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Governance supporting distributed energy systems for low carbon urban development

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Abstract: Global change is required from a strong dependency on high consumption and carbon intensive economies to reduced consumption and low carbon society construction. Cities can offer an enormous contribution to the reduction of carbon emissions; however this process requires a certain degree of rethinking and redesigning of our cities including, infrastructural restructuring with network patterns and resource flows that foster low carbon urban development.

Distributed systems that support low carbon urban development including, decentralised power, water, waste and transport are becoming popular as a viable alternative or complimentary addition to centralised city services. However, the emerging decentralised systems pose a unique set of risks and this is generating new modes of governance at national, regional and local.

The growing interest in distributed energy systems and the parallel transition that is occurring towards multi-level governance, which can support such schemes, will be examined in this paper. A framework will be used to characterise the different governance structures being used to implement decentralised services; and this study will examine how such approaches promise to facilitate delivery, operation and ownership of distributed city services. An assessment will also be made on a series of economic models and business partnerships that are emerging that offer viable structures to manage distributed energy systems in cooperation with local government utilities, investors and corporate entities.

This research will investigate how certain regulatory barriers to centralised energy systems can be overcome to allow for large-scale implementation of distributed energy options. The possible governance strategies will be demonstrated with reference to some international and national case studies including Woking and London in the UK and Sydney in Australia, which best exemplify the distributed energy systems' model and the success factors and barriers for its implementation.

Finally, the study will discuss the opportunities, challenges and risks that exist for Australia in adoption of such governance schemes, and it will suggest areas where future governance investigation could enhance sustainable planning and development in Australia.

Keywords: *Climate change, distributed, energy, governance, infrastructures*

1. INTRODUCTION

Global change is required from high consumption lifestyles and carbon intensive economies to a society with significantly reduced carbon dioxide (CO_2-e) emissions, increased resource efficiency and security and improved lifestyles. Local municipalities are exploring various carbon reduction strategies to achieve low or even zero carbon urban development that offers a higher quality of living. Urban governance is also concerned with building the capacity of cities to withstand changing climate by increasing the physical resilience of urban infrastructures (McDaniels et al. 2007). One approach gaining increasing attention is the redesigning of low-carbon city centres with distributed infrastructure networks and resource flows that foster community resilience and improved energy, water and waste services (Biggs et al. 2008; Ren and Gao 2010).

Distributed energy options including distributed generation, peak management and energy efficiency measures offer a viable alternative to centralised generation systems (Ren and Gao 2010). Centralised production relies on extensive infrastructure to transport energy and water lengthy distances in a linear and isolated manner; this is wasteful because of line losses and power shedding (Newman 2009). Distributed power and water systems are tailored to match localised demand and resource availability. Small-scale generation close to load creates significant efficiencies, allowing in the case of distributed energy the recovery of heat, otherwise wasted (CSIRO 2009). The system resembles more closely the circular metabolism approach of natural ecosystems that use outputs of various processes as inputs for others (Jones 2008).

In Australia, there is a significant role for distributed energy services in achieving carbon emission reduction targets. Recent reports suggest cogeneration technology could provide a 20% reduction in electricity demand over a 15-year period (Nous Group 2007). Yet, minimal policy has been put in place to realise this value. Since privatisation, government has been reluctant to intervene in an energy market established for large, centralised utilities (Thompson 2008). However, opportunities provided by new technologies and the pressures of climate change are prompting local authorities to explore alternative ways to provide energy.

The emergence of distributed infrastructure systems poses a unique set of challenges for its implementation and management and these are generating new modes of multi-level governance at national, regional and local level (Gough et al. 2008). This study examines the emerging shift towards distributed energy systems and the parallel transition that is occurring towards decentralised forms of governance to support climate change strategies such as, low carbon urban development. An examination of several case studies of cities in this paper will demonstrate certain trends of governance emerging that have significantly impacted the establishment of distributed services and dramatically reduced carbon emissions.

