2014

AEMforum

Australian Energy Market Forum

[Industry Report]

A report of the AEMforum on near-term opportunities within the Australian electricity market.

Executive summary

Affordable, safe, secure and reliable electricity that underpins successful nations is supplied and consumed in a continually evolving and often global space that provides both opportunities and challenges. The AEMforum was formed by business, industry and government stakeholders to help identify near-term commercial opportunities within the Australian energy market. This exercise is meant to be a thought promoter by identifying from a value and control perspective items of significant interest to the market and trends that will influence the market in the near future. The impact of these will depend significantly on timing - such as when affordable storage becomes available. Whilst change offers new opportunities, there are other factors that apply to the traditional market that will remain important well into the future.

The main areas of interest for the AEMforum were near term opportunities within the following sectors:

- Residential;
- Grid connected vehicles and battery storage;
- Big data; and
- ICT.

The near-term opportunities and related matters that attracted the most interest are covered in the body of this document. It is inevitable that this type of consideration will also yield advice that may assist to frame better policy and regulation. Since policy and regulatory matters are outside the scope of this body of work they have largely not been included in this report. Many contributions clarified important and often misunderstood areas and these have been included within the appendices.

This work has identified an urgent need to:

- Identify the policy and regulatory requirements necessary for this evolving market;
- Identify who owns and controls the space now, and in the near term;
- Identify where the likely opportunities are; and
- Evolve a shared and improved understanding of the core issues by enhancing the quality of deliberations.

Key findings

Observations made during the forum itself fell into three broad categories as outlined below. They contain a mixture of opportunity identification and broader comments about the areas of interest.

1: Limitations in the understanding of several key elements of the space and how the market functions;

The Australian energy market is a very complicated space and few individuals have an adequate or complete understanding of the issues. The forum identified several key issues for further consideration:

- Change in demand;
- Change in network use;
- Distributed resources; and
- Pricing and charging.

It is very clear that both supply and demand are changing. There is change in the use of the network due to changing demographics, population growth, renewables and storage, and the role of ICT and big data. Further change will be due to battery storage, grid connected vehicles, and demand side management.

2: Limitations within this space and what should be done to address these.

Substantial changes in the system evolution and its operation means further consideration should be given to the following areas:

- Appropriate rules for the changed and changing circumstances;
- Uncertainty that distributed generation will be a big player;
- National energy management system and implications to the incentive to invest;
- Network pricing should not include the non-supply components and it needs to be cost reflective;
- Policy and regulation that needs to:
  - be anchored by the precept of a free market;
  - deliver consistent outcomes;
  - be appropriate for facilitating change;
  - create an environment that reduces uncertainties in forecasting both short and long term opportunities;
  - be informed by an independent body; and
  - reduce prices.

3: Characterisation of what is happening now, and how this influences what is likely to happen.

- With pricing reform, growth in under-priced sectors, such as PV and air conditioners and high density Micro Grids will decline, but generic growth should pick up, or at least achieve sustainable levels.

- Whilst the current focus has been on generation transmission and networks, the near term focus will include the as yet not fully understood role of DG with potentially large renewable growth based on the availability of cheaper and more reliable battery storage, information services, and the value that releases particularly in the residential sector.

- Control will shift from utilities to ICT-enabled services, and consumers as both generators and voters. Value will mostly reside within the residential sector.

- Whilst EV's have an enormous potential impact, they are not expected to have any near term significant overall impact, but because they may have local issues and will likely have an impact in the long term, planning and infrastructure investment should be done in the near term creating many opportunities and policy and regulatory requirements.

- The residential market is where the value is. Service will be the greatest value-add and planning is essential for this market segment to evolve economically. Thus, planning the evolution of the residential sector is essential.

Contents

1 INTRODUCTION

The AEMforum sought to frame the key elements shaping a value driven evolution of the Australian electricity market. The time period for consideration was short term (<10-15 years). The exercise was not a comprehensive one but rather a framing exercise that was undertaken to establish the general nature of the market sufficiently to identify potential opportunities. Perspectives differed and were at times difficult to reconcile. Where opinions were divided they are not reconciled in this report but stated as given. Views on policy and regulation were of significant importance to the forum. Because of difficulties in forming an accurate and meaningful encapsulation of the very broad views on policy, other than very general observations, specific policy advice has not been included in this report.

The AEMforum was held on the 2nd July 2014 at The Darlington Centre – Boardroom, The University of Sydney the facilitator was Professor Ron Johnston of the Australian Centre for Innovation.

AEMforum participants represented, electricity industry, manufacturing, ICT, mining, IP, EV, services and research.

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1.1 Scope & objectives

The areas that attracted the most interest are covered in the body of this document. Many contributions addressed regulator and policy matters, others clarified important areas which are often misunderstood. Views on policy and regulation were of significant importance to the forum. As mentioned in the introduction, because of difficulties in forming an accurate and meaningful encapsulation of the very broad views on policy, other than very general observations, specific policy advice has generally not been included in this report. Matters outside the scope of this report, but still considered important, including clarifying observations are given in the appendices.

- Identify the major drivers shaping the Australian electricity market over the next 10-15 years;
- Determine the key market characteristics;
- Establish the patterns of ownership and control;
- Identify key the components of value – who will provide the investment, and in what areas? Where is the value held, and added? Who makes the money?
- Identify the key features of this new market; and
- Identify the implications, including for infrastructure.

The sources of information that provided the base that was considered in this report were the AEMforum, a questionnaire; and relevant feedback. To assist in achieving the objectives the forum addressed the following questions:

SPACE
- What are the key space or segments involved?
- What are the key space or segments priorities?
- What are the segment or space priorities?

ACTORS
- Who are the main existing and emerging players within this segment or space?

CONTROL
- Who controls this space or segment?

VALUE
- Where is the market value held?
- Where the market value is added?
- Where are investments concentrated?

GROWTH
- How has the market evolved in recent years?
- What areas of the market can be expected to grow in the future?

DEVELOPMENTS
- What are the most noteworthy and promising developments in this segment or space? How has this market evolved in recent years

RESPONSE TO CHANGE
- What has been the response to changes in this segment or space and what might they be in near future?

IMPLICATIONS
- What are the implications for next ten to fifteen years?
- What does this tell us about this space? What could it look like?
- What are the implications for infrastructure?
- Are there any special steps that should be taken and by whom?

1.2 Opportunities

Traditional value lies, and is added, in the transmission and distribution utilities, energy management, generation and supply. There will be fragmentation of the market as distributor/retailer business models change and new entrants provide competition and new capabilities. New value lies in data and data management. Selected key drivers identified included: declining demand, competition to centrally generated, grid-delivered power, electric vehicles/storage systems, renewable/alternative energy sources, and political and social demand to reduce carbon. There will be an increasing role and opportunities surrounding standards development, appliance manufacturers, demand management, grid connected electric vehicles, battery storage, roof top PV, micro grids, metering, control and ICT (big data).

Information, communications and technologies not only enable opportunities there is also opportunity in their deployment and maintenance. The value will most likely be enjoyed by the global ICT (big data analytics) providers and allied businesses such as metering and communications, telcos (Telstra, Optus, etc.) and communications equipment vendors (Alcatel-Lucent, Cisco, Silverspring, etc.). There will be opportunities in sensor/control devices in in-home devices, such as HEMS, appliances, electric vehicles, cloud and smart phone apps, all connected through the 'Internet of Things' for the electricity networks and their customers. There will be massive amounts of grid related and consumer data - all that represent value to the appropriate entrepreneur.

1.3 Emerging economy opportunities

There was interest in the role Australia may play in electricity availability for less developed countries to support education and improved life quality. At present the key actors are international development agencies (e.g. AusAID) and international development banks (e.g. IBRD, ADB etc.) and UN agencies. The main existing and emerging players are national utilities. The market value hardly exists in some countries, but ideally should lie with local ownership – this space has significant challenges. The primary energy assets (e.g. oil, gas, uranium, etc.) are presently controlled by foreign powers. Future growth is expected in plant and system exporters by the developed world. There has been inconsistent evolution of this market in recent years. The most noteworthy and promising developments in emerging economies are similar to developed nations, although there may be 'technology leapfrog' opportunities (e.g. SMRs, LV DC grids etc.), that could show a different development pathway.

1.4 General market characteristics

The Australian electricity market is probably best segmented according to industry versus residential, and urban versus rural and not on a jurisdictional basis. It has a number of relevant characteristics: It is a relatively small market by international standards, and there has been closure of many bulk electricity users (e.g. aluminium smelters), and a decline of Australia's international competitiveness, relative wealth and electricity affordability. National policies have given very high importance to the environment and climate, and as a consequence there has been a seven year investment hiatus in the real needs, but at the same time a growth in peak demand. There has been a lack of long-term planning particularly planning that recognises the north-south to east-west nature of our energy system. Planning and central policy making is required, with long term bipartisan energy policies.

Market systems no longer operate as effectively as they might. A major question is the significance of the present declining electricity demand and will this continue. In the local grid, ownership & control is presently exercised by governments, network owners, generators, renewable/solar suppliers, large customers, regulators & other rule makers. This will however change - customers are voters as well as electricity users, and are increasingly becoming politically engaged in the generation and use management. Future control of this space will involve consumers (voters), ICT providers, metering, and micro grid owners/operators (resellers). The forum identified the inherent ratio between dispatchable/non-dispatchable electricity and the importance of who controls the balance of non-dispatchable generation (e.g. solar, wind) with its high CAPEX low OPEX. Multi-part tariffs will evolve comprising compartmentalisation of capacity, service and energy.

There is a lack of investment incentivisation, a declining resource base, and a substantial growth in renewables. The traditional market value is held by the natural monopoly holders - essentially T&D but also hydro owners and operators. The market value is added by suppliers of primary energy sources (excluding RE sources), generators and T&D. The investments are concentrated in upstream primary resources (e.g. coal and gas and uranium), generators and T&D asset owners.

In the present context this space is obviously controlled at the moment by the asset owners, but increasingly the vast profusion of market intervention and regulatory agencies will distort natural markets and do not achieve outcomes of the most economic use of resources, including both natural and investment assets. Wrt Generators, T&D owners and operators, the value is held by probably by the natural monopoly holders - essentially T&D but also hydro owners and operators.

Future market growth is expected in the generation market, currently well oversupplied, will in time need new investment as existing assets age and demand growth resumes, albeit slowly. CSG development will be strong once the industry is allowed to operate (demand is growing) and in the longer term nuclear power (Gen III plus and SMRs) will enter the asset portfolio alongside other low emission options, subject hopefully to market economics.

The most noteworthy and promising developments are a growing realisation that the private sector, open to unfettered competition and only necessary regulation, does it best; and the growing acceptance that nuclear power is at least worthy of consideration in the generation portfolio of the future.

The implications for next ten to fifteen years are in related technology, the IT revolution (intelligent grids/open consumer markets) will have a profound impact; also the impact of energy storage systems and the progressive take up of EVs.

2 RESIDENTIAL

The key interest areas within this space were residential technology and residential demand response:

- To ensure that the end user recognises the need and demands the infrastructure to support the deployment of a range of technologies from communications through to age and assisted living; and
- For the electricity asset providers using residential demand response to achieve: greatest utilisation of assets (reduce marginal cost of distribution) and create greater value for investors. The key priorities for information and communications (ICT) providers, management systems providers and others are to create new opportunities and greater value. The key priorities for appliance manufactures: create new opportunities and greater value. The key priorities for consumers are lower cost, reliability, utilise own resources effectively.

