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Urban form and climate change

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Cities come in all shapes and sizes. The idea that these different shapes – whether sprawling like Los Angeles or dense like Manhattan – can play a role in determining the environmental impacts of urban areas is an idea that is gaining currency in both popular and scientific circles. This article will attempt to highlight the role that the 'urban form' of a city can play in either attenuating or exacerbating the production of greenhouse gases. 'Urban form' is a term that has been developed to describe the physical composition of a city. It encompasses an urban area's density (inhabitants/hectare), its mix of land uses (divisions between residential, commercial, industrial, etc.), its provision of transportation options (public transit facilities, auto-related infrastructure) as well as the degree to which urban development is contiguous or 'scattered' around the edges.

Although the link between urban form and climate change is still actively debated, research indicates a 'strong but complicated' relationship between higher densities, mixture of residential and commercial uses, and reduced greenhouse gas emissions. Since most of our energy today (and for the foreseeable future) is derived from fossil fuels, a reduction in energy consumption implies a concomitant reduction in greenhouse gas emissions. One study attempted to quantify the connection between urban form and greenhouse gas emissions by plotting a number of cities' private automobile energy consumption versus their gross density. They found a startlingly consistent relationship, as shown in **Figure 1**.

Clearly, increasing density can substantially reduce transportation energy consumption. It is important, however, not to infer too much from this graph. The disparity between automobile usage in places like Houston and Hong Kong involves factors other than density; cultural differences, income distribution, and levels of auto ownership may also play significant roles. Nevertheless, the graph does demonstrate the significance of one measure of urban form in determining energy consumption and, consequently, greenhouse gas emissions.

This density versus greenhouse gases (GHG) emissions relationship can also be demonstrated on a more local level. A study by Feigon et al. (2003) analyzed GHG emissions in several American metropolitan regions and found that Tokyo-like densities are not required for a relationship to become clear. The results of their study of Chicago are presented in **Figure 2**.

On the left, GHG emissions are shown on a per square mile basis. As is expected, the dense urban core produces greater emissions than the periphery. However, as shown on the right, the emissions per household are actually lowest in the central city. The results demonstrated globally by Newman and Kenworthy (2000) are reappearing here at the fine-grained level of urban neighborhoods.

What are the causes of this relationship? How do density and other aspects of urban form exert such a strong influence on urban energy consumption and, consequently, greenhouse gas emissions? The effect can be divided into two main areas: transportation and residential energy consumption.

Urban Form and Transportation Energy Use

Urban Form can have an enormous impact on the way people travel. As one study succinctly put it, 'the physical characteristics of a place, or urban form, influence how often, how far and by what means people travel'. This seems true intuitively:

A person living in a residential subdivision with cul-de-sac streets and few sidewalks has little choice but to drive to the grocery store and to a job. A person living in an area laid out in a grid of interconnecting streets with a mixture of land uses supported by a comprehensive transit system can choose to walk, bicycle, use transit, or drive. Even with the option to drive, the physical layout of the latter community is likely to generate fewer vehicle trips, and shorter trip lengths overall, and will produce fewer CO2 emissions than the former community. (Feigon et al. 2003, p.6)

This description gives one example of how the layout of cities has an impact on the way people choose to get around. It includes the two most essential points: all alternatives to driving require higher densities and a greater variety of uses than exist in most modern, auto-oriented suburbs. This is important since the private automobile has been identified as the most energy-intensive form of transportation. Reducing the frequency and distance of travel as well as allowing a shift from private automobiles to other, less carbon-intensive forms of transportation is one of the primary areas where urban form can play a role in bringing about reductions in GHG emissions. This is particularly true in the case of short trips.

Non-motorized transportation (predominantly walking and bicycling) is an attractive alternative to vehicle travel because, generally, short trips via personal automobile that are of "bikeable or walkable" length tend to be more polluting. They also constitute a significant percentage of all vehicle trips made (Feigon et al, 2003).

In other words, denser urban form allows for more efficient transportation, especially over the short haul.

Density alone, however, is not entirely effective. Another important characteristic of an energy-efficient urban form is that it provides a good mix of uses; in other words, employment and shopping opportunities are mixed in with residential development. This is not a new idea; industrial-era downtowns and pre-automobile neighborhoods often exhibit an effective mixture of primary uses. However, twentieth century automobile-oriented development separated land use by zone according to function: industrial, residential, commercial, etc. By reversing this trend and bringing people closer to their destinations, urban form can bring about reductions in transportation energy consumption. In summary, more people per area closer to their destinations (shopping, work, etc.) reduces the need to travel long distances while enabling cycling, walking and public transit. This reduces GHG emissions and energy consumption.

Quantifying exactly how much energy could be saved is more difficult. A detailed study carried out by the National Round Table on the Environment and the Economy (NRTEE) estimated that urban transportation accounts for about 10% of total Canadian GHG emissions. In the United States, one third of greenhouse gas emissions come from surface transportation. Using this energy breakdown and the fact that American emissions account for 25% of global emissions, one can conclude that 8% of global GHG emissions are created by transportation within the United States, which helps to underline the importance of reducing transportation energy usage in developed countries.

