Carbon Zero: Imagining Cities That Can Save the Planet

by Alex Steffen

Contents

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Acknowledgments

5.

Consumption: Sharing Capacities to Cut Carbon

Very few individual consumer choices we make have much impact on our carbon footprints. A handful—the kind of home we live in, whether or not to own a car—have huge implications. Most, though, are almost meaningless...until we add them together.

Start adding those small consumer choices together and their impact grows. Indeed, those small choices we don't think of, and the bigger choices we rarely think about, sum up to a lifetime of consumption and waste that produces a massive amount of pollution. That's why consumer goods make up our third-largest source of greenhouse-gas emissions. We cannot build carbon zero cities while overconsuming as we do.

When we do grasp the magnitude of our consumption emissions, our reaction is usually to decide we need to use less. If we use less, the thinking goes, we'll waste less. This is a noble response, almost certainly true in our own lives, and generally true in our cities as a whole. The problem is, how to do it? How do we design our cities so we actually use less?

What we know does not work is to ask people to make different choices. Studies show that almost all of us simply lack the attention and willpower it takes to evaluate the options and choose the climate-friendliest product or service every time we want to buy something. To make matters worse, many times we buy things not because we actually want to own those things in particular, but because the systems we use are set up in such a way that buying or going without are the only options. Other things we buy because we're told we need them and don't have the right information to figure out on our own if that's really true. Still others we consume because keeping them out of our lives is harder than getting them and throwing them out (this is true, for instance, with phone books in most cities). If we're going to tackle our consumption-related climate emissions, we need to rethink this whole system, not just ask people to shop differently.

Surplus Capacity

Is our consumption actually making us happier? And I don't mean, does consumerism make us happier? (The answer's pretty clear that in excess it doesn't.) I mean, do the things we buy serve they needs we want them to? Does buying stuff work?

We don't talk about it much, but most of us own a lot of stuff we rarely use. We buy stuff we think we want, and often end up using it once or twice, and then putting it away in a closet or an attic (or increasingly, a self-storage facility—the construction of rental storage units is a booming industry, even in these recessionary times). I would not be surprised at all if middle-class families in the developed world own ten times more stuff, by volume, than middle-class families did in the 1950s.

And that's just what we keep. Most of us throw away a surprising number of objects completely unused, not to mention all the stuff we toss while it's still perfectly useful (giving rise to a burgeoning redistribution industry of thrift stores, online swaps and "wastematching" services, which find users for things we no longer want). Even the stuff we keep, though, we rarely use to anything like its full capacity.

The example I love is the home power drill. Americans, in particular, are in love with their power drills, but millions and millions of power drills have been sold around the world. Apparently, the average home power drill is used somewhere between six and twenty minutes in its entire lifetime. The rest of the time, it sits quietly stored away, gathering dust. Most people buy their drills for reasons similar to the ones I bought mine, to do a task. I wanted to hang some pictures, so I needed to drill some holes in the wall. I had a job to do, and I didn't have the tool I needed to do it. So I went out and bought a drill to make those holes, then found myself with a drill I've used only a few times since, perhaps for a total of ten minutes.

Since my drill took lots of energy and materials to manufacture, to ship, to sell (and now to store), each of my ten minutes of drilling has a big ecological impact. If we think of the total amount of ecological impact I created as one drill's-worth, each minute, we might say, took a tenth of a drill to provide. Yet what I wanted was the hole, not the drill. The climate impacts of owning a drill were, in my case, an unfortunate by-product of what Victor Papanek would call bad hole-making choices.

A well-built power drill can, with proper care and maintenance, deliver thousands of hours of hole-drilling. When I own a drill and use it for ten minutes total, I am letting all those thousands of hours of surplus drilling capacity go to waste; if I used them fully, each minute of my

drilling would take a minuscule fraction of a drill's-worth of impact.

Of course, I just don't have thousands of hours of drilling to do. I don't even own enough stuff to drill that many holes. To drill for thousands of hours, I would need to become a menace to society, surreptitiously drilling other people's stuff, perhaps working at night and leaving my neighborhood pockmarked with hundreds of thousands of mysterious holes. The idea's absurd, of course. But the fact is, most cities likely have hundreds or even thousands of years worth of surplus drilling capacity lying around. If every drill already manufactured was used with perfect efficiency, we might not need to make another one until the twenty-second century. The same is likely true for all manner of tools, from socket wrenches to lawnmowers, beer-brewing equipment to high-quality scanners. We float in an invisible sea of surplus capacity, and wasting that surplus is a major source of greenhouse gases.

