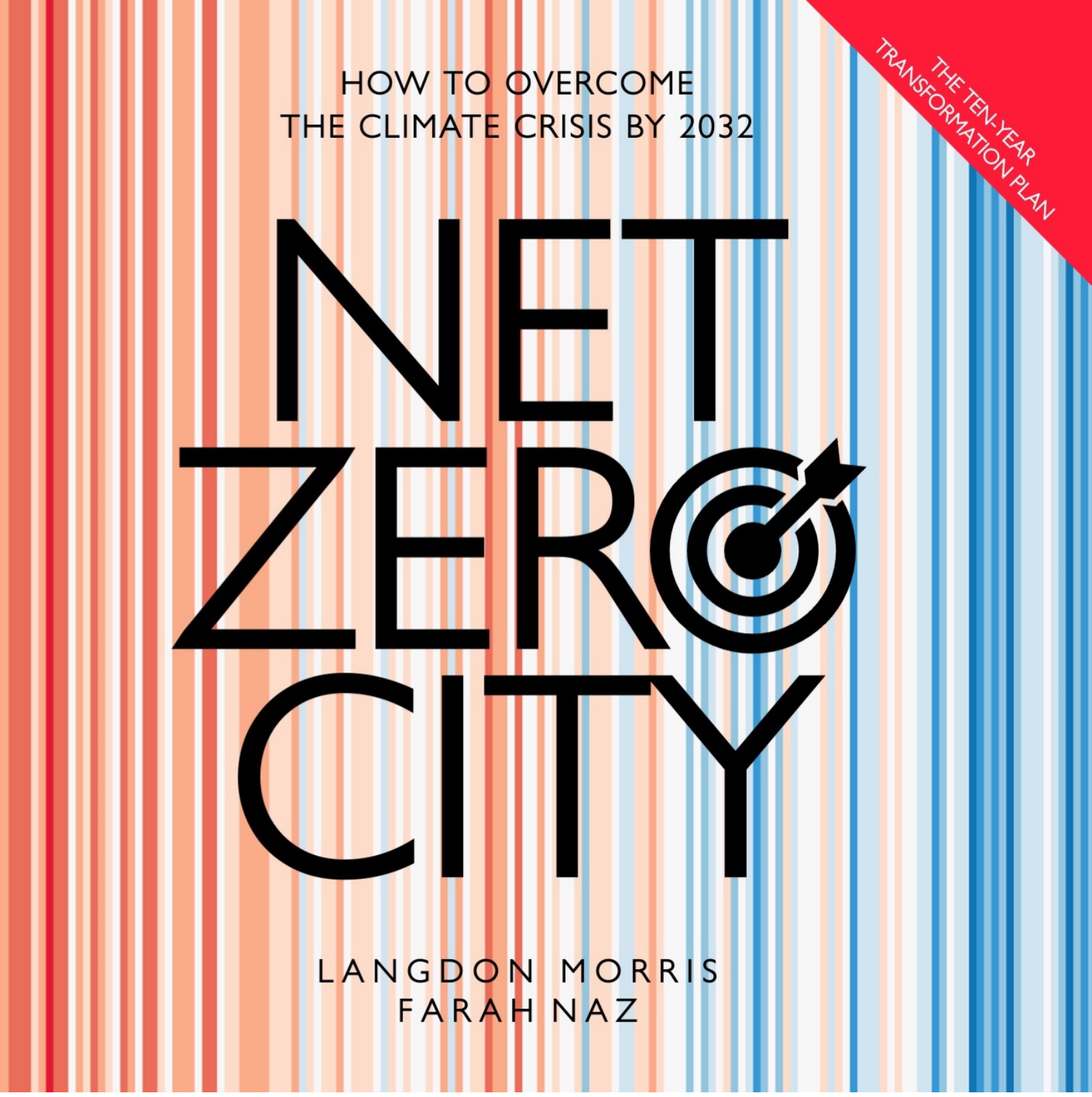

HOW TO OVERCOME
THE CLIMATE CRISIS BY 2032

NET ZERO CITY

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About the Net Zero City Book Summary

This summary version of the book is intended to present many of the main points we wished to convey. It is organized in the same sequence as the book, with a page or two summarizing each chapter. Please remember, however, that in these 20+ pages we are attempting to reflect a book of more than 400 pages, so this extremely condensed version necessarily omits a tremendous amount of detail.

Full Book Contents

Chapter 1
The Urban Innovation Imperative

There is now no doubt that the destiny of humanity lies in our cities. The human population crossed the halfway point around 2010 on our journey toward becoming a fully urbanized civilization, and each day the populations of our cities continue to increase while rural populations decline.

This urban growth is occurring in a time of great turbulence, and due particularly to worsening climate change, the fate of these very cities is now in question. Will they thrive, or will they be overwhelmed by tumultuous storms and bitter droughts brought on by climate change?

Much of the human situation during the next century will be defined according to our capacity to adapt to this new, entirely unprecedented, and frightening set of climate conditions. But in fact we have no choice but to adapt, which also means that we must innovate, and prolifically.

So perhaps it is our ability to innovate that will largely determine our fate. Innovate well and we can survive and thrive; fail to innovate and we are doomed to prolonged suffering and decline.

The necessary innovations will be developed across countless dimensions of modern society. They will involve how we build, what we build, and what we build with. They will impact our systems of food and water, our ideas about a healthy economy, our approaches to governance and decision making, and our use of technology.

And perhaps most of all, they will involve a fundamental change to the energy infrastructure of civilization, both where we get our energy from, and how we use it. CO_2-producing fossil fuels will be replaced by sources that do not produce greenhouse gases, a switch that's going to be expensive and disruptive, which means it's a technological, economic, and social transformation.

But with it also comes a unique and enormous opportunity.

While many have resisted the need to abandon fossil fuels since to them it means sacrifice, in fact the necessity to innovate at this scale, across the entirety of human society, is a very rare gift. We can now focus our efforts on assuring sustainability, livability, equity, and quality of life for everyone. Thus, the **climate emergency** actually offers us the chance to remake critical aspects of our society to be much better than they ever were during the fossil fuel era.

And this transformation will be led by our cities. Cities are the unique milieu where civilization was created, and today they are the innovation catalysts where the transition to a new and sustainable society will emerge to change the world.

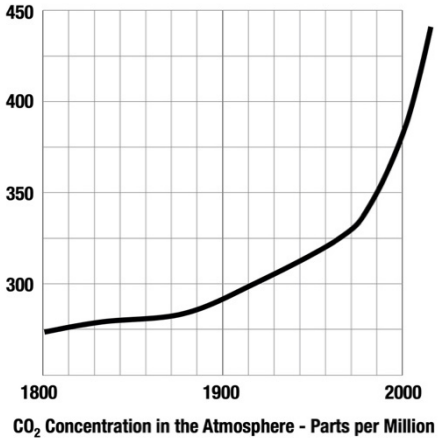
This book is about important interventions, integrations, and innovations, and about how to conceive, design and implement them in a meaningful way for a new or existing city. It offers a Transformation Roadmap for cities, providing multifaceted pathways to overcome the Climate Emergency by attaining Net Zero.

Chapter 2
Net Zero

The global economy of the 20th century was stunningly innovative, and based on its constant pursuit and perfection of countless technological and finance innovations, it was amazingly effective at transforming raw materials into public and private wealth.

