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Publication date
2020

Document Version
Accepted author manuscript

Citation (APA)
Jenkins, A. J., Keeffe, G., Martin, C. L., van den Dobbelsteen, A. A. J. F., Broersma, S., & Pulselli, R. (2020). *Designing the Future to Predict the Future: An ‘urban-first’ approach to co-creating zero-carbon neighbourhoods*. Paper presented at 35th Passive and Low Energy Architecture Conference, Coruna, Spain.

PLEA 2020 A CORUÑA
Planning Post Carbon Cities

Designing the Future to Predict the Future:
An 'urban-first' approach to co-creating zero-carbon neighbourhoods

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ABSTRACT: The natural ecotone between people, community and carbon reduction is the zero-carbon community. Over recent decades, the design of zero-carbon communities has focussed too greatly on carbon emissions and not enough on building communities. Anthropogenic climate change is a human problem, yet people are seldom placed at the centre of design solutions. The City-zen Roadshow is an intensive co-creational approach to creating zero-carbon communities, which places stakeholders at the very centre of the design process. The methodology uses an 'urban-first' approach and champions urban design as the main driver to deliver change. Carbon accounting and energy analysis sit in adjacency with the urban design proposals to deliver interventions that are net zero-carbon, low energy, low waste, socially rich, ecologically diverse, economically robust, resilient, fit for purpose and engaging. The paper describes this novel approach using one roadshow as a case study to illustrate the urban interventions proposed. Living in zero-carbon communities is not just about photovoltaic panels and wind turbines. It is, instead, about thinking differently about the way in which people live and the decisions they make, to provide people with alternative ways of living that are more desirable than those currently available.
KEYWORDS: Urban, Neighbourhood, Co-creation, Zero-carbon, Stakeholders

1. INTRODUCTION

The European Union and the United Kingdom have both pledged to reduce carbon emissions to zero by 2050 [1,2]. This reduction in carbon emissions is critical in reducing the effects of climate change and maintaining a global temperature increase of less than 2ºC [3]. The European Union has seen a fall in carbon emissions of 22 percent between the years of 1990 and 2017 [4] and the United Kingdom has seen a reduction of 44 percent between the years of 1990 and 2018 [5]. To date, big investments in renewable technologies, such as on-shore and off-shore wind farms alongside bioenergy, have led to significant carbon savings [6].

Although these figures represent a significant contribution to reducing carbon emissions, the rate of reduction is not sufficient to achieve net-zero carbon emissions by 2050. To meet this goal, the performance and efficiency of renewable technologies will need to improve, and the cost of those technologies will need to reduce. The burden of reducing carbon emissions, however, does not rest solely on the advancement of technological solutions. The human element of what is a human problem needs to be considered and addressed, and individual people need to understand their role in mitigating carbon emissions.

2. THE ROLE OF THE INDIVIDUAL

Anthropogenic climate change is the cumulative effect of all human decisions made over the past two hundred years. Consequently, the potential impact of small changes in behaviour and lifestyle choices in the future can accumulate to a large overall reduction in carbon emissions. For example, it is estimated that becoming car-free could save at least 1 ton of $CO2_e$ per capita per annum and that eating a plant-based diet could reduce carbon equivalent emissions by up to 1.6 tons per capita per annum. Avoiding a single transatlantic return flight could save at least 0.7 tons of $CO2_e$ per annum whilst purchasing electricity from a renewable provider could save between 0.1 and 2.5 tons per capita per annum [7]. Behavioural change will be instrumental in achieving net-zero carbon emissions, and this has to be driven by education and engagement to empower individuals to take control of future change within their local community.

3. ZERO-CARBON COMMUNITIES

The natural ecotone between people, community, and carbon reduction is the 'zero-carbon community'; otherwise known as a one-planet community, an ecopolis, an ecodistrict, or an ecocity [8]. The idea of an eco-city was first explored in 1898 by Ebenezer Howard in his book 'Garden Cities of To-morrow' [9]. This idea re-emerged during the 1960s and 1970s and was later formalised in 1987 by Richard Register when he published the book 'Ecocity Berkeley: Building cities for a healthy future' [10]. These early ideas focussed on compact developments and mixed land use, a reprioritisation of pedestrians, along with the increased use of public transport and a focus on mitigating ecological damage. Early eco-city principles also included the formations of ecologically and socially just economic development, conservation, and increased resource efficiency [11].

