A-Lab innovation frame 3: 'Creating the Internet of Energy' – Research Context

Innovation Frame 3: Creating the internet of energy

What is this innovation frame?
The future requires the internet of energy: an open but secure interconnected electricity value network which connects distributed energy resources and market participants and delivers value for all customers.

This would be expected to require grid and customer-sited devices to have some form of interface to ensure efficient data transfer and device interoperability, as well as the support of tools that enable informed real-time data-based decision making.

To enable this future, additional infrastructure, including network monitoring devices as well as IT hardware and software to receive, store, organise and analyse the data would be required. This would have to be a secure system, with adequate cyber security measures in place.

This concept of an internet of energy may deliver a number of future benefits that contribute to a more efficient and customer focused electricity delivery system, and includes features such as:

- *Greater access to, and use of, customer and network data;*
- *Increased control and flexibility for customers over their energy use;*
- *Alternative approaches for grid planning, maintenance and operations; and*
- *Improved interoperability of network and customer-sited devices.*

The new opportunities and alternative approaches for grid operations could also include the potential for certain support services being provided through the distributed energy market. The roles and responsibilities for grid operations, planning and management would hence need to be clearly defined, and gaps in the skills and capabilities for those roles filled.

What is the opportunity for innovation?
Some key barriers and areas for innovation required in order to realise the future described in this innovation frame include:

- *The cost to consumers of investment in additional infrastructure and devices (either directly or indirectly through grid and/or retail charges).*
- *The need to reach agreement on an approach to ensure efficient data transfer and device interoperability so that consumers can access the full value of their assets, while ensuring the security of the system and customer data is paramount.*
- *Agreement and clarity on any new roles and responsibilities with regards to grid operations and planning also needs to emerge. Cultural barriers, business drivers and the current incentives models of incumbents may be an additional barrier in this context.*

This innovation frame requires clarity on the value of the internet of energy, and momentum in areas of industry collaboration which can accelerate the progression towards an efficient, interconnected physical trading platform.

This research document is intended to provide background information and supporting evidence for the relevant opportunities, barriers and issues related to the topic of innovation frame 3. This includes a review of international and Australian experiences of solutions to overcome these barriers.

This document covers three main areas:

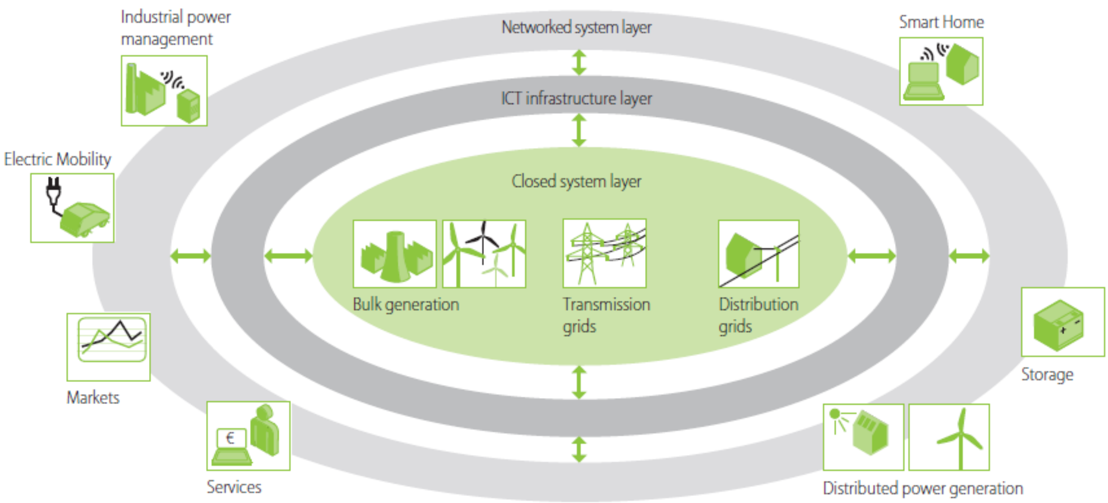
- Background: What are the key changes and opportunities that are driving a need for action in relation to this innovation frame?
- Areas for innovation: What are the key innovation requirements and what will have to be implemented for the future state described in the innovation frame to be realised?
- Australian and international experience: What are some examples of how these issues are being addressed in other markets, and what could this mean for the Australian market?