2.1 Value

Residential value due to demand response is presently probably mostly held in network distribution assets and consumer appliances. The market value due to demand response is added by electricity asset providers driving more effective asset utilisation - lower marginal cost of augmentation and consumer demanding reduced peak cost and increased service. There is also potential to value-add due to market overlays. The investments are probably concentrated in network infrastructure / metering, services, ICT and control.

Residential electricity use is very important by value. Residential sector can contain elements of both supply and demand and the owners are also voters. It is also the most amenable to change and value realisation. Consumer attitudes have changed, there has been an everlasting change to people's attitude to price - both domestically and in industry.

Electricity is losing its fungibility, it is changing from a commodity into an increasingly differentiated product. We should not expect the market to deliver decreased prices for electricity related services but more creative value-added solutions will be evolved. We have seen "green" electricity and we will see bundled offerings by service providers such as Google, and other market entrants. Alcatel has a platform which can manage the market readily - allowing for bundling.

There are several changes in consumption that may lead to increased value of DR: Increased peak periods driven by the increased use of air conditioners and roof top solar has significantly changed loading patterns on networks and this is likely to increase rather than decrease. As the Australian population rapidly increases, urban densities increase dramatically and residences change (from separate homes to flats units or apartments) the residential consumption load will change significantly in nature.

Key Observation: Electricity is increasingly becoming a differentiated value-added product with ICT as an enabler.

2.2 Control

The key residential demand response actors are: network owners, metering and control system vendors, ICT providers, appliance manufacturers, governments, regulators and standards and consumers. Utilities, metering, control and information system operators and providers and appliance manufacturers are the main players at present. Emerging actors are probably best generalised as providers of the services necessary to implement DR: meter providers, ICT providers and the organisations that will facilitate effective residential DR and appliance manufacturers. Other actors are developers and builders, particularly in relation to large multi dwelling unit developments and to a lesser extent in the single dwelling unit space.

Residential demand response is presently controlled by networks operating under regulations. Increasingly information, management and control service providers will exercise greater control as will the main users - perhaps aggregators or system participants yet to be identified.

Key Observation: Residents are increasingly consumers, generators and voters.

2.3 Growth

The main existing and emerging players are technology companies who are looking for a space to grow their markets. Also retail service providers who are looking at developing long term relationships with consumers such as security monitoring, CCTV monitoring and energy management. Content delivery providers are also increasing their role in this space. In time, as the market segment matures and consumers start to demand quality not just quantity particularly in the services such as security, health and aged care, infrastructure will become a determining factor creating a need to have this addressed.

Changing consumer attitudes has created a ready demand for home automation products and prices are coming down. Domestic consumers are increasing seeking services such as the capability to control appliances remotely. To achieve this there needs to be residential technology enabling infrastructure.

Future growth is expected in the provision of services and ICT systems based around smart meter metering and control gateway. Growth is also expected in products including DR enabled appliances and related DR systems. As appliance DR becomes more widespread there will be increased opportunity for a myriad of solutions that enable not only load shifting and peak shedding but also capability to match renewables to demand. Training and education opportunities will increase as space becomes more complex and more regulated.

EVs are not expected to impact the network significantly over the near term but because they are such a significant load it does not take many to impact the network locally which may have implications for their local control.

Key Observation: Residential technology is a growth area.

2.4 Developments

The most noteworthy and promising developments in Residential Technology and demand response are:

- The increasing appetite for home connectivity;
- The internet of things;
- Products with DR interface (AS4755);
- Utilities with capacity to achieve and realise benefits from residential DR;
- Utilities offering incentives for appliance DR (see Energex peak smart program);
- Appliance manufacturers are already producing products that are DR enabled;
- To use smart meters perhaps with increased DR capability to act as a key element of appliance DR
- Standardisation of DR process is relatively well developed and a number of appliance standards for DR have been published and product has been made;
- Over the next ten to fifteen years there is expected to be steady growth in residential technology;
- Utilities are already undertaking limited DR; and
- A number of small scale DR programs are already in place.

Residential demand control (management and response) has the potential to impact across the entire space including: both the gas and electricity sectors, electricity asset providers, electricity service providers, metering and control system vendors, information and Communications (ICT) providers, aggregators, management systems providers, appliance manufactures: hot water, pool pump controllers, air conditioners, EV, residential solar and residential battery storage, laws: statutes/rules/regulation/standards, consumers, educators and trainers.

2.5 Response to Change

The response to change for Residential Technology has been slow albeit, there is work in the area where the Australian Building Code Board is considering creating a National Construction Code - Telecommunications. If this becomes a reality this will assist this segment to grow exponentially.

The critical importance of standards has been well recognised, both international and Australian standards are presently being developed that will enable a multitude of new and growth opportunities in the future. As these standards impact through both regulation and voluntary adoption the markets will evolve according to local, jurisdictional and national circumstances – in many circumstances there will probably be no lasting singular optimal solution but a range of solutions and corresponding opportunities.

2.6 Implications

The most significant implication for next ten to fifteen years is the new value creating opportunities for providers of ICT systems, smart metering/control, appliance manufacturers, network owners, aggregators and other system managers/integrators and educators and trainers. The additional implications are value created by matching renewables to demand and load levelling will mean better use of assets. Preparing for this new complex energy/information world will require planning to extend beyond the network related systems into the home to prove affordable solutions and services.

With the increased awareness of the value of appliance DR from both a supply and consumer perspective solutions, some in their infancy, are reaching the market, supporting structures such as standards have been developed. As appliance DR becomes more widely available more impactful outcomes will result. This will drive an environment for a more complex market with many more participants who will leverage and create viable energy/physical/information/market etc. opportunities.

Key Observation: Underlying demand is rising with population and affluence.

3 GRID CONNECTED VEHICLES – BATTERY STORAGE

Whilst both electric vehicles and batteries may constitute both supply and demand elements they are generally, as far as the near term grid is concerned, loads. Grid-connected vehicles, often incorrectly called EVs, covers plug-in hybrid vehicles (PHEVs) and vehicle energy export possibilities associated with other powertrain configurations capable of power inversion (whether exported to grid or a closed local network - e.g. Fuel Cell Vehicles (FCVs) are able to be developed in a manner so capable). There is some uncertainty about the future. There will be new refuelling behaviour. The role of shopping malls, sports grounds, offices will be important not just as a source of charging but the coordinating attributes will impact networks significantly – for example a big sporting event.

Additional commentary on grid connected vehicles is provided in the appendices.

3.1 Value

The market value is held:

- Probably best described as potential value, as there's actually very little sustaining value today. But this is changing, and there is scope to rapidly accelerate it;
- Market value is not yet in public infrastructure. Whilst the vehicle sales and distribution industry often cites range and lack of public infrastructure concerns as reasons to doubt vehicle uptake, public infrastructure does exist but currently adds very little value - beyond some fringe customers relying on available public charging infrastructure to use EV's in manners for which they are not a best-fit technology (e.g. long range), public charging in Australia is not providing any value beyond home charging;
- Some key questions are: What does deployed public infrastructure do? Does it just alleviate range anxiety? Does it let you not run out of electrons - do you have enough to get home? Does it allow you to complete trips of distance beyond a full tank of petrol would conventionally let you do? Does it let grid-connected cars value-add to your life's usage modes in ways petrol powered cars can't? (I parked here for an hour whilst shopping and came back to find the car charged...) Does it enable free energy - or significantly lower cost energy? Does it help lower societal carbon emissions? Does it help load-balance the grid? It is not clear. Unless an EV is based around public charging infrastructure (e.g. its functionality is non-existent without it – and the case is potentially better, however less clear, for PHEVs) then the value add for public charging infrastructure is as-yet undefined. (This does, however, elucidate a potential and significant market - EVs for public use in a vehicle-sharing context – a moderate-sized fleet among larger car-share operators would present, in the near term, a very significant vehicle order and open up other possibilities for V2G, stationary storage second use… a very homogenous market possibility);
- Currently the market value is in the cars (which is tantamount of saying we're not doing much value-add with them!);
- The market projections for grid-connected cars pass 1,000 cars Australia-wide in 2015. This is a significant milestone. Most of the vehicles simply offer lower running costs than combustion counterparts, and a competitive driving experience as user perceptions of favourable motoring shift away from traditional norms to appreciating quieter vehicles, a connected experience, lesser environmental impact and lower running costs. Until recently the availability of grid-connected vehicles at comparable costs to combustion counterparts did not exist;
- Still, these vehicles need to be charged. Most are to be charged at home, with work a mooted second destination – however the relevant vehicles are still expensive choices in vehicle fleets, thus their mainstream adoption (and accordingly mainstream charging infrastructure in the workplace) on a value basis is some time away;
- Essentially the most immediate untapped value path is in home grid connections. Home charging, where permissible by the utility, can allow consumers to run vehicles at lower cost, lower CO_2e or both… and can be used to abet broader grid arguments;
- Load management; and
- Better network asset utilisation.

The market value is added:

- Services ensuring amenity levels consistent with the status quo automotive paradigm ("it (the service) lets me drive and not worry about range anxiety, getting up in the morning and not being able to get to work, ensures I don't have a flat car when my wife is pregnant and needs to go to hospital, it doesn't leave me wishing I had another class of car in the garage better fit for purpose", etc.);
- Products and services monetising the value space between electric vehicles and their potential to advantageously serve energy networks, whether local/home or regional/national;
- Future possibilities in home energy storage and V2G;
- T&D networks and other electricity supply chain participants;
- Battery manufacturers and marketers;
- Battery systems developers and marketers;
- Motor vehicle manufacturers;
- Electric vehicle manufacturers and marketers; and
- Value for shopping centres is not value of electricity sales but attraction of customers.

The investments are concentrated in:

- Beyond the cars themselves, so far just in public infrastructure at a low level in city centres:
  - With Tesla's arrival this can change, as the company has demonstrated a business model integrating cars, charging solutions and some semblance of low-carbon (and certainly zero-cost) energy for consumers. This in turn provides a veritable value-add to those interested in their vehicles. They are presently the only automaker with such plans in Australia – their vehicles also have the longest range, thus the net number of investments may be so limited. Tesla's AU infrastructure is in a planning stage. Whilst no other manufacturers have offered or planned similar solutions locally, in Japan a consortium of companies (along with government funding) are in the process of rolling out a substantial charging network;
  - Home EVSEs are distributed sparsely at present however it's expected that more mainstream uptake may attract segments homogenous to certain locales;
  - If proper load management were enabled sufficiently for vehicle battery capacity and power characteristics to become part of a value proposition beyond the usual vehicular characteristics, there is potential for investments to be calculated very differently – there'd be an investment wherever there was a car! There is no reason to invest in a larger battery or more significant power capacity presently beyond vehicle range and charge time. This can change.
  - It should be mentioned that it's typical of grid-connected vehicle customers to invest in technologies to generate power locally, which in turn creates investment opportunities in ways to use that energy… e.g. a car;
- Currently, metro and major regional areas;
- Eventually, will be across all socio-economic and geographic areas; and
- Networks, Battery and Vehicle manufacturers and control system developers.

3.2 Control

The GCV market is controlled by:

- Ultimately consumers at present;
- As potential value add this hasn't really been exploited, there are no agents able to own or effect control of it;
- EV charging service providers (network operators);
- Energy network operators;
- No one, in Australia;
- Global forces will determine Battery and Vehicle development, with little influence by Australia;
- T&D Networks can control their tariff (pricing) offerings;
- Regulators;
- Traditional car industry; and
- Owners of shopping centres/sport grounds.