The trick, then, revolves around matching that surplus capacity to people's needs in ways that make practical sense. In the case of tools, a number of solutions are already at work in various cities. Neighborhood tool-lending websites are growing popular. Tool rental is becoming common, spreading even to some big-box stores. Tool libraries have sprung up in a number of communities, and most appear successful. It's increasingly easy to make holes without needing to own a drill.

Technology will only make it easier. More and more objects can be fitted with sensors, enabling users to know their location and status. And when you know where things are, and whether or not they're being used, it becomes much easier to share them. This is certainly the case with cars.

Car-sharing has been around for decades, but until the last few years, you had to be pretty dedicated to participate. Mostly, this was because of sheer inconvenience. You had to know in advance when you wanted the car, and write or call in to the service to request a car reservation. Late returns, maintenance issues, breakdowns and the like had to be laboriously noted, communicated via writing and phone calls, then attended to, resulting in frequent "gaps in service," meaning that sometimes, even when you had written in to make a reservation, your car wasn't there when you arrived. None of this was because the participants

were stupid (far from it), but rather because limited technology made it extremely difficult to share effectively.

Today, however, in many cities I can be walking down the street, decide I want to drive somewhere, take out my phone, find the nearest available car-share vehicle on a map, make a reservation, walk over, use a swipe card to unlock its doors, get in, and drive away. Some services will even let me drive that car anywhere I want in the city and park it there, eliminating even the need to return the vehicle. For many urban-dwellers, car-sharing proves easier than owning a car—with car-sharing, you don't have to worry about buying the right car (indeed, you can have your choice of many kinds of cars), keeping up with maintenance or insurance, finding long-term parking, or selling your car when it gets old. It is certainly cheaper, and for someone like me, who lives in a walkable neighborhood and drives only rarely, it is dramatically cheaper.

Ecologically, this is a huge win. If many people share the same fleet of cars, the surplus capacity can be spread out, meaning far fewer cars will serve everyone's needs, and more people can sell the cars they rarely use. Indeed, a pioneering study in London showed that for every car-share vehicle that became available, six people got rid of their cars. More recent studies suggest that in dense urban areas, as many as twenty people may dump their cars for every new shared car in the neighborhood. If those people drive rarely—if they use their cars the way I use my power drill—then the ecological footprint of every trip they make shrinks dramatically when they car-share (and more so if the shared cars are low-emissions vehicles).

The technical term for an arrangement like car-sharing is a "product-service system." An object that once was a product owned exclusively by one person (a car) becomes a service used by a group of people (the right to drive any of a group of cars). We already use all sorts of product-service systems, though we don't think of them that way: a health club turns gym equipment into a workout service; a library turns books into a reading service; even an elite university turns a group of learned scholars into an education service (college educations would be even more expensive if we all needed to hire our own full-time faculties in order to earn a degree).

Collaborative Consumption and Sharing

Product-service systems don't need to be limited to one product. We're seeing an explosion of peer-to-peer lending and rental services now. Some are "collaborative consumption" businesses that connect people that have surplus capacity to rent with people who need it, skimming a small fee off the top. Examples include NeighborGoods (which connects people with tools and other household goods, to borrow or rent) and GetAround (which connects people with opportunities to rent their neighbors' cars). Other services are noncommercial, simply letting people share and trade informally, like CouchSurfing, which connects travelers with short-term places to stay. I predict we'll see an explosion of these person-to-person systems in the next decade, as well as a more general cultural shift that makes it more acceptable to borrow and share casually among friends and neighbors. In many cases, people find that sharing introduces them to new friends and broadens their community: Some people join sharing networks mainly for their social aspects.

These sorts of systems face some challenges, though. One is that many of us are somewhat introverted and experience interactions with strangers as stressful, and in situations where we're already under pressure (say, the whole family is coming over for Thanksgiving and a pipe has clogged), we may simply find it less stressful to get the tools we need in the quickest, least-interactive way possible: buying them. Another is that, even for the more extroverted among us, some interactions require us to place a large degree of trust in strangers. This may serve to restrict the kinds of things most people are willing to share to those things that are comparatively safe and of little value (it's not a big deal for me to lend someone my drill; it's a much bigger deal to let him stay in my home). Some peer-based services may end up suffering the fate of hitchhiking.

