



## CARBON NEUTRAL COMMUNITIES

Centre for Design, RMIT University and University of South Australia

### **CARBON NEUTRAL COMMUNITIES: DEFINITIONS AND PROSPECTS**

CNC Working Paper No. 1

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**May 2007**

#### **ABSTRACT**

Australia has high greenhouse gas emissions per capita. This presents two significant problems for Australian communities. First, in order to meet global community obligations in reducing fossil fuel use to mitigate global climate effects, these current high emissions must be reduced significantly. For a high emission society such as Australia, the changes required are accordingly significant. Second, high energy users are more vulnerable to a future where greenhouse gas emissions will have a high cost, and where sustainable energy resources will be the norm. In order to build resilience, Australian communities can anticipate and adapt to climate change by reducing their need for fossil-fuel based energy resources.

Carbon neutral communities are a response to the climate change challenge presented to modern fossil-fuelled society. In this paper, the case for carbon neutral communities is reviewed, and definitions for the term are identified and discussed, along with the benefits of carbon neutral communities in the Australian context. The prospects for achieving Carbon Neutral Communities in Australia are examined, and barriers to this end are identified. A project methodology is then outlined for research to contribute towards overcoming these barriers; through the Australian Research Council funded project entitled Carbon Neutral Communities – Making the Transition.

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## 1. INTRODUCTION

### 1.1 Context and Definitions

The concept of carbon neutral communities (cncs) are rapidly gaining prominence amongst policy makers, firms, non-governmental organisations (NGOs) and citizens. This phenomenon is directly attributable to the increased awareness of human induced climate change, and the need to take significant action to mitigate its effects by reducing fossil fuel use. The current state of knowledge and challenge posed by climate change is summarised in section two.

References to the term cncs can be expected to rapidly increase in accordance with the rise to prominence of the concept and related policies and actions. It is necessary to define the parameters of cncs in order to provide clarity and meaning to the term as its use increases. In fact, there are a range of possible definitions, and the following is developed specifically for the ARC Linkage project entitled Carbon Neutral Communities – Making the Transition. Note that in referring to this project the uppercase abbreviation CNCs (rather than cncs which is used to indicate a more general use of the term) is used throughout.

Cncs are inherently linked to the climate change agenda, and refers to the contribution of a ‘community’ to greenhouse gas emissions. Taking a systems approach, the definition parameters for cncs can be summarised as follows:

- Definition of the ‘community’;
- Types of greenhouse gas (GHG) emissions (e.g. carbon dioxide, other oxides, methane); and
- Boundary conditions of emissions (life cycle, operational, physical, etc).

### *Definition of the 'community'*

It is possible to define a community as any group with defining similar attributes, such as common location, goals or characteristics. Hence, an 'online' community may consist of participants scattered across the globe. In cncs, the term community is defined in the broader sense – a group identified by the common attribute of being involved in the transition to cncs. Nevertheless, at different stages, physically-defined communities, such as at city authority level, are also used within the 'community' definition.

### *Types of GHG emissions*

The major cause of human-induced climate change is the combustion of fossil fuels (crude oil and derivatives, coal, lignite, natural gas and other fossilised organic remains in shales and related petroleum deposits). The primary purpose of combustion is to release heat energy, which is then either used for a range of energy services, or converted into other forms of energy before being used to provide energy services – for example, as electricity.

However, there are also a range of other sources of human-induced greenhouse gas emissions. These include:

- By-products and pollutants from the aforementioned combustion processes;
- By-products and pollutants from other chemical processes;
- The release of various greenhouse gases (including oxides of nitrogen and methane) from agricultural and forestry processes; and
- the release of methane from landfill and other waste materials.

A much more complete discussion of the sources of ghg emissions is available elsewhere (e.g. IPCC 2007, AGO 2006). It is important to distinguish greenhouse neutral from zero emission. A carbon neutral community is likely to still produce greenhouse gas emissions although, almost inevitably, to a lesser extent than is currently the case. However, it will be greenhouse neutral in respect of the fact that it offsets these emissions by a variety of means such as the production and export of electricity from non greenhouse gas emitting sources, sequestration of carbon emissions by tree planting or geo-sequestration or through carbon trading. For the purposes of the cnc definition, a carbon neutral community is one which is greenhouse neutral (the term carbon being a short-form common term for greenhouse gases).

