.

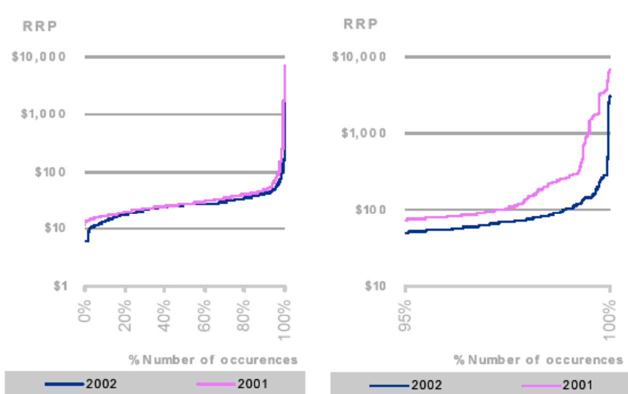

Fig. 3. Spot price duration curve for the October-December quarter for 2001 and 2002 for the South Australian region of the Australian National Electricity Market [11].

NEMMCO acquires frequency-related ancillary services in eight 5-minute markets (raise and lower regulation services and 6 second, 60 second and 5 minute contingency services).

As indicated in Fig. 4, these ancillary services usually cost less than 1% of market turnover to acquire. However, the cost can be much higher if competition in the provision of ancillary services is significantly reduced due to interconnector flow constraints. Under such circumstances, ancillary services must be acquired locally within the constrained region.

At present, ancillary service costs are recovered from market participants according to category. However there is an intention to move further towards a "causer-pays" model for frequency regulation, which would be based on the estimated contribution by a participant to reducing frequency perturbations.

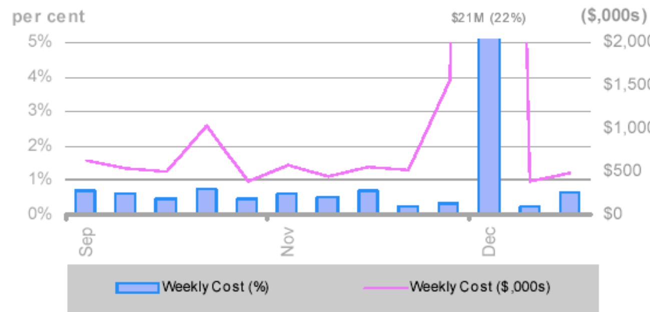

Fig. 4. Weekly cost of acquiring frequency-related ancillary services in A$ and as a percentage of market turnover for October-December 2002 [11].

VI. Remaining Challenges

In 2002, the Council of Australian Governments (COAG), which includes Federal and all State governments, undertook a review of stationary energy sector markets, focusing on electricity and gas. The final report of the review recognized the achievements to date but identified the following remaining deficiencies [1]:

- Confused governance, excessive regulation and perceived conflicts of interest in States that still own important power system resources
- Insufficient generator competition in spot markets in States that have not adequately disaggregated their generation portfolios
- Flawed electricity network operation and investment and poorly defined NEM market regions where States have interfered with the boundary setting process
- Financial instrument markets that are illiquid and hampered by regulatory uncertainty and some specific State initiatives
- Insufficient competition in east-coast gas and uncertainty surrounding investment in new gas pipelines
- Ad hoc and poorly targeted climate change response.
- Some regional areas that have been disadvantaged by poor implementation of NEM market regions.

Key recommendations of the COAG review are [1]:

- Replace the present mixed Federal and State level regulatory structure with a National Energy Regulator (NER), with decisions by NER and NEMMCO to be reviewable by the Australian Competition Tribunal.
- Federal, Western Australia (WA) and Northern Territory (NT) governments to join the remaining governments as co-owners of NEMMCO, with the COAG Ministerial Council on Energy to be the sole provider of policy direction on electricity and gas.
- Further disaggregate and then privatize NSW and WA generation portfolios and implement explicit merger guidelines to control generator market power.
- Abolish existing financial arrangements between NSW and Queensland generators and retailers and facilitate derivative markets.
- Give NEMMCO a NEM-wide planning function, with performance incentives for network service providers (NSPs), a commercial cost-benefit test to approve

regulated inter-regional augmentation and firm inter-regional financial transmission rights.
- Increase the number of NEM regions (currently five) with full nodal pricing in 7-10 years.
- Phase in 30-minute metering and retail competition for all small end-users.
- Enhance competition and network coverage in gas.
- Replace existing climate-change policies for the stationary energy sector with cross-sectoral emission trading except for energy-intensive export industries.

