LOW CARBON LIVING CRC

The Renewable City

The Future of Low Carbon Living

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Authors	Peter Droege et al
Title	The Renewable City: The Future of Low Carbon Living
ISBN	
Date	14 November 2018
Keywords	
Publisher	
Preferred citation	

Australian Government
Department of Industry, Innovation and Science

Business
Cooperative Research Centres Programme

Acknowledgements

This research analysis and compilation is funded by the CRC for Low Carbon Living Ltd supported by the Cooperative Research Centres program, an Australian Government initiative

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The Renewable City: The Future of Low-Carbon Living

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30 October 2018

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1. Preface and summary

Perth is a fertile incubator for important projects and initiatives that emerge from and through the initiative of CUSP, Curtin University, the City of Fremantle and many other organisations enabled by such valuable institutions as the Cooperative Research Centre for Low Carbon Living (CRC LCL). There is a great contribution to be made to transforming the thinking about our immediate living environment and general place in the world – and the opportunities posed by lowering carbon emissions ('carbon' is here always used as short for *carbon dioxide equivalent greenhouse gas (GHG) emissions*: not all GHGs actually contain carbon) embodied in the production of and generated in powering, heating and cooling our residential environments, work spaces and the built environment in general. Commercial energy is to a large extent applied in the building and transport sectors, hence the focus on urban living in shifting the energy paradigm is both astute and profound. Energy renewability, embodiment, efficiency and sufficiency continue to form a magic quadrangle from which to draw instruction for action. Embodiment in particular presents an important growth perspective: as low-carbon living (LCL) gives way to what I would like to call *ultralow-carbon life* (ULCL) it is essential to lower the quantities of 'carbon' - greenhouse gases – in the atmosphere to keep the well-tempered greenhouse from sliding into a hothouse state.

This paper is also an urgent call to heed the need for rapid proliferation of LCL principles and projects, and their mobilization across the built environment production system. It is a call to build an open market for this by creating the required regulatory and policy frameworks, and to remove all the overt and hidden ways in which fossil content is subsidised. This is no longer just urgent but has now become manifestly overdue, as a result of political delays and incumbent industry inertia. And given the importance, even primacy of cities and urban areas in global human settlements, the Renewable City – urban environments, economies, movements and systems entirely relying on renewable energy resources - is now an essential precondition to any hope to stabilising the global climate. The future of low carbon living lies in ultralow-carbon cycle balance, and, consequently, highly carbon retentive cities and regions. Or better yet: a truly carbon negative built and cultural environment, one that removes, sequesters, stores and binds greenhouse gas already in the atmosphere. This cannot be enough: a massive regenerative action agenda needs to ensue to attempt at 'global gardening', the un-development and re-nurturing of Earth's biosphere.

2. Introduction

Humans can be brilliant in short-term, even medium-term planning by individuals or small groups, but modern humankind has proven spectacularly ill-equipped in devising and exerting conscious and constructive, collective, long-term agendas. The delays in critical action over the past generation – in full view of the risks – meant that today, seemingly paradoxically, '100% renewable is no longer enough' and 'the zero emissions target is too high'. In recognising and meeting this challenge lies the very meaning and future of low-carbon living. We know that the UNFCCC targets and frameworks were always far too loose and narrow, and the IPCC projections that were adopted were inadequate. The global politics of carbon implied that we had space in which to reduce the carbon we were emitting disregarding even the possibility that it had not already been blown by the time this very notion of a 'carbon budget' was created, ie an added capacity to pollute the atmosphere, and trade within that bubble. The fact is that by the late 1980's, when climate change began to be popularised in earnest, atmospheric CO_2 concentrations were already substantially above the long-term stable level of 280 ppm, namley 350 ppm (NOAA 2018). There was not then and is not now any historical or empirical evidence that relative climate could be sustained at such increased levels.

3. 100% Is Not Enough – and 0 is Too High

The most positive future to aspire to is a massive propagation of LCL developments, innovations and findings, in buildings, neighbourhoods and communities – and perhaps most importantly and challengingly the existing building stock. Elevating the retrofitting and refurbishment of the energy wasting building and plant stock to a national priority and making it the very foundation of building, construction and planning regulations is fundamental. It pales only in comparison to the equal second priority of decarbonising its energy source, and to dramatically shift away from coal, oil and gas, and retire the dying nuclear industry.

The widespread complacency about the need to reduce carbon rapidly is a most tragic hallmark of modern society. As a result, the equal third and equally urgent challenge lies in endowing the built and (agri-)cultural environment with the ability to also withdraw copious amounts of excess GHGs from the atmosphere and bind them in soils and materials, support biodiversity and sustainably manage increasingly scarce water resources. These simple means have existed as the basis of good land management for millenia but have been largely lost: stop cutting and instead regenerate the natural photosynthetic systems on which we depend for food and fibre and natural system resilience. When actions in cities lead to major reforestation and carbon sequestration not just in products like wood in buildings but in agricultural soils regenerated wetlands, mangroves and coastal areas, then we can begin to see how such urban mechanisms can work to stabilise climate change.

Sustainability principles, once seen as quaint aberrations in a landscape of business-as-usual have emerged as urgent survivability measures, without all really noticing it yet: relying on renewable energy, ending the combustion of fossil resources, transforming carnivorous food culture and industrial agriculture, lowering atmospheric GHGs and binding them in soils and materials, shrinking lifestyle footprints, revolutionising water management, and shoring up biodiversity are essential elements in ULCL actions and demands for the built environment. Ultralow-carbon life means that target horizons shrink to 2020 and aims emerge as 150% - rather than 80-100% - emission reductions. The built, agri/cultural and natural environments together must achieve the net absorption of atmospheric CO_2 and other greenhouse gases.

4. From Low Carbon Comfort to Ultralow Carbon – Historical Context – Paths Out of a Very Predictable Predicament

Earth is not a spaceship, contrary to the seminal sustainable development expression and literary image Spaceship Earth launched in the 19th century and popularised in the 1960s (George 1879, Ward 1966, Boulding 1966, Fuller 1968). It is a fairly ancient planet of 4.5 billion years on a fixed orbit – and yet it presently is also on a rapid journey in its climatic behaviour. Its degree of habitability is transforming in front of our very eyes: it is becoming a different kind of planet. For anyone who thought that she or he might not be so special: the perhaps mockingly named Anthropocene is an unusual moment in this planet's biospheric and human evolution. It would be a very unique moment if Earth were to morph from Goldilocks habitability into what would be a very difficult planet to colonise with enormous technological and financial resources, let alone with the actually quite limited means at our disposal.

Interested in interplanetary travel? Instead of racing for eight months through space to get to Mars, we need to do nothing, continue business as usual and wait for only a few more years to arrive at a wholly new and ferociously alien world: Terra 2 would feel a bit like Venus. This transformation does not come easy, and is being exerted by a century of concerted geo-engineering effort in the form of fossil energy injection, fossil carbon release and other means of transforming land, water, inherited populations, systematically eliminating biodiversity and resilience. We don't know what this planet will look like, or how long its final transformation would take. We hope that we can halt it, that it still depends on how effective current and immediately future measures are and will be to cease the slide into the unknown. Halting the current mutation will take a massive change of exactly the kind presented in this forum as pioneering and lab-like projects, but as a basic requirement for going on, not just an aspirational goal. Astrophysicists Carl Sagan and Stephen Hawking have long mused about the worst-case possibility of a finally stable, average terrestrial surface temperature of 250 degrees Celsius, rather than the present 15, when the stunning temperature-maintaining phenomenon of a living Earth would have been boiled off.

Rationally speaking, looking at such scenarios should not be needed to urge our action. To a rational mind it should suffice to see that we are leaving the safe band of plus or minus 1 degree Centigrade that has represented life on earth in the past 8,000 years where our cities and agriculture have been created – or, indeed, the peak concentrations of 280 ppm which prevailed over the past 800,000 years, a time period that contained the evolution of homo sapiens, and made it possible. Global average temperatures have increased 1.2 degrees Celsius from pre-industrial level. We are therefore at a level of global warming that has taken us beyond any other period in that safe zone we have called the Holocene, and well above the long-term CO_2 concentrations. The knowledge that the continuation of urban and agricultural civilization will be increasingly difficult, let alone that of what we regard as 'advanced civilisation' has not yet moved our policy leaders, however. Will more manifest and imminent threats mobilise constructive action?

