URBAN METABOLISM: LONDON SUSTAINABILITY SCENARIOS

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	'Unsustainable'	**'Towards sustainability'**	**'Sustainable'**
Resource & Land Use	**'Factor 1' ~ 2000** ***Per capita footprint: 6.6 ha*** **= Total ecological footprint ~ 300 x London's surface area**	**'Factor 2' ~ 2015** ***Per capita footprint: 3.3 ha*** **= Total ecological footprint ~ 150 x London's surface area**	**'Factor 4' ~ 2030** ***Per capita footprint: 1.6 ha*** **= Total ecological footprint ~ 75 x London's surface area**
Food	Long distance supply of highly packaged food as norm. Intensive processing. High meat consumption. 30% food waste. Very energy intensive. Only 2% organic, most of this imported. Limited allotment growing and peri-urban fruit and vegetable cultivation.	Reduced long distance supply. Less processing & packaging. Reduced meat consumption. Some food waste recycling. More energy efficient. 30% organic, mostly locally grown 40% UK grains. 50% increase in allotment growing. 40% peri-urban fruit & vegetable supplies.	Regional supply emphasised. Minimal processing. Low meat consumption. Much food waste recycling. Highly energy efficient. 50% organic, incl. use of sewage. 60% UK grains. A further 30% increase in allotment growing. 60% peri-urban fruit & vegetable supplies.
Water/ sewage	Water from Thames & Lea. High flush toilets, etc. No run-off storage. Single household water system. Little sewage recycling.	'Imported' & London water table. Variable flush toilets as norm. Some run-off storage. Efficient household water system. Some sewage recycling.	'Imported' & London water table. Low flush toilets as norm. Substantial run-off storage. Dual household water systems. Routine sewage recycling.
Energy	Dependence on fossil fuels. 18% nuclear. Low building insulation st'dards. Much use of ineff. appliances. Minimal end use efficiency. Minimal renewable energy.	Reduced fossil fuel /more CHP. /some renewable. Improved building insulation standards. More efficient appliances and increased end use efficiency.	CHP/ solar/ wind/ biomass & fuel cells as main energy technologies. High building insulation standards. Common use of high-efficiency. appliances and implementation of high end-use efficiency.
Transport	Emphasis on private transport. Minimal car sharing. Little cycling and walking. Fossil fuel powered transport. Low transport interconnection.	Better transport mix. More shared vehicles. Much cycling and walking. Petrol, electric & fuel cell tr'sport. Good interconnections.	Optimal transport mix. Widespread vehicle sharing. 'Urban village', cycling and walking. Fuel cell & solar-electric transport. Optimal interconnections.
Materials	Wasteful use of materials. Only imported materials. Little product durability. Everything is packaged. Few regional supplies. No regional timber. Unsustainable sources as norm No consumption limitation.	More local and reused materials. Minimal use of virgin materials. Increasing product durability. Reduction in packaging use. Emphasis on regional supplies. Some regional timber. Sustainable sources common. Some consumption reduction.	Minimal waste of materials. Maximise sustainable sources. High product durability. Minimal packaging. Emphasis on local supplies. Regional timber in common use. Shared use of products. Large consumption reduction.
Waste	Linear system. 8% recycling. Little waste separation. Minimal recycling. Most waste disposed in landfills Some incineration. No remanufacturing.	Towards a circular system. 25% recycling. Some waste separation: Reduce, reuse, recycle. Restricted landfill disposal. Minimal incineration. New re-manufacturing industries.	Circular system. 75% recycling. Waste separation as norm: Refuse, reduce, reuse, recycle. Remanufacture of metals, glass, paper & consumer waste into new products has become routine.

The Environmental Sustainability of Modern Cities

Following the economic growth euphoria of the post-war years, increasingly profligate use of resources became the norm in the second half of the 20th century. Cities acquired an essentially *linear* metabolism, with little concern about the origin of resources flowing into them and the destiny of waste emanating from them. This has become a major systemic problem regarding their environmental sustainability. Consequently, dealing with the ever-greater environmental impacts of an urban-industrial civilisation has become one of the great challenges of our time.

