AN HISTORICAL SURVEY OF URBAN DENSITIES AS A CONSEQUENCE OF ENERGY REGIME: DESCENT INTO THE URBAN VILLAGE

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ABSTRACT

This paper is a preliminary exploration into the relationship between urban densities and energy regime. How has urban density been affected by the prevailing sources of energy that have fueled civilization over time? How have these various energy regimes influenced urban form, and what variation of form can we expect in the Ecocity of the future? Instead of speaking in generalities, specific density figures will be analyzed, past and present, from international sources, and from this analysis optimum urban density calculations will be proposed as a consequence of the transition to a "sustainable" energy regime. The concept of the Urban Village, finally, will be projected as the fundamental and comprehensive retrofit solution for a truly sustainable – that is, perennial – trans-urban pattern.

Keywords: Urban Village; Energy Regime; Urban Density; Energetics; Civilization

INTRODUCTION

Inside Howard T. Odum's seminal book, *Environment, Power, and Society* (1971, p.34), lay an impactful phrase: "We may say that phenomena on earth are energetically determined." This must be true for both physics *and* civilization. Later, after demonstrating a quantitative method for measuring real sustainability based on energy analysis, Odum implored us to begin finding a "prosperous way down" (1996, p.287). Now that "Peak Oil" has entered the lexicon, and many are warning of an impending "energy famine" (Heinberg, 2004), we may benefit from following Odum's lead by thinking about "sustainable settlements" in terms of energetic analysis.

An increasing number of analysts are convinced that the peak for oil has already occurred. For example, Kenneth Deffeyes (2008) points to data released by the US Energy Administration that shows world production reached its maximum in May 2005, and now appears to have leveled off on a relative plateau (see www.eia.doe.gov/ipm/t11d.xls). He cites, "*Oil and Gas Journal* reports that world oil production in 2007 was lower than 2006" (ibid). The Post Carbon Institute, in their new guidebook *Post Carbon Cities* (2007, pp.2-3), summarizes the implications of oil decline: "First, oil is absolutely essential to the most basic functions of the industrialized world…Second, there are currently no viable substitutes for oil at current rates of consumption…Finally, and most importantly, our entire economic system is built on the assumption that oil will always be readily available at affordable prices."

This could be serious; yet, oil is not the only essential resource that is peaking. A recent article in *Natural Gas Week* reports, "Geology, logistics, production history and economics suggest that [global] gas output, like global oil output, could plateau, if not peak, sometime between 2010 and 2025…US production peaked in 1973…Canada's gas output peaked early in the decade" (Energy Intelligence Group, 2007). Natural gas decline has serious implications especially for industrial agriculture, considering its ubiquitous use in the production of fertilizers, pesticides, and herbicides.

Furthermore, the production of key minerals that support modern civilization is also entering a downward phase. Says Ugo Bardi, from the University of Florence, “We examined the world production of 57 minerals reported in the database of the United States Geological Survey (USGS). Of these we found 11 cases where production has clearly peaked and is now declining…[This study] strongly supports the concept that “Peak Oil” is just one of several cases of worldwide peaking and decline of a depletable resource. Many more mineral resources may peak worldwide and start their decline in the near future” (2007, abstract). Fortunately, uranium will be one of these depleting resources.

Author Richard Heinberg hits the mark by titling his newest book *Peak Everything: Waking Up to the Century of Declines*. Besides hydrocarbons and minerals, Heinberg forecasts “an end to growth and a commencement of decline in [other] parameters,” including population, grain production, climate stability, fresh water availability per capita, arable land in agricultural production, and wild fish harvests (2007, p.4). Energy, however, is fundamental to all these other parameters. “With the discourse on Peak Oil that has commenced since the beginning of the new millennium has come a focus on energy as the *determining factor* in social evolution – rather than technology *per se*, or ideas, or political struggles” (ibid, p.42, emphasis added).

Clearly then, considering that the world is on the verge of a transition of unprecedented proportions, the prescient development of “sustainable city” models should focus on adapting to and preparing for *severe retraction* as its priority and purpose. On some fundamental level, what will be required to achieve sustainable cities is the restructuring of an historical-cultural pattern – civilization itself – that has persisted for some 5000 years (Mare, 2003).[i] On a deep psychological level, we need to prepare ourselves for reorienting to a brand new cycle, recognizing that we are stepping forth into an entirely new evolutionary trajectory. In this paper, I refer to the new cycle as “Descent into the Urban Village.”