5. Low Carbon – Existing Context – Actions for a Sustainable Paradigm

Halting this slide is the new meaning of Sustainability, which has always been about Survivability. The CRC LCL and the Perth innovations provide the methods and projects for this platform - part of a sustainable development trajectory that is fast becoming a global paradigm. It is the core, the seed of an overdue emergency action agenda. The initiatives presented in this paper all propose to highlight the many extraordinary successes and advances in the proliferation of renewable energy that have been made: the powerful feed-in tariffs; the rise of 100% renewable buildings, communities and regions; the broad march of solar and wind into many countries' power mixes; the revolution of national policies to embrace energy transitions; and the relative rise of renewable energy investment – which has long become the dominant mode in annual capital expenditures in new power generation capacity world-wide.

A renewable city supports, thrives on closer cooperation between the city, its hinterland, the state and beyond. It relies on intelligent renewable energy networks that manage worlds of decentralised renewable energy devices at varying scales. It will need improvements and extensions to existing energy supply infrastructures to improve integration, connection and most importantly, increase accessibility to different types of renewable energy sources. Favourable and compatible spatial planning policies and guidelines at the urban, regional, federal and international levels will be sought to achieve equitable, safe and reliable flows and access to such energy sources.

Cities and Regions Embracing Renewable Energy, a status account

Imagine a world with abundant and ubiquitous energy for all, based only on sunshine, wind and water, powering and empowering our cities and communities from within at little or no resource cost, building local prosperity and strengthening security and social cohesion. Energy and energy technology represent an embedded dimension in this new world rather than an external source or supply system – an essential characteristic of cities rather than an imported commodity. This world is within reach not only because it is so easily imaginable and compelling, but because it is already demonstrated as developing across many cities, towns, businesses and communities today.

No more oil wells and pipelines, coal mines, radiation alarms or power decisions made behind closed doors. Instead, a diverse yet connected multitude of renewable transport, building and industry integrated generation and transmission systems will supplant the centralised power behemoths of the 19th and 20th centuries. This new energy world is renewable and sustainable, local and global, continental and regional. It emerges as a loose and redundant tangle of systems, kept energised by a myriad of consumers and providers, often and frequently switching roles. It links power, heating and cooling, storage and networks, stationary and mobile systems and agents. Applied in islands and across grids alike, it embraces utilities and networks as enablers and communities as accountable partners.

This new world liberates and empowers, resists control by monopolies and sidesteps attacks by terrorists alike. Here cities power themselves and their regions, providing their own industrial, transport, agricultural and residential energy. Indistinguishable from cities and their economies, the energy infrastructure will be financed and owned by communities, investors, users and producers. This is an equitable and exciting world of intelligent prosumers (or *conducers*, or *prod-users*), engaged city leaders, advanced self-sufficient industries and communal cooperatives, made elegant, proficient and efficient by smart web architectures and information technology-based trading platforms.

And now imagine how to get there from here. Plotting the plethora of possible pathways between the already achieved and the still needed is what this paper and presentation are about. Both aim to be helpful along the way, in policy, practical, conceptual and visionary ways. The pair serves many audiences: what may seem utopian to some has already become a reality for others. True, the energy supply in the early 21st century is still overwhelmingly fossil fuel based and kept centralized in the doggedly defended inertia of incumbent interests – but the great and dynamic transformation is already underway and tangibly active, from individual initiatives to industrial investments.

Energy is everything - and nothing is solid: such is a basic tenet of quantum physics. In cities, too, energy is everything, and everything in flux, even when only concentrating on the commercially tradeable energy infrastructure: electric, thermal and kinetic – its modes, forms and technologies, and its policy frames and financially enacted transformations. Cities are all about ‘energy’, both in the cultural sense of their dynamic vibrancy and vitality, and historically, in the sense of their structure being shaped by their energy technology.

Cities are physically formed of and around energy infrastructure: they are increasingly connected and sophisticated bundles of generation, distribution, networking and storage systems bridging power, thermal energy and mobility, storage and networks. Urban centers and their neighbourhood and districts, but also their wider regions become particularly critical, if not essential, in the great energy transformation defining the 21st century – more tangibly so than in each of the sectoral domains of agriculture, industry or transport. This transformation follows a wider emerging trend: the rise of renewable electricity as paramount societal infrastructure around which thermal, mobile, storage, network and, above all, power carrier and conversion strategies are woven, enabling ubiquitous energy harvesting, storage, dispatch, arbitraging – but also local trading and financial empowerment, for individuals, neighbourhoods, districts and regions.

This is where city energy is significant also in a metaphorical sense. Cities have been admired and aspired to, as centers of command, control and communication; engines of growth; drivers of innovation; refuges for the needy; seats of tyrants and home of enlightened citizens; machines and targets of war; and hotbeds of global culture, taste and fashion. So-called modern cities - those of the 20th century - and their form and growth dynamics were and continue to be driven by the spread of that most pernicious potion of all fatal elixirs: petroleum, but also other fossil fuels in their gaseous, liquid and solid forms. As a result, the much vaunted ‘urban age’ is actually an era of a staggering urban explosion, a mythical media matrix of hope and desire, promise and prosperity, fantasy and entertainment, and of alienation and suffering, disillusionment and fear, perpetual conflict and insatiable environmental rapaciousness. The fact that it generated such unflinching admiration and awe can also be traced to the overpowering rise of its incendiary drivers: global coal, petroleum, natural gas and nuclear power industries. Here lies a fatefully fixated association of the metaphorical energy of vibrant cities with the sheer and raw force of various mass energy systems in their early and late-modern incarnations. Like the addicted and the obsessed, too many of us – and especially many of the politically and economically powerful – don’t seem to be able to let go of this cultural fixation easily.

This might be forgiveable were it not for forces of time, physics and chemistry. A vast greenhouse gas stream is constantly being pumped into an atmosphere long oversaturated with fossil fuel exhausts, if we take the planet’s ability to maintain a habitable temperature and biological equilibrium as the ‘saturation’ gauge. This system has begun to reach ‘overshoot’ since we passed the 1 degree Centigrade average temperature rise above pre-industrial levels. To bring it to a sustainably steady state nothing short of an immediate and all-consuming emergency agenda akin to battle mobilization is required – a mainstream movement at war with its own incumbent energy habits. When it comes to the organisation of societal action cities are at an advantage over national governments: local communities can measure time and change in immediate and concrete outcomes. City and also state or provincial leaders are held accountable in more direct ways than national politicians can be.

As a result, so many cities and urban alliances have risen as energy policy makers, innovators, contractors, producers, consumers and implementors, in this great transformation towards a renewable world.

Nowhere is that change felt more strongly than in shifts from old-style centralised power supply contracts to a ubiquitous world of energy markets, increasingly interconnected with if not defined by global, regional and local information systems. The actual shift to renewable energy may not yet have become quite mainstream, even in Germany where more than a third of electricity is provided by renewable sources, but its very idea has long galvanized an entire technology savvy generation, particularly since it fits the new decentralised paradigm of a networked society. In the popular imagination of tech afficionados it increasingly connects the idealised civic benefits of ubiquitous computing and telecommunications of the 1980s with those of an energy singularity, embracing encrypted electronic accounting systems providing access to every energy user on the grid, however small or large. The energy web (Droege 2006) is here to stay. Preparing this new world is the fact that the largest growth in solar PV has been in grid connected centralised power – reversing its ratio to grid connected and decentralised from the early days of PV introduction more than a decade ago (REN21 2017).