1 Background

The future requires the internet of energy: an open but secure interconnected electricity value network which connects distributed energy resources (DER)[1] and market participants to form functional communicative entities tied together by enabling information and communication technologies (ICT). In short and at its most simplified, this involves the overlay of the flow of data onto the physical flow of electrons.

The need for the 'internet of energy' has been relatively widely investigated, and a recent report[2] by the EIT ICT Labs features their vision of the future energy system, shown in Figure 1.

Figure 1 – EIT ICT – Internet of Energy Concept



The emergence of the Internet of Energy reflects the coming together of two significant market trends:

1. Advances in technology and devices connected to the electricity system (specifically including intelligent networks, advanced meters, solar PV, behind the meter devices and other DER),

[1] This includes demand response, energy efficiency, distributed generation, distributed energy storage and electric vehicles
[2] EIT ICT Labs, *Future Energy Grid - Migration to the Internet of Energy*, 2013

and

2. The consequent need for optimisation and efficiency in managing the different characteristics of renewables in the generation mix while reducing the cost of energy services to end consumers.

These have meant that the monolithic, top-down grid of electrons flowing from large-scale generation to consumers is rapidly being supplemented by a complex web of interconnected, unpredictable data-connected systems created from the bottom up. Using the Internet of Energy, economically motivated, decentralised entities can operate price-competitive generation, demand response and energy storage.

New digital equipment will need to be strategically deployed to complement existing technologies. In addition to ICT already widely deployed across the transmission and distribution networks, an additional layer of internet connectivity for smart in-home devices, electric vehicles, other distributed energy resources and additional market solutions will be required. Distributed or 'cloud' intelligence across the layers will enable monitoring, interoperability and data analytics to extract meaningful and actionable insights. This automated, multi-directional and real-time flow of information forms the core of the Internet of Energy.

This concept may deliver benefits which contribute to a more efficient and customer focused electricity delivery system and, specifically in relation to ARENA's core objectives, an Internet of Energy could:

- Increase the ability of the grid to reliably and securely integrate higher levels of distributed renewable energy, and
- Reduce the cost of renewable energy for consumers

The features of an Internet of Energy that supports these objectives includes:

- **Greater use of customer data** for improved predictive ability, energy conservation initiatives, tailored competitive products and services, demand reduction activities and participation in emerging markets
- **More granular network data to reduce capital expenditure**, particularly by encouraging a more precise match between supply and demand, appropriate generation investment, efficient distribution paths and optimised asset operation
- **Increased control and flexibility for customers over their energy use**, including allowing for a higher penetration of decentralised renewable generation and storage, and reduced consumer energy bills
- **Alternative approaches for grid planning, maintenance and operation** based on enhanced simulation models which are informed by better underlying data
- **Improved interoperability** of network and customer-sited devices to enable the efficient and effective provision of services and transfer of value between customers and the wider grid

1.1 Greater use of customer data

Quality, real-time and granular customer usage data will help energy service companies develop innovative, customer focused service offerings and realise the potential of the Internet of Energy.[3]

Currently, communication technologies are generally deployed, owned and operated at the sole discretion of specific market participants with limited consideration for sharing data collected and for device interoperability. This is in part due to commercial considerations, but partly also to restrict

[3] http://blog.rmi.org/blog_2014_09_08_bringing_a_distribution_system_operator_to_life

access to personal data.

The silos created include the respective outputs of monitoring technologies deployed by network service providers (NSP), technology providers with bespoke control solutions (e.g. storage), a wide variety of apps and behind-the-meter products and growing levels of advanced meters.

If this data were made available for secure, bespoke analysis, demand and supply could be forecast more accurately at localised, regional and state levels. Energy conservation programmes, retail products, behind-the-meter services and economic incentives could be targeted specifically. Demand reduction or 'load shedding' arrangements could be agreed and retroactively verified more readily and inefficiencies in the design, maintenance and financing of physical grid infrastructure could be identified and addressed.

Access to customer data in Australia is currently highly dependent upon a customer's metering arrangements. While an advanced meter rollout in Victoria is complete, new metering rules scheduled to come into effect in December 2017 will open up metering services to competition and stimulate the growth of digital meter based products and services in other NEM States[4]. While parties that require metering data to meet their statutory requirements will continue to receive it, a market for customer data will only be enabled if the relevant customer consents to the provision of that data, as a discretionary service under a separate commercial arrangement[5]. To date this customer consent process has been cumbersome and problematic.

