Innovation at the Scale of the City

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"City growth creates problems, and then city innovation speeds up to solve them."

Jeb Brugman
Welcome to the Urban Revolution

Introductory Note

This paper is excerpted from *Net Zero City: How to Overcome the Climate Crisis by 2032: The Ten Year Transformation Plan* by Langdon Morris and Farah Naz. The basic argument of the book is that the climate crisis is an unprecedented emergency for all of humanity, and that our cities must take the lead in shifting to a Net Zero economy. This paper focuses on the process of innovation, and the critical role that innovation will play in the Net Zero transformation in cities globally.

Innovation in the City

It seems that the magical curative powers of innovation are on everyone's mind these days. You'll hear many people saying that, "We need to innovate our way through this." Indeed, innovation in sustainable energy is a powerful market force that has led many coal fired power plants in Britain, Spain, the US, and even India, to shut down permanently, while only a few countries are considering adding new ones.[1] Part of the reason is simple economics: electricity demand during the Covid pandemic dropped, while wind and solar generation have become progressively cheaper. (Which, by the way, is a consequence of innovation.)

Bill Gates, and indeed just about everyone else, agrees about the importance of innovation. In his book *How to Avoid a Climate Disaster*, Gates references the necessity of innovation dozens of times. "We need to start now," he says, "tapping into the power of science and innovation." And then he adds, "Innovation is not just a matter of inventing a new machine or some new process; it's also coming up with new approaches to business models, supply chains, markets, and policies that will help new inventions come to life and reach a global scale. Innovation is both new devices and new ways of doing things."[2] He's definitely right about that. In fact, while we often think of "innovation" as new technologies like the iPhone, we also recognize that social innovation is playing a large part in our transition, as are governance and policy innovations, and economic innovations such as the circular economy framework.

It's also important to note however, that technology cannot save us from bad governance and bad policy, nor can good governance and wise policy save us from destructive economic frameworks. This tells us that it is indeed innovation across the full scope of our complex socio-technical system, including technology, economy, governance, infrastructure, and society, which is now mandatory. So getting extremely good at innovation will facilitate all of these objectives, and thus in this paper we will address the generalized process of innovation as it applies across all domains that make up the city.

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[1]   *The Economist*. "Crushing it." December 5, 2020.
[2]   Bill Gates. How to Avoid a Climate Disaster. Knopf, 2021.
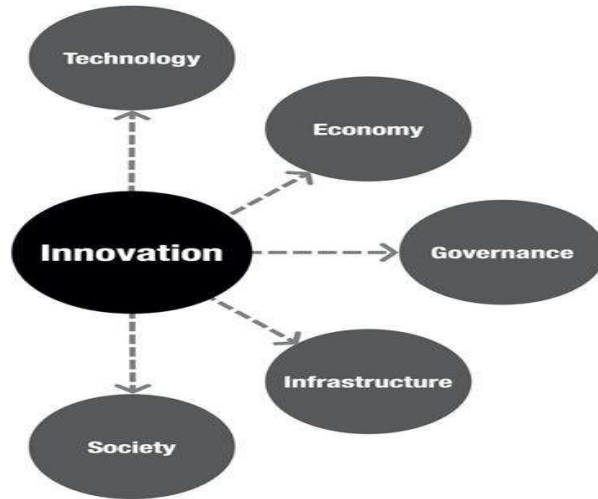
Figure 1. Generalized Process of Innovation

The City: Innovation Catalyst

The history of human civilization, and thus the history of the city itself, can be understood as the history of human innovation. It's certainly also the history of market forces harnessing innovation to bring forth massive changes. The city has been the primary setting and catalyst for the progressive accumulation of knowledge and experience that has resulted in today's global civilization, which provides a very high standard of living for billions of people, increasing life spans, and comforts and entertainments that even kings, queens, and emperors of past eras would envy: cars and jets to travel in, warm homes in winter and cool ones in summer, food in abundance, and endless entertainment on devices that fit in your pocket.

How do cities do this?