Many city leaders have become mindful of or even expert in aspects of the urban energy revolution. One experience is common to all: each path is one of individual discovery. The new edition of Urban Energy Transition (Droege 2018), for example, is not a collection of best-practice cases but a short thematic journey across a number of topics of interest to students and practitioners of urban energy transitions alike. It documents both significant and patchy progress since its first edition a decade earlier, significant in moving beyond the normal shifts that all fields of inquiry are subject to - in science and technology, theory and practice, and in zeitgeist and politics - and patchy, because in these last and critical decades urban, regional and state energy transformation programs proliferated with far less equivocation than among national leaders, where too much 'low-carbon' lip service is still being paid without concrete action. And even here among cities, progress has not been either uniform or all-encompassing across the landscape of city agendas, and even within leading cities renewable energy self-sufficiency is by no means a standard base practice yet in all capital investments in infrastructure or urban development.

Great innovations spread across many cities of the industrialized world, prospering in policies, programs, urban projects and institutional frameworks, in both regulation and finance, and fired up a myriad of conferences. Yet they continue to only slowly reach and are all too often even ignored in many cities and regional conurbations of the global South. Institutional barriers and inertia, dependency on incumbent suppliers and other hurdles put a break on change. And yet, it is here where the opportunities are greatest, not only in the development of renewable energy sources and networks, but also in embracing a resource metabolism that cities of the North have long aspired to, linking food, waste, water and energy (Lehmann 2018).

Cities and regions still rank among the most tangible and dynamic change agents in transformative energy policy and societal action world-wide. The steady rise of renewable energy policy adoptions and target setting measures - particularly among US and European urban centers and agglomerations – is expressed not only in the numbers of active urban energy programs but also in the rising popularity of renewable energy among voters and corporate constituents in general. A significant change since the late 2000's has been the sharp decline in the cost of renewable energy systems and their production. This helped boost the world-wide growth of installed renewable energy capacity, recording an expansion of almost 660 % in wind and over 5,000% in photovoltaic installed capacity between 2006 and 2016. Worldwide investment rose from 113 to 242 billion USD in the ten years to 2016. Despite a numerical, in part system-price based reduction of almost a quarter in new investments from 2015 to 2016 new renewable energy investments continued to outstrip those in new fossil and nuclear generation by a factor of two (REN21 2017). This helps explain why strong progress and substantial renewable energy transformations are achieved by companies, countries, states and local communities against a background of persistent, even growing resistance at some national levels, inspired by incumbent industries.

The quest for leaving the fossil and nuclear age behind is felt equally strongly among local communities, urban governments and leading industries: a perfect trio of change agents. Primarily accountable to local communities, businesses and institutions, cities also depend on national institutions. And here fault lines are building: decreasing political support for climate policies and renewable energy is exerted by national governments that find themselves captive to conventional energy lobbies and interests such as once-progressive Germany, Spain and the perennially reluctant Australia, Canada, Japan and United States. China, by contrast, has become a new global champion of top-down climate agenda and renewables support. Of the nearly one terawatt (921 GW) in installed renewable energy capacity available in 2016 the largest shares were found in China, the United States and Germany, in that order (REN21) – while the greatest PV increases occurred in China, the US, India, Japan and Turkey. Most of this has been in utility-scale renewables. However, in Australia there has been global leadership in rooftop solar where ordinary householders have outstripped the utilities by ten to one and shown climate action despite a decade of national uncertainty in providing energy policy (Newman, 2018).

While the advances in renewables have been highly encouraging, the pressure exerted by the incumbent coal, oil, gas and uranium industries and their public policy supporters comes at the worst possible time. After a decade of spotty to strong growth a period of flagging political commitment to renewable energy deployment threatens to set in. Global climate emission reduction measures and agreed targets ranging from the late Kyoto Agreement to the Paris Climate Accord continue to be missed by a wide margin. It has become patently obvious to all who look at the science that only an immediate and comprehensive campaign to end fossil fuel production and combustion can help sustain life on this planet – accompanied by a simultaneous drive to build and restore the capacity of agricultural lands, wetlands, waterways, sea grass beds, forests – and the entire material and building industry – in a quest to take up the excessive levels of atmospheric carbon in the atmosphere before methane feedback overwhelms any efforts at reduction.

Global statistics point to a decoupling of economic growth from carbon emissions – and the annual emissions growth has indeed begun to actually level off while the global economy kept churning on and growing (Newman 2018). Yet atmospheric CO_2 concentrations continue to rise at an increasing rate: the earth's carbon cycles continue to be overwhelmed, and are possibly already in feed-back mode – pointing to the looming possibility of more than doubling of current greenhouse gas concentrations in a relatively short period of time. These past ten years have been foreboding in the way emission indicators developed – combined with the ubiquitous signs of early climate destabilisation. These were ten years in which atmospheric carbon dioxide concentrations rose from 385 annual mean parts of CO_2 per million (ppm) to 403.26 in 2016 – up from 400 in 2015 (NOAA 2018) to approaching 410 ppm at the publication time of this paper, 2018. These were ten years in which global carbon cycle dynamics – under unabated pressure from wanton fossil fuel combustion, industrialized agriculture, wholesale land clearing and unfettered cement production – began to manifest a number of feedback mechanisms: in the cryosphere, in global forest cover, in the oceans, and the atmosphere itself. Ten years in which the very rate of atmospheric CO_2 concentration increases themselves continued to rise. Ten years in which the health costs of urban fossil energy-based pollution levels continued to soar, and peak air pollution levels spiked in cities around the world to toxic, fatal levels.

This is said without any pathos or hyperbole: the only hope left is for a massively accelerated systemic transformation, away from squeezing tar sands, away from manipulating nations into territorial warfare, and away from fossicking for oil in a melting Arctic region, or drilling for it in remnant nature reserves. 'Not In Our Names' has become the unwritten motto of so many community leaders. Some have already gone further if only so very late on the process. In announcing a five billion dollar lawsuit brought by the City of New York against five petroleum companies Mayor Bill de Blasio remarked in January 2018: 'It's up to the fossil fuel companies whose greed put us in this position to shoulder the cost of making New York safer and more resilient.' (Milman 2018).

Cities and regional governments, including state authorities have found solace and motivation in the many ways of inventing, financing and implementing their own new renewable energy investment strategies and projects, perhaps because they are often left to their own devices. Here a new frontier has opened and new realities have been shaped: urban governance frameworks that in the past seemed less than ideally suited for local energy realities have been informed by effective efficiency campaigns, demand market management and 100% renewable energy drives. Selected here are only a few cities which have modified their administrative and policy apparatuses to advance energy transitions. Both young veterans like the City of Aspen in the US state of Colorado and dynamic newcomers like the Australian Capital Territory or Adelaide teach us about various ways of achieving full renewable energy independence. They stand for countless others, epitomized by the Global Covenant of Mayors, the European Association of Local Authorities in Energy Transition, Renewable Cities, the renewables drive of the International Council for Local Environmental Initiatives, C40, 100 Resilient Cities and many others.

Cities, regions and states are beacons of hope. They signal a possibly rapidly accelerating system-wide shift affecting all aspects of society and its economy. Urban energy systems change from the bottom up and the inside out. Taking the transport sector as example, and using an apt if somewhat unhappy analogy: the system transforms like a warming glacier – thawing at first imperceptibly slowly and seemingly linearly - then faster and faster at an exponential rate, and finally collapsing within only a few years because the melting mechanisms become pervasive across the entire structure. The global transport sector, at the time of writing this paper, was still more than 95% fossil fuel dependent, as described by Jeff Kenworthy in his new findings on hopeful signs in a system of 'glacial' inertia (Kenworthy 2018). It undergoes systemic changes from within that promise a similarly rapid late-stage transformation. This is where the usefulness of the glacier analogy ends – and is best replaced by more direct industrial and user innovation references that pale in comparison with the nascent transformation of the transport sector: the rapid replacement of same-old-telephony by multi-modal digital services in the late 1980s, or of film and paper based photography and print by digital imaging and graphic media from the 1990s into the early 2000s: explosive, ubiquitous, networked, multi- and trans-modal, manipulatable, most importantly, visibly manifest and, seemingly, accessible to all. This innovation phenomenon, also referred to in the SR-5 IPCC Report of 2018 (Newman 2018) is central to exponential trends associated with solar, wind, batteries, intelligent networks and electric vehicles.

