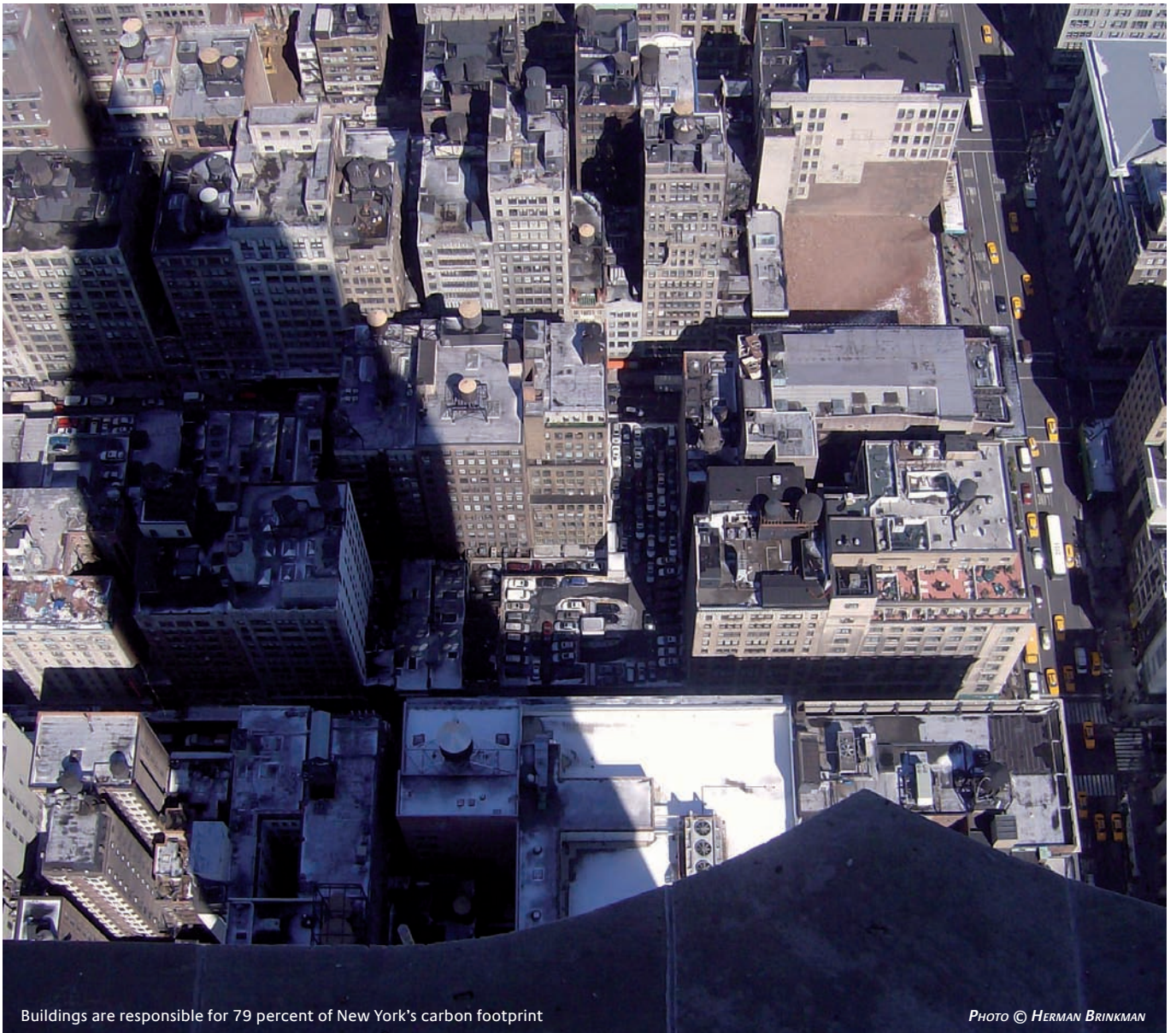


# Smart cities start with smart buildings

Buildings are underplayed in terms of their contribution to emissions with nearly 40 percent of US emissions attributable to buildings compared to just 3 percent for four-wheel drive vehicles. **Ron Dembo** outlines how we must clad buildings to reduce emissions and why changing the occupants' behaviour is key to tackling climate change.



Buildings are responsible for 79 percent of New York's carbon footprint

PHOTO © HERMAN BRINKMAN

The 2009 Copenhagen climate summit has made it clear that we require urgent action on climate change. Scientists calculate that we need to stabilize the concentration of carbon dioxide in the atmosphere at no more than 350 parts per million (ppm) to prevent runaway global warming and its potentially catastrophic impact on our civilization and the natural world as we know it. We are already at 390ppm, and adding to this at roughly two ppm a year.

In other words, we not only have to halt the increase in global carbon emissions, we have to turn the process around, and fast. We have to reduce global carbon emissions by 80 percent or more.

This will take an enormous effort on many fronts. When we look at the major sources of carbon emissions and where the efforts are currently directed, there is one area where we have scarcely scratched the surface, and that is our buildings.

