Small Energy Markets, Scattered Networks and Regulatory Reforms: The Australian Experience

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The global experience with regulatory reforms that promote competition in small electricity markets, especially characterized by scattered networks serving low-density load, is limited. We contribute to this knowledge and policy gap by analyzing the reform experience and policy options in Australia's Northern Territory (NT) market. This market underwent vertical separation and it is now regulated under the national regulatory framework. A virtual wholesale market was created as a stepping stone towards a fuller wholesale market. We find that the new regulatory reforms have improved wholesale market transparency and accountability. However, the anticipated prospect of lower energy prices to consumers will not materialize in the absence of effective regulation and more ambitious changes in the sector. More private participation in electricity generation and retail in the short-term and intra-regional market integration in the medium term may be appropriate policy options as the demand for electricity grows. Market integration can facilitate and not hinder the development of renewable energy. However, we conclude that reforms in smaller electricity markets such a NT should be geared towards meeting the environmental and de-carbonization objectives from the early stages given the potential for tropical leadership in off-grid supply of renewable energy.

Keywords: reforms, small markets, renewable energy

JEL Classification: L94; L51; Q40

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1. Introduction

The reforms of the 1990s have had a significant impact on the architecture of electricity markets worldwide. Broadly speaking, these reforms saw the unbundling of the utilities, the introduction of competition in generation/production and retailing and the re-regulation of the distribution and transmission networks (Jamasb et al. 2017). Privatisation and corporatisation of government owned enterprises supplemented these reforms to ensure that profit maximisation, rather than other objectives, governed the firms' behavior in the newly created competitive markets. The pursuit of efficient regulation of the network businesses meant that, at least theoretically, monopoly power would be constrained be that by private or public owned firms.

These reforms were predicated on the economies of scale associated with the transport of energy and the potential for competition to drive lower prices and innovation in generation and retail. These fundamental principles led to policy decisions that promoted market integration, where the transport network played an important role to achieve lower electricity prices for consumers.

The energy landscape around the world, however, has changed considerably over the last three decades. The emergence of sustainability and climate change related goals has led to a significant uptake of renewable energy, which has created challenges for both wholesale markets and the efficient investment on transport. Moreover, the substantive rise in the number of consumers becoming prosumers, either through improvements in energy efficiency or through distributed generation, has already changed the operating framework of the electricity supply industry (Sioshansi, 2015). Arguably these changes will become more pronounced as electricity storage costs decline further.

While these developments will impact electricity markets worldwide, the focus of this paper is on small electricity markets. A key question being raised by policymakers with regards to such changing energy landscape is the extent to which competitive reforms are necessary and desirable in small energy markets with high renewables potential and dispersed electricity networks.

A small power system is characterized by a system size lower than 1000 megawatts (MW) (Besant-Jones, 2006). Earlier estimates suggested that 100 countries have power markets under 1000 MW (Bacon, 1995). The smallness of the system implies that vertical and horizontal unbundling would generally be infeasible and uneconomical leading to significant losses in economies of scale and scope, while at the same time not realising the benefits of competition (Besant-Jones, 2006) as costs, and therefore prices, would likely increase.

There have been few studies that explicitly studied the implications of competitive reforms on small electricity systems since the pioneering study by Bacon (1995) who suggested the need for intermediate reform options for countries with too small power systems. For example, Millan and Vives (2001) emphasized that the implementation of competitive reforms in small power markets are difficult. Hence, the focus should be towards creating an integrated market. Perez and Ramos-Real (2008) studied the different options to achieve a suitable internal market for electricity within the European Union accounting for small and isolated power systems. Their results showed that vertical industry structure and the design of the grid operator and its attributes are key features for the efficient operation of any electrical system. Nepal and Jamasb (2012) assessed the issues and options in reforming smaller electricity systems of developing countries under twin conditions of political instability and increasing electricity demand. They conclude that the creation of an independent regulatory authority is more important than vertical unbundling of the sector in small power systems.

We aim to contribute to this scarce literature on small power systems by studying the Australian experience with competitive reforms. The focus of this case study approach is on the Northern Territory (NT) electricity market in Australia with around 700 MW of on-grid installed capacity. The NT market operated as a vertically and horizontally integrated multi-utilities business from the 1980's until 2014 under the Power and Water Corporation (PWC). The Territory embarked on a set of reforms since 2012 to promote competition and efficiency in the electricity supply industry and greater alignment of regulatory arrangements with those operating in the National Electricity Market (NEM)[1] with a view to improve outcomes for Territory electricity consumers (NT Government, 2014).

The NT market is characterised by scattered electricity networks, many of which serving the low density loads of remotely based indigenous communities, and often exposed to extreme weather conditions. Its location close to the tropics implies that the NT is also rich in solar energy resources. This paper analyses the reforms and draws some policy lessons, which may be also relevant to other smaller markets globally located in geographically complex settings such the small island economies in the Asia Pacific, South East Asia and the Caribbean where reforms are ongoing and there is a need to decarbonize their economies.

The remainder of the paper is structured as follows. Section 2 reviews the Australian experience with reform emphasizing the NT case. Section 3 compares the performance of the smaller NT market with the existing wholesale markets in Australia in terms of wholesale and retail prices and quality of supply. This is the first study to assess progress and outcomes of electricity market reforms in the NT. Section 4 draws the policy recommendations for other smaller energy markets based on the performance of the NT market within the more liberalised Australian markets. Section 5 concludes the paper.

[1] The NEM is the Australian wholesale electricity market operating in Queensland, New South Wales, Tasmania, Victoria and South Australia. See section2 for more details.