### *Boundary conditions*

There are three main sets of boundary conditions which must be set in defining cncs:

- Physical/spatial limits;
- Temporal limits; and
- Process/system limits.

Physical limits can be set, for example, at the city authority level, as in the two CNC case studies of Manningham, Victoria, and Playford, SA. Here, the CNC limit is defined as the city boundary. Where relevant, physical/spatial limit boundaries may also be set at the household, site, or firm level.

Temporal limits refer to the timescale over which emissions and effects happen – and therefore the overall extent to which 'neutrality' of additional climate change effects exist. In general, temporal limits are set at 'natural' levels, although in specific

circumstances, approximations may need to be drawn, in which case these will be based on a combination of theoretical principles and consensus drawn from relevant literature. An example may occur in calculating carbon offsets from re-forestation projects.

For example, consider the life cycle of a building. Given a 'typical' use pattern, lifespan, and fossil-fuel based energy supply system, the associated ghg emissions will be dominated by the space heating/conditioning energy, lighting, hot water and other electricity/appliance requirements during use (i.e. operational energy). However, fossil fuels will also have been used in the manufacturing of raw materials for the building and its production, marketing and transport. The building will also typically have maintenance requirements, which typically have their own fossil fuel based energy needs. In this example, the CNC calculation of ghg would be limited to the operational energy use of the building. There are invariably truncation effects in drawing the process system boundary. However, these are minimised through a combination of reference to relevant Life Cycle Assessment standards (e.g. ISO14040), and through the use of 'rule of thumb' and estimation calculations.

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## 1.2 Aims and Objectives

The aim of this Working Paper is to develop an appropriate programme of research which will contribute to the transition of current Australian communities in becoming 'carbon neutral'. The objectives which need to be met in order to achieve this aim are as follows:

- Develop a working definition for 'carbon neutral communities' for the CNC project (see 1.1 above);
- Provide a background and context by summarising the climate change debate and policy development to date;
- Examine the prospects for Carbon Neutral Communities in Australia;
- Determine the barriers to creating Carbon Neutral Communities in Australia;
- Develop and present a research plan to contribute to overcoming the barriers to creating Carbon Neutral Communities.

## 1.3 Layout and Approach

Section 2 provides background and context by summarising the climate change debate. Section 3 examines the prospects for realising Carbon Neutral Communities in Australia and summarises the benefits and opportunities in making the necessary transition. In recognition of the challenges involved, Section 4 outlines key barriers to creating Carbon Neutral Communities in Australia. Section 5 explores means to overcome these barriers and presents a research project – the CNC project, in this endeavour, while Section 6 concludes this Working Paper.

## 2. Background: Climate Change policy development

About 29 billion tonnes of greenhouse-causing gases are released into the atmosphere annually by human activities, including 23 billion from fossil fuel burning

and industry (IPCC, 2007). Climate scientists invariably accept that human activity, especially those activities related to the production and use of carbon-based energy sources, have caused or are exacerbating global warming, and predict serious consequences for the planet (IPCC, 2007). This position reflects the overwhelming evidence linking human-induced climate change and recent extreme weather events, sea level rise and climate trends, and consequent severe damage to human life and supporting ecosystems (IPCC, 2007; G8 Presidency, 2005; Lowe, 2005; Flannery, 2005).

CSIRO (2005) modelling predicts severe impacts for Australia, including increased frequency and severity of extreme weather events such as floods and droughts, changed weather patterns that will undermine key agricultural regions, and rising sea levels for coastal communities. Results include changes in disease vectors, rising insecurity and risk in various aspects of the economy and society, and irreparable damage to key biodiversity stocks and ecosystems such as the Great Barrier Reef. These impacts have potential long-term implications for Australia's environmental and economic sustainability and security.