2. URBAN ENERGY INFRASTRUCTURE SYSTEMS

2.1 Role of Infrastructure for Low Carbon Urban Development

The dynamics of urban infrastructure systems can be understood rather than simple physical entities but as 'socio-technical regimes' that while facilitating large resource flows also contribute immensely to environmental problems such as air, water and soil pollution and global warming. Infrastructure networks shape urban settlement, mobility, construction engineering and technology innovation. They thus play a significant role in socio-ecological issues like climate change and therefore urban governance needs to recognise their impact on carbon emissions and consider restructuring infrastructure in its carbon management strategies. Although infrastructure systems have substantial implications for urban governance, until recently, they have attracted little attention in contemporary governance studies (Monstadt 2009).

2.2 Centralised and Distributed Energy Systems

Conventional centralised electricity in cities relies on coal-fired power for its generation and is the largest contributor to the build-up of carbon emissions in the atmosphere. It is extremely inefficient as 2/3 of the energy generated as heat is rejected as steam through cooling towers or water-cooling systems (Jones 2007). A further 9% loss of energy occurs in the grid transmission (2%) and distribution (7%) networks so that less than 33% of the energy delivered is consumable energy (Jones 2008). These energy systems are inherently inflexible and can be easily damaged (Biggs et al. 2008). A disruption in one area cascades into impacts on other areas (Cutter et al. 2008) and therefore they are particularly vulnerable to climate-related catastrophes (Vogela et al. 2007) or even terrorist attacks (Newman 2009).

Decentralised energy services are connected to the distribution network not the national grid transmission network. They typically involve combined heat and power (CHP or cogeneration), combined cooling, heat and power (CCHP or trigeneration), renewable energy and fuel cells. This system avoids grid losses by generating and supplying electricity nearby consumer loads and using the recovery of waste heat from power generation to provide additional heating, hot water and cooling services to customers rather than just electricity. This scheme results in up to 90% efficiencies (Jones 2008) and provides value to customers whilst enhancing the financial viability of decentralised energy (Walsh et al. 2010). The threat of climate change along with national security is influencing governments to consider distributed energy systems as a viable alternative because they offer structural robustness, low cost, reliable operation and significant carbon reduction opportunities (Yazdani and Jeffrey 2010).

2.3 Barriers to Distributed Energy Services

The cost for decentralised energy services is very different from licensed central energy schemes because distributed services are delivered via the retail of heating, cooling and electricity directly to customers, which provides access to a higher price per unit above sale into a wholesale market (Thompson 2008). Since distributed energy services involve a different energy market a unique regulatory status should be provided (Jones 2007). However, current market barriers and high costs all deter development in decentralised energy schemes and disadvantage their potential for achieving carbon reduction goals (Jones 2007).

New governance approaches are required such as, electricity regulatory and licensing systems to allow medium and larger decentralised CHP or CCHP schemes to participate freely in the energy market. Markets function at their optimum when they remain competitive without barriers to entry for new entrants within the market and with prices and quantities traded that reflect supply and demand conditions (ESAA 2009). Establishing incentives in the regulatory system for innovation and the introduction of new 'smart grid' technologies will assist network service providers to better manage distributed energy generation (ESAA 2009).

3. GOVERNANCE

3.1 Multi-level Governance (MLG)

The term 'governance' refers to an approach or perspective to examine issues relating to the governing process (IEA 2009). Governance perspectives are no longer based on hierarchical, authoritative and linear control but new governing processes are concerned about flexibility, decentralization and networked specialization (Metzl 2001). Governance literature is interested in the flexibility of social systems to deal with changes; openness of institutions to provide broad participation of different actors; effectiveness of individual actors to interact at varying scales; social structures that promote learning and adaptability without limiting options for future development (Bulkeley and Betsill, 2005; Walker and Salt, 2006). In this study, multi-level governance can be understood as the complex system of interactions between actors at all levels of government, engaged in the exercise of authority (IEA 2009).