Though hitchhiking was once (and may still be) relatively safe, a small number of violent assaults have made it feel like a nonviable means of trip-sharing in the minds of almost all Americans. Sharing services could come to be seen as dangerous as well. One recent scandal involved a woman who rented out her apartment on the short-term rental site AirBnB and then (she said) essentially had her life upended when the renters trashed her apartment, stole her things, and violated her privacy.

Even if such stories represent rare and unlikely events, they may put a serious crimp in the willingness of many people to participate in sharing systems.

This combination of social friction and fear of strangers may, I think, drive more and more of these product-service systems to become restricted to networks of verified members. For many people, having a corporate intermediary (whether for-profit or community-based) is worth the extra cost if it provides a layer of safety and privacy. Far from slowing the growth of sharing efforts, I think intermediated systems will actually throw the whole phenomenon into overdrive.

Opportunities abound here. As we begin to look at our cities through the lens of capacities, rather than ownership, we quickly see the panoply of existing surpluses and a variety of business models to turn those surpluses into services. Some already exist (car-sharing is booming); some are being explored now (everything from shared high-fashion wardrobes to shared workspaces); some remain untested. In every study I know of, these sharing services have been shown to reduce the ecological impacts of the shared products. The unused capacities floating in our cities represent huge opportunities for lowering the carbon footprints of our consumption, while growing thriving businesses and providing new jobs.

And the more compact and people-focused our cities, the better these systems work. After all, if we live in a sprawling city and discover that the nearest drill we can use is a half-hour drive away, we're much less likely to find that a viable alternative than if we live in a compact walkshed and find that the nearest drill is a couple of blocks away, or that we're within the delivery zone of a nearby tool library. And walkshed living adds an extra incentive to using product-service systems. Since our homes tend to be smaller, it costs us more hassle and money to store stuff we don't use very often. Living in a 1,200-square-foot townhouse, for instance, we're much less likely to think it makes sense to keep a whole workshop of tools just in case we might one day want to use them. The more compact your living space, and the denser and more connected your walkshed, and the more it makes sense to share, rent, and buy services instead of buying stuff.

Rethinking Needs

It's one thing to make something and then endeavor to use its capacities as efficiently as possible; it's a brighter thing altogether to invent different ways of living so we don't need the thing in the first place. Not making trumps using well.

To truly reduce our emissions we need to reimagine how things work, transforming the needs in our lives and filling them in new ways. Design can bundle capacities, eliminating the need for many objects. Nathan Shedroff likes to use the example of the iPhone, which has eliminated the need to carry separately a mobile phone, an audio player, a PDA, a camera, a map, a watch, and a host of other small objects (he reminds us that not long ago to look at a lot of images we had to use photo albums and slide viewers, for instance) by combining all those functions into one hand-held object. (Not that an iPhone is a perfect product: It is far from sustainably designed, built by workers in shocking conditions, and designed to be constantly obsolescent. But the same could be said for all the many products it replaced.)

Our cities are full of systems and things that made sense in an industrial era; they're still around because they remain profitable, but they are far from the last word on how things can be done. The way we uses spaces is a telling example.

We are conditioned to think of an office as a discrete place with a variety of spaces (conference room, work areas) that demand their own support systems (like office equipment and receptionists). Thus, if we want to run a professional business, we're led to believe, we need to rent a large office, buy a bunch of equipment, and hire enough support staff to make us look good, even if we don't have enough work to keep them fully engaged. Such a setup is often abundant in surplus capacities, from the unused conference room to the idling copier to the receptionist playing solitaire, waiting for the phone to ring.

Increasingly, though, smart businesspeople are looking for ways to share those surplus capacities. They're co-locating the offices of their businesses, for instance, finding it's much easier (and cheaper) to work in spaces with flexible systems (like moveable walls and adjustable lighting that can be "reprogrammed" to serve a number of needs, from offices

to a lecture hall), while sharing the support services involved, from copy machines to custodial workers. In this way, ten smaller, leaner companies may thrive where one larger, more "professional" company struggled. And because those surplus capacities came with ecological costs, sharing them reduces the carbon footprints of the businesses involved.

