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Low-carbon cities: Lifestyle changes are necessary

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Abstract

Today, more than half the world's population live in cities, and the UN expect this figure to rise to two-thirds by 2050. Already, cities are responsible for an estimated 70% of global energy use. Cities must cut their energy use in order to reduce greenhouse gas emissions, the Urban Heat Island effect and urban air pollution, and global fossil fuel (especially oil) depletion. Available approaches include shifting to alternative energy, energy efficiency improvements, and energy conservation. We find that although both increased use of renewable energy and energy efficiency improvements are desirable, they will be unable to reduce significantly fossil fuel use by 2050. This is important because many researchers argue that large reductions in oil, and to a lesser extent other fossil fuels, will be needed within the next two decades, because of their mounting energy, monetary and environmental costs. Achieving the necessary large cuts in both fossil energy use and their accompanying emissions will, we argue, necessitate energy conservation, largely though lifestyle changes.

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Keywords: Climate change; energy efficiency; fossil fuel depletion; lifestyle changes; low-carbon cities; transport energy.

1. Introduction

The United Nations has estimated that 52.1% of the 2011 global population lived in cities, and expect that by 2050, this share will have risen to 67.2%, or 6.45 billion people for a population estimate of 9.6 billion [1]. Urban areas are responsible for two-thirds of global energy, a figure that can only rise with further urbanization. Since many OECD nations already have 80-90% urbanization levels [1], OECD urban areas probably account for a similar share of the OECD energy total. Recognising the importance of urban energy use and CO_2 emissions, several 'eco-cities' are being planned from scratch (for example,

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Masdar City in the United Arab Emirates), and many existing cities are taking steps to convert themselves into 'green', 'low-carbon' or 'smart' cities.

We need to distinguish between two possible meanings of the term urban energy: energy release *in* cities and energy use that can be *ascribed* to cities. The first meaning (with energy release ultimately in the form of low-grade heat) is important for urban air pollution as well as the urban heat island effect. This effect, in which temperatures in cities can be several degrees higher than the surrounding region, results from a number of processes [2], including urban heat release. The second meaning is relevant if cities are to reduce their large contributions to global greenhouse gas emissions and fossil fuel (especially oil) depletion. This paper shows why energy reductions through lifestyle changes are needed for cities to have low ascribed carbon emissions.

2. Proposed technical solutions for low-carbon cities

Cities, like countries overall, have several possible options for reducing their carbon footprint. First, they can greatly increase their use of non-fossil sources of energy i.e. nuclear and renewable energy. No great increase in the shares of either nuclear or renewable energy is anticipated by the US Energy Information Administration [3] out to 2040 (see Table 1 for their Reference Scenario). Their nuclear power projection can be considered optimistic, given that nuclear power has been losing share of global electricity output since the mid-1990s [4]. Also, Dittmar [5] has argued that even for an annual nuclear growth rate of only 1%, uranium production will peak in less than a decade. Renewable energy has a much lower energy return on energy invested (EROEI) than fossil fuels [6]. Further, wind and solar, the only sources with large potential, are intermittent, and so for large penetration will need energy storage [7]. This will further lower the net energy output, increasing the cost of delivered energy.

Table 1. Global energy shares in 2010 and forecast for 2040, by fuel type [3]

Energy type	2010 (%)	2040 (%)
Fossil fuels	84.0	77.4
Renewable energy	10.7	14.5
Nuclear energy	5.2	7.0

A second approach is to improve the energy efficiency of all energy using devices—for urban areas particularly passenger and freight vehicles, and space heating/cooling and water heating in buildings. Although there have been large efficiency gains in some areas, particularly in lighting (lumen/watt), overall energy efficiency must consider the entire fuel supply chain, not just the device itself. Heinberg [6] has argued that the EROEI is already falling for fossil fuels, and, overall, will fall even further as we shift to alternative energy sources. Rising inputs for energy production will negate much of the energy savings from improvements to device efficiency. Energy efficiency can often be in conflict with other desired aims such as yield in agriculture (output per hectare) or speed in transport—non-motorized transport is far more efficient than car travel, but much slower [8]; efficiency is also subject to the energy rebound effect [7]. Efficiency gains have not stopped the continued rise in global energy use [4].

Two other technically-oriented solutions, carbon dioxide reduction through carbon capture and storage or reforestation, and global albedo reduction by geoengineering, are often proposed. Mechanical carbon capture and burial is expensive in both money and energy terms. The potential for carbon sequestration in forests and soils to slow global warming is modest at best [8], and may even exacerbate it [9].

Geoengineering could slow or even reverse temperature rises, but could reduce precipitation in critical areas, and would not address ocean acidification. It would also face political risks. Modelling work on energy futures supports the conclusion that neither energy alternatives nor energy efficiency can produce the needed deep reductions in fossil fuel use needed by 2050 [10,11]. In brief, low-carbon cities will also have to be low-energy cities.

3. Discussion and conclusions

Given that technical solutions cannot deliver low-carbon cities within the next few decades, major lifestyle changes will be necessary [12, 13]. How can these changes be achieved? We can gain some insight by looking at those OECD cities which already have lower than average per capita transport or domestic energy use. A more complete measure would be ascribed per capita energy or carbon emissions for different cities, but the needed data is seldom available. Such comparisons show that energy prices are important; petrol, natural gas and electricity prices in the EU and Japan can be as much as three times higher than those in the US [14]. The result is that the former countries' primary, transport, and electrical energy use per capita are only about half the corresponding values in the US. Although deep reductions in energy and carbon emissions could be obtained by very large increases in energy costs (e.g. by means of a carbon tax), large increases would be inequitable, and, at present, politically infeasible. Some rise in energy prices is probably inevitable, but other measures are urgently needed.

