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A Network of Circular Economy Villages:
Design Guidelines for 21st Century Garden Cities

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Abstract

This paper advances the development of a hypothetical, systems-based approach to the design and development of smart rural villages—a network of circular economy villages (CEVs). The method is to assimilate visionary ideas from 20th century town planning literature related to decentralisation and the development of new towns in rural areas, identifying key design principles. The present trajectory of infrastructure design and emerging development models are then analysed to modernise the design principles for implementation in the 21st century.

The proposed CEV development model applies circular economy strategies to every aspect of the smart rural village development including financing, ownership, spatial planning, design and material selection.

The purpose is to open the possibility for a research institute, perhaps in partnership with a local council and a major developer, to bring together skills necessary to prototype the CEV development model.

Keywords: Town Planning, Circular economy, Energy transition, Regenerative Agriculture, Life Cycle Planning

1 Introduction

Reviving visionary town planning ideas of the early 20th century, this paper examines how these can inform the development of smart and sustainable villages in rural areas. Synthesising these ideas with 21st century technologies and business models, a set of guiding principles for planning, financing, design, construction and management of smart rural villages is developed.

This paper continues the development of a specific model for smart rural villages, previously described as regenerative villages (Liaros 2019) and referred to now as Circular Economy Villages (CEVs) (Liaros 2021). The term 'Circular Economy Villages' seeks to capture the growing interest and support for circular economy ideas. The development model incorporates life-cycle costing, management of water cycles, seasonal food cycles and plans for various stages in the life cycles of residents. CEVs also adopt the design principle for organic settlements proposed by Mumford (as cited in Stephenson 2018, p.284) whereby the urban, rural and natural landscapes are "meshed in synergistic fashion". Accordingly, CEVs incorporate a food production system and managed natural landscapes into the development plan. Infrastructure for renewable energy and water cycle management enhance the efficiency of food production. By integrating energy and water micro-grids and a regenerative agricultural system with the built environment, these can be designed to provide the community's basic needs, including food, water, energy, shelter, plus work opportunities within the village environment. The energy infrastructure can also be designed to power a fleet of shared electric vehicles for movement within and outside the village.

This paper shows how the town planning literature can be read to inform the development of a framework template for the smart and sustainable settlements. Starting with Ebenezer Howard's, 'Garden Cities of Tomorrow' (1902), principles for decentralisation and the development of new townships in rural areas are identified. In 'the City in History' (1961) Lewis Mumford offers the concept of the organic city in contrast to the mechanical city. Organic cities are those where both culture and nature thrive in harmony, with technology used to enhance natural systems. Frank Lloyd Wright similarly developed ideas for a return to nature enabled by technology with his Broadacre City (2011).

The proposition is that, while these historical ideas are sound, they have only been implemented sporadically and partially due to certain political, economic and technological obstacles. Section 2 of this paper examines these visionary ideas to identify principles that can be adopted for the development of smart rural villages.

To apply these principles in the 21st century it is important to acknowledge that the benefits of scale and complexity achieved through the agglomeration of people in cities can also be achieved—perhaps more efficiently—by interpreting cities as a network of village-scale communities. Section 3 outlines various reasons why development scale is important.

Section 4 argues that the technological obstacles, including the economics of implementation, have now been overcome. This section will illustrate how various categories of infrastructure are changing, with the trajectory pointing towards local, integrated, precinct-scale, circular economy infrastructure rather than large-scale, centralised, and linear (one-directional) infrastructure. Significantly, it will be shown that the trajectories of individual infrastructure types are converging, enabling the development of an integrated, systems-based approach to the design of village infrastructure. An energy micro-grid can cycle water through a site and power a fleet of electric vehicles. A water system can store energy, irrigate agriculture, and supply fresh water for residents. Agriculture systems can clean water, manage organic waste, and produce biofuels. Buildings can be designed to minimise energy demand, house farm workers, and generate income for the community.

Section 5 examines the trajectory of the development industry, identifying emerging and expanding sectors and opportunities. Once again, it is precinct scale development—such as build-to-rent, co-living, retirement villages and student housing—that are becoming more feasible and desirable.

Section 6 discusses the effect of the COVID-19 pandemic. Political obstacles relate to two complementary issues—the desire of citizens for policy change and the enactment of policy change itself by governments. In the past, citizens have generally been unwilling to move to regional areas due to the lack of employment opportunities (Matthews 2020b). The rise of remote working may mean that people take their jobs with them. In addition, the incorporation of infrastructure and facilities in CEVs can create further work opportunities that are co-located with housing. The COVID-19 pandemic is causing many to reflect on all aspects of life, including where to live and the nature of work. It is spurring people to leave cities (Matthews 2020b; Guaralda et. al 2020; Kotkin 2020), while also opening possibilities to reshape our cities (Barns 2020; Matthews 2020a). Past trajectories ought not to be simply extrapolated linearly into the future. Dramatic events can cause transitions to be accelerated leading to paradigm shifts in the ways we live and work and arrange our cities.

