WORLD ECONOMIC FORUM

Net Zero Carbon Cities: An Integrated Approach

INSIGHT REPORT

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Contents

Foreword

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Francesco Starace and Jean-Pascal Tricoire are Co-Chairs of the Net Zero Carbon Cities: An Integrated Approach programme at the World Economic Forum.

Why is it so important that we decarbonize cities? How should we do it?

These are the questions we have addressed in this paper.

The first question is easy to answer: the cities in which more than one-half of us live account for nearly two-thirds of the CO_2 emissions that lie at the root of our planet's looming climate crisis. Skyscrapers in megalopolises, shopping malls, SUVs and the growing use of air conditioning all consume a vast amount of high CO_2 content energy.

The answer to the second question is more complex.

While many cities are increasing their commitments on and progress towards becoming net zero carbon emitters, they still have a long way to go. With climate change accelerating, we need action on three fronts. First, most of our energy needs to be produced from renewable sources. Second, we need cars, public transport and heating to be powered by electricity. Third, we need a more efficient system. This involves making everything - from factories and homes to transport and consumer devices - more energy efficient and interconnected. Smart energy infrastructure is the fundamental interconnector of such an integrated, efficient system.

Digitalization is key to integrating assets and actions to make decarbonization successful. Consider, for example, technologies that automatically adapt the cooling or lighting in a building to occupancy levels at any given moment, or digital tools that allow the operators of a manufacturing site to run operations more efficiently.

Progress on these fronts is, for the most part, taking place in isolation. We should be thinking about improving the way in which the energy profile of buildings - homes, universities, swimming pools - complement each other. Often rooftop solar panels supply energy to just "their" building, not to the wider neighbourhood. Electric vehicle (EV) batteries store power for only one car when they could also potentially act as an energy storage reserve for the surrounding community. To be more successful in confronting climate change, cities can use digital technologies to integrate and connect these individual assets throughout the urban area, designing and retrofitting our cities to be more compact and accessible.

This Global Framework highlights the advantages and opportunities of taking a more integrated approach to urban and energy planning. By aggregating insights from stakeholders throughout the urban ecosystem, it describes how cities can achieve systemic change and a greater-than-the-sum-of-the-parts effect by maximizing energy effectiveness and efficiencies among the interfaces of energy, buildings and transport.

The technologies to bring about such system-wide efficiencies already exist. Cities can take full advantage of their potential and recognize that investments in greener, more efficient cities benefit not just the environment, but also the jobs market, public health, the well-being of communities, and the overall liveability and sustainability of an urban area.

To meet our climate goals, policy-makers, business, infrastructure and real estate developers, city administrators, civil society and the financial sector all have a role to play. This Global Framework seeks to create a common language and an integrated agenda for urban stakeholders. There is no one-size-fits-all answer, but there are many experiences, success stories and tools to share. As co-chairs our ambition is to accelerate a sustainable transition in cities, supporting mayors in creating value for their communities. We welcome stakeholders to join us in this effort – *Net Zero Carbon Cities: An Integrated Approach.*

Overview

Across the globe, cities account for most of our carbon emissions and energy use. While cities cover 3% of the earth's land surface ,[1] they create more than 70% of all carbon emissions,[2] mainly from buildings, energy and transport. They also consume 78% of the world's primary energy. Currently, 54% of all people live in cities – a percentage that is projected to rise to 68% by 2050. As the population grows, so does new construction, resulting in even higher energy consumption and carbon emissions.

To keep global temperature increases to 1.5°C or below, cities have to achieve net-zero emissions by mid-century.[3] As the world faces economic, health and social setbacks due to the COVID-19 pandemic, solutions that solve multiple issues are critical and can maximize limited resources.

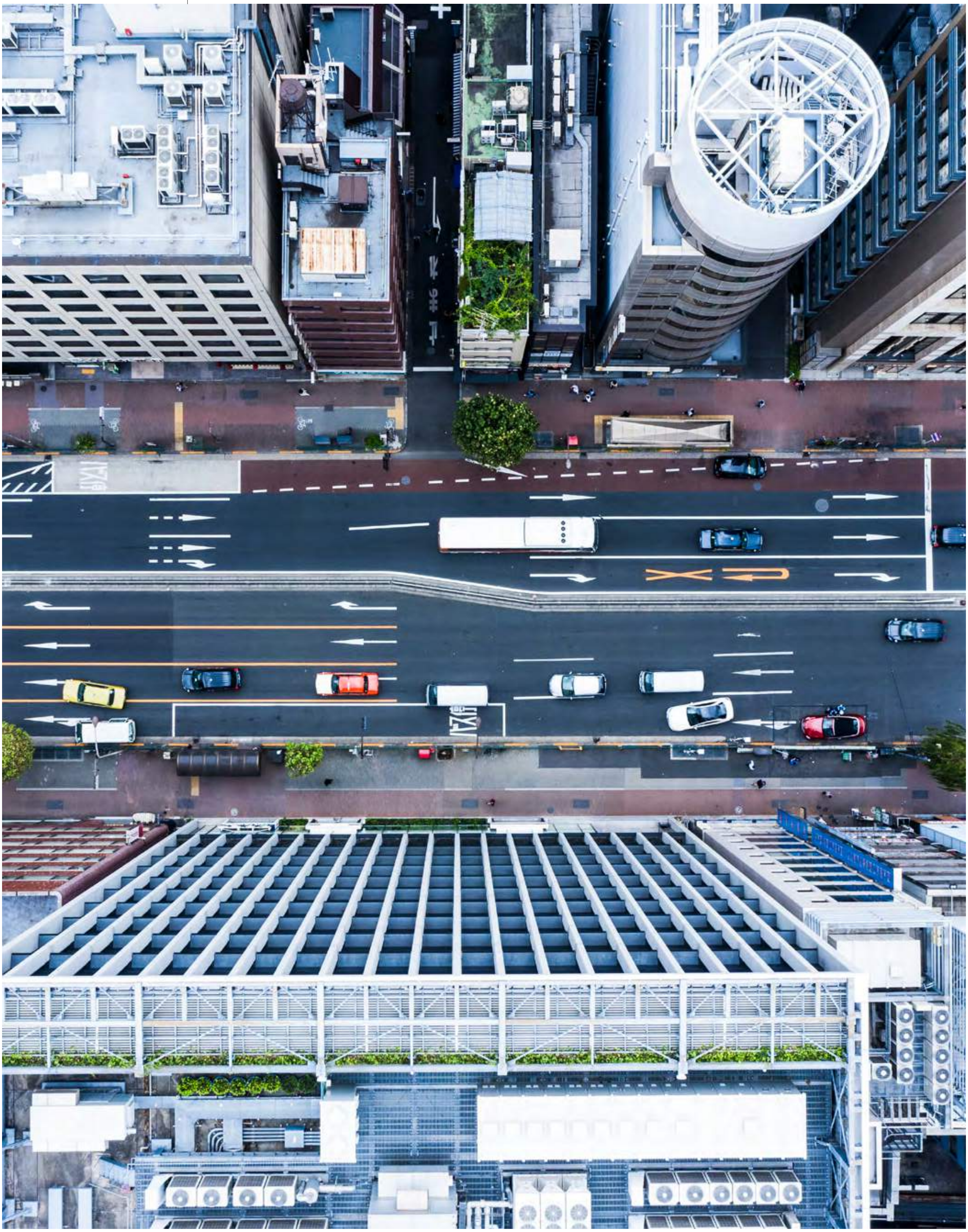
This report provides a global framework and recommends an integrated energy approach, defined as "systemic efficiency", as a solution to the current environmental, economic, health and social crises. Systemic efficiency encompasses clean electrification, smart digital technology, and efficient buildings and infrastructure, along with a circular economy approach to water, waste and materials. Planning and digital technologies that integrate buildings, energy, transport and water systems are central to systemic efficiency.

By taking a holistic approach, cities have an opportunity to boost their resilience to withstand a range of potential future climate- and health-related crises. This framework aims to provide solutions that will enable cities to rethink the delivery of urban infrastructure and ensure that it is greener, smarter, resilient, more equitable and efficient.

Systemic Efficiency

Systemic Efficiency is a delivery mechanism that encompasses clean electrification, smart digital technology, and efficient buildings and infrastructure, along with a circular economy approach to water, waste and materials.

1 An integrated approach for cities



City and national level leaders, as well as private businesses, often approach urban infrastructure with recommendations, policies and actions from their individual sectors (energy, buildings, mobility). While this can help move cities towards a net zero carbon future, integrated solutions will result in greater impact.

The need for an integrated approach becomes clear when looking at energy flows (See Chart 1). As an example, this diagram representing the US shows that 67.5% of primary energy is wasted ("rejected"). Primary energy sources ((shown along the top of Chart 1) transform into fuel and electricity for cars, homes and industry. Burning fossil fuel as primary energy sources produces waste heat and requires additional energy consumption due to extraction and transport of the fossil fuels. By shifting to renewable energy as the primary energy and increasing electrification of end uses, there is far less waste. Rewiring America recently published research showing that electrification would save more than one-half the energy cities think they need – 25% in the heat waste converting fossil fuels to energy; 15% with efficient electric transport; 11% finding, mining and refining fossil fuels; 6-9% with efficient heat pumps to electrify buildings; and 4-5% in for unburned fossil fuels (such as asphalt).[5]

CHART 1

Estimated US Energy Use in 2019: ~100.2 Quads[4]

