Chapter 7
Sustainable Urbanism: Creating Resilient Communities in the Age of Peak Oil and Climate Destabilization

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A Perfect Storm

It is becoming increasingly clear that the twenty-first century marks a turning point in human history (Berry 1999, 1988; Korten 2006; Lazlo 2006), the outcome of which will be determined by our collective response to two intractable and interconnected problems that are already combining to create a perfect storm which threatens the human prospect (Kunstler 2005).

There is a growing consensus among petroleum geologists, energy analysts, and other observers that we are now riding on the "bumpy plateau" of peak oil and that the era of easily accessible, cheap oil has now passed (Heinberg 2005; Roberts 2004; Deffeyes 2001). At present we consume four times as much oil per year as we discover each year, and discoveries worldwide peaked in 1965. While projections vary, it is estimated that by 2030 the world will have approximately 25 % less oil than is currently available and 50 % less by the year 2050 (Hopkins 2008–2009, 20; Pfeiffer 2004, www.peakoil.com). This irreversible and exponential decline in available oil supplies will be occurring against the backdrop of exponentially increasing world demand, driven in large part by the emerging economies of India and China and by an exponentially increasing world population that is expected to grow from about 6.7 billion today to more than 9 billion by 2050.

Since every activity and process in the modern world is dependent upon the ready availability of a constantly growing and inexpensive supply of fossil fuels, the onset of the age of peak oil, with natural gas and coal soon to follow (Heinberg 2009a; Darley 2004), signals not only the end of globalization but the end of global industrial civilization as we have known it (Hopkins 2008–2009, 18–53). It is no

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I. Wallimann (ed.), *Environmental Policy is Social Policy – Social Policy is Environmental Policy: Toward Sustainability Policy*, DOI 10.1007/978-1-4614-6723-6_7,

longer possible to produce our way out of this energy crisis, and no combination of alternative energies will be able to be put in place soon enough and at a large enough scale to avoid the radically disruptive effects of the end of cheap oil (Trainer 1996, 2007; Heinberg 2005, 2009b; Newman et al. 2009, 26–27).

The linked crises of exponential population growth and the irreversible decline in availability of cheap fossil fuels are occurring within the context of a dramatically worsening process of climate destabilization and environmental degradation caused by human activity. Without rapid and truly effective action to limit the production of greenhouse gases, it is now virtually certain that in this century we will cross key climate change tipping points leading to a world inhospitable to life as we have known it since the arising of human civilization some 5,000 years ago. A number of leading climate scientists, such as James Hansen (2009), have concluded that we may have already crossed some of these thresholds and set in motion an irreversible process of runaway climate change driven by positive feedback processes over which we have no control (McKibben 2010; Orr 2009; Hansen 2009; Lovelock 2006). At the very least, it seems certain that the world is now committed to a global temperature increase of nothing less than 3° C in this century with consequences that will continue for many thousands of years. The potential implications of even this level of global warming are almost unthinkable, including the disappearance of Arctic summer sea ice; the melting of much of the Greenland and West Antarctic ice sheets by the end of this century, which in itself would result in a rise in average sea level of some 7 m (Hamilton 2010, 8); the complete melting of the Himalayan glaciers, which feed the great Asian rivers that supply water to some 2 billion people; the retreat of the world's boreal forests much further to the north; the loss of at least half and perhaps all of the Amazon rainforest; and, possibly, the melting of the great Siberian permafrost which would release enough methane and carbon dioxide to cause over time the melting of all the remaining ice on the planet, causing a sea level rise of some 70 m (Hamilton 2010, 11).

For the 150,000 people who currently die each year because of climate change-driven events, this grim future is already happening, and for the 250,000,000 or more people who will become climate change refugees by mid-century, the consequences of continued burning of fossil fuels will soon be all too real (Orr 2009, xi).

Even without runaway climate destabilization, human beings are already the cause of the greatest extinction of species since the period 65 million years ago when the dinosaurs became extinct (www.well.com/~davidu/extinction.html). Indeed a growing number of scientists conclude that we are now living in the era of the Sixth Extinction (Leakey and Lewin 1996; Ehrlich and Ehrlich 1981). It is estimated that by the end of the century, one quarter or as many as half the species on earth will vanish due to habitat destruction driven by population growth and urbanization, toxic pollution, and ecosystem collapse due to rapid climate change (www.well.com/~davidu/extinction.html; Orr 2009, 157). It is all but certain now that the combination of oceanic warming, acidification, and rising sea levels will cause the death of all the world's remaining coral reefs as early as mid-century, which will contribute greatly to the continuing collapse of oceanic fisheries. With more than 60 % percent of all the earth's ecosystems already stressed beyond sustainable levels, the radical instabilities that will continue to be created by global climate change threaten to completely overwhelm all the earth's living systems, further fraying the fabric of life and undermining our belated efforts to sustain a civilized human presence on this planet (Millennium Ecosystem Assessment 2005, www.millenniumassessment.org/en/Condition.aspx).

Alternative Futures

Various authors have mapped out possible responses to this rapidly developing crisis of crises, especially with regard to the future of cities (Coates 1981b, 53–88; Newman et al. 2009; Heinberg 2004; Holmgren 2009; McKibben 2010; Orr 2009). At present more than half the world's people live in urban areas, and it is estimated that by 2030 there could be as many as 5 billion people living in cities, or some 60 % of the global population (Newman et al. 2009, 4). Buildings produce 43 % of the world's carbon dioxide and consume as much as 48 % of the world's supply of energy (Newman et al. 2009, 4). Furthermore, the location and distribution of buildings determines the energy intensity, size, and nature of the transportation sector. It is not possible, therefore, to consider how we can respond to peak oil and climate destabilization without addressing the question of the design and functioning of buildings, towns, and cities.