2. The Australian Experience

Australia joined the reform bandwagon of the early 1990s by creating the Victoria Power Exchange in 1994. Other states followed suit (see Table 1 below) with market-based reform measures as expounded in earlier studies (Quiggin, 2001; Sharma, 2003). The National Electricity Market (NEM) was then created, comprising the eastern jurisdictions of Australia including Queensland, Victoria, New South Wales, and South Australia. Tasmania joined the NEM in 2005. The NEM is an energy-only market, where generators bid their supply functions and prices are determined so that the system demand is met. Prices are set for every half hour, and such prices are used by the Australian Energy Market Operator (AEMO) as the basis for the settlement of financial transactions for all energy traded in the NEM. The NEM is one of the transparent energy only markets in the world (Simshauser and Nelson, 2013).

The NEM has a total installed capacity of about 50,000 MW with coal (both black and brown) being the source for 74% of electricity generated. It is one of the world's longest interconnected power networks, incorporating around 40,000 km of transmission lines and cables. The Australian Energy Market Commission (AEMC), the Australian Energy Regulator (AER) and the AEMO are the three key regulatory bodies established under the National electricity Law and the National electricity rules (see Nepal, Menezes and Jamasb, 2014).

Western Australia responded to the reform initiatives in the NEM by initiating the Wholesale Electricity Market (WEM) for the South West Interconnected System of Western Australia (SWIS) in 2001 (Simshauser and Wild, 2009). The market commenced operation in 2006. The reforms involved implementing the WEM and unbundling the vertically integrated state-owned and operated Western Power Corporation into four separate entities: Verve Energy (generation), Western Power (networks), Synergy (retail sales) and Horizon Power (the vertically integrated entity that services regional Western Australia). The Independent Market Operator (IMO) administered the WEM while the Economic Regulation Authority (ERA), as an independent regulator, is responsible for performing market surveillance of the WEM in conjunction with the IMO. The functions of the IMO and ERA were established by three legislative instruments, namely, the Electricity Industry Act 2004, the Wholesale Electricity Market Regulations 2004 and the Wholesale Electricity Market Rules 2006.

Gas (43%) and coal (49%) are dominantly used to generate electricity in the WEM. The SWIS represents 90% of the WA power market with total generation capacity of around 6100 MW. Unlike the NEM, the WEM is a net pool based on separate capacity and energy markets. Energy is traded in the Short Term Energy Market (STEM) with a net pool arrangement which is used mainly for trading uncontracted energy that is generated beyond the bilateral contracts between generators and retailers.

NEM	WEM	I-NTEM
1994: operation of the Victorian power exchange *1996*: unbundling of transmission from generation and a market was launched in New South Wales *1997*: accounting unbundling took place in South Australia following early corporatization efforts in 1995 *1998*: Queensland mimicked the reforms that took place in New South Wales *1998*: Establishment of the world's most transparent energy-only wholesale market in the Eastern jurisdictions (i.e. the National Electricity Market (NEM)) *2005*: Tasmania joined the NEM	2001: Initiation of reforms *2006*: the wholesale electricity market (WEM) commenced its operation in September *2006* : disaggregation of Western Australia's vertically-integrated electricity utility, Western Power Corporation, into four separate state-owned entities – Verve Energy (generation), Western Power (networks), Synergy (retail sales) and Horizon Power (the state's regional power supply entity) *2006*: creation of an independent market operator and regulator *Phase I of the EMR commenced on 06 March, 2014* *Phase II of the EMR commenced on 24 March 2015*[2]	*2000*: NT Government initiated the reform process with the establishment of the Utilities Commission 2012: NT government decided to improve efficiency of Power and Water Corporation (PWC) 2014, July: PWC split into Territory Generation, Power and Water, Jacana Energy in accounting and legal terms 2015: Responsibility transferred to the AER for network price regulation and oversight of network access. 2015: Operation of the interim Northern Territory Electricity Market
Energy only pool	Net Pool based on separate capacity and energy markets	Virtual pool
System size: 50,000 MW	System size: 6,100 MW	System size: 700 MW

Table 1: Timeline of Reforms across the Australian markets

The reform of the NT electricity supply industry (ESI) was initiated by establishing the Utilities Commission on 17 March 2000 under the *Utilities Commission Act. This was* part of wider reforms by the Northern Territory Government to create an economic regulatory framework for regulated industries. The reform also eliminated PWC's effective monopoly over supply of electricity to final consumers and introduced competition among generators and retailers from April 2000. The NT ESI is governed by various

[2]Phase 1 comprised an assessment of the strengths and weaknesses of the current industry structure, market institutions and regulatory arrangements and an examination of options for reform to better achieve the Electricity Market Review objectives. Phase 2 will comprise two stages, firstly the detailed design of a set of selected reforms and implementation arrangements (see https://www.finance.wa.gov.au/cms/Public_Utilities_Office/Electricity_Market_Review/Electricity_Market_Review.aspx for the details).

legislation administered by the Utilities Commission, including the *Utilities Commission Act*, *Electricity Reform Act,* and *Electricity Networks (Third Party Access) Act*.

The NT Government implemented the reform program by improving the efficiency of the Power and Water Corporation (PWC) and moving it to a commercially sustainable footing as a part of mini-budget of 2012 (NT Government, 2014). PWC was split into three separate state-owned contestable and regulated entities in accounting and legal terms in July, 2014, namely: Territory Generation (the largest electricity producer owning 592 MW of installed capacity and contracting an additional 114.5 MW from the Independent Power Producers (IPPS)); Power and Water (responsible for managing the networks) and Jacana Energy (the energy retailer). Further steps include the transfer of the economic regulation of the electricity networks to the AER; establishment of a wholesale electricity market and reform of the electricity retail sector. The Territory is looking to the NEM as a model (NT Government, 2016).