The need for a range of policy responses and a large, multi-pronged research effort that will reduce Australia's contribution to global warming by reducing GHG emissions is clear. The Australian government has committed Australia to GHG reductions based on Kyoto targets. The policy agenda must now gather and generate the knowledge to develop and implement appropriate signals to enable Australia to achieve deep cuts in greenhouse gas emissions.

Reducing the carbon/greenhouse-induced bases of climate change is a major challenge in a coal- and oil-powered economy such as Australia. Such a strategy has long lead times, which makes the realisation of immediate policy impacts challenging (see OECD 1999). Nevertheless, governments around the world are already responding to the need to act now, and numerous longer term goals have been set both within Australia and overseas (e.g. The National Greenhouse Strategy (NGS) - *Advancing Australia's Greenhouse Response*; Kyoto Protocols, etc). Since 2006, notable landmark reports have highlighted the economic rationale and ethical and security imperative for taking substantial action to counter the human contribution to climate change (e.g. Stern, 2006, IPCC, 2007).

Australia's National Research Priorities relate to the climate change challenge. For example, NRP1: 'Environmentally Sustainable Australia' states that: "climate change can be expected to have complex, long-term consequences for the environment, for our agricultural and marine production systems and for communities". The research is of particular relevance Goals 4 and 7 of NRP1. Goal 4, *Reducing and Capturing Emissions in Transport and Energy Generation* emphasises meeting the emissions target set for Australia at Kyoto and the need to develop alternative energy technologies and ecologically sustainable transport and power generation systems. The research contributes directly to this goal by reducing GHG emissions in urban communities. It will also lead to demand for greater uptake of alternative transport and greenhouse saving products and services, which will have positive economic benefits for relevant Australian manufacturing and service industries. Goal 7 *Responding to Climate Change and Variability*, calls for Australia to increase "our understanding of the impact of climate change and variability at the regional level across Australia, and address the consequences of these factors on the environment and on communities". The research has a clear focus on this by providing strategies for addressing the consequences of climate change; identifying the non-technical barriers to uptake of GHG reducing technologies and measures; and developing and proving practical methods for overcoming these barriers.

Policy responses delivering action towards these National Research Priorities are varied across Australia to date. The Local Governments for Sustainability movement is establishing policy commitments to address regional and global environmental challenges at the local level. It has sampled the 386 local governments in 43 countries participating in the Cities for Climate Protection Campaign. This research demonstrates that concrete actions have improved local energy management and reduced GHG emissions (Skinner, 2000; www.iclei.org). Cities for Climate Protection® (CCP) is the largest local government greenhouse program in the world, with 206 councils now participating across Australia. The 2004 Energy White Paper, *Securing Australia's Energy Future* established the Solar cities program in Australia to trial new sustainable models for electricity supply and use. The Australian Greenhouse Office has developed information and guides for homeowners (AGO, 2001). At the buildings level, recent research for the AGO has also progressed the application of Life Cycle Assessment to energy use in buildings, and compared Australian house energy performance to that overseas (Horne et al, 2005a, 2005b, 2005c). Carbon neutrality is a central environmental goal in Victoria and South Australia, the two States in which this study is based.

In Victoria, policies are being pursued by regional Greenhouse Alliances, comprised of local councils committed to delivering greenhouse neutral regions by 2020, by targeting low emission and decentralised power generation, as well as new generation transport and cleaner fuels. Melbourne aims to end its contribution to global warming via a Zero Net Emissions by 2020 strategy, supported by research on sustainable production and consumption (Horne et al, 2005d). In South Australia, there has been significant movement towards the diversification of energy supply, e.g. via wind turbine project developments. Renewable energy based initiatives reflect two priorities in South Australia's Strategic Plan: reducing greenhouse gas emissions in line with Kyoto and reducing South Australia's ecological footprint. The City of Adelaide is establishing the scope of potential energy efficiency savings, while Transport SA is addressing transport energy issues by partly switching its bus fleet to natural gas and biodiesel. These initiatives are reflected in similar policies in other States/Territories (e.g. Landcom, 2005).