If our urban areas are a major part of the problem, the good news is that they might also become a significant part of the solution. It is estimated that in the United States alone, a shift away from sprawl toward more compact, mixed-use development could result in a savings of some 80 million metric tons of carbon dioxide annually by 2030 (Newman et al. 2009, 5). It is for this reason that the four images of the future that are described below focus on our urban areas.

Civilizational Collapse

Similar to Richard Heinberg's "Last One Standing" scenario (Heinberg 2004, 55–85), this image of the future could simply be called business-as-usual. All that is required for global industrial civilization to collapse of its own life-denying tendencies is for existing power structures, such as the fossil fuel industry and the politicians they own, to continue to deny the reality of both peak oil and climate destabilization and to continue to block all action to make the transition to a more sustainable, renewable energy-powered society based on ecological design principles. The longer such denial and inaction continues, the more certain the collapse scenario becomes.

Given the present lack of any meaningful action on either climate or energy issues in the United States as well as the rest of the world, it is not hard to envision what the near term future will look like. If and when the global economy recovers from the Great Recession, demand for oil and other fossil fuels will rapidly increase. Since we are now at or near the peak of oil production, rising demand will soon outstrip supply, leading to a dramatic increase in energy costs, which will cut short any economic recovery, plunging the world back into recession. If oil prices remain high, there is even the possibility of a return of "stagflation" (rising prices combined with falling demand) which we saw in the 1970s since oil is the basis for nearly all the world's economic production. Market-driven responses to peak oil will continue in this way to destabilize the world economy until it is no longer possible to deny that indeed the peak has arrived and that the future will only bring an ever-increasing gap between supply and demand as well as ever-rising costs (Heinberg 2007). This realization will lead to even greater speculation on oil futures, which will drive the price of oil to new, unheard of levels perhaps plunging the global economy into another great depression. At this point, unless the nations of the world can agree that global capitalism and "free markets" are incapable of dealing with finite energy resources and decide instead to cooperate in creating protocols for sharing the world's diminishing supplies of oil (and soon natural gas and coal), it is virtually certain that there will be more economic upheavals as well as more wars over access to oil (Heinberg 2005; Ruppert 2009).

As this economic, social, and political crisis unfolds, the effects of rapidly accelerating climate destabilization will compete for headlines (Orr 2009, 17–27). Rising sea levels and stronger and more frequent hurricanes will continue to threaten all the coastal cities of the United States and other nations, resulting in massive property loss and, as was the case in the aftermath of hurricane Katrina, the beginning of the migration of people away from low-lying areas to higher ground. Droughts in the mountain west and southwest of the United States will continue to worsen, threatening water supplies for Phoenix and Los Angeles, and even formerly rainy regions such as the southeastern states are likely to see a recurrence of the serious droughts which have occurred there in recent years. As the Sierra snowpack continues to decline, there will be even more frequent and severe water shortages in the central valley of California and, as Steven Chu recently observed, by century's end it is entirely possible that "there's no more agriculture in California" and that the viability of the state's urban areas also will be threatened by permanent and critical water shortages (McKibben 2010, 156). Higher temperatures, as well as larger floods and longer droughts, will continue to combine in the Midwest to significantly reduce agricultural productivity in that vital region. Tropical diseases will begin to spread into previously temperate regions, and new diseases will emerge that affect people as well as the native flora and fauna of every bioregion in the country. All of these trends will accelerate the decline of biological diversity and ecosystem resilience throughout the nation and the world. As this future unfolds, more and more capital and labor will need to be siphoned off from other needs, such as the creation of an alternative energy infrastructure, to fight forest fires, provide disaster relief, protect existing coastal cities against rising seas and violent storms, and rebuild and eventually relocate displaced communities in an age of diminishing real wealth created by irreversible declines in net energy availability.

In these and many other unforeseeable ways, the complex interaction of peak oil and climate destabilization will confront the United States and, indeed, all of humankind, with crises of unprecedented urgency, scale, and complexity. Regardless of how it plays out, sometime within the next 10–15 years, it will become obvious to all the peoples of the earth that we have entered what author James Howard Kunstler calls the "long emergency" (Kunstler 2005). It will then be all too clear that without urgent and drastic action to prevent or mitigate the catastrophes toward which the world is headed, the collapse of global industrial civilization over the course of the twenty-first century is a very real, even likely, possibility (Tainter 2003; Diamond 2005; Catton 1982; Homer-Dixon 2006, 2009).

The only question remaining will be how the peoples of the earth will manage the collapse. Will the process be chaotic and violent or will it proceed by humane and measured steps (Dobrowski and Walliman 2002)? Will it be guided by the principles of equity and social justice or will it be guided, as it is now, by the principles of power and privilege? Will we attempt to prop up global industrial civilization by using the last drops of increasingly dirty oil and the last reserves of even dirtier coal, thereby accelerating the process of climate chaos, or will we move forward together toward a new, more life-enhancing future built around renewable energies and clean technologies? It is within this context that the following three scenarios will present themselves as possibilities.

Sustainable Enclaves for the Wealthy

This image of future, which involves creating "sustainable" enclaves for the rich," is quite similar to the "divided city" scenario described by Newman et al. (2009, 47–51). Especially in the United States, where the last 30 years have seen an unprecedented growth in income inequality as well as the creation of age, race, income, and class-segregated gated communities for the wealthy, it is easy to imagine a future in which American elites will in fact recognize the reality of peak oil and climate destabilization but will use their power and wealth to build "eco-enclaves" entirely for themselves (Newman et al. 2009, 48). As is now increasingly the case, the poor and the rapidly diminishing middle class will be left to fend for themselves in a nation and world visibly falling apart.