HISTORICAL DENSITIES

Before evaluating some historical densities, to see how they may inform optimum densities in a 21^{st} century ‘sustainable’ context, it will be useful to step back a bit and appreciate the subject of density more generally, for as Jenks and Dempsey caution, “density is a bit of a minefield” (2005, p. 293). How so? It seems that historically, “a wide range of different measurements have been used, including: persons per hectare, dwellings per hectare, habitable rooms per hectare, bed spaces per hectare, and floorspace per hectare” (Woodford, *et al.*, 1976, in ibid), making conversions dubious. Then there is the question of whether density calculations are “net” or “gross.” “*Net density* is identified with the number of dwellings in relation to the land area exclusive of public rights-of-way – the streets and sidewalks, parks and playgrounds, schools and commercial areas – whereas *gross density* usually pertains to the number of dwellings in relation to an area of land including all public rights-of-way and other related land uses…[T]he significant measure for the general texture of the physical form is expressed by gross density” (Eisner, *et al.*, 1993, p.460).

Pont and Haupt (2007, pp.64-5) further inform, “Only when density is seen as a composite of aspects, such as intensity, compactness, height, and spaciousness…can it be satisfactorily used to differentiate between urban fabrics, understand their characteristics, and design guidelines for future developments.” Since this paper will be comparing densities cross-culturally as well as historically, simple gross population figures per given area may be assumed

– keeping in mind the very general nature of their depiction, lacking in specificities of spatial distribution and the multiplicities of possible usage.

What, then, were the densities in the world's first cities? As usual, Mumford provides elucidation:

> Probably the normal size of an early city was close to what we would now call a neighborhood unit: five thousand souls or less. So at the beginning of differentiated urban association, the city still retained the intimacies and solidarities of the primary community…Frankfort, digging in Ur, Eshnunna, and Khafaje, which flourished about 2000 B.C., found that the houses numbered about twenty to the acre, which gave a density, he calculated, of from 120 to 200 people per acre, a density certainly in excess of what was hygienically desirable, but no worse than that of the more crowded workmen's quarters in Amsterdam in the seventeenth century" (1961, p.62).

It's important to realize that these first cities were basically fortresses, bound by thick walls, within which the people were packed for protection from marauding city-states. Of the urban form, "we see something that has grown out of the conditions of the primitive village, not laid out on any system of town planning. The unpaved streets were narrow and winding…large houses and small are tumbled together, a few of them flat-roofed tenements one storey high, most of them two storeys, and a few, apparently of three" (Woolley, in Kramer, 1963, p.89).

These relatively small, mud-brick houses were the domiciles within which the people did their living, much as they do today. Mumford emphasizes this continuity: "[I]t is interesting to note that the small houses found in Mohenjo-Daro [the seat of another proto-civilization from the Indus Valley], from about the middle of the third millennium B.C., were two stories high and about thirty by twenty-seven feet: about the same size as a modest house in Greek Priene about 200 B.C., which measured twenty-six feet by twenty. Neither would have seemed out of place in the East End of London in the eighteenth century…What is most significant in these figures is their remarkable constancy over a period of some five thousand years" (1961, p. 62).

This "constancy" could very well represent a perennial *human* scale. And what of overall populations in pre-industrial cities? Were they also fairly constant? Kirkpatrick Sale, in his perceptive book *Human Scale,* in a chapter titled "The Optimum City," assures us that this is so:

> During most of its celebrated life, Athens as a city seemed to have hovered around 50,000 people…Italian cities that began and nurtured the Renaissance…did not grow to more than 80,000, and most of them had closer to 50,000 – the Rome of Michelangelo with perhaps 55,000, the Florence of Leonardo 40,000, and Venice, Padua, and Bologna at their height probably 50,000-80,000. New York and Philadelphia at the time of the American Revolution had fewer than 30, 000 people…In fact, it seems that only on very rare occasions did pre-industrial centers ever go much beyond 100,000, and then only temporarily…It has only been in the last two centuries…that giant conurbations have emerged and lasted.
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> The conclusion of the protean Constantine Doxiadis, after a lifetime of categorizing such things, seems quite on the mark: "If we look back into history…we find that, throughout the long evolution of human settlements, people in all parts of the world have tended to create urban settlements which reached an optimum size of 50,000 people" (1980, p.194).

