CLEANTECH CITIES

Accelerating Climate Action Through Startup and Corporate Innovation

LACI

C40 CITIES

IN COLLABORATION WITH pwc

A new partnership for public-private collaboration on climate action in cities

THE C40-LACI PARTNERSHIP

In January 2019, C40 and the Los Angeles Cleantech Incubator (LACI) announced a new partnership that aims to embrace innovation and accelerate climate solutions that reduce greenhouse gas (GHG) emissions in cities. We recognize that city governments globally are focusing on identifying collaborative climate solutions, including ones that engage citizens, academics and the private sector in the design process of innovative city projects.

The goal of this partnership is to equip key city actors with the business case, evidence and best practices to increase engagement with the startup, entrepreneur, incubator, accelerator and corporate innovation community. At the same time, we need to remove barriers for startup and corporate innovation to work with cities while ensuring we meet the needs of our most underserved communities.

First, we will develop an evidence base to inform how startups, entrepreneurs and corporate innovation can scale up and deliver solutions for cities to help limit global warming to 1.5°C, the target identified in the Paris Agreement. We will then explore how to kick-start and replicate action.

The Los Angeles Cleantech Incubator (LACI): Founded as a city-led innovation initiative and as a vehicle for economic development by the City of Los Angeles and its Department of Water & Power (LADWP), LACI has helped foster an innovation ecosystem in Los Angeles in addition to helping 78 portfolio companies raise $221million in funding, $220million in revenue, create 1,750 jobs, and deliver more than $393million in long-term economic value.

C40: C40 Cities connects 94 of the world's greatest cities to take bold climate action, leading the way towards a healthier and more sustainable future. Representing 700+ million citizens and one quarter of the global economy, mayors of the C40 cities are committed to delivering on the most ambitious goals of the Paris Agreement at the local level, as well as to cleaning the air we breathe.

OUR COLLABORATION WITH PwC

PwC is committed to doing business with purpose and helping others to do the same. Our global Sustainability and Climate Change practice continues to facilitate progressive action on the Sustainable Development Goals (SDGs), placing great importance on the transformative role of both cities and technology.

Our international cities advisory team helps city governments chart a course for good growth that embraces the rapid changes in technology, society and climate. An example of our work is our Innovation for the Earth initiative, a collaboration with the World Economic Forum (WEF), which looks at the disruptive role of frontier technologies in creating sustainable cities of the future. PwC's Scale Impact accelerator programme provides startups and SMEs in the cleantech space with access to corporate networks, business skills and investor relationships. PwC is excited to draw on its knowledge and experience working in these areas to collaborate with C40 and LACI.

ABOUT THIS PAPER

This paper intends to shine a light on the new and exciting opportunity for cleantech startups and corporate innovation to accelerate climate action in cities. We seek to bring together some of the disparate parts of this nascent innovation ecosystem into both a strategic case for action and a way forward.

We interviewed a range of city officials, innovators and ecosystem actors from around the world to provide insights to this propositional paper and we are grateful for these contributions. We have also learnt that there remains a significant knowledge and coordination gap for climate innovation activities within cities. This paper only scratches the surface therefore, offering a point of departure for future efforts to build on.

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CLEANTECH CITIES
Executive summary

Cities are our single greatest prospect for meeting the urgent challenge of climate change. While accounting for a 70% and growing share of global emissions today, cities also offer a highly efficient means of avoiding a climate crisis by decarbonizing energy, transport and consumption at scale. Encouragingly, we have already identified many of the solutions needed to secure a safer 1.5°C future. The real emergency is that despite the urgency highlighted at the UN Climate Summit in September 2019, and by increasing climate protests led by youth and across cities the world over, this action is not happening nearly fast enough.

A new stimulus is needed. Too often the burden of action falls solely on city governments who have some - but not all - of the tools, powers and resources required to meet this challenge. This working paper explores how cities can evolve as powerful and collaborative cleantech ecosystems, offer a testbed, market and network that supports 'impact entrepreneurs' to collaborate on climate action.