Quite simply, Geoffrey West tells us that: "Cities provide a natural mechanism for reaping the benefits of
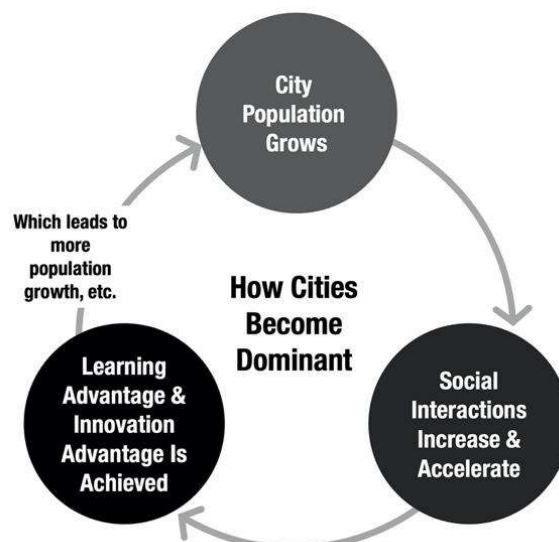
high social connectivity between people conceiving and solving problems in a diversity of ways."[3]
Yes, it is indeed "high social connectivity" that is key, and West goes to note that "the resulting positive feedback loops act as drivers of continuous multiplicative innovation and wealth creation." West also observes that social networks grow as the population of the city grows, so the social system functions within the context defined by the physical structures and infrastructures of the city. As city size increases, the number of these interactions increases, and they also occur faster and faster. This dual acceleration explains why large cities gradually become dominant: they gain a distinct learning advantage that immediately becomes an innovation advantage. As long as they sustain these trends, they continue to grow even more dominant. The only thing that stops them is when, as in the case of Detroit, the local economy collapses, and then the social networks that have formed around the dominant industry also collapse, and decline sets in.

But consider that the online world now melds us all into effectively one global city, and indeed we observe that the scale and impact of innovation is continuing to expand as its speed is increasing everywhere. This is new, and we don't yet fully know how to anticipate what it will lead to, but it's quite likely to be significant. In rather more technical language, West also notes that, "A city is an emergent complex adaptive system resulting from integration of physical resources and energy with human interaction, which give rise to increasing economies of scale, innovation, and economic output. Cities are effectively machines for stimulating and integrating the continuous positive feedback dynamics between the physical and the social." Which is to say, cities are engines of innovation.

Hence the question we pose here:

> How can the city become an even better catalyst for,
>
> and accelerator of,
>
> the search for the innovations
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> that will enable us to achieve Net Zero
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> in time to avert disaster?

Cities do have their great points, interaction and culture and all that, but as we also know very well, our world's cities are not paradise. Wealth is unevenly distributed, and billions of urbanites still suffer from poverty, hunger, and deep insecurities regarding the basics of life. And now, as we now know, there's climate change, which will likely have disastrous impacts on cities. Ironically, then, we are experiencing major side effects from the enormous innovation-driven technological and economic progress of the 20th Century, the fossil-fuel induced global warming which now endangers us all. The brilliant innovations of the fossil fuel age have brought unprecedented wealth and comfort, but now also the deadly side effect.

> And so we are confronted with the challenge of directing our innovation efforts towards
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> mitigation of and adaptation to a changing climate, a global challenge that will be met only
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> through innovation.

There is no other way.
Hence, our collective capacity as innovators will be one of the most important factors determining our collective fate. Success at creating innovations that effectively address climate change will enable us to overcome its damaging impacts, adapt to its rigors, and perhaps even reverse the accumulation of greenhouse gases in the atmosphere.

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[3]   Geoffrey West. Scale: The Universal Laws of Growth, Innovation, Sustainability, and the Pace of Life in Organisms, Cities, Economies, and
        Companies. Penguin Press, 2017.

Optimism and Obligation

Viewed on a global scale, the response to Covid-19 offers reasons for optimism. US National Security Council notes that, "The successful development and worldwide distribution of the COVID-19 vaccine in 2020-21 focused global attention on the importance of scientific research, innovation, and technological development to address emerging global challenges. Networks of research institutes, governmental agencies, nongovernmental organizations, and private corporations operating in OECD countries ramped up information-sharing and developed coordinated approaches for research and development."

And they did so with unprecedented speed.

Deploying our innovation capabilities to address climate change is no longer just an option, it is also a responsibility:

1. **Social and Moral Obligations**
   We must protect ourselves and our fellow citizens from the harm that prolonged and pronounced climate change will cause.

