Sydney Law School

Legal Studies Research Paper
No. 13/23

April 2013

Climate change adaptation and electricity infrastructure

Rosemary Lyster & Rebekah Byrne

‘Climate change adaptation and electricity infrastructure’

by

Rosemary Lyster* and Rebekah Byrne**

The threats of climate change to electricity infrastructure have been well documented and may be considered in terms of climatic variables, impacts and implications. The Intergovernmental Panel on Climate Change’s 2012 report entitled Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation provides the most recent assessment of climate change impacts on electricity infrastructure as well as discussing the economic costs of adaptation measures and global and regional climate disasters, implications for development, recovery and reconstruction, and technologies for extreme events. This chapter sets out the scientific case for legal and technology adaptation responses in the electricity infrastructure sector in the face climate extremes and disasters. It proposes the adoption of the Smart Grid as one of the technological adaptation measures and relies on the experience of the Queensland flood disasters in Australia in 2010 to provide some generic examples of how governments and utilities might respond to protect electricity infrastructure.

Keywords: Extreme climate events and disasters, electricity infrastructure, adaptation, Smart Grids, Australia, the European Union, the United States, Queensland Floods Commission of Inquiry

The threats of climate change to electricity infrastructure have been well documented and may be considered in terms of climatic variables, impacts and implications.[1] The climate variables include: increase in intensity of extreme wind; increased frequency and intensity of storms and bushfires; increase in temperature, number of hot days and electrical storms; and decrease in rainfall. The impacts are predicted to be: damage to transmission and distribution above-ground assets resulting in increased blackouts; reduced network capacity along with accelerated deterioration of assets; and an increase in the number and length of blackouts due to electricity demand exceeding supply. The implications considered as economic impacts include: increased capital and maintenance expenditure on electricity transmission and distribution infrastructure; increased demand for skilled staff leading to shortages in this area; short term lost revenue to transmission and distribution companies; accelerated depreciation and deterioration of assets; and increased power prices to consumers. Additional demand side implications, particularly in developed economies, include: community security risk; increased insurance costs as a result of business and food loss; traffic congestion/accidents/no traffic lights and short term unemployment leading to hindered

*Rosemary Lyster is Professor of Climate and Environmental Law at Sydney Law School, the University of Sydney and Director of the Australian Centre for Climate and Environmental Law. She is a legal consultant to King & Wood Mallesons.
**Rebekah Byrne is a student in the Master of Environmental Science and Law at the University of Sydney and was a student in Rosemary's 2012 Energy and Climate Law unit of study.
[1] *Assessment of the Impacts of Climate Change on Australia's Physical Infrastructure* (Australian Academy of Technological Sciences and Engineering (ATSE): 2008); *Energy network infrastructure and the climate change challenge report by Parsons Brinkerhoff to ENA* (Energy Networks Association: March 2009); *Network Infrastructure* (Garnaut Climate Change Review: 2008) Chapter 19; *The Vulnerability of Energy Infrastructure to Environmental Change* (Chatham House and Global EESE (July 2009); Mladen Kazunovic, Ian Dobson and Yimai Dong 'Impact of Extreme Weather on Power System Blackouts and Forced Outages: New Challenges; Maunsell Australia *Impact of climate change on infrastructure in Australia and CGE model inputs* (Garnaut Climate Change Review: June 2008); available at http://www.garnautreview.org.au/CA25734E0016A131/WebObj/02-AInfrastructure/$File/02-A%20Infrastructure.pdf (viewed 7 December 2009).

emergency responses; train service disruption; life support/health risk; deterioration in quality of home life and building services disruption including elevators and lifts.[2]

This chapter sets out the scientific case for legal and technology adaptation responses in the electricity infrastructure sector in the face climate extremes and disasters. It proposes the adoption of the Smart Grid as one of the technological adaptation measures and relies on the experience of the Queensland flood disasters in Australia in 2010 to provide some generic examples of how governments and utilities might respond to protect electricity infrastructure.

Managing the risk of extreme climate events and disasters to electricity infrastructure and supply

On 28 March 2012, the Intergovernmental Panel on Climate Change launched its latest scientific report entitled *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (SREX Report).[3] This Report provides the most recent assessment of climate change impacts on electricity infrastructure as well as discussing the economic costs of adaptation measures and global and regional climate disasters, implications for development, recovery and reconstruction, and technologies for extreme events.

Extreme events and extreme impacts on electricity infrastructure

[2] Maunsell, ibid at 4
[3] Available at <http://ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf> accessed 21 July 2012

The SREX Report states with high confidence that extreme impacts on humans and social systems will depend on the degree of exposure and vulnerability to that extreme event, in addition to the magnitude of the physical event. As such, even non-extreme events can result in extreme impacts on human systems where vulnerability and exposure are high. For example, an extreme event with a large spatial scale (as in an ice storm or windstorm) can have an exaggerated, disruptive impact on electricity transmission and distribution networks due to the systemic societal dependence on the networks.[4] The Report notes that electricity transmission infrastructure is particularly vulnerable to extreme storm events, particularly wind and lightning, extreme rainfall events and floods, drought, and in some cases heatwaves.

- *Extreme storm events*

The SREX Report notes that the passage of storms across France in 1999 caused the greatest devastation to an electricity supply network ever witnessed in a developed country. During the storms, 120 high-voltage transmission pylons were toppled, and 36 high-tension transmission lines were lost, representing one-quarter of the total lines in France.[5]

Another example is the 2008 Chinese ice storm which affected 100 million people for days, weeks or even a month, depending on their location.[6] It inflicted direct economic losses exceeding US$20 billion demonstrating that an extreme event of this nature can undo socioeconomic and ecological structures that have taken decades to

[4] Ibid at 42, 235
[5] Ibid at 249
[6] See Benzhi Zhou et al. 'The 2008 Chinese Snow Storms: The Socioeconomic-Ecological Impacts and Sustainability Lessons Learned' (2011) *American Meteorological Society* 47 available at <http://www.cfern.org/wjpicture/upload/wjxz/wjxz2011-7-5-10-40-42.pdf> accessed 21 July 2012

establish. The electricity grid was the first critical infrastructure to fail across the affected region with 80% of the power supply facilities damaged in the province of Guizhou. In the province of Hunan, the electricity grid supplying electricity to the city of Chenzhou was almost completely destroyed and had to be rebuilt, leaving more than four million people in the dark for several weeks. The failure of the grid triggered a cascade of breakdowns of other essential services such as water utilities, and cooking and heating for millions of families became impossible. Hospitals and factories were forced to close and mines were submerged because of inoperable pumps. China's principal mode of transportation, the railway system, was disrupted by powerless electric trains. Highways and airports were also closed because of treacherous conditions. With all transportation systems compromised, supply chains of energy, food, and other vital goods were severely compromised. Coal reserves reached emergency levels and power plants had to be shut down. Food shortages occurred suddenly and unexpectedly resulting in soaring food prices, in some cities by 1,000%. [7] The failure of China's transportation hubs affected the entire country with the consumer price index nationwide increasing by 34% between December 2007 and February 2008.[8]