VII. Commentary on the COAG review

In most respects, the analysis of the COAG review appears reasonable and its recommendations appropriate if not always practical:

- Governance challenges may be hard to resolve because widely divergent community understandings and expectations of electricity industry restructuring remain [12]. Also, there is still a debate as to the effectiveness of the restructuring process [13]. However, as the COAG review has identified, a restructured electricity industry requires a coherent policy and regulatory framework to address the important issues that competition cannot resolve. Therefore, this challenge must be faced.
- It is difficult and quite possibly inefficient to guarantee high levels of competition between generators at all times because of the "flow" nature of the electricity industry. High spot prices can result from generator and network characteristics and failings in market design as well as deficiencies in ownership structure.
- Network services are likely to remain an uncomfortable combination of centrally planned and deregulated activities for some time to come, because accurate network representation in a market ("full nodal pricing") would require more refined definitions of services and risks, as well as greater end-user participation, than appears feasible at present.
- To date, derivative trading in the Australian electricity industry has mainly involved bilateral contracts between generators and retailers, without representation of the network aggregation function and with little information on aggregate traded volumes. Also as discussed in [1], government-imposed vesting contracts and successor arrangements remain in place in some states. Government action will be required to improve these arrangements.
- An effective climate change response would require policies that support innovation and industry development in addition to the emission trading recommended by the COAG review.

VIII. Future Directions

Further progress in electricity industry restructuring in Australia should be consistent with key aspects of electricity industry operation:

- The ability to continue to deliver flows of end-use energy services is always at risk due to exogenous events as well as the decisions of industry participants and constraints on equipment operation. These risks depend on both availability and quality of supply. They may be mutually dependent, vary with time and location and be hard to quantify.
- Decision-making in the electricity industry has short-term inter-temporal links due to the lack of cost-effective electricity storage and long-term inter-temporal links due to capital intensity, construction lead times, and social and environmental externalities.
- A restructured electricity industry requires three main decision making environments – commercial trading environments in which participants are expected to act as independent competing agents, regulatory environments, in which centrally determined rules of behavior are implemented and specific directions are set, and policy making in which broad industry directions are set. Commercial trading environments are most appropriate for well-defined, commoditized goods or services for which independent decisions can be take. They face difficulties when there are important interactions between industry participant decisions. Regulatory environments can make some decisions in the presence of interactions but face difficulties when complex trade-offs must be made between conflicting societal objectives.

With this background, possible future directions will be discussed under the following topics: – temporal issues, location-related issues, enhanced end-user participation, enhanced sustainability, and governance and regulation.

A. Temporal issues

Temporal issues can be categorized as short-term and long-term decision-making and risk management.

In the very short-term, the need for continuous, rapid and complex decision making precludes reliance on commercial decision-making. Thus the operation of a restructured electricity industry remains centralized and largely unchanged from the traditional power system operation model. However its reach should more clearly extend to the demand side of the industry and there must now be an interface between centralized power system operation and commercial decision-making. The key tasks of industry operation are:

- Security analysis, to define an acceptable envelope for near-term future industry operation, including constraint setting for a forward-looking spot market.
- Target tracking, to move physical industry operation towards a commercially-specified target, such as the solution of a forward-looking spot market
- Disturbance rejection, using "ancillary services" to maintain availability and quality of supply until a revised commercial target becomes available and possibly longer.
- Longer term decision-making for issues that are difficult to commercialize, including some aspects of availability and quality of supply. Also, on-going centralized guidance may be required for large resources that can influence prices. This guidance could be in the form of participant-specific price signals [8].

Typically, a "spot" or "balancing" market lies at the interface between commercial and centralized industry operation. It has the task of determining (by forecast or commercial processes) the energy services that are to be delivered in the next spot market interval and the resources that are to be used to do so. This must take place within an envelope of acceptable industry operation, defined by security constraints and equipment ratings such as thermal and rate of change limits.