Since then, the idea of an eco-city has developed into a vehicle to directly reduce carbon emissions and energy use through the design and implementation of 'place' [12]. Unfortunately, very few examples encompass the holistic approach of eco-cities due to an over-emphasis on reducing energy use as the primary driver of mitigating climate change [13, 14, 15]. Whilst it is important to understand energy use at a neighbourhood and city scale, renewable energy and its efficient conversion into heat, light, and work does not provide any meaningful depth to a community.

Figure 1: The first UK eco-town, 'North-West Bicester'.

This can be seen in examples such as North-West Bicester in England, which can be used as an example to illustrate the shortcomings of current zero-carbon developments (fig. 1). This project was the first eco-town to be completed in the UK and it boasts rooftop photovoltaic panels, an on-site combined heat and power plant, efficient insulation, rainwater harvesting and green garage roofs. It is a zero-carbon development but there is no green space for families to enjoy, neither is there a central square to facilitate community activities. The site is awash with hard surfaces and there are no on-site conveniences to reduce car journeys. Bicester town centre is a 30-minute walk away, or a 9-minute bike ride, with no cycle routes running through, to, or from, the development. The development is disconnected from its surroundings and offers no incentives for residents to change their behaviours. North-west Bicester, therefore, is a traditional English development with the gilt of zero-carbon credentials. Residents who live there are unlikely to take a walk because there is nowhere to walk to, and they would be unlikely to go for a bike ride due to the lack of safe bicycle routes. Although the development will save many tons of carbon over its useful life, it could have saved many more if it had considered the impacts of providing a healthier, happier and more connected lifestyle to the residents that would ultimately bring the site to life.

4. THE CITY-ZEN ROADSHOW

The built environment plays a significant role in how people choose to live their lives and the decisions they make [16, 17, 18]. Therefore, to create zero-carbon neighbourhoods that holistically address economic, social, ecological and environmental issues, new methodologies are required that are holistic in nature. In addition to this, these new methodologies need to consider the human element of the challenges ahead to help deliver zero-carbon developments that are net zero-carbon, low energy, low waste, socially rich, ecologically diverse, economically robust, resilient, fit for purpose and engaging places to live.

This was the premise of the City-zen Roadshow, which formed part of the wider EU initiative 'City-zen'. The City-zen Roadshow combined local stakeholder knowledge with global expertise to co-create future zero-carbon communities. The City-zen Roadshow aimed to work closely with people from the hosting city, such as city leaders, neighbourhood associations, urban planners, and residents to co-create future zero-carbon propositions that were fit for purpose, both in terms of carbon savings and improvements to the communities. The philosophy behind this approach is to leverage zero-carbon development to improve the quality of life and to include stakeholders from the very beginning to maximise the impact and the advocacy of the interventions proposed. Over four years, the roadshow has visited ten cities: Belfast, Izmir, Dubrovnik, Menorca, Roeselare, Preston, Nicosia, Sevilla and Amersfoort. These were chosen due to already engaging in zero-carbon initiatives and the prior enthusiasm of the municipalities and stakeholders regarding the roadshow methodology.

5. AN 'URBAN-FIRST' APPROACH TO ZERO-CARBON

In addition to the co-creational nature of the City-zen Roadshow, the methodology utilises an 'urban-first' approach, which champions the role of urban design to deliver widespread change. Although urban design is at the forefront of this methodology, carbon accounting and urban energy systems work in adjacency to the urban design proposals to deliver holistic and meaningful interventions (fig 2.)

The methodology begins with separate analyses of existing carbon emissions, energy use and the urban form, alongside societal and contextual considerations. These investigations are driven by guided tours around the city, insights provided by local residents and conversations with local stakeholders and city leaders. These elements, when combined, derive an overall brief for the project, including urban challenges, the carbon footprint and overall energy use. After this, a series of urban explorations are developed alongside local stakeholders to address the key social, economic and environmental challenges within the neighbourhood. These explorations are then developed further with the assistance of carbon accounting and urban energy systems to improve the carbon mitigation of each intervention. After this, the methodology returns to the urban explorations to include additional elements such as energy centres and community farms, in addition to assigning areas for photovoltaic panels, vehicle charging points, and wind turbines. The carbon mitigation of each intervention is calculated and combined to give an overall carbon mitigation value for the urban design strategy. Finally, a transition roadmap is developed, which identifies a series of annual goals to achieve net-zero carbon emissions by 2050.