- *Drought*

According to the SREX Report, severe droughts may also affect electricity supplies if the supply of cooling water to power plants is disrupted or hydroelectricity schemes are

[7] Ibid at 52
[8] Ibid at 53

compromised.[9] For example, drought has a serious impact on electricity production in New Zealand where around two-thirds of supply is from hydroelectricity and low rainfall results in increased fossil fuel electricity generation, which the Report regards as a maladaptation to climate change.[10] In December 2011, the Balkans experienced an acute region-wide electricity shortage as a result of dramatic falls in water levels to hydroelectric dams during a month-long drought. The hydroelectric power plants only managed to produce 10 KWh which was the lowest production level since 1926.[11] A severe drought between 2009-2010 in southwest China crippled the region's hydroelectric power generation sector. Hydroelectric power has been the preferred energy option in the water-abundant and mountainous southwest regions of China, including Yunnan, Guizhou and Guangxi, Sichuan Provinces and Chongqing District. Overall, drought has reduced the hydroelectricity capacity of the southwest power plants by 40 percent. In Yunnan Province, the generated power decreased by 20% while in Guangxi Province 90% of the hydro capacity was reported to be 'paralysed.'[12]

- *Extreme Rainfall Events and Floods*

Risk management and adaptation methods are important in reducing the effects of flooding on electrical infrastructure and the resultant exposure and vulnerability of communities. One of the most recent case studies of the impact of floods on electricity

[9] SREX Report above n 3 at 249
[10] Ibid at 261
[11] Georgi Mitev Shantek, 'Serious electricity shortage hits the Balkans' *Southeast European Times* (21 December 2011) available at <http://www.setimes.com/cocoon/setimes/xhtml/en_GB/features/setimes/features/2011/12/22/feature-04> accessed 23 July 2012
[12] Xina Xie and Michael J Economides 'China's Hydroelectric Sector Crippled by Severe Drought' *Energy Tribune* (12 May 2010) available at <http://oilprice.com/Alternative-Energy/Hydroelectric/Chinas-Hydroelectric-Sector-Crippled-By-Severe-Drought.html> accessed 23 July 2012

infrastructure is the devastating flood events that struck Queensland, Australia in 2010/11. There was widespread damage to the electricity network with power outages experienced even where the local electricity infrastructure was not damaged. This was either the result of damage occurring elsewhere to connection parts of the network or because of precautionary disconnections to prevent electric shock.[13] During the floods, 300,000 customers lost power in two major towns, Ipswich and Brisbane. In the Lockyer Valley, one of the most seriously affected rural areas in Queensland, much of the electricity infrastructure was destroyed causing 5,000 people to lose power.[14] The Australian government established the Queensland Floods Commission of Inquiry which released its Final Report[15] in March 2012. The Report includes important recommendations on increasing the flood resilience of electricity infrastructure and will be relied upon in this chapter.

- *Heat waves*

There is increased likelihood of disruption of electricity supplies during heat waves.[16] This is because both generation and transmission generate heat and on hot days this can be reinforced by positive feedback loops as demand for electricity rises with greater use of air conditioners. This compromises the ability to dissipate heat from parts of the system although this is crucial for the continued effectiveness of the infrastructure. The heat related risks to coal-fired power stations also include the following: work on coal

[13] Queensland Floods Commission of Inquiry, *Queensland Floods Commission of Inquiry: Final Report* (March 2012) 239 http://www.floodcommission.qld.gov.au/publications/final-report accessed 23 July 2012.
[14] Ibid at 239
[15] Ibid at 240
[16] SREX Report above n 3 at 259

mines is minimised on high risk days due to coal's combustibility; the potential danger of bushfires to power stations and, by implication, transmission infrastructure; and the warming of water that is supposed to cool the steam turbines.[17] The impact of heatwaves on electricity infrastructure was evident during the 2003 extraordinary heat wave in Europe. In France, electricity became scarce, construction productivity fell, and the cold storage systems of approximately 20 to 30% of all food-related establishments were found to be inadequate.[18]

A similar phenomenon was recently witnessed in the Southern Eastern metropolitan regions of Australia which experienced a record-breaking heatwave in 2009 where maximum daily temperatures were 12-15 °C above the seasonal average. Night-time temperatures were also unusually high with the heat build-up exacerbated by exceptionally low surface moisture resulting from an extended drought over an extended period. The heatwave occurred as an intense, long-lived Phase I which caused the most apparent human distress from high temperatures, followed by Phase 2 where extreme heatwave conditions combined with severe bushfires across the region.[19] Such experiences demonstrate that there is little resilience to unexpected perturbations such as extreme heat waves if an electricity system is already operating with little spare capacity. The vulnerability of electricity infrastructure can be increased by a combination of driving forces such as ageing infrastructure; rapidly increasing demand (especially from air conditioning), and the predicted increase in the frequency and

[17] See *Impact and adaptation response of infrastructure and communities to heatwaves: the southern Australian experience of 2009* (National Climate Change Adaptation Research Facility (NCCARF October 2010) at 49 available at <http://www.isr.qut.edu.au/downloads/heatwave_case_study_2010_isr.pdf> accessed 23 July 2012
[18] SREX Report above n 3 at 257
[19] Above n 17 at v

severity of climate-related extreme events.[20] One of the adaptation responses might be the undertaking of scenario testing for potentially hotter and more prolonged extreme events on continuity by infrastructure and electricity service providers.[21]

- *Extreme Events, Impacts, and Development*

There is general consensus that, when compared with developed countries, developing countries are more economically vulnerable to climate extremes. This is largely because: developing country economies have less resilience as they depend more on natural capital and climate-sensitive activities, such as cropping and fishing; they are often poorly prepared to deal with existing climate variability and physical hazards; maladaptation due to the absence of financing, information, and techniques in risk management, as well as weak governance systems is likely to exacerbate the damage; in regions with a fast-growing population and asset stocks (such as in coastal areas) little attention is given to climate-proof investments; low levels of economic development mean that there is an adaptation deficit and a lack of ability to transfer costs through insurance and fiscal mechanisms; and developing countries have large informal sectors. However, in some cases developed countries also suffer severe disasters because of social vulnerability and inadequate disaster protection as witnessed with Hurricane Katrina in New Orleans, United States.[22]

Strategies for electricity supply during extreme events

[20] Ibid at 75
[21] Ibid at ix
[22] SREX Report above n 3 at 265

The SREX Report draws together experiences from a number of recent disasters to indicate strategies that might be adopted during extreme events. Disaster events may compromise electricity supplies so that partial or total blackouts are experienced. The strategies that might be adopted during extreme events include conserving energy, relying on alternative forms of energy, including alternative forms of generation, the rescheduling of activities to a future date, or focusing on the low- or no energy elements of the business operation. All of these demand side management responses might be combined with advance electricity storage, for example when low precipitation reduces hydroelectricity production. As discussed above, this has already occurred in many jurisdictions but may also be increasingly problematic due to climate change projections. Yet another strategy could include rationing electricity supply in accordance with a legally sanctioned process which recognises a list of priorities between various sectors such as industry, agriculture, electricity production, and domestic water supply.[23] This legislative technique is already adopted in Australia, for example, where water for ‘critical human needs’ enjoys priority over all other claims on a water source.[24] Also various types of water access licences are prioritised with water utilities enjoying the highest protection. In the event of drought where water allocations need to be reduced, the access licences enjoying the least legislative protection will have their allocations reduced first.[25]