Some of these constraints may be represented in the spot market design but others may not. For this and other reasons, overlaps between industry operation and commercial processes are inevitable. Thus a challenging problem in electricity industry restructuring is how to set the boundary between industry operation and spot market and how to manage the hand-over in accountability for future industry behavior from industry operator to market participants.

This process is implemented in the Australian NEM by using a linear program (LP) to determine a market solution (prices, quantity targets) for the next five minutes based on a five-minute demand forecast (see www.nemmco.com.au for a description of the procedure). Commercial transactions are conducted using 30-minute averages of the 5-minute prices.

This approach has a number of weaknesses. The set of constraints in the LP is large and high 5-minute prices can arise for obscure reasons. Further disaggregation of generator ownership may do little to alleviate this situation. Also, this approach may not give the ideal separation between the very short-term risks that are best managed centrally by industry operators from the somewhat longer-term risks (~30 minutes and beyond) that individual industry participants may be able to manage efficiently.

A careful review of the coordinated design of industry operation and spot market design might result in a decision to abandon 5-minute energy pricing in favor of a longer market interval such as 30 minutes, in conjunction with an expanded role for ancillary services. This would allow easier control of the exercise of generator market power in the spot market and make it more reliable as a basis for derivative trading. It might also allow the use of an improved approximation to nodal pricing and reduce the need for regulatory oversight and intervention.

B. Location-related issues

The Australian NEM incorporates a regional model of the main transmission network in the spot market, with different representations of inter-regional networks and intra-regional networks. Of necessity, this is an abstraction from the underlying network and it causes inevitable mismatches between market representation and physical industry operation, with consequent distortions to commercial outcomes.

However, full nodal pricing would still be an abstraction from physical industry operation and, in practice, would not eliminate the concept of market regions.

For example it is very unlikely that nodal pricing would be extended into the set of (reconfigurable) radial distribution feeders connected to a transmission network via a particular zone substation.

Thus full nodal pricing is better approached as a process of defining a lower limit to the size of market regions [6]. This decision can be affected by a number of issues:

- Industry participants connected to the same radial feeder cannot usually be regarded as independent commercial agents because of economies of scale in network capital costs, difficulties in allocating scarce capacity and strong interactions related to availability and quality of supply. These problems are more complex if there is a mix of "embedded generation" and end-users connected to one radial feeder.
- Industry participants connected to meshed networks cannot be regarded as independent agents if plausible contingencies (ie sufficiently likely to create significant risks) result in a radial configuration with problems of the above kind.
- Implementation of nodal pricing in a meshed network should address network-related operating constraints in an efficient manner. This means that voltage preference functions should be used in preference to hard voltage constraints [6] and outage risks should be appropriately managed, with associated incentives and penalties for network service providers.

Thus the lower limit to practical market region size may lie at a level above full nodal representation of a meshed transmission network depending on how strongly meshed it is [6].

Within market regions, the key to improved management of distribution networks is enhanced end-user participation in ancillary services, spot energy and derivative trading. This would allow the value of distribution network services to be established more by commercial mechanisms and less by regulators assessing network asset values and approving network investment plans.

C. Enhanced end-user participation

There appear to be two distinct alternatives for enhancing end-user participation in a restructured electricity industry:

- Implement a local market for the end-users and embedded generators connected to a zone substation.
- Franchise a distributor-retailer for the end-users and embedded generators connected to a zone substation.

In the first approach, a local market operator would offer carefully designed tradable instruments for network connection, ancillary services, spot energy and derivatives. These would combine signals from the regional market with signals relevant to the local context. Participants would choose an appropriate mix of these instruments and in-house options with the assistance of independent "energy service facilitators". This approach emphasizes decentralized decision making over regulated decision making and may be most appropriate for more sophisticated participants in urban areas.

In the second approach, a franchised distributor-retailer would be charged with achieving least-cost (in a broad sense) energy service outcomes for the industry participants connected to the distribution network, taking account of local resources and the services available in the transmission-level market. This approach emphasizes centralized, regulated decision-making and may be most appropriate for disadvantaged participants in rural areas where issues requiring group-decision making are likely to be important.

