Integrated Renewable Energy Infrastructure - Challenges And Opportunities

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Abstract—**Traditional approach to the sustainable built environment focuses on the passive design and energy efficient heating and cooling technologies. Most of the green building rating systems reward buildings with integrated renewable energy power generation, such as building integrated photovoltaic (BIPV) or wind power. Experience indicates that while such initiatives can be justified by achieving the desired rating outcome or a demonstration of the owner's commitment to sustainability, rarely they can be justified from the commercial point of view. In many cases such initiatives begin to be seen as a cynical attempt at scoring points rather than demonstrating efficient design or environmental sustainability. While renewable energy generation is undoubtedly the right way for the future, the commercially viable strategies for integrating them with the built environment receive much less attention. It seems that the renewable energy sector and the built environment sector have not yet developed a framework for the integration of the two, both on the technical, commercial and legal levels. Smart grids can provide partial solution to such integration. The proposed renewable energy infrastructure consists of the distributed sources of renewable, or low emissions, power generation and also include thermal storage component designed to offset adverse effect of thermal, and electrical, demand fluctuations of buildings due to ambient temperature variations. The paper provides examples of integration of GeoExchange infrastructure with different sources of distributed, renewable energy generation. The paper also discusses some of the key commercial and technical challenges related to the integrated renewable energy infrastructure. The paper discusses some of the opportunities and challenges of integrated approach to the development of precinct scale sustainable built environment and its supporting renewable energy infrastructure. It also proposes a two-tier sustainability rating system which aims to encourage integration of renewable energy resources with urban design.**

Keywords- Reknewable energy; district energy; sustainable precincts; green building;rating schemes.

I. Progress on Climate Change Policy to Date in Australia and the Role of the Building Sector

Renewed awareness on climate change driven by global protocols and climate change summits are driving governments to set standards for environmental governance. The Australian federal government has currently committed to a 25% reduction in Green House Gas (GHG) emissions from 2000 levels by 2020 [1]. In order to deliver these targets the government has proposed options for the implementation of a carbon price in Australia and renewable energy targets where the federal government aims to deliver 20 per cent of Australia's electricity supply from renewable sources by 2020 [1].

As energy use by buildings (residential and commercial) accounts for approximately 20 per cent of Australia's greenhouse gas emissions [2], the introduction of stricter energy efficiency standards mandated through the Building Code of Australia (BCA) 2010, proposed new mandatory disclosure provisions and fiscal incentives such as the Green Building Fund and Renewable Energy Bonus Scheme aim to reduce GHG emissions from the building sector. Furthermore, sustainability agendas and environmental stewardship is now embedded in many corporate policies, which then influence decisions to incorporate sustainability principles into new development and buildings.

Using building environmental assessment methods such as Green Star, BCA (Building Code of Australia) FirstRate, NABERS (National Australian Built Environment Rating System) and LEED (Leadership in Energy and Environmental Design) provides third-party verification that a building was designed and built using strategies aimed at improving performance across environmental metrics: water efficiency, CO_2 emissions reduction, improved indoor environmental quality and materials stewardship. In this context there is an opportunity for environmental rating systems to encourage and promote renewable energy and other sustainability infrastructure as an integral part of the sustainable built environment.

The aim of this paper is to discuss and develop the idea of district level sustainability infrastructure as a driver for full integration of renewable energy resources with urban design. In creating a discourse around this concept the paper is structured as follows: Section 2 argues that large scale sustainable infrastructure such as renewable energy, co/tri-generation and recycled water should be provided at a district network level such that individual buildings can tap into these resources rather than the building itself having to provide these costly and complex systems and services to meet its sustainability objectives or green building rating system criteria. This is illustrated by examining the provision of GeoExchange Infrastructure (GXI) as a means of precinct, or subdivision, scale integration of renewable energy storage, generation and distribution with the built environment. Section 3 presents the case study of vicurban@officer to illustrate the financial viability of coupling district level sustainable infrastructure with individual high performance passive building design. Section 4 discusses the potential for resource sharing between buildings connected to a district infrastructure network. Section 5 presents an argument for a two tired green building rating system; where the buildings passive design elements are assessed separately to its large scale active sustainable systems such as renewable energy and recycled water which, have a strong correlation to the urban infrastructure. Finally Section 6 examines the role of the local government in driving these sustainable district level infrastructure networks.