This emerging shift towards a multi-layered and cooperative style of governance has parallels to the increasing preference for a distributed systems approach to energy infrastructure networks rather than centralised electricity generation (Briggs et al. 2008). For example, in a distributed model, more actors are employed at a local level and as specialised 'niche' operators rather than generalised; agents are situated within networks of resource and information exchange rather than isolated and hierarchical; and this reflects a system of co-dependency that links diverse organisations and increases the potential for improved mutual learning, cooperative management and innovation (Briggs et al. 2008). Coordinated action between multiple levels of government can help with improved access and implementation of distributed energy systems (Alber and Kern 2008)

3.2 A Framework for Analysis of Governance Strategies

A framework can be useful to characterise the different styles of governance being applied by municipalities to implement climate change measures (Bulkeley and Kern 2006). This paper will use the following framework to examine the governance options used to implement distributed energy schemes in the below case studies:

a) **self-governance** is the capacity of local government to manage its own actions, it relies on institutional innovation and strategic investments such as, the purchase of energy-efficiency appliances for municipally owned buildings;
b) **governing through enabling** involves local government establishing partnerships with the private and voluntary sector and encouraging community engagement for example, coordinating public education campaigns for energy efficiency;
c) **governing by provision** occurs through the provision of services and financial resources by national government in return for local action such as, grants for energy-efficiency measures;
d) **governing by authority** requires national intervention in local politics through regulation and the use of sanctions such as, issuing ordinances on mandatory use of renewable energy (Alber and Kern 2008).

3.3 Governance Finance Models and Partnerships

Historically, in Australia and internationally local governments have held significant roles in utility provision. Local government municipalities were often in the best position to expand local infrastructure networks, thereby ensuring public access and regulating prices. Now days these services are mainly administered by state owned utilities that control resource delivery to customers. However, internationally there are some municipal ownership models in existence which continue to allow for effective operation and administration of decentralised energy systems, which balance social, economic and environmental factors in the public interest. Furthermore, deregulation of electricity markets over the past 15 years has led to some municipal utilities being operated by the private market (Walsh et al. 2010). A variety of economic models and business partnerships exist that provide viable structures to establish and manage decentralised energy systems, these will be highlighted in this study in the below case studies.

4. CASE STUDIES

4.1 Borough of Woking, UK

The Borough of Woking in the UK has succeeded in removing the entire community off coal-fired grid by installing a small district electric and heating utilities based on cogeneration. Over a period of 14 years, 81 cogeneration and trigeneration units were established and connected over a 'private wire' system to provide economically viable, efficient and resilient electricity, heating and cooling services to resident. Through the UK Electricity Order 2001, the Council was permitted to generate, distribute and supply electricity directly to customers at economical rates (Jones 2010). Governing through enabling modes prompted the local government to establish partnerships with the private sector to finance a revolving fund for CHP schemes, these delivered sufficient energy gains for savings to be reused as revenue for other energy efficiency and renewable energy projects. Importantly, the Council's strategy did not rely on government funding to initiate action and used local investment (seed funding) to build-up capacity as a framework for long-term investment and action in carbon emission reductions. By establishing its own municipal utility the local government could set rates to ensure customers experienced immediate savings over the previous system, which generated community support for more decentralised utilities' projects.

Further public/private joint ventures with Denmark's Energy Services Company (ESCO) Thameswey Ltd and Thameswey Energy Ltd provided greater resources to increase the scale of generation by tenfold and assist in management of the utilities. The ESCO provided the framework to build, finance and operate small-scale CHP facilities of up to $5MW_e$ electricity output (Walsh et al. 2010). Under an enabling agreement for exempt supplier operation with EDF Energy, the interconnected infrastructure, buildings and thermal networks could exchange energy across the distributed generating sites in a shared local electricity trading scheme, which involved an advanced building energy management system (BEMS) to control the system (Jones 2010). Through a combination of enabling and self-governing modes such as, energy efficiency measures undertaken in council-owned buildings, Woking reduced carbon emissions by a staggering 80% in 2007 compared to 1990 base-level emissions and achieved cost savings of nearly £4.9m (Jones 2010). Self-governing was relatively easy for the Woking municipality as it owns and operates most local government buildings and can therefore exercise power over its technology choice decisions and consumption.