Yet even if vehicle – bicycle, car, bus, train, ships and planes - propulsion were at the verge of becoming electric, and even if all cities were to be powered by the sun tomorrow morning, this could not absolve governments, business and communities from two other great immediate responsibilities: curbing consumption of scarce natural resources and the attempt at slowing, even halting the onset of runaway climate change through a rapid restoration and strengthening of the earth's biological capacity to lower atmospheric greenhouse gas concentrations through wetland regeneration, afforestation, wetland and moorland rebuilding and the transformation of agriculture into a CO_2 absorbing land use.

The embedded, lifestyle-based dimension of energy consumption is a vast and still largely ignored challenge in city policies: the references studied for this paper suggest that due to the lack of policy attention it is also starved of research funds. And the greenhouse gas sequestration in land cover and aquatic systems, but also carbon rich building and infrastructure materials – with carbon pulled from the atmosphere – forms part of a nascent scientific and industrial domain that has not fully entered the day-to-day policy framework and practice perimeters of cities and regions.

These are at once the most hopeful and unnerving times – the kind of times the applicable Chinese proverb calls 'rich in opportunities. This paper arrives at a forked turning point in urban and human history: which way will we turn? Will we careen further down fossil fuel alley, a dark and dangerous cul-de-sac into which some governments and major industries still drive us – or escape the carbon cave into the light: embracing cities and regions that prosper under enlightened local, state and national leadership on their renewable resources, creating value for their communities, businesses and local and regional environments? Whatever the future holds for us all, this much is certain: cities and regions that are free of fossil (and nuclear) dependency will not only help slow the global ride into a different climate but also fare incomparably better socially, economically and environmentally in the unfolding climate drama (Droege 2018).

The following ten groups of important initiatives offer views - in ascending scale - into a sizeable and growing pool of constructive and tested practice that is to be transformed into mainstream. Presented are cases, themes and topics that epitomise the transformation from the Fossil to the Renewable City. What used to be an aspiration goal now has become an existential necessity.

6. Current and Emerging Approaches to Low Carbon Living

6.1. Renewable Nuclei: Active Homes

Low Carbon Sustainable Building: Josh's House, Perth, Australia

Carbon Positive Building: B10 Active House, Stuttgart, Germany

Figure 1. Josh's House, Perth.
© Josh Byrne, Perth 2013

Figure 2. B10 Active House, Stuttgart by Werner Sobek.
© Zooey Braun, Stuttgart 2014

Model buildings are powerful ways to develop, study, demonstrate and inspire about the deployment of buildings providing their own energy from local renewable sources and to share excess power with neighbours or the grid. Two buildings from opposite ends of the world highlight two very different approaches. Josh's House in Fremantle is a large and lived-in demonstration family home with garden, and 'Werner's House' in Stuttgart is a model research exhibition of the future: a modes-sized, modular, prefabricated unit for bungalow style or stacked apartment deployment. They perhaps also highlight differences in our attitudes about life and culture, and the production of the built environment.

Josh's House is a residential 'living lab' near Fremantle demonstrating that high performance, energy positive housing is accessible now as a mainstream market offering. Completed mid-2013, the 10 Star NatHERS rated home was originally fitted with a 3kW solar PV system, a gas boosted solar hot water system and conventional energy efficient appliances. Monitoring of the operational energy requirements of the home demonstrated that energy usage was less than half of the local average and power generation was double of that consumed. The subsequent inclusion of a grid connected battery system enabled 81% self-reliance in solar power whilst continuing to export surplus to the grid. The house also includes a range of sustainable water management features such as rainwater harvesting, greywater reuse and water sensitive landscaping, resulting in a 90% reduction in mains water usage. The latest upgrade is the inclusion of an electric vehicle (EV) for family transport, along with an electric heat pump hot water system and an induction stove, enabling disconnection from the gas supply. The solar system has been upgraded to 6.4kW of PV with a 5kW inverter to meet the additional energy loads and remain energy positive. All aspect of this project have been extensively documented on video and factsheets, with these resources made openly available through the project website (www.joshshouse com.au) along with live performance data. The principles of how to build this house and its power and water systems have been used in the scaled-up projects below that enable the research team to examine the opportunities provided by shared infrastructure. (See joshshouse.com.au for papers, films and media coverage of this house).

B10 is 'Werner (Sobek)'s House' built by a prefabricated home manufacturer in Stuttgart's Weissenhof Siedlung. The techniques and the innovations developed and tested range from the building's design, production and assembly to the harvesting, storage and targeted local distribution of energy from renewable sources. B10 was completely prefabricated, with all building elements modularised for waste-free disassembly and reuse, based on an rigorous approach to industrial production combined with a high degree of customization. The building's timber structure is lightweight and entirely recyclable, just as the façade and other features. Surplus energy harvested by PV panels and solar heat is either stored in B10 or passed on to a neighboring historical monument. Energy distribution is managed by an intelligent automation system specifically developed for B10. B10 generates 200% of its energy consumption: the premise is that the process of rebuilding and upgrading existing neighbourhoods is far too slow and therefore new infill buildings should be designed and built as generators and batteries to serve conventional neighbourhoods. This is a prototype supported by the German government, designed to boost existing neighbourhoods' renewable energy supply: B10 provides power to the neighbouring Weissenhof Museum, a Le Corbusier designed building. (adapted from Sobek 2018).

6.2. Renewable Cities & Quarters

City Energy Transitions: 100% Renewable Plans for Frankfurt and Munich, Germany

Active City-House for the Renewable Metropolis: Active City House, Frankfurt, Germany

Figure 3. Freiham-Nord Masterplan, as part of Munich's 100% Renewable Energy City Concept. © Anis Radzi 2018

Figure 4. Active-City House, Frankfurt by HHS Architects. © Anis Radzi 2018

The 100% renewable energy region movement is a growing force in Germany. Cities, too, increasingly move to control their energy destiny. Several German metropolitan cities adopt the regenerative resolve and initiative shown by the smaller 100% renewable villages and districts. The efforts by large metropolitan cities like Frankfurt am Main and Munich in combining bi-partisan political support, strategic planning and partnerships across sectors and administrative boundaries, raise the share of renewable energy, boost energy savings, and enable the testing of innovative energy infrastructure technologies. Critical were the urban planning and sustainable building frameworks these cities have put in place to guide their shaping of a 100% renewable city.

The urban planning centred approaches by the metropolitan cities of Frankfurt and Munich in Germany to achieve 100% renewable energy reveal the dynamics of the broader 100% renewable movement, its impact on villages, towns, cities and regions, and its relation to advancing the urban sustainability agenda. A well-developed system of governance for the deployment of renewable energy systems (RES) has evolved at several spatial planning levels in Germany, giving rise to a rich energy relevant domain of spatial considerations for city planners, urban designers and architects in the design of RES infrastructure for metropolitan areas that are based entirely on local and regional sources.

Successful examples in both cities illustrate how respective energy concepts are achieved, overcoming a range of specific regulatory, technical and methodological challenges. Frankfurt, to date, has the largest number of energy-efficient high-rise buildings in Germany with > 1500 apartments, and > 300,000 m2 of surface area built to a passive house standard, including schools, day nurseries, and sports halls (Stadt Frankfurt am Main, 2013). Growth in energy efficient building has been propelled by municipal obligations that require passive houses to be built on city land or land purchased from the city. It has also been boosted by the city's "Green Building Frankfurt" prize, awarded to architects, planners, and construction firms for building innovative sustainable green structures. By requiring design submissions to comply with strict energy standards, the built results have brought great improvements to the quality and energetic performance of entire city quarters.