1.2 More granular network data to reduce capital expenditure

In Australia, network data, including load, voltage and potential constraints, is currently only shared with third-parties at the discretion of the NSPs. There have been some attempts to improve the transparency and access to this data, including the ARENA and Institute for Sustainable Futures project to make network constraints data available to identify opportunities for distributed energy resources and demand management.[6] This data will be updated annually, but for the provision of non-network alternatives to system constraints, more granular and timely data would be required.

This data would enable the creation of more effective solutions to network constraints and wholesale electricity supply issues - through demand response programmes and virtual power plant aggregators – which will help reduce capital expenditure across networks and the large-scale generation fleet.

To enable this future, additional infrastructure, including network monitoring devices as well as ICT hardware and software to receive, store, organise and analyse the data may be required.

1.3 Increased control and flexibility for customers over their energy use

Improvements to interoperability and device plug-and-play capabilities, provide customers with greater awareness, control and alternative options for their energy use: whether this be domestic production and consumption, access to emerging distributed energy markets via the grid or control of appliances. This includes a swathe of commercial opportunities for different types of DER, as well as in-home devices such as smart thermostats and other appliances which, if integrated with the wider

[4] The end of the NSW Solar Bonus Scheme has already stimulated the deployment of advanced meters for solar customers in that state.

[5] AEMC, Rule Determination, National Electricity Amendment (Expanding competition in metering and related services) Rule 2015, November 2015

[6] http://arena.gov.au/project/mapping-network-opportunities-for-renewable-energy/

network, can operate to generate benefits for all stakeholders.[7]

Customers will become active participants in energy interactions. Prosumers will smooth their domestic demand and minimise grid purchases wherever possible. Informed households reacting to the real-time price signals the Internet of Energy provides might be further incentivised to adopt connected technologies, utilising home energy management systems (HEMS) enabled by sensors and controls connected through a wireless home area network (HAN) to manage their energy use and appliances set to their preferences for comfort, convenience or cost. Their devices will 'sense' and avoid high system prices, or opportunities to benefit from value signals from the network or other energy markets.

Customers would have more incentive to sell to their neighbours. Given Australia's high penetration of residential PV systems, the Internet of Energy could lead to massive competition in the supply of electrons, giving customers the ability to extract value from their DER via direct peer-to-peer trading, community energy business models and virtual power plant aggregators. (Please see innovation frame 1 for more a more specific focus on these developments.)

1.4 Alternative approaches for grid planning, maintenance and operation

Having high-quality, timely and granular data available will aid network planning by taking account of distributed renewable energy generation, new loads such as EVs and the operation of other DER. Improving forecasting tools to will also enable remote fault diagnosis and enable predictive, pre-emptive maintenance. Improved forecasting accuracy will further contribute to more efficient integration of renewable energy to the grid.[8]

The analysis of quality aggregated data from across the network can lead to real-time visibility and analysis of operations, predictive analytics to improve generation planning and load forecasting and address intermittency issues. As the grid becomes more complex, system operators could use automated analytical models dispersed throughout the Internet of Energy to help make real-time decisions affecting operational efficiency. Opportunities will emerge in cost and process optimisation, broad-based customer insight, dynamic pricing models and data-led decision making.

Real-time data can provide new opportunities and alternative approaches for grid operations, including the potential for certain support services being provided through DER markets. This includes the provision of ancillary services such as voltage and frequency control using DER and demand response aggregators and further improving grid operations by enabling coordination of the multi-directional power flows resulting and enhancing load and network monitoring.[9] Lower grid maintenance costs could be enabled by automated fault diagnosis, minimising site visits and enabling predictive maintenance.

In addition to optimising customers' energy sales and purchases (Section 1.3), the Internet of Energy can facilitate requests from the DNSP to manage the customer's load and use DER to provide alternative ancillary or stabilising services to the network.[10]

Recent trials from the Institute for Sustainable Futures further support that connected DER can help grid operators improve security and reduce costs.[11] Electro-mechanical voltage regulators tend to be

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[7] Electric Power Components and Systems, *Smart Home Activities: A Literature Review*, February 2014

[8] National Renewable Energy Laboratory, *Integrating Variable Renewable Energy: Challenges and Solutions*, September 2013

[9] New York Department of Public Service, *Staff White Paper on Clean Energy Standard*, January 2016

[10] National Renewable Energy Laboratory, *Electric Energy Management in the Smart Home: Perspectives on Enabling Technologies and Consumer Behaviour*, August 2013

[11] Alexander D., Wyndham J., James G., McIntosh L., *Networks Renewed: Technical Analysis*, Institute for

both expensive and located within transformers at substations, meaning traditional voltage management affects many properties at a time. However, internet-connected distributed inverters would allow the home network to communicate with the local system operators and request support services or reactive power – but this requires network businesses to be open to a collaborative relationship with customers, and for tariff structures to reflect this shift (Section 2.1).