So we have conformation that dwelling sizes and overall populations of urban centers remained fairly consistent through most of human history. Then what about actual densities? The inimitable Phil Hawes has compiled some data that extends this consistency: According to his research, Athens in 500 B.C. had a gross density of 136 persons/acre; Alexandria in 100 B.C.

likewise, 136 persons/acre; Pompeii in 79 A.D. had 156 persons/acre; Catal Huyuk in 8000 B.C. was at 188 persons/acre; Jericho in 6500 B.C., 200 persons/acre (another fortress), and similarly, Amsterdam in 1670 had a *net* density of 200 persons/acre, while cities in Holland as a whole in the 1600s averaged 120-130 persons/acre (2007, p.2). Thus, densities as well hovered within some optimum human-scale range.

It is immensely significant that Sale made his distinction at *pre*-industrial centers; that is, further analysis will reveal that all indicators remain fairly constant up until the onset of the Industrial Revolution. This period, of course, marks the transition between energy regimes: the transition from reliance on *renewable* organic sources to ever increasing dependence on *nonrenewable* organic sources: fossil fuels: coal, and then later hydrocarbons.

The Wikipedia has this to say:

> The onset of the Industrial Revolution marked a major turning point in human social history, comparable to the invention of farming or the rise of the first city-states…In the later part of the 1700s the manual labour-based economy of the Kingdom of Great Britain began to be replaced by one dominated by industry and the manufacture of machinery. It started with the mechanization of the textile industries, the development of iron-making techniques *and the increased use of refined coal*…The introduction of steam power (fuelled primarily by coal) and powered machinery (mainly in textile manufacturing) underpinned the dramatic increases in production capacity (p.1, emphasis added)… The major change in the metal industries during the era of the Industrial Revolution was the replacement of organic fuels based on wood with fossil fuels based on coal (p.5).

The time periods here are roughly from 1760 to 1830. Apparently a Second Industrial Revolution kicked in around 1850. The modern age of petroleum dates from 1859 (Walton, p.2).

Up until this age of fossil fuels, we can imagine settlements all over the world relying on organic, renewable fuels and natural processes, such as sun, wind, water, the regular flooding of rivers, gravity irrigation, draft animals, etc. The size, population, and density of these settlements were limited by their energy regime: energy was the *determinate* factor. Energy was conserved and extended – and entropy retarded – through knowledgeable *design*. Buildings were limited in height and placed relatively close together to conserve heat; settlement size was limited per relation to transportation distances; overall population was limited by proximity to and productivity of agricultural lands; density, as a rough coefficient of population and size, accordingly leveled off at a relative optimum. Yet ask any ecologist: the introduction of a new energy source into a system surely will accelerate the metabolism. Since energy density, as in joules per given volume, increases with the transition from wood to coal, can we expect the introduction and increasingly intensive uses of this higher density energy source 'coal' to have corresponded to higher density settlement patterns during the Industrial Revolution? This certainly proves to be so:

> During the 19th century, towns and cities in Britain experienced a process of unprecedented rapid urbanisation. By the 1840s London was a huge city of 2½ million people, and the industrial cities of the North – for example, Birmingham, Leeds, Liverpool and Manchester – were growing with astonishing rapidity (Jenks and Dempsey, p. 288)[ii]

The authors go on to cite a certain high density building form called "housing courts" with "back-to-back terraces" that resulted in Liverpool "in densities of around 700 persons per acre" (Muthesius, 1982, as quoted in ibid). We can assume that these impoverished industrial workers heated their spaces with coal, and were fed by the productivity of an increasingly mechanized agriculture, using steam-powered railroads to transport surplus into urban centers.