It is unlikely, however, that in the long run, this attempt to prop up existing elites and power structures will be able to prevent the decline and eventual collapse of the US economy and, eventually, global industrial civilization itself. But the very attempt to preserve and extend a predatory capitalist system which is based on the creation of scarcity and structures of inequality would very likely lead to violent internal conflicts which would threaten to unravel the entire fabric of society (Klein 2007). So, in the end, the strategy of creating eco-enclaves for the rich would turn out to be simply another scenario for civilizational collapse.

Urban Deconstruction and Re-ruralization

Whereas the previous scenario would involve the preservation and the creation of some mixed-use urban areas for the privileged, as well as some tightly guarded and redeveloped suburban and exurban districts and food-producing regions, the "urban deconstruction" scenario presumes that the great population concentrations in the nation's (and the world's) metropolitan areas would no longer be able to be sustained with increasingly scarce and expensive fossil fuels and the more diffuse energies of renewable energy sources that will be available in the future. Thus, it is presumed that civilization as we now know it would enter an irreversible period of deconstruction into simpler social forms. This scenario envisions that, over the course of this century, the populations of existing cities and nations would be radically reduced by pandemics, food shortages, extreme weather, and other natural catastrophes, as well as terrorism and armed conflicts at home and abroad. Some of the survivors, it is imagined, would be dispersed to small towns and rural areas, while those remaining in metropolitan areas would be absorbed into a network of eco-villages (gen.ecovillage.org; Newman et al. 2009, 44–47; Bang 2005; Jackson and Svensson 2002) aimed at providing a significant portion of their own basic needs for energy, food, housing, and work by renewable means (Holmgren 2009, 42). At their best, such enclaves might function in a way similar to Heinberg's "Lifeboats," attempting to preserve the best of global industrial civilization's knowledge and skills amidst the turbulence of its decline (Heinberg 2004, 139–161).

Some advocates for this scenario of the collapse and re-ruralization of cities (think Detroit) see the suburban and exurban perimeter of our sprawling, multi-centered metropolitan areas as opportunities for sustainable energy and food production, rather than as the slums of the future as many of those envisioning the complete and rapid collapse of our auto-dependent cities imagine (Holmgren 2002, 2009; Newman et al. 2009). In a sense this rather dystopian image of the future bears an uncanny, if ironical, resemblance to Thomas Jefferson's idea that Americans should not pile themselves up in cities, as in Europe, but should preserve freedom and virtue by creating a decentralized nation of yeoman farmers and household-scale manufacturers living close to the earth (Coates 1981b, 72–73). Once again, however, this scenario for adaptation to the ongoing process of civilizational collapse during the twenty-first century would likely fail because of the great interconnectedness of global industrial civilization. It is not possible for any individual or any group to escape the collapse of the larger whole of which they are a part and upon which they ultimately depend.

Toward a Meta-industrial Society: Creating Resilient Cities and Sustainable Bioregions

The previous three scenarios are all one-sided images of the future that offer only limited and limiting visions of human possibilities. Since they are merely reactive rather than proactive scenarios, they fail to inspire the action necessary to change our direction and respond creatively and effectively to the challenges of our time. Yet, as poet William Blake once said, "Everything possible to be believed is an image of the truth" (Blake 1994). The future is likely to be made up of aspects of all these scenarios as we struggle amidst growing chaos to respond to the "long emergency" that we can no longer prevent or avoid.

The meta-industrial image of the future, first articulated by cultural historian William Irwin Thompson in 1978 (Thompson 1978, 57–103) and expanded upon by Gary Coates in 1981 (Coates 1981b, 53–88), envisions a cooperative, planetary process of change aimed at the creation of a world of more humanly scaled, renewable energy-powered eco-communities, self-reliant cities, and sustainable bioregions (Coates 1981b, c, 525–551). This vision of human possibilities is based on the presumption that the peoples of the earth are indeed capable of understanding the nature and magnitude of the crisis of sustainability and that they can and will rise up to work together to avoid either a complete civilizational collapse, a world of divisive and divided cities for the elites, or a massive "die-off" and the loss of all the civilizing effects of urban areas characteristic of today's complex societies (Coates 1981b, 53–88). This scenario is based on the understanding that the unavoidable deconstruction of global industrial civilization is in fact the necessary precondition for the creation of a spiritually based, ecologically derived, and life-enhancing planetary civilization based on the principles of tolerance and cooperative community and supported by the intelligent use of environmentally and humanly appropriate technology (Coates 1981b, 73–85; Schumacher 1973, 1979; Da Samraj 2009). While it is difficult to imagine that such a utopian vision of the human future is even a remote possibility, it is the only scenario that is capable of inspiring action toward a more hopeful future.

The meta-industrial vision is similar in many ways to aspects of Richard Heinberg's "Powerdown" scenario, which he describes as being the "path of self-limitation, cooperation, and sharing" (Heinberg 2004, 87–115). It also has many of the characteristics of the "energy descent" scenarios outlined by permaculturalist David Holmgren (Holmgren 2002, 2009, 56–89), the "Transitions Towns" movement inspired by Rob Hopkins (2008–2009; Chamberlin 2009), and the "resilient cities" image of the future articulated by Newman et al. (2009). All of these positive scenarios propose that we can simultaneously address the crises of both peak oil and climate destabilization by working cooperatively to create more livable, resilient, and sustainable communities for all the peoples of the earth and not just for the wealthy elites within and among nations (Coates 1981a; Chamberlin 2009; Hopkins 2008–2009; Friedman 2008). This hopeful vision of a sustaining and sustainable future, as it relates to the design of resilient cities and their surrounding bioregional landscapes, is articulated by Newman et al. (2009, 51–52) in the passage below:

