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Article

WGV: An Australian Urban Precinct Case Study to Demonstrate the 1.5 °C Agenda Including Multiple SDGs

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Abstract
The WGV project is an infill residential development in a middle suburb of Perth, Western Australia. Its urban planning innovation is in its attempt to demonstrate net zero carbon as well as other sustainability goals set by urban planning processes such as community engagement and the One Planet Living accreditation process. It is a contribution to the IPCC 1.5 °C agenda which seeks to achieve deep decarbonization while also delivering the UN Sustainable Development Goals (SDGs). Solar photovoltaics and battery storage are incorporated into the development and create net zero carbon power through an innovative 'citizen utility' with peer-to-peer trading. The multiple sustainable development features such as water sensitive design, energy efficiency, social housing, heritage retention, landscape and community involvement, are aiming to provide inclusive, safe, resilient and sustainable living and have been assessed under the SDG framework.

Keywords
decarbonizing; sustainable development; Sustainable Development Goals; sustainable precinct; zero carbon

Issue
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1. Introduction

WGV is the name of a new infill development focusing on meeting the 'missing middle' of medium density housing in Australia (Thomson, Newton, & Newman, 2017). WGV is in White Gum Valley, a low density suburb of Fremantle which is undergoing redevelopment as the first generation of housing from the 1950s is being replaced or restored with a denser and more sustainable housing product. It has been created by LandCorp, the Western Australian government's land development agency, with a charter to demonstrate innovation in urban planning and development. This article aims to show how WGV demonstrates how it achieves the two key components of the UN's 1.5 °C agenda:

1. Net zero carbon, a goal now being required by global commitments if climate change is to be kept below the 1.5 °C warming limit as suggested by IPCC;
2. A series of other sustainability outcomes that can be related to the UN Sustainable Development Goals (SDGs) which all nations are committed to achieve, especially SDG 11 which aims to make settlements 'inclusive, safe, resilient and sustainable'.

As a LandCorp development WGV must also be a commercially viable urban development product that can be sold into the market. It must, therefore, be able to create innovation within housing market constraints.

This article sets out to examine the extent to which WGV aspires to, and is achieving the 1.5 °C and SDG goals as well as being a marketable product. It will do this by examining the urban planning context, the urban planning process to deliver this, the results that can now be seen and what these suggest are the conclusions for urban planning.

2. Urban Planning Context

2.1. The 1.5 °C Agenda and Urban Planning

Climate change impacts on development and growth globally with the main contribution resulting from urban carbon emissions (Wang, Zhao, He, Wang, & Peng, 2016, p. 1066). The Paris Agreement in 2015 was an important step in creating a global climate change response that was shared and equitable for the parties involved. This was a key development as it has the potential to limit global temperature increase to 1.5 °C above pre-industrial levels (Roberts, 2016, p. 71). The IPCC are now assessing the options for achieving the 1.5 °C agenda (Boucher et al., 2016, p. 7287). The Paris Agreement has introduced a 5-year submission cycle for Nationally Determined Contributions (NDC), through the creation of voluntary short-term domestic climate policies together with the measurement, verification and monitoring of the NDCs for all parties. However, cities have a chance to commit to both short and long term processes that can help drive the 1.5 °C agenda.

Cities make a large contribution to greenhouse gas (GHG) emissions (Kennedy et al., 2009) as they are epicenters for economic activity and therefore represent a challenge but also an opportunity for climate change policy (Corfee-Morlot, Cochran, Hallegatte, & Teasdale, 2011, p. 169; Solecki, 2012, p. 557). Cities are where most economic growth now happens and so in their choices over infrastructure, technology and urban planning outcomes they can play an important role in developing mitigation strategies to reduce carbon emissions (Rosenzweig, Solecki, Hammer, & Mehrotra, 2010). For the first time the UN have set an urban goal, as part of the SDGs, which sets out seven indicators for urban development (as set out below). Therefore urban planning needs to try and achieve these seven indicators in every part of the urban development process and thus these goals must play a pivotal role in shaping future trends for infrastructure, land use and urban activity (Corfee-Morlot et al., 2011, p. 169; Kennedy et al., 2009; Yam et al., 2016) as was concluded by the UN Habitat Conference (UN Habitat, 2015).

Cities offer a platform for local level adoption of multi-scale approaches to climate change (Ostrom, 2010, p.27) with over 10,000 climate actions recorded (C40, 2015). Cities within Australia have been leaders in the push for sustainable cities, for example the City of Fremantle (where WGV is situated) has been at the forefront of climate action mitigation and adaptation with policies such as Carbon Neutrality which was the first in Western Australia in local government (City of Fremantle, 2011). Cities can "bend the climate curve" at a global scale with a 2-pronged approach of ambitious mitigation and transformative adaptation actions (Roberts, 2016, p. 71). Cities can act as the "starting point for the use of low-carbon ideas and technologies" (Wang et al., 2016, p.1066) to help achieve 1.5 °C and promote the benefits of low-carbon cities. The 1.5 °C agenda is an important opportunity for local governments as they play a key role in urban planning and are vital in creating the vision of low-carbon, sustainable, climate resilient and vibrant cities (Roberts, 2016, p. 71).

Without adaptive and innovative urban planning, it has been shown that urban expansion alone can raise temperatures by 1–2 °C (Georgescu, Morefield, Bierwagen, & Weaver, 2014, p. 2909). Cities that are "green, inclusive and sustainable" (The World Bank, 2010) are becoming increasingly important and therefore are a key focus for urban planning. This article outlines how urban planning in WGV can demonstrate how to achieve the 1.5 °C agenda.

2.2. The SDGs Agenda and Urban Planning

The SDGs are succeeding the Millennium Development Goals (MDG) and are a universal international consensus on sustainable development where a range of collective goals have been agreed upon including ending poverty and reaching gender equality (Sachs, 2012, p 2206). The SDGs are a transition from the MDGs and are furthering and expanding the pursuit of these goals into the future (Sachs, 2012). In 2000, the member states of the UN agreed upon the vision for the MDGs and recognized the need for global cooperation in the spheres of "development, peace and security, and human rights" (Singh, 2016). The MDGs were an expression of international public concern over significant issues such as "poverty, hunger, unmet schooling, environmental degradation and gender inequality" (Singh, 2016). To combat these global challenges a set of eight goals were established to enable the establishment of a set of quantifiable and time-bound objectives to ensure awareness is raised on these issues (Griggs et al., 2013, p 305; Sachs, 2012, p. 2206).