"Perhaps the most gigantic fact in the whole urban transition [during the Industrial Revolution] was the displacement of population that occurred over the whole planet. For this movement and resettlement was accompanied by another fact of colossal import: the astounding rise in the rate of population increase…The general increase in numbers was accompanied by a drawing of the surplus into cities, and an immense enlargement of the area of the bigger centers. Urbanization increased in almost direct proportion to industrialization" (Mumford, p.448).

Much has been written about the sordid living conditions of the displaced industrial workers slaving away in those "Satanic Mills;" yet these conditions were direct consequences of the increased densities, densities that were indeed historically unprecedented. Many former one-family houses were converted into "rent barracks," where the standard became one family per *room*. Cheap, shoddy worker tenements for up to 20,000 were constructed near the factories. The factories themselves were massed since "steam worked most efficiently in big concentrated units…The more units in a given area, the more efficient was the source of power: hence the tendency toward giantism...It was the change of scale, the unrestricted massing of populations and industries, that produced some of the most horrendous urban effects" (ibid, p.456).

Unfortunately, we're still living with some of the "horrendous effects" of that dim period in the history of urbanism; for aesthetics, conviviality, livability, social amenities – indeed, even *design* – were abandoned in the interest of an unrestricted, profit-driven, moronic utilitarianism. As industrialism spread across the planet, spurring the mass migration from rural lands into dense conurbations, it was the rapid, chaotic, energy infused (some would say 'market-driven') growth itself that ensured someday the pattern would become unsustainable. In that vein, the sustainable Ecocity is a solution to a problem that has its roots in those days, in that attitude.

MODERN DENSITIES

Still in England, for that is where most of the data seems available, the squalid living conditions in those grimy, coal-choked slums eventually became subject to legislative intervention. "[I]t was the Public Health Act of 1875 that proved a landmark…It led to a form of development that transformed cities throughout the UK into the early part of the 20th century" (Jenks and Dempsey, pp.288-89). This development was called "bye-law" housing, because it gave power to urban authorities to enforce standards. "The density of this form of development in the cities…ranged between 60 and 200 persons per acre" (ibid, pp.289-90). This conforms to Old World patterns; although it must be remembered that these were *net* densities – strictly residential – lacking any social, public, or community space. These fairly high density housing blocks, often filling in monotonous square kilometers, were also a consequence of the instituting of new *zoning* laws, a segregated view of the urban environment designed to make sharp distinctions between land-use for industrial, residential, or other purposes. "[T]he main purpose of urban use zoning at its inception was to stabilize real estate values in residential neighborhoods" (Kunstler, 1993, p.55).

Also as a reaction to the degrading influence of industrialism, new forms of "model villages" started to appear. Port Sunlight near Liverpool and Bourneville near Birmingham were constructed in the late 1800s, well outside traditional city boundaries, at low densities of between 20-40 persons per acre (Jenks and Dempsey, pp. 290-91). Around this same period, in 1898 Ebenezer Howard published his *Garden City* program. Construction of the first Garden City, Letchworth, began in 1903 at a density of 20-60 persons per acre, and Welwyn Garden City soon followed (ibid, p.291). These so-called "green" developments *did* include parks, public places, civic buildings, and commercial space all arranged within a thoughtful circulation pattern, so they were the predecessors of the Urban Villages of today.

Of course, the United States soon followed the British precedent. "In New York City, where the population ballooned from 696,115 in 1850 to 3,437,202 in 1900, the slums marched north up Manhattan island in successive waves, driving the better-off before them" (Kunstler, p.36). Apparently, density levels "in a few blocks on the Lower East Side" in 1905 were as much as 1000 persons per acre! (Hall, 1998, p.752). Owing to the new commuting flexibility of the railroad, the "better off" began to deploy themselves along rail lines around the periphery of the congested city stench. This was the beginning of the "suburb." "The prototype of the railroad suburb in America was Llewllyn Park" (Kunstler, p.46). Now, Llewellyn Park made no pretense about wanting to integrate residential with commercial, as the Garden Cities did. Instead, this new suburban model was packaged as 'manor-life' within an idyllic country setting, where every home-owner could have their own estate on a very low density one to twenty acres nestled within park-like ambience. Another pioneering example of the "railroad suburb," begun in 1869, was a development called "Riverside," outside of Chicago. "The plan called for a higher density than Llewellyn Park, with many more building lots per acre, but the theme was still romantic landscape… [to] promote the illusion of rural living" (ibid, p.48).