The first key to this approach is making information about the grid and market opportunities available to stakeholders in both directions. The availability of such information will be enabled through the additional layers of monitoring, control and interoperability described above. The second key is ensuring that customers have a direct incentive to participate – a 'local support' payment or mechanism. Finally, consumers' devices need to be aggregated in such a way that system operators can interact with many properties simultaneously.

1.5 Improved interoperability

Interoperability refers to the seamless, end-to-end connectivity and convergence of hardware and software from the generator, through the electricity network and to the devices behind the customer's meter, enabling coordination of energy flows with real-time, bidirectional information.[12] Technologies such as switched Ethernet, TCP/IP, high-speed wide area networks, and high-performance low-cost computers provide capabilities barely imagined when most historical substation automation protocols were designed.[13]

Improved interoperability and common protocols would enable the 'plug-and-play' integration of new devices to the grid and Internet of Energy. This would provide easier access for customers to the full value and functionality of their DER. This relies on a future with common protocols and frameworks and open industry standards that securely and efficiently transmit data within a relatively closed environment (such as a home or industrial area network) and/or transmit data externally to a central location or cloud.

2 Areas for Innovation

The potential opportunities of the Internet of Energy are significant, and technological progress in the realms of connected devices, advanced meters and distributed energy resources seem to be making much of this change inevitable.

However, there are some key challenges and areas for innovation that are required to ensure society can make the most of the future described in this innovation frame. These include:

- The **cost to consumers** of investment in additional infrastructure and devices and the associated **evolution of tariffs**
- The **role of cybersecurity, data protection and privacy**
- **Protocols for efficient data transfer and device interoperability** so that consumers can access the full value of their assets
- Clarity on **new roles and responsibilities for grid planning, operation and non-connected infrastructure**
- **Policy and regulation updates**

[12] GridWise, *Reliability Benefits of Interoperability*, September 2013

[13] R.E. Mackiewicz, *Overview of IEC 61850 and benefits*, June 2006

These areas for innovation are further discussed below.

2.1 Cost to consumers and evolution of tariffs

As discussed above, the Internet of Energy will both require and drive a significant increase in ICT software and hardware. This drives two parallel areas for innovation: who is responsible for planning and deploying the additional technology required (Section 2.4), and how will this investment be recovered - either directly or through the evolution of grid and/or retail charges?

Scenarios developed by Energy Networks Australia and CSIRO[14] suggest that both consumers and DNSPs are likely to invest significantly in a variety of grid infrastructure components and DER technologies that underpin the Internet of Energy. Integrating and managing a greater share of DER on the distribution network is likely to require additional monitoring and control technologies as well as associated 'big data' processing solutions. Considerable data gathering technology and control solution processing capability is required to bring greater visibility and control to the grid edge. So too is the challenge of effectively integrating information technology (IT) and operational technology (OT) systems within network businesses.

Some of this additional expenditure could be reasonably categorised as an additional regulated asset base component ('ICT RAB') for DNSPs, and thus passed to consumers via their tariffs. Doing so efficiently will require a sound approach to assess the detailed costs and benefits of such a deployment as well as an understanding of the gaps in the current ICT capabilities of Australian DNSPs.[15]

A recovery of the costs of the Internet of Energy could lead to a significant increase in retail tariffs and as noted in Section 1.4, spawn local trading incentives. If individual customers were simultaneously investing what they perceive as a significant amount in networked devices inside their homes, they may have less appetite for what will be perceived as further increases in utility rates. At that point, micro-generators and residential prosumers would likely trade amongst themselves, opting for peer-to-peer trades automatically if grid power were relatively more expensive.

Alternative approaches could include a fee-per-transaction, an annual Internet of Energy access fee and/or a micro-wheeling transaction ledger that was balanced on a monthly or annual basis[16].

Finally, it is also important to consider the impact on members of society unable to afford new Internet of Energy-connected technologies in their homes, and therefore proportionally accruing fewer of the benefits yet still bearing the increased system costs. The industry should encourage a consistent deployment of Internet of Energy ICT to avoid the impacts of varied uptake rates on grid planning and operation (see Section 2.4).