The reforms in NT eventually led to the commencement of the Interim Northern Territory Electricity Market (I-NTEM) in May, 2015. The I-NTEM provides a framework to facilitate the wholesale arrangements of electricity between generators and retailers in the electricity market by introducing an efficient economic dispatch of generation and basic market operation functions. Consumers can then choose to buy electricity from any of the retailers licensed by the Utilities Commission. The creation of a market operator (MO) along with the existing system controller (SC) supports the overall initiative by removing dispatch decisions from the previously vertically integrated company. The MO is also responsible for the publication of market data including daily market prices and virtual settlement statements to participants

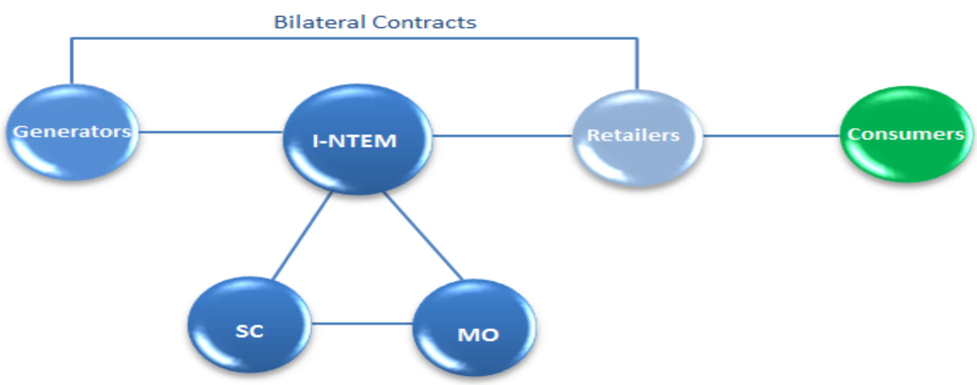

Figure 1: The I-NTEM
Source: Adapted from Power and Water
(https://www.powerwater.com.au/networks_and_infrastructure/market_operator)

The large reserve of gas both onshore and offshore implies that led to an increase in the role it plays for electricity generation in the NT since 1986[3] and this importance will only grow once a carbon price increases the relative cost of diesel and coal. The Darwin-

[3] The generation was dominated by heavy fuel oil and diesel before 1986.

Katherine interconnected system is the only interconnected system linked by a 132 kV transmission line from Darwin to Katherine representing three quarters of the total Territory Generation Capacity. The power networks are highly scattered as shown below in Figure 2. More than 5800km of overhead lines, 3000km of underground cable and 40,000 poles connect Territorians to the electricity network (Power and Water, 2016).

The indigenous Essential Services (a subsidiary of PWC) operates the largest fleet of diesel generators in Australia to provide electricity for remote and regional Territorians (177 diesel generators powering 56 island power stations, and using over 30 million litres of diesel per year). About 72 remote indigenous communities and 66 homelands in the Territory are served by Essential Services (NT Government, 2016). As such, there is a significant scope among remote and regional Territorians to switch to off-grid decentralised renewable energy (solar primarily) and reduce the reliance on the environmentally harmful diesel consumption.

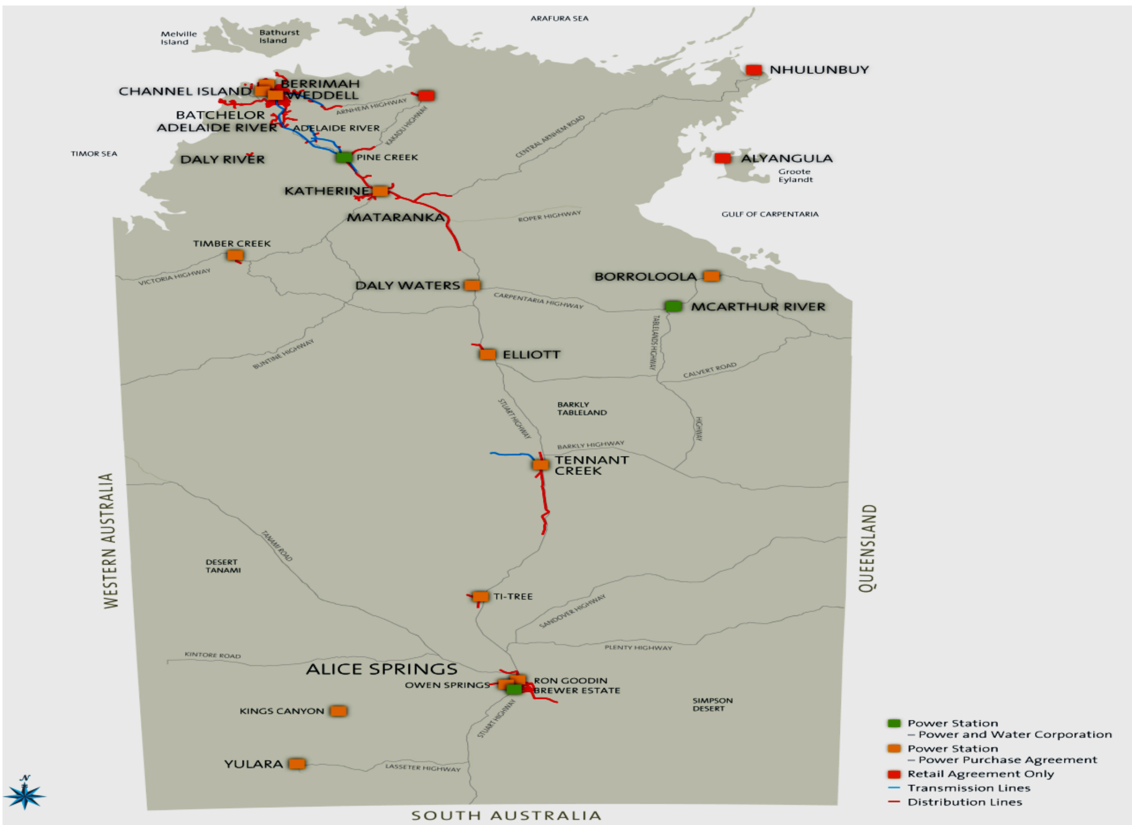

Figure 2: The I-NTEM
Source: Adapted from Power and Water
(https://www.powerwater.com.au/networks_and_infrastructure/power_networks)

3. How are the different markets performing in Australia

The primary argument behind electricity liberalization is that in the absence of natural monopoly characteristics, competition provides stronger incentives for efficiency than regulation (Newbery, 2002). Liberalization was also expected to promote innovation and to improve quality of service. As such, corporatization and competitive reforms were thought to lead to lower consumer prices and more choices, promote reliability, and drive better investment decisions (Quiggin, 2014). For the segments that constitute natural monopolies, independent regulators were created with a mandate to pursue economically efficient outcomes.