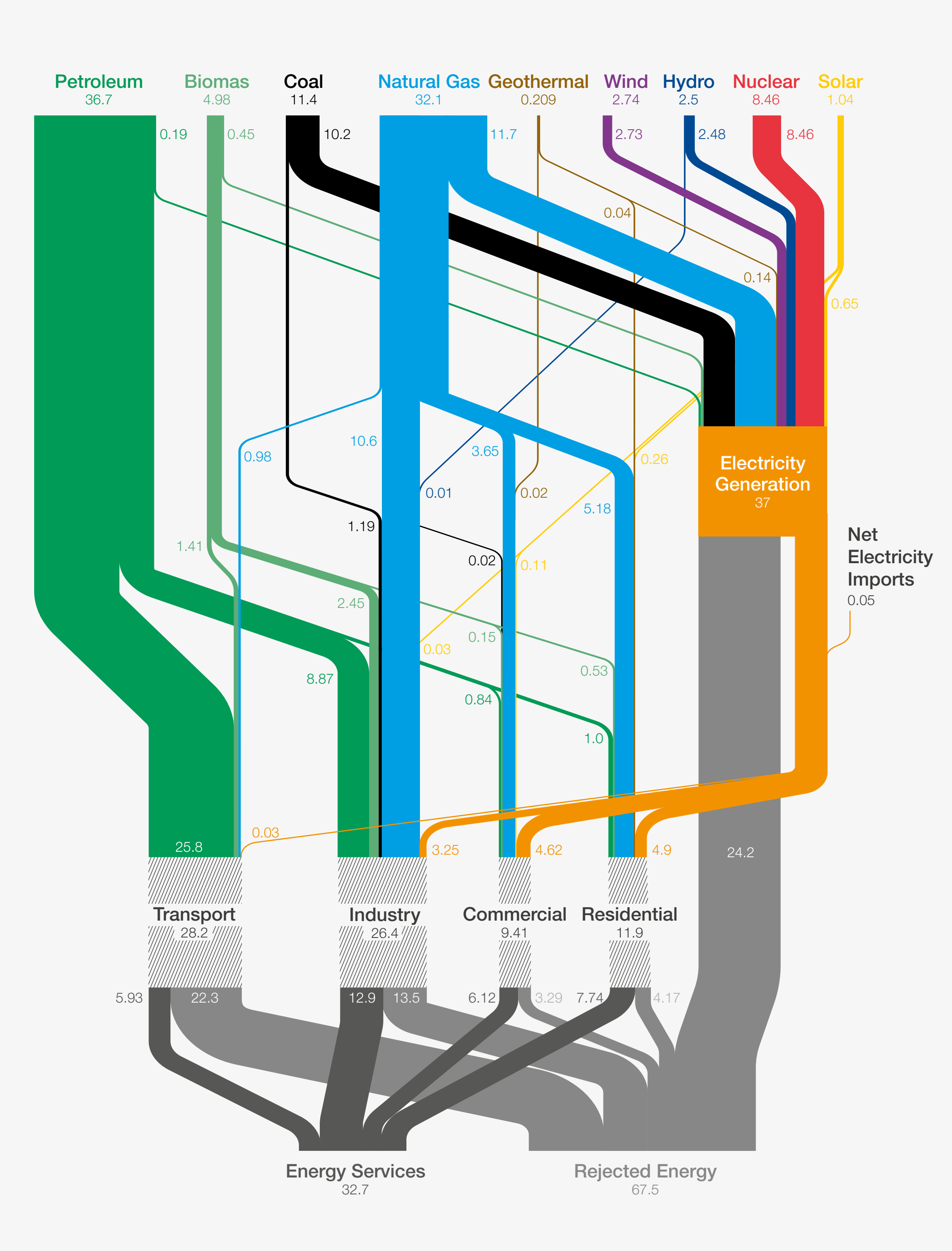


Diagram adapted from Lawrence Livermore National Laboratory (LLNL) and US Department of Energy, Estimated US Energy Consumption in 2019 Energy Flow Chart

An integrated approach to transitioning cities to net zero carbon needs:

1. Implementation of systemic efficiency opportunities (See Chart 2): In the decade ahead, stakeholders cities should focus on increasing renewable energy and electrification of final energy use, while using digitalization to integrate systems – for example, by optimizing energy demand for greater flexibility, accelerating the transition to e-mobility and decarbonizing heating and cooling. They should also focus on reducing land use and transport consumption through smart growth practices aiming at creating a compact urban form.

2. Collaboration throughout the city value chain: Public-private cooperation among various sectors – infrastructure, real estate owners and developers, mobility, equipment and technology providers, and utilities – will create a more integrated, optimized system. City- and national-level policy and financing mechanisms should support these opportunities.

CHART 2

Opportunities for the decade ahead

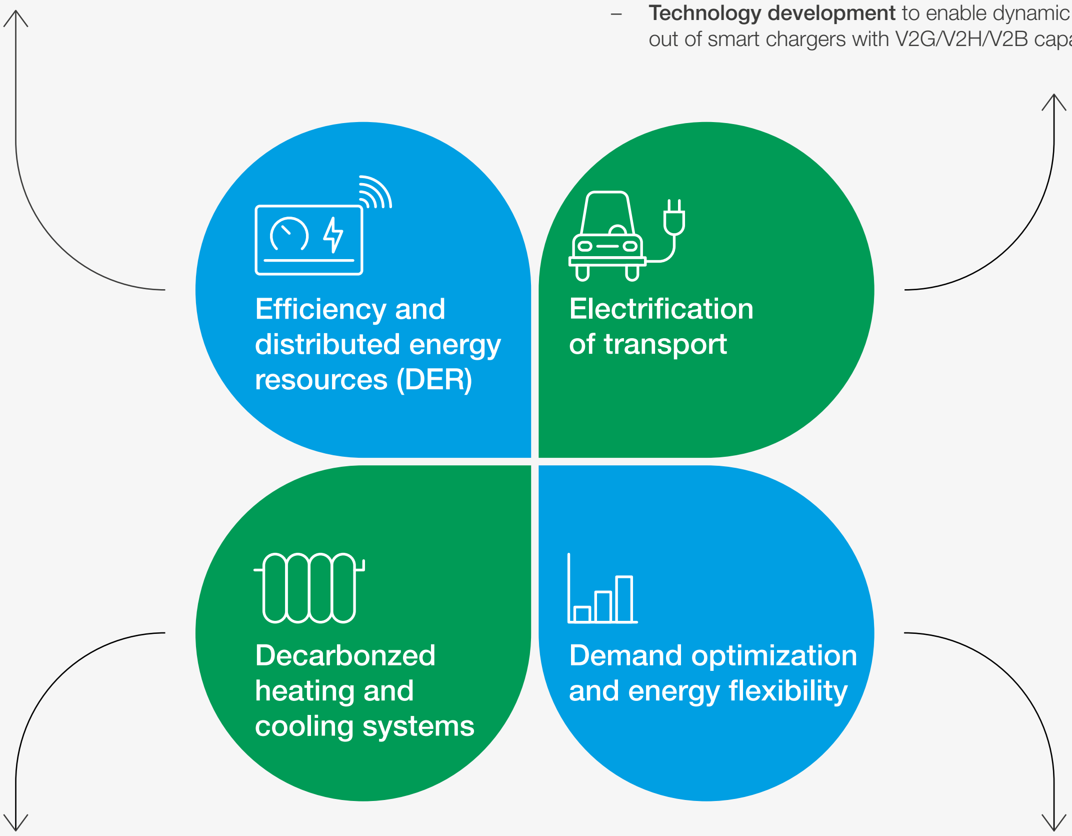
To accelerate the move towards net zero carbon cities, these opportunities were identified as priorities to enable systemic efficiency.[6]

Improving energy productivity

- **Building efficiency:** Strengthen support for smart efficiency retrofits and renewable energy projects, with a focus on low-income households, neighbourhoods and commercial properties.
- **Smart, efficient appliances:** Increasing the deployment of smart, efficient appliances such as air conditioners.
- **Distributed solar and behind-the-meter batteries:** Combining distributed solar with small-scale batteries to bring generation closer to demand, therefore reducing T&D (Transmission and Distribution) system losses.

Electrification of personal vehicles, fleets and public transit

- **Policies and regulation:** Clean air zones, national ICE vehicle sales phaseouts and enhanced vehicle emission standards. Cross-industry synergies, i.e. E-mobility and utility players investing in EV infrastructure and smart charging. Planning permission and building regulation to support EV charge point installation. Efficient price signals complementing supply curve, which enables new revenue streams (e.g. ancillary services).
- **Sponsorship, co-financing or subsidies** for BEV (Battery Electric Vehicles) purchases and charge point deployment.
- **Technology development** to enable dynamic pricing and roll out of smart chargers with V2G/V2H/V2B capability.



Limiting the role of fossil fuels

- **District heating and cooling (DHC):** Networks of underground insulated hot or cold water pipes that service multiple buildings within a district, creating synergies in the supply of heating, cooling, domestic/industrial hot water and electricity.
- **Electrification of heating:** Flexible use of heat pumps, potentially connected to district heating networks. Adapting dynamic pricing for heat pumps can encourage customers to shift heating loads to off-peak times.

Optimizing demand to meet supply curve

- **Dynamic pricing, ToU (Time of Use) rates and demand response:** Can increase customer participation, further reduce wind and solar curtailment, and save money for customers.
- **Aggregation:** Create new incentives and programmes that encourage aggregation from DER to provide peak load and congestion management and voltage support services.

Benefits of the integrated approach in cities

Investing at scale in efficient, clean energy solutions will boost economies while delivering positive environmental, social and public health outcomes for residents. The potential for job creation in particular is remarkable. Rewiring America found that with proper financing and regulatory reform, transitioning to a net-zero economy would create 25 million new jobs in the United States over the next 15 years, with five million sustained jobs by mid-century, which is roughly double the number of jobs supported directly and indirectly, by the current energy industry.

In 2020, the World Economic Forum, in collaboration with Accenture, developed the System Value framework. The framework enables leaders to more holistically evaluate economic, environmental, social and technical outcomes of potential energy solutions throughout markets, shifting focus from cost to value. Analysis was carried out in several global markets to demonstrate the framework. The analysis shows that continued investing to advance the energy transition in cities could deliver positive outcomes that result in the creation of jobs, reducing GHG emissions and significant co-benefits in terms of human health and water usage in the short term.[7] To learn more about this framework and market analysis please visit the System webpage.

CHART 3 | **Maximizing system value benefits for cities across the globe**

Europe

Decarbonizing Europe's cities, through efficiency initiatives, leveraging digitalization and demand optimization for greater smart flexibility, and accelerating electrification through transition to e-mobility and decarbonized heating systems can yield significant benefits to **2030**:

263Mt

Potential for 263Mt extra reduction in **CO_2 emissions** in 2030. Electrification of transport, decarbonizing heating and cooling and optimization of demand will be main drivers.

680k

Potential for 680k extra 1 year **jobs** up to 2030 in areas such as smart charging and development of e-mobility infrastructure; installation of efficient appliances e.g. heat pumps, smart metering and other demand optimization initiatives.