2.2 Cybersecurity, data protection and privacy

The security of the Internet of Energy, like any data network, is crucial. Power systems are classified as critical infrastructure, and as such, rigorously defended from physical and electronic threats.[17]

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[14] Energy Networks Association, *Electricity Network Transformation Roadmap - Interim Program Report*, December 2015

[15] It is also possible that connected consumers can play a role in helping to operate and stabilise the grid (Section 2.4) and reduce the overall RAB.

[16] New York will provide interesting case studies on this in future. The New York State Energy Research and Development Authority has engaged consultants to further assess the issue of service charge development. The results will be posted on their website: https://www.nyserda.ny.gov/

[17] Australia-New Zealand Counter Terrorism Committee, *National Guidelines for Protecting Critical Infrastructure from Terrorism*, 2015

The electricity sector will be at an enhanced risk of cyber-attack as the Internet of Energy becomes more widespread. As a massive network of distributed yet interconnected systems, a smart grid offers a large electronic surface area using multiple protocols and with many points of access. As the Internet of Energy continues to expand, it will offer an ever-increasing target. In particular there is currently limited understanding of how to properly secure the intersection of information technology and operational technology.

In theory, a successful breach at that critical juncture could either jeopardise physical grid performance and control, consumer data confidentiality or both. The different layers of the system are likely to require bespoke security measures: securing a SCADA system or substation will be quite different to protecting personal information or access to a home area network.

Many Australian power sector businesses already participate in the broader national Computer Emergency Response Team (CERT) programme[18] and will be aware of the Australian Signals Directorate's cyber strategies[19], but a specific sectoral initiative may be needed to identify the risks in more detail and issue ongoing guidance on how consumers and industry players can help mitigate these. Given security risks, new market and trading opportunities created by the Internet of Energy may choose to take account of the breadth of technology available, including blockchain and other cryptocurrencies.

2.3 Effective data transfer and interoperability standards and protocols

Currently, there is limited interoperability between technologies deployed on the electricity network and behind the meter, as this is essentially left up to each asset owner to decide. Residential technology providers currently tend to offer bespoke communication and control solutions to accompany their hardware. Advanced meters and a range of other monitoring technologies are unable to efficiently transfer data to relevant stakeholders and operate in a coordinated fashion with other devices on the network. As well as limiting the flow of data that underpins the Internet of Energy, this risks slowing down the process of system-wide dissemination of corresponding solutions. The lack of common standards may also result in both consumers and technology providers being slow to adapt to new technology developments in the market.[20]

There has been significant work on standards such as the Common Information Model for power systems (CIM, see also IEC standard 61870-5), the IEEE 1547 series to facilitate integration of DER into the distribution grid and the IEEE 2030 series of standards focusing on the role of ICT technologies in enhancing DER integration by providing interoperability solutions.[21]

However, it has proven difficult to make these abstract, wide-ranging models that include devices, process and data tangible for power systems or communication engineers. The global ICT industry has therefore also been developing the International Electrotechnical Commission's standard 61850, which outlines a unified standard object model describing the information available from the different primary equipment, the protocols for communication between devices and the communication language for substations and into the Internet of Energy.[22]

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[18] More detail on CERT at *https://www.cert.gov.au/about*

[19] Australian Signals Directorate guidance at: *http://www.asd.gov.au/infosec/mitigationstrategies.htm*

[20] EIT ICT Labs, *Future Energy Grid - Migration to the Internet of Energy,* 2013

[21] National Renewable Energy Laboratory, *IEEE 1547 and 2030 Standards for Distributed Energy Resources Interconnection and Interoperability with the Electricity Grid,* December 2015

[22] There are over 100 IEC standards that apply to smart grids and the Internet of Energy. The IEC has produced a comprehensive white paper on the importance of standardisation: http://www.iec.ch/whitepaper/pdf/iecWP-energychallenge-LR-en.pdf

In 2013, the AEMC published its advice to the COAG Energy Council on how a shared market protocol for advanced meters could be developed in the National Electricity Market (NEM). It envisions the establishment of new B2B procedures and a 'B2B e-hub', managed by AEMO, which at a minimum would enable communications between parties to support services set out in the minimum services specification included in the competition in metering rule change.[23]

The two extreme scenarios for the future involve either a collection of incompatible solutions or a comprehensive plug-and-play infrastructure that meets the requirements of all stakeholders.[24] The challenge is determining where along this spectrum the most beneficial outcome exists, and how to move industry and associated stakeholders in that direction.