### **3. Prospects for Carbon Neutral Communities in Australia**

While it is recognised that ghg emissions arise from various sources, amongst those which add specifically to the total stock of climate change gases in the atmosphere, the main concern widely expressed comprises the emissions from the combustion of fossil fuels for energy. Most such energy is consumed in cities, particularly in buildings and transport (Fien, 2004a; Hamnett, 2000; Gleeson et al, 2000). Research has been conducted on the technologies and design of greenhouse gas (GHG) reduction options for cities and buildings (e.g. Hamnett, 2005a/b; Goldie et al, 2005; Jenks and Dempsey, 2005; Roaf et al, 2004a/b).

Theoretically, ending the use of fossil fuels could deliver carbon neutrality (notwithstanding other greenhouse gas emissions). However, an abrupt end to fossil fuel use without a well-planned transition and adoption of alternatives would be catastrophic for both social and economic sustainability. Fossil fuels are currently integral to our food supply, everyday materials, indoor comfort, leisure, transport, and economic productivity. Indeed, until the oil price shocks of the 1970s, it was widely assumed that energy consumption and economic growth were linked in a simple linear relationship.

Technically, the shift away from fossil fuel combustion can be achieved over a limited and planned timescale through a combination of energy efficiency and switching to renewable sources of energy. Rather than this transition costing the earth, on the contrary, it is necessary to save the earth from major climate change effects. Well defined national benefits can accrue from this change (both economic and social) for the business community, policy makers, community groups and the broader Australian population.

The transition to carbon neutral communities is a fundamental response to National Research Priority 1, through developing (i) practical measures for reducing GHG emissions in Australian urban areas, (ii) strategies for overcoming barriers to greater uptake of energy efficiency and alternative technologies and (iii) ways for Australia to meet its greenhouse reduction targets. Both direct and indirect economic benefits can result for Australia through energy savings; developing the social capacity for further savings in the future, stimulating innovation in urban design, building design and transport use; promoting new business opportunities; and encouraging more sustainable lifestyle decisions.

#### **4. Barriers to creating Carbon Neutral Communities in Australia**

A range of barriers – some technical but most non-technical – need to be overcome in order for the transition to CNCs to be achieved. Indeed, three fundamental problems remain in the drive to urban carbon neutrality:

- (i) Speed of change;
- (ii) Community engagement with the process; and
- (iii) Lack of capacity for change at the organisational and community level (Lowe, 2005).

Strategies for reducing GHG-induced climate change often promote technical solutions and the use of command-and-control and market-based measures such as economic and legislative instruments (IPCC, 2001). These have proven successful when employed in a consistent manner across all social economic sectors. Their limitation is that they are unable to produce the intrinsic motivation and action competence required for broadly-based industry and community understanding, commitment and action. The pervasive nature of carbon-based lifestyles and work practices in Australia demands additional strategies based upon education, capacity-building and encouragement of voluntary measures, which a recent report of US National Research Council calls “new tools for environmental protection” (Dietz and Stern, 2002). Using such tools requires “an understanding of the behaviours and the individuals and organisations whose behaviour is to be changed” (p. 11). A useful body of work exists which seeks to deconstruct behaviour at a number of levels, from global agencies down to the individual consumer (Reddy, 1991, Rolls, 2001, Shove, 2003). Classification of consumer types, analysis of motivational factors in inducing behaviour change and design strategies which can script or enforce less carbon intensive behaviour are all addressed in this literature and are directly relevant to this research.

Many barriers stand in the way of the transition to CNCs. Cost is a potential factor, although this depends on the costing approach, and there is evidence that carbon-neutral developments and their related environmental savings can be achieved at little or no extra cost, and can even produce ‘win-win’ outcomes of both cost and environmental damage reduction (WWF, 2005). Other non-technical barriers may be culturally specific, but are poorly understood (Kellett, 2003; Stevenson, Tilbury, Fien and Schreuder, 2002; Clemitshaw, Kellett et al, 2002). There is not a large body of

research into non-technical barriers to GHG reduction, although one US study (Tonn and MacGregor 1998) identified a range of barriers to communities becoming more sustainable, for example, a lack of prescriptive goals for community action; strong external forces, especially economic, working against sustainability; short-term and the complexity of decision making, behavioural change and capacity building processes. There is therefore a need to identify the role of these and other barriers in Australian case study communities, and to develop strategies to overcome them.