It was a fossil fuel economy, and many of the largest companies by revenues and profits were companies whose basic business model consisted of extracting carbon fuels from the Earth, using them to deliver energy, and venting the exhaust gases into the atmosphere. At the scale of a million cars and trucks 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, as we now approach dangerous levels of CO_2 in the atmosphere.

74 quadrillion pounds of CO_2 were released into the atmosphere in 2019 due to human activity.



CO_2 Concentration in the Atmosphere - Parts per Million

Therefore, the 21st century innovation challenge requires us to transform that very economy, and to replace its underlying fossil fuel energy systems. But rather than wrecking the economy in the process, as many have feared, we can instead recreate it to be better.

This challenge is much 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.

We have no time to waste, because the massively adverse impacts of climate change are becoming more evident as they also become more destructive with each passing year. Leaders in science and government have realized that unless we quickly make significant changes to how we live and work, we are tragically destined to endure significantly worse climate conditions than we are presently experiencing. We already have irrefutable evidence that climate change threatens to destroy entire cities on all continents, and to cause massive damage to those that it doesn't entirely wipe out. Horrible floods, punishing storms, exhausting droughts, and massive fires are now daily news, and apparently much worse is soon to come. It is indeed a climate emergency.

Our current systems for living are significant producers of greenhouse gases precisely because of our reliance on fossil-based energy for cooling and heating, transportation, lighting, and the production of goods and services. As all of these activities are concentrated in the world's cities, if we are going to limit the Earth's warming to a tolerable range, we must learn how to limit greenhouse gas emissions being generated by and from our cities.

> C40 Cities tell us: "In terms of size, cities occupy only two percent of the world's landmass. But in terms of climate impact, they leave an enormous footprint. Cities consume over two-thirds of the world's energy and account for more than 70% of global CO_2 emissions. And with 90 percent of the world's urban areas situated on coastlines, cities are at high risk from devastating impacts of climate change, such as rising sea levels and powerful coastal storms."[1]

As a result, we must now develop

new tools
new behaviors
new mindsets, and
new systems for living ....

This presents a civilization-wide innovation challenge – and an opportunity – of the highest order.

The term "Net Zero" describes the goal, which is a building, company, city, or civilization, that produces no net greenhouse gases at all.

Climate scientists have suggested that achieving Net Zero prior to 2032 must be adopted as a global priority for governments at all levels, from neighborhoods to nations, in order to avoid permanent alteration of the climate and a worsening crisis situation for billions of people.[2]

What we therefore require is an inclusive approach organized across the entire economy, among all nations, in full partnership between public and private sectors, with the public fully engaged, and on an accelerated schedule. Eliminating our dependence on fossil fuels and shifting to a Zero-Greenhouse-Gas economy and society requires coordinated action on a scale we have never attempted before. It will also reflect a new social contract between people and the policies that guide their governments.[3]

An Unnaturally Speedy Transition

"Getting to zero requires a much broader approach: driving wholesale change using all the tools at our disposal, including government policies, current technology, new inventions, and the ability of private markets to deliver products to huge numbers of people.

"We have to force an unnaturally speedy transition, which introduces **a level of complexity in public policy and technology that we've never had to deal with before."**

Bill Gates
How to Avoid a Climate Disaster

But how do you change the behavior of a huge and complex system, the cities that are central to an entire human civilization?

This is indeed our enormous innovation challenge, and it is one unlike any that humanity has ever faced. It will require extensive changes to our ways of living, as we are obliged now to completely shift the energy supply of the global economy by inventing a new energy system to power the post-fossil fuel society.

Already more than 2000 municipal, state, and national jurisdictions in 34 nations have recognized this crisis, have declared a climate emergency,[4] and have committed to developing, disseminating, promoting, and especially implementing the strategies, frameworks, technologies, and methods necessary to achieve Net Zero. Organizations including the United Nations, C40 Cities, The International Energy Agency, the International Renewable Energy Agency, The World Economic Forum, The World Green Building Council, the World Resources Institute, Climate Tracker, and many others, are developing precise definitions and tools to facilitate this journey, investors are funding them, and companies and governments are starting to implement them.

As professionals working in this field across the globe, we have observed, however, that most of these efforts have their own particular focus areas and themes. What has remained missing is the critical link between the global-scale vision and the systemic transformation that connects these pieces into a coherent and actionable whole at the scale of the city. What's also missing is the necessary means to accelerate our progress toward Net Zero, because we're running out of time.

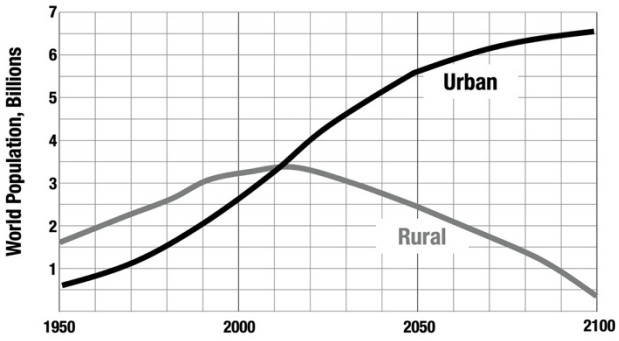
Thus, the purpose of this book is to present a comprehensive Transformation Framework that reaches across many disciplines to provide an accelerated, ten-year roadmap that cities can follow to reach Net Zero.

"There has never been a collective human endeavour more ambitious than stabilising the climate."[5]

Chapter 3
Cities and the Net Zero Transformation

Cities may be the most complex among all of humanity's many inspired creations. They not only tell us about our past, but as the locus of human lives, human aspirations, and now human evolution, they are the containers of our future, profoundly shaping both who we are, and who we may become.

Consider that in 1800, only 3% of the world's total population lived in cities, a total of about 30 million people. Most cities of the 1800s and before served as points of connection and trade between the vast rural expanses and emerging global markets, which is why nearly all of them were located on navigable waterways.



Now there are more than 3.5 billion urbanites, 110 times more. Our cities are still focal points for trade, but due to the totality of globalization, cities more importantly now function as information and knowledge hubs in global economic networks. Or as sociologist Saskia Sassen tells us, "We are seeing the formation of a new urban economy,"[6] and this includes, in the words of British journalist Doug Saunders, "... a complete reinvention of human thought, governance, technology, and welfare."[7]

Current trends suggest that by 2100, about 95% of the total human population of perhaps 8 billion will be living in some sort of urban setting, while fewer than a billion will still be rural inhabitants. Hence, over the course of the next 80 years, the number of urban inhabitants will increase by about 4 billion, an astonishing average of 50 million new urbanites per year.

This accelerated transition from a predominantly rural population to an entirely urbanized one took only 200 years in a process that has entirely remade all of human civilization. The Industrial Era burst of speed, creativity, and innovation is unlike anything else that had ever occurred across all of human history.

Quite in contrast, over thousands of years from the creation of the first towns and cities, and during the millions of years prior to that, change was usually intermittent, and what change did occur was usually confined to events and discoveries in a single place that spread only gradually. But now, suddenly, within the space of two quick centuries, nearly everything about how we live and work is different.