In this section, we will present the performance indicators of the three wholesale markets in Australia with a view to capture the underlying features of these different markets and their regulatory frameworks. The performance indicators used are wholesale electricity prices, retail electricity prices, network costs and network interruptions.

3.1. Wholesale Electricity Prices

The commencement of the I-NTEM in 2015 facilitated an interim trading arrangement leading to half-hourly wholesale electricity prices becoming available for NT. A new generator is required to secure customer contracts upfront through a licensed retailer and to generate a volume of electricity on half-hourly basis that is equivalent to the customer demand during that half hour. In the absence of market power and any generation capacity support mechanism, the spot prices in a wholesale market should over time reflect the long term marginal cost of electricity generation.

Figure 3 shows the typical average daily wholesale electricity prices for a month across the NEM[4], the WEM and the I-NTEM. These daily prices were obtained by averaging the publicly available real-time original and official half-hourly spot prices for electricity. Using averaged daily prices accounts for the time differences between the different Australian states. Half hourly electricity prices are also extremely volatile and also subject to price spikes owing to the non-storability property of electricity and the characteristics of electricity demand and supply.

The wholesale price, on average, is the highest in NT followed by the NEM and the WEM. The generators and retailers enter into bilateral contracts at agreed prices covering all customer demand in the I-NTEM while market settlements are virtual. There are no financial cash flows through the spot market.[5] The virtual settlement price is the energy-only price and does not contain any separate investment components such as capacity payments. This component is considered unnecessary as the Territory's generation capacity is sufficient in the medium –term (NT Government, 2016).

The price variability (as suggested by the standard deviation - see table 1 in appendix) is similar in WEM and I-NTEM. Both of these markets are heavily reliant on natural gas for

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[4] We have not included Tasmania in the data since the state has faced an unprecedented energy crisis since early 2016.

[5] The I-NTEM is a transitional stage towards a full wholesale market. While there are no financial transactions taking place in the market and prices are determined by bilateral contracting, generator dispatch is determined based on the generators' offers. Moreover, the generators utilise the I-NTEM settlement statements to determine the settlement quantities for their bilateral contracting arrangements.

electricity generation. The price variability remained the highest in the NEM due to a combination of factors such as the need to instantaneously match supply with demand; the spread of total volume consumed over time; load profile; generator outages; variability in fuel commodity prices and weather factors.[6] Price variability is an inherent feature of a liberalized electricity market (Newbery, 2004).

The National Electricity Rules have set a market spot price cap of AUD 13,100/MWh and a market spot price floor of –AUD 1000/MWh for the financial year 2013-2014 (AEMO, 2014). The WEM has a maximum short term energy Market (STEM) price of AUD 346/ MWh and a minimum STEM price of AUD -1000/MWh. The market price cap prevents the wholesale spot prices rising too sharply during extreme peak load events or at times of reduced base load capacity. The price cap is the maximum price at which generators can bid into the market and can be automatically triggered if it is necessary to involuntarily interrupt electricity supplies. The minimum spot price guarantees dispatch by bidding at negative prices when a generator is too costly to turn off. However, the bilateral contracts are of critical importance to the proper functioning of I-NTEM market.

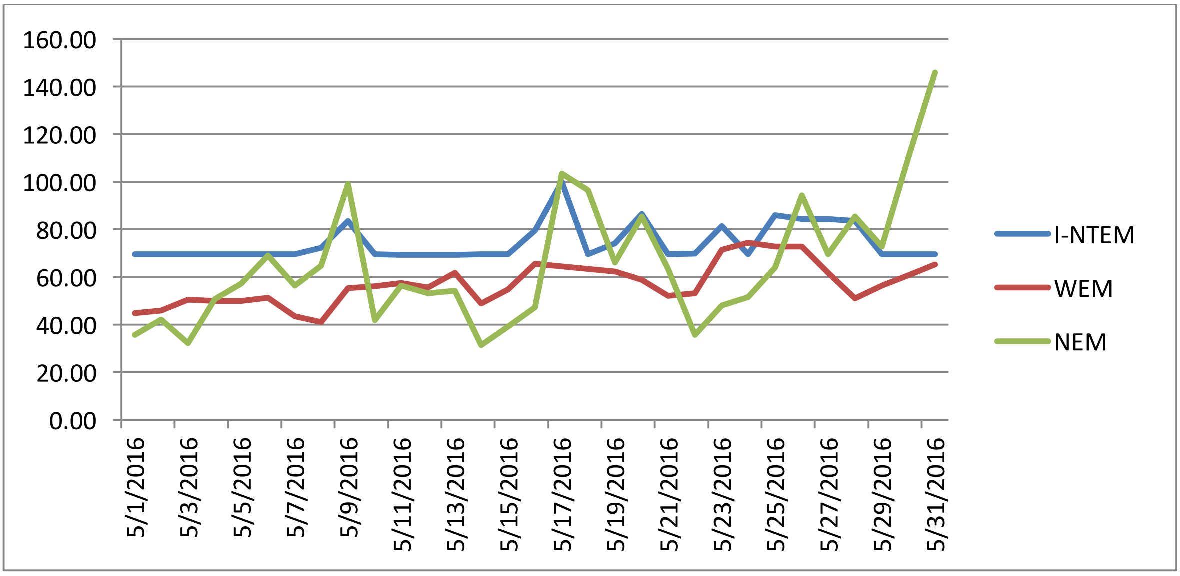

Figure 3: Averaged daily wholesale electricity prices for the month of May, 2016
Source: Adapted from AEMO, Power and Water and WEM