Framing the Costs of Extremes and Disasters

[23] Ibid at 307
[24] *Water Act 2007 (Cth)* Part 2A
[25] *Water Management Act 2000 (NSW)* s. 58

The economic costs associated with climate extremes and disasters can be categorised as impact or damage costs and adaptation costs. Impact costs may be either direct or indirect costs. For example, a direct impact will occur when electricity transmission lines are destroyed by wind. However, where this causes businesses to cease operations, putting many people out of work and creating other socio-economic problems, these may be classified as indirect impacts. Adaptation costs are those associated with: adaptation planning; actual adaptation such as risk prevention, preparedness, and risk financing; reactive adaptation such emergency disaster responses, rehabilitation, and reconstruction); and finally the implementation of adaptation measures. The benefits of adaptation include the value of avoided impacts and damages as well as the co-benefits generated by the implementation of adaptation measures.[26]

- *Estimates of Global and Regional Costs of Disasters*

Although the losses due to the failure of electricity infrastructure during weather and climate extremes are not specifically itemised in the SREX Report, the overall losses build the case for the urgent adoption of climate adaptation strategies and legal responses. Estimates of annual losses global weather- and climate-related disaster losses have ranged from a few US$billion in 1980 to above US$200 billion in 2005 (the year of Hurricane Katrina), not counting indirect and intangible losses. On a global scale, annual material damage from large weather and climate events has increased eight-fold between the 1960s and the 1990s, while the insured damage has been found to have

[26] Idem.

increased by 17-fold. Between 1980 and 2004, the total costs of extreme weather events were US$ 1.4 trillion, of which only one-quarter was insured. The human impact of natural disasters is unequally distributed across regions with Asia experiencing the highest number of weather- and climate-related disasters in the period 2000 to 2008. Economic loss was distributed as follows: Americas 54.6% of total loss; Asia, 27.5%; and Europe, 15.9%. Africa accounted for only 0.6% of global economic losses, but economic damages from natural disasters are underreported in this region compared to other regions.

Middle-income countries with rapidly expanding asset bases have borne the largest burden, where during the period from 2001 to 2006 losses amounted to about 1% of GDP, compared with 0.3% for low-income countries and less than 0.1% of GDP for high-income countries, based on limited evidence. In small exposed countries, particularly small island developing states, these wealth losses expressed as a percentage of GDP and averaged over both disaster and non-disaster years can be considerably higher, exceeding 1% in many cases and 8% in the most extreme cases between 1970 to 2010. This indicates a far higher vulnerability of the economic infrastructure in developing countries.

It is also important to note that the number of weather- and climate-related disasters has increased more rapidly than losses from non-weather disasters, which could indicate a change in climate extremes, although there are other possible explanations. Drought and flood losses may have grown due to a number of non-climatic factors, such as increasing water withdrawals and a decrease in storage capacity in catchments as a result of urbanization, deforestation, the sealing of natural surfaces, and channelization. These adversely affect both flood and drought preparedness.[27]

Electricity technology choices for adaptation and disaster risk reduction

Technology embraces a range of areas, including information and communication technologies, roads and infrastructure, food and production technologies, and energy systems. Technology choices can either alleviate disaster risk or significantly increase risks and adaptation challenges. For example, storms can render modern energy systems and centralised communication systems, which are dependent on physical structures, highly vulnerable to damage. It has been suggested that relatively centralized high-technology systems, such as the traditional electricity grids, are 'brittle,' and, while they offer efficiencies under normal conditions, in the event of emergencies they are subject to cascading effects.[28]

Another focus on the positive role of technologies in climate extremes is that they may assist with information collection and diffusion, including by monitoring possible stresses and vulnerabilities and communicating with populations and response agencies in the event of emergencies, although in some developing regions access to such technologies may be limited. Numerical climate models have also been developed in recent decades to provide multi-month forecasts, which can be used to prepare for floods and droughts.[29]

When considering adaptation responses for electricity adaptation, large dams may be regarded as mitigating drought and generating electricity. However, there may

[27] Ibid at 271
[28] Ibid at 493
[29] Idem.

be unacceptable social and ecological displacement costs and unless constructed to accommodate future climate change, they may present new risks to society.[30]

The Promise of Smart Grids

The Smart Grid is an integration of advanced, two way communications systems and sensors with the transmission and distribution network, which enables utilities to optimise grid performance in real-time.[31] Through demand responses it provides incentives to consumers for reducing energy consumption and it provides for a better integration of renewable energy sources into the grid. For the purposes of resilience the Smart Grid gives utilities an enhanced ability to identify the location of a failure and quickly re-route electricity to locations where demand is most critical. This could occur during times of climate change-induced crisis, or peak demand, and prevents outages through proactive diagnosis of the grid and its individual elements. Importantly, it enhances the ability of the grid to continue to provide power following a catastrophic event and to support vital emergency responses as well as military, economic and social activities during a crisis.[32] Although much of the literature to date assesses the interface between the Smart Grid and climate change mitigation, there is barely any mention of the adaptation benefits emanating from Smart Grid technology. If the Smart Grid improves efficiency and DSM and encourages distributed energy sources its mitigation benefits are clear. Yet the fragility of electricity networks to climate change impacts

[30] Idem
[31] See Rosemary Lyster, 'Smart Grids: Opportunities for Climate Change Mitigation and Adaptation' (2010) 36(1) *Monash University Law Review* 173-191
[32] *The Smart Alternative: Securing and Strengthening Our Nation's Vulnerable Electric Grid* (The Reform Institute June 2008) at 2, 8

suggests that the Smart Grid might also assist utilities to respond to blackouts, and other climate change induced crises, more effectively than is currently possible.