The transition from MDGs into SDGs was enabled through a significant consultation process within and by the UN which began in 2012. The SDGs were adopted in September 2015 and provide the current international framework for addressing global sustainability, with a framework of 17 goals, 169 targets and numerous indicators (Wellard, 2017, p 16) (see Figure 1). Having a cities goal (number 11) was a major step forward for urban planning in a global context.

The SDGs are interconnected and somewhat lacking in a structure to enable their delivery with so many different areas that are meant to be achieved simultaneously. The key features for delivery of the SDGs are partner-

Figure 1. The UN SDGs. Source: Global Goals (n.d.).

ships and demonstrations and hence an obvious place to do this is where economic growth is being focused, in the cities of the world. The SDG that focusses on cities is SDG 11 which states "making cities inclusive, safe, resilient and sustainable"; this incorporates seven indicators that have been selected to measure and monitor SDG 11's delivery (Table 1).

This article is seeking to show that the WGV example is tackling both the challenge of 1.5 °C in terms of energy and GHG innovations and that it can simultaneously achieve multiple SDGs using the urban planning framework. The SDG Framework and the Urban SDG Indicators will both be used to assess WGV as well as the demand and hence saleability of the development.

Urban planning should be an effective tool for achieving the SDGs as it often uses established frameworks and guidelines that can be selectively applied or adapted to meet the targets for achieving the SDGs. The world now needs many demonstrations of how to achieve these multiple goals through integrated urban developments. Shared-learning from such demonstrations can contribute to the international cooperation required to address the risks posed by climate change and its impacts through the SDGs (Griggs et al., 2013, p 305).

2.3. The WGV Context and Urban Planning

WGV is an infill residential development that evolved into a demonstration housing project, located in the capital of Western Australia, Perth. Perth has a Mediterranean climate with an average of 8.8 hours of sunshine per day, 300 cloud-free days a year ideal for solar energy (BOM, 2016). The development aims to offer an example of innovation in sustainable housing featuring a range of innovations but having a special focus on whether the solar energy can be enough to create a net zero emissions development. It is also an important demonstration of how to turn a middle suburban redevelopment site into a workable, saleable product at medium density, an agenda of interest across Australia and other car dependent cities in North America (Newman, 2015; Newman, Beatley, & Boyer, 2017; Thomson et al., 2017). The residential development is situated on the site of a former school which ceased to operate in 2008 and provided a site of 2.3 ha with approximately 100 housing units now being built in a medium density format and with a highly mixed tenure. Figure 2 is an artist impression of the site, which in early 2018 is about 70% completed.

WGV aims to demonstrate that precinct-scale design can contribute to sustainable development by incorporating various building typologies, climate sensitive designs, urban greening, water and energy management strategies, as well as including affordable housing options and a sense of place and community.

This article outlines how the aspirations of the WGV development and actions implemented to date demonstrate inclusive urban planning and design that can lead to the achievement of various SDGs as well as being zero carbon. By using the SDGs as a template against which to assess WGV, we can identify to what extent the WGV development has contributed to achievement of the SDGs. This article illustrates the demonstrated attempts to realize the ambitions of achieving both the 1.5 °C agenda and the SDGs at the WGV residential development.

3. The Urban Planning Process

The urban planning process is outlined to show how it incorporated both the 1.5 °C agenda and the SDGs.

This article has been developed based on data from various research projects that are utilizing WGV as a

Table 1. Indicators used in analysis of Goal 11: "Make cities and human settlements inclusive, safe, resilient and sustainable". Source: compiled based on UN SDGs indicators.

Target
11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums.
11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.
11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage.
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.
11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.

Figure 2. Artist impression of the WGV residential development, in the suburb of White Gum Valley. Source: LandCorp (2015).

case study. The data is drawn from a combination of semi-structured interviews with diverse stakeholders involved in the urban planning process, archival records, correspondence with WGV planning stakeholders, resident interviews of their expectations for moving into the precinct and current resource use, modelling as well as building monitoring.

While the WGV development was not specifically designed with the seventeen SDGs in mind, archival records show that it was developed with the general principles of sustainable development as a driver. Therefore, rather than assessing WGV against specific SDG indicators, this article takes a qualitative approach and assesses the WGV development process and outcomes against the principles of the SDGs and the 1.5 °C agenda. This assessment takes a localized approach, examining how an infill residential precinct in a developed country might contribute to achieving the SDGs at a local level.

As the construction of the WGV development is not fully complete, this article will focus on the as-designed phase of WGV with some early results that can help answer the question about its zero carbon goal. Future research and publications will follow the completed project, including a longitudinal study of resident resource use in the various dwellings in WGV and comparison of the as-designed and as-used electricity and water technology features.

The urban planning process methodology was typical of any LandCorp development where a strong emphasis is put on innovative design and parallel community engagement to see the extent to which it can deliver on the innovations in that community, but also how it can complete their obligation to be a commercial success.

3.1. The Urban Planning Process and 1.5 °C

Sustainable development through urban planning is necessary for cities to successfully adapt to climate change as it is aimed at achieving urban livability while avoiding adverse impacts, such as resource depletion and GHG emissions, within and outside the urban perimeter (AlQahtany, Rezgui, & Li, 2013, pp. 177–78). The core principles that have been accepted for sustainable urban planning according to AlQahtany, Rezgui and Li (2013, pp. 177–78), include: being responsive to market needs; integrating with multiple systems including transport, energy, housing and utilities; using partnerships; considering social, economic and spatial inequalities caused by climate change; and considering local culture and context. By utilizing the opportunity presented by this conflux of issues, the SDGs and the 1.5 °C agenda can be furthered through the use of sustainable urban planning and this is what set the context for LandCorp's process.