The impacts of all this urbanization in the short, medium, and long terms are only beginning to be understood, but they are undoubtedly fundamental to who we are becoming, and to the critical choices that humanity will face in the coming years and decades. Many of these choices pertain particularly to climate change and the Net Zero Transformation, and will have significant impacts on cities and people, on urban design, infrastructure, economics, governance, and culture, on quality of life, livability, and equity, all of which are the subjects of this book. Individually and especially together, they compose a highly dynamic and complex milieu.

Chapter 4
The Urban System Framework

Cities are profound drivers of both cultural and economic growth because they concentrate resources, expertise, and consumers in a single place. This drives innovation across all sectors, and also leads to abundant economic opportunities.

Cities are centers for business, trade, learning, entertainment, culture, for creativity, social interaction, exploration and discovery, and expression of ideas and possibilities, all in one. Great cities are also places of inspiration.

"Cities exist to eliminate transport costs for people, goods, and ideas."

Edward Glaeser
Triumph of the City

Cities exist because people want to live in them, and they are built according to how they were designed (or mis-designed).

Indeed, most of the qualities and characteristics that we consider to be the deeper expressions of human civilization are enriched in the city, and thus it's no accident that the root of the word city, *civic*, comes from the same word family as the root of the word civilization. The countryside provides food, water, lumber, minerals, and fossil fuels; it is primarily in cities that these are transformed to become civilization.

This does not mean that natural landscapes and spectacular vistas do not evoke inspiration – certainly they do. Nature is as subtle as a waving field of wheat or the vast expanses of the Mongolian steppe, as intense as the rain forest, or as majestic as the Himalaya or the Andes.

But we are not the makers of natural beauty; our focus here is our cities, of which we are the makers. Built by human hands, infused with human genius, according to human intent and human design, they serve as the containers for human society, culture, innovation, and the human economy. Now that we are an urbanized species, cities are the setting for human evolution also.

Whatever humanity is going to achieve through civilization and to become via evolution will be determined henceforth in our cities.

Today we must transform our cities by intention to respond to the climate emergency, an urgent need that's also a big change from their prior, non-directed evolution. This means that we must think and act systemically, which also means that we must understand the **city-as-a-system.** Consequently, **we must have a reliable model that explains in great detail how cities work.** For this we propose the **Urban System Framework**, an approach based on the work of the London School of Economics LSE Cities Center. With this framework we seek to describe the systems that make the city what it is.[8]

The challenge in this is that too much detail will be counterproductive, but too little will leave us missing key perspectives. In seeking the right balance, we focus on five major sectors, two of which are primarily tangible and physical, two of which are quite intangible, and at the center core overlapping the others is the powerful emergent factor that comes about as a result of the other four:

Urban Governance & Policy
Urban Design
Urban Infrastructure
Urban Economics
Urban Culture and Society

Depending on your point of view and your objectives, your preferred model may emphasize or deemphasize particular aspects of the city, so while we cannot claim that this Urban System Framework model depicts universal truths, we have found that it provides us with a useful thinking guide, and as we will see it in later chapters of this book, an action framework as well.

This principle that we must have a good model of the city in order to manage it well is an insight from the discipline called "systems thinking," a field that offers deep perspectives into all sorts of systems, from relatively simple ones like machines and assembly lines, to the extremely complex ones such as cities, organisms, brains, and ecosystems. Our study of systems thinking underlies much of what we write about in this book.

Two key insights from systems thinking are first, the need to examine complexity from multiple viewpoints, and second, to do so over time. Systems thinking not only looks at the micro, but the meso and the macro levels, and at the interconnectedness of all three. It also explores the consequences of our thinking and actions not just right now, but across an overall time continuum, because these interconnections are not static, but dynamic.

Indeed, any system's behaviors generally come about due to **interactions** between the parts, so studying the interactions is critical to understanding what is, and what may become possible. This is a quite different path than from the parts-first view that underlies most analytic approaches.

In cities, both culture and economy likewise emerge from the interactions of all the countless parts and facets, so although we have necessarily organized our thinking about this system by describing it as five essential sectors, we do so only to better understand (and manage) their separate behaviors. Much of our discussion will concern interactions, and the behaviors that result from the integrated urban system.

This is the system through which humanity will address the challenges of climate change, and ultimately link it with the broader process of evolution, for which the city is now the container and catalyst.

Chapter 5
Net Zero Theory of Change

Social scientists teach that if we wish to change the behavior of a complex system such as a city, or change how people in the city behave, we are most likely to be successful if we are guided by a "theory of change." Such a theory expresses an understanding of how change occurs in such a system, and how we can induce our preferred changes to occur. This theory will help direct our focus to wherever we should emphasize our efforts for optimum results, thus helping us to be highly effective change agents.

Conversely, if we lack an effective theory of change then we are condemned to missteps, failed initiatives, wasted time, and in our case, to a much worse climate disaster.

Here we present seven axioms that together describe how we propose to approach the Net Zero change-making process:

1. Structure Wins, which addresses common barriers to change, and explains why this transformation begins in cities.
2. Everything Speaks, which describes the imperative of consistent communications when leading change.
3. Innovation Is Mandatory, concerning the urgent need for new solutions to address our unprecedented climate emergency.
4. The Big Shift, a broad perspective on the general processes of ongoing change that are already occurring throughout society.
5. The Theory of Wisdom, a bit of guidance about the type of solutions we require, and how we will find them.
6. The Urban Twin, a critical tool to help guide the Net Zero Transformation.
7. And finally The Social Dynamics of Structural Change, a general framework suggesting how change really occurs.

To achieve the Net Zero Transformation, our efforts will have to reflect all seven of these axioms.

Urban Governance & Policy
Leadership, participation, and decision making.

Chapter 6
Urban Governance and Policy

As we take heed of the warnings from scientists who tell us that we must reach Net Zero in our cities in the 2030s to avoid a worse or worst-case climate crisis, it's obvious that achieving transformation will require significant changes in how we work and live. We have already discussed how societies change, and here we will look more specifically at the role of governance initiatives that may be needed now. Because ...

> **All aspects of large-scale change inevitably have to do with governance and policy, which is fundamental to how we prepare for the future, and then meet it successfully.**

It's certainly true that crisis itself is a frequent motivator of change, and as the Covid crisis has vividly shown, much can change in a very short time. In contrast with Covid, however, the climate crisis has been a slow-motion drama with roots going back a century. It consisted until recently of mostly incremental and invisible changes that too many people found too easy to ignore. As the era of ignoring is at an end and the era of massive and detrimental impacts has arrived, we will therefore find the determination and the means to facilitate the necessary changes.

Global Best Practices: Net Zero Governance and Policy

Governments play a critical role in promoting and enabling important changes to occur, and achieving the Net Zero vision will certainly require very strong government leadership.

Consequently, the questions we ask here are,

> **What are the necessary approaches to governance, policy-making, and policy implementation that will enable the Net Zero Transformation?**
>
> **How should governments and government leaders be involved?**

Here we share 14 timely examples:

1. From Vision to Policy
2. Coping with Uncertainty with Scenario Planning
3. Civic Engagement and Adaptive Governance
4. Policy Alignment
5. Global Cooperation
6. Carbon Taxes
7. Investment
8. Public Education
9. UAE: Visionary Governance and Leadership
10. Denmark: Leadership for a Green and Sustainable World
11. Focused Governance
12. Engage with Leadership Early On
13. Facilitate Behavioral Change
14. Require Climate Risk Disclosure

Urban Design
Determining the physical forms of buildings, neighborhoods, cities, and regions.