II. RETHINKING OWNERSHIP AND PROVISION OF SUSTAINABLE AND REKNEWABLE BUIDING SYSTEMS AND SERVICES

The stakeholders involved in the design, construction, operation and use of sustainable buildings are the building developer and operators, owners and occupants, local councils, planning and regulatory agencies, the local community and the commonwealth government. All these stakeholders interact with the building on different levels. Starting at the level of commonwealth government, the sustainable features of the building and its reduction in resource use contribute to the overarching commonwealth resource minimisation targets and environmental objectives. To the local government or planning and regulatory body, the building represents progress made in the community in recognising and promoting environmentally sustainable design as the resource use within that community is reduced. At the level of local government the availability of sustainable infrastructure and the level of urban environmental governance within the local community both complement and drive the sustainable aspects of the building. For the developer/operator the sustainability of the building presents a marketing opportunity; to raise the developer's community profile, showcase the developments sustainability credentials and increase return on investment. However the implementation of individual building scale sustainable services which, is required for higher levels of "environmental performance" such as renewable energy systems, co-gen, tri-gen, and grey/blackwater treatment systems often involve a high cost premium. This can sometimes be a deterrent in the desire to pursue sustainable design especially adopting voluntary green building rating scheme assessment. For the owner/occupiers the sustainability of the building represents potential operational energy savings and an improved indoor environmental quality. It may also be a means to promote their corporate ethos and environmental policies. However the owner/developer must also pay for the higher cost associated with the large scale sustainable building services and systems. These usually include recycled water, renewable energy and sustainable transport and are typically delivered at the site level and have a strong correlation to the local urban context, community and landscape. Opportunity exists for the provision of this infrastructure at the local government/precinct/district level by supplying reticulated, recycled water, district energy systems and the provision of sustainable transport options, routes and links. A building when placed in a certain location and community will play a role within that community's socio-economic and environmental context. The idea of sustainable development should extend beyond the realm of individual buildings. Building based sustainable services should be incorporated into the wider urban infrastructure network, involve other parties such as the community, adjacent buildings and councils which, are all stakeholders in their immediate built environment. The building should be seen as part of an integrated precinct or neighborhood resource and energy system. This concept is illustrated in Figure 1.

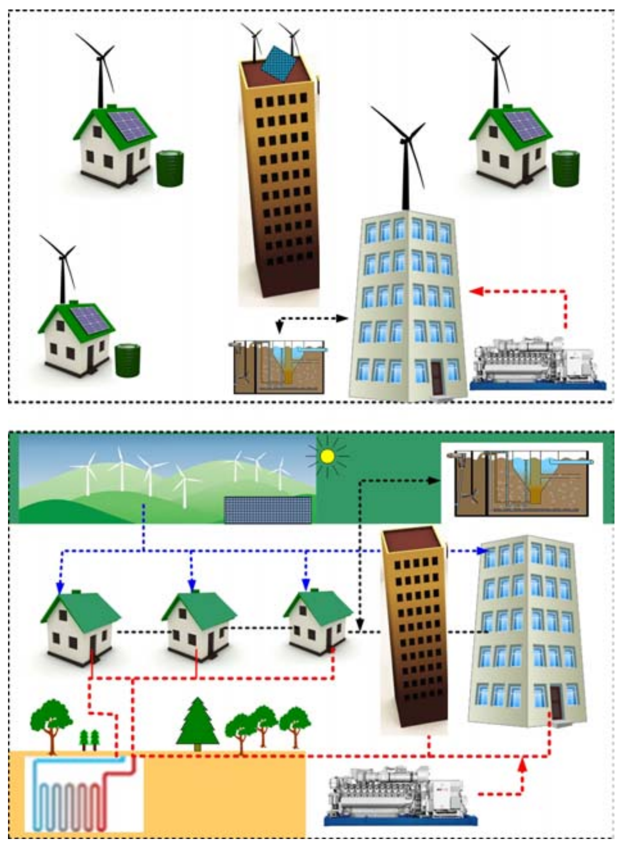

Figure 1. Buildings with individual sustainable and reknewable sevices (top) and buildngs integrated with district based sustainable infrastructure (bottom)