The reduction of non-renewable energy use and carbon emissions was a key focus for WGV and is central to its vision, as is necessary for achieving the 1.5 °C agenda. Through various initiatives and innovations such as energy efficient design, use of renewable energy and tech-

[1] Figures based on average Perth consumption for single residential dwellings, when adopting WGV's Design Guidelines and Sustainability Upgrade Package.

nologies, the reduction of grid energy consumption was set at 60% for WGV and 100%[1] in dwellings taking advantage of a WGV sustainability rebate package. Energy reduction measures such as the use of solar power, embedding of energy efficiency requirements in the design guidelines, and a precinct layout ensuring that homes are north facing, therefore benefiting from solar passive orientation, were major urban planning initiatives to reduce carbon and improve occupant thermal comfort.

In order to meet the 1.5 °C agenda it is necessary for rapid transformation so that any new development can make a significant contribution to the necessary changes in global emissions. Rapid transformations cannot be done using large scale centralized power systems; however, in cities where new developments are happening all the time an organic and exponentially increasing process can occur if the new technologies for energy efficiency are implemented as part of the new development. This is termed disruptive innovation as it is demand led and can cause dramatic change in short periods of time (Green & Newman, 2017a). Roof-top solar and lithium-ion battery storage were seen as having the potential to create such disruptive innovation. These were brought in through the involvement of academic advice (from Curtin University in partnership with industry) and were made possible to implement with assistance from a Federal Government grant to demonstrate how they can be used to contribute to savings, both monetary and carbon.[2]

During its design phase, WGV was established as a 'living laboratory' for a four-year research project supported by the Cooperative Research Centre (CRC) for Low Carbon Living and Curtin University (Burbridge et al., 2017). This research project was set up to provide collaborative innovation guidance, monitoring of energy and water usage and technology performance, as well as sharing the learnings with industry, government and the wider community.

Energy efficiency and other low carbon measures that were required in the design of WGV include:

- Climate responsive design and landscaping to harness the sun's energy to provide natural heating and cooling solutions, including intelligent use of trees for seasonal shading;
- WGV Design Guidelines set a minimum seven-star[3] energy efficiency rating;
- Mandated rooftop solar of 1.5kW for all attached and detached single dwellings with extra panels (upto 3.5kW) provided for single lot dwellings (through the WGV Sustainability Package Rebate);
- Battery storage and solar panels for the apartment developments;
- A shared Electric Vehicle for use by the community;
- Solar hot water systems or heat pump technology;
- Energy efficient electrical appliances;
- Energy efficient lighting solutions;
- Low energy space heating and cooling systems;
- Education material and support provided to residents.

Innovative research programs conducted as part of the project include:

- CRC for Low Carbon Living research program and partnerships to monitor energy use and water use, technology performance and facilitate knowledge sharing;
- Australian Renewable Energy Agency (ARENA) research program and partnerships to test viability of solar battery storage on strata buildings;
- A unique solar power and battery storage technology research trial in a shared strata-building setting at the Gen Y Demonstration Housing Project;
- A governance model to allow shared solar photovoltaics (PV), battery and monitoring systems to be used in medium density apartments; the governance models involving peer-to-peer (P2P) trading and using blockchain technology to be tested at 50 units of WGV;
- A study of household resource practices with comparison to individual baseline practices from before the residents move into WGV.

As well as the technology to enable rapid transformation of the energy provided, there was a necessary consideration for the management system in the WGV precinct and in this we have focused on how to create a Citizen Utility as set out by Green and Newman (2017a, 2017b). The context for this is set out below.

There is a growing trend in Australian energy markets where energy consumers have started to produce their own renewable energy—over 30% of households in Perth now have roof top solar panels representing some 700MW of power. Households are doing this to complement the grid sourced electricity they have traditionally relied completely upon. High retail energy prices coupled with low energy sale prices are incentivizing households to generate energy behind the meter and to store any surpluses. For the first time in history, network operators are now having to consider a future where householders are treated as both producers and consumers. However, whilst owner occupied low-density suburban households have benefited most from the renewable shift, several barriers still exist for those in strata (common property) arrangements as in WGV. Shared roofs have in the past been difficult to make available for the use of solar panels due to strata title governance requiring all residents to agree. This project aimed to get around that barrier by building solar and storage into the shared contracts

[2] It is worth noting that since the purchase of the PV and batteries the cost of these have continued their dramatic decline and are now being mainstreamed in a number of urban developments in Perth.

[3] Nationwide House Energy Rating Scheme—7 Star is above the mandidatory 6 star performance benchmark.

of all residents and providing a clear set of benefits by enabling them to have much better options for power into the future. This approach has been called a 'citizen utilities' approach, where a distributed, decentralized, decarbonized and democratized energy market is created (Green & Newman, 2017a). The Citizen Utility at WGV was therefore set up as a model for how a multi-residential medium density strata title company, that manages the shared spaces in a building complex, can also manage the power using a blockchain software system involving P2P trading (Green & Newman, 2017a, 2017b). One of the complexes was also fitted out with a shared electric vehicle linked into the solar energy and the Citizen Utility.

The importance to urban planning of these innovative energy models is that to phase out large scale fossil fuel power systems will require local urban developments that can become completely zero carbon with full electrification of buildings and transport (Kennedy, Stewart, Westphal, Facchini, & Mele, 2018). The technology for individual buildings and individual vehicles is well established but how to join them together into an urban system is the big question. WGV seeks to help answer this. The project is just one precinct but it is establishing a model for how it can be fitted into an urban system consisting of multiple precincts joined together through P2P trading. WGV was the first example of P2P to be established in Australia and possibly the world.[4] Thus citizen utilities across multiple precincts can create whole cities with their buildings and transport powered through these distributed, linked systems exchanging their energy services (Glazebrook & Newman, 2018). Considered in aggregate, Citizen Utilities will give rise to Precinct Utilities and Urban Utilities: decentralised and distributed utility services operating throughout the world's cities and suburbs. As WGV is one of the first of these in the world to be established and tested the project has considerable global significance with other precincts already copying the technology and the governance/management system created[5] (Kennedy et al., 2018).