The explosion of social software coupon services also demonstrates how people are learning to recognize and manage surplus capacities. These services exist in large part because of the ability of small groups with networked services to find, package, and sell cheaply the surplus capacities of various businesses. Unsold skydiving trips, empty restaurant tables, unused yoga studios—all are essentially worthless to the businesses that have them. When a service makes it cheap to sell these surplus capacities for a small profit (and a large discount to the consumer), the businesses gain more customers, gather marketing momentum, and raise their potential for future profits at little to no cost. This often proves a good deal for everyone involved. I suspect we have only scratched the surface of businesses that arbitrage surplus capacity to make a profit, in part because I think we're only beginning to grasp the true magnitude of surplus capacities in our cities, or the additional capacities waiting to be released by rethinking how we do things in the first place.

It's not about the quality of the mousetrap. The world abounds in "better mousetrap" ideas, many of which are, as Thoreau quipped, "improved means to an unimproved end." Many of our ways of doing things are legacies of an era when information was expensive, and materials, energy, and labor were cheap. We've seen the example of how much more wasteful (and expensive) it is to drive around looking for bargains, rather than going online, finding the best deal, and having it delivered. We've seen the example of smart grids storing surplus power while it's cheap and using it when demand is high. We've seen the example of car-sharing, wherein easy access to information about nearby unused vehicles has transformed the experience of car ownership. All these, though, are mere harbingers of a larger trend.

People are already using old capacities in completely new ways. Take the "pop-up" business. A pop-up restaurant, for instance, involves a temporarily vacant space that a start-up kitchen rents for a limited time

in order to make money feeding people good food on slim margins, build recognition, and grow a patron list. Take the "share front" retail model, where a group of craftspeople, artists, or other producers occupy an empty storefront and sell their work collaboratively, sharing operating costs to a point where small businesses can afford retail presence. For that matter, take the short-notice swap meets (public bartering without the bureaucracy), the rolling speakeasies (unregulated nightlife on the fly), or the popular fitness "boot camps" held in local parks. All of these require physical spaces that are sitting un- or under-utilized, the power of walkshed technologies to gather people quickly, and expertise in quick-starting projects; they use those assets to provide affordable services people want as an entry to business. And as they grow (or fade), jump and move about, merge with other efforts or evolve into new shapes, these businesses bring their customer networks with them, grow those networks, combine and magnify them. Because at the core of these "temporary" businesses is not a service in a space, but a set of human relationships. Having that set of relationships gives them the ability to leverage surplus spaces into profitable businesses...and lower their carbon footprints.

The number, complexity, and capacities of those relationships are exploding in urban cores these days. The trend shows no sign at all of slowing down, in large part because the two things driving it the hardest—new technologies and new urban perspectives—are both still on very powerful growth curves. New abilities generate new potentials, and we're in the early days of a technological revolution at least as big as the industrial revolution. Add enough new abilities together, let them cross-pollinate and accelerate each other, and they generate new realms of possibility.

New Technologies and Adding New Capacities

Our homes may be cluttered with screens and gadgets, but most North Americans have only partially digested the technological revolution of the last twenty years. We still don't quite know what to do with the capacities we already have, how to manage the impacts of all this constant connectivity, or how to define our relationships with coworkers, friends,

and extended family in a world of shifting boundaries and telescoping intimacies. Many of us are confused, uncertain, and a bit afraid. This is particularly true for those who formed their expectations about life before the rise of the Internet.

We've only seen the swell on the horizon, though—the big wave has not yet arrived. Technology is still hurtling forward. Noted technologist Ray Kurzweil predicts that we'll see a billion-fold increase in computation-per-dollar—we might think of this as meaning our machines will work a billion times faster but cost the same—in the next 25 years. Now, I tend to question some of Kurzweil's other predictions, but even if he were, say, 99.9% wrong on this one, the result would still be a million-fold increase. Let's go on to say that as things get more complex and jumbled they demand more processing power to deliver the same amount of perceived benefit. Let's say it takes a thousand times as much computation power: This would still mean computers in 25 years will be 1,000 times more powerful than they are today.

But even focusing on the computers betrays a twentieth-century way of thinking. What's most powerful about technology in an urban environment isn't the engineering sophistication of our digital tools as much as the new abilities they give us to smarten up the dumb physical stuff around us; gain insight through the data about how we use objects, systems, and spaces; and allow social relationships to find new uses for them. The ability to track, monitor, measure, collate, extrapolate, and so on and so forth, means we're beginning to amass vast amounts of data about how things work, how people use them, what things are where in what relationship to each other and in what state. As both augmented reality and small tracking/monitoring chips become more powerful and cheaper, we're gaining the ability to see our cities in ways no human beings ever have seen them before.