4.2 London, UK

Woking's role in pioneering a path for decentralised energy within UK's privatised energy market inspired action across London. Similar to Woking, London could distribute and supply electricity to consumers through the UK Electricity Order 2001. However, regulations restricting CHP connection to only 1,000 households were unsuitable for London's high density. It is more cost and energy efficient to install larger CHP and CCHP, multi-utility schemes (including electricity, heating, cooling, air-conditioning, water supply, data and telecom) than small facilities restricted to individual buildings (Carr 2007). These regulations and high costs to decentralised energy within the UK electricity market and licensing arrangements created barriers for installation of London's site wide approach.

In 2006 London used enabling governing modes to initiate a joint venture ESCO with the London Climate Change Agency (LCCA), for private sector finance, and with EDF Energy, a major UK energy company with significant experience in delivering energy services, to develop a large-scale decentralised energy plan (Jones 2010). London's joint equity project meant their partners could share their risk and the local government could benefit from the private sector energy and finance expertise, as well as reduce the municipal's capital requirement. Together with the LCCA and the Major of London enabling tools of persuasion and joint lobbying were used to apply pressure for a reviewal of barriers. In addition, a Working Group in 2007 was formed. These tactics resulted in the emergence of a new supply licence that permitted decentralised generators to operate above the public wires distribution network instead of the transmission network and thereby, avoid the nationalised centralised electricity market (Jones 2010). In 2009 existing supply licences were changed through the UK energy regulator Ofgem, to permit licenced utilities to work with distributed energy generators in an electricity trading system that balanced imports and exports between sites. Eighty-one decentralized energy plants across London could exchange surplus electricity with standby and top up energy groups (Jones 2010). Ofgem also introduced a cost reflective charge in 2010 to account for the short distances travelled by electricity via distribution networks compared with grid electricity (Jones 2007). London now uses a combination of 53% decentralized energy and 47% large scale renewable energy in its bid to achieve the 60% reduction in carbon emissions by 2025 target that is proposed in the Mayor's Climate Change Action Plan (Jones 2008).

4.3 Sydney, Australia

Australia's City of Sydney has adapted aspects of Woking and London's approach to overcome its own barriers to decentralised services. Nearly 80% of Sydney's carbon emissions originate from centralized coal-fired energy generation and this stationary sector is also the source of the most cost effective carbon emission reductions. In the past co or trigeneration schemes in Australia have been established merely on a base load approach to gain Green Star accreditation or limited due to perceived risk and a lack of understanding on how to maximize the potential of such technology. Traditionally, the New South Wales (NSW) non-regulatory barriers to distributed energy generation included unreasonable technical requests and high connection costs that were disproportionate to the size of the decentralised energy schemes for connection to the distribution network. These barriers discouraged users and NSW lacked the necessary regulations to avoid anti-competitive conduct by distribution network operators. An alternative framework and legal arrangement was needed to achieve Sustainable Sydney's 2030 targets and this required the municipal enterprise to 'lead from the highest level, provide transparency of purpose and generate confidence in the private sector'. Although Sydney lacked the same statutory powers of the Mayor of London, the City could still establish its own planning and development strategy as an enabling government tool to incite public discussion and motivate change. Local government enabling modes were used to coordinate meetings between the NSW Departments of Energy, Climate Change and Water and the Premier's Office to discuss regulatory barriers. Further enabling measures created a Working Party to apply increasing pressure for action (Jones 2008).