One way of expressing the relationship between urban form and transportation energy use is that a denser, mixed use urban form is a necessary but not necessarily a sufficient condition for reducing energy consumption in cities. Other means, such as congestion pricing or higher fuel taxes, may be necessary to finally push people away from the automobile, but without other options provided by a change in urban form they cannot be effective. As Newman and Kenworthy (2000) write, "Achieving a more sustainable urban form inevitably involves the development of densities that can enable public transport, walking and cycling to be viable options."

Urban Form and Residential Energy Consumption

The residential sector has also been identified as an area where energy efficiency can be improved through physical changes to the urban fabric. The shared walls, floors and ceilings of higher density dwellings inherently increase energy efficiency. Higher densities also allow for more energy efficient technologies. One study estimated that significant energy savings over conventional detached housing could be made by designing houses to make the most of solar energy for heating and cooling, and using shared walls and floors like those in terrace or apartment housing.

Several studies have attempted to quantify the energy savings that are possible in higher density living arrangements. The best of these have incorporated Life-Cycle Analysis (LCA) into their studies. This methodology incorporates all the energy use and greenhouse gas emissions inherent in the construction materials used to construct both low and high-density residential development. LCA allows the development of a more realistic understanding of the environmental impacts of residential densities. Using LCA, two recent studies came up with maximum possible energy reductions on the order of 45% per capita (Norman 2005).

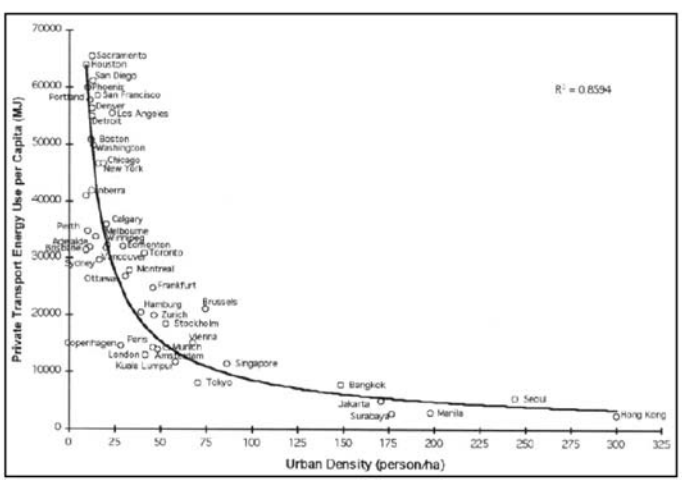

Figure 1. Source: Newman and Kenworthy (2000)

While residential density can help to reduce the greenhouse gas impacts of the residential sector, it is important to note that there are some value judgments implicit in these analyses. For example, reductions in residential energy consumption are often much more significant on a per capita basis than a per square meter of living space basis, which brings up moral and ethical questions about how much living space is really necessary for an individual.

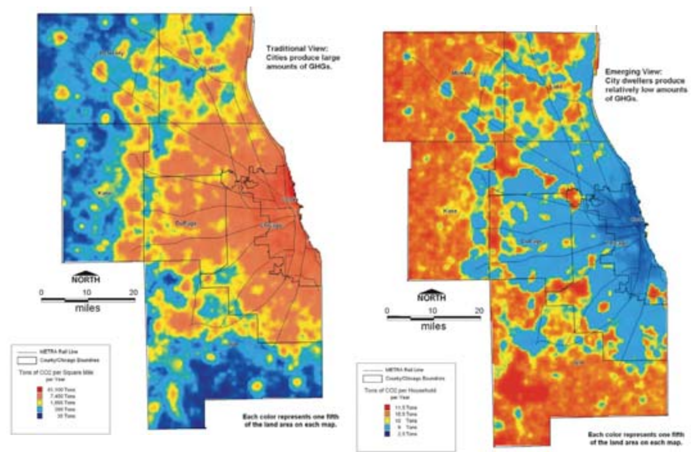

Figure 2. Source: Feigon et al (2003)

åIssues and Conclusion

For those who hope that cities in the developed world can transform to reduce their climate impact, some positive news has emerged in recent years. The process of gentrification is an indication of a renewed desire among affluent people for dense, mixed-use neighborhoods. Other research has demonstrated that American cities are reversing a 50-year trend and becoming denser at the edges. These phenomena demonstrate that we may be moving in the direction of more carbon-friendly cities, at least in the developed world. However, to help achieve reductions commensurate with the scale of the climate problem, practical solutions will need to be found to redesign our cities that are both socially acceptable and environmentally effective. Although a significant body of research has developed around the implications of urban form for energy use and greenhouse gas emissions, the challenge of the 21st century will be to find sensible ways to put this knowledge to good use.

References

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