The “Aktiv-Stadthaus” is a cooperative apartment block designed by HHS Architects and developed by Frankfurt’s own municipal housing agency. Completed in 2016 on a former inner-city parking lot, the “plus-energy” building covers the entire electricity demand of 74 apartments through a building-integrated PV roof and facade system coupled with an on-site energy storage facility. The infill development has transformed the image of the inner-city area as a place for high-quality, sustainable living. As a “power-and-storage” station, the block has demonstrated that urban buildings can help ease the ability of the city to cover its energy needs with renewable energy sources. And by using the locally-generated and partially-stored PV current in the block to power electric vehicles for shared use by residents, the development has contributed to raising their mobility and interaction with the city. (adapted from Radzi 2018)

6.3. Replicable Renewable Energy Districts

Net-Zero Energy Districts: An Integrative Business Model for US cities

Renewable Malls: Transforming Shopping Centres Into Flexible, Decarbonized Urban Energy Assets

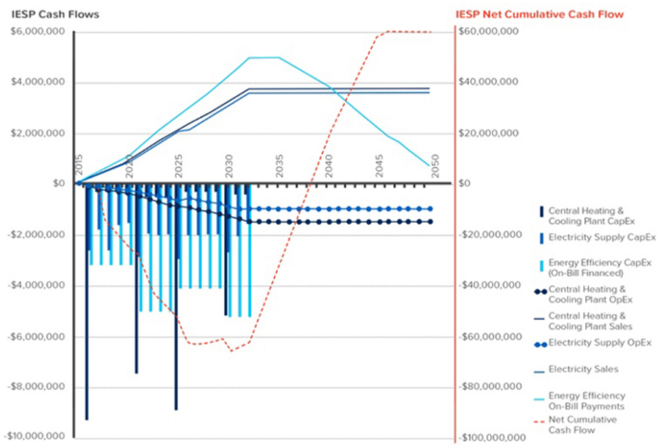

Figure 5. Sample IESP Cash Flow for Net Zero Energy Districts © Rocky Mountain Institute 2018

The Rocky Mountain Institute (RMI) has developed an integrative business model for developing net-zero energy (NZE) or ultra-low energy districts in a way that is attractive to the district developer, parcel developer, and tenants, as well as beneficial to the local electric grid and neighboring community. While many elements are broadly replicable, this business case was first modeled specifically for the developer of a proposed 180-acre, 6 million square feet mixed-use NZE development located on a former industrial site in a midsize US city. The RMI uses the term net-zero energy to describe the general concept where the energy consumption of a building or multiple buildings is offset by renewable energy on an annual basis and should not be taken as implying alignment to any one specific, more granular, definition.

Figure 6. Robinsons Place Dumaguete, Manila. © ABS-CBN News 2018

Urban systems de-carbonization is achievable if supported by measures for energy efficiency and integration of renewable energy sources (RES). In this context, a key role can be played by shopping malls. They are usually identified as "icons of consumer society," but they also have a huge energy retrofitting potential. Moreover, they can have an active role in the future smart grid, connecting buildings and energy infrastructures. Photovoltaic (PV) and energy storage systems (ESS) play a fundamental role in exploiting such potential, and can very quickly become a cost effective solution contributing to emissions reduction, as demonstrated in the presented case study. Considering the short economic perspective of investors, the capital expenditure associated with retrofitting could be a barrier, and the evaluation of suitable economic indicator of primary importance to choose among several retrofitting strategies. Despite the fact that overall legislative frameworks and regulations do not promote shopping centers as key energy and social infrastructures to achieve ambitious targets in the ongoing urban transformation, energy-efficient shopping malls massively using RES and ESS can actually become the backbone of the city of tomorrow. (Barchi et al 2008)

6.4. The Sun's Urban Energy Systems

PV City: Effective Approaches to Integrated Urban Solar Power

Solar City: The Urban Fabric as Solar Power Plant: Amsterdam, London, Paris, New York, Seoul, Tokyo

Figure 7. Veteran Freiburg Solar Settlement, Vauban, Germany. © plusenergiehaus.de 2012

Figure 8. Renovation of Halle Pajol by Jourda Architectes, Paris. © apur.org 2017

Photovoltaic (PV) energy systems are on their way to be, or have already become, the cheapest source of electricity in most countries. They have reached a cost level that makes PV competitive in several market segments: the cost of generating electricity from PV has reached parity with retail electricity prices, i.e., socket parity. PV is also particularly suited for the integration into existing and new infrastructure, for example, in buildings, canopies, sound barriers, and the like. For this reason, solar PV represents a key technology for prosumers at the building, district, and city level. In the 2016 draft of the recast of the RES and electricity EU directives, the concept of self-consumers is pushed as a driving force toward decarbonisation of the electricity and heating sector at the city level associated with the creation of local energy communities and collective selfconsumption as an emerging business model. (Moser at al 2018)

The degree of urbanisation has made the decarbonisation of cities and urban areas a paramount importance. The implementation challenge is particularly poignant in the urban energy services sector, where conventional infrastructure-scale solutions deepen climate injustice. Conventional infrastructure-scale energy production components (i.e., fossil fuel powered power plants) must be contrasted with the “solar city,” where the urban fabric is reconstituted as a platform for decentralized production of solar electricity at a scale that advances the twin aims of sustainability and justice, yielding the economic, social, and environmental implications of urban decarbonization. The issuing of solar bonds and other financing means has been modeled to show that a city of the size and nature of New York, studied along with Amsterdam, London, Munich, Seoul and Tokyo, could be financed with a 10-12 year investment maturity horizon. The city has a potential solar energy to power conversion capacity – calculated on reasonably available roof areas only - of nine GWp or 11 TWh per year, providing about a quarter of its annual power consumption on average: Manhattan 6%, the Bronx 31%, Brooklyn 35%, Queens 42% and Staten Island 48%. (Byrne and Taminau 2018)

6.5. Large-scale Urban Regeneration Programs and Systems

Renewable Wilhelmsburg: recruiting the International Building Exhibition to fight climate change

Implementing the Heating Sector Transition

Integrated Urban Infrastructure: Energy Storage and Sector Coupling

Figure 9. IBA Wilhelmsburg. © IBA-Hamburg 2014

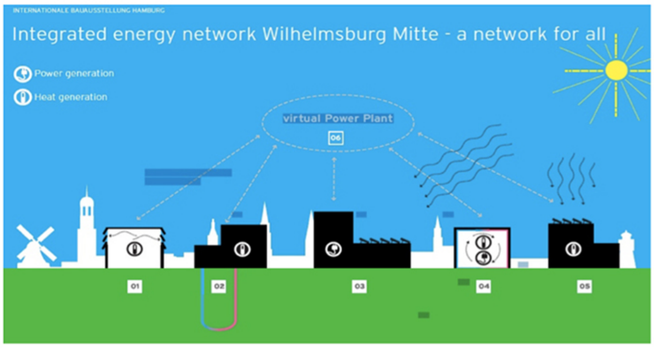

Figure 10. Renewable Wilhelmsburg. © IBA-Hamburg 2014

Germany has a long history of building exhibitions, beginning in 1901. A building exhibition is always more than a showcase for architecture: building exhibitions drive urban development (IBA Hamburg, 2009). Building exhibitions concentrate and coordinate private and public spending on construction in an area or region with specific problems, as well as specific opportunities. So, they represent a treasure trove of more than a hundred years’ experience when it comes to finding innovative solutions for the most pressing problems of urban community life. Many ideas still live on today. From 2007 through 2013 Hamburg hosted an international building exhibition (IBA) on Europe’s largest river island, Wilhelmsburg. It initiated 70 building and 14 social and cultural projects (IBA Hamburg, 2014) in order to demonstrate what is possible when an entire city district is remodeled according to social and environmental considerations. These projects were designed to show what the future of modern environment friendly town planning might be, and how cities could be remodeled in a climate-friendly or even climate-neutral way. Another advantage was that a neglected district of Hamburg with a negative image could be reinvented as a pioneer of energy-efficiency and social inclusion. To realize the “Future Concept Renewable Wilhelmsburg,” IBA specified four operational fields. First of these was the refurbishment of the existing building stock, second, `new buildings of energetic excellence’, third ‚local district heating’, and fourth ‚local renewable energies’. (Hellweg 2018)

The heating sector represents one of the biggest challenges to achieving climate neutrality in regions with cold winters. Local municipalities will have an important role to play in this process. In Germany challenges arise with the transformation of the heating sector and the possibilities for action facing local municipalities. There are two main areas of action: the energy-efficiency retrofitting of existing buildings, and the transformation of district heating systems. With respect to the energy-efficiency refurbishment of building stock, it is important that cities and municipalities look at private, as well as public properties, and address concerns about historical preservation and social issues. District heating grids allow for the cost-efficient integration of renewable energy and waste heat sources; however, operating conditions, and in some cases network structures, must be modified accordingly. (Sparber et al 2018, Weiss et al 2018)