$36bn

Potential for $36billion cumulative **human health benefits** due to lower air pollutants through 2030. Meeting additional demand with renewables, continued grid investment and improving systemic efficiency in urban centres are main drivers.

87bn litres

Potential for 87 billion litres-worth reduction in electricity base case **water footprint** in 2030. Specific savings possible from efficiency and demand optimization initiatives.

Brazil

Significant benefits are possible by **2025** through continued investment in "connected and efficient cities":

45Mt

Potential for 45Mt cumulative reduction in electricity base case **CO_2 emissions** through 2025 based on ~7% efficiency gains through more efficient appliances and public services, electric mobility and distributed generation.

>1m

Potential for >1 million **jobs** by 2025 across smart buildings (construction, materials), grid modernization and efficient appliances, such as HVAC and lighting.

$3.4bn

Potential for $3.4billion cumulative **human health benefits** due to lower air pollutants to 2025. Meeting additional demand with non-hydro renewables and improving systemic efficiency in urban centres are main drivers.

1.5bn litres

Potential for 1.5 billion litres reduction in electricity base case **water footprint** in 2025. Savings resulting from deployment of non-hydro renewables and improving efficiency across grids and in cities.

United States

Replicating the investment level of the 2009 US Recovery Act, the US could focus on implementing smart buildings and energy infrastructure, keeping energy costs low for consumers. Combining this with road transport electrification and deployment of electric heat pumps could yield the following benefits by **2025**:

110Mt

Potential for 110Mt extra reduction in **CO_2 emissions** through 2025. Clean electrification of buildings, mobility and industry combined with demand optimization will be main drivers.

550k+

Potential for more than 550k extra 1 year jobs to 2025 in areas such as smart technology and efficiency upgrades to government and education facilities, weatherization assistance programmes, and investments in e-mobility and storage.

$14bn

Potential for $14billion cumulative **human health benefits** due to lower air pollutants to 2025 purely due to more aggressive efficiency programmes, as well as demand optimization and electrification.

183bn litres

Potential for 183 billion litres reduction in **water footprint** to 2025 explicitly through increased investment in efficiency initiatives.

India

Energy efficiency investment economics are strong in India. Focused improvement in A/C efficiency and bolstering building efficiency standards for new residential and commercial building construction, combined with grid optimization to reduce transmission and distribution losses could lead to the following benefits by **2025**:

151Mt

Reduction in **CO_2 emissions** to 2025.

$13bn

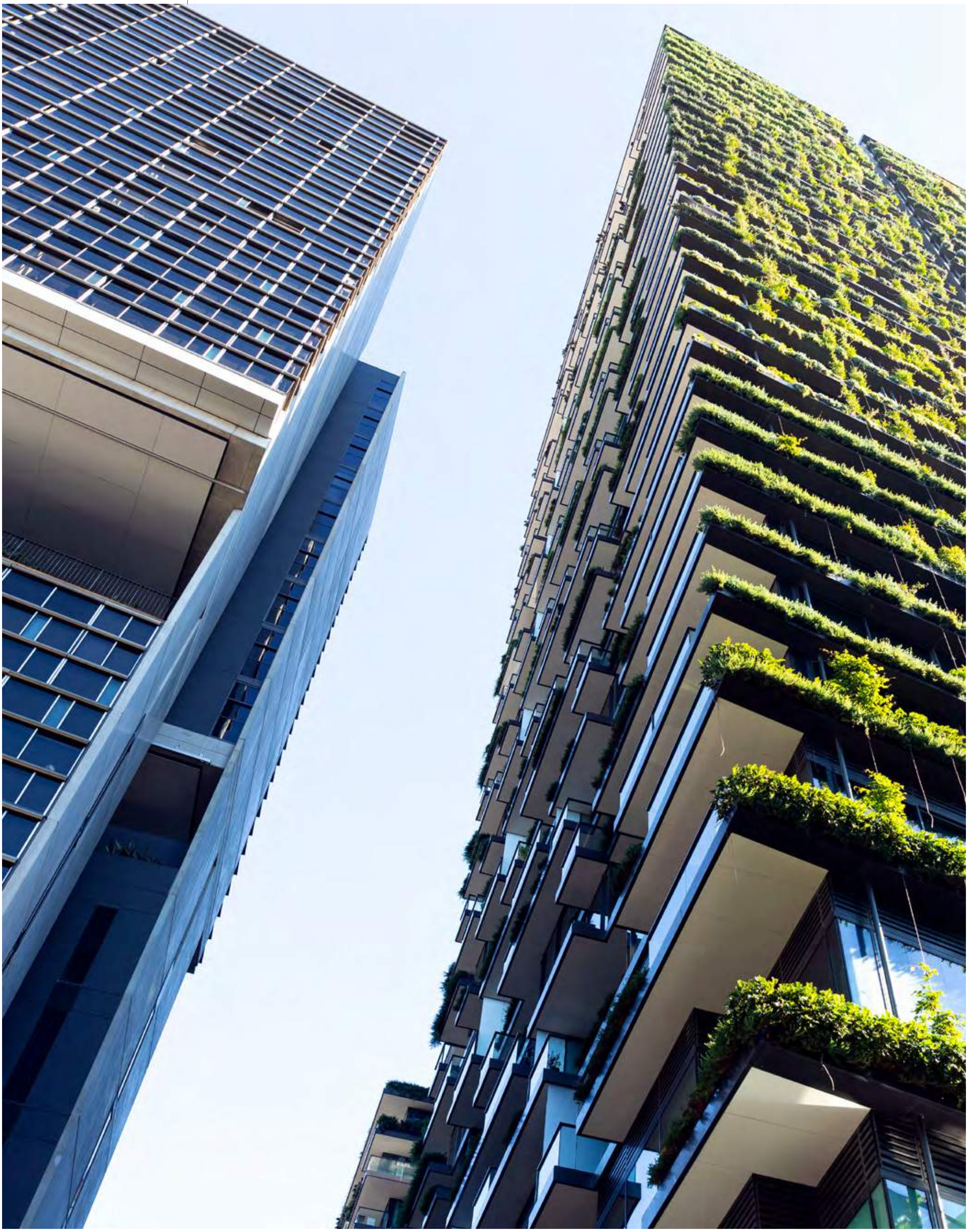
Potential for $13billion cumulative **human health benefits** due to lower air pollutants through 2030.

268bn litres

Potential for 268 billion litres reduction **water footprint** through 2025.

Excerpt from the system value framework, developed by the World Economic Forum in collaboration with Accenture, 2020.

2 How to transition to an integrated approach



To transition cities to a net zero carbon future, this framework recommends focusing on ultra-efficient buildings, smart energy infrastructure and clean electrification alongside consideration of compact urban form.

Ultra-efficient, connected buildings combine high performance and low-carbon buildings materials with electric systems, distributed energy and intelligent management systems to maximize efficiency.

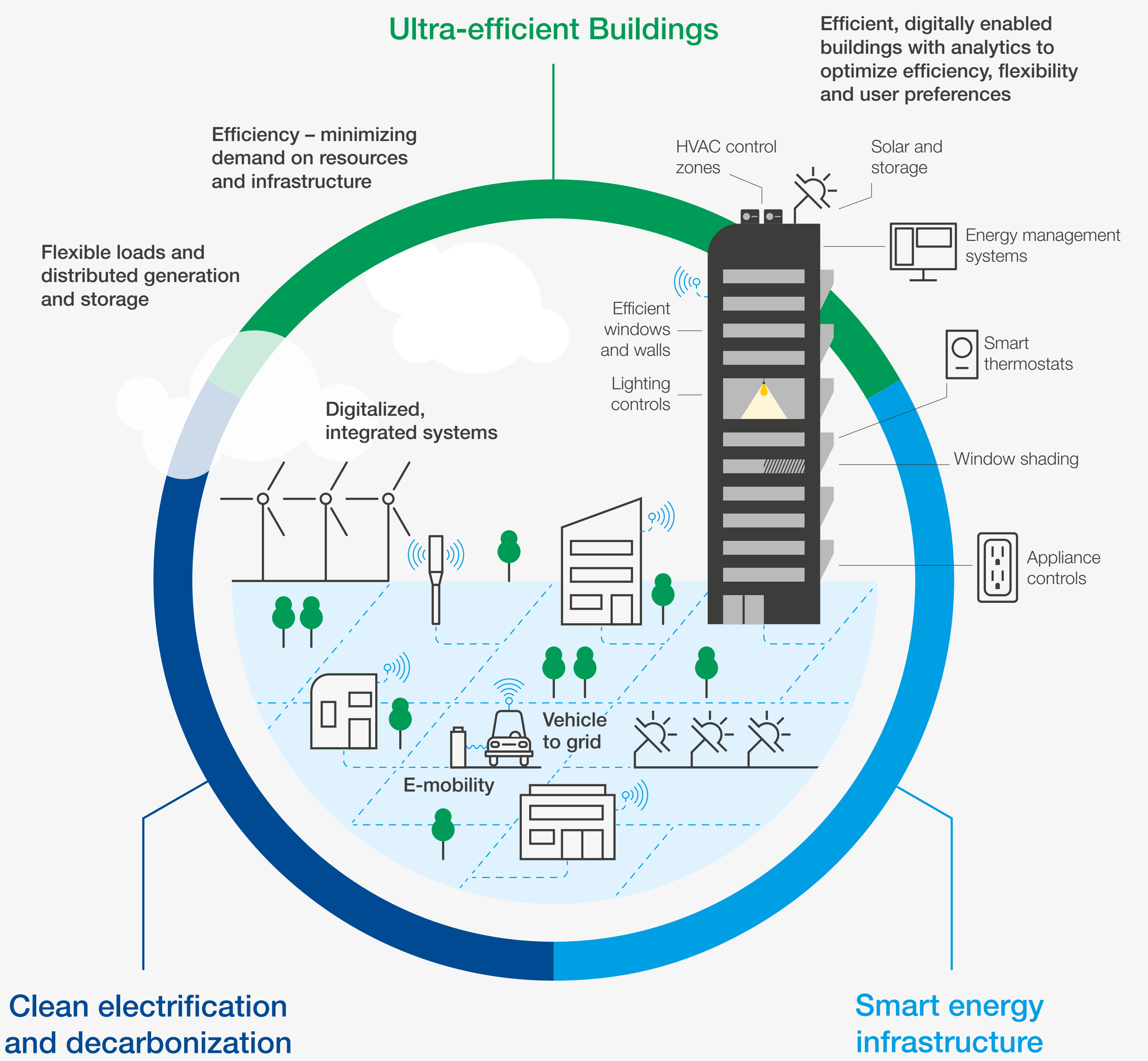
Smart energy infrastructure includes a cost-effective, secure electricity distribution grid, smart meters and e-mobility charging stations.