We discover that consumer solutions developed by **startups**, such as micro-mobility, home energy management and packaging alternatives, create opportunities for more collective and engaged action that taps into private channels of investment and expertise. The rapid scaling of e-scooters tackling part of the last-mile challenge shows how quickly breakthrough ideas can be deployed and scaled in cities using private finance and harnessing consumer demand. Startup 'unicorn' ventures such as Bird and Lime are each now valued at over $1 billion, representing some of the fastest growing businesses ever seen.

Similarly, **startup and corporate innovators** have huge potential to take a fair share of risk on new technologies, plus access skills and investment that is often beyond the reach of other ecosystem actors. These emerging collaboration models are not flawless, facing barriers in adoption and implementation, but they are fast, disruptive and show the promise of scale.

At the same time, city governments need to invite and partner with innovation in tackling the compounded challenges that cities face. City governments can leverage cleantech solutions that address not only climate change and the Fourth Industrial Revolution but also provide improved citizen outcomes.

The urgency of the challenge demands boldness in action. If we can find the mechanisms to stimulate, enable and manage the potential of startups and corporate innovation we will have a better chance of succeeding.

Highlights of our findings include:

- Cities, as a marketplace of actors, contain the ideal ingredients for climate innovation to thrive. We focus on how urban innovation and new collaborations can be accelerated and scaled in three areas of opportunity: **advanced mobility solutions, intelligent energy systems and more conscious consumption**.
- We find that these innovations enhance established solutions by offering significant additional and accelerated reductions in greenhouse gas emissions. We estimate that through disruptive innovation and new technologies, climate innovation in cities can target an **additional 1.3 $GtCO_2e$ of GHG reductions by 2030, a 35% enhancement to a 2 degree emissions reduction pathway and with more immediate impact that makes 1.5°C a possibility.**
- We find that these innovations also offer co-benefits and significant investment potential. Our estimates suggest that climate innovation presents just over **$5 trillion of new global investment opportunities in cities by 2030**.
- Greater action is stymied by a confused and uncertain ecosystem of support for innovators and collaborators. An immature enabling environment can lead to adaptive tensions due to the speed of change for people, regulators and local governments.

We propose three initial recommendations on what can be done now to enhance the urban innovation ecosystem and empower a range of actors quickly and at scale:

HELP CITIES TO DRIVE CLEANTECH STARTUPS AND CORPORATE INNOVATION: City governments need support to advance efforts to make it easier and faster for entrepreneurs to put in place solutions that city decision makers need and want. Our first recommendation is for climate and development assistance to be channeled into targeted support to city governments to help them better identify, commit, plan, prepare and cater for startup and corporate innovation that helps meet the city's climate goals - while meeting community needs, particularly those neighbourhoods and populations most underserved as well as suffering from the consequences of air pollution and climate impacts.

HELP ENTREPRENEURS AND INNOVATORS SUCCEED BY UNLOCKING THE POTENTIAL OF URBAN INNOVATION ECOSYSTEMS: Cities need to find the physical space and permission for entrepreneurs, startups, corporate innovation and collaborative action. The innovation-commercialization lifecycle needs to be supported within and between cities with coordinated but flexible support to a range of enabling factors including; market access, networking, commercials, finance, testing and piloting, procurement, data management and IP. Our second recommendation, therefore, is that every city with a budding or existing cleantech ecosystem should identify an existing intermediary or new and independent aggregator(s) to provide linkages and facilitate connections across the ecosystem at the city- or city-region scale, while working with community groups.

CREATE A GLOBAL PLATFORM AND PARTNERSHIP TO DRIVE INTERNATIONAL LEADERSHIP: Our third recommendation is that a new initiative, in the form of a platform or program should be created to champion accelerated urban climate action via. startups and corporate innovation. This platform would be tasked with harnessing network effects, enhancing partnership and support the collation and sharing of knowledge to support and inspire both action and replication.