This reimagining of the work-life balance, together with issues like unaffordable housing, traffic congestion, high cost of living, noise, stress and loneliness, represent some of the factors pushing people out of cities. Rural councils seeking to attract these people should offer pull factors, drawing them to their particular area.

Rural living is a lifestyle choice and so greater connection to nature and community should be reflected in the development form. For development to occur, it must firstly be enabled by the planning policy framework, which should offer a clear planning approval pathway. This has been outlined by the author in a previous paper (Liaros, 2019). Additionally, development outlined in planning policies must be aligned with the type of developments proponents are willing to build.

The final section seeks to synthesise the town planning literature and the trajectories of infrastructure design and the development industry. Through this discussion, a set of design principles is developed. These would clearly articulate the vision for CEVs, informing council's planning policy and the development design brief provided to an urban designer or architect. This would ensure that the council and developers are working towards a common goal for the common good. Desirable common goods include housing affordability, environmental sustainability, improved public health and social cohesion.

2 Development principles from the town planning literature

2.1 Decentralisation and new towns

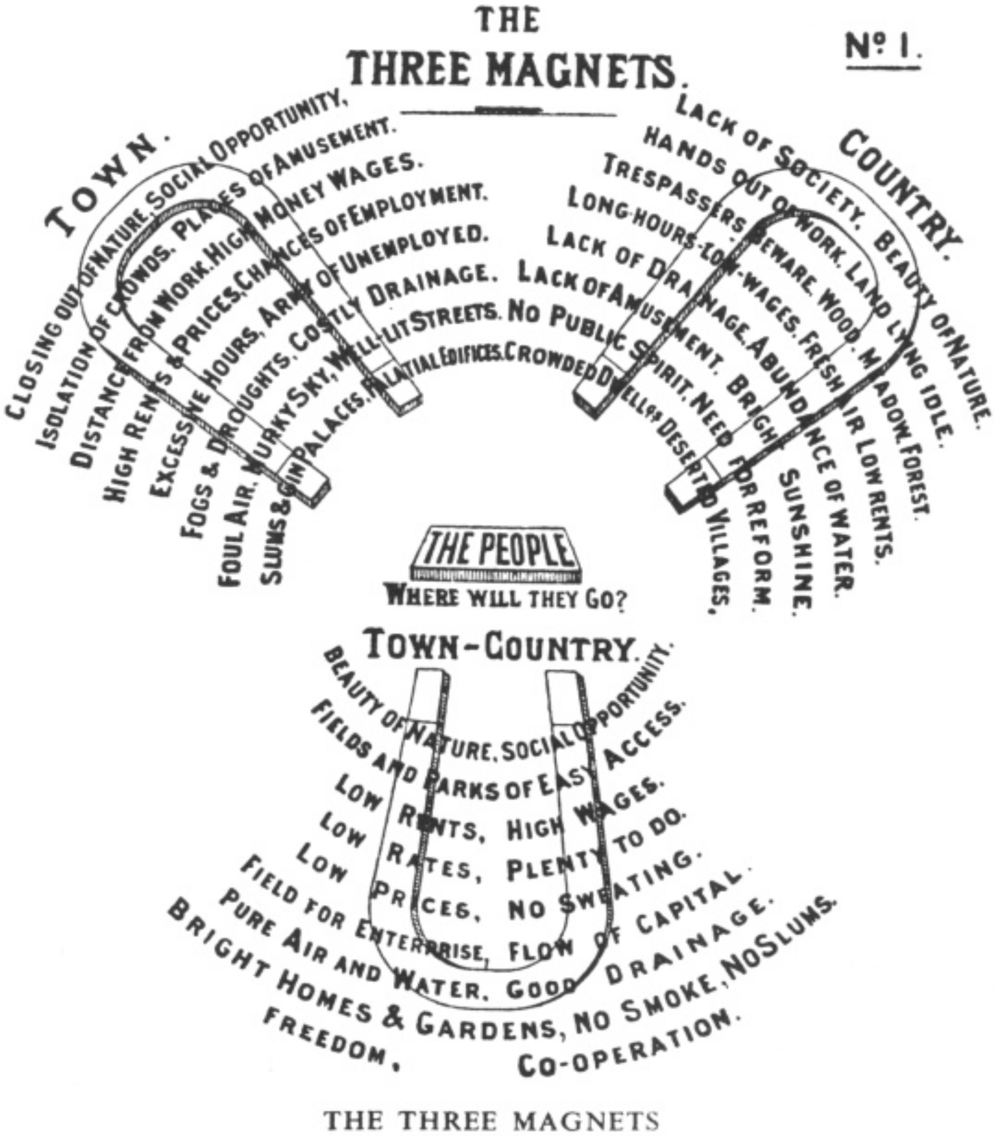
The study of town planning over the last century or so, evolved to address the problems of congestion and pollution caused by this agglomeration of manufacturing and factory workers in cities. With the massive upscaling of fossil fuel burning factories due to the industrial revolution, it was necessary to maintain healthy living environments, so regulations to protect health and amenity were introduced. Polluting workplaces were also separated from the places where people lived through land use zoning. This, in turn, created the need for transport infrastructure to get people to work. The ever-increasing size and density of cities over the twentieth century made these problems—of conflict between different uses, as well as managing transport and amenity—ever more acute.