2. **Economic Obligations**
   We must preserve the functioning of the economy upon which nearly everyone depends, so we will have to sustain it while transforming the systems that provide its essential energy, and altering how we manufacture goods and how we consume them. This is roughly equivalent to redesigning and then rebuilding the airplane, while in flight.

3. **Stewardship Obligations**
   And we are responsible for protecting all living species, which are naturally adapted to their various ecological niches, and which may be severely challenged as Earth's ecosystems are altered by the changing climate.

In some industries, the pace of sustainability innovation is already accelerating. As we noted above, for example, while the International Energy Agency had expected solar energy prices by 2020 to be at about $195 per megawatt hour, the actual price was tremendously less, between $30 and $60, and this was of course the direct result of innovation. Bringing the same level of success at innovation to a much wider range of industries means applying it throughout the entire economy. Yes, we must continue to transform energy production, but we also have to address building technology, construction, materials, transportation, communications, agriculture, and chemicals by harnessing the innovation potential that exists throughout the world's public and private sectors.
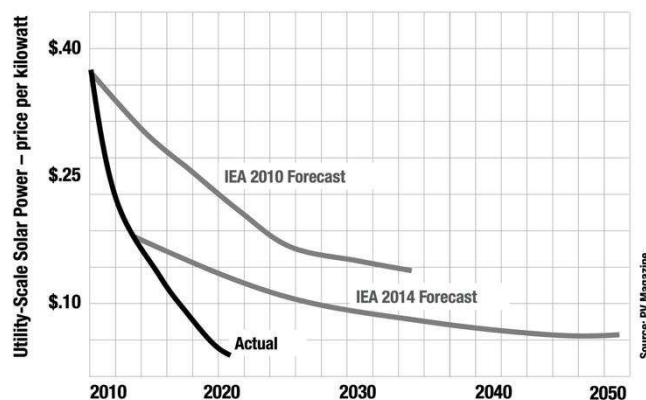
Solar Cost Plummets Decades Ahead of Forecasts

To do so, we'll need to significantly deepen the world's expertise in the process of innovation as we also speed it up enormously. What we require is an approach organized across the entire economy, among all nations, in partnership between public and private sectors, with the public fully engaged, and on an accelerated schedule. This is action on a scale we have never attempted before, scaling up innovation on a global basis.

Mastering the Innovation Process

The innovation process is on one hand very simple, as it's all about trying new things, but it can also be maddeningly difficult. Psychologist Alison Gopnik notes that when you observe young children playing, you're likely to see them make dozens of tests in the space of a few minutes.[225] How high can I build a pile of blocks? What happens if I hit it? Can I make a bridge? What would water do it? What if I throw it across the room? Can I draw on it? And when they see a friend doing something interesting, the quick response is, "Can I try?"

Children are designed for learning, which they do mostly by experimenting. The difficult part of innovation, at least in today's adult world, is mostly due to two factors. One, the increasing complexity of the technologies and systems that we need to change, and two, our chronic (and dysfunctional) fear of making mistakes.

To transform our global energy system, we will accelerate experimentation to accelerate innovation.

Scaling Up Innovation

The global economy of the 20th century was stunningly innovative, and based on its constant stream of innovations, amazingly effective at transforming raw materials into public and private wealth. But it was a fossil fuel economy, and while at the scale of a few million cars and trucks and a few hundred power plants this became a vast source of economic growth and profit, at the scale of billions of cars and tens of thousands of power plants, this has proven to be self-destructive. Therefore the 21st century innovation challenge requires us to transform that very economy.

This challenge is perhaps an order of magnitude more complex than what was achieved in the 20th century, primarily because we no longer have time for it to unfold at its own pace. Nor is it a matter of waiting for innovations to emerge spontaneously from efforts of the private sector. Nonetheless, there are welcome signs of progress, such as Shell Oil's approach, announced in February 2021, which describes its planned transition to cleaner energy. 89% of Shell Oil shareholders voted three months later to back the plan, which includes the intent to reach Net Zero carbon emissions by 2050.[5]
Now the challenge is to replicate this progress across thousands of companies, and in 200+ nations, and to engage billions of people, all at the same time. And for this we require a plan.