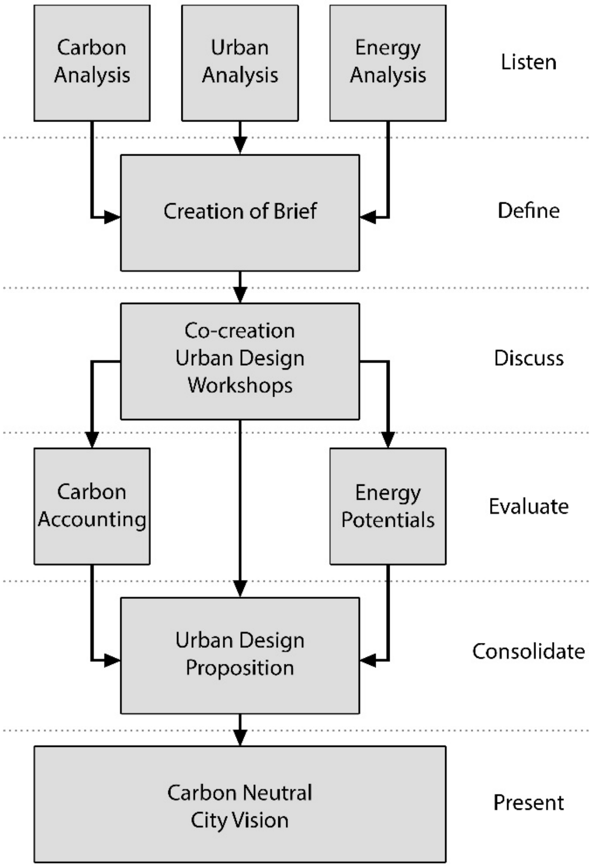

Figure 2: The 'urban-first' zero-carbon design methodology

6. ROESELARE, BELGIUM: CASE STUDY

To contextualise the urban-first approach of the City-zen Roadshow, a case study will be used to illustrate some of the urban interventions developed alongside local stakeholders. The city of Roeselare in Belgium will be used for this purpose due to the extensive participation of stakeholders and the breadth of urban interventions proposed. The city of Roeselare invited the roadshow to visit them to engage creatively with stakeholders and reduce their carbon footprint to zero.

6.1 Listen and Define

Upon arriving in Roeselare, the 'roadies' were taken on a tour around the urban centre to see the carbon reduction measures that are currently in place or under construction. Later, the roadies were shown around the neighbourhood that would be the focus of the investigations and met with several local stakeholders who spoke about their neighbourhood. The neighbourhood was located south-west of the city centre in between the two ring roads that define the structure and form of the city. When walking around the neighbourhood it became clear that several key characteristics defined it. These included disconnections both from the city and the adjacent natural landscapes, low building density, periodic flooding, the lack of a defined centre, poor legibility, and low quality public green space. These key challenges would help form the brief for the project and define the scope and scale of the interventions.

Through detailed conversation with the municipality, the energy use and resulting carbon footprint of the city was calculated. The energy use of the city was estimated to be 2.28x6e kWh per annum. The life cycle analysis emission factor of the energy produced to power the city was calculated to be 0.181 kg$CO2_e$/kWh based upon a 33 percent contribution from gas, a 17 percent contribution from renewables, and a 50 percent contribution from nuclear energy. The carbon emissions of Roeselare were estimated to be 412,396 tons of $CO2_e$ per annum and the carbon footprint was equivalent to 30,548 hectares of forest, which is five 5.1 times larger than the cities geographic area of 5979 hectares (fig. 3). The area of forest was calculated based upon the ability of forest land to sequester 1.35 kg of $CO2_e$ per square metre per annum [19].

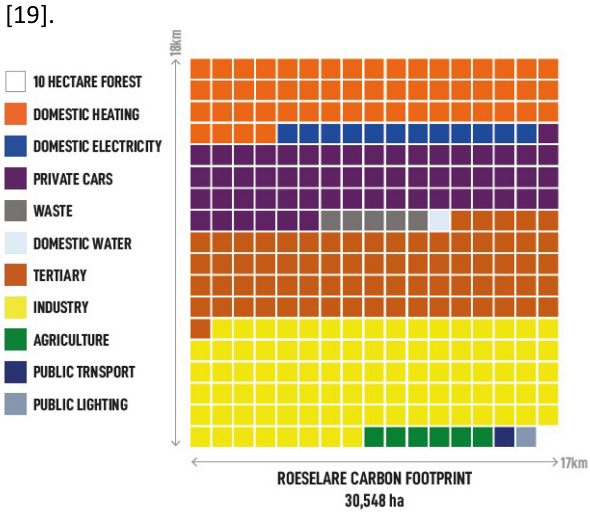

Figure 3: The carbon footprint of Roeselare. Each square represents ten hectares of forest land.