We urgently need to get ourselves on track for a safer climate. We call for collective action by:

City governments - to embrace and enable innovation economies through vision and leadership, including clear articulation of climate goals and needs.

Ecosystem intermediaries - to champion the opportunity and collaborate to support key actors.

Investors - to engage with the climate innovation ecosystem to better understand and evaluate risk while adapting financial structures to reflect market dynamics.

Academia - to direct new research and curiosity to evidence and unlock new cleantech solutions for cities.

Innovators - to persevere with better forms of communication, collaboration, sharing and learning.

Communities - to use your voice and participate in helping to test and adopt meaningful action, while meeting the needs of underserved communities who feel climate impacts and air pollution most severely.

1 Introduction

Economic, demographic and technological shifts are changing society in the midst of a climate emergency, creating both an imperative and an opportunity to act. Over the past 15 years, the cleantech industry and smart city initiatives have emerged in response to climate and competitiveness needs, both spurred by technological advances. Progress has been promising, from large-scale solar energy to interconnected, real-time city monitoring and operations, but these solutions are yet to reach their full potential.

Business as usual models are not enough to deliver climate action at the scale and pace required to limit global warming to 1.5°C, the target identified by the Paris Agreement. Several barriers exist to scaling cleantech, ranging from hardware-based product challenges to skills gaps, and cautious public procurement processes that may slow down or limit opportunities for innovative solutions to deliver climate action at scale.

City governments alone cannot solve the problem and startups cannot easily replace existing city functions either; the focus needs to be on scaling climate innovation in cities with innovative technology and solutions implemented by new business models. What innovators can do is create new space, and room to grow in the adjacencies between traditional city operations, optimising how the city functions and is experienced.

We also now know that food, travel, recreational and manufactured goods create a 'consumption footprint' in cities that is much greater than their direct operational emissions. This is where innovators in business-to-consumer markets can really thrive and scale, with exciting potential to support climate action by individuals as more conscious consumers of local and sustainable products.

Despite a range of initiatives developed in response to scaling challenges, the urban innovation ecosystem remains disjointed and more support is needed to capture this emerging opportunity.

This paper is structured in five parts:

In section 2, we define climate innovation in cities and give examples of it in action. We then review the current, fragmented landscape of climate innovation in cities, based largely on interviews with city officials and ecosystem actors around the world.

In section 3, we use scenario analysis to identify the potential GHG impact and market size of scaled-up climate innovation in cities.

In section 4, we provide an overview of the journey innovators need to go on to reach climate impact. We explore the barriers to innovators and city governments working together, and the tools already in use to overcome challenges.

In section 5, we set out three recommendations for enhancing climate innovation, focusing in particular on the role of city governments, ecosystem intermediaries and the global community to enable scale and amplify impacts.

In section 6, we make an urgent call to action to all stakeholders, asking each to play its role in accelerating climate innovation in cities.

Climate innovation in cities is an exciting new opportunity that enhances planned action on climate change. It can therefore add to, but not replace, important actions such as behavioral change, clean energy, infrastructure and active or public transport solutions.

2 What is climate innovation in cities?

DEFINING CLIMATE INNOVATION IN CITIES

The cleantech industry has gained significant attention in the last decade, increasingly driven by emerging national policy commitments to climate action and declining relative costs of clean technologies. By 2020, the market value of cleantech is already expected to reach $1.3 trillion and grow to $2.5 trillion by 2022.[I] As a maturing market that represents the 'modern way' of servicing our urban needs, this offers an enticing investment and entrepreneurial opportunity.

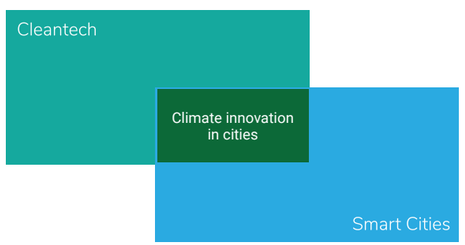
CLEANTECH SOLUTIONS OPTIMISE THE USE OF NATURAL RESOURCES, BE THAT ENERGY, WATER OR MATERIALS, REDUCE POLLUTION AND GHGs, AND HELP US ADAPT TO THE IMPACTS OF A CHANGING CLIMATE.