Hendricks[33] claims that a truly national clean-energy Smart Grid comprises two distinct components: an interstate 'sustainable transmission grid' which will transport clean utility-scale renewable energy to the market across long distances; and a digital 'smart distribution grid' to deliver this electricity efficiently to local consumers.[34]

- *The sustainable transmission grid*

The electricity industry traditionally includes generators,[35] market customers (electricity retailers and end-use customers),[36] network service providers who own, operate or control either a transmission[37] (TNSPs) or distribution (DNSPs) system,[38] market network service providers (MNSPs),[39] and special participants who may be appointed to perform various functions such as taking responsibility for operations during power system emergencies. Within this sector, large power plants are connected to the transmission system which supplies local distribution networks and large industrial

---

[33] Bracken Hendricks *Wired for Progress 2.0: Building a National Clean-Energy Smart Grid* (Center for American Progress April 2009)
[34] Ibid at 10.
[35] Generation is the process used to create electricity.
[36] Market customers comprise both electricity retailers and end-use customers. Retailers purchase wholesale electricity through the spot market, or from local generators who sell their entire output to them. The electricity is then sold to customers, increasingly within a contestable retail market. End-use customers purchase electricity directly from the spot market which they then consume.
[37] Transmission is the process of transporting electricity at high voltages from where it is generated, often over long distances, to groups of electricity consumers.
[38] TNSPs control the high voltage transmission assets that carry electricity between generators and distributors, while DNSPs operate the low voltage substations and wires that transport electricity from these substations to customers. Distributors hold a franchise over the regions in which their poles and wires are installed but must also be given access to customers outside their regions by using rival distribution networks.
[39] MNSPs are entrepreneurial interconnectors, with a minimum capacity of 30 MW, that offer their capacity to transport power into the market through a bidding process similar to that used by generators.

users. Electricity flows down stream and primarily in one direction from high-voltage transmission network to low-voltage distribution feeders. As mentioned above, the traditional grid might be regarded as a 'brittle' type of infrastructure in the face of climate extremes and disasters.

The Smart Grid, however, allows the interconnection of distributed generation at almost any point in the transmission grid. Distributed generation includes small-scale generation (including wind, landfill gas, biomass and hydro), cogeneration or combined heat and power plants, small stand-alone diesel generators and domestic or small commercial photovoltaic solar generation.[40] There are many benefits associated with distributed generation. These include:

- Reducing demand from the grid by installing a distributed generation plant close to the point of consumption. This can reduce distribution and transmission losses, reduce constraints on power lines and defer the need to upgrade the grid
- Improving the security of supply during peak demand
- Improving power supply to remote communities
- Facilitating the uptake of large-scale new renewable energy sources. Currently high-voltage transmission grids are not situated where many renewable energy sources are developed
- Locating power supply closer to end users.[41]

- *The digital smart distribution grid*

[40] See Nirmal-Kumar C Nair and Lixi Zhang 'SmartGrid: Future Networks for New Zealand power systems incorporating distributed generation (2009) 37 *Energy Policy* 3418 at 3419
[41] Idem

Smart distribution grids involve:

- integrating new technology into local electricity distribution networks, such as smart meters at individual homes and businesses to improve energy efficiency
- grid monitoring and control devices for improving the efficiency of electricity distribution within local networks by utility companies
- better tools for information sharing with consumers
- pricing and control systems to integrate distributed energy resources such as solar panels, energy storage devices, and
- electric vehicles. The electric vehicles would be charged off peak and then feed power back into the grid when they are parked either at work or at home during the day.[42]

Proposals for a Smart Grid in Australia, the United States and the European Union

The development of Smart Grids has become a priority action in Australia, the European Union and the United States as part of each jurisdiction's commitment to reducing greenhouses gas emissions, improving energy efficiency and encouraging the uptake of renewable energy sources. Each jurisdiction has only recently, in 2009, released its policy platform for the establishment of Smart Grids.[43] The policy

[42] See Hendricks, above note 33 at 12; see also *SMART 2020: Enabling the low carbon economy in the information age* (The Climate Group: 2008).
[43] China has also adopted and begun to construct Smart Grids. China's 12th Five-Year Plan sets the goal of accelerating progress on Smart Grid development supported by the Decision of the State Council on *Accelerating the Fostering and Development of Strategic Emerging Industries.* Local councils have also

documents provide encouraging signs that the Smart Grid is likely to become a reality within the electricity sector in these jurisdictions where they will play a meaningful role in delivering mitigation and adaptation climate change benefits.

Australia

The principal policy document for Australia's transition to a Smart Grid is *Smart Grid, Smart City: A new direction for a new energy era.*[44] Consistently with the discussion above, the document envisages both *grid-side* applications to reduce line loss and improve fault detection and restoration, and *customer-side* applications to assist consumers to manage their energy consumption. It is estimated that the adoption of Smart Grid technologies could deliver at least $5 billion of gross annual benefit to Australia.[45]

The customer-side applications would include:

- Information – on energy use or GHG emissions provided by website or in-home display

begun to adopt Smart Grid policies such as Jiangsu Provinces's *Smart grid industry in Jiangsu Province Development Plan Outline.* State Grid Corporation of China (SGCC) is the principal promoter of Smart Grids in China and has begun to develop a standardization policy for Smart Grid. In the past year, SGCC has launched 228 pilot projects across a range of areas including: smart substations; electric vehicle charging infrastructure; and a technical support system for Smart Grid Deployment. The most comprehensive pilot project is the Sino-Singapore Tianjin Eco-City; see Yanshan Yu, Jin Yang and Bin Chen, 'The Smart Grids in China – a Review' (2012) 5 *Energies* 1321-1338. See also Fu Liwen, Zhao Huiry, Guo Sen 'An Analysis on the Low-carbon Benefits of Smart Grid of China' (2012) 24 *Physics Procedia* 328-336; Yuan Jiahia, Hu Zhaoguang, 'Low carbon electricity development in China – An IRSP perspective based on Super Smart Grid' (2011) 15 *Renewable and Sustainable Energy Review* 2707-2713.

[44] Available at http://www.ret.gov.au/energy/Documents/smart-grid/smartgrid-newdirection.pdf accessed 1 August 2012

[45] Ibid at 7

- Controls – using in-home displays, automated controls for appliances and programmable thermostats with communications, and
- Tariffs which fluctuate according to time of use, critical peak pricing and real time pricing.

These applications would be enabled using smart metering infrastructure.[46]

The grid-side applications would include: integrated Volt-VAR control;[47] fault detection, isolation and restoration; substation and feeder monitoring and diagnostics; and wide-area management. Other key elements would include distributed energy storage, distributed generation (such as solar panels on residential rooftops), and electric vehicle support.[48]

The Smart Grid communications network will comprise three key elements:

- Homes are networks to connect smart meters and intelligent devices and appliances with residences
- Wide Area Networks which allow for two-way communications between a residence and the distributor substation, and
- Backhaul Networks which links the distributor substation to the utility.[49]

[46] Ibid at 17
[47] Currently, utilities use on-line power flow estimates which rely on stale data. If utilities were to use an integrated volt-VAR control system they could determine the optimal settings for all distribution voltage regulating and control devices which would assist with their obligation to maintain a set voltage to their customers. By collecting feeder voltage measurements from selected advanced geospacial intelligence (AGI) nodes at strategic feeder locations (for example, at feeder extremities), the nodes can report these measurements on a periodic basis. The integrated volt-VAR system can use this information to maintain the required level of service to customers.
[48] Above n 44
[49] Ibid at 19

As the policy document presciently notes, ‘the increased data that such a communications network would produce requires careful consideration of the physical and cyber security measures required to effectively manage the smart grid.’[50] Synergies between smart grid deployments and the National Broadband Network (NBN) program have also been noted given that the NBN will create a robust, high-bandwidth communication network to most homes and commercial premises.[51]