The Innovation Master Plan Framework

During the last ten years, a major part of our work has focused on developing an innovation management framework called the "Innovation Master Plan," which addresses the process of innovation in a comprehensive manner. This approach has been adopted widely and is now used around the world in the public and private sectors, and is also being taught in universities and business academies.

The essential principle upon which the framework is based is the realization that any innovation effort, no matter how large or small, must address five essential questions:

1. The linkage between strategy and innovation, which assures that innovation efforts are directed at strategic priorities. **This is the "why" of innovation.**

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4   Alison Gopnik, Andrew N. Meltzoff, and Patricia K. Kuhl. *The Scientist in the Crib: What Early Learning Tells Us About the Mind.* William
        Morrow, 2000.
5   The Economist. "The world this week." May 22, 2021.

2. The careful management of innovation portfolios, a key tool for managing the inherent risks in innovation. **This is the "what" of innovation management.**

3. A fast and efficient innovation process, through which the transformation of uncertainties and questions into ideas, and ideas into value is accelerated. **This is the "how" of innovation.**
4. An engaged group of people who are participating in the innovation journey together. **This is the "who" of innovation.**
5. And the requisite tools and methods that help to overcome any and all obstacles constitute **the "where" of innovation.**

You have immediately noticed that there's also a sixth basic question that we all learned in grade school, the question of "when." But we already know the answer to that one. Because "When?" is "Now."
Let's take a deeper look at all five.

Why Innovate
This question probes the deeper purposes of innovation – why should we undertake this in the first place? Our answer throughout this book is obvious. The "why" question is also a strategy question, as it invites us to consider our broader strategic goals as an enterprise or as a society. Seen in this way, the innovation effort is a means to an end, Net Zero, but not the end itself.

What to Innovate
Innovation always involves taking risk. After all, if we knew the answer already we would instead engage in "engineering" the solution, but since we don't know, we have to innovate, that is, to learn something new. Historically there has been fear of and resistance to innovation throughout the architecture, engineering, and construction industries, in part because of habit and inertia, in part because of cost, and in part because of timeline pressures. Given the urgency of our current needs, these industries now have to embrace innovation and make it a systematic element of every project in the built environment.

This refers, of course, not only to building industry innovation, but to all facets of innovation across governance, society, and the economy, as well as in technology, where the momentum of innovation has been a strong driving force throughout the Industrial Era (and which we discuss in more detail below).
And when we're engaged in such a learning process, the most effective way to do it is to conduct as many experiments as possible in the least amount of time. Some of these will be expensive Experiments, and they will take a great deal of expertise to prepare.

What we therefore do is create an innovation portfolio, a collection of research projects that address various facets of the Net Zero Transformation, and we actively manage that portfolio and each of the projects within it.

The alternative, which is not at all attractive, is to let projects unfold randomly, but that is definitely not a success strategy, nor is it an acceleration strategy.
Portfolio management as we mean it here is a lot like venture capital investing. Venture capitalists are quite particular about where they invest, and many remain heavily engaged in management after making their investments. They're also voracious learners, and they develop huge networks of friends and experts to assure they remain on the leading edge of knowledge in their fields.

And despite all this diligence, a success rate of 20% is considered exceptional, mostly because innovating in modern industry is just so difficult, even for experts. We suggest that active portfolio management is essential if the success rate for innovation in the Net Zero Transformation effort is going to be as good as what venture capitalists can achieve.

How to Innovate
The innovation process is a learning process, and it should be shaped by the best knowledge about learning, and how learning is transformed into new technologies, products, services, and business models. That's perhaps why Einstein is reported to have said, "We call it 'research' because we don't know what we're doing." That is, we have much to learn.

The term "design thinking" is often used to describe key learning steps in the innovation process. This three-step approach as described by our colleague Honey Bajaj[6] begins with the Immersion in the problem or issue, continues on to Inventing possible solutions, and then to Implementing the best through prototyping and testing. There's much more to it, but the key point here is that a disciplined cycle of these three steps often yields excellent results, and consequently it has become standard practice throughout industry, not only for developing new products, but for services and business models as well.