City populations, alongside their energy and mobility needs, are all projected to grow rapidly in the coming decades, particularly in developing economies. With concerns over sustainability and resource constraints, there is also a bigger necessity for cities to act intelligently in the interest of its citizens. A parallel market is growing in 'smart cities' that is expected to reach $717 billion by 2023.[II] Smart city solutions are more than buzzwords. New data and technology applications are creating demonstrable benefits for urban citizens, especially in the digital and services spaces that can address more complex lifestyle and consumption challenges.

SMART CITIES GROW AND ENABLE CITIZEN ENGAGEMENT, INTEGRATE HARD INFRASTRUCTURE, SOCIAL CAPITAL AND DIGITAL TECHNOLOGIES TO MAKE CITIES MORE RESPONSIVE, RESILIENT AND 'LIVEABLE'.

Innovation plays an important role in both of these areas to turn challenge into opportunity. This paper specifically explores the intersection of cleantech and smart cities – see Figure 1 – focusing on adopting technology solutions that catalyze urban climate action.

Figure 1: Positioning the climate innovation market

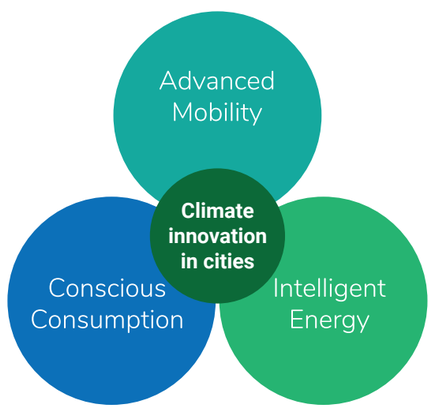


MAKING SPACE: THREE NEW AREAS OF OPPORTUNITY FOR CLIMATE INNOVATION IN CITIES

Climate innovation in cities can be broadly categorised into three areas of opportunity based on current trends and key areas identified for future action – see Figure 2.

Intelligent energy includes solutions in virtual grids combining several supply sources, micro generation and advanced demand management across multiple sectors. The transition to a low carbon economy needs reliable alternative and renewable energy sources to be available to all citizens. Within our homes and buildings, energy solutions need to empower consumers to make environmentally efficient choices. Intelligent solutions that adapt to consumers' lifestyles are emerging within the smart home devices market, with startups such as Nest Labs, now Google Nest, reimagining outdated devices such as thermostats into smart ones that learn, react and embody the home. Many city governments are also rethinking their whole energy management approach, e.g. with connected street lights that evolve existing power grids into smart grids.

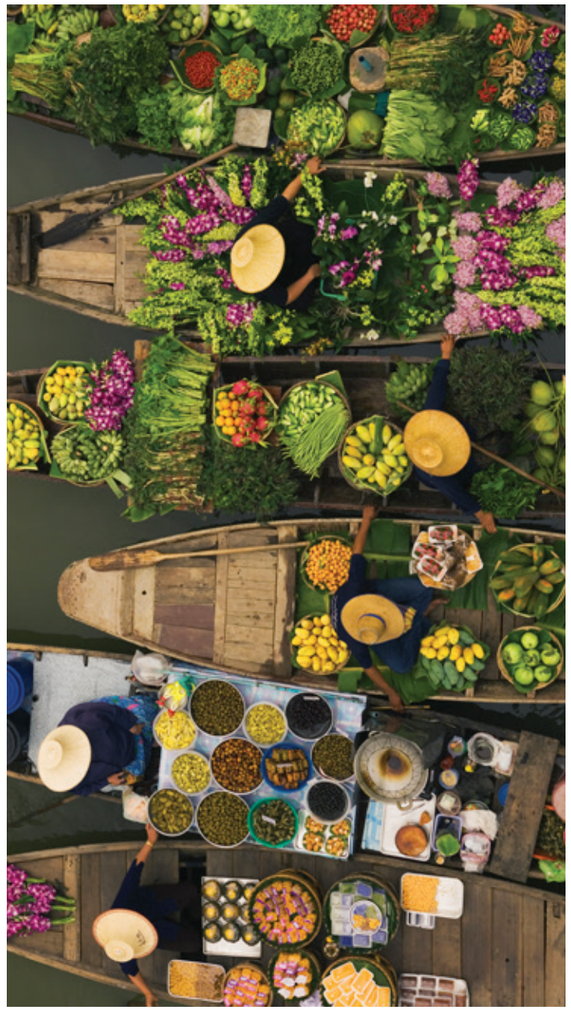
Figure 2: Opportunity areas of climate innovation in cities