> The resilient city scenario occurs when the access and alternate forms of fuel and buildings in eco-enclaves that were the province of the wealthy in the divided city scenario are provided for all. People will have access to jobs and services by transit or walking as well as the use of electric cars for short car journeys. Intercity movements will move toward fast electric rail and will be reduced considerably by the new generation of high quality interactive video conferencing. Green building design and renewable fuels will be a part of all neighborhoods. The city will develop new rail links to all parts of the city, walkable centers will be created across the city-region using the best green buildings and infrastructure. In the areas between the intensively developed transit centers and corridors, urban eco-villages will be established to help manage the city's ecological functions such as extra renewable energy production and water and waste recycling: these will be linked into a citywide green infrastructure through clever control systems and local management. Urban eco-villages

> will also grow specialized agricultural produce and manage areas of urban biodiversity: they will be largely self-sufficient though they will still be within a reasonable distance of the city for many urban functions.
>
> In the rural regions around cities most agricultural and forestry production will focus on food and fiber and biofuels for the city and its region, thus reducing food and fiber miles. The manufacturing of products will become more localized and be more biologically based to replace petrochemicals. The towns where goods are produced will be well linked by freight rail to the city.

As Buckminster Fuller once said, "The best way to predict the future is to design it." The design of such resilient human ecologies, which would have to be carefully and gracefully integrated within the naturally occurring ecosystems of which they are a part, constitutes both the means and the ends of the great transformation that lies ahead. Like any naturally occurring ecosystem, the rate at which energy and resources flow through any human ecology is directly determined by the structure of the system. The structure of global industrial civilization, especially as it is hard programmed in the sprawling auto-based pattern of human settlements in the United States, was created by, and can only be sustained by, uninterrupted flows of ever-increasing amounts of cheap concentrated fossil fuels. In theory and in practice, it is impossible for the material culture of such societies to be operated with any combination of more diffuse renewable energies (Trainer 2007; Heinberg 2009b). Thus, to create a society capable of being sustained by renewable means, it is essential that the human habitat itself be restructured in ways that make such an outcome possible. All policies for economic, social, and political changes must be evaluated according to their ability to create new settlement patterns comprised of resilient and sustainable buildings, towns, and cities as well as more ecologically and socially viable rural landscapes and bioregions (Coates 1981d, 401–414).

Emphasizing the eco-technical aspects of sustainability, Newman et al. (2009, 55–148) list seven characteristics for the design of resilient cities, which they see as the building blocks for the creation of a sustainable society:

1. *The renewable energy city*. Urban areas should be sustained by renewable energy technologies at every scale from the region to the neighborhood to the building level.
2. *The carbon-neutral city*. In order to address the crisis of climate destabilization, it is necessary to create carbon-neutral urban (and rural) environments.
3. *The distributed city*. Rather than relying on large-scale, centralized, and centralizing energy, water, and waste technologies, wherever possible, smaller-scale, community-based systems should be used.
4. *The photosynthetic city*. By "greening" the infrastructure of existing and new settlements, it will become possible to provide a significant amount of the necessary food, fiber, and other ecosystem services locally.
5. *The eco-efficient city*. By closing the loops of existing "waste" streams, cities will be able to provide a significant portion of their needs for energy, materials, and nutrients necessary for sustainable organic food production.
6. *The place-based city*. By creating climate-adapted buildings, towns, cities, and landscapes through the use of more locally sourced materials, it will also be possible to strengthen local economies while establishing an authentic sense of place.

7. *The sustainable transport city*. Only by creating more compact, pedestrian-friendly, mixed-use places to live, will it also become possible to provide renewable energy-powered options for public transit and personal vehicles.

Resilient Cities: A Case Study of the Sustainable Urban District of Kronsberg (Hannover), Germany

While there are at present no existing cities anywhere in the world that meet all seven of these criteria for resilience, there are a number of urban districts which begin to come close, including “Solar City Malmö” in Sweden (www.solarcity.se, Ritchie and Thomas 2009, 161–169); Hammarby Sjöstad in Stockholm, Sweden (www.hammarbysjostad.se/); “Eco-Viikki” in Helsinki, Finland (Eco-Viikki 2005; Gauzin-Müller 2002, 82); and the Vauban and Rieselfeld districts in “Solar City Freiburg,” Germany (Gauzin-Müller 2002, 69–74; Guzowski 2010, 52–67; Ruano 2002, 92–93). However, the largest and, in many ways, the most exemplary project to date is the garden city of Kronsberg, located on former agricultural land near the Hannover trade fairgrounds in northern Germany (Farr 2008). Planned within the frameworks of William McDonough’s “Hannover Principles” (McDonough and Braungart 1999) and the United Nations Agenda 21, Kronsberg was designed and built through a participatory process as a model sustainable urban district for EXPO 2000, a world’s fair hosted by the city of Hannover. As a model sustainable community, Kronsberg is a moderate- to high-density (47 dwelling units per acre) urban district (Farr 2008, 242; Copur 2007, 8) that successfully demonstrates the integration of the technological, social, ecological, and human aspects of sustainable community design (Coates 2009). It was designed through a very public and participatory process to include the following elements:

A compact urban fabric, comprised of five medium to high-density mixed-use neighborhoods planned to house a socially diverse population of 15,000 people in 6,000 energy-efficient dwelling units when it is fully built out sometime between 2010 and 2015. To date two neighborhoods have been built with more than 3,300 dwelling units housing some 6,600 residents. Development is continuing with the construction of large private residences to the north.

Multimodal transportation linkages, providing connections to the nearby expo trade fairgrounds as well as Hannover city center by means of a light-rail line (less than a 20-min ride), as well as automobile arterials and bike paths which connect to Hannover and its surrounding region.