To address these urban issues and to manage continued population growth, three broad strategy options emerged: (a) increase the density of the urban zone, (b) increase the area of the urban zone and (c) build new townships. The first two options reflect the limited concerns of ‘urban’ planners who seek to accommodate and manage the growth of existing mega-cities. ‘Town’ planners, on the other hand, are also concerned with the distribution of populations across the landscape, examining the scale and pattern of settlements including planning for new settlements.

In ‘Garden Cities of Tomorrow’ (1902, p.11) Ebenezer Howard noted that the continual flow of people into cities reflected the various attractions of city life but also caused many urban problems. He proposed the development of Garden Cities—a blending of the best aspects of town and country life—which would act as an alternative attractor outside the existing cities and result in effectively “redistributing the population in a spontaneous and healthy manner.” (Howard 1902, p.14)

It is on this principle that the success of any strategy for the development of a network of CEVs rests. That is, to discover a method for redistributing the population in a spontaneous and healthy manner. On the bottom magnet of figure 1, Howard identifies the factors that he considers would draw people out of the cities based on the combination of the best aspects of town and country life. Table 1 below lists Howard’s design principles on the left and on the right, we provide suggested equivalent design principles that could be used for developing smart rural villages.

Figure 1 To draw people out of congested cities, garden cities should offer the best aspects of both urban and rural life as shown in the lower 'town-country' magnet. Source: Howard (1902)



While Howard proposes an abundance of open space, he retains the division between urban zones and rural food producing zones. This reflected the mechanistic thinking of the time, which was more strongly expressed in Le Corbusier's Ville Radieuse (Radiant City) from 1930, wherein the city was conceived as a giant machine. Le Corbusier's response to the congestion and disorder of the urban environment was to raze it to the ground and rebuild it in an ordered, symmetrical and standardised manner. The immense scale of the tower buildings romanticised man's technological prowess and saw man as separate from nature.

Table 1 Conversion of Howard's attractors into design principles for circular economy villages

Howard's attractors of people to Garden Cities (1902)	Equivalent possible design principles for Circular Economy Villages (2021)
bright homes and gardens, no slums, fields and parks of easy access,	high quality, passively designed housing, no more than two storeys to ensure easy access to open space
beauty of nature, pure air and water, good drainage	located in attractive natural landscape integrated with well managed water systems
no smoke	energy generated by clean renewable energy systems
low rents, low rates, low prices	affordable housing and low cost of living
plenty to do, no sweating, cooperation, high wages	sufficient collaborative work opportunities and support for innovation creates a local economy that generates income for residents
freedom, fields of enterprise, social opportunity	innovation and entrepreneurship supported and encouraged
flow of capital	the development financing structures should be based on long-term capital offering a consistent flow of moderate investment return to investors rather than on short-term, speculative, sporadic and high-risk returns

Lewis Mumford was a principal critic of this approach arguing that it was hazardous to human well-being and that the space between buildings, being distant from homes, was not used as intended and effectively became a wasteland. Mumford (1961) advocated for a more organic approach to planning, and for human-scale buildings no more than one or two storeys. For Mumford the city was more than a collection of buildings; it was a living entity. Stephenson (2018) identifies Lewis Mumford, John Nolen and Sottish polymath Patrick Geddes as the key proponents of the city as a living organism—and critics of the dominant orthodoxy of the city as a machine. Stephenson (2018, p.282) argues that the notion of sustainability took root in the work of Nolen and Mumford as their arguments for limiting the growth of cities evolved into the 'limits to growth' generally as it applies to sustainability.

Mumford therefore provides some additional principles for Circular Economy Villages. He argued that human settlements should be limited in scale, with "urban, rural and natural landscapes … meshed in synergistic fashion" (Stephenson 2018, p.284). Population growth should therefore be managed by building more settlements rather than growing the size of any one settlement. In his 1927 book ‘New Towns for Old’, Nolen argued for regional cities to reflect the topographical and climatic conditions of their locality.

The meshing of urban, rural and natural landscapes suggests an integrated infrastructure ecosystem incorporating food production. The division between urban and rural areas is an artificial boundary that puts food outside the city limits and therefore beyond the scope of urban planning. In creating a systems-based approach, it is imperative that food systems be incorporated into the development model.