2.4 Grid planning, operation and non-connected infrastructure

Greater penetration of DER presents new challenges and complexities for network service providers (NSPs) to plan, operate and manage their network in a reliable and safe manner. From a planning perspective, internet enabled-DER has a flow-on effect to the transmission network, and an argument can be made that distribution and transmission planning should be integrated.

This entails having an integrated solution for demand forecasting, taking into consideration DER growth on the distribution network, and where on the network additional DER can be safely added. While the opportunities are significant, 'smarter' geospatial demand forecasting using more accurate data provided by the Internet of Energy will require greater processing power, more complex models and enhanced sharing between relevant stakeholders.

From an operational perspective, the NSPs are responsible for network management functions such as network switching and reconfiguration as well as managing voltage levels, power factor and power quality, all of which is impacted in some way by increasing levels of DER and more proactive consumers. A future network with plentiful DER, as well as the market/platform services envisioned in innovation frame 1, will require advanced ICT technologies and integrated operational processes to enable real-time responsiveness to ensure a safe and reliable energy supply.[25]

These technical and conceptual changes present related human and cultural challenges for incumbents in the industry. Roles and responsibilities will be redefined and new skills and capabilities will increasingly required. Experience with, and trust in, the capabilities of new technologies to support the network will be critical to the transformation and ultimate utility of the Internet of Energy to the wider sector.

On a related note, incumbent stakeholder staff may struggle to transition to a more customer-centric, data-enabled and collaborative operating climate.[26] These challenges will be particularly acute where incumbents cede some of their operational control to customers or new entrant organisations.

Non-connected or ageing infrastructure also poses a challenge. There may be assets deployed today that either cannot be internet-connected or for which no business case can be made – yet which still play a role in day to day network operation. These must also be factored into the new data-intensive models underpinning planning and operational decision making.

[23] AEMC, *Final Advice - Implementation advice on the shared market protocol*, October 2013

[24] EIT ICT Labs, *Future Energy Grid - Migration to the Internet of Energy*, 2013

[25] Lawrence Berkeley National Laboratory, *Distribution Systems in a High Distributed Energy Resources Future*, October 2015

[26] PricewaterhouseCoopers – Global Power & Utilities, *Customer engagement in an era of energy transformation*, 2016

2.5 Policy and regulation updates

Electricity policy, rules and regulations in Australia - and most other jurisdictions – evolved with the development of the linear flow of electrons from large fossil-based generators to consumers, and for ensuring a limited number of well-regulated players conformed to those rules.

In some ways, the Internet of Energy is the natural culmination of the major developments in the sector in the last twenty years, including the rapid increase in internet-connected devices in homes, the spread of the mobile internet, the falling price of PV and rise of prosumers, the significant increase in retail electricity prices and support for advanced meters in Victoria and beyond. It may now be worth fundamentally reconsidering the policies that drive the sector, as well as the regulations and rules that govern it.

New operating models that involve customers in grid stabilisation and voltage management may require new rules and market approaches. A suite of refreshed policies can also consider the other major opportunities and challenges presented here: data collection, analytics and security; protocol standardisation; consumer access and peer-to-peer power trading; the impact of increasing amounts of localised renewable energy on the NEM's wholesale market; the protection of vulnerable consumers; grid planning and operating responsibilities; consumer tariffs and asset remuneration, and so on.

3 Australian and international context

It is worth noting that there are localised or segmented Internet of Energy-related projects underway in both local and international energy systems.[27] This report presents a few specific examples that bear specific consideration:

3.1 ARENA's Networks Renewed project – shifting the focus to the consumer

ARENA's co-funded Networks Renewed project seeks to increase the penetration of DER by paving the way for distributed PV and energy storage markets in such a way that they have a beneficial impact on the quality and reliability of the national distribution networks. It specifically seeks to challenge the perception that distributed PV increases voltage variability and destabilises the conventional central dispatch model.

The Institute for Sustainable Futures (ISF) at the University of Technology Sydney is leading two trials of over 150 newly-installed internet connected inverter technologies to provide network support services – in New South Wales facilitated by Essential Energy and in Victoria partnering with United Energy – with the technical analysis published online[28] for review by all interested stakeholders.

The results of the trials suggest that using smart inverters to communicate reactive power requirements is eminently feasible – but that this will require a shift to a definite focus on customer centricity / collaboration.