3.2. Residential Electricity Prices

Household energy prices have increased around 61 per cent between 2008 and 2014 despite an overall drop in residential energy use across Australia (ABS, 2016). The extent of price increases varies across jurisdictions given differences in population, climate, consumption patterns and government policy. The rise in the end user electricity prices undermines the intended objectives of reforms in Australia (Chester, 2015). Figure 4 below separates the costs of electricity supply as a percentage of an end user electricity

[6] For instance, the NEM exhibits large demands met from different sources unlike the WEM and NT which exhibit smaller demand and more uniform supply.

bill across the three markets into competitive electricity market costs (wholesale and retail), regulated network costs and environmental policy costs. The competitive market costs includes the capital costs and fuel input costs for electricity generation (wholesale) and retail fees (service charge, contract joining/cancellation fees, etc.).

The electricity network costs are regulated involving different incentive regulation (or price control) regimes across the network segments. For example, the Australian Energy Regulator (AER) determines the maximum revenue (*revenue caps*) that the transmission companies can recover from the network users and sets the maximum prices that electricity distribution companies can charge to consumers (*price caps*) (Simshauser, 2016)[7]. The environmental policy costs reflect the cost associated with the Renewable Energy Target (RET) that scaled down from 41,000 GWh to 33,000 GWh by 2020[8].

The residential electricity prices for electricity in NT and WEM are set by the government implying that the prices charged does not necessarily reflect the underlying costs of supplying electricity due to embedded subsidies. Residential prices are expected to increase by 6.2% on average till 2018 in WEM driven by increases in wholesale and retail costs, regulated network costs and environmental policies (AEMC, 2015). Residential electricity prices in the territory are also expected to increase due to the expected increase in regulated network costs and environmental policy costs even though a downward revision of the Territory Generation's prices following the contractual arrangements will decrease the wholesale costs.

In the NEM, residential prices are expected to be stable over the next three years with lower network costs due to downward revenue determinations by the AER offsetting higher generation costs owing to increasing consumption as forecasted by AEMO and retirements of thermal generators leading to supply curtailments.

[7] In QLD, ACT and TAS, distribution networks are regulated using revenue caps while weighted average price caps are used in NSW, VIC and SA. In Western Australia and NT, economic regulation is undertaken by the Western Australian Economic Authority and the Utilities Commission, respectively, under the national framework.

[8] The RET has two components: Large-scale Renewable Energy Target (LRET) incentivising larger renewable power stations and Small-Scale Renewable Energy Scheme (SRES) incentivising small-scale renewable energy systems such as solar panel systems, small-scale wind systems, etc.

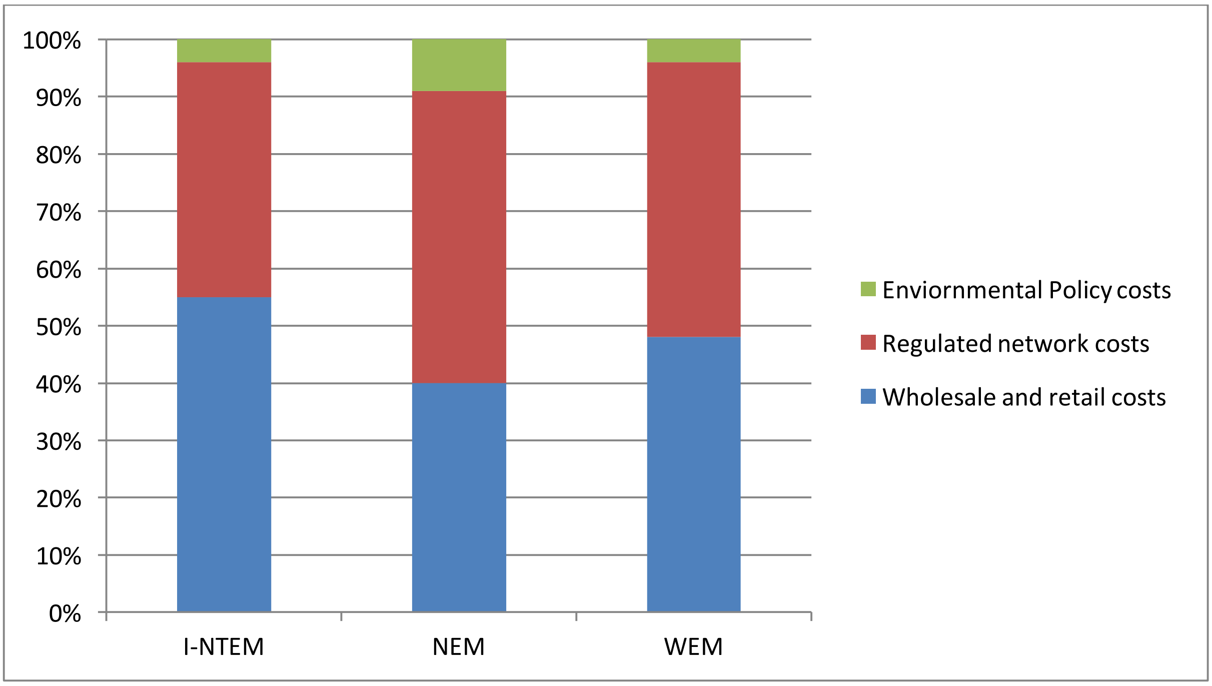

Figure 4: Components of Electricity Supply
Source: Adapted from AEMC (2015)[9]

3.3. Energy Losses

One of the important objectives of electricity market was to promote operational efficiency. The underlying concept was that competitive wholesale and resale markets would lead to better operating practices in generation and retail – firms have no option but to pursue efficiencies to be able to remain competitive in the market place – and effective regulation would incentivize transmission and distribution companies to operate efficiently. A key measure of operating performance for transmission and distribution companies is the quantum of energy losses (Kessides, 2012).