Clean electrification is electricity backed by zero carbon energy (e.g. wind and solar). When possible, transport, heating and cooling, lighting and home appliances can all be run on clean electricity.

Compact urban form refers to the the physical characteristics of the built living environment, including the shape, size, density and configuration of settlements and network.

This chapter highlights how each of these drivers can be designed and planned to interact in the integrated system, to accelerate the net zero carbon transition in cities.

CHART 4 **Integrated energy systems in cities**



A | Ultra-efficient buildings

Challenge

Buildings are at the heart of the decarbonization equation. They are the source of approximately 40% of global greenhouse gas emissions – of which approximately 30% come from building operations and 10% from construction and materials,[8] – in what is referred to as embodied carbon emissions.

Solutions to decrease building emissions have largely focused on the level of individual buildings, mainly because of the lack of an integrated system-wide strategy. For example, urban planning and policy-making do not consider how buildings can interact at scale. Yet, to drive faster progress and greater efficiency, buildings should interact with each other as well as with the power grid and other assests.

Heating and Cooling

Heating and cooling represent the most significant share of cities' energy demand. Efficient technologies for temperature regulation that can deliver net zero carbon are widely available today; the challenge is scale.

To transition heating, buildings must break away from fossil fuels and increase efficiency. Well-insulated buildings, warmed with district heating or heat pumps, can significantly reduce the demand on the system. In the case of district heating, networks provide the opportunity to optimize the distribution of available heat among users in the system. In fact, excess heat from industrial processes can be reinjected into the shared network. An example is Vattenfall's SamEnergi scheme whereby excess heat is purchased from companies such as data centres and coffee roasteries. Heat is transferred using existing district heating infrastructure, enabling a more circular energy system.[9] Additionally, with a digitized system, heat demand can be better tracked and managed to further boost efficiency.

As for cooling, 1 billion people are at high risk due to lack access to cooling and a further 2.2 billion lack access to clean and efficient cooling.[10] Driven by rising living standards and temperatures, the global demand for space cooling is due to grow at unprecedented rates. According to the IEA, by 2030 the number of installed air conditioners will increase two-thirds from the 2 billion units installed today. Without major efficiency improvements to cooling equipment, electricity demand for cooling in buildings could increase by as much as 50% globally by 2030, with consequent stress on grids in peak hours.[11] To learn more on the sustainable cooling visit SE4all Cooling for all initiative.

Opportunity

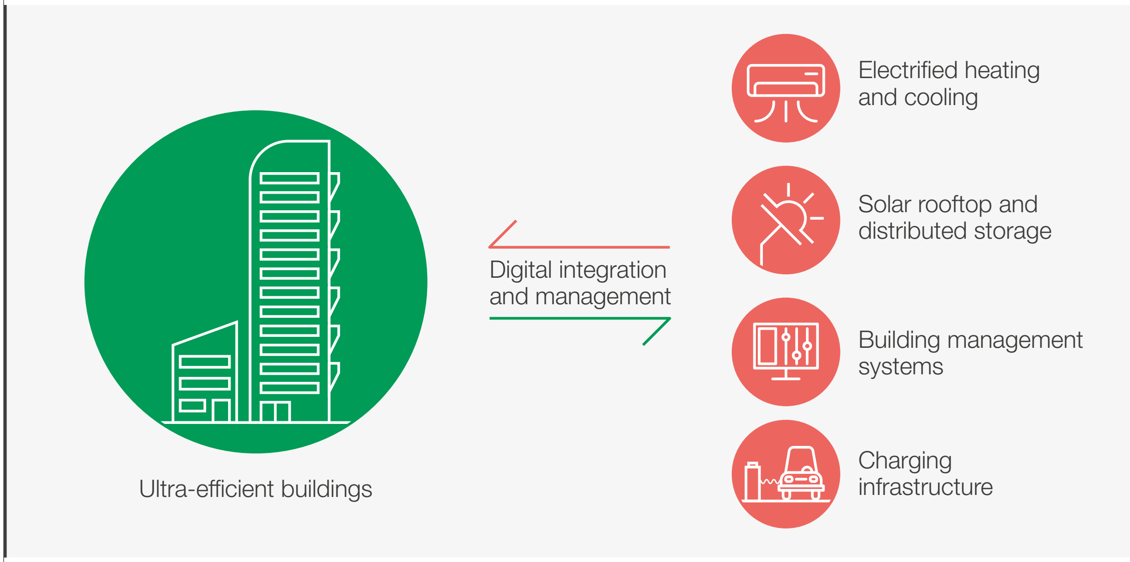
The combination of efficiency, clean end-use electrification, active energy management, integrated design and digital technologies can significantly reduce building energy consumption and emissions. This can be achieved through new collaborative approaches to urban planning and policy-making, combined with the application of smart technologies and innovative design, all supported by effective financing.

It is important to distinguish between new net zero carbon developments and retrofitting existing buildings, which present different challenges for emerging and developed countries. For much of the Global South, emissions reduction will stem from new developments, which must balance affordability and efficiency. In the developed world, both new development and retrofitting investments are essential, though retrofitting is a larger challenge, particularly in the economically-stressed residential sector.

Retrofits are key to meeting net zero carbon targets. For example, converting 30% of the building stock by 2030 (i.e. 3% per year) to fully electrified heating with heat pumps and digitized with 50% energy efficiency gains would lead to:

- 20% reduction in energy demand
- 35% reduction in emissions (assuming 40% decarbonization of the electricity mix)[12]

How can buildings contribute?



1. Integrating technologies

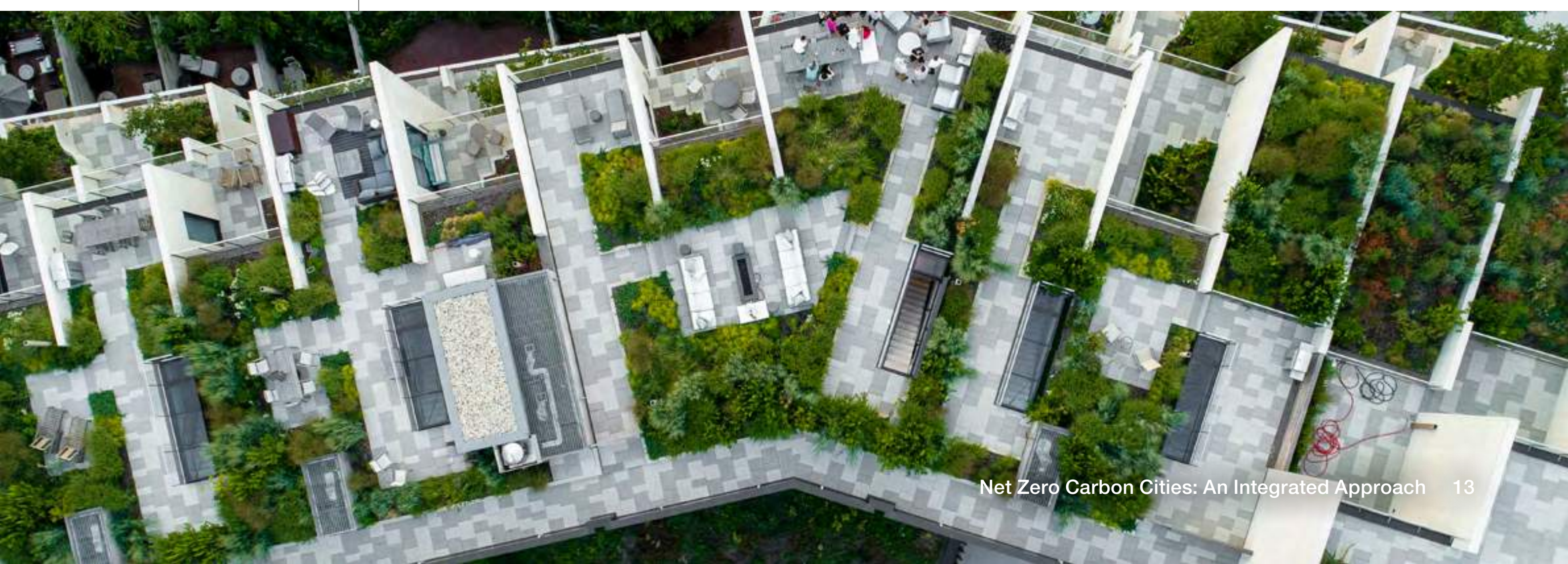
Buildings can provide services to, or benefit from, other sectors, such as mobility and energy, leading to faster decarbonization. Opportunities include:

- Electric vehicle charging in buildings can allow for the optimization of energy produced via distributed energy resources such as rooftop solar. This enables a faster and more competitive penetration of renewable energy. Smart meters and dynamic pricing will also play an important role.
- Buildings can provide grid flexibility and other services through building management systems and demand aggregators. Benefits include the reduction of upstream costs, such as congestion relief and investment deferrals.
- Buildings can also share their electricity with local renewable energy communities, enabling emerging, efficient and resilient sharing models to evolve.

2. Examples of enabling policies

Existing buildings
Monitored Lifetime Performance: This establishes final energy and emissions limits per floor area that tighten over time and requires owners to implement efficiency and electrification retrofits and/or integrated systems packages (including grid-interactive controls, renewables, etc.) to comply. These policies can allow for interventions to be "right-timed" with the building life cycle, such as at normal-course equipment replacements or other capital events – including at the district scale. In developed countries, this is the highest priority.

New construction
Building codes can require fully electric, highly efficient, grid-interactive buildings with on- and/or off-site renewable energy systems and smart e-mobility infrastructure. Building codes can also require the use-of-lifecycle assessment and set embodied carbon benchmarks with reduction targets.[13] Prioritizing a circular, zero-waste approach through the use of reused and reusable materials, modular and off-site construction methods alongside design for maintenance and deconstruction will help mitigate the carbon impact of buildings.[14] A ban on new fossil fuel connections and related infrastructure can also be applied to accelerate the transition.