3.2 ENA & CSIRO's Electricity Network Transformation Roadmap – with consumers in the driving seat

CSIRO and Energy Networks Australia (representing gas and electricity transmission and distribution

[27] https://arena.gov.au/project/networks-renewed/
[28] http://tinyurl.com/NtwrksRnwd

businesses) partnered to develop an Electricity Network Transformation Roadmap (NTR). This striking features of this roadmap, when compared to similar efforts in the UK, Germany, parts of the US and for the Gulf Cooperation Council (GCC), are that a) the NTR pivots specifically around the role of the consumer in the future of the grid and b) it adopts a very long term horizon, which facilitated discussion of the potential for future disruption while keeping current business interests at arms' length.

Working backwards from 2050, NTR participants used an "if-then" analysis to determine that both DER and the national network would benefit from a dynamic network optimisation market in which DER services could be traded in a time-bound and geo-spatial manner[29].

3.3 New York's Department of Public Service: Reforming the Energy Vision to create a DER market

The New York Department of Public Service (DPS) has taken steps towards implementing significant market reforms through its Reforming the Energy Vision (REV) program and has recently developed guidance to utilities to plan for and create a new, diverse, investment-friendly, and customer-oriented electricity system.

The DPS highlights that the new capabilities required to develop distribution system platforms (DSPs) are likely to require ICT and data management capital expenditure that fall outside of 'normal' utility operations of a utility. This expenditure will be recoverable through the existing rate-based approach, and in recognition that utilities are required to develop these capabilities, the DPS stipulates that this expenditure will not be subject to retrospective review.[30]

The REV further outlines its vision for improving grid planning and operations, which includes utilities developing:

- New planning functions to be implemented to better integrate DERs into the grid, increasing the reliance on DER to meet system needs, accurately valuing DER, and enhancing coordination between distribution and transmission system planning.
- Better coordination of the multi-directional power flows resulting from increased DER penetration on the network, and new functions to enhance load and network monitoring to improve grid operations.

3.4 Artemis: focusing on integrating cutting-edge EVs in the EU

The EU-sponsored ARTEMIS[31] project focuses on deploying the latest Internet of Energy developments to enable and support the large-scale uptake of electric mobility in Europe, specifically by testing electronics that will need to be embedded in future generation of intelligent EVs. The 38 research and technology partners – a mixture of business and academia – funded half of the original EUR 45 million budget, with the other half funded by 10 EU member states. This project highlights the significant and broad-based impacts of a diverse consortium collaborating on a select issue with the Internet of Energy concept.

The project's focus is on the architecture, hardware, software and distributed embedded systems needed to implement a secure, real-time interface between a smart energy grid and large numbers of devices, generators and/or loads (particularly EVs – but also buildings, appliances, solar panels,

[29] http://www.energynetworks.com.au/electricity-network-transformation-roadmap

[30] New York Department of Public Service, *Staff White Paper on Rate Making and Utility Business Models*, July 2015

[31] Further information on Artemis and study results at: http://www.artemis-ioe.eu/.

etc) in large numbers at the edge of the system.