Australia's first commercial scale smart grid trial is known as *Smart Grid, Smart City.* It is led by the utility Ausgrid and is a $100 million initiative across five sites in Newcastle, Sydney and the Upper Hunter. At least 30,000 households will participate in the three year trial which will gather information about the benefits and costs of different smart grid technologies in an Australian setting. The technologies being tested include:

- A web portal that allows users to actively monitor their energy use online, calculate their energy costs and green house gas emissions
- A variety of household energy monitoring systems, including a wireless control system that allows appliances to be operated remotely from a computer or smart phone
- Improve the reliability and efficiency of the electricity network through the adoption of better monitoring and measuring devices
- Distributed storage and generation devices, including fuel cells and battery storage, and
- Electric cars.[52]

---

[50] Idem
[51] Ibid at 37.
[52] See <http://www.smartgridsmartcity.com.au/About-Smart-Grid-Smart-City.aspx> accessed 28 July 2012

The European Union

Under the EU's Energy and Climate Policy, the EU has adopted the goals of reducing greenhouse gas (GHG) emissions by 20% by 2020 and increasing the proportion of renewable energy in the EU's energy mix by 20% by 2020. In the longer term, the EU has committed to reducing its GHG emissions by 80% by 2050 compared with 1990 levels. The EU's Strategic Energy Technology Plan (SET-Plan) is the EU's response to the need to accelerate the development of low carbon technologies to ensure their widespread market take-up. Seven Technology Roadmaps 2010-2020 have been developed for the implementation of the SET-Plan in the areas of wind energy, solar energy, bioenergy, Carbon Capture and Storage, the electricity grid, sustainable nuclear energy and Smart Cities.[53]

The EU has identified three interrelated challenges for electricity networks including: creating a real internal market, integrating a massive increase of intermittent energy sources; and managing complex interaction between electricity suppliers and consumers. The total public and private investment needed in Europe is estimated to be €2 billion.[54]

The objective of the European Industrial Initiative on the electricity grid is to enable 35% of the EU's electricity to be supplied from dispersed and concentrated renewable sources by 2020 and completely decarbonised electricity production by 2050. The Initiative will also develop a market-based pan-European network by integrating national networks and engage customers as active participants in energy efficiency

[53] See *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Investing in the Development of Low-Carbon Technologies* Commission of the European Communities: October 2009)
[54] Ibid at 5

while also anticipating new developments such as the electrification of transport. Twenty large scale Smart Grid demonstration projects, involving 1.5 million customers, will be supported initially whereby smart meters will be rolled out and the automation and control of whole networks will be trialled.[55] Other significant features include: electricity storage; dynamic pricing mechanisms and appropriate ICT tools.[56] Local renewable energy sources, especially PV and wind applications, will also be fostered.[57]

Meanwhile, under the Smart Cities Initiative, the development and deployment of 10 smart grids in cities will be established while the large deployment of low carbon transport systems and alternative fuel vehicles will be developed and tested. The Smart Cities Initiative, which also includes provisions for zero energy buildings, is likely to cost €10-12 billion over the next ten years.[58]

Three recent European Commission Mandates are facilitating various elements of the Smart Grid. They include Mandates for smart metres,[59] electric vehicles[60] and Smart Grids which must all be coordinated with each other. The objective of the *Smart Grid Mandate*[61] is to develop or update a set of consistent standards within a common

---

[55] See *Commission Staff Working Document: Accompanying document to the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Investing in the Development of Low-Carbon Technologies* (Commission of the European Communities October 2009) at 10.
[56] Ibid at 39
[57] Ibid at 49
[58] Ibid at 12
[59] M/441 EN, 12 March 2009, available at <http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/2009_03_12_mandate_m441_en.pdf> accessed 28 July 2012
[60] M/468 EN, 4 June 2010, available at <http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/2010_06_04_mandate_m468_en.pdf> accessed 28 July 2012
[61] *Standardization Mandate to European Standardisation Organisations (ESOs) to support European Smart Grid deployment* M/490 EN available at <http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/2011_03_01_mandate_m490_en.pdf> accessed 28 July 2012

European framework to integrate a variety of digital computing and communication technologies and electrical architectures, and associated processes and services.[62]

The United States

Under the *Federal Power Act* (FPA), the transmission of electricity in interstate commerce by public utilities, and the reliable operation of the bulk-power systems across most of the United States, falls under the jurisdiction of the Federal Energy Regulatory Commission (FERC).[63] The Commission also has a new responsibility under Title XIII of the *Energy Independence and Security Act of 2007* (EISA)[64] to issue a rulemaking to adopt standards and protocols to ensure Smart Grid functionality and interoperability[65] in interstate transmission of electricity and in regional and wholesale electricity markets.[66] Furthermore, the *American Recovery and Reinvestment Act of 2009 (Recovery Act)*[67] provided the US Department of Energy with $4.5 billion to implement Title XIII of the *Energy Independence and Security Act of 2007*, which requires the modernisation of the electric power grid.

---

[62] Ibid at 2

[63] 16 U.S.C. 824.

[64] Pub. L. No. 110-140, 121 Stat. 1492 (2007) (EISA).

[65] According to the GridWise Architecture Council, the term 'interoperability' refers to the ability to: exchange meaningful, actionable information between two or more systems across organizational boundaries; assure a shared meaning of the exchanged information; achieve an agreed expectation for the response to the information exchange; and maintain the requisite quality of service in information exchange (i.e., reliability, accuracy, security); see *Interoperability Path Forward Whitepaper* (GridWise Architecture Council 2005) at 1-2, 2005, available at <http://www.gridwiseac.org/pdfs/interoperability_path_whitepaper_v1_0.pdf> accessed 1 August 2012.

[66] See *Smart Grid Policy* (Federal Energy Regulatory Commission: March 2009) at 6-7; available at <http://www.ferc.gov/whats-new/comm-meet/2009/031909/E-22.pdf> accessed 13 December 2009

[67] H.R. 679; see Title IV – Energy & Water Development

In March 2009, FERC released its *Smart Grid Policy*[68] for comment. The *Policy* points out that section 1301 of the EISA states that it is the policy of the United States to support the modernisation of the Nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth, and to achieve each of several goals and characteristics, which together characterise a Smart Grid.[69] These goals and characteristics are defined by the Act as:

- Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid
- Dynamic optimization of grid operations and resources, with full cyber-security
- Deployment and integration of distributed resources and generation, including renewable resources
- Development and incorporation of demand response, demand-side resources, and energy efficiency resources
- Deployment of 'smart' technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation
- Integration of 'smart' appliances and consumer devices
- Deployment and integration of advanced electricity storage and peak-saving technologies, including plug-in electric and hybrid electric vehicles, and thermal storage air conditioning

[68] Available at <http://www.ferc.gov/whats-new/comm-meet/2009/031909/E-22.pdf> accessed 15 December 2009
[69] EISA sec. 1301, to be codified at 15 U.S.C. 17381, cited by FERC ibid at 6