The governance models developed at WGV to manage energy and GHGs were set up to research the shared benefits, risks and costs between developers, owners, tenants, strata bodies and utilities. The models also include the energy system design, billing, legal addendums for dwelling purchasers and dwelling leases. The financial aspects of the governance models are being further studied, tested and demonstrated in three different strata lot developments over time. The models developed were set up to be adaptable and scalable to suit different development types. The project thus provides scalable and generalizable models for shared ownership of solar and storage in medium density developments. The WGV site serves as a demonstration of the effectiveness of the governance model in enabling greater solar PV and storage to be adopted across apartment housing in Western Australia and across other parts of Australia and the world (Green & Newman, 2017b). Once established any housing, whether high density or low density, will be able to make the most of being in a local Citizen Utility. The urban planning implications of these Citizen Utilities are not known so the project has many years of examining such matters.

3.2. The Urban Planning Process and the SDGs

The first step in innovative and perhaps controversial urban regeneration projects was to develop an effective community engagement process to support the inclusion and participation of diverse voices. The second step was to develop the innovations in sustainability using an accreditation process and innovative approaches to urban design, affordable housing, landscapes and water. And the final process was to create a Master Plan with associated scenario planning.

3.2.1. Community Engagement and Community Culture

The community in the City of Fremantle where WGV is located is well known as a center for sustainability (Beatley & Newman, 2009) and strong commitments to carbon neutrality as one of its core principles. The development at WGV needed to take advantage of this commitment to sustainability and to further encourage and develop this culture, while providing a practical demonstration for sustainable living in Australia. Through energy saving initiatives, affordable living options and a wide range of shared amenities, WGV aimed to become a community where it was easier and more affordable for people to live in a sustainable manner. To achieve this goal, the developers of WGV created a partnership with the City of Fremantle and other stakeholders to develop a series of strategies and incentives, such as building attractive community spaces, community housing and introducing new residents at the development to community activities, to help achieve this sustainable standard of living. A further incentive for residents to commit to WGV's vision is a funding package worth up to $10,000 for eligible single-lot buyers where the price and installation of technologies such as solar power, water tanks, advanced tree provision and smart meters, is offset.

WGV aimed to be 'inclusive' in the following ways. It set out to provide a range of affordable housing typologies and rental/ownership options, with a mix of 23 single residential developments, two apartment sites, a Gen Y demonstration housing project and one affordable housing apartment site. It aimed to address the rising cost of living through the reduction in use of mains water and retail electricity; thereby offering lower operating costs for residents. A sense of community is supported through the provision of community-based re-

[4] https://onestepoffthegrid.com.au/peer-peer-solar-trading-kicks-off-wa-housing-development
[5] https://onestepoffthegrid.com.au/tag/peer-to-peer-trading

sources such as barbeque and picnic facilities, nature play areas, and informal seating to foster community contact and promote livability at WGV. Transport in WGV is an issue as it is not centered around a major public transport system; however, a regular bus service is within a short walking distance from the WGV precinct. Several alternative transport modes were developed in WGV such as walking and cycling paths, provision for electric car recharging, an electric car-share program on site, and bike parking spaces. Help with the building and construction process was provided to future owners through workshops on sustainable house and landscaping design. Lessons learnt throughout the development of the precinct are being shared between the government and industry stakeholders, research partners, and the residents through online publications and research-related events.

Archival records together with interviews with stakeholders demonstrate that the development process was characterized by the following features:

- Visioning for sustainable development and a site/context analysis early in the business case development stage;
- Incorporating community participation through workshops at an early stage (before detailed planning was completed) that enhanced local context, sense of place and community aspirations, particularly relating to affordable and sustainable housing;
- Bringing together various planning-related professionals such as urban planners/designers, engineers, landscape architects and estate architects to ensure collaboration between stakeholders. This collaborative and participatory approach enabled multi-disciplinary planning professionals to simultaneously consider the positive and negative impacts of each other's proposed planning actions upon each other's plans, in the context of the developer's overarching vision for a sustainable development. This ensured fundamental design requirements for solar access (including to adjoining sites), communal open space and active building facades were included.

These three elements in the planning processes were necessary to ensure that WGV could simultaneously reduce urban GHG emissions and achieve the SDGs as outlined in the results section below.

Germinating from the abovementioned community workshops arose an understanding of the community's desire for a residential development that was in keeping with the strong environmental and community-oriented values of the existing local community. One key aspiration was the desire to secure a site for a housing cooperative for a group of local artists known as SHAC (Sustainable Housing for Artists and Creatives). At the time, SHAC was unincorporated and non-financial which presented logistical challenges in terms of securing land and financing a building.

Consistent with SDGs 16 and 17, a local partnership between SHAC and a local community housing organisation (a not for profit social/public housing provider called Access Housing) was facilitated via the developer. The partnership process guided the artists' cooperative toward incorporation as a legal entity, which enabled its recognition within a legal and financial context. In an innovative partnership, the community housing provider entered into a novel agreement with SHAC to purchase a parcel of land at the WGV development and build housing for SHAC. The community housing provider then enabled an inclusive design process giving SHAC early input into the building's design, incorporating many of their unique needs as residents, including artistic spaces for them to work onsite (Ward, 2016).

This partnership approach between tenant and landlord represented a new way to develop an affordable housing project for this community housing organisation and demonstrates the importance of grassroots empowerment and inclusion in the implementation of SDG 16 (Lawson-Remer, 2015). The outcome is access to sustainable housing for people who experience financial challenge due to the atypical labor market patterns of the arts industry (Throsby & Zednik, 2011). Further, the early introduction of artists and creatives into this residential development supported the function that culture and art play in facilitating civic development and inclusion (Plant, 2016).

3.2.2. Sustainability Accreditation

In recent decades, various certification systems have been developed to support sustainability in the urban planning process that could be used by developers to further the SDG and 1.5 °C agenda (Newman et al., 2017). Initially limited to the building scale, some systems have since recognized the need to encapsulate a more holistic and wider community scale approach to sustainability (Haapio, 2012). Some of these certification systems have been criticised as they often do not include clear and specific targets aimed at performance and that evaluation of final outcomes can be deficient (Wangel, Wallhagen, Malmqvist, & Finnveden, 2016, pp. 200, 204, 210). However, most innovative developments use accreditation to help provide a systematic approach to precinct scale sustainability (Rauland & Newman, 2015; Webb et al., 2017).