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[6]   Honey Bajaj is Head of Customer Experience & Insights at Tata Digital. She shared this model of Design Thinking with us for inclusion in our recent book The Innovation Formula.
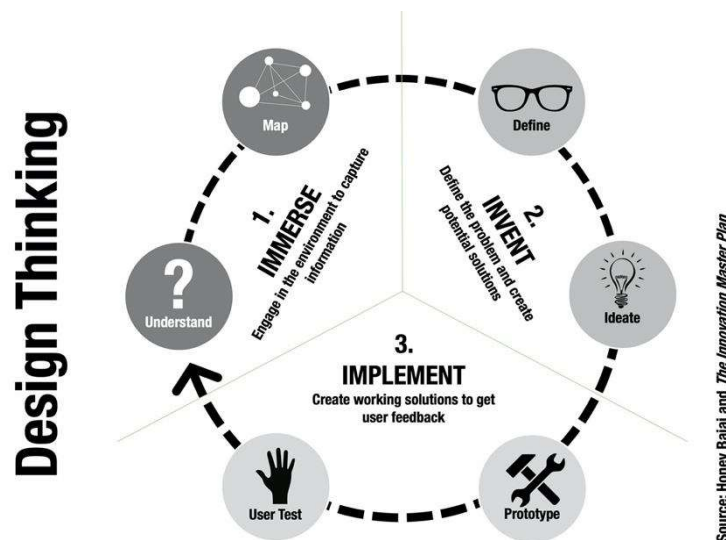
For our purposes, it's important to emphasize that design thinking frameworks provide quite useful guidance for those working on social, economic, and technology innovation, three critical innovation domains for the Net Zero Transformation.

In addition to design thinking, there are dozens of tools that can be applied depending on the type of innovation project, from systematic patent analysis in a process called "TRIZ," to "ethnographic research" into attitudes and behaviors, to the "stage gate" method that is often used for project and portfolio management.

One important motivation to use these tools is that in the final analysis, great ideas are not so easy to come by. In fact, most ideas aren't very good at all, but proficient innovators know that success is partly a matter of quantity – it usually takes working through a lot of so-so and bad ideas to find great ones – and this comes about largely as a consequence of the quality of the process itself. Rigor matters.

Who Innovates

We used to think of innovation as something that occurred in closed and private labs, but recently we've learned that opening up the innovation process can lead to outstanding results. "Open innovation" or "ecosystem innovation" frameworks and tools enable us to engage with people around the world to solve technical and conceptual challenges.

The Net Zero challenge requires essentially all of us to change our behaviors, and therefore, an open Net Zero innovation effort with 7+ billion co-participants will form a meaningful pathway that can contribute significantly to the creation of our shared future. It will, of course, require a significant effort at innovation management to achieve effective innovation at this scale.

Where to Innovate

The tools and infrastructure that enhance innovation can involve physical and virtual innovation labs, innovation management software and dashboards, and learning and training programs to help people improve their skills.

Each element of this framework contributes something important to the overall goal by addressing a specific aspect of innovation practice, and each plays a significant part in achieving success by bringing discipline and rigor to a process that is also open-ended and which requires new discoveries and learnings.

It's also worth considering for a moment what the alternative to a master-planned approach to innovation might be. Without a plan, we would only have a random collection of innovation projects, and

the likelihood that they would provide sufficiently innovative options and solutions is pretty slim. Randomness cannot be expected to add up to satisfying results, and it's certainly not the best option for addressing the climate emergency we now face.

Stated quite simply, cities, regions, and nations should prepare their own Innovation Master Plans to assure that their innovation initiatives and investments are well targeted, *and* well managed. Further, they need to address not only technology and the built environment, but the accompanying social and economic dimensions to assure an integrated, inclusive, and equitable path forward. Indeed, as described by the Carnegie Mellon University Integrated Innovation Institute, technical, social, and business innovation are necessary elements of a holistic approach.[7]

1. **Technical Innovation**
   The process of developing new and/or modifying existing products and services is known as scientific/technological innovation.

2. **Social Innovation**
   Social innovation is research and development into the ways to bring innovation to human scale in specific local and regional contexts. Social innovations can include the creation and implementation of new approaches in the context of health, well being and learning, ethical / social / cultural / legal frameworks, public policy, leadership, human resources and other key components of society that influence health outcomes.