In practice, however, it is not clear that the reforms have been successful in incentivizing network businesses to reduce losses. For example, empirical evidence from other island-based economies such as New Zealand suggests that vertical separation has had no effect on reducing distribution network losses even though average number and durations of interruptions fell (Nillesen and Pollitt, 2011).

Table 2 provides the network attributes of the transmission and distribution networks across the three markets. The overhead networks are vulnerable to extreme weather conditions especially in the Territory which faces harsh climatic conditions during the wet season. The energy losses amounts to around 9% of total energy generated, which is relatively high as compared to a much larger market like the NEM with around 10% loss, which is comparatble to energy losses in other large markets, with geographically

[9] The cost components can vary across different states in the NEM. The percentage presented is an average estimate based on Commonwealth Treasury.

dispersed consumers such as Canada (9% loss)[10]. Energy lost during transmission and distribution in the WEM is around 7%.

The disperse nature of the distribution networks make them vulnerable to energy losses as they bear around 90 percent of power failures while around 10 percent of power failures are caused by failures in the transmission system (Hammond and Waldron, 2008). Underground networks, though more capital expensive, are more secure than overhead networks in extreme weather conditions.

	Transmission (kms)		Distribution (kms)		Energy lost during transmission and distribution	
	Overhead	Underground	Overhead	Underground	Transmission	Distribution
I-NTEM[11]	721	39	4981	2931	3.71%	4.96%
WEM	7732	70	68332	24169	6.7%	
NEM	43309		730642		10%	

Table 2: Electricity Networks in the wholesale markets
Source: AEMO, Power and Water, Western Power

4. Policy Options for Small Energy Markets

Creating competitive retail and wholesale markets is difficult since the unusual physical and economic attributes of electricity makes market design a significant institutional and technical challenge (Joskow, 2006). Vertical separation and unbundling of competitive segments from regulated monopoly segments remain the vital elements of reforms worldwide even across smaller electricity systems. However, technical aspects of electricity supply such as the real-time need to match demand with supply favour the vertical integration between different supply stages resulting in vertical scope economies in terms of coordination economies, market risk economies and specialisation economies (Kwoka, 2002). Hence, the net benefits of regulatory reform in smaller electricity market are debatable. The choice between vertical integration and unbundling is to be guided by the economies of coordination and scope versus the potential efficiency gains from competition and increased efficiency across minus the increment in transactions costs (Pollitt, 2008).

The sub-sections below discuss some policy options for reforming the NT electricity market that are also of general relevance to other smaller power markets globally. These policy options are discussed with a view to providing directions to current reform pathways in NT.

[10] See http://data.worldbank.org/indicator/EG.ELC.LOSS.ZS.
[11] Numbers are based on Power and Water (2012).

4.1. Promoting entry

The ideal enabling conditions for a competitive generation market are adequate generation capacity, modest growth in electricity demand and access to natural gas (Green and Newbery, 1992). Evidence suggests that prices will be closer to competitive levels under sufficient number of competing generators and adequate spare capacity under these conditions (Newbery, 1995).

Therefore, a standard first step to electricity market reform is to allow Independent Power Producers (IPPs) to sell electricity into the wholesale market. This step is usually taken alongside the requirement that all users buy electricity through the market (either retailers who then resell to smaller consumers or large users). The rationale is that power sector restructuring can benefit consumers through increased competition, liquidity and eventually efficiency (Woolf and Halpern, 2001).

The wholesale and retail costs component as a percentage of the total residential price of electricity is the highest in NT among the three wholesale markets in Australia (see figure 4 above). Hence, there is a significant scope to scale down these costs through enhanced competition by promoting greater involvement of IPPs in electricity generation and retailers in electricity supply.

In the case of the NT electricity market, however, its small size limits the effectiveness of wholesale markets as only a limited number of generating companies can be supported. This can lead to oligopolistic market situations and can be susceptible to market power in the absence of market monitoring (Domah, 2002). Nonetheless, wholesale prices can be aligned with the long-run marginal cost of generation even if generation is concentrated provided that entry in generation is contestable and generators are allowed to contract with retailers/large customers (Newbery, 1998). The effectiveness of competition will depend upon how contestable the market is and, therefore, related to how easy entry is.

Currently, Territory Generation has contracted 114.5 MW of electricity under a single buyer model (SBM) from IPPs. Private participation through IPPs can be improved by changes in market rules. For example, changes in market rules can involve: a) creating a legally enforceable and comprehensible set of efficient procedures to replace a complex set of trading arrangements, b) providing incentives such as capacity payments to improve operating performance and reliability by encouraging IPPs to participate and absorb market risks[12], and c) ensuring non-discriminatory access to transmission and distribution systems (Woolf and Halpern, 2001).

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[12] There is a proposal to include a capacity payments component in the full NTEM is desirable to encourage new generator to participate in the market (NT Government, 2016). The other two larger markets in Australia (NEM and WEM) have made participation compulsory subject to a minimum generator unit. Whether this market rule is also appropriate for a small market looking to expand

A change in market rules to enhance contestability can include allowing IPPs in NT to sign direct long-term contract with retailers. There is also scope for a forward contracting market to be designed to ensure that the trading opportunities between retailers and IPPs and between retailers and the incumbent generators are maximised. This of course will have implications for the wholesale market, which will essentially become a wholesale spot market to settle differences between the amounts that have been contracted forward and the actual amounts dispatched.