6.2. Discuss, Evaluate and Consolidate

To tackle the key challenges of the neighbourhood, a series of urban design workshops took place in several locations at different times of day to maximise stakeholder engagement. In collaboration with local stakeholders, a number of urban interventions were developed with a focus on providing relevant infrastructures to facilitate walking and cycling to and from the city in order to minimise car use, to increase the density of the neighbourhood, to create a defined neighbourhood centre in order to provide both public open space and to provide opportunities for local businesses, and to address the periodic flooding of the adjacent culvert.

The culvert that was in place was very narrow and offered very little capacity to deal with peak rainfall. Due to the lack of green space in the neighbourhood, water runoff was also very high. Therefore, it was proposed to widen the culvert and create an elevated walkway along one side to create a nature walk to and from the city (fig. 4). The culvert would also be fed by a new sustainable drainage system that would incorporate swales and ponds to maximise water attenuation and minimise discharge into the culvert, which would also create new habitats for local wildlife.

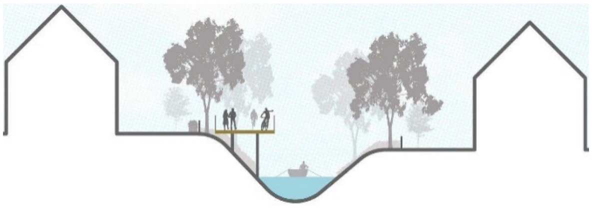

Figure 4: Widening of the culvert to create a nature walk and improve connectivity.

The neighbourhood was in desperate need of a direct route towards the city to greatly reduce the number of needless car journeys taken. The neighbourhood suffers from poor urban planning that favoured the creation of multiple cul-de-sacs, which generally pushes people towards making needless car journeys to travel relatively small distances. To address this, several cul-de-sacs were connected together with minimal loss of private land, to create an uninterrupted route to the city centre.

Figure 5: The neighbourhood cycle route with a food and energy producing canopy.

This route could be used by those walking, running or cycling and was covered by a canopy to make it useable regardless of the weather. The canopy also produced food and electricity for the local neighbourhood. When paired with an electric bicycle sharing scheme, this intervention would be capable of greatly reducing vehicle carbon emissions (fig. 5).

The intensity of the neighbourhood was very poor, offing almost no space for local amenities or recreational activities. To address this, a neighbourhood centre was proposed that could facilitate these requirements (fig. 6). This centre would offer a supermarket, retail space, a large open park and a boating lake to further increase water attenuation. Large greenhouses in addition to a large rooftop urban farm on the retail unit would help to grow food for the local population; not only creating jobs but also reducing food miles. The creation of a centre helps to reorient and reinvigorate the neighbourhood, whilst providing the residents with access to nature and much needed open space.

Figure 6: The new neighbourhood centre including retail space, a rooftop farm, open green space, and a boating lake.

Low building density is considered to be a problem because it forces people to spread out over a large area and, as a result, some residents can be much further away from the goods and services they require, which increases travel distances and the number of car journeys made. Low-density settlements also promote urban sprawl, which eats into natural landscapes over time. In the north-east of the neighbourhood there are some pockets of land and several old buildings that were unoccupied that could facilitate the development of apartment blocks placed between the neighbourhood centre and the city centre. This would help provide the space needed for additional amenities such as doctors, schools, and places to meet. These new blocks would create large areas of flat roofs that would be perfect locations for rooftop farming.

Figure 7: A row of 'technoterps' including aquaponic flood defences and rooftop greenhouses.

Many of the properties in the neighbourhood benefit from flat roofs, which offer potential opportunities for other rooftop farms. The idea of the ‘technoterp’ was created, which incorporated flood defences made of raised beds and fish tanks to run aquaponic systems that grew food on the roof (fig. 7). Where flat roofs were not present, community block farms were created to increase the overall resilience of the neighbourhood.

In addition to the urban interventions proposed, the supporting energy infrastructures were also a key component of decarbonising the neighbourhood. The output of these interventions was not simply to quantify the scale of renewable technologies required, but also to break down those vast numbers into annual deliverables. This manifested as the installation of seven hectares of roof- and ground-based photovoltaic panels every year, one hectare of thermal photovoltaic panels every year, and one 4MW wind turbine every year before 2050 to meet the electricity needs of the city. To meet the high-temperature heating demands of the city, it would need to increase the existing district heating network by 10 GWh and connect 850 homes per year, increase industrial waste heat capture by 10GWh per year, install 4GWh per year of solar collectors, and install an additional 4GWH of high-temperature storage per year up to 100GWh. To meet the medium- and low-temperature demands of the city it would be necessary to thermally renovate 1100 properties per year, capture 2.5GWh of medium-temperature waste heat per year up to 35GWh, and increase aquifer and borehole heat storage by 3GWh per year up to 80GWh for both medium- and low-temperature heat by 2050. These deliverables were also proposed at the urban scale to determine where these technologies could be positioned (fig. 8).