3. **Business Innovation**
   Business innovation focuses on the delivery of appropriate design solutions and services where and when they are needed, at an economical price.

To succeed in their innovation efforts, communities and companies need to develop innovation leaders to nurture these efforts along, and innovation portfolio managers to coordinate across projects, initiatives, technologies, industries, and geographies.

Innovation Assessments

The Innovation Master Plan approach also provides a detailed framework for rigorous Innovation Assessments (or Audits), through which cities, regions, government agencies, and companies, can learn in detail about their current performance and capabilities as innovators, and target effective improvements that will significantly enhance their efforts. These assessments often gather information from a wide variety of sources through interviews, surveys, and research activities. By comparing the findings with the best practices identified by the Innovation Master Plan Framework, areas of strength and weakness become evident, and it becomes clear where the most promising areas are, and where improvement is needed. Assessments can also provide helpful guidance on the right metrics that will be used to track progress and improve performance.

A City's Assessment Findings: The Master Plan

What would a typical city's Innovation Assessment be likely to reveal, and what would its Innovation Master Plan prescribe? Here is a typical outline of themes that an Assessment and Master Plan might reveal:

1. Overall Environment for Innovation: How good is it?

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[7]   Carnegie Mellon University, Integrated Innovation Institute. https://www.cmu.edu/iii/about/index.html

a. Civic Leadership
b. Civic Engagement
c. Private Sector Engagement
d. Key Improvement Strategies
2. Innovation in the Private Sector: What is the Net Zero partnership strategy?
    a. Large company innovation
    b. SME innovation
3. Innovation in the Education Sector: How can we prepare the next generation of innovators?
    a. Primary and Secondary Education
    b. Trade Education
    c. Colleges and Universities
    d. Academic Research and Case Studies
    e. Public Education
4. Innovation in the Investment Sector: Funding the Future
    a. Informal and Angel Investment
    b. Venture capital
    c. Banking
    d. Government Grants and Investment
    e. Sector Specialization and Competitive Advantage
    f. Risk Management
5. Innovation in the Government and Regulatory sector: Policy and Guidance for Net Zero innovation efforts
6. Innovation Specialization and Targets
    a. Where to Focus: Highest Leverage Opportunities
    b. Leveraging Local and Regional Advantages
    c. Electrification and de-carbonization
7. Public Innovation Infrastructure
    a. Incubators, Accelerators, and Hubs
    b. Public-Private Partnerships
    c. Open Innovation Initiatives

Addressing each of these important topics will reveal a great deal about innovation in any city, and provide excellent guidance to accelerate it. This effort will certainly expose many opportunities where innovation successes could make a huge difference, and one of the key focus areas for this, of course, is technology.

Technology Innovation
During the Industrial Era it was the powerful combination of steel, fossil fuels, and entrepreneurship that enabled the global economic boom, and the rapid population growth that accompanied it. In our times, digital technology is shaping the global economy, with its enormous impact on all aspects of our social and economic lives. Digital technology is also shaping the urban milieu, altering the structure and functioning of the city as well as its extensive infrastructure.

Reflecting this shift, a few years ago the pioneering venture capitalist and co-founder of the dot-com era company Netscape, Marc Andreesen, coined the cute phrase "software eats the world." He meant that software technology is becoming so powerful and so pervasive, and the hardware it runs on is so inexpensive, that proficiency in software engineering has become the most critical differentiating factor in

the competitive marketplace. Clearly Andreesen was correct, as the last three decades of digitalization throughout the economy have shown how powerful software can be in the marketplace and the community.

Thus, we must consider the questions,

What role is technology already playing in helping cities to achieve the Net Zero Transformation?

How is technology accelerating our progress?

And what else should we be doing?

Yes, we still depend on all aspects of the industrial system, but we have now surrounded our machines and ourselves with a new enveloping layer of digital information and communications capabilities, and it is the evolution of this digital reality layer that is largely driving change in our lifestyles, behaviors, attitudes, and expectations.

And in our economy.