Thus was initiated the prevailing – and by now all too familiar – settlement pattern of the modern era: the sprawling, energy guzzling, low density, unpretentiously wasteful suburb. The prospect of living outside of the city became tangible for the less-than-wealthy with the mass introduction of the Model-T beginning in 1908. This proved to be a boon for companies like Standard Oil, who were actually searching for applications for the vast stores of the energy resource they had cornered. Oil – and its refined products gasoline, kerosene, etc. – have an even higher energy density, as in joules per litre, than coal. How, then, has the transition to this energy regime determined modern urban densities?

To place things in perspective, consider this energetic analysis:

> Traditional societies either drew their food, feed, heat and mechanical power from sources that were almost immediate transformations of solar radiation (flowing water and wind), or harnessed it in the form of biomass and metabolic conversions that took a few months (crops harvested for food and fuel), a few years (draft animals, human muscles, shrubs, young trees) or a few decades (mature trees) to become usable.
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> [In contrast], modern civilization is withdrawing accumulated solar capital at rates that will exhaust it in a tiny fraction of the time that was needed to create it. Traditional societies were, at least in theory, energetically sustainable…[M]odern civilization rests on unsustainable harnessing of the solar inheritance.
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> [T]his very dependence on fossil fuels has given us access to energy resources that, unlike solar radiation, are both highly concentrated and easy to store. As a result, both aggregate and per caput energy consumption of modern societies have risen to unprecedented levels (Smil, 2006, pp.84-5).
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> *[C]ities and conurbations with populations in the multi-millions could not have arisen without high energy densities of fossil fuels,* portability of refined oil products, great convenience of natural gas, and superior flexibility of electricity (Smil, 1991, p.309, emphasis added).

This is what I perceive to be the "heart of the matter:" It was the nature and quality of refined oil itself, as an energy source with particular characteristics – highly concentrated, easily transportable, compact in storage, multifarious in its usage – that determined the nature and form of the settlement pattern. Data from the website Demographia.com show that even while overall populations have soared exponentially, "exactly in parallel with oil production" (Campbell, 2003), the actual density of urban areas in the developed world has dropped accordingly. Thus, the energy density has been distributed and invested over an ever-expanding built-up area, and re-constituted at the scale of a multitude of individually detached dwellings, shopping centers, business parks, roadways, etc.

Yet, in another sense this data can be misleading, for calculations of "urban density" aggregate both suburban areas and city centers. While the intrinsic qualities of oil allowed expanding populations to be randomly distributed horizontally over the landscape, these same qualities permitted the dramatic vertical densification of the built-up area in urban cores. The construction of these 'sky-scraping' cores would not have been possible without the high energy densities of hydrocarbons;[iii] and while the prevailing pattern has been to create a Central Business District, where the tallest buildings are reserved for the influx of armies of commuting workers during the day, periodically hyper-inflating population densities, there are examples of specific high-rise sub-centers in the developed world with gross residential densities far exceeding that of the densest Old World conditions. McHarg, for instance, estimated the average density of the midtown area of Manhattan to be 600 persons per acre (1992, p.194). Demographia.com registers the Mong Kok section of Kowloon in 1990 at 668 persons per acre; and by comparison the most crowded district of Shanghai, Nanshi, in 1998 had 230 persons per acre. Such hyper-densities must feel all the more congested considering that, in the case of Manhattan for example, the streets occupy some 30 percent of the land area (Eisner, *et al.*, p.94).

And what about the developing world?

> Examining patterns of urban concentration in developing countries, one finds that, alongside increases in urbanisation, developing countries have also experienced sizable growth rates of urban concentration over the past 50 years. Specifically, whereas the growth of large cities (i.e. cities of more than 5 million inhabitants) has been slow or even zero in the industrialised world, developing nations are experiencing ever greater population concentration in large urban agglomerates and in mega-cities (defined as cities with a population greater than 10 million). For example, between 1975 and 2000, the number of mega-cities increased from 3-15 in developing countries, compared with a rise from 2-4 in developed countries (Bertinelli and Strobl, 2007, p. 2500).