Chapter 7
Urban Design and Master Planning

Urban design and urban master planning are related disciplines that focus on optimizing the forms and functions of the built environment.

Urban design does this at the scale of cities and regions, while master planning considers the project scale concerning specific building sites, districts, and neighborhoods. Both will be important contributors as we transform our cities to achieve Net Zero.

URBAN DESIGN: PHILOSOPHY

> Urban designer Richard Marshall: "The tremendous growth of the world's population (most of which will be in cities) combined with an increasing awareness of the limited capacity of the environment, require a radical rethinking of urban design's engagement. Urban design should be nothing less than a search for new forms of settlement appropriate to the conditions of today. This will inevitably require the abandonment of accepted "conventions" of urban form, patterns and morphologies, and a recalibration of definitions of the city to bring them in line with current realities. Meaning in urban situations is manifest through the social city. **Urban design's role should be the articulation of *meaning* through the provision of a physical structure (and infrastructure) which supports this activity."**[9]

Both urban design and master planning are central to the process of city building, which generally occurs through a prolonged process of negotiation, discussion, conception, design, investment, construction, and reconstruction that takes place across years, decades, and centuries. The development of a city's form emerges as the result of this constant evolutionary process that may involve millions of stakeholders, many of whose interests are often competing and conflicting.

This brings us, then, to some key focal questions:

How do we conceive of, design, and build Net Zero cities, both by creating new ones and by refitting existing ones?

What are the necessary design guidelines and principles that facilitate Net Zero?

Global Best Practices: Urban Design and Master Planning

Urban Design and Master Planning are focused on the overall design and configuration of a city district, an entire city, or a city region. This involves considerations across many dimensions:

The aesthetic dimensions, the ambition to make the city beautiful;

The economic dimension, the ambition for the city to create opportunity and private and public wealth;

The functional dimension, the ambition for the city to operate efficiently; and

Many social dimensions, including promoting health and well-being, equity and equality, and education.

Here we describe many excellent examples of Urban Design and Master Planning efforts that are already contributing to the Net Zero Transformation at three different scales, the building, the district, and the city.

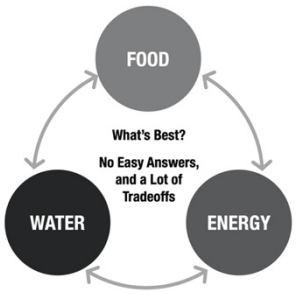
We know that the city needs to change, but to what should it change? These examples give us much to consider.

15. Enact Net Zero Design Standards
16. Design to Scale
17. The 15 Minute City
18. Environmental Management Systems
19. Dubai: Emirate-Scale Master Planning
20. Shanghai: 2035 Urban Master Planning
21. Luxembourg & Boston: Behavior Change by Urban Design Via Free Public Transit
22. Msheriab City: District-Scale Mass Transit
23. Colombia: Community Engagement and Freedom of the City
24. Bicibus Barcelona
25. Paris Plages
26. Qatar: District-Scale Master Planning
27. District-Scale Utilities
28. Lugo, Spain: Urban Ecosystem Services
29. Dubai: World Trade Center, Phase 2, Building Complex Master Planning

Urban Infrastructure: **FEW Nexus**

Chapter 8, Part A: The FEW Nexus

The concept of the Food-Energy-Water Nexus, also known as "the FEW Nexus," is intended to address how these three life essentials are highly interconnected throughout human society. It is being advanced as a new and more effective tool for managing all three in these times of scarcities and environmental challenges. It is especially targeted at managing their complex interrelationships, for as we well know, they are mutually interdependent.



To produce food we of course require water and energy.

Water is also essential for sustaining life, agriculture, and is also integral to energy production.

Producing nearly all types of energy requires water, and producing some energy sources such as ethanol actually reduces the food supply, such as when corn crops are diverted to fuel production.

Since none of these three is independent of the other two, thinking about them systemically is extremely helpful in "normal" times, and now mandatory in our hyper-stressed times. Further, there's no getting around the fact that each of these is a critical and highly complex topic on its own, each is a huge challenge to manage well, and when we consider our moral obligations, an even larger challenge.

The FEW Nexus thus addresses these poignant and critical questions:

In times of scarcity as we now may be entering, what are the allocation priorities for food, energy, and water?

Who decides?

How do we balance the necessities of focus and investment between all three critical areas?

How can we balance the energy needed to produce each of these essentials?

What innovations are required to assure future security?

Finding the right balance of allocation priorities between food, energy, and water, managing the tradeoffs between them, and responding to possibly new levels of scarcity are key issues that the FEW Nexus concept can help us address regionally and globally.

This is a critically important focus now because in addition to the impact of climate change on the availability of the FEW resources, we have also to consider the issue of scale. Today, nearly 8 billion people drive about 1.8 billion cars[10] that pump out still more greenhouse gases every mile or kilometer that they're motoring down the road, and 8 billion of us are currently drawing our essential electrical energy from about 2425 coal-fired power plants around the world[11] that also produce about 15 billion tonnes of greenhouse gases annually.

Global Best Practices: The FEW Nexus

The Food-Water-Energy Nexus addresses complex interactions between these three critical necessities based on the understanding that they are mutually interdependent and that any effort to manage one inevitably involves the other two. Only by looking at all three holistically can we assure that we meet basic human needs.

The broader context in which the FEW Nexus is also relevant is our world of increasing population, continuing urbanization, and destructive climate change. According to the UN Food and Agriculture Organization (FAO), by 2050 the world will need 50% more food to accommodate its growing population, energy consumption will also increase by about 50%, and water requirements will increase by 10%. As demand across all three grows, there will be increasing competition between them.[12]

For example, the FAO also observes that, "Large-scale water infrastructure projects may have systemic impacts, producing hydropower and providing water storage for irrigation and urban uses, but possibly at the expense of downstream agro-agricultural systems, and with social implications such as the need for resettlement."

This leads us to the question,

> **How shall we manage the critical integration of the three basic human requirements, food, energy, and water to attain security for the entirety of humanity?**

Here are 14 fascinating examples:

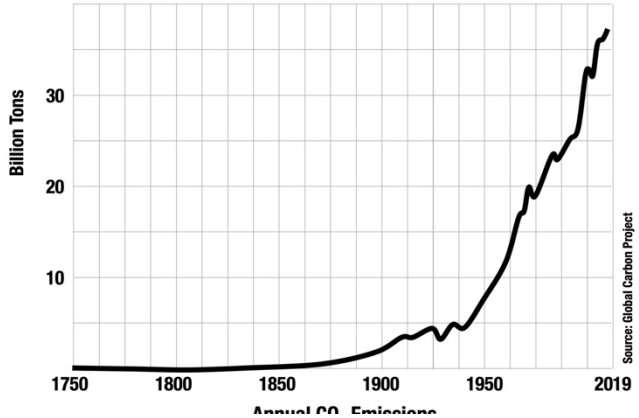
30. The Nexus as a Thinking Tool
31. Nexus Thinking and Managing, 2032
32. The Nexus as an Operational Tool: Data, Metrics, Measurement, and Innovation
33. Scenario Planning and Trade-Off Analysis …
34. … and Facilitation
35. FEW Data Management
36. … and Dashboards
37. Norway: Climate Dashboard
38. British Columbia: Energy and Emissions Dashboard
39. Vermont Community Energy Dashboard
40. UN FAO: Participatory Assessments
41. Gulf Cooperation Council: Food Security Innovation
42. Jordan: Water Security Through Governance Reform
43. Chile: Fog Traps