Diverse public amenities, including a primary school, sports hall and sports fields, a comprehensive high school, three day-care centers, a youth center, community meeting rooms in every housing block, an arts and multiservice community center, a health center, and a shopping center located at the meeting of the two neighborhoods.

An ecological landscape design (the “city as garden” theme) maximizing on-site rainwater retention and natural aquifer recharge, providing tree-shaded streets lined by sidewalks and bioswales, as well as a varied network of pedestrian paths connecting all the therapeutically restorative and recreational green spaces within each residential block.

Integrated living and working realms through the provision of employment opportunities at the nearby fairgrounds and an adjoining office park that itself provides more than 3,000 information industry jobs, all within easy walking distance of all the neighborhoods.

An efficient, decentralized, and integrated energy system that uses two natural gas-powered CHP (combined-heat-and-power) units to provide district heating as well as electricity to the entire community.

Renewable energy systems for additional electrical power in the form of three large wind generators located on nearby Kronsberg hill, as well as building integrated photovoltaics placed on the primary school and community center, that, combined with the CHP units, provide more electricity than the district needs (with a 74 % reduction in carbon dioxide emissions in 2001 compared to ordinary developments).

Urban agriculture in the form of the nearby *Kronsberg organic farm and rural workshops*, containing an organic farm, dairy and cheese-making operation, butchery, brewery, bakery and farmers' market, houses for business proprietors and farm workers, and an inn for participants in workshops on sustainable agriculture.

An ecologically varied adjoining landscape, comprised of restored native woodlands, wetlands, and pastures for recreation and nature study, that also provides links by means of walking and cycling trails to Hannover's many forests, parks, and gardens.

The Kronsberg Planning Area

Kronsberg is located on the western slope of a long low hill adjoining the Hannover industrial fairgrounds as well as an existing office park. Rising some 30 m above the surrounding landscape, this locally prominent landscape feature offers residents of Kronsberg clear views in all directions and is preserved as an ecologically varied landscape for recreation and nature study. It is also the site for three large wind generators (3.58 MW), which provide a significant portion of the electrical power needs of the community.

The site is surrounded by high-speed automobile arterials which connect it to Hannover city center as well as more distant cities. A new tramline links the center of Kronsberg to the center of Hannover with a journey time of 20 min. Walking and bike paths provide additional connections to the fairgrounds and the city center (Schottkowski-Bähre 2000, 9).

An international competition, which was held in 1992 for the design of the fairgrounds as well as the adjoining proposed new urban district of Kronsberg, was won by Arnaboldi, Cavadini, and Hager of Locarno and Zurich. Within the framework of this scheme, a competition for the Kronsberg area itself was won by Welp/Welp and Sawadda of Braunschweig in 1993 (Schottkowski-Bähre 2000, 11). This plan, which is based on the creation of identifiable neighborhoods linked by a gridded network of local streets, became the basis for further competitions for the design of individual blocks. The Kronsberg development is a model for participatory planning led by city government, which worked with citizens to set the social, ecological, and technological goals for the district as a whole, and the private sector developers and architects who realized these goals through their particular block designs.

From the beginning, a primary aim of the master plan was to create a compact high-density district with clear edges. A 3.5 km tree-lined aleé stretches along the eastern edge of the neighborhoods, forming a border with the fields and wooded areas of Kronsberg hill. The tramline and through road forms the edge of the neighborhoods on the western side of the development. Between this transportation spine and the existing neighborhoods of the nearby Bemerode community is an area providing a district park, schools, and sports fields. Perpendicular to these two bounding transportation arteries are wide green corridors and hillside avenues designed as parks to absorb rainfall and provide places for small social gatherings and quiet contemplation. These avenues visually and functionally join the densest part of the community to the nature preserve, creating a sense that Kronsberg is indeed a city in a garden.

To date two of the planned five neighborhoods have been built, providing housing and related commercial and public meeting spaces, for some 6,600 people. Each neighborhood is focused around a neighborhood park. The district square, which was planned with the participation of residents, is located adjacent to the tramline in the northern neighborhood where it connects with Kronsberg-Mitte. It includes a shopping center with stores, cafes, and restaurants; a church center; a health center; a structure containing various community meeting spaces; and a facility for the elderly.

In both neighborhoods, large perimeter blocks (on average 360 ft on edge) with highly varied green communal interior courts encourage social interaction, while also shaping coherent street cavities on their public sides for auto and pedestrian movement. Mixed-use blocks up to five stories high line the tramline and thin out to two-story terraced housing (10 % of all housing) as the landscape rises toward the Kronsberg hill to the east. Access to all the residential blocks is provided by a grid of narrow tree-shaded streets, designed to allow access for local traffic to all dwelling units. Bounded by the aligned facades of apartment buildings, all of Kronsberg's streets encourage walking as well as casual neighboring. A well-shaded pedestrian and bicycle lane runs straight through both neighborhoods on a north-south axis. The east-west distributor streets, which run perpendicular to the slope, visually and functionally connect the tramline to the Kronsberg hill nature preserve. Streets running north-south, which are parallel to the slope of the site, are used solely for making connections with residential parking areas. Altogether, everything has been done in order to discourage car use while encouraging walking and bicycling within the entire Kronsberg area.

Planning for Social Diversity

Planning for social diversity, which is a necessary part of social sustainability, is equally as important as planning for technological and ecological sustainability. The mix of housing types in Kronsberg was based on a desire to provide for flexibility as the needs of tenants change and to encourage social diversity through the provision of a mix of varied apartment sizes, including apartments designed for large families as well as units supporting new lifestyles. By mixing a variety of financing and ownership forms within blocks and limiting the proportion of social housing, the desire was to avoid the problems created by social and economic division. To promote owner-occupied housing, which can have a stabilizing effect in a new community, 300 terraced units were erected in the early stages of development.