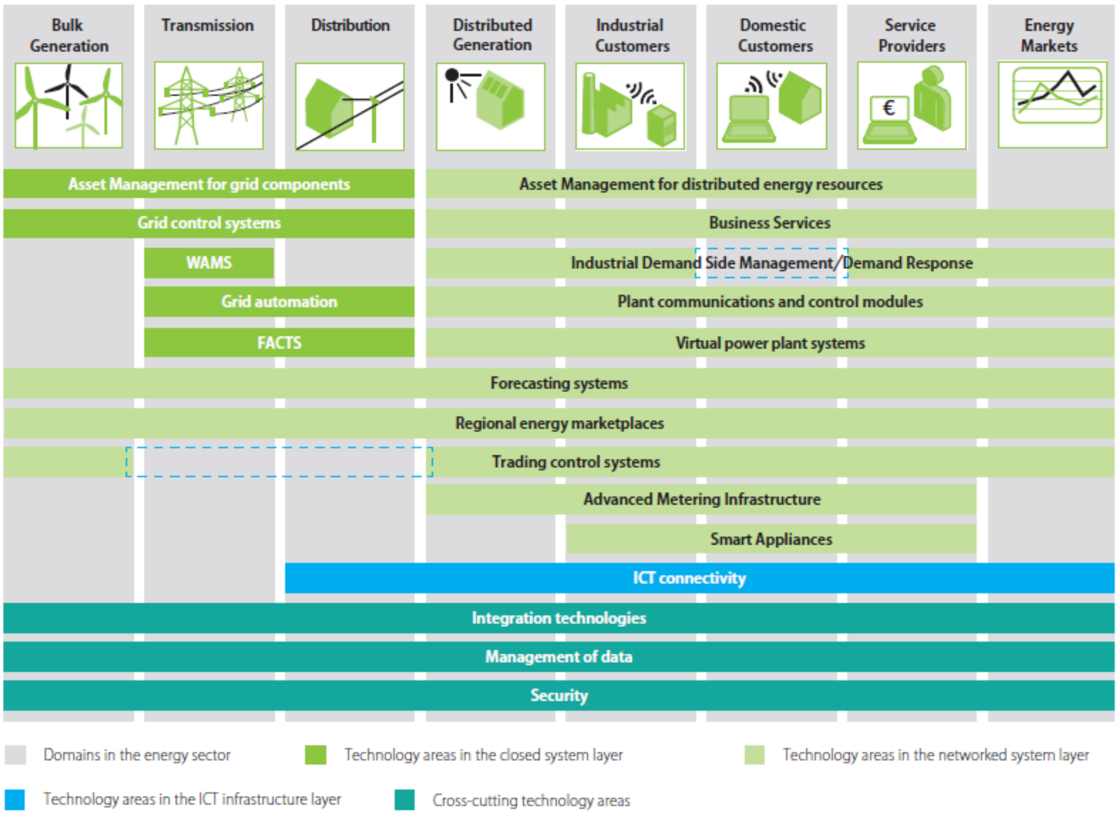
The partners involved are investigating modular options for new electrical components, researching a variety of energy storage concepts, communication protocols, vehicle architectures, multi-core microcontrollers, integrated circuits and power electronics as core modules for power converters and chargers.[32] In so doing, they have created protocols, IP and patents that will be mandated and standardised in future generations of European EVs.

3.5 EIT's report on the necessity of upgrading Europe's common ICT system

The report released by the EIT ICT Labs[33] investigated the ICT requirements of the European electricity system. The report foresees a 'closed' layer of the grid operators, enabling asset monitoring and grid automation, and a 'networked' layer where standardised interfaces ensure interoperability of devices. According to the report, there would further need to be an ability for a level of control from the 'closed' layer to 'networked' layer to ensure grid stability.[34]

The concept and interrelationships are shown in Figure 3.

Figure 3 – EIT IC Labs – ICT Requirements Concept



[32] The smaller, original ARTEMIS project has now been wrapped into a much bigger pan-European embedded intelligence and economic policy program: https://artemis-ia.eu/

[33] EIT ICT Labs is a Knowledge and Innovation Community (KIC) supported by the European Institute of Innovation & Technology (EIT). Its mission is to turn Europe into a global leader in Information and Communication Technologies

[34] EIT ICT Labs, *Future Energy Grid - Migration to the Internet of Energy*, 2013

Source: EIT

The EIT has taken a 'whole of system' approach to developing the requirements for the electricity system. As shown in Figure 3, the foundation for the interconnected future energy grid is made up of solutions to improve technology integration and data management. ICT connectivity is maintained between customer-sited devices and certain elements of the distribution network, while the ICT link to transmission and generation would be limited. This would then enable a range of benefits and alternative services across the system.

4 Concluding Remarks

This review has found that there are very significant potential benefits to a system that can effectively harness the power of the Internet of Energy. It has also recognised that parts of the Internet of Energy are either inevitable (such as the growing deployment of internet-connected devices) or likely (such as business model disruption by new market entrants).

However, there are limitations within the current system that will need to be addressed to realise the potential of a high proportion of integrated DER and renewable energy on an intelligent network, including:

- The need to ensure secure and efficient data transfer and device interoperability across the network, and appropriate cost-recovery mechanisms to ensure efficient outcomes
- The need to rethink and redefine what roles and responsibilities will be required for grid planning and operations and how DER may be integrated into these functions
- The need to rethink the relationship between incumbent players and new market entrants
- The need for an overarching policy umbrella that reflects this new system, as well as appropriate cascading rules and regulations.

Part of the purpose of this innovation frame is to provide a platform for key stakeholders to learn from local and international experiences on this topic and to generate innovative ideas to overcome limitations currently in the market.