Both strategies would require that all industry participants install metering that could record spot market interval energy and important indicators of supply availability and quality. Both strategies would also require the design of standardized ancillary service, spot and forward contracts for small participants (forward volumes could be developed using profiling techniques) and the adoption of a service-value model for the economic regulation of intra-regional transmission and distribution networks. Both strategies would emphasize energy service solutions that were both economically efficient and environmentally sound.

D. Enhanced sustainability

The Australian electricity industry has large climate change impacts due to the dominance of coal as a primary energy resource. The climate change intensity of the electricity industry has worsened due to restructuring because coal has increased its share of the primary energy market.

This is partly because no cost has been attributed to climate change emissions but it is also because there are barriers to key response strategies that lie outside the market rules per se. These include improved end-use efficiency, fuel switching and greater reliance on renewable energy generation.

End-use efficiency could be enhanced by increasing support for demand-side decision makers, including end-users, equipment and appliance manufactures, urban planners and infrastructure developers. Barriers to the participation of renewable energy generators have been identified and could be addressed by a range of mechanisms [3], [4].

E. Governance and regulation

Governance is a form of high-level, long-term group decision-making that determines the policy framework and rules and guidelines within which lower level decision-makers operate. This might include policies related to issues such as national security, climate change, regional development, and equity issues. It includes the question of balance between centralized and decentralized decision making.

In a Federation such as the Australia, Federal and State governments can be elected with conflicting policies on issues of this kind. Thus it may not be easy to eliminate the confused governance and conflicts of interested identified in the COAG energy market review.

Also, it is difficult to achieve stability in industry governance over the time frame required to allow a smooth transition to a restructured industry. Therefore it is important to implement an approach to industry restructuring that is robust with respect to internal and governance disturbances.

There are noticeable differences in public perceptions of the outcomes of industry restructuring to date in different Australian States, with that in South Australia currently being perhaps the most controversial, with particular concerns regarding the privatization process and high retail prices during times of summer peak demand [12].

Regulation can be regarded as comprising commercial, economic, environmental and technical aspects, all of which can be important and inter-related in the context of the electricity industry. In Australia, these tasks are split between a number of bodies at Federal and State level, giving rise to the perceptions of excessive regulation identified in the COAG report.

Some complaints of excessive regulation could be addressed by improvements to market design that would allow regulators to step back from micro-management, for example with respect to short-term "re-bidding" of generator spot market offers. Similarly, more effective network representation in the spot market would reduce the need for intrusive regulation of network services and difficulties in reconciling competitive and regulated interconnectors.

However, other aspects of regulation reflect the particular characteristics of the electricity industry, including the lack of intermediate storage, the shared nature of the network, the size range of industry participants and the industry's social and environmental externalities. Therefore, it is likely that there will always be an important role for regulation in the Australian electricity industry.

IX. Conclusions

Electricity industry restructuring in Australia has reached an important decision point. Competition between large generators has been largely effective albeit with some concerns about ownership structure and market power at times of supply constraint. Network services remain largely regulated but they cannot be clearly separated from the competitive services currently provided by generators or those that could be provided by end-users. Therefore there is pressure to enhance competition in the provision of network services and, at the same time, calls for government action to augment transmission between market regions to remove occasional flow constraints. As recommended in the COAG review, it would be desirable to increase the number of regions in the National Electricity Market but this faces political opposition. It would also be desirable to review the design of ancillary service and spot markets.

The implementation of retail competition has been more successful for large end-users than small ones and more successful in some states more than others. Participation by small industry participants could be greatly enhanced by installing metering for all participants that could record both interval energy and important indicators of availability and quality of supply. Additional support should be provided for end-use decision makers, including consideration of equipment and infrastructure issues.

To date, electricity restructuring has worsened rather than improved Australia's climate change emissions and there is not as yet a coherent response strategy for the industry.

Thus electricity industry restructuring in Australia remains an unfinished process despite the successes that have been achieved to date. It appears likely that another decade will be required to fully address the important deficiencies that were identified in the recent COAG energy market review [1]. Careful attention to enhancing the compatibility between the commercial trading framework, ancillary services and the underlying physical industry would accelerate the process.

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XI. BIOGRAPHY

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