While Kronsberg was initially planned primarily for market rate housing, with only 20 % planned for social housing, changes in demographics have meant that social mix has changed from what was initially intended: at present about 40 % of residents are immigrants with German ancestors who have moved to Germany from the former Soviet Union and other east bloc nations. These families were accommodated by raising the minimum thresholds for social housing income (Kier, personal communication, 2008).

Another highly successful initiative intended to support social diversity and the integration of diverse populations is the Habitat International housing block, a residential block of apartments for families from many nations and ethnic and religious traditions, including Muslims, that is located in Kronsberg-Mitte. Its public plaza opens directly off a local north-south running street, inviting residents and visitors to stop at the resident-operated café (Schottkowski-Bähre 2000, 116–117).

Because of the responsive and effective social services available on-site at the KroKuS multiservice community center as well as the high-quality and socially supportive unit and block designs, the graffiti-free Kronsberg district continues to experience a high level of user satisfaction.

Ecological Open-Space Design

The street grid, along with urban design guidelines provided as part of the master plan, has created a unifying framework within which more than 40 private architecture and landscape design firms have designed an architecturally varied townscape. The district includes a large amount of open space as well as a variety of intensively used green spaces. A number of playgrounds are located close to the apartments throughout the block in each neighborhood. Ground floor apartments feature private patios and gardens. The inner courtyards of apartment blocks, which meet rigorous standards for on-site rainwater retention set by the municipality of Hannover, offer highly varied spaces for social interaction among all the residents as well as play spaces for children.

Rather than using the traditional closed perimeter blocks found in Berlin and other German cities, a network of off-street pedestrian paths connects the open playgrounds and parks of the green interior courts with the gridded streets, offering residents richly varied paths for walking as well as opportunities for encountering others living throughout the district. Children freely roam from one inner court area to another to engage the unique play opportunities offered by each. In addition to providing recreational spaces and therapeutically restorative gardens and green spaces throughout the fabric of the neighborhoods, the community's open spaces maximize on-site water retention in artistically designed ways that encourage play with and appreciation for water. The green avenues linking the eastern and western borders of the neighborhoods also serve as play areas and neighborhood-linking linear parks.

Walking and Multimodal Transportation Planning

Kronsberg has been planned as a compact, pedestrian-oriented community that also offers a variety of transportation options. Automobile traffic is channeled along the eastern edge of the community parallel to the tramline to reduce noise and traffic in the neighborhoods. There are no through-traffic routes in the neighborhoods themselves. Additional traffic-calming measures include 30 km/h speed limits, right-before-left turning priorities, frequent constrictions in road widths, and selectively placed bollards. A dedicated bicycle road traverses the district from north to south for some 1.5 km (Schottkowski-Bähre 2000, 19)

Overall, a third of the cars are placed in underground parking, a third in sunken car parks, and a third in surface parking. No large parking lots are allowed and the small surface lots that are provided make use of topographical changes and landscape plantings to mask their presence.

In order to further minimize the presence of the automobile, the city of Hannover passed a special bylaw for the Kronsberg district that requires only 0.8 parking spaces for each apartment, providing for an extra 0.2 on-street parking. This change in parking regulations allows for greater efficiency of parking during the day and reduces the total number of parking spaces required. All rainwater running off the small, carefully shielded, and dispersed parking areas throughout Kronsberg is channeled into bioswales and artistically designed catchment areas for water cleansing and retention.

Wind Power and Efficient, Integrated Energy Systems

Central to the design of Kronsberg as a model sustainable community is the integration of energy infrastructure and efficiency measures with the district's urban design. The community was designed to reduce carbon dioxide emissions by 60 % compared to the current standards for conventional low-energy residential buildings at almost no extra cost. This goal was achieved through energy-efficient building construction as well as the use of energy-conserving appliances (Rumming 2004, 50–69). In addition the aim was to achieve even greater carbon dioxide reduction of up to 80 % through the use of wind power and innovative design and technical systems, such as superinsulated Passivhaus design. This higher target has nearly been achieved: detailed measurements from 1999 to 2001 indicate that carbon dioxide emissions for each Kronsberg resident were 74 % less than the already high-performing German base case standards (www.passivhaustagung.de/zehnte/englisch/texte/PEP-Info1_Passive_Houses_Kronsberg.pdf, www.hannover.de/data/download/umwelt_bauen/h/co2praesent99-01eng.pdf).

Two district heating systems powered by decentralized natural gas-powered combined-heat-and-power (CHP) plants, which provide both space heat and electric power, further increase total community energy efficiency (Rumming 2004, 60–63). Additional reductions in emissions have been achieved by integrating on-site renewable energy production from building integrated photovoltaics (45 kW peak) on some of the community structures as well as three wind electric generators (3.58 MW total) located on Kronsberg hill (Rumming 2004, 68–69). Altogether more electricity is generated at Kronsberg than the district needs, and the surplus is sold as "green power" to other users in the utility supply district (Rumming, personal communication, 2008).

The ability to achieve these ambitious carbon reductions, and the ability to provide a significant portion of those needs with renewable energy, is based on Kronsberg's commitment to radical reductions in energy demand. One of the most successful architectural experiments in Kronsberg in this regard is the "Lummerland" passive house development, which consists of 32 terraced houses, all with green roofs and private outdoor areas. Based on a 3-year audit (1999–2001), these dwellings met and even exceeded the goal of 15 kWh/square meter heating energy consumption (Rumming 2004, 64–65). It has been determined that if all dwellings in Kronsberg and in Germany were built to this level of efficiency, all residential building energy needs could be provided by renewable means. This finding has led the city of Hannover to mandate the Kronsberg passive house standard for all new and retrofit construction.