A. GeoExchage infrastructure (GXI)

Examples of sustainable district infrastructure systems which, feed into individual buildings and developments within a neighborhood or precinct include geoexchange systems. GXI is an example of a renewable energy storage system utilising large thermal capacity and inertia of the ground. Due to its large thermal capacity and inertia the ground temperature at a certain depth is almost constant throughout the year. Similarly thermal storage effects can be achieved with bodies of water, lakes, groundwater aquifers and ponds. GXI can provide both heat sink and source at the same time, particularly in temperate climates. A heating system combined with GXI will source up to 75% of heating energy from solar energy accumulated in the ground. GXI networks can also be integrated with, and supplemented by waste-to-energy plants, wood biomass, combined heat and power (co/tri-generation) systems and solar thermal systems. Waste heat generated from building services and equipment, especially in neighborhoods which, have an industrial component can be fed into and distributed through a GXI network. In summer where there is a need for cooling, this waste heat can be directed to an absorption chiller which uses low temperature heat to generate chilled/cold water. The GXI network aims to provide a more or less constant water temperature which, can be used for heating or cooling in heat pump systems. Similarly, renewable energy infrastructure such as extents of thermal solar collector panels established at district and neighborhood level can feed into the individual buildings that comprise of the energy precinct. Solar thermal systems can also be integrated into GXI to provide solar cooling through absorption chillers, etc. The building is no longer a stand-alone element in the built environment but an entity integrated with its landscape and neighborhood infrastructure. Figure 2 and Figure 3 illustrate an example of an integrated GXI system.

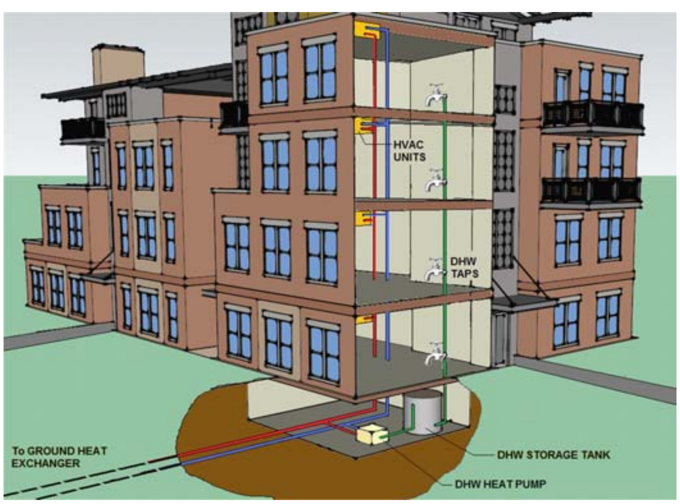

Figure 2. Example of geoexchange system for space conditioning and domestic hot water

Figure 3. Example of geoexchange system integrated with co-gen

GXI lends itself to be a perfect coplement to the smart grid infrastructure. While smart grid is focusing on IT and active supply and demand management, GXI provides natural thermal energy storage component. Coupling the electricity demand for comfort heating and cooling with natural thermal storage, independent of ambient temperature variations provides a means of demand management. Lower and flatter demand characteristic is an inherent feature of GXI, as compared with the traditional air source air conditioning systems.

III. CASE STUDY IN SUSTAINABLE INTERATED DISTRICT INFRASTRUCTURE-VICURBAN@OFFICER

VicUrban@Officer is one of 16 projects selected worldwide by the Clinton Climate Initiative (CCI). It is a 32ha mixed-use site built around the Officer Train station, south-east of Melbourne, Australia. Figure 4 below shows a masterplan of the entire development. Stage 1 of the development is the precinct discussed in this case study. It is a mixed used precinct consisting of residential, commercial, retail and community buildings. It is anticipated that the residential gross floor area (GFA) will be in the order of 130,000m^2, retail up to 40,000m^2 and commercial approximately 50,000m^2. Alternative and renewable energy solutions are being considered for the precinct as part of an integrated district based energy strategy. GXI is one the alternatives being considered.

Figure 5 shows an energy and cost performance comparison between using conventional air source heat pumps for heating and cooling for the residential component of stage 1 and a water source heat pumps coupled to a GXI network. The analysis was done based on a minimum code compliant dwelling (BCA First Rate (FR) 6 Star) as a base line and then compared against better performing design (FR8 and better than 50% FR6 and FR8). Figure 5 illustrates the cost saving produced when a dwelling is designed to better than code compliant standards and coupled to GXI system. It also highlights the impact of building passive design on the estimated size of GXI. It clearly demonstrates how best practice passive design, such as glazing, insulation, shading, building form and orientation impact on the viability of GXI.