Drawbacks of the Digitized City

When contemplating cities suffused with technology, the dangers are immediately apparent. All these data and systems could easily become tools for more repressive political control or (far more

likely in my view) means for corporate influence to penetrate deeper and deeper, extracting profit from parts of our lives that once were private and noncommercial. Indeed, without strong human- and consumer-rights advocacy, our newly digital cities could easily become one step forward and three steps back from a societal perspective. On the other hand, because we are so early in the curve—and because of the excellent work of groups like the ACLU and EFF—we still have the ability to set the political and economic agenda for these systems. If they turn into exploitative nightmares, it will be because we let them. It is completely within our power to choose the opposite.

Addressing another danger—network security breaches—will demand not only more willpower, but also a shift in approach. With the increasing digitization of everything comes a corresponding increased risk in cyber-crime, complex system failures, and simple vandalism. That risk cannot, unfortunately, be met by not changing—our current systems present terrifying vulnerabilities—or by handing responsibility for the problem off to central authorities. The risk can only be met by three strong responses.

The first is open approaches to systems design that allow numerous users to understand those systems and find their weak spots and flaws; software evolved by these approaches has consistently proven more resilient than proprietary, purely commercial competitors, and Jamais Cascio and other leading technology futurists believe these open approaches can be applied across a vast range of systems with similar results.

The second is strong international laws and collaborating legal forces capable of finding and stopping lawbreakers like terrorists and organized criminal syndicates on an ongoing and successful basis. This, we should note, is much more about promoting the stability of fragile states and international rule of law than it is about high-tech espionage.

Third, we should understand when the controls and security systems we need demand people and human relationships, not more algorithms. We've for too long believed that every

relationship can be commoditized and outsourced, and forgotten how critical community cohesion and learning actually are.

We tend to forget, too, how unsustainable our current technologies are. Right now, the entire technology sector is pretty much toxic, climate polluting, and materially unsustainable. Yet this is one area where I am actually fairly confident we can see major progress in the next decade, with breakthroughs in engineering, industrial processes, and product design. Some of the world's smartest people are already at work on this challenge. They just need to work faster.

So, a city of networked systems is no panacea. Built carefully and democratically, however, the digitized city offers powerful new opportunities for emissions reductions.

Smart Urbanism

What can our new insights teach us? If we can reliably incorporate smart technologies into more objects and systems, then we will have many, many times the ability to work with that data to find new opportunities, fine-tune innovations, and model completely new ways to use our systems. And by "we" I don't mean "a few geeks," I mean average, reasonably educated, reasonably skilled people. In just a few years, neighborhood groups, small businesses, school clubs, and activists will have the ability to work with incredibly powerful models at real-life scales in real time. A deeply networked city can offer countless windows of insight we don't currently possess.

Combined with a civic spirit and some design creativity, these insights can make visible the previously invisible. A lot of systems work in ways that are not in the public's interest, that are wasteful of public resources, that privilege rich neighborhoods and powerful users over everyone else, or that simply set default behaviors in ways that channel money from citizens to private interests. (The last is particularly egregious. The litmus test is: If average people had the workings of the system patiently explained to them, would they find the default settings fair, or would they feel they'd been taken advantage of? Most people,

I submit, would be deeply outraged by many of the systems they're currently defaulted into, if they knew their full range of options.)

Networks should reveal their workings. Networked cities that are transparent can make possible better (and fairer) operations of existing systems. They can also launch another wave of urban systems innovation based on rethinking the flow of systems, constantly modifying and improving their operations, and automating routine tasks that previously seemed unmanageable. When computation is cheap and data is open, every part of a city can get smarter.

One example I quite like the idea of is networked rain barrels. Right now, Seattle (like many cities) has a problem with what are euphemistically referred to as "combined sewer overflows." See, every time it rains too hard, and the storm sewers overflow into the wastewater systems, the flooding water ends up washing raw sewage into our nearby lakes and Elliott Bay. This is both an ecological harm and a human health risk. Some systems thinkers at Seattle Public Utilities, though, came up with an interesting proposal. Seattle is already a town where many people are using rain barrels and cisterns to harvest the rain that falls on their roofs for use in their gardens. If those barrels and cisterns are already full when a heavy rain falls, the excess runs off into the storm sewers, where it adds to the flooding problem. If they are empty, on the other hand, they fill up with that rainwater and flooding is alleviated. The problem is timing it so that every heavy rain encounters empty and waiting barrels and cisterns. Well, using the networked systems already being deployed throughout our city, we could wire all those cisterns and barrels with simple switches that would open and release their water on a certain signal from the Utility. That way, when a major storm is coming, the city's cisterns and barrels could release their water when it is safe to do so—before the rain starts falling—and be ready to absorb the new rainfall, keeping it out of the sewers. Given that it is a multi-billion-dollar task to upgrade every storm sewer in the city, even subsidizing these networked rain barrels and cisterns would be cheaper (and, of course, this approach would lower water consumption to a certain degree).