Ecological Systems

The Kronsberg urban district was designed to demonstrate environmentally responsible best practices with regard to water and soils as well as waste reduction and management. "The Ecological Optimization at Kronsberg" plan was recognized at EXPO 2000 as one of the best decentralized projects in the world (Schottkowski-Bähre 2000, 26).

The rainwater management plan was aimed at ensuring that the development would not negatively affect the existing balance of on-site water absorption and aquifer recharge. This goal made it necessary to develop an entirely new form of green urban infrastructure for rainwater management. Rain falling on the gridded network of narrow streets within the district is absorbed by the bioswales which line them. All rainwater falling on buildings and paved areas within the blocks is collected, absorbed, and slowly released in the green spaces of interior courtyards.

This process of on-site rainwater retention is treated as an opportunity for design expression in the form of ponds, wetlands, rock gardens, and intermittent water courses. By thus making water visible in an aesthetically beautiful and ecologically functional way, residents are made aware of the beauty and centrality of this primal element that is so central to all forms of life.

Water conservation is also built into the design of all dwelling units in the form of water-saving fixtures. Educational exhibits and information packets are used to increase resident awareness of the need to conserve water in all aspects of everyday life.

A primary goal of the "waste" management plan was to avoid creating waste in the first place, even during the construction phase of the project, where recycling rates of 80 % were achieved (Schottkowski-Bähre 2000, 29).

Waste separation and collection is encouraged on an everyday basis through the placement of presorting bins within each apartment and attractively designed containers close to the houses in each block. Composting of organic waste is also encouraged and supported by a grants program.

Low-waste consumer habits are supported by a variety of means, including the provision of a network of repair and alteration services that operate under the motto of "mend it, don't dump it." An advisory board monitors the effectiveness of the waste management system and prepares educational materials for residents and businesses.

A central part of the Kronsberg soil management program was to reuse the large amounts of soil excavated during the construction phase of the project. Rather than transporting some 100,000 truckloads of soil away from the site, the excavated soil was used to create biotopes typical of the area, make two hills from which to view the surrounding landscape, build a sound buffer alongside a nearby highway, fill and seal an old landfill, and provide landscape enhancements for the nearby world exposition grounds (Schottkowski-Bähre 2000, 30).

The Kronsberg Nature Preserve: Creating Biodiversity

In addition to being the location of the three wind electric generators, Kronsberg hill has been shaped as an ecologically varied landscape for food production, recreation, and nature study. Its woodlands, meadows, parks and avenues, pasture, and arable land, which are linked to other such preserves in the Hannover region, offer residents of this dense urban district a chance to experience the natural world close at hand, demonstrating that nature, technology, and the city can coexist in harmony. The creation of this biodiversity preserve was made possible by the original decision of the city to build a compact urban district on this greenfield site rather than allowing the spread of low-density suburban development to cover the entire area.

Urban Agriculture

If we are to create a sustainable pattern of settlements, it will be necessary to shorten the distance between where food is produced and where it is consumed. This goal was achieved, at least while it was in operation for a number of years, by the provision of the Kronsberg organic farm and rural workshops, which were located within walking distance of all residents. This complex, which was also developed as an EXPO 2000 demonstration project, was created to integrate agricultural production, food processing, and marketing. It was designed to be powered by building integrated photovoltaics and methane from anaerobic digestors fueled by animal and agricultural wastes. The complex included an organic farm, a dairy and cheese-making operation, butchery, brewery, bakery and farmers market, houses for business proprietors and farm workers, as well as an inn for participants in the many workshops held in the farm's educational facilities. By locating such an operation close to the Kronsberg urban district, the idea was that children as well as adults would not only be able to buy locally produced organic food but they would also be able to develop knowledge of and appreciation for a part of life that, in less holistically integrated settings, remains abstract and distant. While in the end this farm operation has not been able to sustain itself financially, it remains a key part of the Kronsberg sustainable city development paradigm. The design of all neighborhoods, towns, and cities, whether newly built or retrofitted, must include provisions for urban agriculture and agricultural urbanism (de la Salle and Holland 2010) if we are to create more secure and resilient communities in the age of peak oil and climate destabilization.

Final Thoughts on Kronsberg as a Model Resilient and Sustainable Community

It is clear that in order to create a resilient and sustainable pattern of human settlements, we must create socially diverse, mixed-use, humanly scaled, and livable eco-communities, both urban and rural, that integrate renewable energy production, compact design, multimodal transportation linkages, climatically adapted architecture, organic agriculture, and ecologically based land use planning. Based on the dictum that "whatever exists is possible," Kronsberg demonstrates that it is indeed possible even now to create such livable communities which radically reduce our carbon footprint and are capable in the future of operating entirely with renewable energy.

While Kronsberg is in many ways exemplary, there are some areas where it has fallen short. The organic farm and market did not succeed financially, perhaps because it was located too far away for residents to walk to and it was not located near enough to the tramline, making it only accessible as a destination by car.

Also, to date, Kronsberg has not been able to support the number and variety of shops and businesses necessary to make it an economically self-sufficient district with regard to shopping for everyday needs. Perhaps if Kronsberg had not been built on a greenfield site but, rather as some proposed, as an infill project within Hannover proper, it might have been possible for its shops to have had a large enough catchment area from adjoining areas to be more successful. Achieving a critical mass of urban density must therefore be seen as the key to economically viable sustainable urbanism.

Some architects and urban planners have also criticized Kronsberg for not being dense enough to be a real urban district and for being too dense to be a truly suburban development, concluding that it is the worst of both worlds. There is some truth to this observation. Because Kronsberg has large blocks with open green interior courtyards, it often feels like it is a city set inside a very large garden. Green nature is everywhere, and one seldom sees large numbers of people out on the streets as one would see in a densely populated urban area. While residents do have access to nature in the public realm, they have only limited private outdoor space for gardening and other activities. In a lower-density real suburban district, residents would have much larger patios and gardens.