The generation and transmission processes of renewable energy still takes mainly part in rural and peri-urban areas – not yet in urban centers at sufficiently significant scale. Many technologies easily implemented in lower density districts such as wind, water or biogas production are not yet adopted for application in urban areas – one exception is solar power and thermal energy. But even solar electricity is more widely applied in lower density and rural areas although its application in urban areas matches the existing grid infrastructure well. In contrast to rural areas with grid integration problems energy infrastructure in urban centers is already well prepared for renewables integration. There are almost unlimited energy storage possibilities with enormous capabilities but also large differences. There is a fundamental necessity to combine and couple the different energy sectors for electricity, heat, cold, gas and transport. Only in coupling the energy sectors and using cheap and efficient energy storage options from one energy sector to solve challenges within another the energy transition process can be managed in an efficient way. (Stadler and Sauer 2018)

6.6. Lifestyle-embodiment of Low Carbon Living

Kalkbreite Cooperative, Zurich, Switzerland

Ortoloco, Zurich, Switzerland

Figure 11. Kalkbreite Housing Cooperative by Müller Sigrist Architekten. © Martin Stollenwerk 2018

Figure 12. Ortoloco community events. © Ortoloco 2018

The Kalkbreite development, completed in 2014, stands for a class of communally designed and operated, internally networked, cooperatively owned inner-urban *flexispaces*: core living spaces with common, flexibly rentable support spaces for meeting, working, living and accommodating guests. Genossenschaft Kalkbreite is a cooperative of 850 members comprising neighbourhood residents, tenants, and several local associations. It is responsible for the management of the Kalkbreite development, a large-scale mixed-use urban project located in Zurich-Aussersihl, Switzerland. The project was constructed based on the principle of creating and leasing affordable residential and commercial spaces, combining living, working and culture, integrating a mix of social groups and shared facilities, and promoting sustainable development. All of which had to be in line with the objectives of the so-called 2000-Watt Society. The principles sustain vibrant urban life within one neighbourhood block, both enhancing and drawing from the vitality of the wider setting.

The building is organised around internal network spaces. The cooperative works well with Zurich-wide agricultural cooperatives like *Ortoloco*. This is one of several urban and regional agricultural cooperatives serving the metro-city of Zurich. These own and lease agricultural space and operate it on biological and agroforestry principles. Reducing food miles and global consumption, Ortoloco and a series of other similar cooperatives are a good match and expression of emerging lifestyles. They serve city dwellers that become vested in and support one another through shared cultivation, harvesting, storage, distribution and consumption largely based on city dwelling communities within bicycling distance.

Ortoloco is a self-managed vegetable cooperative based in Dietikon, Zurich. As a joint initiative of farmers and consumers, Ortoloco leases 1.4 hectares of arable land from organic farm Fondlihof in the Limmat Valley of Zurich to create their own community vegetable farm. Over 60 types of vegetables and a variety of edible wild herbs are harvested weekly, distributed and consumed by members of the cooperative.

The cooperative operates on the principle of producing quality local food, ensuring fair working conditions, and maintaining sustainable production methods. Members of the cooperative participate in making important decisions, and are involved in the operation of the farm. This means that costs, risks, and profits are shared. The cultivation of vegetables takes place according to the directives of Bio Suisse, a Swiss certification for organic produce. The range of produce available to consumers change according to the seasons, and is distributed through established food "depots" and consumed weekly though vegetable bags subscribed for at least one year by members from Zurich, Dietikon and surrounding areas.

Ortoloco was inspired by the book Neustart Schweiz, which described a vision for a local economic model that ensured a community a wide range of services such as a bakery, dairy, and kindergarten amongst others, all of which were managed by local citizens. Individuals involved are expected to lend their specific skills to the neighbourhood. Whole neighborhoods instead of individual households would jointly organize projects, especially in the development of local food supplies.

6.7. Fremantle As Renewable Laboratory

From White Gum Valley (WGV) to Smart City Renew Nexus

Figure 13. WGV Living Lab. © CRC Low-Carbon Living Laboratory 2018

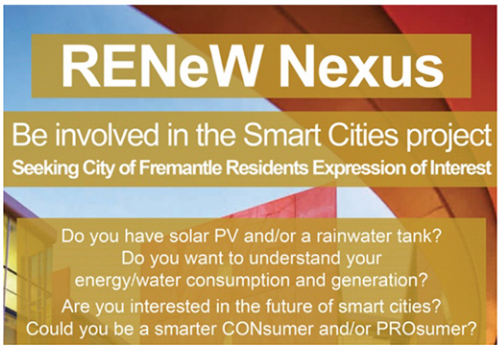

Figure 14. RENeW Nexus. © Curtin University 2018

Ten House Living Lab Study

The objective of the Ten House Living Labs project was to understand which factors influence house performance, as previous research has shown that houses designed to be energy and water efficient often do not perform as intended. While the design is important to minimise resource consumption, the way houses are used can have an equal effect on performance.

The project consisted of a longitudinal study of ten detached suburban family homes located in the City of Fremantle. While these houses had a mix of demographics and building designs, they all presented energy or water efficient features, such as solar panels, solar hot water and rainwater tanks. The houses also presented elements of climate sensible design. The ten houses had their electricity, water, gas, solar energy generation, rainwater use and internal temperature monitored for two years. The first year of data collection was used to establish a baseline in terms of occupant behaviours and practices and to evaluate the homes from a design perspective. During the second year, a behaviour change program was implemented, providing each household with a series of tailored tools designed to increase their awareness and facilitate a reduction of water and energy while enabling occupants to maintain a high-quality lifestyle.

This project demonstrated that while the energy efficient houses perform better than standard Australian dwellings, they do not operate to their full potential. Overall house performance is attributed not only to construction quality, maintenance and technology but also to everyday house operation. The latter is driven by occupant practices, which are reproduced sequentially as part of an established routine. The results of the Ten House Living Labs project were used to develop the concept of the Home System of Practice, which explains occupant dynamics within a home and enables the creation of innovative technologies to improve resource efficiency while fulfilling occupants' needs.

Mainstreaming Zero Energy Homes

This national project is working with major land developers and builders to deliver a series of Net Zero Energy Homes (ZEH) in residential display villages around Australia with the aim of better understanding cost and market perception barriers to this offering whilst increasing engagement amongst industry players.

A key stage of the project includes collaborative design charrettes with builders to ascertain the steps required to get their 'base design' to ZEH status whilst tracking cost and trade capacity implications. The second stage involves surveying visitors to the display homes to understand the level of interest in the design and technologies underpinning the ZEH performance, versus interest in other house features. These activities are being captured in a series of videos and industry reports for wide dissemination.

To date, ZEH display homes have been built in Townsville (Queensland), and Melbourne (Victoria), and others are underway in Perth (WA) and Canberra (ACT). Findings from the design and building of the ZEH homes are that major energy efficiency gains were obtained mainly from additional insulation, glazing upgrades and energy efficient appliances (hot water systems and air conditioners in particular). In addition, only a relatively small sized PV system (4kW) is required to cover the net needs of a typical Australian household provided that the building envelope is designed appropriately for the climate and the appliances are energy efficient.

WGV Living Lab

WGV is a 2.2 ha medium density, 100 dwelling residential infill development located in the City of Fremantle. Led by the WA State Government's land development agency LandCorp, WGV demonstrates design excellence on many levels by incorporating diverse building typologies (detached houses and apartments), climate sensitive considerations, solar energy generation and storage, innovative water management and creative urban greening strategies. The project has received international certification as a 'One Planet Living' community.

Researchers are following the WGV development process from construction through to occupancy, using a 'learn-by-doing' approach to research where innovations are tested in real-life settings with the aim of informing policy and industry outcomes. Research activities include the monitoring of different dwelling types to assess design performance, as well as the impact of technology choice and occupant behaviour on energy use and carbon emissions. The project is also exploring the inter-relationships between developers, local government, builders and purchasers, low carbon aspirations and outcomes, and how these can be better aligned.