Sydney established a locally authority owned company led by the Lord Mayor, called the Sydney Climate Change Agency Ltd (SCCA) to deliver climate change projects through public/private joint ventures and reinvest returns into the business instead of allocating profits to the public sector. Establishment of this municipal company allowed the City to form an ESCO with the subsidiary Energy Australia and enable trade and supply of electricity over the public wires network as 'virtual private wires' at retail prices. Even though distribution use of system (DUoS) charges still applied for Energy Australia, the sale of electricity at retail prices meant its value increased by 400% (Jones 2008). Therefore, the issue of potential loss of DUoS income for Energy Australia was overcome. The City is now able to retain considerable control at relatively cheap capital for the ownership of the ESCO through a subsidiary.

As part of a 'macro-decentralised' approach, Sydney is installing a network of co and trigeneration, waste to energy plants and water treatment called the 'Green Transformers' to provide localized electricity, heating and cooling, as well as recycled water services. The scheme will trade electricity across the local distribution networks through 'virtual private wires' and incorporate monitoring and control systems, such as Building

Energy Management Systems, monitoring and targeting software and metering, to provide a ‘smart grid’ approach (Jones 2010). Other multi utilities such as electricity, potable water, non-potable water, open access or broadband and even sewage and drainage systems can be integrated into this macro system. Such an approach lends itself to a multi utility service company (MUSCO) arrangement (Jones 2008). This network is estimated to supply 330MWe of power by 2030, which is 70% of Sydney’s required electricity, reduce 20% GHG emission, and provide thermal energy to 36% dwellings and 43% non-residential buildings. When combined with renewable energy supplies, Sydney could completely relinquish its coal-fired power dependency (Jones 2010).

5. DISCUSSION and CONCLUSION

This study has explored some of the opportunities available for distributed energy systems by reviewing case studies of existing and proven developments, which have all brought together important governing elements. The majority of actions taken appear to concentrate on self-governing and enabling modes in which municipalities have the most decision power. Modes of authoritative governing were less obvious as the municipalities seemed reluctant to exercise legal power through firm regulation and strategic planning. Whilst modes of governing through provision did not appear perhaps due to the liberalisation of energy markets (Alber and Kern 2008). Crucial to their achievement has been effective policies, government leadership, application and integration of technology, sound economic models and an engaged community.

Benefits of local ownership and operation of utilities and the provision of district energy services to the community have been shown in each of the case studies. Woking’s joint equity partnerships through the Thameswey Ltd ESCO provided not only investment in exchange for an ownership share of the project but also the finance and expertise of the private sector to implement district scale renewable energy projects. London demonstrated the capacity to look beyond immediate, bottom-line considerations and balance investment return with customer rates to improve infrastructure development and dramatically cut carbon emissions. Whilst identification and removal of specific deterrents is critical, the UK experience demonstrates the value in cohesive and proactive policy settings.

In Australia, there have been a series of processes to assess regulatory and market-pricing barriers to distributed generation at the National level. Recent policy developments surrounding carbon mitigation are providing greater financial incentives for distributed energy applications, as well as a much-needed review of regulatory constraints. The likelihood of a carbon price being integrated into electricity costs in Australia is stimulating interest in decentralised energy projects. Some of the opportunities available have been discussed in this report, including the prospect for Sydney of local government ownership and operation of utilities and providing district energy (e.g. heating, cooling and electricity) services to buildings in the community. However, in Western Australia (WA) significant reforms are still required for its complex regulatory framework. Currently, the entire WA model is outdated and based on conventional, centralised generation and distribution of electricity so it needs to needs to be modified to better accommodate embedded generation options (WASEA 2009). An energy market is needed in WA that is open and competitive with improved network regulations and less barriers for admission especially for smaller scale distributed generation (WASEA 2009). For example, tariffs are not cost reflective and a distributed service provider receives no financial reward for deferring capital infrastructure (WASEA 2009). Building incentives within WA’s regulatory regime for new ‘smart grid’ technologies will improve management of increased distributed energy generation (ESAA 2009).

The key lesson from all these case studies is that, freed from the complexities of centralised infrastructure, distributed energy services such as, co and trigeneration can realise their profitable potential for building capacity for long-term investment in carbon emission reductions to achieve major carbon abatement, increased local energy security and community resilience to climate change at cost savings for local government and residents.

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