The market rules can also be adapted early in the sector restructuring process to minimize the administrative costs of participating in the market so that barriers to entry are precluded. For instance, it is recommended an independent system operator (ISO) be established early on as the dual role of Power and Water as both the market operator and system controller conflicts with non-discriminatory grid access arrangements. The ISO then has a responsibility for controlling the access to and use of the transmission grid by competition generators and retailers including commercial solar power producers. There has been limited progress in retail competition with the exception of competition for larger commercial customers. Jacana Energy remains the dominant supplier across for all consumption levels, despite the implementation of Full Retail Contestability in 2010. [13]

4.2. Need for Intraregional Market Expansion

The smallness and dispersed nature of the Territory market may mean that the costs of regulatory reform and structural separation exceed the benefits. In this case, competition resulting from regulatory reform may not be feasible and if feasible, may not be effective unless the market expands. Interconnections can be an effective way to increase competition and market integration in smaller and concentrated wholesale markets. The main advantages of larger and integrated markets are enhanced security of supply and a reduction in reserve capacity needed to maintain a given level of system performance (Valeri Malaguzzi, 2009). Integrated markets, in general, can lead to the higher social welfare than if the markets were to remain separate since the total economic surplus is maximised as the most expensive energy (Neuhoff and Newbery, 2005).

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remains a separate topic of future investigation. However, earlier studies such as Oren (2000) have argued that the use of "capacity payments" is the least desirable approach that undermines the long-term efficiency objectives of the electric industry restructuring.

[13] Retail price regulation ceased for all small customers using between 750 MWh and 2 GWh in the Darwin-Katherine market on 1 August 2015 and in the Alice Springs and Tennant Creek market on 1 January 2016, with a three year subsidy provided to assist in the transition from constrained to cost-reflective tariffs (NT Government, 2016). These customers are able to contract with any electricity retailer in the Territory and receive the subsidy. There has been some retail competition between Jacana Energy and Rimfire Energy since 2015 (NT News, 2015).

In the case of NT, however, it is currently not economically feasible to physically connect with the NEM or WEM. This is considering the low-load density and smallness of the market when compared against the costs involved in capital intensive transmission networks and regional interconnectors. A more realistic prospect can be the establishment of intraregional interconnections, as demand for electricity grows, amongst the main urban centres in Darwin, Katherine, Tennant Creek and Alice Springs, in addition to the existing Darwin-Katherine interconnection. The institutional framework for intraregional market expansion is already in place as these markets are also becoming subject to relevant provisions of national energy laws and rules governed by the AEMC and the AER. However, this may entail undertaking an informed social cost-benefit analysis of interconnector expansion within the NT at the start given the geographic dispersion and low population density.

The empirical evidences on the net benefits of integrated markets are already evident from the small pockets of regionally integrated markets globally such as the Nordpool, the South African power pool (SAPP), the Central American Power market (SIEPAC), etc. As such, market integration can facilitate and not hinder the development of large-scale renewable energy by accounting for the complementarities in electricity demand patterns, diversity in generation resources and access to larger markets.

4.3. Effective Network Regulation

The market-based reforms of the early 1990s was based on the principle of "competition where feasible, regulation where not" in regulating electricity markets (Newbery, 2002). The AER is responsible for the economic regulation of the natural monopoly segments and, accordingly, sets network access charges for based on incentive regulation frameworks. Network related costs represent a major share in a residential electricity bill in the NT (see figure 4 above) and have experienced sharp increases. Networks costs in the other two markets now constitute around 40–50% of an average household's electricity bill. Network costs have more than doubled since 2007 (AER, 2013). There is a myriad of reasons for the increase in network costs, including larger capital expenditures to increase network reliability to flaws in the existing network regulatory environment (Productivity Commission, 2013). However, a series of decisions by the AER in 2015 have led to a fall in network costs.

One of the integral components of regulatory reform in NT is the replacement of local law and rules relating to electricity networks with those applying under the national regime. The reform has implied in the shift of the regulatory burden from the Utilities Commission to the AER since 2015. While arguably the AER has greater expertise and independence than the Utilities Commission, effective network regulation is a complex and difficult task facing all energy regulators. An earlier study by Nepal, Menezes and

Jamasb (2014) identified and recommended several policies to enhance the effective regulatory capacity of the AER including greater independence for the AER, better coordination among regulatory institutions, greater use of benchmarking analysis, greater customer involvement, and improving market transparency.

The broad point here is that effective regulation is key to the success of market reforms in the NT. This is backed by considerable international empirical evidence that the extent of the efficiency gains to consumers resulting from energy sector liberalisation depends upon the underlying regulatory regime and regulatory institutional framework (Newbery, 2004).

4.4. Leadership in Off-Grid Electricity Supply

A significant fraction of the population in the Territory rely on off-grid energy.. Around seventy-two remote communities are powered by diesel generation and in some instances augmented with solar PV generation, while around sixty remote communities are grid connected. The heavy reliance on diesel and the high cost of diesel, with the NT having the highest priced diesel in Australia, has raised concerns about the risk of dragging remote and indigenous communities into energy poverty alongside contributing to environmental damage costs. Solar power with battery storage has already proven to be economically and socially preferable to diesel generation in the Munungurra community of Tennant Creek with power bill dropping by more than half in a space of 3 months; the population growing from three to 40, and local jobs and a school springing up (Wild, 2016).