3.3 Growth

At this stage, with no EV incentives, by 2020 Australia is expected to have a 20% EV take up in wealthier suburbs. A recent trial in Cairn's with 5 vehicles was without time control and led to a stressed grid as all load came on together at peak hour. But with time controls, and even better with opt-in with manual or boost override, stress on the system may be controlled. Cloud based control processes in rest of world is a long way off. Capital is not the key issue, nor batteries, Australia is just a small market. Fleets are the target customers.

The following areas of the market are expected to grow in the future are:

- Where there are competitive price points on fixed + variable costs compared to combustion vehicles, and where the net value proposition can be demonstrated to be of net transparent benefit to a consumer - particularly if it offers synergy with electricity energy costs;
- Otherwise, growth will remain solely constrained by vehicle price, with some movement owing towards Gen Y preferences to value perceived environmental impact favourably at a limited price penalty;
- Near-to-mid term growth of PHEVs is anticipated as the fixed vehicle costs of a PHEV against a hybrid powertrain are not significantly different where battery sizes are manageable (~5-8kWh); economies of scale of newer batteries and the more favourable performance of PHEVs on vehicle emissions test cycles make these vehicles amenable. These vehicles occupy lower power and energy requirements. This may afford an according growth in EVSEs. This is 'expected safe growth' within 10-15 years;
- PHEVs of serious battery capacity (~20kWh+) or EVs may become affordable in mainstream segments in closer to 15 years (in lieu of other factors, e.g. subsidies);
- Initially metro and major regional areas - eventually, will be across all socio-economic and geographic areas; and
- Battery market growth as a network or "broader electricity supply chain" support service will likely be limited – depends upon T&D tariff offerings of the future.

The market has not significantly evolved in recent years. EV sales - slow start -> moderate pick up -> exponential uptake of EVs as prices move from 'early adopter' to 'main stream'. Vehicle cost has decreased to the point where grid-connected vehicles can be bought competitively within a broader product offering (e.g. the Outlander PHEV costs as much as a high-spec diesel version of the same car); this is not a function of the Australian market, more of external forces and some potential price stimulation. It will continue (see Tesla) but not across all segments equally. As mentioned, this will commence broadly in 2015. In 'recent years' not a great deal has happened.

Load management associated with vehicle charging has been raised, but not qualified, as a concern. The work involved is not without merit as the prescience and need for relevant solutions can change. Demand response is not yet viewed as an enabling technology in a mainstream sense; however various agents within the automotive industry are starting to appreciate this view.

3.4 Developments

The most noteworthy and promising developments are:

- The provision of demand side services such as battery charging - which will be in commercial centres, public car parks, shopping centres, etc. will need very sophisticated control systems. Chargepoint provides numerous support services - energy, billing and demand management. These will change behaviour patterns - cloud systems will be involved;
- The reduction in price of the vehicles to the point that they are attractive on a fixed + variable cost basis to consumers irrespective of energy source creates a basis for discussions. This is less a function of battery energy density and more a function of production scale, rationalization of cell formats, thermal performance and the like;
- Low-grid-impact charging infrastructure is particularly promising from a cost and amenity perspective, however presently only Tesla[1] is offering this, and it appears to be a closed system. If the financial impact of such solutions could be integrated into larger economic concerns, then the potential for truly low-cost transport energy in applicable sectors is significant;
- The identification of homogenous transport segments is one of the most significant emerging developments – the development of vehicles for purpose rather than around the limitations of an electric powertrain. "Where is it better to have a vehicle that's electric?" Yet this remains broadly untapped as the developments are recent, and it will take time for the vehicles to come to market. This moves grid-connected vehicles away from price competition and more towards a value-based argument;
- Telematics, thought to be diffuse by 2020, will allow significant data throughput from vehicles and should enable smarter interactions with grid energy. Most vehicles sold locally by 2020 will have a SIM card on-board;
- Vehicle manufacturers are beginning to commence manufacture of stationary batteries using over-supply, out-of-specification batteries or second-life batteries reclaimed from existing vehicles;
- The strong correlation between grid-connected vehicle ownership and off-grid power source ownership suggests that bundling vehicles with energy contracts is highly possible, and ties in with noted shifts in vehicle ownership preferences: Gen Y customers prefer, and will pay for, sustainability and connectivity. The presence of a significant, growing market with preferences for the potential synergies afforded by grid-connected vehicles is significant;
- Battery chemistry improvements, translating to greater energy storage capacity and delivering greater EV driving range;
- Australia being a small market will be driven by USA and this is where our standards will come from; and
- In the US and the EU, EV acceptance is high and EVs are common in these markets. AU will follow at a slower pace, but already interest in EVs is growing rapidly.

3.5 Response to change

The response to changes and what might they be in near future:

- We should be cautious using US or EU data because price factors in the Australian market are significantly different, as are infrastructure concerns, driving cycles and many other factors. We are data deficient - the local market is very much learning of the potential of grid-connected vehicles and awaiting demonstration;
- The most significant change is a very recent price amenity of grid-connected vehicles in some segments. The customer base has responded with strong demand, however these remain small segments. This early demand has afforded the possibility to drive down the cost of early-generation EVSEs by importing them in volume; however prices still remain significantly above parity with larger markets;
- The number of segments with grid-connected vehicle options will increase before a generational decrease in the price of these vehicles in mainstream makes (Tesla being an exception in 2018 owing to vertical integration of cell manufacture). Thus the barriers to implementation (infrastructure cost and

[1] **Editor's note: also see http://www.coppertech.org/news/News.php/Index/viewnews/id/243/lan/1**

availability, energy supply, etc.) may diminish prior to barriers to market entry (cost of the cars themselves);

- Were federal government policy changed to incentivise such vehicles to a parity level, a significant change in the near term may be seen. There are, however, currently no policy levers linking grid-connected motoring to diminished net carbon output. Until this can be demonstrated it is considered unlikely that a near-term enabling policy will exist. The increasing availability of vehicles from reputable markets does increase the near-term possibility that large corporates may seek to create closed networks of vehicles and low-carbon energy sources, and seek to partially fund these through carbon-related government grants. This is mentioned for significance owing to the small size of the net grid-connected vehicle market in the near term and the accordingly strong effect a few significant fleet customers may make; and
- The T&D industry "watches with interest", while battery promoters "talk up" their prospects.

From a network perspective there are several scenarios:

- Either: The T&D industry will implement radical network tariff reform, in which event, there will be limited take up of "batteries" by mass market customers seeking to provide "support services" to the electricity supply chain;
- Or: Those promoting batteries will leverage the view that "time of day" TOU tariffs are highly cost reflective, to develop a market which enables mass market battery purchasers to generate a benefits stream that makes battery adoption commercially viable for the customer, but which, provides little benefit to T&D.

Alternatively:

- Either: The T&D industry will develop "controlled load offerings to electric vehicle owners, which are acceptable and attractive to customers and which drive improved utilisation of T&D networks and in so doing drive lower T&D unit cost outcomes;
- Or: Intermediaries, such as "vehicle recharge outlet providers" will come to dominate this market and provide "on demand" charge points. But in so doing may impose poor, or even unsustainable, load profile outcomes on the T&D system, and achieve relatively poor cost outcomes for electric vehicle owners;
- Or: In the event that in the absence of suitable controlled load arrangements, the cost of on-demand charging becomes uncompetitive and nothing much might happens.

More commentary on this matter is provided in the appendices.

3.6 Implications

The implications for next ten to fifteen years are:

- Automotive and energy industries (and other participants) must walk hand-in-hand to enable solutions;
- The mid-term value-add lies in synergies between largely-disparate vehicle sales and distribution and energy industries. This necessitates new business paradigms, however the possibilities are great;
- The mid-to-long-term value lies in value synergies between grid-connected vehicles and changing macro-social paradigms: trends against vehicle ownership, trends towards uptake of smaller-than-current vehicles in line with increasingly hyper-urban social models, trends towards the acceptance of renewables and a social understanding of the role of energy storage in a sustainable energy economy changing the view of vehicle energy storage systems from a vehicular part to an energy infrastructure asset, shifts away from driving and towards being transported (with what technology sets and usage paradigms these bring);
- The latter paragraph highlights trends for which data exists in various regional studies, but for which uptake is not yet defined in an Australian context. It provides value opportunities that are, of all powertrain configurations, most amenable to grid-connected vehicles. It is provided to show, however, that value can be generated by acceding to these paradigms, or that otherwise an industry will be pulled to them in a latent sense;
- The overriding implication for the automotive industry concerns a lack of availability of equitable crude oil by 2040-2050, which is within two vehicle generations of a 10-15 year outlook. It takes

some four vehicle generations for any key technology to become mainstream; irrespective of the market demand at 10 years, by 15 we must be prepared – at least in an energy supply context - for significant diffusivity of grid-connected vehicles within the subsequent decade;

- Different energy demand patterns;
- Potential for energy storage and V2G as part of a transaction based energy economy;
- Sophisticated communications;
- Charging infrastructure;
- Social/behavioural considerations;
- Cloud updates; and
- Demand-response standards will enable consistent approach to EV demand and supply control.

Key Observation: It takes some four vehicle generations for any key technology to become mainstream; irrespective of the market demand at 10 years, by 15 we must be prepared – at least in an energy supply context - for significant diffusivity of grid-connected vehicles within the subsequent decade.

4 DISTRIBUTED GENERATION

The term distributed resources is used here to encompass all elements of a network that may be used to source distributed generation DG [2] (also termed embedded generation) or sink electricity. For example a battery storage system is able to both store electricity from the grid and supply electricity to the grid. Loads such as hot water can also be turned on and off and form a distributed resource from the networks perspective. The forum mainly focused on distributed generation which is a significant element of the electricity space[3].

A number of general observations were made regarding DG where it was at the time defined as standalone systems below 22kV. But notes that all RE comes in by HV transmission (wind, hydro, geothermal, solar thermal, biomass, etc.). Presently, only rooftop PV comes in via the LV “exchange network” so in this sense the only DG of significance now is PV.

It was observed that coal fired power stations were common with nine power stations in Sydney city. Now they have gone, replaced by large central generation and HV transmission, much of it ageing. The network is no longer able to support decentralised generation.

Any large solar systems will certainly supply via the HV system. Opinion was divided on the impact of DG on transmission and network assets. On one hand it is possible that investment in the replacement of up to 13; 132kV and one 330kV transmission cables could be avoided, if Sydney were to embrace inner Sydney generation (presumably gas fired).

However, it was pointed out that if a limited number of centrally located (near CBD) generators were to be commissioned, there would still be a need to replace many of the 132kV cables, since these cables have multiple “off take” load points, supplying zones substations, throughout suburban Sydney. Unless every one of these “off takes” was to be replaced by generation (with adequate alternative supply arrangements), the bulk of these 132kV networks will still be required. The mistake people make is to think of these 132kV cables as Transmission cables – they are actually better characterised as distribution cables**.** It was noted that major HV cables under Sydney will need to be replaced before long.

The key areas of interest in embedded generation were:

- Embedded generation (PV), demand response, controlled loads (DRED[4] & off peak hot water etc.);
- Renewables matching - the real time control of loads to match embedded / exported generation to demand; and
- Grid stabilisation / quality of power through intelligent real time control of GIWH (grid interactive water heaters), load shifting (e.g. water heaters) to benefit grid by better matching of load to embedded generation power fluctuations / quality, optimisation of self-consumption of PV generated electricity.

Additional commentary on DG is provided in the appendices.