Modern cities depend heavily on materials and energy from outside their boundaries. London's per-capita ecological footprint, at 6.6 ha, is lower than that of New York or Los Angeles, at more than 10 ha, but in a world of cities, where American, Australian and European lifestyles are copied all over the world, significant improvements in resource productivity are called for. A particular concern is the huge dependence of modern cities on fossil fuels. But policies to deal with these problems have, more often than not, addressed the *effects* rather than the *causes* of the problem.

Friedrich Schmidt-Bleek, formerly of Germany's Wuppertal Institute, is the originator of the important concept of 'Material Input Per Unit Service' (MIPS). He is highly critical of prevailing sustainability policies: **"**Current environmental policies *cannot* lead to sustainability because they essentially address the output-side of the economy, they do not focus on lowering resource consumption (in fact, they often spawn additional resource investments), they are basically non-precautionary, they attempt to increase the supply of "environmentally friendly" energy and materials and they cause enormous non-market-driven costs that most countries cannot afford."

Schmidt-Bleek is also one of the originators of the Factor 4 concept, and the founder of the Factor 10 Institute, which seeks to define practical ways of significantly improving resource productivity by reducing MIPS in modern urban-industrial systems.

Sustainability Scenarios

The chart above indicates ways of achieving concrete progress towards creating environmentally sustainable cities, with London as the chosen example. Many of the proposals are concerned with MIPS-style up-stream rather than end-of-pipe measures. The necessary changes will need to be driven by a combination of innovative policy and regulation, technological development and behavioural change.

The existing environmental strategies of the Greater London Authority, if implemented, would contribute significantly towards a Factor 2 reduction in resource use. Sadly, there are few indications that the UK government intends to introduce appropriate policies to help London become the exemplary 'sustainable world city' that the mayor wants it to be. Achieving really significant improvements in resource productivity, and creating a truly circular metabolism, are distant goals. However, growing concern about the impacts of climate change on London may speed up introduction and implementations of appropriate policies at city and national levels.

Resource use has to do with *lifestyles* as well as uses of *technology*. Making cities work efficiently requires major changes in both. To create an environmentally sustainable London means reducing its resource use – as measured by its ecological footprint – by a factor of around 4. But often this may require a Factor 10 improvement in the performance of London's engineering systems.

The following paragraphs discuss the London Sustainability Scenarios, as proposed above, in more detail:

Food

Few cities have a food strategy, on the assumption that urban food supplies are provided commercially by supermarkets, street markets and corner shops. But given that around 23% of a household's carbon footprint arises from its food choices, food provision must be seen as an integral part of the process of reducing urban footprints.

London's current food system is probably more global, and less environmentally sustainable, than that of any other city anywhere. Heathrow used to be London's market garden, but now it is the staging post for a large proportion of London's fruit, vegetable and meat imports carried in the bellies of jumbo jets. This highly fossil fuel dependent system is likely to continue as long it is cost effective. Increases in the price of aeroplane fuel, including fuel taxes, will ultimately become a spur to reduce the food miles of London's food system.

London's food waste is another major factor in its profligate food system. Over 30% of food brought into London does not end in human stomachs but on landfills such as Mucking. In a world of potential food shortages this is an unacceptable way of dealing with food.

London is now in the process of developing a food strategy, but it is unlikely to influence food supply and consumption patterns without substantial support from national government policy. Londoners are choosing to eat more and more organic and more locally produced food, but the primary motivation seems to be personal health rather than concern for creating a more sustainable food system.

Water and Sewage

The bulk of London's water originates from the rivers Thames and Lea and from reservoirs around the city. London is notorious for its leaking water pipes and in recent years Thames Water seems to have been able to do little to improve water leakage rates. Meanwhile London's own water table has been rising because a legacy of contamination has made it too costly for it to be used to supply drinking water. Water shortages in dry years such as 2006 are starting to concentrate the mind of decision makers, and additional future demands from a growing population in and around London is likely to encourage more efficient water use. New ways of processing and using water from London's water table may have to be found in the coming years.

Best practice in efficient water use is likely to inform decisions on the uses of new water technology in London and this is likely to include run-off collection, as well as grey water flushing, efficient toilet cisterns, efficient shower heads and other techniques in use around the world. Water metering is also likely to become the norm.