This kind of smart urbanism allows us to take the old, physical, analog systems around us and make them work together in new ways.

We don't need to replace all the physical systems that make our cities possible if we can adapt them to create new capacities. Dumb things can be woven into smart systems, but those smart systems will change the nature of those dumb things.

Recombinant Manufacturing

Key to reweaving the urban fabric is remaking the things within it. I say "remaking" rather than making, because we've already manufactured a lot of the stuff that will be lying around in twenty years, and when it's too expensive to replace that stuff, we'll need to figure out how to get it to work better. Huge volumes of objects in our lives will need to be upgraded, retrofitted, repaired, or reused in some way. Because many urban instantiations are particular, if not unique, reworking them is a job that takes attention and skill: in cities, almost every job's a special order. There are no ubiquitous answers. Each task will need to be approached with new tools, skills, and ways of thinking. That demands a community of innovative re-makers.

The tools are already here. With the advent of cheap design software and personal manufacturing machines, we're seeing a democratization of design itself. Previously, almost all professional-quality design was done for corporate clients or by corporate design departments. This one fact alone limited the field of design possibilities people would likely consider to the very narrow range of products company leaders were interested in exploring. Sure, there were student designers, lone geniuses, a handful of nonprofit design efforts, and rebellious start-ups, but the vast, overwhelming majority of designed things were designed with a corporate client in mind.

Now something else is happening: a culture of making is emerging. Many, many more people have access to the digital tools and the free instruction that allow them to create at home designs that only a few decades ago would have required entire departments of designers, engineers, draftsmen, prototype makers, and so on. With "open source" hardware designs, simple versions of many functional components of products are becoming freely available to incorporate into new inventions. With cheap fabrication equipment, making a working prototype

is a comparatively trivial task. Even small-scale manufacturing is becoming in some cases a garage-workshop affair—printing and fabricating designs downloaded off the Net.

Our minds have not caught up to the implications of this, to put it mildly, but over the next decade or so we're going to see a Cambrian explosion of designs and design thinking whipping up all sorts of new potentialities out of the ether. We'll see the least of it where we're wealthy and more worried about lawsuits than poor design (and the most of it in places where meeting basic needs is still a challenge), but even in the richest cities, "makers" will be rolling out a dizzying host of new answers to the problems of daily life, fresh off their laser cutters and 3D printers and into our lives.

While makers scatter their new solutions across our cities, "re-makers" will be hard at work transforming many of the objects already there. For, as mentioned, even while we reimagine the systems of our cities, many of the pieces of those systems will still be old, pieces for which we'll need to find adaptive reuses. Rethought systems will be working with rebuilt components, in other words. Rebuilding those parts will demand a sense of the interrelationships between objects, and insight into the limits of how much each object can be hacked, tweaked, reshaped, and refitted. The result will be, I suspect, recombinant: We will seek new evolutions of old things, adapted into new purposes in changing systems. The making and remaking of such objects can be thought of as recombinant manufacturing.

Sustainable design, new delivery methods, product-service systems, mutual organizations, and permeable ownership all offer the potential of much lower consumption-related footprints for greater effective prosperity. Recombinant manufacturing brings the possibility of not only creating nearly-carbon-neutral new things, but also integrating old things into new low-carbon systems.

The Death of Speed

When we talk about trade, the debate conventionally breaks down into two sides: one that believes trade will not only grow in volume

but speed, and one that believes energy costs will slow trade to a trickle. Both may be mistaken. The most likely result, it seems to me, is that trade will both grow and slow.

Think of it as "the death of speed." The amount of energy needed to move objects is a function of how much they weigh and how fast we want them to go. Heavy objects take a lot of energy to move, even slowly; all objects take a lot of energy to move very quickly. Therefore, moving heavy objects quickly is incredibly energy-intensive.