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[2] **The AEMO (AEMC Fact sheet - Distributed generation, 30 November 2012) definition of distributed generation refers to smaller generation units that are located on the consumer’s side of the meter. Distributed generation is also referred to as embedded generation. Examples of distributed generation units that can be installed include: roof top solar photovoltaic units; wind generating units; battery storage; batteries in electric vehicles used to export power back to the grid; combined heat and power units, or tri-generation units that also utilise waste heat to provide cooling; and biomass generators, which are fuelled with waste gas or industrial and agricultural by-products.**

[3] **The Clean Energy Council puts total volumes of distributed co-generation at approximately 3338MW, 593MW of which is powered by renewable resources. This is equal to about 7% of the total installed generation on the NEM.**

[4] **Demand response enabling devices as per AS4755**

4.1 Value

The forum questioned the present value of DG - and questioned the case for assuming that it can provide meaningful electricity at a price we can afford. It was noted that there are successful businesses based on offering both PV and some tri-generation.

The market value is held in high kW loads that can be manipulated in real time (shifted, turned on and off etc) without affecting the amenity, or imposing additional costs on the stakeholders, i.e. households and businesses typically.

Investment required is in adding technology to the loads to enable real time control and monitoring and in the development of the necessary software / systems etc.

The market value is added by harnessing the real time capability to control aggregated loads such as through the use of intelligent real time control harnessing the power of geospatial database technology. Results will be a much more efficient grid, smoothing out generation demand mismatches, flattening and even eliminating traditional demand spikes which in turn will defer or eliminate network capital investment. Savings can be used to reward customers who participate in such Grid Interactive programs, encouraging further uptake etc.

4.2 Control

The key actors are manufacturers, telecommunications companies, “home and business owners”, utilities (DNSP’s), aggregators, geospatial data base companies, government, AEMC / AEMO.

No one is in control of this space at the moment, however there are only a few players that are in a position to put the jigsaw together effectively and bring the opportunity to reality.

4.3 Growth

The market is at an early fledgling stage. Consolidation of standards and players over the coming few years should see increased activity in the areas described. Any further increases in electricity price will only cause a faster adoption of the technologies described, changes to consumer behaviour and regulatory focus to accommodate solutions to the issues described.

Opinion was divided on the status of distributed generation, one view is that apart from roof top PVs, distributed generation is not evolving meaningfully at present and is unlikely to. Others posited that, with the advent of commercially viable battery storage, rooftop PVs would potentially enable customers to economically go “off grid”. Furthermore if, the efforts of the US motor vehicle industry that are going into the development of “fuel cell” cars are successful, then fuel cells could potentially become viable as a distributed generation source as well. Whilst such “off grid scenarios” are possible, they are highly unlikely, other than for remote and isolated locations.

For practical and economic reasons it was felt that DG had limited future in urban areas even though for gas there is adequate supplies below our suburbs now but we may not use it. Renewables generally exhibit far too low an energy density (40MW of PV requires a huge physical area) and may be appropriate for regional locations (10% of energy in NSW). Wind/hydro are all delivered by the network that needs to be planned and paid for. For system stability 200+% generation capacity is required (including base load) and storage requirements for a reliable service.

The following areas of the market are expected to grow in the future: intelligent control (matching load use to embedded generation etc.) of firstly high power consumption devices such as air conditioners and water heaters followed by EV’s. Smart predictive algorithms that learn habits, seasonal consumption, etc., utilise weather forecasts, knowledge of tariffs etc. that best generate, store and utilise energy in the home/business.

4.4 Developments

In addition to the comments made in the last section that also apply here, is was noted that there have been significant developments in the real time control of consumer loads that do not affect consumer amenity or impose a commercial barrier to adoption but rather encourage mass market uptake through "reward" mechanism such as reduced tariff's annual rebates/participation payments etc.

Key Observation: **With the advent of commercially viable battery storage, rooftop PVs would potentially enable customers to economically go "off grid", although this is unlikely in the near term except in remote or isolated locations.**

4.5 Response to Change

The response to changes now and in near future are illustrated by a number of trials around the world re GIWH (Grid Interactive Water Heaters) and control of AC / Water heaters etc for Demand Response, Load Matching etc. The type of trial is dependent on the location and the dominant source of grid power. For instance in Nova Scotia there is a trial re remote control of domestic water heaters to better utilise and match the large and varying amount of electricity generated from wind farms. In Hawaii there are similar trials but with PV as the renewable energy being "matched". There is no doubt that a "smart grid" and real time control of Water Heaters, AC and other loads can contribute to a much more efficient grid, smooth out generation demand mismatches, flatten and even eliminate traditional demand spikes which defers or eliminates capital investment. Savings can be used to reward customers who participate in such Grid Interactive programs.

Key Observations:

One of the greatest benefits from grid connection is that it enables customers to very effectively share generation capacity.

Investors will not invest adequately with present uncertainty while old plant deteriorates, crisis in 5 to 10 years, catastrophe in 10 to15 years.

Investor uncertainty is compounded by a lack of long term policy on DG.

4.6 Implications

The implications for next ten to fifteen years are:

- A whole new raft of business opportunities and the emergence of the "Prosumer". Also utilities need to adapt and change their business models. DNSP's need to understand they are the road, the tollway. DNSP's need to adapt and be flexible in how they charge for use of that roadway and expand on their traditional views of who are their customers and how / who can use the roadway to better leverage that asset. As an example, enabling Peer to Peer trading and other business opportunities can work with the right regulatory / commercial environment.

- Punishing Solar PV / embedded generators through higher fixed charges makes no sense and will simply accelerate the "Utility Death Spiral" and send more people off grid once battery technology reaches the all critical tipping point.

5 SERVICES

IT and good information management can lead to much better and more economic management of the system through smart load control. With a degree of good data knowledge and forecasting this will work. IT and smart data management is undoubtedly the way ahead. This is the experience of evolution in other advanced economies, using smart sensors and intelligent software.

Some of the topics involved are:

- Better analytics – predictive models;
- Data deficiencies;
- Increased energy management;
- Information on consumers;
- Interoperability;
- Load management - Home energy management systems;
- Mitigation of costs of upgrades; and
- Smart appliances.

5.1 BIG DATA ANALYTICS

Big data analytics involves the uptake of advanced intelligent grid technologies, leading to open markets and greater choice of products and price (just like the stock exchange has developed) and the impacts the uptake of advanced energy storage technologies, especially in the field of EVs.

The present key priorities are:

- To allow utilities to make use of the large amounts of network and customer data that will be collected in the medium and long term;
- To allow existing players and new entrants to offer new services and capabilities to electricity customers; and
- The development of international performance and equipment standards.

Additional commentary on Big Data is provided in the appendices.

5.1.1 Value

The market value is added by utilities/investors and anyone who either owns or has access to the data. The investments are concentrated in: 'over the top' organisations who can get access to all or a part of the data within utilities to implement systems to gather and process the information.

5.1.2 Control

The key actors are:

- Companies who specialise in data Analytics;
- Companies with tools to manage large number of devices;
- Transmission and distribution utilities and retailers; and
- International standards authorities and all the relevant national standards committees who feed into them.

The main existing and emerging players are:

- All transmission and distribution utilities;
- Appliance vendors, car manufacturers, large consumer retail outlets;
- New entrants, such as Google, Apple and any company who can get access to grid or customer data;
- Retailers;
- The major suppliers (e.g. IBM, CISCO, etc.) plus the EV and battery suppliers; and
- The market value is held by utilities/investors and anyone who either owns or has access to the data.

Big Data Analytics is controlled by:

- Distribution utilities since they have access to both grid and customer data;
- Retailers since they have access to customer data;

- 'New' entrants, such as Google, meter providers;
- Other companies who are looking at the Home Energy market e.g.. HEMS, appliance and car manufacturers; and
- Unclear on the role of the regulator (AER) and other bodies who may have an influence on issues such as privacy.

5.1.3 Growth

Future growth in Big Data Analytics is in the use of big data analytics to:

- Improve the reliability of the grid, through improved fault finding, reduced repair times, improved asset management and other areas;
- Increase the range of services provided by distributors and retailers; and
- Allow entry into the energy market for the new players, who will also want to offer new services and capabilities to electricity customers.

5.1.4 Developments

The most noteworthy and promising developments are probably advanced storage battery technologies, followed closely by IT and the Cloud etc., enabling technologies for a very different future.

The most noteworthy and promising developments in in Big Data Analytics are:

- Large number of grid and customer devices to generate or process data or to provide some level of control;
- Millions of smart meters;
- Tens or hundreds of thousands of sensor/control devices;
- Millions of home devices, such as hems, appliances, electric vehicles; and
- Cloud and smart phone apps.

The market has evolved in recent years by:

- Recognition of the issue and first steps to plan for its inclusion in utility/retailer bau;
- Interest from new entrants;
- Recognition that there are many new business models possible, both for utilities and new entrants; and
- An understanding from both utilities and customers that the old relationships, such as a bill per quarter, will not be sustainable in the 21st century.

5.1.5 Response to Change

The response to changes appears to be rather slow. Australia does not seem to like being an 'early adopter' despite it being well placed to do so with a small well educated population.

5.1.6 Implications

The implications for next ten to fifteen years are:

- The 'Internet of Things' for the electricity networks and their customers;
- Massive amounts of grid related and consumer data; and
- Fragmentation of the market as distributor/retailer business models change and new entrants provide competition and new capabilities.

Key Observation: Ownership or access to data will be very valuable and a key market driver.

6 UTILITY COMMUNICATIONS NETWORKS

A high priority of the utilities communications network is the availability of ubiquitous communications to underpin many developments in utility network evolution in the short, medium and long term.

6.1.1 Value

The market value is held, concentrated and added by utilities and their investors. The utility communications segment is controlled by utilities for investment proposals as a part of the 'Reset' cycle and the regulator (AER) for approval of investments.

6.1.2 Control

The key actors are transmission and Distribution utilities, telcos, communications equipment vendors. Possibly retailers as well.

The main existing and emerging players are all transmission and distribution utilities, telcos (Telstra, Optus etc.), communications equipment vendors (Alcatel-Lucent, Cisco, Silverspring etc.) and metering (Landis-Gyr) and control companies.

6.1.3 Growth

Future market growth is expected to grow in:

- Communications networks extending deeper into distribution networks (lower voltages) and to homes, in the case of devices such as smart meters and home energy management systems; and
- Increased use of sensors for more targeted grid management, improved reliability and incorporation of renewable power sources.

6.1.4 Developments

The market has evolved in recent years by the move away from PDH/SDH networks to IP networks and increased support within utilities for communications network transformation; consolidation onto IP/MPLS networks.

The most noteworthy and promising developments are:

- Capabilities of networking technologies, providing utilities with the ability to both extend the reach of their telecommunications networks and to collapse multiple physical networks onto a single network infrastructure;
- IP technologies developed for the carrier market being enhanced to cater for utility-specific requirements;
- Lower prices for sensor and other technologies, such as CCTV, Wi-Fi and Access Control making it more economical for utilities to undertake large scale deployments;
- Increased use of Ethernet interfaces for sensor and other technologies; and
- Increased availability and use of fibre by utilities, allowing deployment of both low bit rate (e.g. sensor) and high bit rate (e.g. video) services.

6.1.5 Response to Change

The response to changes in near future include increased use of sensors, extension of communications networks and general utility network transformation.

6.1.6 Implications

The implications for next ten to fifteen years are a continuation of the above as utility networks eventually extend into the home; impact of the 'Power of Choice' notwithstanding. Also see Big Data Analytics: how to get value from all of the data collected.

APPENDIX A. Guiding principles

A basic guiding principle may be that Australians want clean, cheap, reliable, safe and secure services provided by an accessible (affordable) energy supply and achieved with minimised negative externalities.