Figure 8: The energy production plan for the city including two rings of photovoltaic panels alongside highways, a ring of wind turbines, three 100% electric communities in addition to rooftop and ground-based photovoltaic panels.

6.4. Carbon Savings

Both the urban and energy interventions proposed have varying impacts when considering the reduction in carbon emissions. Each intervention reduces carbon emissions outright, but factors such as increased energy consumption in the future must also be taken into consideration. In addition to this, it can be difficult for municipalities to determine which interventions would have the largest impact and which should be prioritised. For example, the carbon emission savings brought about by improving the thermal performance of building skins would be fifteen times greater than those provided by the combined savings of increased recycling, LED streetlights and electric buses (tab. 1)

Table 1: Impact of urban interventions on the carbon footprint of Roeselare, Belgium (initially 30,548 hectares)

Energy Intervention	**Carbon Reduction**
Building envelope improvements	15 %
Wind Turbines	12 %
Solar collectors and MT storage	10 %
Electric cars	10 %
Thermal photovoltaic panels	6 %
Rooftop photovoltaic panels	6 %
LT heat grids with aquifer heat storage	5 %
Cycle routes and electric car share	5 %
Waste incineration for district heating	4 %
Solar collectors and HT storage	4 %
HT industrial waste heat for district heating	4 %
Biomass for industry	3 %
Urban trees and green spaces	3 %
Ground level photovoltaic panels	2 %
Recycling, LED Lights and Electric Buses	1 %
Energy use increase	-3 %
TOTAL	**87%**

The remaining 13 percent of carbon emissions would need to be taken up by forest land planted specifically to sequester these emissions. An area beyond the outer ring road of the city was allocated for this, which would provide residents with a place to recoup and spend quality time with loved ones; a strange by-product of developing zero-carbon communities by typical standards.

7. CONCLUSIONS

The City-zen Roadshow is a holistic approach to designing future zero-carbon communities that focusses on the multifaceted drivers of society, environment, ecology, and economy that helped drive the first explorations into eco-city design. The roadshow created a platform to experiment with intensive co-creational design methodologies as a way to meaningfully engage with local stakeholder, who would ultimately play out the strategies of future zero-carbon communities. The urban-first approach developed as part of the roadshow took the power of urban design and used it to reshape ‘sustainability’, enabling stakeholders to view it through the lens of health, wellbeing and quality of life, rather than simply using the car less, spending money on LED bulbs or investing in building insulation.

What was found through the roadshow is that, not surprisingly, local stakeholders are deeply passionate about the places in which they live, and that to be given an opportunity to shape that place – whilst simultaneously reducing its carbon footprint as well as improving the quality of life - is something stakeholders are very thankful for. Not only that, but the process has been well received in each city and enjoyable for all involved. The symbiotic relationship that was created between stakeholders and global experts through the vehicle of the roadshow not only allowed for the quick prototyping of ideas, due to efficient and effective feedback loops, but it also enabled local stakeholders to feel connected to their city, which is a key component of civic wellbeing and achieving 'eudaimonia' [20]. This approach helped build a lexicon amongst stakeholders, enabled advocacy of zero-carbon strategies, and created a foundation from which meaningful debate can occur before such interventions are formalised by municipalities. Enabling meaningful collaborations at such an early stage in the zero-carbon transition process also makes it possible to strengthen communities that were open to change and ensures that momentum continues to occur after the roadshow leaves.

The redesign of the neighbourhood in Roeselare provides local residents with an improved quality of life whilst reducing net carbon emissions to zero. It is hoped that the interventions proposed are put into practice within a short space of time across the city, and that the ideas developed help other cities address their own climate challenges in the future. Living in a zero-carbon community is not just about photovoltaic panels and wind turbines. It is, instead, about thinking differently about the way in which people live and the decisions they make out of convenience and habit, which not only detract from their health and happiness, but also cause undue strain on the environment. Ultimately, someone has to design the places in which people live, and the City-zen Roadshow has proven that guiding stakeholders along an engaging design process can bring about impactful designs that are fit for purpose, net zero-carbon, socially accepted, and rather interesting to engage with and live amongst.

ACKNOWLEDGEMENTS
The City-zen Roadshow is a collaborative research project run by Queen's University Belfast, TU Delft, The University of Siena, Vito Energville and Th!nk E.

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