One Planet Living (OPL) is an accreditation scheme developed by Bioregional, a UK firm that created BedZED in London. The OPL scheme is an international sustainability initiative based upon the idea that people need to live within the limits of one planet's natural resources. OPL provides a framework, built around 10 principles (see Figure 3), which guide sustainable development. The use of OPL at WGV innovatively addresses the concerns of certification systems raised by Wangel

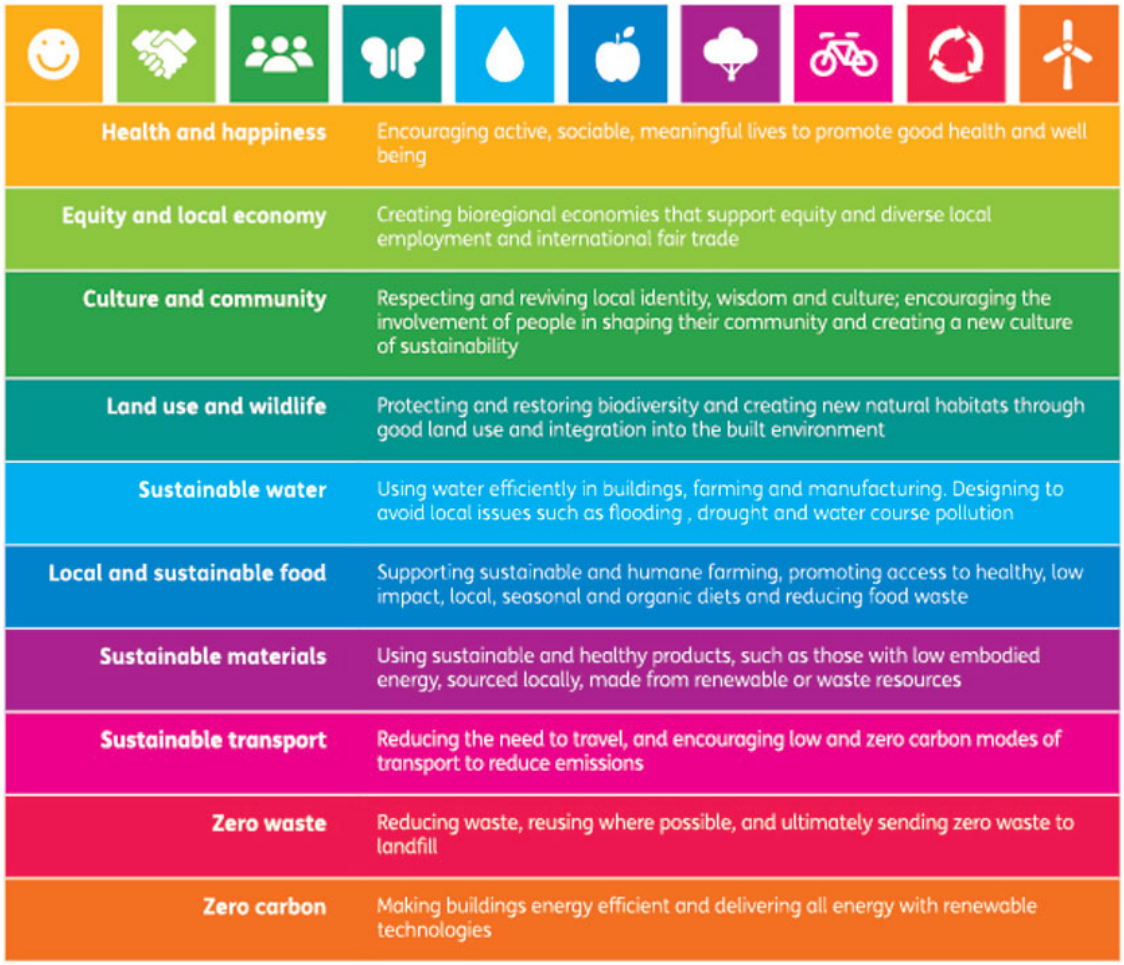


Figure 3. The OPL Goals. Source: Bioregional (n.d.).

et al. (2016) through specific performance targets, post-planning evaluation while taking a holistic approach to sustainable urban planning.

WGV is Western Australia's first residential project to achieve national recognition for its adoption of the OPL scheme to guide each stage of the urban planning and development. It is only the second project in Australia and only the eleventh worldwide to achieve an international endorsement as a One Planet Community through OPL. The City of Fremantle is one of the first One Planet Council's in Australia, therefore the required One Planet Assessment Report for WGV links in well with the City's One Planet Strategy and provides a solid framework for community members to implement sustainable living practices within their own homes. The main goal of OPL is to create neighborhoods where it is easy, attractive and affordable for people to live enjoyable and healthy lives using an equitable share of the earth's resources. As it requires zero carbon and has a range of 'inclusive' requirements, it is an ideal accreditation system for guiding the 1.5 °C agenda with the SDGs.

At WGV, the OPL's 10 principles were used to help guide the development and to demonstrate to the community, and potential buyers, that the project is a pioneering, real world, highly innovative, urban development.

3.2.3. Urban Design

The WGV project applied a multi-faceted design approach to sustainability with affordable housing and numerous environmental initiatives integrated into the design. The partnership between various stakeholders was seen as the basis for the development to be set up as a 'living laboratory' where energy use, resident behavior, energy initiatives and the implementation of the WGV Design Guidelines (LandCorp, 2015) can be monitored and assessed. WGV features innovative and pioneering energy, water and climate responsive design, innovative housing design for each of the development sites, e.g., the Gen Y project and a free open source website for the exchange and sharing of information on the design process.