A key question to answer is: do we believe in a market? The market has been distorted. For example, over last ten years there has been costs introduced into electricity that are not directly related to distribution costs. Introducing subsidies enable justification of inconsistent objectives. For example, reliability presently comes at a very high cost then we introduce low reliability solar and subsidise it. There are enough challenges coming forward for networks and their component of the electricity price should reflect the network needs alone. There is a difference between direct network costs and costs associated with various government schemes. The two cost elements should be separated: the cost of the network should be the cost of capacity plus the cost of service; and additional scheme costs should be paid for by a different mechanism outside the network charge.

The general policy and regulative priorities should be to:

- Develop long term stable bipartisan national energy system policies which stand the test of time. State control is increasingly costly, counterproductive, additive to sovereign risk and thus increasingly alien to foreign investors;
- Reduce the excessive overlay of non-value adding agencies at both state and national level;
- Consistent at all levels. The current policy framework is inconsistent and non-optimal leading to uncertainty in all segments that is reflected in uncertainties in forecasting both short and long term opportunities. The present policy approach to the market needs to deliver consistent outcomes; and
- Government policy should be directed to reducing costs and prices, electricity needs to be supplied at a cost we can afford.

Policy makers should note:

- Policy and regulation need to be anchored by the precept of a free market, they need to deliver consistent outcomes and appropriate for facilitating change;
- Policy and regulation is inadequate and would be better informed by an independent body;
- The Australian energy market is a very complicated space and few individuals have an adequate or complete understanding of all the issues;
- SCER[5] should drive AEMO; SCER needs long term experts - three year contracts are insufficient. Important trading partners including Japan work on 30-40 year cycle;
- There are likely to be very significant changes in the ways the system evolves and operates and the rules must reflect this;
- Policy and regulation will need to adapt and be anchored in clearly articulated precepts, consistent in outcomes and communicated with broadly understood concepts in a shared language;
- The present system has taken away the incentive to invest;
- Pricing of non-supply components should be cost reflective; and
- Residential service will be of significant value and policy and planning is essential for this market segment to evolve economically. Planning of the evolution of the residential sector is essential.

[5] The Standing Council on Energy and Resources (SCER) has replaced the Ministerial Council on Energy (MCE)

A.1 Renewables

The overarching view of participants was the critical role of the development of correct policy including the process to achieve this.

We are currently struggling to frame a realistic energy action plan to achieve the above. We (Australia) require a concise energy policy that is above politics. Given the extreme complexity of the development of an energy policy is there an adequate appreciation by politicians of the magnitude of the task? Numerous studies "showing" that we can easily go to 100% renewables in the medium to short term tend not to give much thought to the practicalities of running a reliable, cost effective supply and distribution system and consider that we can ditch most of the fossil power generation infrastructure we have now without cost – wealth destruction does have a cost and somebody will have to pay for it.

Perverse outcomes such as the potential for overall societal welfare will be negatively impacted as continued investment in high cost PV generation capacity, leads to underutilised "sunk cost" capacity, in networks. The policy approach to the market needs to deliver consistent outcomes. As mentioned above, introducing subsidies enable justification of inconsistent objectives e.g. reliability presently comes at a very high cost then we introduce low reliability solar and subsidise it. Recent reductions in Feed-in Tariff for roof top PVs impact in an inconsistent manner. It might also be reasonably asked if demand management is a failed policy tool. Under-priced sectors, such as PV and AC and high density Micro Grids. With pricing reform, growth in these sectors will decline, but generic growth should pick up, or at least achieve sustainable levels.

A simplified view of how the energy systems will evolve over time may be valuable to governments (Federal and State). A future vision (what is the best, changing mix of energy technologies and distribution systems – the mix is important) and a hard-nosed application of the necessary practicalities of the supply of energy services – taking into account what we have now, could distinguish such an approach from others that seem to me to ignore reality and put a dogmatic view – all renewables for example. Again it is how the mix will change in magnitude and over time that is important. And it needs to be done while managing the minimisation of wealth destruction. This is not easy.

The key to presenting a clear picture to government is with a hard headed techno-economic approach not driven by energy class wars with a future vision that addresses the fundamental goal of cheap, reliable, and safe services provided by accessible energy supply.

APPENDIX B. ELECTRICITY PRICING

B.1 General observations

The single biggest issue for industry is identifying what can be done to reduce the costs of electricity. Current prices are detrimental to industry and may drive some offshore (e.g. vehicles and aluminium). It was suggested that the current pricing system does not work and perhaps a failed policy tool.

It was also noted that the full impact of rising gas prices is yet to be quantified Australia operates in a global energy market - currently 76% of Australia's energy is exported. Planning needs to account for global factors such as the expectation that Japan's population will reduce by 2050 from 120m to 80m, though China and India will expand dramatically.

Domestic consumers now pay at least 30c/kWh for electricity, but of that the generation costs are only about 6c/kWh. The impact of rising gas prices on domestic electricity costs is therefore marginal. However, for large industry, whose electricity price is dominated by the generation costs, rising fuel costs will have a greater impact. Off grid distributed energy will need back-up to achieve the required security, either by battery or higher installed generating capacity than needed if grid connected. There are new products entering the market in the storage sector. Self-managed local grids are being invested in by banks.

B.2 The Legacy of Traditional T&D pricing

Traditionally, largely because of past metering limitations, and because it didn't seem to matter very much, the mass market for T&D network access has been priced, via "energy only" (kWh) charging, as measured by the energy throughput or energy delivered to the end use customer.

Factually, kWh is NOT a cost driver for T&D. But has been (and still is) used as the surrogate for the actual cost driver, which is System Capacity (kW or more accurately kVa). This was so because historically kW (kVa) metering systems were simply not economic for the mass market. Furthermore, in the absence of competition, for grid supplied electricity, and perceived low price elasticity of demand, the need for more cost reflective price signals for the mass market was not considered a priority.

But today we now have both competition (albeit competition that has been supported by various substantial subsidies) from rooftop solar PV (and micro grids), and the emergence of material price elasticity. In these circumstances it is critical that the T&D industry price its product accurately – otherwise it will lose overpriced loads, to the competition and get to keep the under-priced loads. Which is exactly what is happening. PVs and air conditioning loads are notable examples of this (reselling by Airports is another). Customers with ACs present very poor load factor loads to the network – i.e. the kWh supplied, per kVa of demand - is small. So when networks attempt to recover AC demand driven costs via the uniform kWh charge, the AC costs to the network are under recovered. As a consequence the overall uniform price goes up. Non-AC customers subsidise the AC customers who, because they are price sensitive, reduce their demand for kWh, thus exacerbating the situation. Customers with PV present an even more critical distortion. These customers reduce their demand for network-supplied energy but without a commensurate reduction in their demand for network capacity. Under the current NET metering arrangements for PV installations, these customers avoid paying the full kWh rate for every kWh generated and consumed internally. In so doing they, not only, avoid paying for the legitimately avoided cost of energy generation (of the order of 6 to 8 cents per kWh), but also avoid paying for their share of network capacity costs, that is built into the kWh rate (of the order of 22 to 24 cents per kWh, for domestic customers). Thus it is that these customers are also subsidised – by customers who don't have PV (and this is in addition to the subsidies involved in paying PV customers grandfathered legacy FIT tariffs). Again the overall uniform energy only price rises to compensate, and again customers curtail their kWh demand, thus again exacerbating the situation.

Today's electronic metering technologies now provide a commercially viable kW (kWh) mass market metering capability, which now makes a shift to capacity (or capacity type) metering and pricing viable. The only economic hurdle is the inevitable need to "write off" the existing investment in the existing stock of very long life old technology (electromechanical) meters. The bigger hurdle is the societal (and political) hurdle of implementing new tariff arrangements which will see "winners and losers".

B.3 Ideal Electricity Tariffs

The obvious impact of tariffs on demand is apparent but to date the T&D industry are concerned about growing penetration of AC and PVs (and Micro Grids) and do not appear to be able to bring about tariff reform.

The key tariff priorities are: cost reflective network pricing, understanding what "cost reflective network pricing would look like, setting and determining responsibility for "hardship" policies & programmes, quality of policy and regulation and developing alternative approaches to "geographic" tariff equalisation.

The conceptually (almost) ideal pricing arrangements for T&D are arrangements which measure and charge customer for their contribution to the industry's cost drivers. Of which there are, fundamentally only two – the demand they impose on the shared network and the costs of servicing customers (such as billing systems, call centres, accounts and metering). Thus at least a two-part network tariff – comprising a fixed charge per customer (differentiated by customer class) and a charge per kVa (differentiated by system level and customer class) - is appropriate. (Highly differentiated yearly TOU tariffs are an alternative.)

More appropriately a three part tariff reflecting the full system costs should be used, separating out the marginal energy cost typically around 6c/kWh (but appropriately recovered as a TOU energy charge), a demand or capacity charge (in $ per kVa) and a service charge.

Thus, there should be three part Tariffs comprising:

- A fixed charge per customer (differentiated by customer type) - This charge would cover, both retail and T&D aspects of, customer service and residual network sunk costs;
- kWh charges - which ideally would be TOU and potentially "dynamic" in some way. But depending on customer sophistication a range of alternatives is appropriate, including single rate kWh, and possibly (as a policy intervention) either inclining or declining block kWh charges; and
- A kVa charge - which ideally would reflect the LRMC of providing network capacity.

At the retail level energy generation costs need to be added, and these, for the mass market, are sensibly recovered using time of day, TOU tariffs.

There are some complications. These arise in relation to the sunk costs of legacy investments in connection assets (which by their nature are used exclusively by individual customers) and in relation to "controlled loads". Under today's capital contribution arrangements, assets which are used exclusively by an individual customer (or shared in a fundamentally equal way by a small group of customers) are ideally paid for by those customers, at the time of their construction, (by way of an up-front capital payment). This is broadly recognised as the most economically efficient way of price signalling these costs to the market. Unfortunately there is a considerable quantum of such investments which pre dated today's "capital contributions" approach and which amount to a legacy of sunk costs, which are appropriately recovered through an addition to fixed charges (as this is the least distortionary approach). Moreover not all distribution businesses have fully implemented these ideal "capital contributions" charging arrangements.

It is however the case that the current level of fixed charges, incorporated into retail tariffs, are generally much lower than would be required to fully recover such non demand related sunk costs and actual customer related costs. As a consequence these non-demand related sunk costs are currently loaded into the kWh charge, in addition to the demand related costs, thus further distorting the network-pricing signal.

Geographically differentiated tariffs (or the imposition of "Tariff Equalisation Contributions" from micro grids is also a part of the conceptual tariff ideal.

B.4 Capacity Charging and Renewables

There are many factors that influence the reconciliation of capacity charging with remote renewables developed as part of an immutable policy objective. Capacity charging may promote higher utilisation of assets from a demand perspective but renewables by their very nature are not necessarily correlated with demand.

To understand this apparent irreconcilable situation it is necessary to answer the overarching question: Do we believe in market solutions or not?

If not then we can mandate outcomes (not really politically acceptable, but this tool has a proven place - building and appliance efficiencies, for example).

Alternatively "regulated" pricing arrangements may be distorted to achieve the desired outcomes. The problem with that approach is that, short of direct and transparent subsidies, it imposes a cost burden somewhere else, thus giving rise to suboptimal resource allocation (allocative efficiency suffers).

If it is accepted that market solutions (subject to market, rather than price regulation) provide for optimal allocative efficiency, then it becomes of paramount importance that we price our product to be cost reflective, and that any policy interventions be transparent.

To address the reconciliation issues we must first identify the product, and this is the key to resolving the matter.