Some of the meanest concentrations rival the worst abuses of the Industrial Era: the Bab-El Sharia section of Cairo in 1966 had 550 persons per acre, and the Marine Lines Ward of Mumbai in 1981 held 619 persons per acre (www.demographia.com/db-dense-nhd.htm).

Could the increasing concentrations in the developing world, which are projected to continue increasing (Stanvliet and Parnell, 2006), have been possible without the ubiquitous flow of hydrocarbons? The answer is in the negative; for although there is not room here to provide a full account, one merely has to re-note how heavily dependent on fossil fuels is industrial agriculture: natural gas in the production of synthetic fertilizers, herbicides, and pesticides, and oil in transportation, mechanization, packaging, etc. "The world's cultivated land expanded only by about one-third between 1900 and 1990, but average energy inputs per cultivated hectare increased more than eighty-fold…Rising applications of fertilizers and pesticides and growing use of machinery and irrigation translated into much higher yields of staple crops" (Smil, 1994, p.191). Back in North America, a food exporter, apparently it takes 10 calories of fossil fuels to produce one calorie of food (Quinn, in McBay, 2005). The world simply could not have gone from feeding 1.5 billion people in 1900 to feeding over 6.65 billion people today – with an increasing percentage of these people crammed into the mega-cities of the developing world – without the massive influx of cheap fossil fuels. What will happen in the mega-cities now that the supply of fossil fuels is "peaking" and will soon begin to decline? Despite projections, I think it is only a matter of time before there is a mass exodus out of the cities and back to the villages: de-urbanization, re-localization, and recovery of manually-intensive traditional farming methods.

No evaluation of modern densities would be complete, however, without giving voice to the utopians – visionaries of the ideal living situation, much like the visionaries assembled here at the Ecocity Summit. In this case, I refer to Le Corbusier, famous for the curious aphorism, "the city is a machine for living:"

> Le Corbusier argues concentration versus congestion. He demonstrates that his [Cite Industrielle] will concentrate the people, conserve the daily hours they consume in horizontal travel, and direct this time into productive effort and leisure. He contends that the American skyscraper is too small and proposes a residential population of 6 million on Manhattan, with a density of 400 persons per acre and 88 percent of the ground left free and open. In his City of Tomorrow, the density is 1,200 per acre in 60-story office towers with 95 percent of the land in open space, a "green" city (Eisner, *et al.*, p.124).

OPTIMUM DENSITIES IN SUSTAINABLE FORM: THE URBAN VILLAGE

Except for a few dissenters (e.g. Neuman, 2005; Stretton, 1998), there seems to have been reached some common agreement that the way to make cities more "sustainable" is to increase urban density (notably defended in an impressive set of articles collected by Jenks, *et al.*, eds., 1998, 2001, 2005). Mayor Sam Sullivan, of Vancouver, B.C., has become a spokesperson for this perspective:

> [W]e should be talking about how better urban planning and densification of our cities can significantly reduce our impact on the environment…Vancouver has become the first city in North America to formally establish an official policy of well-planned, high quality densification…[W]ith an ageing population, rising home prices and an increased public interest in protecting our local and global environment, the time has come for us to embrace density as a tool to make cities more sustainable and livable...Why do we need to embrace density?... Densification reduces urban sprawl. When people live closer to where they work, they travel less often in carbon-emitting vehicles…Increased density also leads to neighborhood town centres becoming economically viable with an increased selection of local shops and services (2007).

Sullivan's argument is particularly relevant for the sprawling patterns of western North America, where he resides. His appeal echoes (or may have been derived from) the "Compact City" vision:

> The compact city is being promoted…as a component of the strategy formed to tackle the problems of unsustainability. The rationale for its implementation relies heavily on a set of strategic benefits, which are said to be the outcome of more compact urban forms. The arguments are, by now, familiar: in more compact cities travel distances are reduced, thus fuel emissions are lessened, rural land is saved from development, local facilities are supported and local areas become more autonomous…[M]ore compact cities can only be achieved through a process of making existing cities more dense, of encouraging more people to live in urban areas and of building at higher densities: of 'intensifying' cities (Williams, *et. al.*, 1998, p.83).