London's sewage is currently transported to large treatment works such as Beckton and Crossness in 19th century sewers. Some decades ago, a proportion of it was used as fertiliser and soil conditioner, but the bulk of it was being dumped in the Thames Estuary. Now most of London's sewage is dehydrated and then burned in an incinerator, with the permanent loss of carbon as well as plant nutrients such as potash, phosphates and nitrates that ought be returned to farmland. As factor 10 thinking becomes more prevalent, it is likely that new, smaller scale eco-friendly sewerage technologies, such as Eco-Machines, will increasingly come into use, with the plant nutrients contained in sewage being used in urban-fringe farming and market gardening.

Energy and Transport

London currently consumes around 20 million tonnes of oil equivalent every year, or two supertankers a week, producing some 60 million tonnes of CO_2. In a world affected by climate change and limitations on the use of fossil fuels, every effort needs to be made to wean London off the routine use of oil, gas and coal.

The most significant advances in engineering for sustainable development are likely to be found in urban energy systems. CHP systems are offer very major opportunities, halving fossil fuel use as compared to conventional power stations. Cities such as Copenhagen, Helsinki and Hanover have shown that CHP, coupled with very high levels of energy efficiency, can offer huge benefits. If wind power is added to the mix, as in the case of Copenhagen where 20% of electricity supply now comes from wind turbines, very significant further reductions in fossil fuel use can be achieved.

In the case of London, the so called London Array, consisting of some 270 3.5 MW off-shore turbines, is intended to supply no less than 25% of London's domestic electricity. The wind farm would be located more than 20km off the Kent and Essex coasts in the outer Thames Estuary. "When fully operational, it would make a substantial contribution to the UK Government's renewable energy target of providing 10% of the UK's electricity from renewable sources by 2010. Based on the current schedule, it is expected that the project would represent nearly 10% of this target. It would also prevent the emissions of 1.9 million tonnes of carbon dioxide each year." www.londonarray.com

The prospects for solar PV are looking increasingly bright. Technical breakthroughs, such as those recently announced by the US/German company Nanosolar, promise to make PV technology cost competitive with conventional power generation in the near future. Nanosolar is currently in pilot production of its paper-thin flexible solar cells in Palo Alto and has started ordering volume production equipment for the new factory in a 100 million dollar investment. Nanosolar says that "the new plant could produce upward of 1 million solar panels every year, enough to produce 430 megawatts of power – nearly triple the output of all existing solar panel manufacturing facilities in the US." www.nanosolar.com

Supported by appropriate "feed-in legislation", as introduced in 15 EU countries, solar energy prospects for cities are vast and hold the promise of delivering factor 10 reductions in fossil fuel-based urban electricity generation and CO_2 emissions.

Prospects for Factor 10 engineering in urban transport are well covered in Hugo Spowers' paper on fuel cell technology. He makes clear that we need to look not only at engine and brake technology but also at materials used for vehicle bodies. In addition, we need to look at the potential for significant reductions in car use. The London congestion charge, together with support for public transport and cycling has been a useful start, but only a start. Much more needs to be done to assure mode switching from public transport to cycling, etc., to enable efficient, flexible journeys.

Materials and Waste

The urban metabolism consists of the entire input of resources used by city people, and their subsequent output of wastes. As suggested above, modern cities tend to have a *linear* rather than a *circular metabolism*. Many materials are used only once and then end up in a landfill. For cities to exist in the long term, they need to function in a similar manner. High resource productivity is the key to the necessary changes.

In nature every output by an individual organism is also an input that renews the whole living environment of which it is a part: the web of life hangs together in a chain of *mutual benefit*. To become sustainable, cities have to develop a similar circular metabolism, using and re-using resources as efficiently as possible and minimising materials use and waste discharges into the natural environment.

In London a start has been made by the creation of bodies such as London Remade. But this is only a first, tentative step. London needs to trawl the world for examples of best practice. Implementation of a policy of efficient materials use certainly involves the uses of new technology. But equally it requires the participation of Londoners in a "culture of sustainability". Steps in this direction will be encouraged by the growing realisation that environmental sustainability is good for generating new businesses and new jobs.

This seminar offers a great opportunity to explore the engineering options for sustainable urban development. Factor 10 reductions in urban resource consumption use look feasible in various sectors. It is important to clarify more precisely were the most significant gains can be made.