The retail customer of the electricity supply industry, buys at least two quite different products:

- The first is energy (kWh), for which he should pay appropriate kWh charges and, arguably, a fixed per customer charge to cover customer services, the cost of which is customer number driven; and
- The second is his access to the capacity of the T&D network. As discussed previously these are appropriately charged as a capacity charge - likely to be a combination of a kW (or kVa) rate and a fixed per customer charge. With an additional component to the fixed per customer charge to cover network customer services, the cost of which is customer number driven.

The appropriate pricing structure for T&D, (leaving the niceties of system stability etc., to one side), has nothing to with the sources of generation. To the extent that generators do impose some need for additional network investment that, represents a service to those generators, which is appropriately paid for by those generators, typically as a capital contribution.

So, if the various forms of "sustainable electricity generation", present different cost profiles, for the generation of energy, OR, if there is to be policy intervention to subsidise a particular technology (e.g. FITs for rooftop PVs), then that, is appropriately reflected in the price of energy, in the energy market and as transcribed to the retail energy rates.

It follows, as noted elsewhere, that retail tariffs (at the mass market level) are appropriately three part Tariffs.

If, as a policy intervention, customers are to be required to "subsidise" renewables, then that "subsidy" should be imposed as a "non distortionary" levy.

The simplest way to do this, is by adding the subsidy to the fixed per customer charge. If the subsidy is delivered by adding it to either the energy or demand charge, then competitive neutrality becomes an issue, unless the levy is also imposed on all competitive energy sources. And even this approach provides only a "least worse" solution.

B.5 kVa Charging

The matter of setting the kVa charge, is a complicated and somewhat vexed one. It sounds conceptually simple, but is not. Indeed we have a long way to go in working out what kVa charging, for the mass market would look like.

Charging for kVa, rather than kW, does in effect capture the reactive component of supply. Ideally real and reactive power we could be charged (interval meters also give us this capability). But kVa charging does motivate power factor correction and is roughly right.(Opinion is divided if it actually over signals the benefit of PFC.

Firstly, there is the issue of what to measure. Interval Metering gives us all the options.

We could measure the customer's actual annual peak demand.

Or we could measure his demand at the time of System peak, or perhaps more appropriately, the local network peak.

But question whether actual demand is what really drives network investment? We invest to meet "climate corrected" forecast demand. Last year's demands are therefore little more than a surrogate for this forecast, so there is a strong stochastic element here. Therefore some degree of smoothing is appropriate.

There is also the alternative of using extreme forms of time of year TOU tariffs. They would work just as well and "in the limit" are really the same thing.

Secondly, how do we measure LRMC, and to what degree of granularity?

Ideally (but totally unacceptable to customers), we would measure this at a fine level of granularity, so that we could capture the differences in cost that are driven by load density, and the differences in the NPVs of the different development (expansion/replacement) scenarios of each fine segment.

Or we simply do a whole lot of averaging and in so doing blunt the price signalling effectiveness.

The discussion about measurement of costs at a fine level of granularity may seem a bit pedantic.

But appreciate:

- That the cost differential across different geographical areas, driven by differences in load density, are orders of magnitude in quantum. And even within purely urban areas, can vary by as much as five to one. But uniform tariffs are a policy intervention of long standing. This is what makes Micro Grids attractive to their promoters, not cheaper generation costs, or avoided Transmission costs.
- LRMC is the NPV of future network development (augmentation and replacement) plans. If no augmentation or replacement is required for decades to come, the NPV will be a third or a quarter of what it would be, if the augmentation/replacement is imminent.

Obviously we can't make tariffs too complex, or too differentiated (Administratively and politically too difficult, not to mention customer comprehension).

The likely compromise will be geographic and "development timing" averaging, which will mean that some parts of the network would still be overpriced and some under-priced. But at least all the customers of each geographic segment would be charged in accordance with the thing they control - their load profile. Hopefully a greater degree of geographic differentiation would be achievable, through customer (rather than territorial) differentiation.

One further complication, since geographic areas that are in imminent need of augmentation/replacement would be under-priced (Average LRMC << actual LRMC), it would also be appropriate to have specific geographically differentiated demand management programmes, for these areas. Programmes which specifically pay customers to reduce load - such as with so called "critical peak pricing" programmes.

B.6 The T&D business

Transmission and Distribution businesses are, from an end use customer, mass market, pricing setting perspective, one and the same business. Notably, Western Power in WA and TasNetworks, in Tasmania (and PWC in the NT) are combined T&D businesses.

It is important to understand whether Distribution (with or without Transmission) is one business and the various interests aligned.

Most distribution businesses do also conduct some ancillary business - but they are just that - of no consequence in setting distribution strategy.

Most mass market metering, is still currently a part of the regulated monopoly business. However the policy direction, at least at the federal level, is to make this a contestable service that could be owned by independent metering service providers. A development that distribution businesses are not too happy about, since the interests of the independent service provider, who will be selling services relating to the same meter to Retailers, Aggregators and to Providers of Home Load Management services, will not necessarily be aligned with network interests.

A bigger issue, however is that the interests of retailers and networks do not align well. Retail is a margins business, they care little about the costs of network, as they simply "pass these through". They do care about generation costs as they buy these competitively and can get in front by "canny" buying and good risk management.

B.7 Electricity price fungibility

Electricity is losing its fundability, it is changing from a commodity into an increasingly differentiated product. We should not expect the market to deliver decreased prices for electricity related services but more creative value-added solutions being evolved. We have seen “green” electricity and we will see bundled offerings by service providers such as Google, and other market entrants. Alcatel has a platform which can manage the market readily - allowing for bundling.

APPENDIX C. THE DEMAND GROWTH HIATUS

C.1 Declining Electricity Demand

Mandated Government policies have driven massive increases in energy efficiency in buildings, lighting and electrical appliances. And sectorial decline in Australia's international competitiveness has resulted in the loss of key electrical loads such as aluminium smelters. These factors, along with the GFC and customer response to price increases has caused actual declines in electrical energy demand.

However once the market for new efficient appliances and lighting reaches saturation, and electricity price rises ameliorate, demand can be expected return to growth. Higher incomes and population growth will drive growth. The industry does expect growth to return, but after a hiatus of perhaps 7 years. And when it does return it will be at lower levels than in the past - probably less than 1% per annum.

The one factor that might cause a continuation of the energy growth decline is the prospect of continued growth of rooftop PV cells. Unfortunately, whilst electrical energy growth has stalled, growth in peak demand has not – or at least not to the same extent (it is only in the last few years that "temperature adjusted" peak demands, in some Australian states have declined). For this and various other reasons the industry has been obliged to continue to invest, during this energy growth hiatus (for asset replacement, improved system security and to service growth "hot spots", which arise as a result of demographic change). And even though (kWh) sales volumes have not grown the costs of servicing these new/additional assets have been added to the asset base for Regulatory price setting purposes. Hence unit (kWh) prices have increased. Customer sensitivity to these price rises has, in turn, driven further declining demand, further exacerbating the price increases.

The key factors contributing to the recent declines in the ratio of energy throughput to peak demand, have been the growth of air domestic conditioning load and roof top PV. Rooftop PVs in particular contribute to the erosion of energy (kWh) sales, but arguably do nothing to reduce peak demand for electricity.

C.2 The Prospect of Stranding of Transmission and Distribution Assets

In a truly competitive world, where markets determine prices, any reduction in demand for a business's product will give rise to a reduction in revenue which, if it is expected to continue, will ultimately result in asset valuation write downs. Under current Regulatory arrangements, monopoly T&D business are, in effect guaranteed a return on their investment in assets, regardless of how well the historical (sunk cost) assets are used. There are controls on new investments.

Whilst the industry does have some concerns that these Regulatory arrangements could change, and that a return on stranded (or underutilised) assets might no longer be allowed (i.e. that the Regulatory asset base would be optimised), there is little likelihood of such change, unless and until peak electricity demand also declines. This is because, while ever peak demand holds up, these assets are required to service that peak demand.

If PV with battery storage eventuates, a likely positive outcome will be an overall improvement in load profiles (the ratio of energy throughput to peak demand will improve), but in the absence of other serious growth drivers another likely outcome will be a serious reduction in peak demand and the emergence of seriously underutilised T&D asset capacities. If this happens then the economic argument for "asset optimisation" and "write down of the Regulatory Asset Base, would become quite compelling. A counter argument regarding Regulatory and even Sovereign Risk, and indeed whether such action would amount to a breach of the Regulatory Contract, leading to claims for compensation, would no doubt be mounted – there is much history behind the current arrangements.

Fundamentally the economic argument is that it is better to discount the cost recovery of sunk cost assets, to levels which ensure they are used, rather than price their usage at full cost recovery if at that price customers choose not to use (or to underutilise) them. The argument is sound – better to use what you've got, rather than build something new – even if the cost of the new is less than the (now sunk) cost of the existing.

APPENDIX D. EV

D.1 Opportunity or Threat

Whilst some representatives of the distribution industry, promote the idea that electric vehicles and the system capacity required to supply them, will require huge investment in distribution infrastructure and therefore pose a threat to the viability of the industry, those prognostications are premised on the assumption that this new load will be an uncontrolled (and uncontrollable) load, which would be imposed on the system, at the unconstrained whim of the customer.

Such a scenario is consistent with, a total absence of either mandated controls or the implementation of pricing systems that would motivate customers to use their charging requirements so as to improve electrical infrastructure utilisation and reduce unit kWh costs.

If electric vehicles were allowed to connect to the network in a totally uncontrolled way, and with no changes to current tariff structures, there is evidence from the Ausgrid Smart Grid/Smart City trials, that whilst substantial network augmentation would be required, the supply of such load would nevertheless be economically viable. And in my view likely to lead to a long term lowering of network kWh charges. That said, the controlled load/cost reflective tariff approach would lead to far better outcomes.

The distribution industry already has many decades of experience in managing “controlled loads”. “Off peak” hot water tariffs have been around since the 1930s. Typical electric vehicles can be expected to present a similar daily energy requirement (perhaps twice as much), as do typical domestic hot water systems. A key difference is of course that electric vehicles can and do “move around”, such that the charging requirement, is not as static or predictable as for hot water. Whilst this is a key difference, it will be mitigated by: the natural “diversity” that exists between customers (customers’ requirements vary randomly between customers, such that the aggregation of requirements is both considerably less than the sum of their individual requirements and is far more predictable) and, the industry’s capacity to influence customers’ behaviour through the pricing mechanism.

There is, generally enough “unutilized capacity” in the late evening and pre-dawn period, (the load trough) to meet the likely EV energy requirement, for the foreseeable period, up to perhaps 50% market saturation. If the day were ever to come when this trough in the load profile were filled then, overall load factors would be such that expansion of network capacity would be economically attractive.

That said, there would be a need for investment, in some parts of the lower levels of some networks and in customer’s installations.

For many networks, where the practice has been to provide a minimum of 100amps capacity, at the house service level, even the addition of a 12kW charging load, provided it was operated in the “off peak” controlled load mode, would present very few service loading challenges. But for those networks, which have traditionally provided only 50 or 70 amp services, some investment at the service, level is likely to be required.

At the low voltage street mains level, provided the aggregate diversified (managed diversity through load control programmes) demand did not exceed the “trough capacity”, there should be minimal need for network reinforcement. The same is true of the capacity at higher system levels (for which the statistical certainty of the aggregate demand is high.) The unknown, at these system levels is the value of the “engineered diversity of the control systems – for storage hot water, an outcome as low as 30% can be achieved. My guess is that for motor vehicles, the result may be even lower (as many vehicles will require no more than a short top up.)