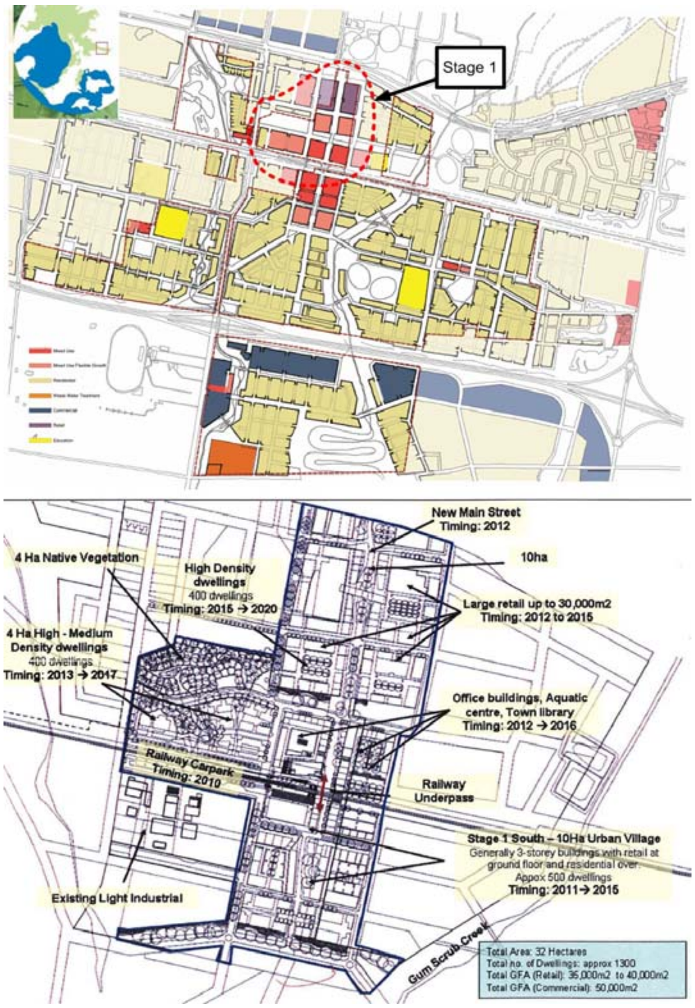

Figure 4. vicurban@officer MASTERPLAN

Main Street – comparison between air source AC and GeoExchange

	FR 6*	FR 8*	50% FR 6*	50% FR 8*
No. Loops	416	272	208	136
MD reduction, kW	648	424	324	212
Cost, $'000	$4,156	$2,719	$2,078	$1,359

Inner South – comparison between air source AC and GeoExchange

	FR 6*	FR 8*	50% FR 6*	50% FR 8*
No. Loops	1,392	911	696	455
MD reduction, kW	2,171	1,420	1,085	710
Cost, $'000	$13,923	$9,108	$6,962	$4,554

Figure 5. vicurban@officer sample calcualtiopns for Geoexchange at Officer

IV. INFRASTRUCTURE CONTEXT FOR SUSTAINABLE BUILDINGS-OPPORTUNITY FOR RESOURCE SHARING THROUGH SUSTAINABLE DISTRICT LEVEL INFRASTRUCTURE NETWORKS

The rating systems as well as local and regional regulation do not address resource sharing in building design and operation. In instances where commercial buildings are located adjacent to each other it is possible to share resources; especially renewable resources. For example; if a building harvests rainwater, generates waste heat or produces solar hot water that far exceeds its own demand, there is no concession or credit driven by regulation or the green building rating system, which, promotes the supply and distribution of this excess to nearby and adjacent buildings that may not have the production capabilities or systems. This will reduce the overall municipal potable water and electricity demand. Although such schemes may be eligible for innovation points under Green Star and LEED; subject to the judgment of assessors, they need stronger policy driven support mechanisms to be adopted by developers. Developers should be encouraged to contribute to infrastructure schemes that extend beyond the buildings site boundaries and incorporate nearby buildings and communities. In order to make these schemes viable and cost affective to the developer, cost of additional reticulation and connection infrastructure would need to be supported by concessions and mutually beneficial commercial funding models.

V. THE DICHOTOMY OF THE GREEN BUILDING RATING SYSTEM

There exists a dichotomy in green building design, construction and operation where different building design and operational elements are delineated at building level and site level. Therefore, in order to encourage and promote renewable energy and other sustainability infrastructure as an integral part of the sustainable built environment and sustainable building construction and operation we propose a two-tier green building rating system. The building level sustainability features such as the fabric, shading, massing and services are assessed separately to the larger site level features such as renewable energy, recycled water, sustainable transport and local ecology.