- Provision to consumers of timely information and control options
- Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid, and
- Identification and lowering of unreasonable or unnecessary barriers to the adoption of smart grid technologies, practices, and services.’[70]

FERC’s *Smart Grid Policy* discusses each of these aspects and invites comments on the *Policy*. FERC also advises that section 1305(a) of the EISA directs the National Institute of Standards and Technology (the Institute) ‘. . . to coordinate the development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems.’[71] NIST has developed a Smart Grid Conceptual Reference Model which will be further developed and maintained by a Smart Grid Architecture Board.[72]

FERC indicated in its *Smart Grid Policy* that once NIST’s work has led to sufficient consensus on interoperability standards, it is directed by legislation to adopt, through the rulemaking process, the standards and protocols necessary to insure smart-grid functionality and interoperability in interstate transmission of electricity, and regional and wholesale electricity markets. However, in July 2011, FERC determined that there was insufficient public consensus on the adoption of federal standards. Consequently, NIST has developed the *NIST Framework and Roadmap for Smart Grid*

[70] FERC above n 68 at 6
[71] EISA sec. 1305(a), to be codified at 15 U.S.C. 17385(a), cited by FERC above n 67 at 6
[72] See *NIST Framework and Roadmap for Smart Grid Interoperability Standards Release 1.0 (Draft)* (National Institute of Standards and Technology: September 2009)

Interoperability Standards, Release 2.0.[73] The Framework comprises voluntary standards to be adopted by all Smart Grid stakeholders including utilities and suppliers, testing laboratories and certification organisations, and State government regulators. One of the important agencies that will continue to develop these standards is the Smart Grid Interoperability Panel which is a public-private partnership dedicated to continuing coordination, acceleration and harmonisation of standards for the Smart Grid.[74]

The two largest Smart Grid programs being managed by the US Department of Energy (DOE) are the Smart Grid Investment Grant (SGIG) program and the Smart Grid Demonstration Program (SGDP). The aim of the Smart Grid Investment Grant (SGIG) is to accelerate the modernisation of the nation's electricity transmission and distribution systems and promote investments in smart grid technologies, tools, and techniques that increase flexibility, functionality, interoperability, cybersecurity, situational awareness, and operational efficiency. There are currently 99 SGIG projects with a total budget of about $8 billion which have received federal financial assistance for up to 50% of eligible costs.[75] The Smart Grid Demonstration Program (SGDP) aims to demonstrate how a suite of existing and emerging smart grid concepts can be innovatively applied and integrated to prove technical, operational, and business-model feasibility. The aim is to demonstrate new and more cost-effective smart grid technologies, tools, techniques, and *system* configurations that significantly improve on those currently in use. SGDP projects are cooperative agreements with the DOE, whereas the Smart Grid Investment Grant projects are grants. There are two types of smart grid projects selected for the SGDP - regional smart grid demonstrations and

[73] Available at <http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf> accessed 30 July 2012
[74] Ibid at 9-10
[75] See <http://www.smartgrid.gov/recovery_act/overview/smart_grid_investment_grant_program> accessed 30 July 2012

energy storage technologies. The regional smart grid project seeks to verify smart grid viability, quantify smart grid costs and benefits, and validate new smart grid business models at scales that can be readily replicated across the country. The second includes energy storage technologies such as batteries, distributed applications, and the grid integration of renewable resources such as wind and solar power.[76]

Flood resilience measures for electricity infrastructure in the face of climate change

This chapter has identified the many climate change threats to electricity infrastructure and has suggested that a Smart Grid might prove to be an appropriate technological adaptation response to climate extremes and disasters. However, it is also appropriate to consider the adaptation responses that need to be adopted to try to protect existing and future critical infrastructure from climate extremes and disasters in the future. It is not feasible to identify the many legal responses required to facilitate adaptation responses to each type of threat to electricity infrastructure. However, it is instructive to learn from one of the most recent disasters to elucidate the vulnerability of electricity infrastructure to climate extremes - the 2010 Queensland floods. As indicated above, the Queensland Floods Commission of Inquiry's Final Report can be relied upon to provide some generic adaptation responses with respect to only one of the many types of climate extremes which might impact on electricity infrastructure. The Final Report highlights the need for electrical infrastructure to be more resilient, flexible and efficient to address the needs of vulnerable communities as a result of flooding linked to climate change.

[76] See <http://www.smartgrid.gov/recovery_act/overview/smart_grid_demonstration_program> accessed 30 July 2012

The Commission identifies two main reasons why the location of electricity infrastructure is vitally important in areas susceptible to flood.[77] In the first instance, existing infrastructure that cannot be viably moved to a more flood resilient site must be protected and second, as there is a statutory requirement to provide electricity supply, development in flood susceptible areas may be unavoidable.[78]

Before turning to the recommendations in the Final Report there are a number of preliminary, theoretical questions that arise for consideration in the context of climate adaptation law. Each deserves detailed treatment but is raised here to flag a number of important considerations for further research and discussion.

Governance, the law-making process, risk regulation and the precautionary principle

- *Coordinating multi-jurisdictional responses*

In most countries there are different levels of government, including federal, state and local, using different methods to mitigate and control damage from disasters. These include strategic land use planning, town planning, building codes and a range of engineering standards, warning systems, disaster responses and community education.[79] One of the questions that arises is whether it is desirable for a federal government, where it has constitutional authority, to attempt to mandate consistency across all jurisdictions with regard to flood adaptation responses. Where it lacks authority, should this be managed through a process of cooperative federalism such as exists the

[77] Queensland Floods Commission of Inquiry, above n 13 at 245
[78] Ibid.
[79] Diane U Keogh et al, 'Resilience, vulnerability and adaptive capacity of an inland rural town prone to flooding: a climate change adaptation case study of Charleville, Queensland, Australia' (2011) 59 *Natural Hazards* 699, 700

Australian Council of Australian governments, comprising the Federal, State and Territory governments? Is it even feasible with the borders of a state jurisdiction to require all local governments to adopt model flood adaptation provisions developed by the State government? Or are the geophysical and socio-economic components of each area so unique that model provisions would serve no purpose?

- *Questioning the efficiency of the law making process*

Another question when confronting adaptation to climate extremes and disasters is the law-making process. In the face of climate disasters should legislators remain bound by the procedures of Green Papers, White Papers, Bills, regulatory impact statements, draft Regulations and review by Parliamentary Committees? What is the role of public participation and notice-and-comment procedures? Does participation lose its place in climate change governance and knowledge formation when there is 'little time to make detailed projections or wait until better information is available'?[80] Or does it become even more crucial?[81] If flexible and responsive regulation is required to meet the demands of climate disaster risk management is a democratic deficit justifiable?