Our culture loves shipping heavy things fast over long distances. Think of weekend tropical vacations, overnight over-seas package delivery, or fresh-cut flowers and wild fish flown in from across the world; but also, think about an entire economy locked into just-in-time production methods, low-inventory retail, and so on.

As energy prices rise, and we feel strong pressure to reduce transportation emissions, it will make less and less sense to ship heavy stuff far and fast. That doesn't mean the skies will be completely emptied of jets, or the roads of tractor-trailers. It means flying will become more expensive, as will airfreight and even truck shipping. Things that don't need to be moved fast won't be; lower-speed and more-efficient options will become more common. In fact, rising energy costs are unlikely to change the economics much for commodities that already travel slowly: with global growth, we're likely to see a lot more slow shipping, not less.

According to the experts I've spoken with, it seems very likely we'll see a strong continuation of the trend towards increased investment in freight rail and high-speed passenger rail projects; in energy-efficient marine shipping (including sail-assisted shipping, perhaps); and even perhaps in the resurrection of some old services like passenger ships. We almost certainly will see low-carbon fuels (the airports of the future may smell like burned olive oil) and electric engines powered by clean energy. All of this could mean a sharp drop in the emissions associated with global trade, as well as a change in its nature.

Localized production and repair could gain some unexpected boosts here, similar to the return of manufacturing to the developed world caused by some large corporations' policies of "on-boarding"—requiring that suppliers be distributed geographically overseas and include some domestic production capacity so that if a major disturbance occurs, the whole supply chain won't shut down (like we saw happen after the Japanese quake of 2011, which nearly brought some electronics production to a halt). Metro regions that develop versatile, distributed, clean manufacturing capacities (building on what they have now), could see the death of speed increase demand for their region's goods.

Upskilling

Remaking our cities will demand hard work, lots of it, and one thing missing from many city climate plans is the workers. Fitting our cities together anew is going to demand an outburst of new abilities in workforces that most of American business has left behind. If cities want to change at the pace demanded both by global economics and planetary realities, they will have to intentionally "up-skill" their workforces.

Sure, some have focused on the "green jobs" that change is creating, which is all fine and good. But I think that focus blurs the larger picture: All of the skills it takes to keep a city running need to be upgraded. Every system we change, from pipes to wires to fleets of shared cars, demands first having workers who can build and maintain the new system.

Carbon zero cities can't be built without respecting—and investing in—the workers who will build them. We're talking about a massive practical education task, done with minimal resources, and starting in many cases from essentially no existing institutions or programs. Over the last thirty years the US in particular (but, in general, most of the developed world) has underinvested in—or flat-out dismantled—the vocational schools, union apprenticeship programs, and other educational opportunities that for decades helped unskilled workers join the skilled trades and industries. Now, these programs will need to be reinvented nearly overnight to upskill tens of millions of workers.

I don't know the answer to this problem, except that I suspect it will likely mirror the revolution currently unfolding in American higher education, where skyrocketing tuition costs, outdated instruction methods, and weak job markets have sparked an explosion of reform ideas and do-it-yourself entrepreneurs, who seek to replace the American university with something that more directly (and affordably) meets the needs of more students. I suspect cities that successfully involve their workforces in change will be highly experimental in educating those workforces.

Scenius, Attention Philanthropy, and Incubation

The need for cities to upskill workers is matched by the need for cities to invest in new capabilities in the professions, business and civic culture. "Economic development," in a carbon zero city means something very different than building convention centers, attracting tourists and offering tax breaks for business relocation. It means making the city a hub of new thinking.

New thinking itself gives a city a competitive advantage. Expanding local adaptive capacities—nurturing the ability of our cities' public institutions, businesses, and communities to change quickly—is critical to climate action, but looms even larger when we begin to broaden our scope of concern beyond sustainability. Because ecological concerns, energy problems, and resource scarcities represent only part of the rising tide of change eating away at the beach on which our sense of the normal is built. We must force ourselves to remember that even without the planetary imperative to build a bright green society, the flow of technological innovation, the increased pace of competition due to globalization, and the released energies of billions more people finally able to think beyond the pressing needs of daily survival, would likely wash away everything we're used to thinking of as solid. But the massive challenge of global sustainability pushes those waters higher than ever: the next few decades are likely to be the economic equivalent of a 100-year storm.