Urban Infrastructure: **Energy**

Chapter 8, Part B
The Energy Transformation

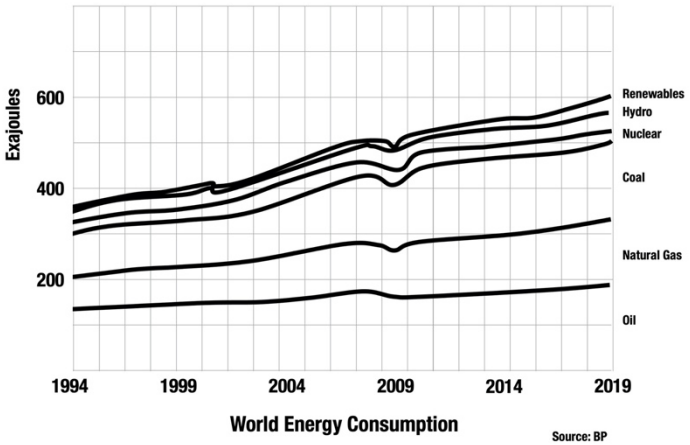
Modern civilization, as experienced through the contemporary global economy, requires huge quantities of energy to facilitate all aspects of modern life.

For the last two hundred years, fossil fuels in many forms have been abundant and abundantly used to meet this increasing need. Global spending on energy in 2020 totaled a tidy US$ 6.3 trillion, and about 83% of the total energy consumed was from fossil fuels.[13]



Global emissions of CO_2 have also increased sharply. From nearly nothing in 1750, emissions increased to about 6 billion tons of CO_2 by 1950, and then leaped in the second half of the century to reach about 30 billion tons by 2000, and now is about 36 billions tons of CO_2 each year.

The British Petroleum report for 2019 shows that fossil fuel consumption of nearly 600 exajoules resulted in the release of 34 billion metric tons of CO_2 (which is 74 quadrillion pounds, or 7.4 x e13), and now that climate change is having a major impact, it's evident that we are obliged to shift away from their use and adopt other sources for the energy we require. This shift, widely known as the "energy transition," is now under way.



At the beginning of the 20th century, more than 90% of global emissions came primarily from Europe and the United States, but as the century progressed and Asia's economies developed, Asian nations have come to emit about 53% of the world's total, of which 27% comes from China.

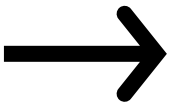
The International Energy Agency, a nongovernmental organization focused on assuring energy security, was established in 1974 to help design a response to the OPEC Oil Crisis. The title of its 2021 report, *Net Zero by 2050,* quite clearly describes its revised objective, to leave the oil industry entirely and reinvent a sustainable energy foundation for society.

Indeed, in its 227-page report, the IEA calls for "a total transformation of the energy systems that underpin our economies." Its warning is clear, telling us that 2021 is the "critical year at the start of a critical decade for these efforts," which must start turning the world's Business As Usual energy system dominated by fossil fuels into a future "powered predominantly by Clean Technology, and mostly renewable energy such as solar and wind." The report also presents a roadmap consisting of more than 400 milestones showing how this transformation should happen over the next 30 years,

including an immediate call for action to end new investment in fossil-fuel extraction towards achieving net-zero electrification by 2040.

Here is a quite pointed statement of the need:

> We are approaching a decisive moment for international efforts to tackle the climate crisis – a great challenge of our times. The number of countries that have pledged to reach net-zero emissions by mid-century or soon after continues to grow, but so do greenhouse gas emissions. This gap between rhetoric and action needs to close if we are to have a chance of reaching net zero by 2050 and limiting the rise in global temperatures to 1.5°C. **Doing so requires nothing short of a total transformation of the energy systems that underpin our economies.**[14]



While the overall message is compelling, we have concerns that the 2050 target date may be too far in the future, as by then it will likely be too late to avert global disaster. Climate scientists are clear that we should be targeting Net Zero earlier than 2050, so our focus here is on defining a Ten Year Net Zero Transformation journey, 2022 – 2032.

Global Best Practices: The Energy Transformation

The essential question with respect to the energy transition is entirely straightforward:

> **How will we transform our urban energy systems away from the current very high reliance on fossil fuels …**
>
> **… to completely different forms of renewable, sustainable energy that is free of greenhouses gases?**

Here are 14 recommendations and examples of successful energy system interventions and transitions:

44. Audit Existing Energy Sources and Uses
45. Set Targets: 10 Year Energy Sources and Uses Forecast and Goals
46. Adopt Policy for the Transition
47. Set Targets: 20 Year Energy Sources and Uses Forecast and Goals
48. Electrify the Economy
49. Engage the Public in the Energy Transition
50. Dubai: Strategy for Net Zero
51. USA Energy Transition Model and Investment Plan
52. Saudi Arabia: Net Zero by 2060
53. Multinational Energy Shift
54. Model Net Zero at the Building Scale
55. Net Zero Best Practice Construction
56. Become “Net Positive”
57. Become “Net Positive” in Water
58. Measure Greenhouse Gases According to ISO Standards
59. Leverage Solar Power Cost Advantages
60. Develop Offshore Wind Innovation

Urban Infrastructure: **Data Science**

Chapter 8, Part C
Urban Data Science

The Ten Year Transformation Roadmap that is the subject of Part 3 covers a vast implementation landscape with a specific focus on cross-sector integration. Within our various sectors and industry silos we may have an idea about what needs to be done, but the linkages across are lacking, and this is what we have attempted to address. Naturally there are many points of overlap, and one of the most significant concerns data, information, knowledge, and analytics.

We recognize that data is now an essential element of the urban infrastructure. However ...

> "Adequate data tends to be the limiting factor on the quality of our estimation, modeling, understanding, decision-making, and prediction. While there is a lot of data about FEW systems, it is often challenging to locate, access, or use. … Fusing data for different parts of the FEW system remains a serious challenge."[15]

And ...

> "Lack of data, limited data interoperability, and data incompatibility are a few of the many data challenges hindering meaningful integration of relevant nexus data. Integrative and interdisciplinary frameworks and models are needed to create compatible datasets, which will then support decision-making, for example, through interactive platforms and maps."[16]

These comments, with the agreement of pretty much everyone else that's in any way involved in the quest to Net Zero, tell us that managing the Net Zero transformation requires that we develop a robust infrastructure for data collection, management, and analysis.

Let us repeat and add a bit to the formulation as we have already stated it above:

Formulation of sound policy is informed by effective analysis ...
And effective analysis can be done only when we have the right data.
So without reliable data, policy is merely guesswork.
Without reliable data and a robust system for collecting and managing it, in other words, we are lost.