The objectives of the fist tier should be the assessment of the building level sustainable features based on matrices such as water use reduction, energy consumption minimisation, thermal comfort and the provision of a healthy indoor environment. The objectives of the second tier assess the interaction and integration of the site level sustainable infrastructure with the building function and operation. This would refer to the availability of district energy, renewable energy options and recycled water supply and reticulation etc which, the building could tap into, as well as the availability of sustainable transport routes and how the building caters for the use of these facilities through allocation of bike storage, etc. The objectives of the second tier assessment is to build social awareness of community infrastructure and its role in achieving sustainable community outcomes, increase equity in sustainable infrastructure and encourage economic activity through access to this infrastructure. The provision of building level sustainability features is the responsibility of the developer/owner whereas the provision of the site level sustainable infrastructure should also involve the local planning authority and local government agencies as they are all stakeholders in the buildings use and operation. The site level sustainability features should be assessed in relation to the availability and provision of such sustainable infrastructure within the surrounding landscape and local community.

In green building design it is important to look beyond the building supplying the entire infrastructure required for it to operate sustainably but examine a sustainable building within a community which provides sustainable infrastructure such as a recycled water network, district heating etc. To achieve this, provision of district level sustainable infrastructure must be mandated by strong environmental commitments from governments and be supported by the local government policy and planning processors. A two-tiered system provides for better social inclusion and equity as sustainable infrastructure is made available and accessible to all. A two tiered system also makes green building construction and operation more feasible as the large-scale sustainable infrastructure is provided at the community level and the cost shared by all stakeholders and not merely the developer/owner.

VI. The Role of Government Stakeholders in Driving Sustainable Infrastructure

Planning authorities must integrate sustainable infrastructure with their urban renewal and redevelopment plans. Zoning laws and requirements should encourage symbiotic or related developments and industries to be sited in the same areas with an intention for resource sharing and building resource networks. In this way, through careful land-use planning and the design of individual buildings and developments the sharing of utilities and resources can be facilitated. Strategies to develop sustainable infrastructure could include support for distributed generation, waste heat utilisation, financial incentives to locate developments near energy and waste heat sources, establishment of district heating zones, establishment of wastewater reuse zones, local level investment in GXI, wind and solar technologies and financial and technical assistance for building level alternative technologies. Consequently the availability of the types of sustainable infrastructure will mean it will be easier for the buildings to meet their green building rating system objectives. Availability of this sustainable infrastructure will also shape building design and the systems installed.

Local authorities have a key role to play in the provision of sustainable infrastructure. They are also at the level of government that has direct interaction and access to the community and are responsible for educating local communities and disseminating knowledge on sustainability, they are also in charge of current supply and maintenance of infrastructure. Local authorities are also aware of local issues and the infrastructure and sustainability needs particular to a community. Local issues on sustainability may vary from wider overarching commonwealth policies on sustainability. Different environmental segment may have regional and local priorities. Therefore local government is well placed to drive sustainable infrastructure and the subsequently encourage and facilitate green building development and adoption of green building rating tools. However, local government needs the support of overarching commonwealth and state legislature which will set a blueprint for sustainable development.

While the technological aspect of GXI and integrated infrastructure is reasonably well understood, its commercial and legal framework is much less understood. Before GXI, and similar concepts, become the reality some pressing questions in relation to the ownership, revenue generation and allocation among potentially diverse stakeholders have to be addressed. GXI technology provides solution to some key challenges facing energy generation and distribution at the precinct level, such as reduction of maximum demand and energy use, reduction of volatility of demand and integration of renewable energy resources. However, prospective GXI operators will have to develop commercial models which redistribute costs and benefits in an equitable manner among its key stakeholders.

VII. Conclusion

Often green building design and adoption of green building rating systems is seen as having an increased cost component over conventional design which can be a deterrent for builders and developers to pursue these options. The increased costs usually arise from installation of larger scale sustainable building systems and services such as grey/blackwater treatment systems, sewer mining, cogeneration, tri-generation and renewable energy systems. If this type of infrastructure could be provided at a community and local level it would free up capital for other less costly elements of the sustainable building design such as through building form, orientation, passive ventilation strategy, daylight strategy, exposed mass, shading devices, high performance glazing and insulation.

There needs to be planning and policy instruments that implement sustainable infrastructure at regional, local and community neighborhoods such that buildings can be slotted into this context of sustainable infrastructure. The building therefore only needs to be designed with the focus on the environmental performance of its façade, fabric and equipment in mind, the larger scale sustainable infrastructure such as wastewater treatment, renewable energy generation is provided at the local level. In the long run this will enable building design with better environmental performance since the burden of high cost infrastructure has been removed freeing up capital for lower cost passive and active solutions.

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