Advanced mobility encompasses electric, autonomous, optimised and data-enabled mobility solutions that reimagine the way we move within cities. Our pace of lifestyle changes call for innovative business models. This is exemplified by the recent exceptional growth of electric scooter startups - with a market valued at $17.4 billion in 2018, set to reach $41 billion by 2030. E-scooters offer a convenient low-carbon alternative to short car-trips, addressing the first- and last-mile problem while disrupting roads and stunning city officials worldwide. Despite strong consumer demand, their capacity to scale and maximise potential has been limited by a lack of understanding of the regulatory landscape and compatible infrastructure.

Conscious consumption is about cities, businesses and individual consumers supporting a circular economy that radically reforms how we use innovative construction techniques and materials, eliminate waste, grow and process food products and manufacture consumer products. Recent C40 research shows that including consumption-based emissions in current GHG accounting methods increases urban emissions by some 60% in a cohort of 79 participating C40 cities. Shifts in consumer behaviours for more sustainable products and services make this an area ripe with opportunity for startups and corporates alike. Banyan Nation, an Indian plastics recycling startup, is transforming supply chains of national companies, working with L'Oreal for example on reusing bottled products that are, in turn, consumed in cities. For conscious consumption solutions to truly scale, several issues need to align in a city, such as producers, people, policy and innovators.

This report only touches on a handful of examples within the vast array of urban cleantech solutions, which are growing and diverse in nature. They are all however at different levels of success, with some advancing rapidly and others having shown early signs of promise but running into problems. See box 1 for illustrative examples of emerging climate innovation.



Box 1: **Examples of climate innovation in cities**

gridComm is a Singapore-based start-up leveraging Internet of Things technology to connect existing power line communications, semiconductors, devices and systems to create city-wide 'smart' grids.[VI] According to our analysis, for the average city with 100,000 streetlights, introducing LED connected ones across all cities with populations above 750,000, would result in 17.7 $MtCO_2^e$ annual emissions reductions.[VII]

Google Nest is a pioneer in the smart home revolution,[VIII] with Google having acquired the original startup Nest Labs for $3.2 billion in 2014 after only 4 years of operation.[IX] It currently operates in over 21 countries[X] and the majority of its customers can be carbon neutral within 8 weeks.[XI] The Nest Learning Thermostat alone has saved approximately 25 billion kWh of energy to date – equivalent to powering the planet for an hour.[XII]

Bolloré Blue Solutions is exploring the potential for electric vehicle (EV) charging infrastructure and car sharing services.[XIII] Its Autolib car sharing service was launched in various cities but uncovered different operational issues. Since, however, its charging network has been used as a platform for other EV car sharing services to emerge within cities. It worked closely with the City of Los Angeles to build on lessons learned to launch in Los Angeles as **BlueLA and** directly deliver benefits that address the city's low-income community needs.

See Box 2 for an additional example in advanced mobility on the rise of e-scooters.