At the consumer level it is apparent that willingness to accept technological change is partly influenced by price but also by issues relating to convenience, concerns at technological reliability and maintenance, social status, opportunity cost and perceptions about the superiority or otherwise of new technologies. The parameters of decision making are many, and vary according to income, education, location and attitude to the environment. At the supplier level, issues of market share and shareholder perceptions are key drivers of company policy. Government policy on green electricity generation and carbon trading can be influential in setting a framework for changes in practice by generators and suppliers. The complex interplay of these factors within a hierarchy of providers and consumers is a challenge for this research. Energy efficiency measures within the home can provide a focus for study since they encompass much of the above. In particular the requirement to address retrofit of existing homes in addition to mandating higher levels of efficiency in new housing stock is a key issue to be addressed. Concern at the effects of policy prescriptions in this field for socially disadvantaged households also presents a challenge within this agenda.

## **5. Overcoming the Barriers**

Many viable strategies are already available, including demand-side reductions via energy efficiency and sustainable design strategies and technologies, as well as supply-side reduction, through fuel switching or reconfiguring energy services. GHG emission offsetting, an increasingly popular strategy used by institutions and individuals, is also an option, along with other sequestration possibilities. However, a community can only voluntarily become carbon neutral when businesses, institutions, households and individuals choose to act in concert to reduce the overall greenhouse gas (GHG) emissions of their activities and have the knowledge and skills to do so. Indeed, such intrinsic motivation and action competence are the only drivers found to be statistically reliable influences on sustainable behaviour (Brewer and Stern, 2005; Stern, 2000; De Young 1996).

Previous research provides a basis for considering how barriers may be overcome. For example, a recent research project in the UK demonstrated how an urban community in England could transform itself from a higher-than-average dependency on fossil fuels into a carbon neutral community (Kellett, 2007). The research identified a number of crucial findings. Firstly, enormous potential exists to transform institutional, fiscal and technological arrangements to achieve large-scale carbon reduction. Secondly, urban areas often possess significant renewable energy resource potential. Finally, activating these, and thus moving to carbon neutrality, requires five things: (i) initial baseline energy assessment (ii) carefully costed analyses of local energy efficiency potential; (iii) identification of barriers to carbon reduction strategies (iv) identification and testing of implementation measures to overcome these barriers; and (v) capacity building and organisational learning to act in appropriate ways.

### **5.1 The CNC Research project**

It is clear from the discussion above that research is required which focuses on mechanisms to overcome non-technical barriers to achieving CNCs, particularly those relating to behaviour and social capacity. The CNC project aims to assist Australia in becoming a world leader in applying innovative methods to overcome non-technical barriers to achieving carbon neutrality at community level.

Specifically the research aims to:

1. Identify carbon neutral potential and social, economic, cultural and capacity barriers to achieving this potential in Australia;
2. Assess the application of established techniques to address such barriers and provide practical solutions to the carbon transition problem in Australian cities;
3. Develop and test strategies for building the capacity needed to facilitate the breakthrough required in achieving carbon neutral communities by 2020, the key date in the The National Greenhouse Strategy; and
4. Disseminate this knowledge to project stakeholders and the wider community.

Cities were chosen as the focus of this research because most energy is consumed in cities. Four case studies have been selected (three mixed inner and outer urban areas within a large central city (Melbourne), and one mixed urban area within a smaller city (Adelaide)). The emphasis is firmly placed upon both carbon and resource assessment and identifying practical ways forward for urban areas to reduce their carbon footprint, including through building what the OECD (1994) calls "societal capacity for the environment". Building societal capacity for the environment involves the three tasks of developing:

- Local frameworks which are open to public participation and scrutiny and the education of citizens to use them;
- Processes for integrating public participation into environmental policy and decision-making; and
- Capacity for strategic environmental action by all stakeholders.