Case Studies

Lidl Distribution Centre, Finland

Lidl's distribution centre in Järvenpää, with an area of 60,000 square metres, is the nation's largest warehouse. Completed in 2019, the centre operates on 100% renewable energy and produces more energy than it consumes throughout the year. To achieve the highest efficiency possible, the digitally-enabled warehouse employs a microgrid along with a comprehensive building management system to collect, forecast and optimize the operation of on-site resources using real-time data and predictive machine learning algorithms. It is also the first building in Finland with a combined heating and cooling system that stores heat for colder days or supplies the excess to the city heating network – heating water for approximately 500 private homes. Similarly, the distribution centre provides electricity grid services to the Finnish system operator, securing grid stability. The project used the integrated Schneider Electric EcoStruxure™ Microgrid and EcoStruxure Building Operation solution, delivering energy cost savings of up to 70%.

EDGE Olympic Building, Netherlands

Completed in 2018, the EDGE Olympic building in Amsterdam is an office building redeveloped from an old post office. The developer shaped the project on a holistic four-pillar approach of well-being, sustainability, design and technology. The building embraces circular, zero-waste design principles and smart digital infrastructure to optimize energy use. A total of 50% of the materials used were recycled from the original building, including the natural stone taken from the façade, which was repurposed for use as flooring. The top two floors are constructed from wood, which can be disassembled relatively easily for future reuse. The building's digital infrastructure allows employees to adjust workplace conditions, such as temperature and lighting through an app, maximizing liveability. The building enjoys constant environmental monitoring thanks to 15,000 sensors that measure indoor climate performance. It is energy neutral and enjoys 70% less consumption than the average non-residential building. The workspace is also relatively affordable; though the building incorporates the latest advances in well-being and sustainability, rents are no higher than market rate, helping to secure occupancy rates of more than 90%.

B Smart energy infrastructure

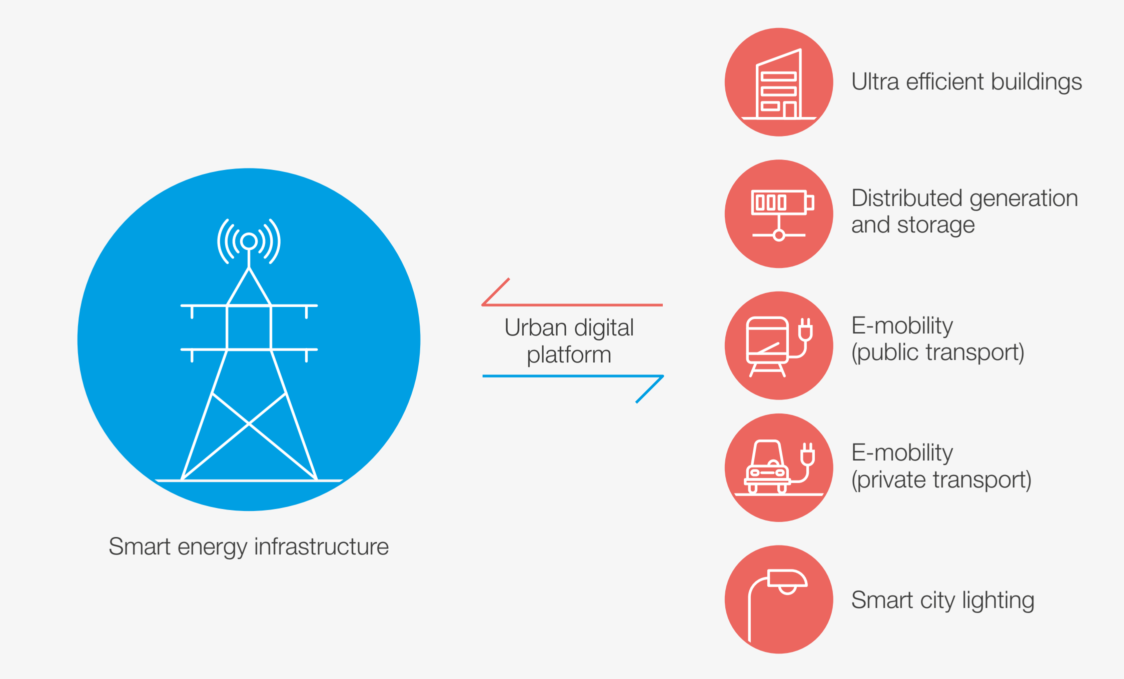
The challenge

Smart energy infrastructure – power generation, distributed energy sources, wires, heating and cooling networks, smart meters, smart charging and everything that encompasses the "grid" – is what makes cities run. Energy is fundamental for socio-economic development, underpinning all other services. Without energy infrastructure, there is no power, no telecommunications, no waste-water treatment and no electric transport. The acceleration towards a net zero carbon future calls for infrastructure development and modernization, especially in cities. The challenge is that the infrastructure and associated policies and regulations were designed for a different system. Energy infrastructure was developed decades ago for a centralized power system, not for an increasingly decentralized and digitalized system based on high volumes of renewables. Meanwhile, policy and regulation are also struggling to keep up with advances in technology.

The opportunity

The opportunity is to create a net-zero integrated energy system in cities. This system can seamlessly facilitate near-constant interactions between energy infrastructure, buildings and electric vehicles. A modern energy infrastructure will act as the backbone of this integrated urban energy system. Policy and regulation can accelerate this integration, creating the necessary conditions for digital technologies to drive more efficiency, higher volumes of renewable energies and new business models linked to supply and demand optimization. Policies and regulations will also need to incentivize the right infrastructure investments at the right time.

How can smart energy infrastructure contribute?



1. Integrated technologies

A future integrated energy system will be based on high levels of renewables and more robust, digitized and resilient networks. New infrastructure investments will be needed.

For example, to achieve integrated energy systems in Europe, the European Parliament recently estimated that approximately €40-62 billion per year will need to be invested in transmission and distribution grids between 2021-2050.[15] At the same time, however, technologies will play an important role; for example, advances in power flow control technologies can help make better use of spare capacity existing in today's grids while also tackling congestion problems.[16]

Advanced metering infrastructure will be required throughout public services to facilitate demand optimization and efficiency improvements. Data platforms will be required to integrate electricity, gas and water meter readings, combined with street lighting, waste management and parking data, among other internet of things (IoT) applications. Interoperability throughout technologies and communication protocols will be essential.

One of the key challenges for these urban data platforms will be the real-time transformation of data into useful information for a range of stakeholders. This information can then be used to make better informed decisions, such as where to invest in new energy infrastructure or when to charge smart appliances. Beyond that, over time, building management systems will enable connected devices to react to signals, such as energy and even water prices.

Finally, more charging infrastructure will be needed as increasing numbers of drivers choose electric vehicles. Charging infrastructure in cities should be deployed in combination with technologies such as distributed energy resources and building management systems. It will also need to be integrated thoughtfully with grids, to fully exploit the flexibility of EVs while ensuring the stability of the energy system.

Digitalization and stakeholder collaboration clearly play a fundamental role in the modernization of existing and the development of new energy infrastructure, as well as the scaling up and deployment of new technologies.

2. Enabling policies

Policy-makers should ensure that city, regional and national policies for energy infrastructure support and reinforce each other. Outcome-based regulations should be designed to support the implementation of policies. Policy-makers can contribute through:

– Defining resilience roadmaps with short-, medium- and long-term objectives to incorporate regional, cities and cross-sector planning efforts[17]

– Promoting equitable access to energy, closely working with cities' administration to manage sub-urban development

– Preparing for the governance of the increasing amount of data associated with the energy flows, e.g. who can access data, who owns the data, privacy etc.

– Redesigning the regulatory paradigm (see Chart 7)

– Recommendations made in a previous World Economic Forum report on EV's for Smarter Cities bear repeating[18]

For more detail on the integration of mobility with the electricity system see [Electric Vehicles for Smarter Cities: The Future of Energy and Mobility.]

CHART 7

Redesign Regulation paradigm

Change the rules of the game, enabling new roles for network operators, innovation and full integration of decentralized energy resources

Evolve the revenue model

– Promote innovation and efficiency through outcome-based regulation

– Remove bias towards capital expenditures by allowing non-wire alternatives to compete

Integrate Distributed Energy Resources (DERs) into markets and monetize their services

– Clearly define role, asset type, and ownership of DERs
– Enable adequate market design, allowing independent aggregation and location-based valuing of DERs

Modernize system planning

– Shift from distribution network operators to distribution service platform providers
– Break regulatory silos (geographies, industries, sectors) through integrated plans
– Reassure investors by clarifying the transition path and regulatory timeline

Use price signals by redesigning rate structures

– Introduce dynamic prices and assess efficacy of flexible demand charges

Source: Electric Vehicles for Smarter Cities: The Future of Energy and Mobility, World Economic Forum, 2018, http://www3. weforum.org/docs/WEF_2018_%20Electric_For_Smarter_Cities.pdf

Case Studies

Vila Olímpia, Brazil

Vila Olímpia, once a rural and marginal district of the São Paulo metropolitan area, has become known as the city's own "Silicon Valley" and is a model for the cutting-edge high-tech district of the future. The Italian company Enel developed South America's first Network Digital Twin in partnership with the local government authorities and the Agência Nacional de Energia Elétrica (ANEEL), the national regulatory body that contributed to the financing of the project. This Twin model simulates the grid based on approximately 5,000 sensors installed on the actual grid, each communicating information on the status in real time to the energy distributor and local stakeholders. The Twin uses network automation, artificial intelligence, the IoT, and 3D modelling to manage the system and improve service quality. For instance, it will facilitate grid inspections – carried out with the help of Augmented Reality – and move from corrective maintenance, which repairs problems, to preventive maintenance, which can spot a risk ahead of time and act on it in advance. The digital platforms also create greater awareness of energy use, efficiency, and savings. The Twin also acts as a laboratory to test the interaction of the grid, EV charging points, solar rooftop generation, energy service providers and consumers.