It is worth noting that traditional TOU tariffs, which offer the customer low “off peak” prices, after some nominal late evening time, typically 10.00 pm, do not provide the same desirable outcome. Left to their own devices, customers, incentivised by uncontrolled TOU tariffs, will logically charge their vehicles commencing at 10.00pm sharp. The synchronised connection of so much load will exceed the capacity of both the local low voltage network and of the upstream network. In this regard TOU tariffs will promote poorer outcomes than the simply single rate anytime energy only tariff, since, without the TOU incentive the customer commencing charging at his convenience, and natural diversity exists – this has been demonstrated by the Smart Grid/ Smart City trials, conducted by Ausgrid.

Because electric vehicles are mobile, the availability of an overnight cheap “controlled load” charge will not suit all customers, and even those who find it suitable for most of the time will occasionally have a requirement to charge their vehicles, other than at off peak times. The extent to which such needs will aggregate to a level, which will trigger the need for substantial network investment, will depend upon the market segment concerned. Where the requirement is very occasional, and provided there are no societal factors, which would motivate synchronous behaviour, we can rely upon natural diversity to ensure that the aggregate demand is at a sustainable level. However since occasional requirements, despite the benefit of diversity, are likely to drive a requirement for additional investment, it is important that such use be appropriately priced. Where the non-off peak requirement is routine, such as for the commercial fleet sector, there is a strong likelihood of the charging demands of vehicle to be synchronised. Whilst there may be some benefit from controlling such loads the benefit is likely to be marginal and moreover is unlikely to be acceptable to the customer. Inevitably, such customers will either adapt their requirement so as to render overnight charging feasible, or pay for daytime charging at rates which are unlikely to be competitive with current day petrol costs.

D.2 Vehicle To Grid (VTG)

VTG – A nice idea, but not a game changer. On two counts. Firstly, it will in my view add very little value, in terms of its contribution to improving network or even generation utilisation, at least not until high saturations of EVs are achieved. Secondly, the complexity of the relevant customer contract and the management of customer expectations will likely lead to implementation costs outweighing realizable benefits. To benefit the grid, VTG capacity would need to be available at times of system stress (a total of about 500 hours per annum – 5 to 6% of time – but, on @ 40 days only of each year) – and then arguably only in those parts of the grid which are stressed. Most of the load profile smoothing that the grid needs will be deliverable by management of the positive load involved in charging electric vehicles – the additional benefit of using them as negative load (VTG) is complex to implement, will face considerable customer resistance (and vehicle manufacturer resistance) and would be called upon at times when the majority of vehicles are either in use as vehicles, or at locations where their contribution is not required.

APPENDIX E. SUPPLY

The following observations were made:

- The price of standby capacity is far too low and energy too high;
- Why are prices up by 42%?
- How can businesses operate with high prices and with no certainty?
- Industries will go overseas as already occurring (automobiles, aluminium, others) exacerbating the trend - the death spiral much beloved by the RE lobby;
- There is a crucial difference between energy (MWh) and capacity (MW) - it is important for tariffs to reflect capacity as well as energy delivered;
- About 4c/kWh of today's typical energy tariff is actually energy charge. The rest is for capacity and service costs. This must be reflected in the tariff structure;
- NSW had its peak demand in January 2014 - hit 2MW higher than ever before, despite the loss of steel works and aluminium. Plenty of generation available so demand was easily met, but appears that underlying demand is rising with population and affluence; and
- Demographic changes - 28% is residential - which is where the voters come from.

E.1 System Demand Plus Reserve Capability

Consideration of System demand plus reserve capability is dependent on adequate consideration of non-dispatchable generation and dispatchable generation plus storage. The key actors are demand, Investors, government, Regulator, AEMO. The value is held by investors but it is controlled by the regulator, AEMO, market forces may be adequate. Over the next ten to fifteen years investors will not invest adequately with present uncertainty while old plant deteriorates, crisis in 5 to 10 years, catastrophe in 10 to15 years.

E.2 System Stability

System stability involves demand, generation and system configuration. The key actors are from demand, investors, government, regulator, AEMO. At present the value surrounding system stability is held with investors. System stability is controlled by the regulator, AEMO, market forces cannot control ratio non-dispatchable to dispatchable generation. Implications for next ten to fifteen years Government incentives for non-dispatchable or dispatchable to keep ratio within safe stability limits particularly as non-dispatchable increases in conjunction a deterioration in plant due to a lack of investment.

E.3 Low-Voltage Exchange Network

The low-voltage (LV) exchange network refers to the new use of the distribution network, localised renewable energy generation and battery storage.

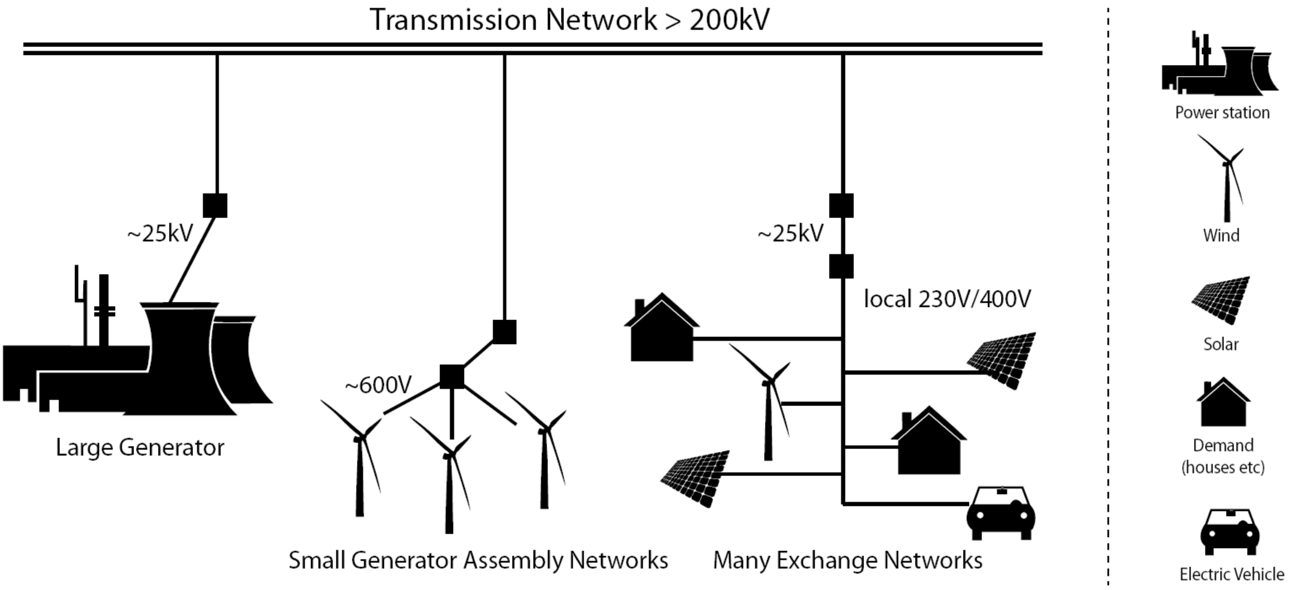
The fundamental concepts underpinning the concepts of a low-voltage exchange network are given in the report Maximizing The Performance Of Additional Renewable Generation in an Electric Power System, J Sligar, Sligar and Associates.

The priorities are engineering & economic modelling the LV distribution network based on various scenarios of household PV power generation, EV & plug-in HEV, and stationary battery uptake. The key actors are LV grid owners/operators (e.g. Ausgrid), PV array suppliers, smart meter manufacturers, EV OEMs, charging station installers/operators, stationary battery suppliers. The main existing and emerging players are Ausgrid (for central Sydney area), Toyota (existing player in auto industry), Tesla (future player in auto industry), may be Google and others (future player in smart-grid IT space).

The market value is currently held in the existing LV grid infrastructure. The market value is added in domestic PV-based power generation and the associated reduced need to purchase electricity from the grid, avoidance of the need to purchase fuel to run cars in the CBD, arbitraging the electricity spot price via domestic electrical energy storage. In the future, public investment should be concentrated in the development of the LV electrical grid (415 V & 11kV layers) to enable seamless distribution, storage and controlled distribution of domestically generated electricity. Private individuals will pay for the investments in PV arrays, EVs, and stationary batteries if the market drivers are there. At present the LV network is controlled by the LV grid owners/operators (e.g. Ausgrid).

In recent years there has been widespread adoption of domestic PV arrays in Australia, in most cases as a result of substantial government incentives. Future LV network market growth is expected in domestic PV-based power generation, battery storage, EV & plug-in HEV charging (and eventually discharging i.e. V2G). The most noteworthy and promising developments over the last 10 years include Low cost, mass produced PV cell arrays and associated inverters. Over the next 10 - 15 years we can expect to see low cost, mass produced, Li-Ion domestic battery storage and low cost, mass produced EVs and plug-in HEVs. There has been very little response from the LV grid owners/operators to date, other than some regionally-based smart-grid trials - principally aimed at gathering data. But the technology is moving very fast in this area, and prices of the key technologies is falling as volumes increase The implications for next ten to fifteen years are that if EVs and plug-in HEVs are adopted widely by the market in Australian CBD areas, there could be difficulties involved in charging these vehicles, even in off-peak times.

A diagram that depicts the assembly and exchange network from ICAA report: *ICAA P1.2 Networks With Renewables Overview R2.pdf* which is available on the ICAA website.



Courtesy ICAA

E.4 Distributed Resources

One of the greatest benefits from grid connection is that it enables customers to very effectively share generation capacity. As standalone generators, customers would have to invest in generation (and storage) capacity that was sufficient to meet their “all time” maximum demand (that is what they expect and get from the grid). But because customers’ individual maximum demands never coincide (unless deliberately contrived to do so), the aggregate demand of any collection of customers is always less (considerably less) than the sum of their individual peak demands. The ratio of the aggregate to the arithmetic sum of customers’ demands (defined as the diversity factor) varies dependent on the class of customer concerned and on the number of customers being aggregated.

For domestic and small business customers the ratio can be as little as 0.3 if aggregated to system level, but @ 0.5 or 0.4, if aggregated locally (dozens to hundreds of customers).

Thus it is that even under a technologically and commercially viable “distributed generation” scenario, grid connection has the potential to considerably improve the overall economics of generation. Additionally, because it also allows customers to share generation redundancy, it also has the advantage of being able to provide a level of reliability, which, if it were to be matched, by standalone systems would require, untenable quantities of generation redundancy. A factor of one tenth would not be an exaggeration.

E.5 Ramp rate technologies - renewables

Ramp rate technologies refers to a problem with high penetration renewables is that they are variable, the output changes over the order of seconds to hours. It is mainly the short term variability that is the problem. For example, a large PV array can be operating at full output under clear skies one moment and then a cloud bank comes over the array and output falls to zero in a second or so. This negative ramp in the output can ruin the stability of the associated grid – particularly in remote area grids. To avoid this, the system must include some sort of facility to ramp up the grid output as quickly as it falls away. The obvious technology to do this is a big enough battery bank that can supply power at the required (instantaneous in the case of batteries) rate to keep the system on an even keel and give time for other generation to take over, such as gas and/or diesel start-up. Batteries are a reliable, if expensive solution. But there are other technologies coming along that can also manage ramp rates. These in include diesel/flywheel hybrids, dynamic resistors, even weather/cloud tracking systems that forecast when additional generation needs to come on line, and at what rate. It is all about managing effective “spinning generation”, the term being used in its broadest sense.

E.6 Density, Diversity and Load Factor (Network Economics)

Two key concepts relevant to an understanding of network economics and, asset utilisation in particular, are load factor and diversity. Another key factor, which drives network economics, is load density.