- *Do climate extremes and disasters require a new risk regulation and legislative response?*

It has been suggested that we have entered a new era in which human-generated catastrophic risks become normal, global in scale, seemingly unpredictable or at least

[80] Nick Pidgeon and Catherine Butler 'Risk analysis and climate change' ((2009) 18(5) *Environmental Politics* 670 at 670
[81] Pidgeon and Butler suggest that an analytic-deliberative process might be preferable; ibid at 681

highly uncertain. In this view, traditional means for governing risks, ranging from insurance and conventional expertise through to the nation state, cannot deal with these new problems. Entirely new political and legal forms are required to govern this environment. [82] Does climate change elucidate some of the very characteristics that render conventional risk analysis tools problematic'[83] and demand a regulatory agenda 'that is far more ambitious and radical than anything risk regulation has needed to contemplate up to now?'[84] Risk regulation typically substitutes acceptable risk for unacceptable risk by delineating to discrete manageable segments an otherwise 'amorphous totality of risks.[85] Risk governance responsibility is then individualised, while actual regulation is preceded by information gathering, classification and risk assessment so justifying the regulatory activity and delineating decision-making authority to responsible agencies and individuals.[86] In the context of climate change, the stabilising yet cumbersome and time-consuming law-making process must become agile, flexible and responsive. Yet with climate risks, the regulator is faced with indications of possible harm, even catastrophic harm, yet insufficient data to conduct a 'proper' risk assessment.[87] How can legislation facilitate decision-making in this context?

- *Should climate adaptation and disaster laws adopt a Catastrophic Harm Precautionary Principle?*

---

[82] See Heyvaert V. 'Governing Climate Change: Towards a New Paradigm for Risk Regulation' (2011) 74(6) *The Modern Law Review* 817 at 835
[83] Pidgeon and Butler above n 96 at 671
[84] Hayvaert above n 98 at 835
[85] Ibid at 820
[86] Idem
[87] Idem

Integral to a new risk management framework for dealing with climate extremes and disasters are concerns about making decisions in the context of 'uncertainty' rather than 'risk'.[88] Environmental Law, especially planning and assessment legislation, is a body of law which emerges as being particularly helpful in trying to enhance the resilience of electricity infrastructure. Yet in this area risk discourse has proliferated as a means of framing and managing potential threats, particularly in the area of environmental impact assessment.[89] Faced with 'uncertainty' about the 'risks', the precautionary principle,[90] found in all Australian environmental statutes, holds that 'if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.' Does catastrophic risk[91] require a different approach? Should a Catastrophic Harm Precautionary Principle be adopted which holds that 'In deciding whether to eliminate the worst-case scenarios under circumstances of uncertainty, regulators shall consider the losses imposed by eliminating that scenario, and the magnitude of the difference between the worst-case scenario and alternative scenario?'[92]

Learning from the 2010 Queensland floods

- *Floodplain management*

[88] See, for example, Sunstein CR, 'The Catastrophic Harm Precautionary Principle' in Farber and Faure above n 7 at 141
[89] Pidgeon and Butler above n 96 at 671
[90] See Rosemary Lyster and Eric Coonan, 'The precautionary principle: a thrill ride on the roller coaster of Energy and Climate Law' (2009) 18(1) *Review of European Community and International Environmental Law* 38; Rosemary Lyster, 'The Relevance of the Precautionary Principle: Friends of Hinchinbrook v Minister for the Environment' (1997) 14 *Environmental and Planning Law Journal* 390-401. Godden L. and Peel J., *Environmental law: Scientific, policy and regulatory dimensions* (1 ed, 2010); Peel J. *The precautionary principle in practice: Environmental decision-making and scientific uncertainty* (1 ed, 2005)
[91] See Viscusi and Zeckhauser above n 3
[92] Sunstein above n 104 at 165

The Queensland Floods Commission of Inquiry made a number of recommendations regarding floodplain management which translate easily into generic recommendations in other jurisdictions, with the obvious proviso that similar legislative framework exists and there is capacity to adopt the recommendations. The Commission recommended that a recent flood study of the most flood-affected catchments and of all urban areas in the State should be initiated and made available. The flood study should be comprehensive and collate or create data on: rainfall data; stream flow data; tide levels; inundation levels and extents; data on the operation of dams; and river channel and floodplain characteristics.

Suitable hydrologic models should be produced and validated. A suitable hydraulic model should also be produced which is able to determine flood heights, extents of inundation, velocities, rate of rise and duration of floods.[93] Local councils should keep these studies up-to-date. The body conducting a study should consult with surrounding councils and others to check whether they are doing any work that might assist with the development of the study. Elected council representatives should be informed of the flood study so they can consider its consequences for land use planning and emergency management.[94] The data used in flood studies should be maintained in a repository so that all levels of government and dam operators can access it. Councils with requisite resources should develop floodplain management plans, and, where development is expected to occur, they should develop flood behaviour maps which indicate at least three 'zones of risk'. Where they lack resources, they should develop a flood map which shows at least three examples of the likely extent of flooding. Similar

[93] Above note 13 at 12
[94] Ibid at 13

recommendations are made for non-urban areas where limited development is likely to occur. Where no assessment of the likelihood of flooding has been done, councils should inquire into whether a development site could be subject to flooding.

The State government should ensure that all councils have sufficient guidelines for understanding best practice in the performance of flood studies and the production of flood maps. All flood mapping should be displayed on council and government websites and property specific information should be available to the general public, including by searching an online database. Prospective purchasers should be alerted to the risk of flooding including by standard contract conditions drawn up by the Real Estate Institute of Queensland and the Law Society of Queensland.[95]

- *Local planning instruments*

The Commission recommended that the State government should draft ‘model flood planning controls’ that councils can adapt for local conditions and it should require these controls to be reflected in new planning schemes. The government should include in the controls a model planning scheme policy and a requirement that councils have a flood overlay map in their planning schemes.[96] These should be included by local councils even if the Queensland government does not require them. A flood overlay map should identify the areas that are: known to be affected by flood and on which council can impose different planning controls; and areas for which there is no flood information available. Assessment criteria relating to floods should be consolidated by councils in their flood overlay codes. Councils should be allowed to amend planning

[95] Ibid at 14
[96] Ibid at 15

schemes to update flood mapping information by way of the minor amendment process as long as adequate public consultation has occurred.[97]

- *Development assessment in practice*

Local councils, as development consent authorities, should maintain flood maps and overland flow maps for use in development assessment which should also be made available to the applicants.[98] Whether or not this is included in a model planning scheme policy, councils should require stormwater and flooding information to be included in development applications (DAs). Information should be provided to development applicants either at pre-lodgement meetings, or at the time of receiving the DA, about how flood risks will be assessed.[99]

- *Floods and electricity infrastructure*

The Queensland Floods Commission of Inquiry made very specific recommendations regarding planning for climate change adaptation and risk reduction for the electricity sector.[100] These recommendations are generally related to new development of infrastructure.