The Gen Y Demonstration Housing Project is a prime example of quality urban design with its efficient use of the residential block through density and shared infrastructure and services. The increase in density has not come at the expense of livability for its residents and neighbors with each apartment having private and communal areas, generous ceiling heights and high thermal efficiencies. The Gen Y Demonstration Housing Project has been accredited with a gold medal level life cycle

analysis by eTool (Beattie, Bunning, Stewart, Newman, & Anda, 2012), meets the principles of the OPL sustainability framework and has been designed to meet the essential requirements of Liveable Homes accessibility standards. The development was awarded the Australian Urban Design Award for Urban Design, Policies, Programs and Concepts: Small Scale in 2017.

A key aspect of the development project is the climate responsive layout which integrates solar passive design principles which ensure natural light, cross ventilation to each apartment and use of sustainable materials such as green concrete using low carbon furnace slag that increases thermal mass. Initial conversations with residents indicated that although they have moved from housing that has had air conditioning and heating systems that were regularly used, they are comfortable in the new dwellings that do not have these, verifying the climate responsive design. The three apartment developments on site have been designed to use renewable energy, water sensitive practices and battery storage technologies which include the installation of a 9kW Photo Voltaic system with battery storage, a 10,000L underground rainwater harvesting tank, and performance monitoring for all key services. The performance monitoring undertaken through the living laboratory research will provide valuable input for future developments on how the urban design principles perform with residents living at WGV, ensuring the results can be utilised by other developments targeting the SDGs and 1.5 °C agenda.

3.2.4. Affordable Housing

Affordable housing is critical for any development striving to be a model for multiple SDG goals. In Australia, it is estimated that 13% of the population is living under the poverty line, many of these children and old aged pensioners (Australian Council of Social Services, 2016). WGV addresses the lack of affordable and diverse housing in Perth through a range of dwellings and the inclusion of 15% affordable housing stock in the development (Housing Authority, 2016). The partnership between LandCorp, Access Housing and SHAC came together to deliver a community housing development specifically for local artists and their families at WGV. This initiative aims to support the local creative industry and encourage greater diversity and culture within the community. The partnership provides affordable housing for artists who work in the cultural and artistic center of Fremantle but have been priced out of the residential housing market and were travelling long distances (upwards of 50kms) to work and cultural events, often not using public transport. The SHAC development is part of a diverse range of housing and living options within WGV and includes apartments, townhouses and single homes that has attracted a broad cross section of society to WGV, resulting in a strong diversity of residents.

Along with the SHAC development, WGV is home to the Gen Y Demonstration Housing project, which is a practical demonstration of sustainable and cost-effective housing to suit living in the 21st century as well as two other demonstrations of social housing: a Baugruppen Model housing co-op and a privately funded housing co-op. WGV thus provides a practical demonstration of several new housing models that can be replicated to provide affordable housing for a range of people.

The various apartments of the WGV project also explored how to address the problem of the 'missing middle' of medium density housing, where cities like Perth have a plethora of either low-density single family homes in outer suburbs or higher-density apartments in inner areas, but not medium density dwellings in middle suburbs (Thomson et al., 2017). This project demonstrates a solution where the gap between single homes and apartment blocks can be bridged through some increase in density while also integrating well within the landscape of low-density housing surrounding the area.

The diversity of housing options was a key way that WGV was inclusive of the local community and could facilitate SDGs.

3.2.5. Landscape and Water

The creation of an attractive and highly liveable environment was seen as central to the design for WGV where local biodiversity, shade and shelter and opportunities for community interactions are supported. Through careful planning, 25% of the existing trees were retained in the subdivision design. Beyond this, there was a prioritization on the reuse and repurposing of materials to minimize waste. Before site work commenced on the project, a tree assessment was undertaken to determine suitable timber for harvesting and reuse with the development. Limestone recovered during project civil works was also incorporated into the landscape to celebrate local materials.

There was a fauna relocation program undertaken prior to site works commencing and the strategic provision of habitat structures has been considered within the new landscape. The planting of new trees was a priority with the project aiming to match the predevelopment canopy density while increasing dwelling density. This is an important strategy to improve livability but also contribute to the urban forest of the greater area. The re-engineering and revegetation with native plants of a large stormwater sump adjacent to the precinct was undertaken in partnership with the City of Fremantle to create a public space that was both attractive and engaging with the public while maintaining biodiversity and fulfilling its original drainage function (see Figure 4).

Overall the landscape design aimed to reflect White Gum Valley's character, support local biodiversity and promote community use of public spaces. 30% of the street trees are edible fruit species to support local food production and foster community sharing of resources. Public spaces include BBQ facilities and shaded picnic areas, nature play areas, informal seating and a network

Figure 4. Left: installation of drainage cells as part of the retrofitting of the stormwater sump; right: the completed stormwater sump with a newly landscaped parklet for community use. Source: LandCorp (2015).

of walkways and cycle paths to encourage active, outdoor lifestyles.

A range of positive benefits is set to be achieved as a result, including:

- Improving community health and wellbeing through the creation of an attractive and engaging outdoor environment;
- Providing habitat and native food sources to support local wildlife;
- Activating public open spaces to foster community cohesion and improved safety;
- Encouraging shared local food production to build community;
- Utilizing locally sourced materials, including repurposing of demolition materials to minimise waste.

Integrated Urban Water Management (IUWM) is a key feature of the precinct. The project is targeting a reduction of mains water consumption by 60–70% compared to the Perth average per capita consumption across the various housing typologies. To meet this goal, there is leading in-house and ex-house water efficiency measures, rainwater harvesting on the single residential lots and the Gen Y Demonstration House (for toilet flushing and washing machines), and a community bore water supply for irrigation. Each of these initiatives is supported by a combination of Design Guidelines (controls) and developer incentives (sustainability package) to increase successful implementation.

In addition to mains water reduction through efficiency and source substitution, water sensitive design has been applied to ensure stormwater is carefully managed across the landscape to promote local infiltration and groundwater recharge.

3.2.6. Master Plan and Associated Scenario Planning

Once the outline of a potential product was determined meeting all the above design objectives and providing a saleable product, it was possible to draw up a Master Plan and assess various scenarios that provided the planners and developers with necessary densities and expected outcomes for WGV. Such modelling was done using the Kinesis Modelling tool (Beattie et al., 2012) to assess the cost of the housing products, the carbon emissions, water consumption, transport and proportion of affordable housing. The project was then put to the market.