The research takes an essentially empirical approach which incorporates both quantitative and qualitative methods to address both the technical assessment and social and economic factors in transition. A group of CNC partner organisations (POs) will provide resources for the project, including funding support, input in to project advisory processes and data and other assistance with fieldwork and case studies. These partners are as follows:

- City of Manningham, VIC
- City of Playford, SA
- Consumer Affairs Victoria
- International Council for Local Environmental Initiatives
- Moreland Energy Foundation
- Community Power
- Northern Alliance for Greenhouse Action

There are six phases in the study.

#### *Phase 1: Preliminary research and fieldwork*

A literature review of themes related to the carbon economy, climate change and local government, technical and non-technical approaches to reducing GHG emissions, and approaches to community change will be updated as the study progresses. Detailed studies of socio-demographic structures, economic activities

and trends, and environmental issues and priorities will also be undertaken. Discussions with the POs can provide further case studies as required, as the research progresses. This review work is providing the contextual information upon which data collection and interpretation in Phases 2-5 will be undertaken and the dissemination strategies in Phase 6 planned.

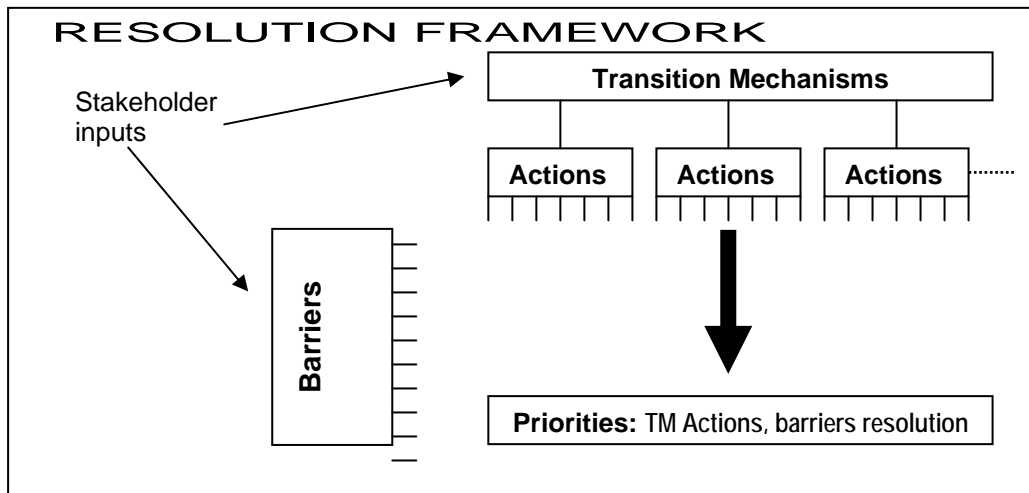
#### *Phase 2: CNC Assessment: Baseline, resources and opportunities*

A 'carbon assessment' will be undertaken for the whole of the City of Playford and City of Manningham. This will involve establishment of a methodology and data gathering to establish the baseline conditions, followed by identification of energy efficiency opportunities and renewable resource assessment. It is a fundamental assumption that evaluation of carbon saving techniques must rest on a clearly quantified and established baseline. Calculation and analysis of this baseline should be derived wherever possible, from locally generated statistical data (Grant and Kellett, 2001). A method for undertaking energy efficiency assessment already exists (Mortimer et al, 1998, Grant and Kellett, 2002a), as for renewable energy resource assessment (Grant et al, 1994, Grant and Kellett, 2002b), which requires further research and development for the Australian context. Carbon dioxide abatement options will be ranked according to cost effectiveness and payback time. Target reductions in carbon dioxide output for each of the case study areas will be identified, and action research project plans established, including household and community level Transition Mechanisms such as smart metering, greenpower packages, and social capacity initiatives.

#### *Phase 3: CNC Appraisal: Transition Mechanisms and barriers*

Transition Mechanisms will be developed and expressed in a range of formats. For example, in the case of individual agencies, firms and building owners, *specific business plans* will be drafted to identify carbon reduction and financial cost saving opportunities. At the neighbourhood level, *community fora* will be established to generate recommendations for action and examine alternative strategies while area-wide policy frameworks will be reviewed and analysed against the quantitative and qualitative information to provide *planning and policy guidelines* for carbon reduction.