Buildings are responsible for nearly 40 percent of energy consumption and carbon dioxide emissions in the US. Operating them consumes over 70 percent of all electricity generated in the region. The emissions rate is most intense in cities, with buildings responsible for 79 percent of New York's carbon footprint, 73 percent of Hong Kong's, and 52 percent of London's carbon footprint. To put this in perspective, four-wheel drive vehicles count for just 3 percent of emissions in north America.

This comes as news to many people, including environmentalists. Buildings do not immediately come to mind when people think of carbon villains. The reason is that until recently we never measured things like the carbon emissions of buildings, or if we did we certainly never aggregated the measurements in any meaningful way. But once we know this information we cannot ignore it. If we are serious about tackling climate change, we have to do something about our buildings.

### Retrofitting is not enough

So far, the focus has been on new buildings. Hence we have the Leadership in Energy and Environmental Design (LEED) standard in north America, PassivHaus in Germany, Building Research Establishment Environmental Assessment Method (BREEAM) in the United Kingdom and others. These standards are important. They are helping create a new

generation of buildings with the potential for significant energy savings.

I use the word "potential" deliberately, because it turns out that many of these buildings are not delivering the promised carbon reductions. This is because although the infrastructure of the building has been addressed, the culture of use has not – but more on this later.

Only a tiny proportion of our buildings are new and meet modern energy efficiency ratings. Most of our buildings are not only old, they are likely to be with us for a long time yet. For example, over 50 percent of non-residential buildings in England and Wales were built before World War II. Most non-residential buildings built anywhere since then are reinforced concrete structures with an expected life of 60 years or more. This presents us with a massive problem. We have to somehow reduce the carbon emissions of almost our entire building stock. We have to retrofit millions of buildings with energy efficiency measures. You can get a sense of the scale of the challenge if you go to the top of the Rockefeller Centre and look down the avenues of New York. We have to deal with all those buildings, keeping in mind that New York is just one city.

We have some ideas about how we need to tackle the problem. We know we need to insulate and draught proof. We know we need to fit low energy lighting and more efficient heating and cooling systems. A number of such projects are already under way, including a USD 175 million programme in Washington to retrofit 400 government and private buildings. But there are two problems with this approach. The Washington programme is aiming for 25 percent energy efficiency gains. This is a long way from the 80 percent reductions we need. The other issue is that with many of our older buildings it is the structure itself that is the problem.

### Re-skin the tower blocks

Many high-rise buildings and tower block apartments were designed and constructed with little thought for energy efficiency and with a fairly rudimentary understanding of building envelopes. Their outer walls and often their inner cores are reinforced concrete. They have no thermal barrier between their interiors and the outside weather. Their concrete structure captures the heat in summer, so the buildings



Dr. Ron Dembo is the founder and CEO of Zero-footprint, an organization dedicated to a mass reduction in global environmental impact

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need air-conditioning, and it radiates away the expensively generated heat in winter. In energy efficiency terms, they are a disaster.

We cannot knock all these old buildings down and rebuild them to LEED specifications. It would cost trillions of dollars and create an environmental nightmare. So we are going to have to thermally isolate them – by attaching a layer of cladding that will provide an insulating barrier between the buildings' interiors and the elements. We need to give them a new skin.

This 'reskinning' can actually have a number of benefits besides insulation. The gap between the new skin and the old walls could be used to carry the piping, ducting and cabling for retrofitting the lighting and air-conditioning. This would make the retrofitting process much quicker and cheaper. The cladding itself could generate energy if it was made of photovoltaic cells. And finally, if we pay attention to the aesthetics of the cladding materials, the new skins could be used to give our cities, and particularly the vast swathes of utilitarian post-war apartment blocks that blight many skylines, a much needed facelift.

Retrofitting on its own can reduce building emissions by around 25 percent, but combined with reskinning it can achieve 70 percent or more. Now we are getting much closer to our target of an 80 percent reduction in carbon. ▶

## The ZEROprize

The ZEROprize of USD 10 million, the largest architectural prize in the world, will be awarded to the design team able to take an older concrete high-rise structure and, using re-skinning along with other retrofitting technologies, reduce its carbon, water, and energy footprint to net zero while maintaining the highest architectural design standards. The ZEROprize, like the prizes for spaceflight, genomics and other endeavours, is modelled on the Orteig Prize offered for the first non-stop flight from New York to Paris and won by Charles Lindbergh in 1927. These prizes have proved a highly effective way of unlocking the creative ingenuity of engineers and inventors, and seeding significant investment in the solution of difficult problems. The more recent USD 10 million Ansari X Prize for private spaceflight generated USD 100 million of investment. Zerofootprint hopes that the ZEROprize will generate the interest and investment that will result in cost-effective, replicable, scalable, energy-efficient re-skinning materials and methodologies which can be applied to a large number of buildings across the globe, and which will enable us to begin tackling the huge carbon footprint of buildings.