The addition of a diverse, regenerative agricultural system creates a point of difference from apartment buildings and dormitory suburbs, while also contributing significantly to the development of a local economy. Value-adding to the locally grown food—preserving foods and selling through local restaurants—would significantly expand the village economy. Food is a fundamental need, and the city is a system that provides for the needs of its citizens. Therefore, the production of the food required to sustain urban populations should be an essential part of the city and city planning.

The best way to manage and provide residents with food, water and energy is to develop precinct-scale infrastructure. A renewable energy micro-grid can power a water micro-grid, which would irrigate the agricultural system. To develop these efficiently, the infrastructure systems should align with, and enhance, the local geographic and climatic conditions. In accord with Mumford’s organic city, it would be like an organic system grown out of the landscape, enhancing the capacity of the land to sustain a discrete population of people.

Like Mumford, Frank Lloyd Wright also protested against the machine city and argued that it “promoted dehumanising values, robbed people of their individuality and jeopardised their democratic lifestyle. He felt people would reap the full benefits of the Machine Age only by returning to their natural home, the land” (Nelson 1995, p.339). More recent research on the effect of the built environment on public health (Kent et al, 2011) confirms the importance of connection to fresh food, connection to community and a walkable environment.

Wright suggested that new technologies—in particular, the motor car and “electrical inter-communication”—were already transforming cities “whether the powers that overbuilt the old cities otherwise like it or not” (Wright 1935, p.345). His vision for the Broadacre City, presented as a model at an Industrial Arts Exposition at the Rockefeller Centre in 1935, offered a decentralised pattern of settlements as the solution to the many physical, economic, and political problems of the urban centre. Wright’s concept of a decentralized network of settlements that were limited in scale, with population growth managed by replicating rather than growing the size of the settlement, is a useful principle for the development of a network of Circular Economy Villages.

While Howard proposed a local economy, new settlements remained substantially dependent on the nearby major centre. Wright suggests that communities should be self-governed and self-sufficient, based on small-scale farming and manufacturing. This would also transform the economy by eliminating complex, global distribution systems. “Methods of distribution are simple and direct. From the maker to the consumer by the most direct route” (Wright 1935, p.346).

Howard’s book and subsequent work eventually led to the development of 28 new towns in the United Kingdom. In Australia, Canberra and Griffith were designed by Walter Burley Griffin, an American architect who had worked for Frank Lloyd Wright. Both were built in the early to mid-twentieth century but in recent decades there seems to be little appetite in Australia for the development of new towns. Almost all town planning, from research to delivery, is presently concerned with increasing density of existing settlements or adding suburban sprawl on their edges. While Springfield on the edge of Brisbane is regarded as a new city due to its scale, it is part of the Brisbane metropolis. The concept being developed here is of interdependent but discrete political economic units.

To encourage the development of smart and sustainable villages in rural areas—in the form of CEVs—it is proposed to build on the work of Howard, Mumford and Wright. The following sections outline certain limitations and obstacles to their proposals that, when overcome, would substantially improve the potential for the development of CEVs. New technologies and business strategies that have only very recently become available open possibilities for a uniquely 21st century development form.

2.2 Development Scale – Cities as a network of villages

Howard's proposed satellite cities had a population of 32,000 while Wright proposed a population of 5,000 in each settlement. New population centres of this scale represent major initiatives that would necessarily need to be managed by a government-owned development corporation as was the case for the new towns in the UK. Instead, a much smaller development scale is proposed, a precinct or village for a small community, perhaps just 200 people. Developments of this scale can be delivered by a larger cohort of developers and development professionals. The smaller scale makes project management simpler, while also simplifying ongoing asset management and governance. At more granular scales, the infrastructure consists mainly of natural ecosystems and relatively simple technology that can be more readily managed by the community itself (Foth 2018).

Rather than a large population in one place, scale and complexity can be achieved through the organic networking of settlements across a broader area. A network of villages in a bioregion would still deliver substantial population growth if this were desired, while also retaining the rural landscape character treasured by these communities. Such development units would also allow for a more incremental approach to the development of rural landscapes, allowing regional communities to determine and manage the scale and timing of growth.

Critically, for developments of this smaller scale, it is feasible to use existing town planning legislation and development processes (Liaros, 2019), which can readily be tailored for this purpose. Proponents would need to work closely with the local council and community to achieve the desired outcome—one, two or a network of villages within a local government area. The identification of appropriate localities for settlements, through current community strategic planning processes, would be the first step, followed by more detailed policies in respect of planning instrument amendments, infrastructure agreements, concept planning and establishment of development controls.