Consumers Energy, Michigan

Four years ago, Consumers Energy, Michigan's largest energy provider, relied on power plants that burn fossil fuels for 74% of the electricity it provides to 6.7 million of the state's 10 million residents. The company is now undertaking a significant roll-out of smart thermostats, and smart meters – which enable remote tracking and management of energy consumption – to transition to renewable energy generation. Consumers' plan is to generate more than one-half its electricity from renewable sources by 2040, adding six gigawatts of solar power (requiring 59 square miles of solar panels) as well as a smaller amount of wind power. To date, these innovations have allowed Consumers Energy to retire seven of its coal-fired power plants and the company plans to retire the remaining five by 2040. The transition will cost at least $25 billion over the next decade to replace ageing gas and electric equipment and prepare the grid for more renewables, batteries and electric vehicles – capital investments that should eventually boost returns for shareholders because of inexpensive renewable energy.

C | Clean electrification

The challenge

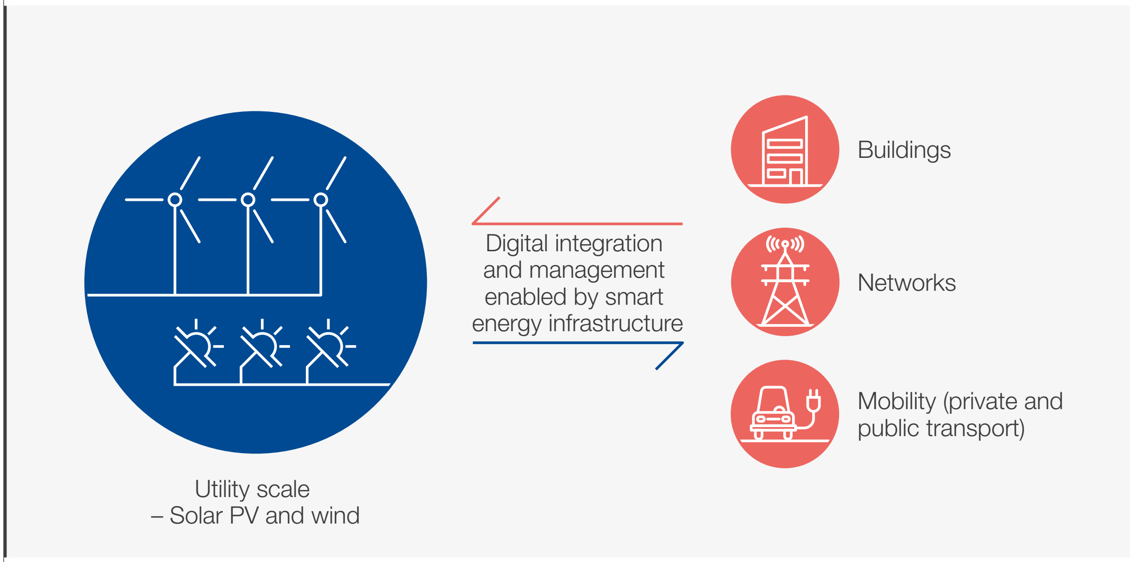
Most of the energy consumed in cities today comes from fossil fuels. Fossil fuel combustion is used for heating, electricity electricity for cooling and appliances, and transport. These fuels are delivered from inefficient transformation processes, particularly when it comes to heating and transport.[19] Today, technologies are available to electrify cities backed by renewables, but the challenge is to scale up those renewables and build or reinforce grids to accommodate the electrification, both of which will require investment.

The opportunity

Clean electrification makes the entire systemic efficiency concept ignite, moving the biggest energy-using sectors in cities – buildings and mobility – to the electricity vector, while supporting the development of renewables. Electrification unifies sectors with shared connections. For example, it can be used to power buildings and transport, allowing them to interact as resources for each other in new ways. Buildings and vehicles can draw and provide energy to each other as needed.

Energy efficiency complements electrification. By reducing initial demand, for instance by insulating buildings and using district heating and cooling, the required build-out of electricity infrastructure is also reduced. Together, clean electrification and efficiency can usher in a carbon-free future.

How can clean electrification contribute?



1. Integrating technologies

Clean electrification enables grid integration throughout multiple sectors that were either independent or only narrowly interactive before. The previous model has utilities providing energy or fuel, while customers send back payments, with small amount of information flowing. Today, a dynamic system is possible. Energy, payments and information can flow in all directions through buildings, transport and the grid. This enables more robust demand response programmes, time-of-use and locational pricing, and energy storage services.

Electrification of buildings. Thanks to smart heat pumps, heating and cooling loads (the largest energy uses in most buildings) can now be handled by the same piece of equipment. Heat pumps on average are about 4 times more efficient than traditional fossil fuel technologies.[20] In addition, this technology centralizes equipment needs, which simplifies grid integration by having only one system to work with, instead of establishing two separate smart meters, submeters etc. for two different fuel sources. It also reduces construction costs and avoids installation and maintenance costs for dual infrastructure.

Electrification of mobility. Besides having a crucial role in fostering individuals' transition to zero-emission vehicles, cities may leverage the huge potential associated with electrifying public transport. In addition to the intrinsic benefits of decarbonization and noise pollution reduction action, electrically-powered buses bring along innovative real-time smart management technology, optimizing battery consumption.[21] In addition to recharging electric vehicles, smart charging can provide storage capacity and services to the grid and buildings, resulting in system cost savings. According to IRENA, smart charging can significantly reduce the peak load and therefore avoid grid reinforcements, at a cost of 10% of the total cost of reinforcing the grid.[22]

2. Examples of enabling policies

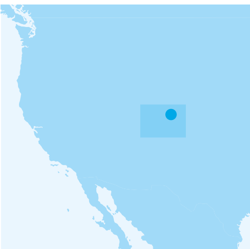
Energy policies should promote clean electrification at a system level. For instance, policies should support integrated heating and cooling systems to meet safety needs and rising demands during extreme weather conditions, such as cooling during more frequent heat waves. Policies also need to address educational and skills barriers to heat pump adoption, making the population more aware of low-carbon heating options and rolling out training programmes for heat pump installers. Moreover, energy tax and up-front subsidy reforms for heat pumps could help in the transition.

Case Studies

Meishan, China

Meishan, with a population of 700,000, in Zhejiang province, is a near-zero carbon zone, combining economic development driven by emerging low-carbon industries and achieving near-zero carbon emissions. Once a small fishing village, Meishan is now an industrial port city with warehouses, high-tech industries, tourism, commerce and residential services. The government coordinated planning for innovative solutions for cleaner energy infrastructure and near-zero carbon development, collaborating with energy service providers to allow stakeholders to share the risks and returns of the more efficient energy system. The near-zero carbon zone projects include a smart, near-zero carbon port, with gradually electrifying container trucks, improved mass-transit coordination, high-voltage on-dock power charging stations, and renovation of old communities, using smart technologies to improve roads, water supply, power supply, information, logistics, flood control and wastewater treatment facilities.

Peña Station NEXT, Colorado



Located next to Denver International Airport, Peña Station NEXT is a net-zero energy real estate development powered by a solar mini-grid with storage and connected to the local grid. The project, which covers about 2 km^2, comprises 100 solar-powered residences and commercial buildings, and was planned as a community-centric, transit-oriented development with energy efficiency, green buildings, renewable solar energy and emissions-free mobility. Two solar PV systems, one 1.6 MW and another 259 kW, power the development with renewable energy. A large on-site battery system strengthens energy resilience. Smart technology, overseen by Panasonic CityNOW, provides robust fibre infrastructure, a microgrid powered by clean energy, and smart streets that monitor air quality and light intensity. The project was a partnership between electric utility suppliers, real estate developers, landowners, and other stakeholders.[23]

D Compact cities

The challenge

Carbon emissions continue to climb in many cities, despite the advance of clean technologies.

Worldwide, cities are seeing tremendous suburban growth and outward expansion. For example, cities in China are declining in density, as reported by Pew Research and the World Economic Forum.[24] In the United States, at least 5 of the 24 mayors on the Climate Mayors Steering Committee are supporting major highway expansions while simultaneously attempting to reduce transport emissions.[25]

The opportunity

Though often harder to quantify than simple asset turnover, improving the efficiency of our urban form is often the lowest cost strategy for reducing emissions throughout energy sectors. If fast-growing cities fail to adopt the right patterns of development now, emissions will be locked in for decades.

Conversely, drawing on urbanist principles, such as better land-use, urban design, transport planning, and housing policies and practices, will make the vision of net zero carbon cities that much easier to realize – requiring fewer EVs, heat pumps, building retrofits, batteries, and solar panels to achieve the same result. Just as energy efficiency in individual buildings enhances the benefits of heating electrification technologies, efficient urban form helps us decarbonize each of the other systems that comprise a city. Compact, connected and clean cities with consistent densities use less land, materials and energy than sprawling cities. Similarly, higher densities make infrastructure investments more economically feasible, whether its district heating and cooling or a metro system. As one example highlighted by the Coalition of Urban Transitions' report "Climate Emergency Urban Opportunity", Stockholm and Pittsburgh have a similar population size, but Pittsburgh uses approximately five times more land than Stockholm and has more than five times higher emissions per capita. Meanwhile, Stockholm is recognized for its high quality of life and thriving, inclusive economy, due in part to its compact, connected form.

This strategy also directly benefits disadvantaged communities – those with the poorest access to affordable housing, high-quality transit, economic opportunity and essential services.

How can urban form contribute?

To prevent the future growth of emissions related to car-oriented design, cities can embrace sustainable transport and land-use planning practices. The number one emissions abatement measure in some fast-growing metropolitan regions is to address housing needs through urban infill rather than suburban sprawl.

Mixed-use development the concept of 15- or 20-minute neighbourhoods such as that led by Paris and Melbourne enables people of all means to live close to jobs, essential services and recreation. Street redesigns and infrastructure investments that prioritize mobility alternatives will disproportionately affect lower-income communities that tend to be transit-dependent.

In addition to reducing (and preventing) emissions, intelligent urban form can enhance economic productivity and increase cities' tax bases (by enabling the clustering of talent that define successful cities in the first place). It can reverse the trend of suburbs, cannibalizing tax revenue and burdening cities with debt associated with highway and public utility expansions. It can help preserve ecosystems and agricultural land on the urban periphery. It can make cities more equitable by prioritizing the convenience of transit-dependent low-income families. It can even reduce range anxiety for EV owners by shortening the distances they are required to drive.