Load factor is a measure of how efficiently customers (usually collectively) utilise their load profile. It is the ratio of the average demand of the profile (kW) to the peak demand (kW) of the profile. Otherwise expressed as the normalised ratio of energy throughput to maximum demand. The usual measure is the annual load factor, since profiles follow annual cycles. However for some classes of assets, the whole of asset life (or all of time) load factor is more relevant.

Diversity is a measure of the complementarities of customers’ loads. Diversity arises because customers’ requirements vary randomly between customers, such that the aggregation of requirements is both considerably less than the sum of their individual requirements and is far more predictable. The measure of diversity is the ratio of the collective aggregate peak demand of a conglomeration of customers, divided by the arithmetic sum of their individual demands. The more customers in the conglomerate, the better (lower) the diversity and the less variable the peak demand.

Load factor and diversity bear an inverse relationship to each other, and are very different depending upon the level of the system that we are talking about and the customer class. It’s all about the extent to which the assets at the various different system levels are capable, of being shared by customers and therefore, of being aggregated.

At the very top of the traditional System hierarchy: generation, (when connected to an electrically unconstrained network), is shared by all customers (connected to the system). Collectively the generators aggregate the loads of all customers. The benefits of diversity (intraclass and interclass) are fully realised, and the collective load factor is high (of the order of 50%). Intraclass domestic diversity at this level is typically as good as 0.3.

At lower levels of the system, fewer and fewer customers are connected together, the benefits of diversity get smaller and smaller and load factors decline.

At the individual customer connection level there is no diversity benefit (diversity factor is unity). Load factor is highly customer specific. Industrial load factors can be quite high (in excess of 80%) but mass-market load factors are low. Annual average domestic load factors lie typically in the range 0.05 to 0.15, depending on climate and demographics.

So far as overall asset utilisation is concerned there are two additional factors, which have a bearing:

- The first is the timeframe over which asset capacities can be economically and practicably varied.
- The second is the discrete nature of economic (and often standardised) plant capacities.

These factors determine just how well asset capacities can be matched to the demand.

At the generation level, despite the seemingly large scale of economic capacity increments (traditional technologies), increments are in fact small relative to the size of the NEM and, despite the long lead times involved and the associated forecasting, planning and market issues, it is feasible to add increments annually and therefore to closely match generation capacity to next years forecast demand.

Overall capacity (ex reserve margins) can be very closely matched to demand. I.e. technical utilisation is high and overall utilisation (kWh per kW of capacity) is therefore closely matched to load factor (kWh per kW of demand) at @ 50%.

At the T&D level, the position gets progressively more and more stochastic the lower the system level. Economic increments are generally large, when compared to the demand that they will serve, and forecasts are less reliable. For these reasons optimum economic increments inevitably serve the future load requirements for many years (often decades) in to the future.

At the individual (mass market) customer connection level, it makes no sense to increment asset capacities progressively and in any case it is impossible to forecast annual variability of demand. Connection asset capacities are therefore set to match the "all time" likely maximum demand of the connection – assessed with a high degree of pragmatism. Typically domestic connection assets are rated at 25 kVa. Typically the average domestic annual maximum demand is @ 10kVa, while the fully diversified annual maximum demand, is @ 3kVAa. BUT the average annual load is less than 1kVa.

Because demand at this level of the system is so erratic, and progressive augmentation so impractical, capacity at this level of the system is poorly matched to demand. Technical utilisation is poor (average @40%); load factor is poor at @ 10% and overall utilisation is far lower at @ 4%.

As we move to higher system levels, the position quickly improves. At the domestic distribution centre level, which aggregates typically 100 domestic customers, technical utilisation might be as high as 80% (ex security of supply margin); load factor typically 27% and overall utilisation 22%.

From the perspective of overall network investment, domestic connection assets are relatively low cost assets, hence the poor utilisation of these assets is of secondary concern (Moreover there is a sense in which, at the domestic level, a "connection is a connection is a connection" and costs vary little regardless of capacity – a 100 amp service is only marginally more expensive than a 50 amp service.

E.7 A Note about Distributed Generation and Micro-Grids

The above analysis does have some important implications for various distributed generation scenarios.

At the extreme, where a customer plans to go off grid, then the issue is not simply the capacity of the (no longer required) service. The isolated generation (and control systems) installed must be capable of either meeting the “all time” anticipated peak demand of 25kVa, or of implementing load management systems that limit that peak requirement. Whilst time will tell, it is unlikely that, load management systems will reduce the “all time” peak demand to less than say 12kVa, without occasionally limiting “customer amenity”. An important conclusion from this is that load management systems are more important for “stand alone”, isolated generation systems, than they are to grid-connected systems. Grid connected systems enjoy the benefits of natural diversity, while “stand alone” systems do not.

On the other hand, distributed generation, when connected at higher system levels, attracts substantial diversity benefits, depending on its scale and potential to appropriate interclass diversity as well as intraclass diversity. But in order to get these benefits the generator requires a local distribution grid – and generally speaking, the bigger the grid, the greater the benefit, but with diminishing returns to scale. As a gross simplification, the only part of the T&D system that is avoided by the larger scale distributed generation is the Transmission System. And from the perspective of the domestic and small business customer, Transmission costs are a small part of the total picture. Distribution costs dominate. The contribution that avoided network costs can make to the economics of distributed generation is therefore quite small, and unless the generator can exploit co-gen or tri-gen opportunities, the overall economics of distributed generation would, but for one other factor, be dubious.

That other factor is load density. Put simply the closer loads (customer) are together the lower the quantum of infrastructure required to service them, and therefore the lower the unit cost. The cost per MVa of network capacity, quite literally varies by several “orders of magnitude” depending on the density of the load supplied. Even within urban areas the cost variation can be as much as five to one. And herein lies a serious source of network cross subsidies. The widespread policy driven adoption of “geographically uniform tariffs” has had the result that inner urban customers are subsidising outer urban and rural customers.

Thus it is that “micro grids” make economic sense to their promoters. Not necessarily because of the underlying economics of the micro grid, but because, the investment in a highly dense privately owned micro grid (including airports and shopping centres), with or without generation, enables the promoter to avoid paying any subsidy in support of high cost outer urban and rural networks.

E.8 Spatial Distribution of Assets and Electricity Demand

It may sound obvious, trite even, but T&D assets (Distribution assets particularly) are spatially distributed assets. They serve spatially distributed loads and generators. This has several often-overlooked implications.

Firstly, load growth is not uniform over all of the space served. Consequently, even when the aggregate growth is low (or negative), there will be parts of the network (hotspots) where growth is strong. Investment is required to serve these hotspots, even though overall network utilisation may be declining.

Secondly, the volatility of the “distributed demand” is much greater than that of the aggregate demand (a fundamental principle of statistics). This means that spatial forecasts are less reliable than aggregate forecasts.

Thirdly, economic increments in capacity are relatively larger at the lower levels of the network. Consequently most augmentations provide additional capacity, which is significantly greater than the immediate (trigger) demand. Consequently, also, there is “spare” capacity throughout most of the network, most of the time – conversely only a small fraction of the network is at any point in time, constrained. Demand management, which is targeted at these constraints, produces immediate investment deferral. Generic demand management produces investment deferral, in the future.

Finally, the distribution network is where it is because customers are where they are. A large part of distribution asset investment is driven by customer location, rather than customer demand. Virtually none of it is driven by customer kWh consumption.

APPENDIX F. PV CELLS

There are at least two very different markets for "PV technologies" - The urban rooftop PV market, and the remote systems market, such as in outback NT, WA and northern Qld.

F.1 Urban Roof Top PV

The current "success" of urban rooftop PVs is entirely due to the subsidies that these systems have had and continue to enjoy.

Whilst direct subsidies, and FITs are now substantially reduced by comparison to the recent past, there are still substantial subsidies occurring as a result of the inappropriate "energy only" tariffs of the electricity distributors and the almost universal application of NET, rather than GROSS FIT metering.

For domestic customers, who typically pay around 30 cents per kWh for their mains supplied energy, only @ 6 or 8 cents represents the cost of electrical energy generation. The remainder (the bulk, 24 or 22 cents) represents the costs of supply system capacity. Irrespective of the FIT (for surplus energy exported to the grid), under the NET charging arrangement, when a PV customer, by consuming PV generated energy internally, avoids paying for 30 cents per kWh, energy (not) supplied from the grid, only 6 or 8cents represents avoided generation charges and 22 or 24cents represents DB charges.

Currently, roof top PV cells contribute nothing (or at best very little) to network capacity at time of system peak. Most of the 22 or 24 cent avoided network capacity charge is, in effect a subsidy, paid by non-PV customers to PV customer. If that subsidy were to be removed (by for example the implementation of capacity based charging for network use, or by implementing GROSS metering and charging arrangements), the benefits stream to roof top PV owners would be reduced by about two thirds.

It is also notable that urban rooftop PVs are displacing conventional solar hot water systems. Hot water is being supplied by gas-fired units, instead. The result being that the greenhouse benefit of reduced electrical energy production, is being offset by the increased gas usage required to heat the hot water.

It is also notable that very few urban roof top PV systems are optimally oriented, and maintenance of these systems is currently provided by a "cottage industry", at the whim of the owners.

Large-scale "grid connected" PV systems, on the other hand could be: located, west of the Great Dividing Range (where the sun shines, most of the time): optimally oriented, with dynamic tracking and: optimally maintained. Until such time as distributed roof top PV is supported by "economic" battery storage, (and can then make a contribution to system capacity), the economics of distributed, as compared to centralised PV is dubious.

F.2 Remote Location and Edge of Grid PV

The remote locations and edge of grid market – where PV, though complex to integrate does have a place and which is approaching commercial viability – although still currently dependent on subsidies.

APPENDIX G. BIG DATA

It has been convincingly argued that the ICT industry has the capability, along with modern metering technology, to give customers the tools to proactively manage their electricity demand in real time (using I phones, etc.).

BUT BEWARE the pitfalls of investing heavily into systems, which enable customers to optimise their usage against ARTIFICIAL criteria. It no doubt can be done and there will be a segment of customers who will enthusiastically embrace such activity, but what is the point in "flattening" the daily demand profile, in mid-autumn or spring, when the current peak demand during these periods is only a small fraction of the summer demand.

Distribution businesses costs are driven by "the forecast peak demand", that is expected to occur a few years into the future. Actual measured demand today, is only useful as a predictor for the capacity that the individual customer will require in the future.

Actual demands are not as critical, as the forecast, and sensibly, forecast demands are normalised to standard weather conditions. In this context, a customer's actual peak demand is not as important as his collective requirement for capacity over the 40 or so days of each year when, history tells us, the system peak demand is likely to occur.

Next (periods) network capacity investment is essentially a provision, made to cover an expected (or probable) future demand. Given the randomness involved it is arguable that the precise value of a customer's current year maximum demand (or contribution to aggregate system demand) provides a better forecast than would his average demand over the 240 hours over 40 days, time periods when the peak can confidently be expected to occur. It is also arguable that the purely random variances (as distinct from the underlying value – measured by the 240 hour average) that occur over that period are best dealt with as a risk to be borne by the total customer class, since these variances net to zero, are not intrinsic and, are unknowable in advance. Importantly also it would, from the customers perspective, remove unnecessary criticality from the timing of the demand measurement and provide certainty as to what the time period of the measurement would be. It also provides a basis for using a time of year (TOU) pricing regime, in lieu of demand charging – a network price of @$4/kWh for the 240 "peak Hours" of the year and no kWh charge at other times.