Yet, in the end, the design of Kronsberg may turn out to be a prophetic new model for urban/suburban design in the age of peak oil and climate destabilization. In the future, as natural gas becomes depleted and prohibitively expensive, it would be possible in principle for Kronsberg's combined-heat-and-power district heating systems to be powered with biofuels, making the entire district capable of operating entirely with renewable energy. In the face of the radical increases in food prices and disruptions in food supplies that can be expected in the years and decades ahead, the green interiors of Kronsberg's open blocks are large enough to accommodate highly productive and beautiful edible landscapes, fruit and nut tree orchards, organic vegetable gardens, and year-round food-producing greenhouses, thereby providing a significant percentage of the residents' annual food needs from within its own borders. Also, in the energy- and resource-scarce future Germany and the entire world will be facing, the Kronsberg organic farm may once again be seen as an invaluable asset and be brought back to life, making the community even more self-reliant in the provision of its basic necessities.

Because Germany is experiencing a population decline at the present time, it does not seem likely that more large-scale greenfield projects such as Kronsberg will be built in that country anytime soon. Ironically then, Kronsberg, both as a participatory planning and design process and as a model sustainable eco-community design, should be of greatest interest to the only industrialized country in the world that is presently experiencing significant population growth, i.e., the United States. If we can learn from all aspects of the Kronsberg project, including the effective and creative public/private partnership which made its development possible, we may end up resettling America based on lessons learned from sustainable urban districts such as the garden city of Kronsberg, Germany.

Conclusions

Clearly the transition from a global industrial civilization to a planetary meta-industrial civilization will require a profound combination of economic, social, political, and technological changes. To make this transition, we must first come to understand that all social policy is inevitably environmental policy and that all environmental policy is necessarily social policy. The integration of these two modes of planning into a seamless and democratically constituted whole is a prerequisite for the creation of an equitable, socially just, and environmentally sustainable pattern of human settlements. All social and environmental policy must, in the end, result in the creation of resilient new communities such as Kronsberg (Hannover) and the transformation of existing metropolitan areas into a pattern of compact, humanly scaled, transit-oriented mixed-use developments (TODs) and regenerative agricultural landscapes (Condon 2010; de la Salle and Holland 2010; Tachieva 2010; Dunham-Jones and Williamson 2009).

Such a radical restructuring of our presently unsustainable human ecology will require nothing less than what architect William McDonough calls the "Next Industrial Revolution," a great transformation based on three interrelated principles of ecology: (1) "Waste equals food," (2) "Respect diversity," and (3) "Use solar energy" (McDonough and Braungart 1998, 2002). Rather than having a sole emphasis on labor productivity and a constantly growing GDP, as is the case now, meta-industrial economies will be based on conservation, efficiency, resource productivity, and the creation of a growing sense of real security, happiness, and personal as well as social well-being. Rather than being powered by dirty fossil fuels and large-scale centralized energy systems, the next economy will be operated on the basis of a new generation of clean energy technologies and a decentralized network of distributed power generation. Rather than privatizing profits and socializing costs, this new form of socially and ecologically responsible "natural capitalism" (Hawken et al. 1999; Hargroves and Smith 2005) will convert wastes into resources and be guided by the principles of ecology, equity, and social justice to achieve maximum public benefit rather than maximum private profit.

While even broaching the idea of such a radical transformation of global industrial civilization might seem at the present time to be hopelessly utopian, any future that simply projects a continuation of existing values, institutions, and ways of life merely offers us a hopeless future that is beyond belief. While environmentalists such as Lester Brown (2009), Bill McKibben (2010), and James Hansen (2009) describe possible scenarios for the creation of a renewable energy-based economy resulting in reductions in carbon dioxide emissions that are great enough to avert climate catastrophe, they also tell us that we have only a few short years to change course before the whole matter is beyond human control. While it now appears to be too late to avoid the greatest energy crisis the world has ever faced, as well as the chaos of radically disruptive climate changes already well under way, it is still possible to avoid a catastrophe of Biblical proportions.

As the discussion of the perfect storm of peak oil and climate destabilization at the beginning of this chapter should have made clear, however, there can be no realistic basis for anyone to be optimistic about the human prospect. Yet, there is always the possibility and the necessity of what political scientist, educator, and environmentalist David Orr calls "authentic hope" (Orr 2009, 184–185), a state of mind which requires as its foundation a fearless confrontation with the full reality and truth of our situation rather than willful ignorance, blind optimism, or wishful thinking. As Orr reminds us, Vaclav Havel's understanding of hope must be our guide in the years ahead: "Hope is not prognostication. It is an orientation of the spirit, an orientation of the heart; it transcends the world that is immediately experienced, and is anchored somewhere beyond its horizons…Hope, in this deep and powerful sense, is not the same as joy that things are going well…but, rather, an ability to work for something because it is good" (as quoted in Orr 2009, 182).

The reason for presenting this vision of a meta-industrial society based on the principles of resilient urban design, as exemplified by a case study of Kronsberg (Hannover), is to offer a concrete image of what a sustainable society might look like and what needs to be done practically to sustain "authentic hope." From the example of Kronsberg, it should be clear that by redesigning and remaking the structure, and therefore the functioning, of new as well as existing human settlements, it is in principle possible not only to prevent the most devastating effects of both peak oil and climate destabilization but also to create more beautiful, diverse, and humanly livable communities. The question before us at this moment in history is "what path to the future we will choose?" The time for decision is now, and whatever path we choose, we shall bear the consequences for all future time on this blue-green planet.

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