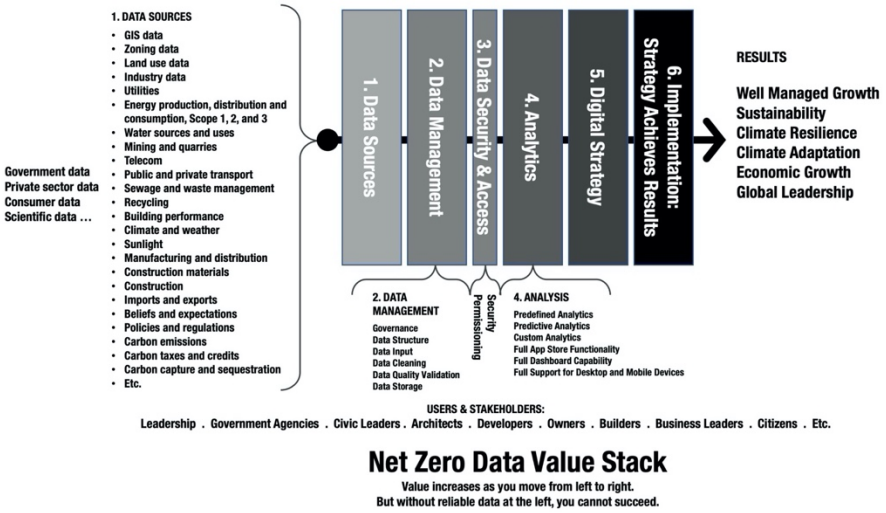
In many cases the data are there, but often they're a random mishmash of scattered collections in incompatible and unconnected formats. They therefore remain mostly inaccessible, even as the sheer volume of data grows by leaps and bounds. Consequently, data management has proven to be a very difficult problem to solve, and over the years the software industry has evolved through three generations of approaches in grappling with it, as described to the left.

Today we're entering the third generation of data management. The focus is on how to get maximum value from data by making it available to the maximum number of people, supported by the most useful tools and formats, so that the data useful not just in hindsight, but also in real time. And with predictive analytics, we can do even better than real time, because we can anticipate future situations and outcomes. You could say, in fact, than in coping with climate change, real time is too late. We have

to know with a high degree of confidence what's going to happen, so we can take proactive measures to protect people, buildings, critical infrastructure, and cities. All of these factors combined will lead to transformational efficiencies for organizations and communities.

The goal is to make the data management system itself nearly invisible, while bringing the tools to create value from data to the forefront. We expect that this will prove to be a critical factor in the Net Zero Transformation.

We have described data as the root enabler of effective policy and decision-making, which helps us to see that there is a clear progression from data collection at its many sources (as listed in the column on the right of the diagram) to data management and then security, followed by analysis, digital strategy development, and then to the meaningful end point, the implementation of strategy through effective action that achieves results.



Net Zero Data Value Stack

Value increases as you move from left to right.
But without reliable data at the left, you cannot succeed.

As noted at the bottom, value increases as you move from left to right, but at the same time you cannot skip any steps, and if you lack solid and reliable data then everything else you want to do becomes moot.

Developing digital strategy without solid data is much like building a house on beach sand – not at all recommended, if you want your house to last! This Value Stack is the model that we are using at Net Zero Urban Twin to facilitate effective data management throughout the Net Zero journey.

Global Best Practices: Urban Data Science

How are data management principles being applied? Here are some very encouraging examples.

61. The Net Zero Data Value Stack
62. Climate Action Tracker
63. Data-Enabled Building Maintenance
64. Digital Twin
65. Smart Utilities
66. The Urban Twin
67. Urban Twin Resilience Framework
68. Net Zero Asset Management
69. Healthy Urban Air

Urban Economics
Creating wealth, taxing it, investing it, and spending it.

Chapter 9
The Circular Economy

A compelling factor that made the economy of the Industrial Era so powerful was the overwhelming abundance it produced: it was an economy of "mass." Mass resource extraction, mass production, mass distribution, mass consumption, and also massive waste.

The most valuable companies of the era were those that scaled to become the biggest – huge oil companies, mining companies, manufacturers, transporters, and retailers. Big was better, and gradually the concept of GDP growth became not just a goal, but a fixation.

The One-Way Economy
A typical modern trash mountain consisting of many tons of waste, here on a one-way trip to the dump, where they will be lost forever.

•••

Buckminster Fuller provided us with a very useful definition of waste when he noted that, "Pollution is nothing but resources we're not harvesting. We allow them to disperse because we've been ignorant of their value."

Barry Farrell
"The View from the Year 2000"
Life Magazine, 26 February 1971

By the 1970s, however, a major transition began to occur, not because of any grand design or government policy, but because of a gradual shift of both mindset and capability away from mass, and towards intelligence. More and more people began to be concerned about damage to the environment, many became interested in quality rather than quantity, and then the computer revolution came along, and began to make things – and eventually everything – smarter and able to communicate. Astute firms paid attention to these trends, and they gradually adjusted their businesses.

These trends were epitomized in a very influential and prize-winning 1982 paper by Swiss architect Walter R. Stahel entitled *The Product-Life Factor,* which presented the idea of an economy based on a circular loop thinking that minimizes energy flow and wastage. Soon thereafter he founded The Product-Life Institute in Geneva to promote this way of thinking and managing.[17]

What has followed since has been what we might think of as a slow-motion sustainability revolution, which has been heavily influenced by a series of books that have developed both the underlying theories and useful practices. A major focus has been framing the major economic transformation of our times: the terminal decline of Industrialism, and the simultaneous birth and maturation of Sustainability.

Nevertheless, twenty years after Stahel, architect William McDonough and chemist Michael Braungart's seminal book *Cradle to Cradle: Remaking the Way We Make Things* presented the idea that instead of making products that were "less bad," the aim should be to make them "100% good."[18] Whereas "cradle to grave" describes an economy that produces endless goods that eventually end up in the landfill, "cradle to cradle" describes a no-waste economy in which the end of the useful life of every product contributes to the birth of the next generation.

It is a radical change for industry as "reduce reuse recycle" becomes fully embedded in all economic activity. Products must be and manufactured from the beginning with reuse in mind, which also means no more throwaway products. Instead, the focus is on reuse, and therefore on durability, adaptability, and quality.

Global Best Practices: The Circular Economy

Realization of Circular Economy approaches begins at the design stage of the built environment, whether the focus is a product, a building, a neighborhood, or an entire city.

Underlying the design of such a Circular Economy approach is a mindset shift, often defined as the transformation away from an "extractive economy" that is organized around devouring vast quantities of nature's materials, consuming them, and creating a huge amount of waste in the process. It seeks instead an economic model based on constant striving to reduce extractive demand on nature's productivity, relying on human ingenuity in reusing and recycling. The Chilean firm TriCiclos states this in a very concise manner:

"Waste is a design error that needs to be fixed."[19]

The MIT Senseable City Lab book *The City of Tomorrow* makes essentially the same point:

"Design must move from the curative to the preventive."[20]

Every city that aspires to become a Net Zero city will most certainly engage in a far-reaching effort to promote a healthy economy and to leverage new economic frameworks in achieving the goal. Cities that embrace circularity embark on a journey that begins with small steps but often ends in a transformation across the entire city's operations. Here we share key steps that cities can take to enhance their efforts on this journey.