The question is obvious: How dense should a compact city be? Cities in wealthy countries, with high per capita energy consumption, have been experiencing an out-migration for decades. For example, the Kensington and Chelsea area of London had a moderate gross density of 74.5 persons per acre in 1951 reduced to a more benign 54 persons per acre by 1996; and the Ville de Paris saw its density decline during the period 1921-1999 from 135 persons per acre to 99 persons per acre (Demographia.com); so it makes sense that as energy supplies begin to dwindle, there will be reverse migration back into the cities. Projects like the New Urbanism are already helping to facilitate this re-population (Calthorpe, 1993; Duany, *et al*., 2000).

Density advocacy needs to be tempered, however; for in its extreme, we have seen the monstrous Cite Industrielle. Vancouver's skyline is already lined with high-rise residential towers; an article from the Seattle P-I a while back averred, "Towers just part of vibrant urban living" (Langston, undocumented). Could this be true? Another extreme form of density is the "megastructure" concept being implemented in Hong Kong – a virtual "city within a city," where mixed-use development can be found all contained within the same monolithic building:

> Hong Kong's megastructures are not the result of any urban theory. The fundamental force behind these developments is the necessity to provide accommodation for a rapidly increasing population…Most of the population live in high-rise apartments, where living on the 60th floor is less and less uncommon. New middle-class developments are being built with densities of 2000 people per hectare [810 per acre] and more. In public housing estates the densities are even higher (Karakiewicz, 1998, p.142).[iv]

The ecological footprint for one of these megastructures must be astounding. Such concentrated, energy intensive forms – with their heating and cooling, their elevators and refrigerators, their appliances and expensive maintenance, etc. – will not be possible in the post-carbon era. Similarly, such imposingly crowded population densities will prove to be unsustainable.

A *sustainable* energy regime will be the progression forward to a *solar*-based energy regime – not all at once, but a complete transition is inevitable, perhaps within the range of a few hundred years. A solar-based regime relies on harvesting, transforming, and extending – for as long as possible – the initial dispersed solar input, and concentrating it at scales commensurate with biomass and organic nutrient accumulation. This perennial system utilizes drastically lower energy densities than what we have become accustomed to in the late Fossil Fuel Age. Since it has been demonstrated that prevailing energy regime is a determinate factor in urban density and form, we can expect the future solar regime to correspond with significantly lower maximum densities at spatial scales limited by the practical, localized extent of organic agriculture and agroforestry – solar economies compel settlements to synergize with local ecologies. In that sense, the "compactness" of a compact city may refer more to reducing total urban surface area rather than to intensifying uses.

Here's one way to look at it: The Fossil Fuel Age was like a vast wave that washed across the landscape. Food production, population, economic activity, etc. all soared exponentially with the massive influx of new energy. Such abundant energy ultimately accelerated the people's lives to a frenzied pace; they became disconnected from the natural cycles, rhythms, and principles that once informed and guided their activities. The wave rushed outward from the former city centers as an indifferent, all-consuming sprawl, burying once living systems and covering the land with a new type of energy intensive infrastructure. The unchecked rapid growth produced an incoherent, discombobulated pattern that proved increasingly dysfunctional as the energy subsided. The wave eventually reached its maximum extension and then began to ebb; food production, population, economic activity, etc. all began to fade – ever so gradually at first, but then with increasing momentum. As the wave receded, it exposed the conspicuously inarticulate infrastructure it had initially washed ashore. Our task is to remold and remake that infrastructure.

During the coming period of energy descent, we will see the most peripheral infrastructure – the exurban subdivisions with their supporting strip malls – abandoned, the land they confiscated returned to forest and pasture. Likewise, high-rise towers planet-wide will become derelict, eventually scrapped for materials, their imposing hulks standing as austere relics of the excesses of the Age of Oil.