First, the State government should draft assessment criteria to be included in the 'model flood planning controls' which require substations to be built to remain operational during and immediately after a flood of a particular magnitude. That

[97] Ibid at 16
[98] Ibid at 19
[99] Ibid at 20
[100] Ibid at 246

magnitude should be determined by an appropriate risk assessment.[101] If substation development is captured during the planning stage this will allow for better locational planning, which will provide better placement of such infrastructure. In some cases, build infrastructure to withstand the probable maximum flood would be prohibitively expensive.[102] Government, in consultation with the community, should determine the magnitude of the flood that the infrastructure should be able to, and a risk assessment should be conducted to determine that level.[103] This risk assessment should be done when 'model flood planning controls' are being tailored to take account of local circumstances. Once the magnitude of the flood level has been chosen, steps should be taken to make the infrastructure resilient to it.[104]

Secondly, if 'model flood planning controls' are not developed by the State government, local councils should nevertheless require in their local planning schemes that substations are built to remain operational during and immediately after a flood of a particular magnitude.[105]

Thirdly, electricity distributors should consider installing connection points where generators could be installed so as to provide electricity supply to non-flooded areas that have had their supply cut during floods. This would help to ensure that where supply has been cut, places further down the line that may be unaffected by flood, can quickly regain supply of electricity.[106]

Fourthly, the State government should consider whether there should be a legislative requirement that customer dedicated assets be built at or above the applicable

[101] Ibid.
[102] Ibid.
[103] Ibid.
[104] Ibid.
[105] Ibid
[106] Ibid

defined flood level and if so, which piece of legislation within the panoply of environmental and electricity infrastructure legislation should contain such a requirement.[107] A guideline produced by the Queensland Reconstruction Authority (**QRA**) proposes that in new high rise buildings electrical equipment should be raised and located out of flood, which may exclude basement locations in some areas. This will improve resilience against flooding.[108]

Finally that the State government should consider implementing mandatory requirements to ensure the sealing of all conduits for the purpose of providing electrical supply below the applicable defined flood level to prevent floodwaters from entering them or flowing into them.[109] This is because electrical connections are supplied through this cabling to commercial and industrial premises with the cables running from the footpath through conduits to the substation inside customer's premises.[110] During the floods, water entered buildings via conduits,[111] which form part of shared network infrastructure cabling. Precautionary disconnections were made to ensure the safety of human life and to reduce damage to electrical infrastructure down the line.[112]

Currently Energex's (one of Queensland's major utilities) manual for commercial and industrial substations, requires the conduit to be sealed to prevent the ingress of dirt but not water or water under pressure. However, after new products are trialled, it is intended to update the manual by mid 2012.[113] In addition, Energex is working with the owners of basements to have existing conduits sealed as it believes building owners are responsible for the location, design, installation and maintenance of electrical

[107] Ibid at 248
[108] Ibid at 247
[109] Ibid at 249
[110] Idem
[111] Ibid at 248
[112] Ibid at 241
[113] Ibid at 249

conduits.[114] A draft standard relating to the waterproofing of conduits and cabling for buildings in flood hazard areas is anticipated to be included in the 2013 edition of the Building Code of Australia.[115] Nonetheless, there must be clear guidance and understanding of who has the responsibility to ensure conduits to basements are flood proofed. At present building owners are responsible for maintenance and design; however, the electricity distributor has the expertise to safely and effectively provide sealed conduit, so the Commission found that the electricity distributor should also have responsibility.[116]

- *Utilities adopt flood resilience measures ahead of regulation*

Following the Queensland floods, the two major electricity utilities, Energex and Ergon Energy, have proposed voluntary flood resilience measures. These measures are not currently mandated in legislation. Ergon Energy, for example, has revised flood level standards for setting up new zone substations and bulk supply.[117] New zone substations are to be built at or above the 0.5 percent annual exceedance probability[118] (AEP) flood level and any infrastructure that would be below this level is now to incorporate flood resilience measures to ensure supply is maintained during and immediately after a flood.[119] Ergon Energy also proposed that if a flood height is not mapped for an area where a new substation is proposed then it will undertake a hydrological assessment

[114] Idem
[115] Idem
[116] Idem
[117] Ibid at 244
[118] Bureau of Meteorology, Australian Government, *Australian Water Information Dictionary*, <http://reg.bom.gov.au/water/awid/id-703.shtml> (definition of 'annual exceedance probability').
[119] Above n 13 at 244

performed by an external consultant.[120] Ergon Energy also reported that although local authorities do not advocate above ground overhead assets in new urban developments, it believes that these are more flood resilient than the preferred underground or on ground assets.[121]

Conclusion

The Intergovernmental Panel on Climate Change's latest scientific report entitled *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (SREX Report) draws the international community's attention to impacts of climate extremes on electricity infrastructure. It also analyses the economic costs of adaptation measures and global and regional climate disasters, implications for development, recovery and reconstruction, and technologies for extreme events. It seems that now is the time for governments to have a cooperative and transparent debate on the implications of climate change and the energy sector.[122] Governments across local, state and federal levels have an important role to play in adaptation to climate change. These roles include government as an adaptor; as a catalyst and facilitator; as intervener or rule setter[123] as they have the ability to facilitate collective action, setting rules and guiding behavioural patterns that shape social interactions.[124] There is a need for a shared responsibility between all stakeholders to build resilient communities. This includes moving forward by planning development that includes legislative changes and linking pieces of legislation for cohesive controls and regulations across all levels of

[120] Idem
[121] Idem 244
[122] Ian Bailey, 'Australian climate politics 2010' (2011) 110 *Arena Magazine* 32, 35
[123] Brent C Jacobs, Peat Leith, 'Adaptive capacity for climate change: principles for public sector managers' (2010) 23 (July – September) *Public Administration Today* 49 at 51.
[124] Ibid at 55.

government. Specifically, governments must ensure essential services, such as electricity infrastructure, are provided and protected, adequate legislation and policy instruments are coordinated, land use planning instruments and building codes support disaster resilience, disaster risks are negotiated and determined, and communities educated for awareness.[125] Likewise business and communities have a responsibility to work with government to build resilience to understand risk, be prepared and responsive. Building disaster resilience is a shared responsibility.

Continuity of electrical supply is essential in managing the severity of effects during and after flood events. This can be facilitated by new technologies such as the Smart Grid concept. New technology built into existing systems and used to replace aged infrastructure has the potential to improve safety, reliability and efficiency of the current inefficient supply of electricity. Moreover, utilisation of new technologies including alternative sources of electricity generation has the potential to mitigate the effects of climate change in reducing greenhouse gas emissions while at the same time addressing adaptation needs. There are many dynamic, often interrelated factors that influence exposure and vulnerability of human populations and natural ecosystems to extreme events. Moreover, individual communities are unique and often require site specific consideration. Disaster risk management coupled with quality infrastructure reduces exposure and vulnerability and improves resilience. It is imperative that decision makers at all levels understand these factors and associated disaster risks to inform appropriate disaster risk management and integrate them into climate change adaptation strategies. Furthermore, there is a necessity for legislation to support and

[125] Queensland Reconstruction Authority, 'Rebuilding a stronger, more resilient Queensland: The capacity to prepare for, withstand, respond to and recover from disasters' (Paper, Queensland Government) 32 http://qldreconstruction.org.au/u/lib/cms/Resilience-doc.pdf accessed 1 August 2012

facilitate flexible, resilient and efficient provision of electricity infrastructure to protect and empower vulnerable communities.