Closed Loop Partners is an investment fund that partners with startups, corporates and city governments to build the circular economy.[XIV] By end-2018, Closed Loop Partners avoided 1.8 million tCO_2^e emissions through its portfolio of investments and by 2030, expects to reduce or avoid up to 36 million tCO_2^e emissions.[XV]

Banyan Nation works with both city governments and corporations to improve plastics recycling across India, where 80% of all plastic is discarded as waste and 40% of this uncollected.[XVI] It also has an IoT data intelligence platform that tracks urban waste flows and is currently being implemented in cities across the states of Hyderabad, Warangal and Telangana.

A NASCENT ECOSYSTEM

From cleantech accelerators and dedicated university institutes to national cleantech clusters and green pilot programs run by municipalities, the ecosystem for climate innovation in cities is a diverse space that has seen several innovators, 'enablers' of growth, and new customers enter the scene. Table 1 below gives an overview of actors and their roles in this ecosystem.

Table 1: Roles of urban climate innovation ecosystem actors

ACTOR	INNOVATOR	ENABLER	CUSTOMERS
STARTUPS	■		
CORPORATES	■	■	■
ACADEMIA	■	■	
INTERMEDIARIES		■	
INVESTORS		■	
CITY GOVERNMENTS		■	
CITIZENS			■

While some cities and countries have more established networks for cleantech, given the myriad of actors, both startups and city governments face challenges of knowing who exactly to engage with and turn to for help. The challenge is not only at the city-level, however, but is repeated at the global level as well.

As an emerging ecosystem, the current landscape for climate innovation in cities remains fragmented. Structural issues contribute to this, for example:

- Cleantech solutions may be targeted at cities, but innovators may not be located there due to costs of space for hardware development;
- Ecosystem actors may operate in silos – sometimes by narrow sectors within cleantech, or alternatively, not focused enough on climate innovation or cities, compounding problems of information flow, and;
- Many intermediaries, i.e. organisations and initiatives that can act as the 'glue' of the ecosystem, already exist to support scaling of climate innovation in spearheading cities and well-known innovation ecosystems, yet are often thinly spread at a macro-level.

The spaghetti bowl of various ecosystem actors and the array of activities they are involved in are illustrated in Figure 3 on the following page.

"CITY-TO-CITY COLLABORATION IS IMPORTANT. This can enable cities to tackle common areas of focus together, sharing learnings and stories of success."

– Bella Liu, Secretary General,
Green and low-carbon development foundation, Shenzhen

Figure 3: Actors and activities in the urban climate innovation ecosystem

3 Sizing the opportunity

Enabling the successful scale of climate innovation can unlock future emissions reductions in cities and present an attractive investment opportunity that delivers co-benefits to wider society. We have conducted some high level analysis using existing data to ask 'what if' innovation in cities could accelerate existing action and create new market opportunities in the process.

BOOSTING GHG EMISSIONS REDUCTION POTENTIAL

An increasing number of cities are setting ambitious emissions reduction targets in line with the Paris Agreement, yet currently identified city-scale actions are not enough to reach these targets.

According to research by the Stockholm Environment Institute (SEI), emissions from buildings, transport and waste in the 600 largest cities are expected to grow to some 15.5GtCO_2e by 2030. Currently identified city-scale actions in these sectors can contribute 3.7 Gt of global GHG emissions reductions on top of what national climate action is expected to achieve by 2030.

However, these actions do not reflect the latest wave of innovation taking place in cities. Our analysis reveals the potential for disruptive innovation to support city governments in narrowing the emissions gap by developing immediate, and privately financed, cleantech solutions.

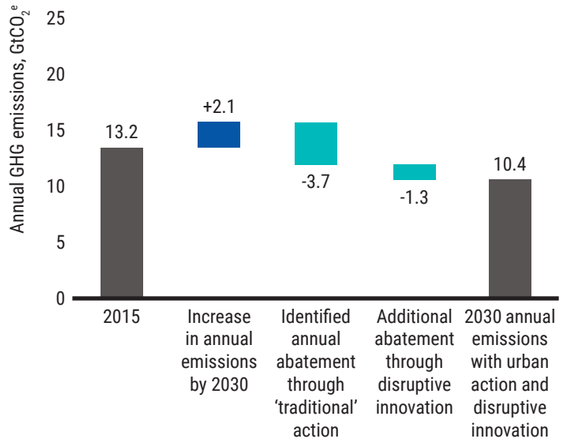
We have explored the extent to which urban cleantech solutions can provide further emissions reductions for cities, in a scenario where they are able to reach transformative potential through successful scale and commercialisation. Building on the report by SEI, which focuses on urban-scale actions in 11 sub-sectors within buildings, transport and waste, we assessed the additional action that private sector innovation – both by startups and corporates – can undertake in each of these sub-sectors.[xx]