An important aspect of the planning process for CEVs is the careful management of land value increases as the land is rezoned from rural to urban uses. To achieve this, the regulatory requirements for the development of a smart rural village must include provisions for substantial open space—80–90 percent of the site area—for natural ecosystems, water management and food production. As an example, an area of 6 hectares would house 200 people at a suburban density. This would leave the remaining 34 hectares of a 40-hectare (100-acre) parcel to be used for connection to food, water and nature. The central characteristic of CEVs is that they enhance the capacity of natural ecosystems to support a given population. Accordingly, housing should not be permissible until the supporting infrastructure has been provided or its delivery is certain.

3 Trajectory of infrastructure development

3.1 Water infrastructure

An essential aspect of planning relates to water management. For several decades water engineers and local authorities have been encouraging the development of more natural water management systems on greenfield and brownfield sites. This approach is generally referred to as Water Sensitive Urban Design (WSUD) and at larger scales, Water Sensitive Cities.

Water sensitive cities integrate water systems planning with land use planning. WSUD is now considered best practice for stormwater management at least for new precinct-scale developments. An example of best practice is Lochiel Park in Adelaide—a project by the state-owned Renewal SA. As shown in figure 2, the site includes substantial open space, with reservoirs and a wetland for storing and cleaning stormwater on site. In addition to managing stormwater runoff, the water system cleans wastewater using natural processes and then recycles it back through the development. According to RenewalSA this has led to a “78% saving of potable water (against the 2004 average)”.

Such significant reductions in demand for potable water serve to illustrate just how wasteful the current single-use water management systems are but they also demonstrate that the technology and expertise is now available to design cities in a far more water efficient manner. Such designs, though, require significant areas of land than present urban densities provide.

Figure 2 Lochiel Park masterplan showing extensive open space, bushland, water reservoirs and wetlands. Source: Renewal SA (2014)

3.2 Energy infrastructure

According to RenewalSA (2014), the renewable energy infrastructure at Lochiel Park achieves a reduction in "energy use by 66% compared to the SA household average in 2004". 'The Cape', another best practice project at Cape Paterson, south-east of Melbourne, generates its own electricity. It has been the subject of research by RMIT University (Moore, 2020), which found that on average, its passively designed homes—all with solar panels—draw 88% less electricity from the grid than the average 6 star rated home. The Cape also incorporates many other ideas proposed in this paper including a co-working hub and very substantial community gardens, open space, and bush regeneration areas.

3.3 Infrastructure ecosystems

Neither Lochiel Park nor The Cape have been designed with energy infrastructure as an integrated system—a micro-grid—nor is the water infrastructure integrated with energy. Yet both already deliver substantial efficiency gains, simply by adding solar panels and batteries to passively designed housing.

The inclusion of passively designed housing at The Cape to minimise energy demand illustrates that greater efficiency gains can be achieved—and a more holistic system created—by managing both the supply and the demand of energy. An energy micro-grid can be designed from the outset to generate, store and distribute energy, matching the supply with the demands of the community. A similar approach could be applied to the water system to create a water micro-grid.

A key aspect of this approach is to plan for a discrete population, which ensures a relatively stable level of demand. Demand management is the most effective strategy for increasing energy efficiency. It is noted that in public discourse, the concept of efficiency does not exactly align with efficiency as defined in physics—the ratio of energy outputs to energy inputs:

$$Efficiency = \frac{Energy_{outputs}}{Energy_{inputs}}$$

In the present economic paradigm wherein production outputs must continue to grow, decreasing the energy input *per unit of output*, still results in increasing overall energy usage (Loh et al. 2020). By fixing the population in the CEV model, the overall energy demand for necessities remains stable. Stabilising outputs allows efficiency to be improved by looking for ways to minimise the input work needed to achieve the desired outputs. Regenerating natural systems is the simplest way to reduce the human and fossil fuel energy needed for food production and water management. Net positive design (Birkeland 2020) and regenerative development (Mang & Reed 2020) adopt this approach. Extending the focus beyond achieving positive outcomes for humans highlights the importance of more-than-human perspectives (Loh et al. 2020; Yigitcanlar 2018).

Planning for a fixed population also simplifies design and provides a level of standardisation that is required in planning regulations.

A much more comprehensive and integrated infrastructure ecosystem could then be developed by integrating water, energy and housing. Firstly, the precinct-scale, renewable energy micro-grid would be designed to provide all the energy needs of the community. When enmeshed with the water system, additional efficiency gains can be achieved as energy can pump or clean water, while water can store or generate energy. Both systems become more efficient when integrated together.

It should also be noted that the managed, water-charged landscape surrounding the built environment offers the added benefit of functioning as an excellent bushfire buffer.

3.4 Infrastructure ecosystem – adding food systems

Given the availability of continuous water supply and open space, it makes sense to also incorporate a diverse agricultural system. Plants can clean water and water reservoirs can provide an environment for aquaculture. Organic waste and cuttings will decompose to build soil depth. Soil, in turn, stores water and slows the flow of water. Organic waste material can also be used to create biofuels as an alternative energy source.