We already know how to do some of this. A number of reskinning projects have already been carried out, although they usually address only one or two of the issues, such as the aesthetics or protection of deteriorating surfaces. Even where we've done it all, it has just been for single buildings, but we need to apply these methods to whole cities. That is why Zerofootprint launched the ZEROprize (see box).

This is just a first step. We can make the infrastructure of buildings zero carbon, but this will be to no avail unless we simultaneously change the culture of their use.

### Don't forget the lights

The Hearst Tower, a 46-storey skyscraper near Columbus Circle in New York completed in 2006, is certified LEED Gold. As its top rating

suggests, its designers went to great lengths to make the building energy efficient and environmentally friendly, including the use of low-emittance glass and high efficiency heating, ventilation and cooling (HVAC) systems.

But when building energy consultant Henry Gifford went by at 2am on July 28 2008 he saw the Hearst Tower lit up like a Christmas tree. For all its good intentions, the building was an energy hog. What is more, when Gifford looked into LEED buildings in general he found that many actually performed worse than comparable buildings with no ratings. This is crazy, and given the urgency of our environmental issues, we just cannot afford it.

The problem, says Gifford, is that standards such as LEED only predict how a building might perform, and do not measure how they actually perform. And this is down to their culture of use.

If we are to cut the emissions from buildings, old or new, by any significant amount we have to change the way people inside them behave. How can we do this? Well, first we have to ask ourselves why the occupants of a building can boast about their LEED certification and then leave the lights on all night? The answer is that the energy we consume and the carbon we produce is invisible.

While the occupants can see the ratings award plaque on the wall as they arrive at the building every morning, they cannot see any measure of the building's actual performance and their own energy use. So the first thing we have to do is make the invisible visible.

### Measure energy use and display it

We already have the absolute energy use measure of buildings. It is their monthly utility bills. But very few people see them. And even if we could, the crude figures would not say anything about whether the building was performing well for its type or not.

Therefore, we need to take these measures and convert them into something meaningful. We suggest converting them to kilowatt-hours per square metre per year (kWh/m<sup>2</sup>/yr). (In fact we suggest three measures: energy as kWh/m<sup>2</sup>/yr, carbon as kilograms per square metre per year, and water as cubic metres per square metre per year to give the full environmental footprint of the building). Once we convert to a common unit, we can then compare one building with another in a meaningful way.



There is evidence to show that just letting people know their energy consumption in more detail, changes their behaviour. A recent project in North Carolina using smart metre and networking technology demonstrated that just by making energy consumption continuously visible to householders and allowing them to make simple adjustments, consumption fell on average by 15 percent, and up to 40 percent in some cases.

There is also much evidence to show that people respond better to relative measures rather than absolutes. If instead of just knowing I consume XkWh of electricity a year, I know that my consumption is twice that of my neighbours (when converted to a common unit like kWh/m<sup>2</sup>/yr that takes into account house size and allows the comparison of like for like) I am more likely to do something about my electricity use. The



Retrofitting needs to be combined with a change in human culture to reduce emissions

PHOTO © MARC MOSS

same applies to buildings. If I know that the office block I work in consumes double the energy of its neighbours I might start to think about how I behave with respect to lighting by turning my computer off at night. Or if I walk into my bank and see a display, which shows me that it is an energy hog, I might start asking questions and demanding some action.

We suggest that as well as giving buildings an energy rating plaque, we need to give them an energy performance display. For this we recommend taking a leaf out of the book of the car industry and give them something like the Environmental Protection Agency (EPA) fuel consumption sticker that you see on cars in the United States. If every building had to display an energy performance sticker we could start to develop some benchmarks. We could compare all

similar buildings in a city – say office blocks, or schools or apartment blocks – and identify the most green and the worst performing.

The EPA fuel consumption ratings for cars not only inform car buyers, they also serve as a policy instrument for government. To improve the overall fuel performance of cars, the US government simply resets the average fuel consumption that a manufacturer's fleet of cars must meet, as President Obama did recently when he raised the US fleet average for cars from 9.4 litres per 100 kilometres to 6.7 litres per 100 kilometres by 2016. If buildings had similar energy consumption stickers, governments could set targets for building performance simply by raising the energy consumption benchmarks.

The introduction of EPA fuel consumption ratings in 1974 sparked a revolution in car design. Thirty years later, the Honda Civic,

for example, was 100 times less polluting. Car manufacturers achieved this by making their vehicles smart. They fitted them with sensors, microprocessors and algorithms to optimise their performance. And they feed all the information back to the driver through the dashboard. Most buildings built today are not much more sophisticated than those built 30 years ago. The gap between the old walls and the new skin on retrofitted buildings could carry the wiring to make our buildings smart. If we made our buildings smarter and fed the information back to the building users, as well as improved their thermal performance, we might be able to reduce their pollution one hundred fold as well.

That really would be a revolution in building performance, and would make a significant contribution to the struggle against climate change. ♦