Although, at present, in many OECD countries, citizens report concern about energy and environmental problems, their behaviour does not always match these concerns. As Steg [15] has noted: 'People are less likely to reduce their energy use when saving energy involves high behavioural costs in terms of money, effort or convenience.' The example of urban transport shows how energy reduction measures can be tailored to individual household circumstances, as changing travel behaviour is generally regarded as more difficult than other energy-saving behaviour. Some trip types for households are more easily changed from car to lower-carbon modes than others. For instance, short car trips could be readily replaced by walking or cycling, and public transport trips to the inner city will often be just as fast as by car, and will avoid parking difficulties and costs. In other words, efforts to change behaviour should concentrate first on changes with low money, effort, and convenience costs. A similar approach could be used for domestic energy savings, concentrating on high-energy uses like space heating and cooling.

Assuming urban households *are* sufficiently motivated to reduce energy, they need information on possible energy reduction methods and be in a position to deploy them [15]. But as Froehlich et al. [16] point out: 'To maximize information's transformative potential it must be easy to understand, trusted, presented in a way that attracts attention and is remembered, and delivered as close as possible—in time and place—to the relevant choice.' Enouraging such lifestyle changes could benefit from the latest IT developments such as ubiquitous computing. We propose that these changes will require multi-dimensional and innovative interactions between novel system designs and users [17]. Providing sufficient, pertinent and timely information to the user(s) will involve answering the following questions: Who is the user? Where is the behaviour happening? What information is sufficient, and when and how should it be provided? Although information provision presently produces only modest energy reductions [18], 'external forcing' from climate change could change matters. In particular, extreme climate events (e.g. floods, droughts, heat waves) are already increasing in frequency and severity in many regions, and so are being personally experienced by an ever-rising share of Earth's population [12]. Fossil fuel depletion, particularly of conventional oil, will also help change attitudes to energy conservation.

Low-carbon cities will require, not only personal lifestyle changes, but also policy changes at the city and even national level. These interact, since in democratic countries the needed policy changes can only occur if citizens consider energy/carbon reductions as priority issues. The voluntary measures discussed are vital to initiate the transition, but the significant reductions in OECD cities in traffic casualties and air pollution in recent decades largely resulted from legislation for blood alcohol limits, seat belts, speed limits, unleaded petrol, and three-way catalytic converters. Such legislation also forms part of the contextual factors [15] under which behavioural change occurs.

References

[1] United Nations (UN). *World urbanization prospects: The 2011 revision*. UN 2012. Accessed on 9 Dec. 2013 at (http://esa.un.org/unpd/wup/index.htm).

[2] Kleerekoper L, van Esch M, Salcedo TB. How to make a city climate-proof, addressing the urban heat island effect. *Resour Conserv & Recycl* (2012):**64**;30-38.

[3] Energy Information Administration (EIA). *International energy outlook 2013*. Washington, DC: US Department of Energy; 2013.

[4] BP. BP statistical review of world energy 2013. London: BP; 2013.

[5] Dittmar M. The end of cheap uranium. *Sci Total Environ* (2013):**461–462**; 792–798.

[6] Heinberg R. Snake oil: How fracking's false promise of plenty imperils our future. Santa Rosa, CA: Post Carbon Institute; 2013.

[7] Moriarty P, Honnery D. *Rise and fall of the carbon civilisation*. London; Springer: 2011.

[8] Moriarty P, Honnery D. Preparing for a low-energy future. *Futures* (2012):**44**;883-892.

[9] Keller DP, Feng EY, Oschlies A. Potential climate engineering effectiveness and side effects during a high carbon dioxide-emission scenario, *Nature Commun*, 5 (3304) DOI: 10.1038/ncomms4304.

[10] Myhrvold NP, Caldeira K. Greenhouse gases, climate change and the transition from coal to low-carbon electricity. *Environ Res Lett* (2012):7;014019 (8pp)

[11] van Vuuren DP, Stehfest E. If climate action becomes urgent: The importance of response times for various climate strategies. *Clim Change* (2013):**121**;473-486.

[12] Rees WE. Cities as dissipative structures: Global change and the vulnerability of urban civilization. In: Weinstein MP, Turner RE, editors. *Sustainability science: The emerging paradigm and the urban environment*, NY: Springer; 2012.

[13] Moriarty P, Honnery D. Greening passenger transport: A review. *J Cleaner Prod* (2013):**54**;14-22.

[14] International Energy Agency. *Key world energy statistics 2013*. Paris: IEA/OECD; 2013.

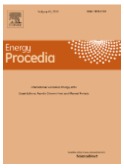
[15] Steg L. Promoting household energy conservation. *Energy Policy* (2008):**36**;4449-4453.

[16] Froehlich J, Findlater L, Landay J. The design of eco-feedback technology. CHI 2010: Home Eco Behavior, April 10–15, 2010, Atlanta, GA, USA.

[17] Wang SJ, *Fields Interaction Design* (FID): *The answer to ubiquitous computing supported environments in the post-information age.* Paramus NJ; Homa & Sekey: 2013.

[18] Delmas MA, Fischlein M, Asensio OI. Information strategies and energy conservation behavior: A meta-analysis of experimental studies from 1975 to 2012. *EnergyPolicy* (2013):**61**; 729–739.

Biography



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