Current industrial and monocultural agricultural systems would not be appropriate for these purposes. Fortunately, a new form of diverse and organic agriculture—referred to as regenerative agriculture or agro-ecology—is already being developed. In 'Call of the Reed Warbler: A New Agriculture, A New Earth' (2017), Charles Massy describes the principles of regenerative agriculture as follows:

1. Maximising the capture of solar energy by fixing as many plant sugars as possible via photosynthesis
2. Improving the water cycle, maximising water infiltration, storage and recycling in the soil

3. Improving the soil-mineral cycle by creating healthy soils that contain and recycle a rich lode of diverse minerals and chemicals
4. Maximising biodiversity and health of integrated, dynamic ecosystems at all levels.

Massy argues that a fifth requirement is a change in human attitudes. Only human agency can trigger landscape regeneration by working in harmony with natural systems. The necessary shift in attitude is from an extractive to a regenerative mindset. Instead of just taking from the land, extraction is counter-balanced by active water, soil and biodiversity improvements.

This revolution in food production systems converges with disruptions in water and energy systems. Indeed, the ability to generate energy and manage water on-site makes the regenerative agriculture revolution possible, overcoming the obstacles to this critically needed transition.

Another obstacle to the transition to regenerative agriculture is that it is more labour intensive than industrial agriculture. Fortunately, a CEV includes housing, some of which can be specifically allocated for farm workers, while other residents may contribute sporadically as needed, such as at harvest time. Rural councils could therefore potentially promote CEVs as housing for regenerative farmers to facilitate this transition.

3.5 Infrastructure ecosystem – adding transport systems

Still further efficiencies and cost savings for the community can be achieved by designing the energy micro-grid to power a small fleet of shared electric vehicles. This could be composed of two complementary transport systems—internal and external. Complementing the compact, walkable environment of the CEV, bicycles and electric golf carts might be used for mobility within the village. Electric cars and vans would then be used for travel outside the village.

From the perspective of a precinct with its own energy micro-grid, car-sharing EVs makes financial sense. In a compact built environment where vehicles are close by, it is easier to share and lower transport costs for everyone. There will be fewer vehicles, and these will be managed and maintained collectively. The energy micro-grid can charge the vehicles, lowering fuel costs. With all this water, energy, food and transport infrastructure, there would be a range of work opportunities within walking distance of housing. This further reduces the demand for vehicular transport or at least allows for more affordable options like bicycles and electric golf carts for commuting within the village.

3.6 Infrastructure ecosystem – adding communication systems

As with the energy transition, the information revolution is characterised by networks of prosumers (individuals or groups that both produce and consume value) trading or collaborating peer to peer. A network of CEVs cooperating as a trading network can provide the necessary scale and complexity required to develop complex products or share rarer skills.

The internet as a virtual network decreases the importance of the city centre as the location of work opportunities. The COVID-19 pandemic has accelerated the transition to online work and tele-commuting from remote work hubs. This suggests that a co-working hub with good internet access and all necessary office facilities should be an essential component of a CEV.

An important innovation for master planned development precincts is the advent of concierge apps that assist in asset management. These allow residents and site managers to communicate efficiently, improving maintenance, community engagement and booking of shared facilities and vehicles. Whilst it is acknowledged that connectivity does not ensure community (Foth 2003), these mobile apps are designed to create a sense of social ownership within the community, intentionally supporting community development.

4 Trajectory of the development industry

4.1 Developer strategies – build-to-rent

All the shared and integrated infrastructure, including water, energy and food systems, as well as electric vehicles, work hubs and other community spaces would be best owned and managed holistically by a single entity.

Fortunately, the recent emergence of the build-to-rent (BTR) housing development model is ideally suited to respond to these requirements. Rather than building housing for sale and transferring the responsibility for asset management to a body corporate, the entire development or precinct is retained in the ownership of the developer and housing is made available for rent only. This allows the developer to plan and design for common assets and for the entire life cycle of a precinct, from planning through to post construction management. In such circumstances, it is in their interests to maximise the durability of assets as this reduces the life-cycle costs of management and maintenance of infrastructure. It is also in their interests to minimise waste and maximise efficiency justifying the inclusion of the infrastructure ecosystem referred to above.

According to the Australian Housing and Urban Research Institute (AHURI 2019), build-to-rent is an established practice in both the UK and USA but has not been taken up in Australia. The AHURI brief cites tax settings designed for the build to sell model—in particular, land taxes, GST provisions, and income tax levels for overseas investors—as impediments to uptake in Australia. Nevertheless, it appears that several major developers are pressing ahead and lobbying governments to address these issues. In a media release in July 2020, the New South Wales state government announced:

> *The NSW Government will introduce a land tax discount for new build-to-rent housing projects until 2040 and a new Housing Diversity SEPP to provide more housing options, greater surety for renters, boost construction and support jobs during the COVID-19 recovery.*

In September 2020, Mirvac opened their first BTR project in NSW at Sydney Olympic Park, financed through a managed investment trust. Such financing models allow for the funding of a pipeline of projects, while future residents could purchase sufficient units in the trust to offset their rent.