4. Results and Discussion

The results are set out to show how well WGV has turned out in terms of the 1.5 °C agenda, the SDGs and the saleability of the product.

4.1. WGV and Net Zero Carbon for the 1.5 °C Agenda

The results from the Kinesis modelling are summarized in Figure 5. They show that WGV was overall likely to be around 59% lower in carbon emissions, 75% lower in water and 21% lower in operating costs. Transport is almost identical as the site it is not well placed for public transport. This is further discussed later in the article.

The Kinesis modelling was undertaken at the completion point of Structure Planning, prior to detailed design and the incorporation of innovative programs like the strata solar energy storage trial on the multi-residential buildings, and the sizing of solar energy systems for the single residential lots to meet a net zero energy status. At the time of publishing this article, detailed modeling of the 'As Designed' scenario that incorporates the full suite of initiatives in partnership with industry and researchers was still being finalized. However it was clear that the potential for a zero carbon power system was now possible—at least in terms of design. As an example, the first multi-residential building to be completed, occupied and monitored (the Gen Y Demonstration House) is close to meeting 100% operational power requirements. Ongoing assessment through the seasons will be required to determine the extent to which the building can meet its operational energy needs. Likewise, the modelling indicates that the residential dwellings will

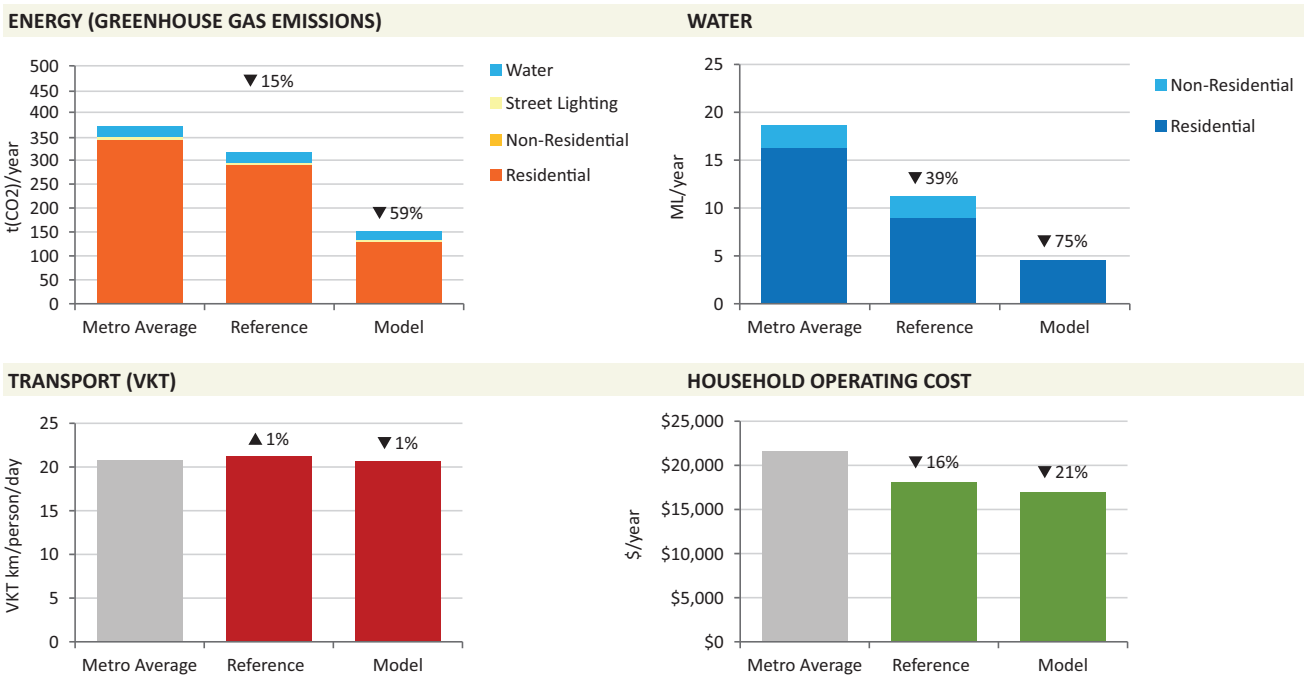


Figure 5. Results of early scenario modelling on WGV.

meet net zero energy, assuming the homes are operated as intended as early data shows between 72% and 98% of the power needs will be met from the solar and batteries. Thus, with the solar energy being exported to the grid (once batteries are filled) this means more renewables are being produced than energy consumed.

The establishment of a monitoring program across the whole site with detailed monitoring of particular developments like Gen Y and SHAC will provide the extent to which the design for zero carbon has been translated into real living situations.

4.2. WGV and the SDGs Agenda

Table 2 summarizes the work at WGV to create an urban development that can be close to zero carbon and at the same time help achieve the SDGs. The Table shows for each SDG how well the SDG has been met in WGV—major, medium or minimal—and what in particular was done.

Table 2 shows that the major focus of the 1.5 °C agenda, achieving a zero to low carbon development, is likely and that at the same time the development has contributed significantly to the SDGs. It demonstrates that, of the 17 SDGs, 12 SDGs were achieved in a major way, and five in a minimal way. This would suggest that a significant urban development demonstration has been achieved in the design of the WGV project. Initial modelling of the infrastructure performance and interviews of the residents indicate that WGV is on track to achieve these goals as planned from the design stage.

Another way to use the SDG framework is to examine the indicators that were set up by the UN for the SDG 11 urban goal. These are set out in Table 3.

Out of the seven indicators only one shows up relatively poorly, the transport indicator, as WGV is not a transit oriented development. However residents are already finding innovative solutions to transit problems, with some returning to their habit of bicycle riding that was not used in their previous households. Others are staying closer to home for recreation with their small children and utilizing the shared spaces instead. For SHAC in particular, the residents have been able to work onsite in the artist studios, or close by in the center of Fremantle, reducing the need to travel the long distances they were in previous housing. The first steps towards making this area more transit oriented through urban planning are happening along the corridor into the Fremantle CBD where a new development around ten times the size of WGV is being planned with opportunities to scale up many of the innovations in WGV; this should include a transit system with innovative smart systems and an autonomous electric bus service that could also be brought to WGV. This would help considerably in completing the agendas for both 1.5 °C and the SDGs.