Cities everywhere will begin decreasing their footprints, withdrawing back into their centers, much as depicted by Richard Register (1987); however, the solar determinate will limit their densities and delimit their spatial area in accordance with pre-industrial character. One-hundred twenty persons per acre was a recurring figure for some of the more cultured centers; yet, taking into account the lower birth rates and more diverse household make-up of the Information Age – not to mention all the embodied energy laying around – a maximum density figure of 80 persons per acre may be more realistic for the new solar-city centers. Total spatial area eventually will accommodate an optimum population of 50-80,000, with density and uses intensified at the center, gradually diminishing toward the edge – and it's so very important to maintain that edge. The urban spatial pattern will be sub-organized into a collection of well-defined districts, each with a distinct function in support of the whole.

The ebbing of the urban/suburban pattern will reveal myriad sub-centers scattered across the former metropolis. These sub-centers will be organized into a mutually-supporting, interdependent network at regional-scale – a non-hierarchical, poly-centric distribution of relatively self-reliant, self-contained, self-maintaining, self-organizing nodes – the Urban Villages. Each Urban Village will be independent in producing its own essential needs – such as food, clothing, energy, shelter, water, etc. – yet also will specialize an industry that can manufacture products for trade within the total bioregion. Because the Urban Village is relatively independent and self-determined, each will generate a variation in culture, music, speech, or dress (Mare, 2006); these will be "the 'new municipiums' self-governed by participatory democracy" (Magnaghi, 2005, p.2). Each Urban Village will be integrated into its supporting local ecology, bounded by a wide green-belt of parks, forest, pasture, riparian zone, wildlife corridor, and farmland. These boundaries are unencroachable: the existence and perpetuation of the Urban Village is completely dependent on the long-term health and vitality of these local ecologies. The green-belts of the new Urban Villages will overlap, forming a sinuous web that extends throughout the human populated areas of the region. Thus, a sustainable, organic, *cellular* pattern will be super-imposed upon the former sprawling metropolis (ibid); and, this cellular pattern will prove to be the most optimum arrangement for the new solar economy.

Unlike the traditional village, the new Urban Village will retain a measure or feeling of urbanity – it is, after all, retrofitting a prevailing urban pattern. Density will increase toward a built-up center that incorporates a variety of mixed-uses, encircling a central plaza. Medium-level urban densities of around 80 persons per acre (as defined by Hawes, 2007) at the center will ensure a lively pedestrian environment with an interesting intensity of uses. An optimum overall population of 5000 (Mare, 2006) will be situated on a recommended surface area of 40 hectares: approximately 100 acres (Krier, 1998, p.128). If 20 percent, or 1000 people, inhabited the Village Center, at an urban density of 80 persons per acre, then 12.5 acres would be required for this center. The remaining 4000 persons, organized into neighborhood units of an optimum 500

(Mare, 2006), would occupy the remaining 87.5 acres of land. This would entail eight well-defined neighborhoods of approximately 11 acres in size, with a net density of 45 persons per acre. Each neighborhood would serve a function for the whole.

These numbers will be uncomfortable for average suburbanites, anesthetically immersed in their fossil fuel-enriched stupor; yet they are moderate by historical standards. If only they could witness the elegance of Tuscany or the Provence! And just think: a ten minute walk in one direction will provide vibrant community life while a ten minute walk in the other direction will find oneself in the peaceful midst of forest or field. This version of the Urban Village, integrated into its encompassing environs, is designed essentially as a solar power converter. The time may come when individual fancy plays less a role in determining lifestyle than does the matter of sheer community necessity. The Urban Village may very well be a more humane way to live.

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NOTES

[i] "Civilization, the culture of cities, originated on the ancient plains of Mesopotamia some 5000 years ago, circa 3000 B.C.

[ii] Sale reminisces, "It was only an eye blink ago, so to speak, that any city reached the size of a million – that was London, in the 1820s (1980, p.74). "In 1865, Manchester had about 6000 people; in 1760, between 30,000 and 45,000…by 1801 Manchester's population was 72,275, and by 1851 it was 303,382" (Mumford, 1961, p.455).

[iii] From a source I can't recall, I read that the tallest building in the world in 1903 was the Eiffel Tower.

[iv] I am reminded of Alexander's Pattern #21: Four-Story Limit (1977, p.114), where he makes the case that living in towers is psychologically deleterious, if for the simple reason that it removes people from the casual, spontaneous, ground level activity on the street, thus confining them alone in their little apartments, needing a formal effort just to go out in public. The affects are especially solemn for children.