70. The Leadership Commitment
71. Follow Pareto …
72. … to the Fourth Industrial Revolution
73. UK: Policies and Guidelines
74. Dubai: Policies and Guidelines
75. Identify Hidden Costs and Subsidies
76. Circular Economy and Policy Effectiveness Audits
77. Circular Economy Business Models
78. Circular Economy Engineering
79. Subsidies …
80. …and Taxes
81. Scale360° Dubai
82. Carbon Capture, Utilization, and Storage
83. Circular Carbon Economy
84. Apply the Circular Carbon Economy Index
85. Design Well to Meet the Challenge of Embodied Carbon
86. Transform the Building Industry
87. Transform the Building
88. Build Sponge Cities
89. Climate Resilience Banking and Insurance
90. Invest in Climate Tech

Urban Culture & Society
How we live together, and how we create culture, innovation, technology, and civilization.

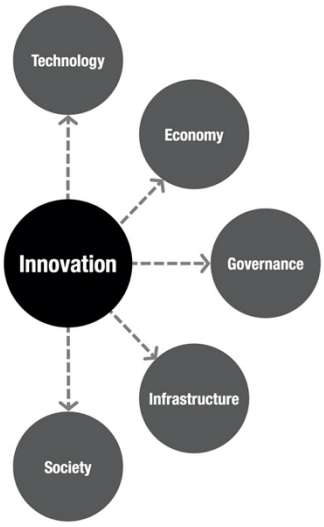
Chapter 10
Innovation at Scale
The Manifestation of Culture

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.[21] 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.)

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

Jeb Brugman
Welcome to the Urban Revolution

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."[22] 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.

And as we have emphasized, the Net Zero Transformation presents an opportunity that only comes very rarely, to bring greater quality of life and equity to our cities at the same time that we remake their structures and infrastructures. The scale of investment, job creation, and redesign that we are embarking upon is indeed unprecedented.

So getting extremely good at innovation will facilitate all of these objectives, and thus in this chapter we will first address the generalized process of innovation as it applies across all domains, and then we'll look more specifically at some incredibly useful innovations in technology and in society.

Global Best Practices: Innovation at Scale

As innovation is indeed a critical factor in achieving the Net Zero Transformation, then we have to get really, really good at it. This raises the questions ...

How shall we manage the process of innovation to guide the search for solutions to our challenging problems in all of the theme

categories, Governance, Urban Design, the Infrastructure, Energy, and the Circular Economy?

And how can we develop greater proficiency in innovation to help solve the physical, technical, technological, economic, social, cultural, and governance problems that we now confront?

Here are 22 compelling examples and useful recommendations that show what innovators are doing to find solutions:

91. Develop Innovation Proficiency
92. Create Innovation Accelerators
93. London: Net Zero Innovation Centre
94. UAE, Saudi Arabia, and GCC Region: Invest in Young Minds
95. Paris: Choose Me
96. Make a Technology Plan
97. Technology 2032 Vision
98. Automate the Urban Metabolism
99. Implement Technology Infrastructure
100. Design Governance and Regulation
101. Social Innovation: Dubai, Shanghai, and Chicago: Enhance and Inform Public Engagement
102. Net Zero Agriculture Innovation
103. Leverage Solar and Wind Power Cost Advantage
104. Transform Urban Transportation
105. Apply Technology Economics: Increasing Returns
106. Make the City Smarter
107. Map Urban Air Quality
108. Monitor Air Quality in Real Time
109. Apply Blockchain in the City
110. Monitor Ecosystems Remotely
111. Apply Machine Learning
112. Discover the “Adjacent Possible”
113. Apply Biomimicry

Chapter 11
The Net Zero Transformation Roadmap

As we were working on the book we discovered a tremendous treasure trove of valuable materials that we have drawn from, as you have undoubtedly noticed as you read through the book, and as you will see reflected in the References and Notes sections. People all over the world are doing great work to address the climate emergency across all aspects of society, and they're sharing a great deal of valuable information in print and on the web.

What we did not find, however, was an overall Action Guide to the necessary transformation. So it seems that as a society, we now have a good understanding of where we need to go, but how we will get there is not so clear at all.

> The IEA Report says it this way: "At present, few Net Zero pledges are supported by detailed policies and firm routes to implementation. Governments need to provide credible step-by-step plans to reach their net zero goals, building confidence among investors, industry, citizens, and other countries. By 2025, all countries should have a long-term CO_2 emissions reduction policy framework in place to provide certainty that the next wave of investment in capacity additions will feature near-zero emissions technologies." [23]

Hence the monumental and burning issue that we must grapple with is the "how" ...

How do we actually get to Net Zero?

How soon do we have to get there?

How do we start this transformation process?

And how do we accelerate our progress?

To address these critical questions, this chapter presents a ten year Net Zero Transformation Roadmap. Why ten years?

> The UN Environment Programme's Emissions Gap Report 2021 finds that annual greenhouse gas emissions need to almost halve by 2030 to limit global warming to 1.5°C, but the updated Nationally Determined Contributions (NDCs) under the Paris Agreement are still insufficient. The Report shows that new or updated NDCs and other mitigation pledges for 2030 give a 66% chance of the world hitting a global temperature rise of 2.7°C.[24]
>
> Thus, to keep global warming below 1.5°C this century, the world needs to urgently put additional plans and action in place to almost halve annual greenhouse gas emissions in the next eight years.

Eight years from the date of this Report is 2030, and thus, our working premise is that if the world's cities were to achieve Net Zero by 2032, ten years from now, this would meet the Report's requirement, and prevent further warming later in this century.

ROADMAP THIS PAGE

Chapter 12
Conclusion: Reaching Net Zero

> "The future does not wait for the hesitant people.
> The more we achieve, the more we realize
> how much more we can achieve.
> We may not live for hundreds of years,
> but the products of our creativity
> can leave a legacy long after we are gone."
>
> His Highness Sheikh Mohammed bin Rashid Al Maktoum
> Prime Minister, UAE[25]

> "When we build, let us think that we build forever.
> Let it not be for present delight, nor for present use alone.
> Let it be such work as our descendants will thank us, and let us think, as we lay stone on stone, that a time is to come when those stones will be held sacred because our hands have touched them."
>
> John Ruskin[26]

Include, Integrate, and Innovate

Climate change is one of the most significant and pressing existential threats of our era. Covid 19, the epidemiological disaster, adds an additional layer of complexity to our already bulging portfolio of looming challenges, environmental, technological, and human-made.

Around the world, policy makers, city officials, and healthcare professionals are properly focused on relieving the profound social and economic distress caused by the pandemic, and in many places they are also addressing stresses that the climate emergency is already causing. Looking ahead, it's clear that there is worse to come.

Meanwhile, the broader process of change continues. At current rates of growth, an additional 2.5 billion people will be living and working in urban areas in the coming decades. This demand can only be accommodated by building the equivalent of a new city the size of Paris each week between now and 2050. By then, however, climate scientists tell us that nearly 1000 cities will regularly experience punishing temperatures in excess of 35 degrees Celsius.[27] (95° F)

As we have noted above, the UN Environment Programme warns that unless major action is taken to cut CO_2 emissions by 50% in the decade of the 2020s, the average global temperature is likely to surpass the level of 1.5°C rise above pre-industrial times, which will be disastrous for billions of people.[28] And UN leader Antonio Guterres has said that mistrust between nations and lack of adequately ambitious goals threaten to make the situation even worse.[29]

Thus, we have reached the point where it's mandatory for us to re-think our definition of success as a global society, as a collection of 200+ nations, and inhabitants of 10,000 cities. We have to abandon our business-as-usual approach and set new goals driven by the by-now very clear climate science, and by the commitment to preserve and protect the health and wellbeing of all citizens everywhere.