In Victoria, the Department of Environment, Land, Water and Planning established a build-to-rent standing advisory committee in September 2018 as "part of the government's efforts to facilitate the development of a BTR sector in Victoria".

Governments and major developers are clearly committed to supporting and advancing the BTR sector, a developer strategy that is ideally suited to the construction and management of the integrated precinct-scale infrastructure of CEVs.

4.2 Other development opportunities – Housing as a Service

The expansion of the BTR sector aligns with similar growing interest in other forms of precinct-scale housing offered as a service. This includes growth in demand for retirement villages as the population ages and demand for co-living opportunities for digital nomads. These development forms could be collectively be referred to as 'Housing as a Service' (HaaS) as they are operated by an entity that manages a site for the provision of housing and associated services.

CEVs could be designed to cater for a diverse age demographic profile, potentially targeting all these markets. Interestingly, Kennedy and Buys (2020) argue that the concept of the retirement village should itself be retired, and that their research shows that "micro-neighbourhoods" with diverse and inclusive infrastructure should be developed for a broad age demographic. They suggest that projects could be funded by "long-term capital rather than short-term debt, for greater financial and community returns". This would be consistent with Mirvac's model of a managed investment trust financing a pipeline of projects.

4.3 Life-cycle costing

With a single entity managing a development project and then retaining assets post construction, financial models would optimally adopt life-cycle costing methodologies. This would drive the design and construction process towards maximising durability to achieve the longest possible asset life, while minimising maintenance costs. Holding on to the village assets post construction allows for regular expert maintenance to be incorporated into life-cycle costs and management plans. This suggests that life-cycle costing should form the basis of financial models adopted for the development of CEVs.

5 COVID-19 pandemic and transitions accelerated

The COVID-19 pandemic will likely increase the demand for smart village projects in rural areas as people escape the cities and work remotely. Border closures also highlight the fragility of global supply chains, and therefore the importance of local resilience. Additionally, the consequent economic impact of the pandemic is motivating state and federal governments to support the construction industry and enable alternative approaches to land development, particularly build-to-rent (BTR) as mentioned previously. A CEV that provides residents with all their basic needs would provide much greater security than suburban housing. Moreover, a village can lock-down—closing to the outside world to stop transmission of a virus—while allowing the people to continue to connect and operate internally.

Kotkin (2020), Barns (2020) and Matthews (2020a) all suggest that the COVID-19 pandemic is accelerating transitions that were already underway. Business and workers alike are recognising the benefits of working from home and telecommuting. As remote work becomes entrenched and normalised in work practices, it no longer matters where workers are located, and regional areas may be more desirable than suburban housing. A smart rural village with a high-quality work hub within walking distance of housing may be very appealing.

Davies (2021) examines data from the Australian Bureau of Statistics and argues that the numbers leaving the cities is relatively small and cannot be described as an exodus. This extrapolation of past data into the future excludes the possibility of paradigm shifts, usually triggered by dramatic events. As people are forced by the pandemic to stop and reflect on their lives, their attention is drawn to other existing issues such as housing affordability, social disconnection, exhausting work and commuting practices and so on. Barns (2020) suggests that this creates opportunities to innovate and reshape our cities, leading to radical city-shaping experiments. In the present context this might lead to:

> *a casting off of rigid modes of separation between work and home, industry and nature, as expressed in city forms. Australia's suburbs may yet be well-suited to a coming era of biophilic urbanism, one that embraces "green infrastructure," regenerative agriculture and productive allotments of either low or high-density urban farms.*

Circular Economy Villages may be only one of many new forms of biophilic urbanism with green infrastructure and regenerative agriculture.

6 The circular economy and local governance

To synthesise the various discussion threads in this paper, the use of the circular economy terminology should be further explained. The circular economy (CE) remains a contested concept (Korhonen et al. 2018) and the 114 definitions identified by Kirchherr et al. (2017) illustrate the diversity of views. Weigend et al. (2020) highlight the limitations of present CE debates and the importance of constructing possible futures, using the future studies method. Bauwens et al. (2020) helps to broaden the discussion, categorising the different CE approaches into four types. Two of these are relevant to our discussion here as they relate to place-based circularity. The development of some new cities and eco-industrial parks in China follow the circular economy principle of minimising waste through design. Zhang (2010) describes eco-industrial parks by reference to industrial symbiosis, which is the cooperative management of the resource flows of co-located or geographically clustered firms.