Following the development of Transition Mechanisms, a range of barriers to their implementation will be identified and explored, in consultation with POs. It is important not to pre-empt the barriers and issues which will be raised. Experience elsewhere suggests that many of the barriers are likely to be non-technical in nature. Cost is likely to be an important factor in inhibiting implementation. However, social, cultural, organisational and policy aspects are likely to be of equal importance, as are issues relating to consumer attitudes and skills availability (Clemittshaw, Kellett et al, 2002). The outcome of this stage of the research will be a much-improved understanding of the barriers to carbon neutral transition and of the mechanisms to overcome these. The Resolution Framework (Figure 1) provides the context through which actions and barriers will be characterised, assessed, and addressed.



**Figure 1. CNC Resolution Framework**

*Phase 4: CNC Barriers Resolution: Action selection and action research*

Transition Mechanisms comprising a wide range of potential actions towards CNCs will be rated according to the barriers to implementation and difficulty of resolution, in the application of the CNC Resolution Framework (see Figure 1). The POs will assist in prioritising actions and barriers resolution. The outcome of this stage of the research will be a much-improved understanding of the barriers to carbon neutral transition and of the mechanisms to overcome these.

At least two further case studies will then be conducted, around action research projects with households and communities. Where possible, control cases will be used to allow assessment of responses with and without capacity building mechanisms in place. The general process of the action research studies will be to elicit (by questionnaire, focus group etc) which technical solutions devised in Phases 2 and 3 they would subscribe to. Then, test how people “live” the changes, and apply techniques of participative capacity building. It is anticipated that such action research will be conducted with householders and businesses/institutions, the latter involving participatory finalisation and implementation of business plans.

*Phase 5: Meta-Analysis and Synthesis*

Case study reports from each of the four case studies will be completed, written and then subjected to cross-case analysis in order to identify patterns of similarity and difference, depending upon the various social and economic variables that define the context of each of the case study communities. These patterns will be used to develop a flexible framework of principles for POs, local, State/Territory and Commonwealth governments to use in policy development and action planning to facilitate the transition to carbon neutrality in urban areas.

*Phase 6: Dissemination*

While listed as the sixth phase, dissemination of findings will not be left to the end. Rather, the collaborative research process in which local governments, industries and community stakeholders contribute to data collection, analysis and interpretation will ensure that communication will be a central and continuous feature of the study. An active, linked, and regularly updated web site will be developed to facilitate dissemination and enabling resources, such as best practice examples, and a publication programme will be undertaken. Workshops and other for a will be

organised to inform and engage external groups such as planners and policy makers both around and beyond the immediate project stakeholders.

## Conclusions

As a response to the climate change challenge, and to emerging policy targets and other responses, there is a pressing need for research and development of new approaches in facilitating the transition towards carbon neutral communities. The CNC project has been developed which will contribute towards addressing this need through a unique combination of integrated, rigorous quantitative analyses and action research for capacity building.

In achieving the aims and objectives of this paper the approach and method for the CNC project has been described, following a logical, staged analysis from review and baseline assessment, through appraisal of opportunities, identification and resolution of barriers, with testing through action research case studies, to synthesis, analysis and dissemination. The research is designed to provide an empirically derived, clear picture of the technical potential for carbon dioxide reduction, and a sign-posted pathway to the creation of conditions favourable to the transition of urban areas to carbon neutrality.

The analysis will include quantification and qualification, and costings capable of comparison against prevailing energy prices. In so doing, it will indicate practical and cost effective measures to transform the case study areas into carbon neutral communities. Outcomes of the research include the publication of clear and practical assessment mechanism for determining energy baselines; determining the cost effectiveness of GHG reduction options and identifying non-technical barriers to carbon neutrality. A central outcome is the application of a Resolution Framework to determine the most practical and acceptable mechanisms for implementation of carbon neutral solutions in urban areas.

The research is designed to provide nationally applicable outcomes, which will be of direct benefit to all urban communities across Australia. Hence, while the project outcomes will be significant for the CNC project case studies, they will have application in all Australian cities, and potentially beyond.

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