4.3. WGV and Market Results

As the West Australian Government land development agency, LandCorp is obliged to deliver its projects on commercial terms. As such, the broad range of innovations described in this article were scrutinized to ensure they were technically and financially viable. Except for the research grants identified, WGV has met the necessary business case considerations of a successful land development based on market return. In addition, the offerings were very well received by the market, with all lots sold in good time at a period where the market was

Table 2. SDGs and how the WGV residential development contributes to their achievement.

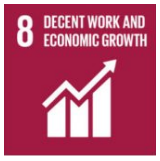
UN SDGs	UN SDGs Defined	WGV Details and Extent	Overlaps with other SDGs
	End poverty.	Major: affordable and social housing.	10, 16
	End hunger, achieve food security and improve nutrition.	Minimal: planting of edible fruit tree varieties; promoting home food growing in the Design Guidelines; connecting residents with local community gardens through the Resident Information Pack.	3, 12
	Ensure healthy lives and promote well-being.	Minimal: attractive and engaging outdoor environments; connecting residents with activities and networks through the Resident Information Pack.	
	Ensure quality education for all.	Minimal: educational demonstration project of sustainable living.	
	Achieve gender equality.	Major: strong women's leadership in social housing.	
	Provide safe and affordable water and sanitation for all.	Major: reduction of water usage, water efficiency, water sensitive design.	3, 17
	Ensure access to affordable, reliable, clean energy for all.	Major: solar and battery storage, energy efficiency, renewables.	9, 12, 13, 17
	Promote decent work for all and sustainable economic growth.	Major: citizen utility, sharing of energy through peer to peer network, 'pro-sumer'; affordable housing.	
	Build resilient infrastructure; promote inclusive and sustainable industrialization and foster innovation.	Major: innovative design and demonstration project fully monitored.	7, 11
	Reduce inequality within and among countries.	Major: Gen Y housing project, SHAC "sustainable housing for artists and creatives" housing project.	

Table 2. SDGs and how the WGV residential development contributes to their achievement. (Cont.)

UN SDGs	UN SDGs Defined	WGV Details and Extent	Overlaps with other SDGs
	Make cities and human settlements inclusive, safe, resilient and sustainable.	Major: shared amenities, community gardens and activities, consultation and innovative technologies.	
	Ensure sustainable consumption and production patterns.	Major: renewable energy, production of resources, resource efficiency.	2, 7, 9
	Take urgent action to combat climate change and its impacts.	Major: zero carbon, renewable energy, accreditation.	7, 9, 11, 12
	Protection and sustainable use of marine resources.	Minimal: advising residents on ethical purchasing programs through the Resident Information Pack, storm water cleaning in innovative sump.	
	Protection and sustainable use of land resources.	Medium: habitat and food sources for local wildlife.	
	Promote peaceful and inclusive societies, provide access to justice, and provide strong institutions.	Major: SHAC, Gen Y housing demonstration project; community engagement.	1, 3, 11
	Work together for sustainable development.	Major: community consultation, partnerships with local, state and federal government; research bodies; private enterprise; and not-for-profit sector.	9, 10, 11, 16

down. Market interest has also been strong on the multi-residential units. This is important context as it demonstrates both the financial viability and market appetite for quality projects that provide leadership in a low carbon future. The challenge is how these concepts can be upscaled and delivered into other regions around the country and the world.

5. Conclusion

Rapidly growing cities need to tackle the agenda of 1.5 °C to keep the extremes of climate change from impacting on global environments, societies and economies. Cities also need to implement urban planning and development that achieves the SDGs in an integrated and systematic way. WGV is an example of how this can happen using established accreditation processes such as the OPL framework.

WGV is a development where precinct-scale planning has been focused upon improving the livability of the development through various building typologies, climate sensitive designs, urban greening, water and energy management strategies, as well as a sense of place and community engagement strategies. Partnerships and early planning of innovations enabled solutions to be found to many problems faced in everyday urban precincts and thus were able to move the development towards achieving its three goals of zero carbon for 1.5 °C, inclusive design for the SDGs and a marketable product to enable mainstreaming.

By using the SDGs as a template for assessing WGV we can see how targets can be reached and the ways in

Table 3. Urban SDG indicators and how they apply to WGV.

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable Targets:	**WGV Achievements**
11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums.	Housing affordability mainstreamed through different housing and tenure types and through reduced operational costs. Basic services all available through community utility.
11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.	Public transport is not much more available as WGV is not close to economic activity or on a transit route of any significance, however it is close to schools, local shops and local green spaces. Walkable and cyclable internal street designs and the availability of a shared EV all assist. Universal access has been built into homes and internal roads.
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.	Inclusive community already exists in the area and WGV builds on that with a landscaped BBQ area, internal streets encouraging walkability and community events organised by residents. The Citizen Utility can use infrastructure management and planning for greater community engagement in urban living processes.
11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage.	Many features of cultural heritage were incorporated into the new development including naming some streets with Nyoongar words, restoration of the old Community Hall restored for public use, local artists engaged in designing elements of public space, reuse of trees removed during the building process on the site.
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.	New solar/battery systems and water sensitive urban design (especially storm water sump) are much more resilient for future climate change or disaster management. Citizen Utility will mean very strong social capital that is also critical to resilience.
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.	Waste management and air quality improved by community infrastructure.
11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.	Green spaces created, existing trees retained and canopy cover planned into the development; Citizen Utility will ensure area regenerates organically.

which they can be made possible. This article illustrates the demonstrated attempts to realize the ambitions of achieving both the 1.5 °C agenda and the SDGs at the WGV residential development through thoughtful and inclusive urban planning. The lessons from it can now be mainstreamed and translated to other environments and cultures.

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Conflict of Interests

The authors declare no conflict of interests.

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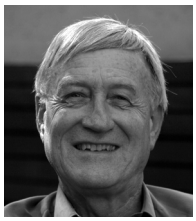

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