A second type of place-based circular economy also involves the cooperative management of resource flows. Small-scale, self-sufficient communities focus on the circular economy of organic materials, particularly integrating agricultural processes to minimise waste and reduce costs. Eco-villages that adopt permaculture principles are examples of this.

The key difference between these two types of circular economy is that the former are financed, planned, designed, built and managed by central governments, while for the latter these processes are carried out by the community living in the relevant place. If the aim is to empower people and communities then the development process must be open to the active participation of future residents.

The key similarity is the cooperative management of resource flows. This builds connections between the various components and stakeholders in the system creating a coherent and integrated system. Circular economy villages are systems that sustain, and are maintained by, the residents that live within them. Rather than being dependent on external actors, a CEV also engages with the human resource flows in the precinct.

This discussion also illustrates that the current focus of circular economy discussion in Australia—principally concerned with waste management—is extremely narrow. The idea of closing the loop and striving for zero waste is the beginning, not the end of circular economy conversations. Circles can exist both spatially and temporally. The temporal dimension is about planning for life cycles. This can, of course, relate to the life cycle of products but could also relate to planning for people's changing needs through their life cycle. It can apply to the phases of development from planning, modelling, design, construction and subsequent asset management to ensure the development is sustainable long into the future.

The spatial dimension relates to the physical layout of a smart village—the design of infrastructure and location of buildings—to manage the water cycle, seasonal food cycles, the carbon cycles as well as inorganic material cycles. With inorganics, cyclical thinking may require the incorporation of waste-to-resource micro-factories for the conversion of plastics, glass and other inorganics into a usable form (Sahajwalla & Gaikwad 2018).

In considering the circular economy from a spatial perspective, one might also examine the location of inter-dependent villages with respect to each other. How far are waste materials transported to close the loop? The obvious response is that is that local closed cycles at the village or bioregional scale are more energy efficient than circles that are closed by transporting waste internationally.

The inevitable conclusion of any examination of the circular economy, where the objective is to minimise waste, is that it would require re-localisation. This would reduce waste heat and pollution from unnecessary transportation. Wherever possible, this involves the co-location of production and consumption. Where this is not possible, trading between CEVs would create an interconnected network, firstly within a bioregion and then beyond.

7 Discussion

The first part of this paper examined the town planning literature identifying a substantial body of ideas for the development of new townships. It was noted that while these ideas are useful, they were mostly developed over a century ago and have not been implemented in full. By proposing a reduction in scale from large towns with thousands of residents to villages of say, 200 people, and incorporating a range of new technologies and business models, it is considered that smart villages, in the form of CEVs, are now possible, feasible and practical.

Ebenezer Howard's design principles, as modified in Table 1 serve as a useful starting point in the development of a set of design principles for CEVs. The subsequent literature review, discussion of trajectories in infrastructure design, emerging development models and circular economy ideas, all assist in elaborating these guiding principles. The following list summarises the key matters that could be adopted in developing CEVs. They are not intended to be comprehensive or final, but rather the start of a conversation.

1. Human-scale buildings, no more than two stories in height.
2. Small scale settlements with a discrete population size, perhaps in the order of 200 people. This would allow the development form to be readily incorporated into planning policies, while also being of a scale that can be implemented by a relatively broad cohort of developers.
3. Design each settlement in alignment with topographical and climatic conditions of its locality.
4. Adopt a systems approach in the spatial arrangement of the settlement. Integrate urban, rural and natural landscapes with an ecosystem of infrastructure, including energy, water, food, buildings, transport and communication. Maximise the efficiency of the system by minimising the input energy required to deliver the necessary outputs.
5. Adopt a systems approach in the planning, design, construction and management of the settlement. This would involve adoption of life-cycle costing to develop durable assets that minimise ongoing maintenance costs. Build-to-rent development models are suitable for this approach and would require a single entity—potentially collaboratively owned through a managed investment trust—to undertake the entire process.
6. Allow future residents to participate in all aspects of the development process. This empowers individuals and communities, supports self-government with respect to these basic necessities, and provides some degree of political and economic independence from other centres.
7. Aim to minimise housing prices and cost of living so that they are more affordable than nearby cities. This can be achieved by capturing the land value

uplift due to land rezoning, and through the establishment of internal exchange arrangements for goods produced within the village.

8. Design high quality and aesthetically pleasing buildings and infrastructure, enhancing attractive natural landscapes. This would include provision of substantial open space integrated with well managed water systems.
9. Local production should be powered by a renewable energy micro-grid to maintain a clean and healthy environment.
10. Settlements should include a remote work hub and guest accommodation to access remote services and welcome visiting specialists.
11. Population growth should be managed by building new settlements rather than growing the size of the settlement.
12. The business plan for the development of a network of settlements should assume a pipeline of these village-scale projects to attract capital.

This hypothetical development model and suggested guiding design principles are intended to open a discussion about innovative approaches to land development that address various economic, social and environmental issues.

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