The enhanced GHG emission reductions available from climate innovation were determined by the additional potential of each subsector for climate action in the three focus areas of this report. These were classified as having either low (10%), medium (20%) or high (30%) potential for enhanced emissions reduction which are determined by a combination of the overall scope for enhancements, plus the speed, agility to adopt new innovations in each subsector. For example, in transport, while cities can introduce policies that encourage the use of public transport and decrease private vehicle use (e.g. congestion zones in city centres), cleantech mobility solutions can complement this to further increase public transport uses that are clean and provide GHG emission reductions and last-mile solutions.

Innovation in process and business models also presents a notable opportunity in waste, specifically recycling. Current levels of production are too high and produce an unmanageable amount of waste and associated GHG emissions, which are only set to rise with increasing global urban populations. Technology, alongside behavioural change, can play a key role in eroding these hard to reduce emissions, supporting resource constrained city governments to successfully manage waste in their municipalities.

We propose that through disruptive innovation and new technologies, climate innovation in cities can target an additional 1.3 Gt of GHG reductions by 2030, a 35% enhancement to a 2 degree emissions reduction pathway and with more immediate impact. See Figure 4 on page 15, supported by Table 2 on page 18. We have also undertaken a brief bottom-up analysis to see what the potential emissions reductions would be from increased e-scooter adoption in cities – see Box 2 on page 16 for detail.

Figure 4: Enhanced GHG emissions reduction potential



Private sector innovation can create new services and business models that promote behavioural change and shape consumer demand. With cleantech solutions, this can reduce additional consumption-based GHG emissions, which are up to 60% higher than sector-based GHG emissions in 80% of the C40 cities.[xxi]

Recent C40 research also shows that even with national government commitments, city pledges and radical consumption interventions, there is still a significant cumulative emissions reduction gap before C40 cities can reach the 1.5°C trajectory they need. In this context, successful deployment and scaling of technology is crucial to tackle this remaining gap. [xxii]

This, however, requires collaboration with the public sector and supportive policies to minimise potential 'rebound effects' of new technologies.

Sizing a nascent market and its impact is difficult, but even using these modest assumptions and conservative estimates, climate innovation in cities can considerately spur climate action to reduce GHG emissions and design new approaches to achieving low-carbon cities.

Box 2: **Bird – startup innovation in e-scooters**

The fast spread of e-scooters in cities across the world has generated a buzz and been met with enthusiasm by many consumers now able to make short trips in a novel way, while city governments decide how to respond, raising concerns over the technology's safety and impact on accessibility of pedestrian walkways.

Bird is a dockless e-scooter rental service, founded in California in 2017. After just one year of operation, the startup expanded across North America, Europe and Asia, announcing that it hit 10 million rides across its 100 cities of operation with over 2 million riders. **Bird is the fastest company yet to reach a valuation of $1 billion in less than a year** and other e-scooter start-ups have closely followed including Lime, Scoot and Skip.

Their breakthrough growth has had mixed reactions from city officials and citizens, with city officials commonly restricting the numbers of units operating in the city, or prohibiting e-scooters entirely from cities unless in designated areas.

Bird reported 15,000 e-scooters in operation within the City of Los Angeles before a cap was introduced in September 2018, limiting the number of scooters allowed anywhere in the city to 3,000. Without barriers to scale, and with adoption levels of 15,000 e-scooters across 600 cities (in line with SEI's analysis), use of e-scooters could result in **1.77 million tCO_2^e emissions reductions in one year**,[xxiii] equivalent to removing 360,000 passenger vehicles a year – see Figure 5 and 6.