As of late 2018, WGV is approximately 60% completed and occupied. Monitoring is underway across the development and data is being utilised by residents, researchers and industry. Insights from the WGV project are being shared with industry and government through tours, speaking events and technical publications. A ten-part web-based video series called 'Density by Design' (www.densitybydesign.com.au) documents the WGV Living Lab story in detail as a means of sharing the project journey and research outcomes to a broad audience.

WGV demonstrates that low carbon residential developments are technically feasible and commercially viable in today's market with 'As Built' modelling and early building performance data indicating that WGV will meet its design goal of being a Net Zero Energy precinct. What's more, the collaboration between industry and researchers, which has been enabled by the CRC for Low Carbon Living, has led to a ground-breaking trial for shared solar power and battery storage technology on strata-titled developments. (see Wiktorovic et al, 2018).

Beyond WGV

This project is examining how to extend WGV innovations in scale across a brownfield redevelopment area in Fremantle. The area is the focus of research by both the CRC's for Water Sensitive Cities and Low Carbon Living. There is an opportunity to prototype a precinct scale sustainable neighbourhood across the whole precinct. The vision is to incorporate a range of innovations such as community batteries, water sensitive urban design, and a potential Trackless Tram transit system linking the precinct to the city centre in Fremantle

'Beyond WGV' will remove major barriers to new energy and water solutions for future redevelopment in the Knutsford precinct. This presents the challenge of establishing a business case and alternative governance models for these new systems. Investigations to date suggest that there are also no major technical barriers to the installation of renewable energy and water systems at a precinct scale, the major challenges sit in the areas of a) developing alternative / integrated water and energy infrastructure that can align with uncertainties of multiple land owners and incremental development patterns; b) engaging the stakeholders including business and citizens over the long term; c) keeping the vision of what is being created, focused for 20 – 50 years; d) developing appropriate governance and business models to support the rollout; and e) in relation to the above, marrying with the Local and State Government decision making frameworks and planning systems. The researchers are also in discussion with City of Fremantle and Land Corp about how to manage the urban renewal process over the long term to realize the vision of Knutsford as a leading sustainable development precinct.

RENeW Nexus

The RENeW Nexus project is supported and funded by the Australian Government through the Smart Cities and Suburbs Program. The program aims to help local governments and communities use smart technology and increase the accessibility and use of public data so that cities, suburbs and towns become more liveable, productive and sustainable and urban service delivery becomes more efficient and effective.

The project sponsor is Curtin University, and project partners include Murdoch University, City of Fremantle, Land Corp, Power Ledger, Western Power, Synergy, energyOS, CISCO and Data 61/CSIRO. The project has begun to explore the theory that the value of solar energy can benefit the grid and community through peer-to-peer trading across the grid. Further, the value of water can be captured if potable water can be supplemented by utilising rainwater and greywater through the subsurface aquifer to other household and landscape systems.

For both solar energy and water systems the focus is on peer-to-peer trading across the power grid or within a micro grid environment, and through a water balance across the aquifer in a development, or storage facilities in an established urban development. This is a distributed system where the transaction layer is blockchain based, and can be deployed with smart metering capability to create a dynamically connected smart city environment. The first trial of this system is being carried out in the City of Fremantle and includes the energy grid provider and retailer, a water provider and retailer, the City, a state developer and most importantly citizens as prosumers and consumers of energy and water.

Data analytics will determine trading logic and suitable conditions that are required, stakeholder satisfaction, utilisation of assets and efficiency gains achieved through peer to peer trading. The project trial will also allow for demonstration of the proposed distributed energy and water ledger that will be implemented at East Village at Knutsford. This project is enabling research and data analysis to support and inform the transition to a new localized energy and water network.

6.8. Climate Design for Social Justice

Solar for Gaza – Low Conflict Living as an existential human right: Gaza

Sustainable Neighbourhood Design in Developing Countries

Figure 15. Solar installation in Gaza. © Jersualem Post

Figure 16. Village solar installation. © Greenpeace

Peaceful cooperation is a precondition for being able to effectively counter the causes of climate change, and successfully adapt to its effects. Solar for Gaza (S4G) was developed in the spirit of the ClimateforPeace.org campaign, a global call for the cessation of armed conflict in order to address one of the world's greatest common enemies: manmade global warming and growing fossil and nuclear energy risks. Solar for Gaza emerged in response to Israel's Gaza Strip bombings between December 27, 2008 and January 18, 2009—officially known as *Operation Cast Lead*—when a group of architectural students in Liechtenstein took up a long tradition of "engagement design," seeking to support academic and civic efforts in Israel and Gaza to address—from afar—the suffering of ordinary people caught in a seemingly permanent and tightening cycle of violence. sketched out a Gaza and its wider region entirely based and prospering on renewable energy. It specified geographical, social, economic, technical, organizational and political factors supporting the incorporation of renewable energy into various phases of relief, recovery and regeneration. It was also advanced as embedded in an inspired regional initiative – Solar for Gaza and Sderot - in a collaboration between the Arava Institute for Environmental Studies, the Institute for Global Leadership at Tufts University and the Chair for Sustainable Spatial Development at the University of Liechtenstein. (adapted from Droege, Teichman, Valdes 2018)

Considering that almost 90% of global urbanization is projected to occur in countries of the developing world, many with substantial social justice, equity and poverty challenges, cities' growth in these countries will both have a significant impact on global GHG emissions, seriously threatening any effort to reduce them – and deepen their dependence on debt inducing fossil and/or nuclear energy dependency. Energy consumption is mainly determined by the building and transport sectors, but is also influenced by other issues that urban growth has to face: rising demand for food and greater demand for potable water, combined with changing rainfall patterns and depletion of aquifers. To cope with all these challenges, a paradigm shift is required, that is, a different urban design approach that affects the urban form, texture, and land use, and the way the basic urban services, such as energy, water, food, and waste treatment, are designed and provided, with a holistic view. A sustainable neighborhood design process in tropical climates is discussed as examplary for one of many developing country requirements, outlining the importance of adopting a systems perspective and considering infrastructure interconnections. (adapted from Butera 2018)

6.9. Modelling renewable resource and value flows

STAR - Mapping regional negative carbon peformance – Renewable energy self-sufficiency and positive income streams: Lake Constance Alpine-Rhine Region, Switzerland-Liechtentein-Austria-Germany

Value-Added and Employment Effects of Renewable Energies and the Energy-Efficiency Refurbishment of Existing Housing: Berlin, Germany

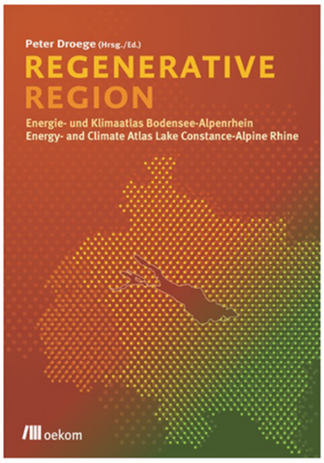

Figure 17. The potential for regions to become energy self-sufficient is illustrated in the Lake Constance Alpine-Rhine Region in Central Europe. © Droege/ oekom

Figure 18. Energetic refurbishment of apartment buildings in Germany. © Jens Wolf/ DPA

The Space Time and Renewables (STAR) model has the ability to model and map on GIS platforms time variable energy scenarios for regions, cities, towns, and neighborhoods. It was developed for the Lake Constance Alpine-Rhine Energy (LACE) Region to not only test when and how it can become entirely independent energetically, or whether it can sequester more atmospheric carbon than it emits, and how much financial value creation can be achieved—but also to demonstrate the model's ability to test time sensitive scenarios for urban planning purposes. The LACE region not only has the potential to become carbon neutral, but even to become a CO_2 sink that binds more carbon than it emits. The investments into the transformation process were assessed and juxtaposed with the fossil/nuclear energy savings. A shift of the systematic differential costs in time can be observed: initially the energy costs will rise, but in the longer term—from 2030 onwards—they will begin to fall dramatically. The savings gained from avoiding fossil and nuclear energy can be invested within the region to generate jobs and prosperity. (adapted from Droege, Genske et al 2018)