The main force of that storm has not yet made shore. No generation in history has lived through the kind of transformations that the young today can expect ahead of them. Even the World Wars pale in

comparison to the planet-wide shifts that are already rolling in, one after another, like breakers on a stormy sea. Like any gargantuan storm, this one will bring tragedy, and plenty of it. This will be most true in places that lack either the resources to adapt or the cultural strength to embrace radical change. They'll get clobbered.

Most cities, though, can choose to invest in the infrastructure of thinking. All but the most gutted have at least some resources to commit. Investing in the ability to innovate would be an extremely smart thing for any of them to do. Even if the sustainability benefits of thriving local design, engineering, and technology cultures were nil— and I don't for a minute believe that's true—promoting better intellectual and cultural infrastructure for thinking about the future is an extremely intelligent basis for any city's economic strategy.

When that infrastructure's working right, we see bursts of innovation coming from three phenomena: incubation, attention philanthropy, and "scenius."

Incubation involves the studied effort to grow useful institutional or entrepreneurial experiments. The mark of successful incubation programs is not making lots of money—that's a by-product. Instead, you can judge incubators by the number of interesting failures or "one-off" successes they spawn. Those are the things that truly expand a city's sense of the possible.

Attention philanthropy is a big term for a simple act: telling people about the stuff you think is cool. These days, when so many ideas compete for our attention, promoting great efforts you know about personally is a form of direct investment. In thriving cities, smart people engage in near-constant attention philanthropy, drawing resources and energy to new ideas and projects from throughout the city.

Scenius happens when incubation and attention philanthropy come together in the presence of the right cultural moment. Scenius is Brian Eno's term for "the intelligence and the intuition of a whole cultural scene. It is the communal form of the concept of the genius." Almost always, the most creative, daring, inventive ideas come not from a lone genius working in isolation, but from a network of innovative people working in close proximity to each other—people who (as Kevin Kelly

points out) value risk-taking work, quickly share new ideas, focus intensely on the products of the combination of those new ideas, and use successes to bring more energy into the scene. Almost always, scenius demands shared locations—places where very different people rub elbows and spark unexpected connections.

The potential for cities to provide the medium in which scenius multiplies can't be calculated in normal terms. A Department of Scenius is probably a bad idea. But it is possible for people who love discussing ideas to find each other, to reach out to other communities of thinking people, get together and see what happens.

Systems Storytelling

I once sat next to a Boeing engineer on a flight out of Seattle. He was a quiet guy, but we got to talking, and he started telling me about the kinds of innovation the aviation industry was seeing. Then he told me something remarkable. Nobody, he said, not one person anywhere, knows everything about all the working parts of a passenger jet. Many engineers know a great deal about specific systems. Other people know how to manage those engineers so that their systems fit together. But nobody could tell you exactly how every part works, how they all are made, and why they were made that way. A system too complex to be understood in its entirety works because of a shared purpose, good information flows, and trust. No one knows everything. The airplane flies anyway.

Civilization is like one of those planes. Nobody understands the whole thing. Because we're so unused to thinking in systems, and because so many of those systems operate largely outside our view, few of us even know the shape of the systems upon which our lives depend, much less all the other more complicated, abstract systems that extend outward from our cities to cover the globe to make up civilization. Yet it flies anyway.

The new urban culture of innovation is revealing to us the workings of systems in cities. It's also revealing the working of cities in those systems. We're seeing that cities are not the streets and buildings found within a set of legal boundaries, but the agglomeration of all

the systems that make life in those cities possible. Our cities and those systems are the same thing.

We are forced, in order to think well about the world, to engage in collaborative thinking across disciplines, fields, and places. We are forced to build models, construct working analogies, and learn to debate systems functions and probable outcomes.

The need to grapple with complexity and interconnectedness as we remake our cities demands more and more facility for telling stories about systems. We require elegance in apprehending complex truths combined with skill in turning models into narratives. We have to be able to share a vision of the kind of airplane we're building, so to speak.

"Systems storytelling" is how urbanites will come to understand the process of building carbon zero cities. In fact, it's an essential twenty-first century civic and journalistic skill: it may be the only thing that truly illuminates how people, in their daily roles as citizens, consumers, and community members, are integral to tackling our planetary crisis.

And, as we will see in the next chapter, the stories of our urban systems need to include nature. Western culture has drawn a line between nature and the city for 400 years. That line was always an illusion. Now, we can't afford to be blind to the reality that urban systems and natural systems are completely intertwined. They are parts of the same metaphorical aircraft.

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