During the 2020-2021 Covid crisis, society and business discovered an even greater reliance on digital technology. For example, the rapid adoption of remote working technologies demonstrated exactly what many of its promoters had been saying for a long time: that technology would continue to gain importance in our social and economic lives. And one indication of the changing structure of the economy is the response of investors to the new situation. The stock values of many technology companies continued to increase even as many firms in traditional industries have declined. Even oil companies, which used to dominate the ranks of the world's most valuable companies, have lost their luster as the economy continues to evolve.

From the perspective of both urban design and urban management, the increasing role of technology is changing how the city functions, and it's clear that technology will play a huge role in the effort to reach Net Zero. It's also clear that a new tsunami of advanced and highly impactful technologies is about to break across the global landscape, which we call a "perfect digital storm."

The Perfect Digital Storm

According to the US National Security Council, "The next decades will see increasing global competition for the core elements of technology supremacy, such as talent, knowledge, and markets, potentially resulting in new technological leaders or hegemonies in the 2030s. Conditions are ripe for both greater international cooperation as well as new types of multifaceted competition and conflict that could define the coming era." New waves of powerful technologies are now arriving. For example, a new generation of highly capable robots is coming into widespread use, and within a few years there may be as many as 10 hard working robots for each person. Our population of about 7.5 billion people could soon be supported by as many as 75 billion robots, which will be doing all types of work for us, from transportation (self-driving cars), health care (carebots and digital companions for the elderly), warehousing and distribution (Amazon already has thousands of mobile robots working in its warehouses), surveillance (many drones are basically flying robots), and of course manufacturing, which is where robots initially showed their potential to make serious economic impacts – all the major auto companies already use robots for many aspects of the auto manufacturing process, and they are now becoming common in hospitals as well, where some deliver medicine, and others do complex surgeries.

It's a clear benefit when robots do heavy, difficult, precise, or dangerous work on behalf of humans. Further, robots don't get respiratory viruses, they don't require meal or rest breaks, and they are treated more favorably than people in most accounting systems and tax codes, as depreciable assets rather than operating costs. But there's also the distinct possibility that so many robots will displace so many workers, which could lead to massive unemployment and widespread distress. As of now, no one knows, but we

must anticipate significant impact.

Furthermore, robots are just one among many applications of technology that we can expect to have huge impacts, as we can readily forecast the arrival of new and powerful technologies across a wide scope of application types. A partial list includes …

> Artificial Intelligence (AI)
> Big Data and Data Analytics
> Biotechnology
> Blockchain
> Drones
> Machine Learning (ML)
> Robotics
> Satellites
> Self-Driving Vehicles
> Ubiquitous Sensors

Because all of these technologies are arriving at about the same time, the notion of the perfect digital storm seems quite fitting.

The Quantum Era

Another potentially transformative technology is quantum computing. It hasn't arrived yet, but when it does it will likely be very impactful, because quantum technology has the potential to solve highly complex optimization problems that conventional computers are simply incapable of. This will naturally have enormous impact on the management of cities, and particularly on management of urban infrastructure, and could well play a significant role in the Net Zero transformation.

Conclusion

In this paper we have explored the importance of innovation in helping humanity adapt to the climate emergency. Cities, we suggest, should develop their own Master Plans to guide their efforts to attain Net Zero carbon emissions. We have also discussed many of the technology innovations that could contribute to our capacity to understand our evolving situation and respond to it effectively. Humanity will be deeply challenged by the climate crisis, and surely our ingenuity, creativity, and innovativeness will soon be appreciated for the critical role they will play.

Notes
[1] The Economist. "Crushing it." December 5, 2020.
[2] Bill Gates. How to Avoid a Climate Disaster. Knopf, 2021.
[3] Geoffrey West. Scale: The Universal Laws of Growth, Innovation, Sustainability, and the Pace of Life in Organisms, Cities, Economies, and Companies. Penguin Press, 2017.
[4] Alison Gopnik, Andrew N. Meltzoff, and Patricia K. Kuhl. The Scientist in the Crib: What Early Learning Tells Us About the Mind. William Morrow, 2000.
[5] The Economist. "The world this week." May 22, 2021.
[6] Honey Bajaj is Head of Customer Experience and Insights at Tata Digital. She shared this model of Design Thinking with us for inclusion in our recent book The Innovation Formula.
[7] Carnegie Mellon University, Integrated Innovation Institute. https://www.cmu.edu/iii/about/index.html