STAR used a methodological 'plug-in' for ascertaining the communal value capture coefficient. The Berlin based Institute for Ecological Economy Research developed a model to quantify the value added and employment effects generated by renewable energies at the local level, to fill the gap concerning the identification of local and regional economic effects of the energy transition. Discussions of climate protection and the energy sector transition are still dominated by cost considerations; however, decentralized efforts such as the expanded use of renewable energies at a communal level yielded new 'value-added' financial flows from salaries, tax income and coporate revenue in the renewable energy planning, manufacture and servicing sectors. But energy-efficiency improvements to existing buildings, too, can have a positive economic impact with respect to local and regional value added and employment. For this the 'renewables value added' approach has been extended to account for the economic effects of energy-efficiency refurbishment of existing dwellings. (from Heinbach et al 2018)

6.10. Urban Carbon Sequestration

The 4M Project: Increasing carbon sequestration and storage in city greenspaces, Leicester UK

Low-Carbon Building Materials: The Soft House, Hamburg

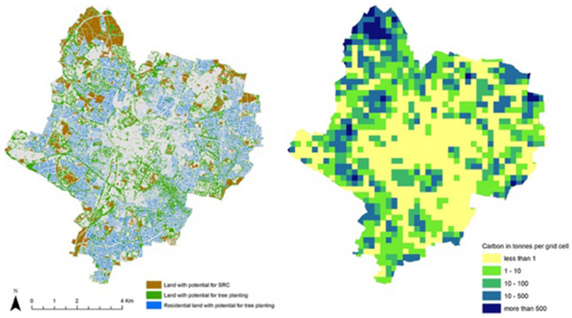

Figure 19. Land potential for tree planting and additional carbon stroage potential in Leicester, UK. © Davis et al. (2011)

Figure 20. The Soft House, Hamburg. © Sheila Kennedy, MIT

The 4M project used a spatial modelling approach to identify areas and landcover types in the city of Leicester, United Kingdom with the greatest potential for increased carbon storage. Davis et al (2011) found that trees accounted for around 97% of the carbon stored in aboveground vegetation, and based on the spatial models, discovered treat potential for tree planting in residential and non-residential settings to increase aboveground carbon storage in the city, as well as to produce biomass that could be used to substitute for fossil fuels. The tree planting modelling assumed planting of mixture of species already existing in the city, and the potential carbon sequestration over 25 years. This is compared to an alternate scenario where short rotation coppice is used to generate woody biofuel. (Davis et al. 2011)

The Soft House, designed by Kennedy & Violich Architecture, is an innovative work/live row housing project which demonstrates novel concepts in sustainable construction and domestic renewable energy generation. Located in Hamburg, Germany, it consists of four apartments units which uses a dynamic textile façade to harness sunlight, alongside solid wood construction. The energy-harvesting textile façade is responsive to movement of the sun, while inside the apartments transparent curtains allow the occupants to partition their domestic layout as needed. The curtains also help to regulate heat and warmth internally. The electricity generated by the external textile façade is fed directly into these LED embedded curtains, which thus is able to provide additional light inside the apartments. A dense wooden radiant floor linked to a geothermal source distributes cooling in the summer and heating in the winter. Each unit has a terrace space, a PV canopy, and a vertical convection atrium space that helps circulate air, brings daylight into the ground floor, and offers vertical views of the sky.

The traditional all-wood construction adopted in The Soft House uses only wood dowel joints with no glues, nails, or screws, and is exposed as the interior finish. The solid spruce wood structure sequesters carbon. Spruce is said to absorb about as much carbon dioxide from the atmosphere as using reinforced concrete emits. The wood is also fully demountable for recycling at the end of the building’s life. The wood structure can be fabricated by local carpenters or small-scale manufacturers. This pilot project in sustainable construction illustrates the ability to create housing with reduced embodied material energy, that retains its soft natural character of the building material. (Stauffer 2013)

7. Negative Carbon – Future Context – Frameworks for a Renewable Paradigm

This is a new paradigm already endorsed by the majority of Australians, and people world-wide. Despite this support, many political leaders and industrial incumbents still adhere to the pathology of fossil fuel dependence. This long resistance, delay and postponement needs to be overcome.

There is mounting evidence that global warming effects as largely triggered by fossil emissions may already be beyond the kind of control implied in standard emissions reduction and renewable energy targets. The spectre of abrupt climate change with dramatic consequences for the human species and its ability to reliably secure food supplies is now clearly manifest – and yet still largely ignored by policy makers and media outlets alike.

We are in the process of passing boundaries of no return, as a series of climate tipping points are being reached. We witness the beginning of Arctic and Siberian methane releases triggered in melting permafrost, and ocean floor clathrates; ocean warming progresses to a point when the seas begin to expel rather than absorb heat as well as CO_2; or the disappearance of polar sea ice that has long created Arctic heat waves in the wake of lowered albedo. Other powerful climate feedback mechanisms include the disruption of Asian monsoon rains, or the escalation of global forest dieback. More than 15 climate tipping point mechanisms are at risk of being triggered, or have already been activated.

As a consequence, sudden climate change even beyond the scale and duration of the historically cyclical Dansgaard-Oeschger or Bond events, in the last glacial period and the Holocene respectively, may be impending. Like these past events, this would be a period of rapid climate shift in response to a build-up of GHG concentrations in the atmosphere – but now unprecedentedly boosted by the nearly explosive burst of fossil fuel combustion based GHG release. Without immediate and far-reaching measures, it is not difficult to imagine, nor can the possibility be excluded, that global temperatures could trigger such a climate and temperature jump within a relatively short time, say though increased methane release.

This is no time for denial or resignation but for massive and unwavering action. This paper calls for an ultra-low carbon action plan, entirely unprecedented in extent and speed. These are not normal times; extraordinary measures have to be taken, with regard to a massive and immediate mobilization of renewable energy systems locally, nationally and globally, to provide 100% of thermal, electric and transport energy from renewable sources as quickly as possible. The rapid cessation of fossil fuel mining and burning world-wide is crucial.

A transformation of carbon intensive farming, forestry and food/fibre production with drastically lower levels of meat consumption is equally critical. Zero emissions, zero external energy, zero waste building and construction practices mirror lifestyles shifting to less embodied energy, water and more renewable forms of resource use.

Critical are:

- the extraction of CO_2 from the atmosphere now oversaturated with greenhouse gas, by massive afforestation and wetland regeneration programs on all continents, and a stop to the clearing of rainforests;

- the raising of organic humus content in urban parkland and agricultural soils; replacement of industrial agriculture with organic farming practices;

- the replacement of organic waste combustion through composting and carbonization, to help reduce emissions and enhance biological carbon sequestration in soil;

- large-scale CO_2 extraction from the atmosphere and its long-term embedding in carbon building and construction material.

The decommissioning of nuclear power plants and termination of new construction programs is also important here. Nuclear power delivers only a few percentiles in global final energy supply, while posing enormous human health, environmental, security and economic risks, and, critically, it leaves a risky legacy in times of climate risks as centralised power systems become compromised by extreme weather events, safe operation ranges are breached and maintenance schedules slip. Also, nuclear power absorbs an enormous amount of funding away from vital renewable energy infrastructures and as it takes on average 17 years to plan and build compared to months for renewables, is highly expensive and is no longer relevant to grids that are rapidly adapting to the use of localized energy.

8. Conclusion: Launching The Perth Protocol

Local, national and global proliferation of the policies and principles underlying the documented initiatives has long become critical – without current policy, regulatory and market frameworks having been yet fully adjusted. To articulate the call for action, we propose the *Perth Protocol*: paradigms and principles to shift to cities and regions regenerated through renewable energy, individual and collective innovation towards a 100% renewable metropolitan region. It is a call to the nation - and nations elsewhere - for states, cities and regions to rise and support fundamental transformation in its economy, institutions and governance to enable the systematic replacement of inherited energy systems with distributed renewable energy infrastructures fully founded on new technologies and community benefits. This also means finding ways of regenerating and retrofitting existing neighbourhoods and their building stock.

9. Contributors and References

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