Importantly, NT has an immense potential for solar power considering a daily average of nine hours of sunshine each day of the year. However, only 4% of the dwellings (the lowest in Australia) had solar PV installed in NT in 2013 (Sunwiz, 2013). There are also significant economic and environmental benefits from scaling up the usage of solar power in NT such as creating income generation activities for communities and displacing the use of carbon intensive diesel fuel. Diversification of energy supply sources also adds to network resilience and improve the security of supply (Hammond and Waldron, 2008) and likely avoid or postpone the need for substantive investment in more extensive electricity transport networks

There are a range of policy instruments to promote investment in solar generation. At the household level, an increase in the regulated feed-in-tariff for renewable energy, to reflect efficient costs, can increase the uptake of solar PV. Currently, households are on a gross feed-in tariff implying that power generated by the solar system is sold back to the grid at the same rate that the power is purchased at. The regulated feed-in-tariff should better reflect the higher value of solar vis-à-vis diesel, including its environmental advantages and the potential savings in terms of reducing or postponing the need for costly network expansions. Second, unnecessary regulatory hurdles contributing to the rising costs of solar PV installation should also be minimized such as the need to require building permits to install panels which costs around AUD 1,000.

While setting tariffs that are more reflective of the costs and benefits of solar is important, there is also the question of how to fund the initial capital expenditures associated with solar. There may be a role for the government and the local communities to provide (micro) financing to fund such expenditures. There is already a growing experience, especially in developing countries, on how best to design micro financing programs and the role of cooperative models in harnessing renewable energy which the NT can learn and experiment with (Thorsten, 2015; Huybrechts and Mertens, 2014). For instance, access to micro finance loans and credits attached to renewable energy sources under sound public governance can promote the access to energy with greater uptake of renewable energy. Finally, we note that the current regularly reforms are silent about the impacts of structural separation and creation of organized wholesale markets in meeting the environmental objectives such as meeting the renewable energy targets.

The NT Climate Change Action Policy (2009) established an ambitious goal of reducing emissions by 60% by 2050 (based on 2007 levels) and of becoming a world leader in providing green energy in remote areas (Climate Council 2014). However, there are currently no formal climate policies, established emissions-reduction targets or specific plans to harness RE sources while the electricity sector has a key role to play towards decarbonisation. Nonetheless, there exists an opportunity to align current anticipated economic objectives of reforms with environmental objectives in the early stages of the market reforms process in NT.

5. Conclusions and Policy Implications

In this paper, we analyzed the process and limited experience with implementing market-based reforms in small electricity systems in a developed country context citing the NT market in Australia as a case study. The major difference between changing contexts is that electricity sector regulation in developing countries have tended to suffer from lower levels of institutional strength in terms of regulatory capacity, accountability, commitment and fiscal efficiency than developed countries (Laffont, 2005). Our case study choice is driven by the recent regulatory reform and structural separation of the vertically integrated entity in the NT market with a view to provide lessons to other small markets globally at the onset of reforms. We have attempted to identify some of the pitfalls in applying to small systems the same logic and rationale that was applied to justify reform in larger systems as policy lessons.

First, it is not clear those structural reforms in the form of accounting and legal separation of a vertically integrated utility necessarily leads to lower electricity prices for consumers. In the same vein, competitive wholesale market and prices by themselves my not lead to lower residential electricity prices. The emergence of effective competition in small markets, so that consumers can benefit in the form of lower prices and more innovation, cannot be taken for granted.

In liberalized electricity markets, the benefits of reform depend upon the market design for wholesale electricity, the extent of competition in retail, and importantly on the regulatory arrangements for the natural monopoly segments of distribution and transmission. . In the absence of appropriate regulatory institutions and market design, the assumption that reforms that promote competition in wholesale and retail through vertical separation will lead to welfare enhancing market outcomes is problematic. For example, the abuse of market power in wholesale electricity markets has been one of the chronic problems facing liberalized power markets (Green, 2006).

Second, competitive reforms need sufficiently large market bases to maximise the benefits from economies of scale and scope that can then flow through lower electricity prices in the presence of appropriate market design and effective regulation. While market expansion in smaller markets may be accomplished by interconnections with the neighbouring markets, this is not economically feasible in the case of NT. However, there may be some opportunity to pursue intra-regional interconnection within NT as electricity demand grows. This of course will necessitate the harmonisation of the institutional framework across different NT regions.

Third, reforms need to reflect and account for the local contexts. There is plenty of international experience that a 'one *size fits all*' approach to electricity restructuring does not work well (Estache, 2016). The I-NTEM and WEM markets are facing similar economic problems in the electricity market such as high costs of generation, strong dominance of fossil fuels (natural gas), the need to accommodate and promote renewable energy, scattered networks, rising residential electricity prices, etc. Hence, the I-NTEM can learn from the ongoing wholesale market reforms and restructuring in the WEM given similarity in contexts.

Finally, market-based reforms are not future proof (Green, 2010) in terms of accommodating and encouraging the development of renewable energy in the transition towards economic decarbonisation. In the case of NT, market expansion through interregional connectors is not economically feasible. While intraregional trade may be a source of market expansion, given the distances and low density, it is unclear whether this by itself will provide enough competitive pressure for the pursuit of economies of scale and scope that may be reflected in lower consumer prices under effective regulation. Importantly, the market reforms are silent on how solar, both at the household level but also small scale commercial generation, can be effectively used to achieve both economic and social goals, such as lower electricity prices, energy security and to avoid energy poverty, and environmental goals.

This has left us to provide answers to questions regarding how to reform small electricity markets to meet environmental objectives[14] as a topic for future research. We conclude that the NT can play a leadership role in renewable energy development in the tropics and share the associated costs and benefits by integrating with the regional markets in the long run.

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[14] There has already been some attempt in answering the question in the UK context by Newbery (2012).

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Appendix

Variable	Obs	Mean	Std. Dev.	Min	Max
I-NTEM	31	74.40419	7.861254	69.31	100.04
WEM	31	57.19548	8.902111	41.04	74.46
NEM	31	65.27336	26.4935	31.46	145.86