Enabling policies

Promoting 15-minute neighbourhoods

Some policies that should be considered include:

– Establishing citywide or district-based "form-based codes" that give developers flexibility in building type, size and use

– Establish a policy for 15-minute neighbourhoods, which will improve access to basic necessities – jobs, food, healthcare, recreation – without requiring the use of a personal vehicle. This is critical for limiting sprawl and reducing emissions associated with non-work trips

– Cities should explore incentives for compact growth and infill housing. These incentives may include streamlined permitting, tax incremental financing (TIF), tax credits for developers and location-efficient mortgages, which provide increased borrowing power for homes in transit- and destination-rich environments.

Prioritizing mobility alternatives

Promisingly, many cities are starting to reclaim auto-dominated spaces for people and alternative modes of transport. Cities can prioritize transit, bikes, pedestrians and electric micro-mobility over single-occupancy cars through policies that align user fees and investment decisions with societal costs and benefits. Specifically, these include:

– Time- and demand-based congestion charges applied throughout a metropolitan area

– Guiding investments away from highway expansions and towards street redesigns and retrofits that prioritize mobility alternatives

– Introduce bans on fossil fuel transport

Case studies

Seoul, South Korea

As highlighted by the report "Climate Emergency Urban Opportunity" the city of Seoul has gone through an extensive transition since the 1950s. The population has grown to now accommodate nearly 10 million within the city limits and 25.5 million in the greater metropolitan area. The City has passed numerous redevelopment acts to replace low-rise, central houses and medium-rise peripheral apartments with high-rise buildings. Similarly, to address the proliferation of informal settlements, the city consolidated fragmented land parcels into contiguous, standardized tracts, enabling large-scale property development and much-needed infrastructure investment. The expansion of well-situated housing interspersed with commercial and public facilities has kept prices affordable and commutes short. High density was enabled by, and gave rise to, an extensive public transport system, including a world-class metro, extensive bus network and many pavements, enabling citizens to enjoy the benefits of agglomeration without severe traffic congestion. Seoul's success in regularizing informal settlements and expanding core infrastructure laid the foundations for the private sector to deliver high-quality, high-density housing in well-connected and vibrant neighbourhoods.

Road and Congestion Pricing: Singapore and London

In 1975, the City of Singapore established the first form of a congestion pricing programme. The Area Licensing Scheme served as a fee ($3 per day, $60 per month) on vehicles accessing the central business district (CBD) during peak morning hours. As an alternative, Singaporean drivers could park on the outskirts of the city and take transit into the CBD for as little as 50 cents. The programme produced immediate effects, increasing public transit ridership from 33% to 70% by 1983. In the 1990s, the programme was replaced with a dynamic, electronic road pricing system expanded to include non-peak hours, furthering improving transit ridership and reducing traffic volume.

London's recent congestion pricing scheme has produced similar results. In the first year of its implementation, the city reduced traffic by 15% and congestion (or time delay) by 30%.[29] Those reductions have largely held firm, with travel demand reduction remaining approximately 25% previous levels. Meanwhile, transit ridership has increased by 7%[30] because of the direct investment of congestion fees into the public transport system.

Water and Waste management

The challenge:

The integrated nature of urban ecosystems cannot be underestimated. Essential public services such as water, solid waste processing, sanitation and land use are closely linked to urban energy systems and their efficient management. The interdependent nature of these systems is an opportunity to optimize the use of resources and material and minimize waste in all forms. In practice, this means cities can foster a circular economy approach, one that eliminates waste and instead reuses or recycles its by-products.

Cities generated 2 billion tonnes of solid waste in 2016, a number that is projected to climb to 3.4 billion tonnes in 2050.[26] Too much waste creates health concerns, degrades the environment and represents a significant economic loss, as cities could re-use resources. For instance, New York City's 2018 budget for its Department of Sanitation was $1.5 billion, the bulk of which was spent on collecting, processing and exporting rubbish – costs that could be greatly reduced if the city applied principles of circular economy.[27]

The opportunity:

A circular economy produces zero waste by reusing or recycling waste into new products and is a key component of more resilient and liveable cities.

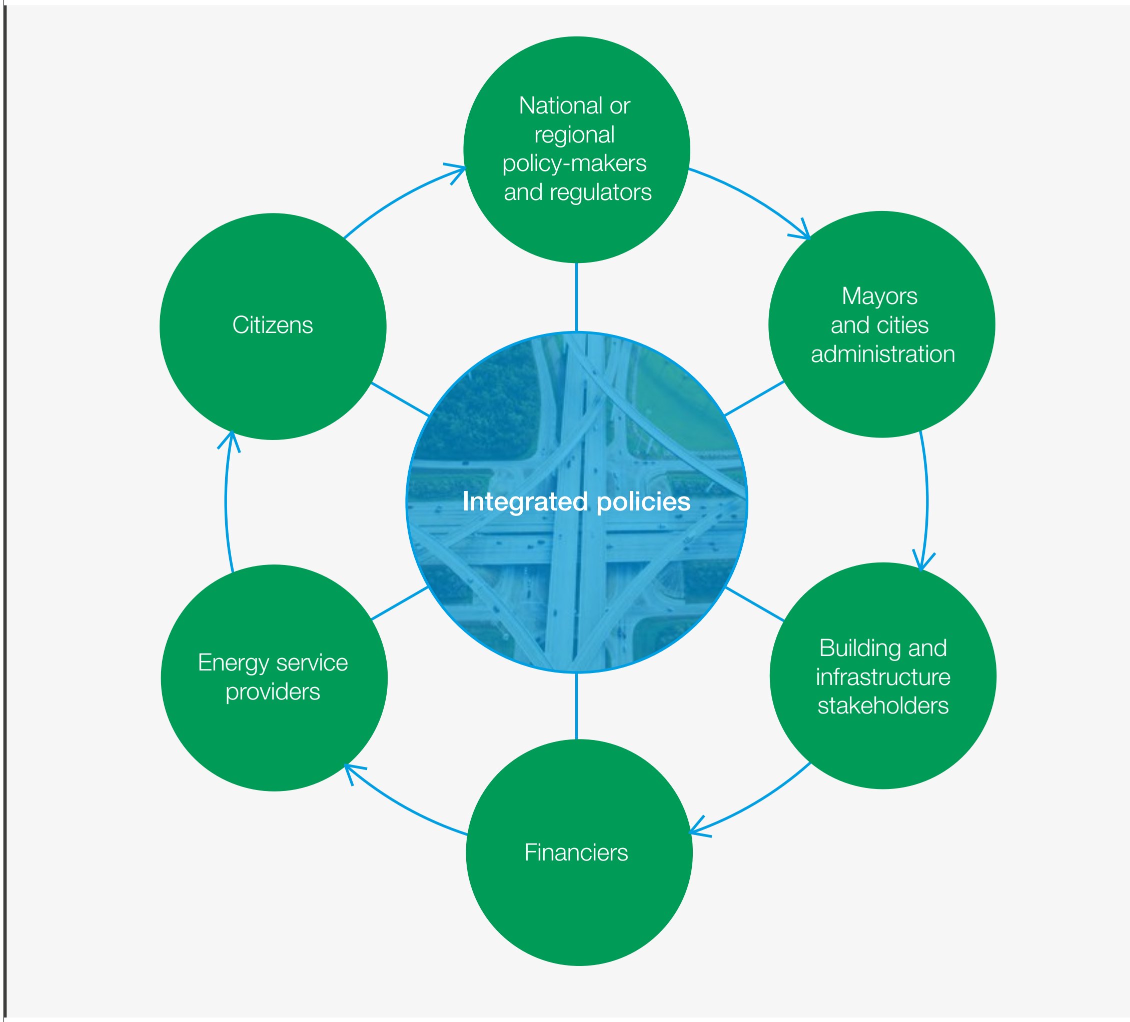
For example, as part of Cape Town's resilience strategy, the Western Cape Industrial Symbiosis Programme (WISP) provides technical expertise to help businesses understand their waste streams, and identify unused or underutilized resources, such as energy, water and expertise. WISP then helps find potential matches for those waste streams, thereby sharing resources, cutting costs, creating new revenue streams and contributing to a circular economy. WISP has diverted 104,900 tonnes of waste from landfills, eliminated 309,200 tonnes of fossil GHG emissions, and generated more than ZAR120 million ($7.2 million) in financial benefits.[28]

To learn more about cities that are taking opportunities to improve efficiency and environmental impact by embedding circular economy principles in urban infrastructure and services read the World Economic Forum report Circular Economy in Cities Evolving the model for a sustainable urban future.

3 Who needs to act?

Integrated policies for stakeholder collaboration

To deliver net zero carbon cities it is essential that city and national governments, business and civil society align and collaborate on a common agenda. This chapter provides a summary of who needs to act and specific recommendations.



A report by the Coalition for Urban Transitions - The Economic Ease for Greening the Global Recovery through Cities – provides recommendations to national government decision-makers for shaping fiscal stimulus packages for a green, resilient and inclusive economic recovery in urban environments.

National or regional policy-makers and regulators

City governments cannot address the challenges of reducing emissions alone. The future of cities depends substantially on decisions made by or supported by higher levels of government. National policy-makers can create policies that drive the redesign of our systems, with public health and economic prosperity as primary goals.

Nations can create road maps, collaborating with cities, to support their transition to clean energy. Currently, fewer than two in five countries have an explicit national strategy for cities, and only a handful of these meaningfully address climate action and human development. These include national energy, tax and transport policies, as well as funding and financing for large infrastructure projects.[31] It is important that policy-makers understand existing and emerging technologies to create road maps that maximize societal benefits while enabling the most efficient and competitive solutions.