The Net Zero Transformation Roadmap presented here is intended as the start of a new way to prepare our mindsets and our cities for a healthy future. The Roadmap shows how we can adopt an integrated systems thinking approach, backed by science, supported by data, and etched by human ingenuity, to rise up to meet the challenge of climate change.

To Shape the Future

> **We are all stakeholders in these discussions, and this is our opportunity to co-create a new normal.**

A multidimensional, integrated approach can enhance our resilience at this critical time, and facilitate a broad social transformation across many critical elements of global society.[30] This book issues an open call for action for the global community to rise up to the challenge, and shows how we can choose a new way of thinking and doing.

This is a time for cross-societal, cross-cultural, and international collaborative action to shape the Future. This is the opportunity to Include, Integrate, and Innovate to co-create the future we want.

Indeed, the scope and complexity of the climate challenge requires aligned, collaborative action on a global scale. Top-down, nationalistic, siloed approaches have failed, and this is the time instead for leaders to be courageous and embrace out-of-the-box ideation, backed by science, supported by evidence, and envisioned by human genius.

No single country, business, or individual can mastermind the prevention of, response to, and recovery from the climate emergency. We must do it together.

The work to be done involves the use of existing technologies and the creation of new ones, a challenge of innovation and of leadership. Recent evidence, and many of the examples included here, have shown that governments can empower and support businesses and entrepreneurs to prove their concepts, adding welcome tools and techniques to our inventory of Net Zero resources.

We must be courageous and commit ambitious levels of resources – both financial and human – to the challenge. We must test ideas, learn from the failures, adopt successes, and move on quickly without prejudice.

How to Behave in an Emergency

Indeed, the response to Covid showed that we can act coherently and decisively when we recognize that a crisis is upon us. We literally innovated our way (nearly) out of that crisis.

The climate emergency demands the same of us now. Unlike Covid, however, it has been a slow-motion crisis, harder to recognize, and easier (until now) to ignore.

Massive change is already occurring globally in addition to the climate crisis – the technological revolution continues, the energy transition has begun, major demographic changes are in motion, and the economic change marking the end of Industrialism and the arrival of whatever is next is upon us.

Industrialism created unimaginable wealth, but it did so at a cost that was unrecognized and unpaid. Now we have to pay that cost, and we will pay in two ways. The costs of enduring, surviving, and adapting to the climate emergency will be

massive. And the cost to transform the energy systems that power the economy and its cities will be massive as well.

But neither can be avoided any longer.

And with these costs come immense opportunities as well. This is our chance to bring all these aspects of change into alignment and steer our civilization toward a positive future

Global cooperation is essential, so we now have to leave behind our debilitating ideas of national independence. We must instead recognize our *inter*dependence, and take action as a global community.

What this emergency calls for, in effect, is a coordinated process of designed social change across all five elements of the Urban System Framework, with the intent to enable implementation of an entirely new energy infrastructure for society, which is what we attempted to portray on the Net Zero Transformation Roadmap. As we saw, this requires design interventions, new policies, and changed behaviors to make them endure, and thus to facilitate the attainment of Net Zero.

There is urgency to this, as each day the increasing amounts of greenhouse gases in the atmosphere threaten to make our future climate conditions even worse.

Leaders, citizens, corporations, and institutions throughout society must take the necessary actions, and for this to occur, all elements of society will require sophisticated and comprehensive help, advice, and guidance. We are making fundamental changes, which by definition are very difficult to achieve.

The Judgement of History

In Chapter 6 we gave the example of scenario planning as a powerful tool to help understand the driving forces and trends shaping the world, and we described the US National Security Council's Scenarios for 2040. It is worth emphasizing here that as of today, all of the negative scenarios they devised are entirely plausible.

That is, if we fail to act effectively, we will most likely be subjecting ourselves to a progressively worsening world situation, for as the climate degenerates the political situation will also degenerate, the world order will deteriorate, and future generations will face untold suffering due to our failure.

It really is a climate emergency, it really is a Code Red, and we really can rise to the occasion to make a better world.

History will not look back favorably upon us if we fail to meet this challenge, but it will appreciate us for doing what is now clearly necessary. And as the 100+ examples presented in this book clearly show, we certainly can do it.

This book also shows how an integrated approach to the problems and challenges of climate change is the most effective way to address the critical challenge that we face today, and explains why the aspiration to achieve Net Zero greenhouse gas emissions in our cities within ten years is an important step in protecting ourselves for the future.

And in doing this work we have not just an obligation to repair the climate, but also an unprecedented opportunity to transform our society to become more just, equitable, and safe for all.

About This Book

This book first took shape during Langdon's studies at the London School of Economics LSE Cities Executive Master's Program, where in a more modest form it was prepared for course work. Its deeper roots lie in the two very full careers of work by its coauthors in architecture, engineering, urbanism, and innovation.

About the Authors

Langdon Morris

Langdon's work in innovation is known globally. He leads the innovation consulting practice at InnovationLabs, where he supports companies, governments, and humanitarian organizations worldwide. (www.innovationlabs.com)

He is also Senior Vice President of The Modern Data Company, where he leads the Net Zero Urban Twin division that was described in this book.

Langdon has written 10 other books on all facets of innovation management that are used in practice and as textbooks worldwide.

Farah Naz

Farah Naz, is an award winning Climate Change strategist with over 18 years' experience in the construction sector gained in the USA, UK, Southeast Asia and most recently the United Arab Emirates (UAE). She is a Chartered Engineer (UK), Fellow of CIBSE, LEED and WELL AP and Verified Research Expert for Dubai Future Foundation. Farah Chairs CIBSE UAE Chapter and is an advocate of STEM education for the future generation.

For the past few years Farah has been based in UAE, where she has been steering sustainability and innovation in the built environment covering the entire Middle East, Saudi Arabia and wider Gulf Region. She leads Specialist Services with a focus on Sustainable Cities, ESG (Environmental, Social and Governance) and Urban Resilience for AECOM across the Middle East and Africa.

Farah was a prime mover in creating the Energy Strategy for the first zero-energy building in the UK, which subsequently won the 2015 RIBA Sustainable Buildings Award (UK). In the Middle East her name has become a synonym for implementable sustainability & energy strategy among others, linked to projects including Museum of the Future, the Louvre Museum in Abu Dhabi, the Bee'ah Headquarters in Sharjah, Expo 2020 Sustainability Pavilion, Masdar Eco Villa, Masdar Housing. Master planning projects like, NEOM, Red Sea, Amaala,and Hudayriat Master Plan.

In her innovating role, she focusses on implementation best practices within the built environment, adopting systems related to Energy Water Food Nexus, Biomimetics, Five Capital model of Sustainability, Liveability and Inclusive Integrated Innovation Frameworks, which will build the foundation of the cities and communities of the future.

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