Mayors and city administration

❝ **We would like to see the majority of cities in China commit to achieving net zero by 2035-2045 to ensure the country can hit net zero by 2060."**

Lin Boqiang, Chair of the World Economic Forum's International Energy Community China

Mayors and city administrators can lead the green and just transformation of our cities to cut emissions and deliver added benefits in terms of job creation, health and resilience. Collaborative, holistic planning will be crucial to this transformation.[32] Real systems change means moving away from planning around individual assets and sectors toward integrated systems, sharing expertise among professional disciplines and industries. Mayors can engage multi-sectoral business, civil society and academic stakeholders, including leaders from urban planning, design, engineering, real estate, construction, utilities, finance and investment to identify and execute integrated solutions that address multiple issues.[33]

For example, the City of Los Angeles has partnered with the US National Renewable Energy Laboratory and a broad coalition of stakeholders, including the local municipal utility, to analyse routes to a 100% renewable-based electric system. The LA100 study will help decisions-makers evaluate infrastructure upgrade needs, taking into account emissions, local air quality and social equity issues.[34]

Building and infrastructure sector

Public and private infrastructure developers (including real estate developers, building owners, operators and occupiers) have to collaborate with architects, urban planners, public transport agencies, engineers, contractors, utilities and others throughout the design and building process to deliver the scale of change required for a net carbon zero future. Digital solutions need to become embedded into this integrated value chain to drive a connected, data-rich future that will enable more efficient, and human-centred design. As important, these stakeholders need to directly address the needs of their most disadvantaged communities, co-creating and jointly implementing solutions and compensating them for their time and insights.

A few ideas for action:

- **Early planning**
  Project sponsors and developers need to identify sustainability and low-carbon opportunities as early as possible to realize maximum benefits. For instance, architects and designers can consider renovating buildings rather than rebuilding them to have the lowest carbon impact. Early planning can better incorporate evolving emissions targets to ensure buildings are positioned to meet 2050 targets while also addressing the challenge of maintaining affordability. Early planning also allows for integrated design among all of the energy assets and uses within the project, which can lead to dramatically lower energy demand and rightsizing of energy systems.

- **Thinking beyond isolated projects**
  Real estate developers can expand their focus beyond single building projects by collaborating with other stakeholders, such as the public sector, to create broader sustainable districts and communities for greater impact. To do so, they will need to consider community needs and integrate technology with the wider urban realm to create a system that is more than the sum of its parts. This offers new opportunities: district energy systems, balancing energy consumption between buildings, and integrating multiple systems such as buildings and mobility. Using one of the growing number of certification schemes for sustainable districts[35] is one tangible way to foster this systems-level approach.

- **Whole Lifecycle Carbon**
  Project design and construction should take into account Whole Lifecycle Carbon (WLC) emissions – those resulting from the construction and the use of a building over its entire life.[36] These include embodied carbon emissions – those associated with raw material extraction, manufacturing and transporting building materials, construction and the emissions associated with maintenance, repair and replacement as well as the eventual dismantling, demolition and material disposal.[37]

- **Accelerating the integration of digital solutions**
  For the full lifecycle of the building or infrastructure asset, digital technology such as Building Information Modelling (BIM) and digital twins (a virtual model of the building with all the information on its properties) can enable greater flow of information between stakeholders in the value chain, resulting in less waste and enhanced energy and material efficiency. This is also key to reducing the performance gap between design and in use operation.

- **Understanding the business case for green buildings**
  To mobilize the real estate industry to develop and retrofit buildings, the return on investment must be clearly understood and compelling. There is wide variance across asset classes and regions on the return profile of these projects, which is a recognized barrier to action.[38] For further reading, please see JLL's report The Impact of Sustainability on Value.

Energy service providers

Energy service providers, especially utility and energy companies, play a key role in increasing renewable energy supply and city electrification. These providers not only supply electricity, but also offer a range of other solutions including the design and implementation of energy efficiency, supply of heating and cooling, offer of distributed resource installation and energy management, including flexibility services to the grid.

A few ideas for action:

- **Communication with customers**
  Provide clear information on different solutions available, including their cost and benefits. Solutions could include household actions such as reducing energy waste, installing solar panels, switching to electric heating and cooling systems, and digitized home energy management systems. Communication could be targeted at individual households or at neighbourhoods or districts.

- **Enable integrated solutions**
  Energy service providers are one of the few stakeholders who can see across multiple assets within a district or city and use data, analysis and financing to support integrated project development, including balancing load profiles across building types, Electric Vehicle Service Equipment (EVSE) optimization, effective utilization of distributed and district scale energy systems.

- **Scale up progressive business models**
  Business models such as Energy Savings Performance Contracting (ESPC) and Efficiency as a Service (EaaS) can make facility improvements with no upfront costs for customers, funded through energy and operational savings (ESPC) or paying per use of the actual output (EaaS). These models can be scaled up to deliver greater impact. BASE (Basel Agency for Sustainable Energy) developed a business model with the objective to scale up the demand for efficient, clean cooling in emerging markets; this model is applicable to many elements of the built environment, beyond cooling. To learn more about Cooling as a Service (CaaS), please visit the CaaS page.

- **Develop innovative solutions for residential customer**
  "Plug and play" solutions may simplify customers' adoption of a product or technology. For instance, photovoltaic systems installed on the home balcony and connected to the domestic socket can be installed and connected easily, allowing residential apartment dwellers greater access to PV technology (with no individual roof availability).[39]

- **Increase technical capacity**
  There is a need to build greater technical capacity throughout the entire value chain, including retraining the skilled labour force currently employed in fossil fuel-based projects towards clean electrification.

Citizens

The way individuals live together, forming communities over time, creates habits, develops culture and sets living standards for lifestyle and the built living environment. As a result, active community members and consumers can impact the acceleration to a net zero carbon future.

Citizens and communities, according to their means, can make thoughtful choices about the way they live and what they consume so that they are aligned with sustainable, climate-friendly values; daily actions, such as purchasing energy services, mobility options and adopting new technologies can support the energy transition in cities.

Financing

One of the principal challenges that cities will encounter as they transition to a net zero carbon future is securing the financing to deliver the necessary infrastructure. The Coalition for Urban Transition estimates that the investments required to reduce urban emissions by 90% would be $1.83 trillion (about 2% of global GDP) per year, which would generate annual savings worth $2.80 trillion by 2030 and $6.98 trillion by 2050.[40] To reach these volumes of investment, all types of financing will be needed, public and private, ranging from commercial banks and private equity to multilateral development banks.

According to financial stakeholders, a lack of available finance is not a critical inhibitor to reaching these investment levels. The most common challenge they cite is a lack of "bankable projects" – projects with a structure and risk profile in line with financiers' expectations. If financiers are not satisfied with the structure and risk/return profile of a project, they will either not invest or ask for risk mitigation measures, which can add to the project costs. Energy efficiency projects for buildings, which typically have large upfront costs and long payback periods, often fall into this category.

Greater collaboration between stakeholders throughout the value chain and financiers can help overcome these obstacles. Involving financing institutions in the early stages of project development could ensure the project's financing, particularly through capacity building on how to deliver projects that are bankable and capable of being financed at scale. At the same time, stable policies are essential to attract investment.

Even with these challenges, things are moving forward. In recent months, some financial institutions have made commitments to Environmental, Social and Governance (ESG) standards, pledging to accelerate climate, socially responsible and mission-oriented financing.[41] Additionally, more innovative financing solutions are appearing, such as the case study below that highlights opportunities in combining traditional and innovative instruments.

To find out more about Environmental, Social and Governance standards and the drive towards a universal set of common metrics and disclosures, see the World Economic Forum's report [Measuring Stakeholder Capitalism: Towards Common Metrics and Consistent Reporting of Sustainable Value Creation](#).

Case study:

The Green Funds Scheme

The Government of the Netherlands subsidizes discounted yields on green bonds by offering bond holders tax incentives. The proceeds from the bonds are used to lend at below-market rates to local green projects. The Green Funds Scheme includes the financing of wind turbines, solar cells, hydropower, heat pumps along with energy savings measures such as LED lamps for street lighting or using waste heat for urban heating. The funding also includes "green" homes and offices, which must meet strict sustainability standards. Since 2001, the Green Funds Scheme projects have led to a decrease in CO_2-emissions of average 0.5 MT annually.

Recommendation for greener, healthier and more sustainable cities

● High accountability ○ Partial accountability

Objective	Action		Mayors and City Administration	Building and Infrastructure players	Energy Service Providers	Citizens	Financiers	Policy-makers
Define the vision								
1. Set baseline and target	1.A	Assess city emission and energy flows, building and infrastructure performance levels. Set ambitious targets.	●	○	○	○	○	○
2. Define the road map	2.A	Coordinate with national level policy-makers.	●					●
	2.B	Develop an action plan, measure and report progress.	●	○	○	○	○	●
3. Inclusive agenda	3.A	Involve citizens to contribute to their own city transition.	●			●		
Collaborate								
1. Enable collaboration and integration	1.A	Create cross-sectoral boards for integrated city planning and development.	●	●	●	●	○	○
	1.B	Establish regular dialogue with academia and businesses.	●	●	●		●	●
	1.C	Use digital platforms to manage assets, energy and data flows.	●	○	○	○	○	●
2. Data sharing	2.A	Share consistent data and KPIs at city level.		●	●		○	
	2.B	Data-driven decision-making.	●					●
3. Peer to peer support	3.A	Engage with global city coalitions to access exemplar solutions and share best practice approaches.	●	○	○			○
Finance								
1. Spur bankable projects	1.A	Develop PA's buildings and infrastructure renewal/ development plan.	●	○			○	
	1.B	Adopt certification standards and buildings codes at city/national level.	●	○	○		○	●
	1.C	Expand PPP model to lower credit risk e.g. retrofitting initiatives.	●	○	○		○	●

Objective	Action	Mayors and City Administration	Building and Infrastructure players	Energy Service Providers	Citizens	Financiers	Policy-makers
Scale							
1. Lead by example	1.A Incorporate mandatory buildings’ energy rating schemes into government leasing policies.	●					●
	1.B Implement green procurement guidelines for city administration.	●					○
2. Adopt digital solutions	2.A Invest in emerging technology and upskilling of practitioners.	●	●	●	●	●	●
3. Share best practice and communicate value	3.A Disseminate the value derived from adoption of best practices and innovative approaches.	●	○	○			●

Source: World Economic Forum workshop, November 2020

This framework recommends an integrated approach and is a call to action for a collaborative and inclusive effort to accelerate the net zero carbon transition in cities by designing policies and financial solutions that will support that transition. Cities must act fast for the world to achieve its climate goals. Plus, by acting, they can also create jobs, boost their economies, and improve the health of their citizens. The World Economic Forum gathered a community of global leaders who contributed to this global framework and committed to share a toolbox of viable solutions for the different cities’ needs. To learn more and engage in the Net Zero Carbon Cities: An Integrated Approach programme please visit the project page.

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