To allow e-scooters to flourish as a solution for micro-mobility a joint approach between the private and public sector is needed to ensure the right infrastructure is in place to adapt to changing consumer mobility choices.

Co-benefits of reducing GHG emissions from transport and from the use of e-scooters include reduced air pollution and congestion, improved health outcomes from cleaner air alongside more active travel, and increased social inclusion.

Figure 5: Illustrative adoption curve of e-scooters per city with current regulation and potential

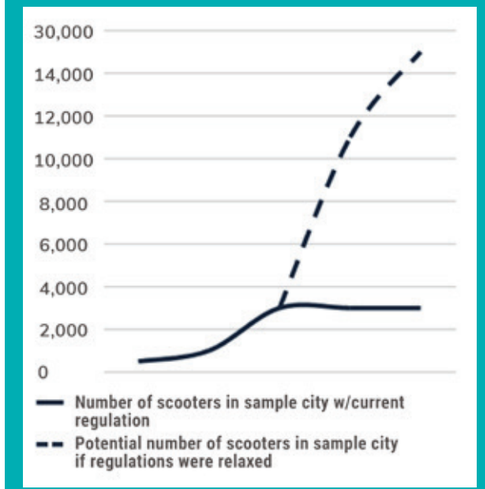
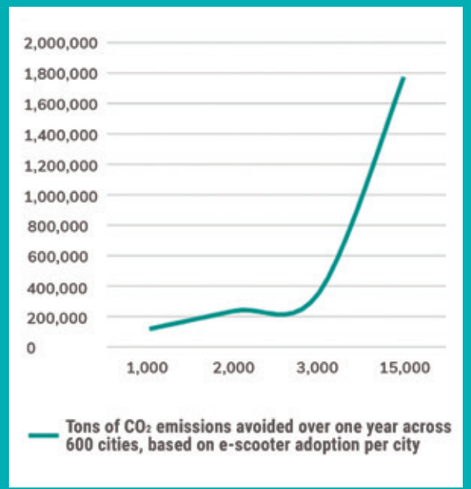


Figure 6: Illustrative GHG emissions reductions from e-scooter adoption in 600 cities



MARKET SIZE: INVESTMENT POTENTIAL AND CO-BENEFITS

Our estimates suggest that **climate innovation presents just over $5 trillion of new global investment opportunities in cities by 2030.**

This is additional to current city-scale actions, which are already estimated by the New Climate Economy to catalyse nearly $15 trillion of global incremental investment by 2030 across the focal sectors of transport, buildings and waste. Our approach to estimating the market size complements the approach to GHG reduction analysis so that the results are comparable. This should be considered a 'what-if' analysis of market potential derived from assumptions, so care is recommended and the results should not be relied upon. Using our previous determinations for the potential level of disruptive innovation across the 11 sub-sectors, we determined the corresponding amount of investment opportunity in each – see Table 2. This highlights the economic benefit for key private and public sector organisations that play a central role in supporting the innovation ecosystem.

Investment opportunities and potential GHG emissions reductions only stand to grow as parallel technological advances, e.g. in artificial intelligence and blockchain, can help unlock further cleantech innovations.

Investing in climate innovation also creates a myriad of co-benefits, both directly and indirectly for the city. City governments are uniquely placed to harness these co-benefits of climate action and stimulate policies that address objectives across different sectors of the economy, e.g. health, transport, housing. We have not included an analysis of these co-benefits here but see Box 3 below for further information or read C40's report Co-Benefits of Urban Climate Action.

Box 3: **Co-benefits of climate innovation**

Scaling of cleantech startups leads to higher productivity and introduces a number of jobs to the economy that contribute to increased economic growth and social prosperity. Specific cleantech solutions create different co-benefits but in general, additional co-benefits include: better health, life expectancy, social inclusion, safety and security of citizens and improved air quality and biodiversity.

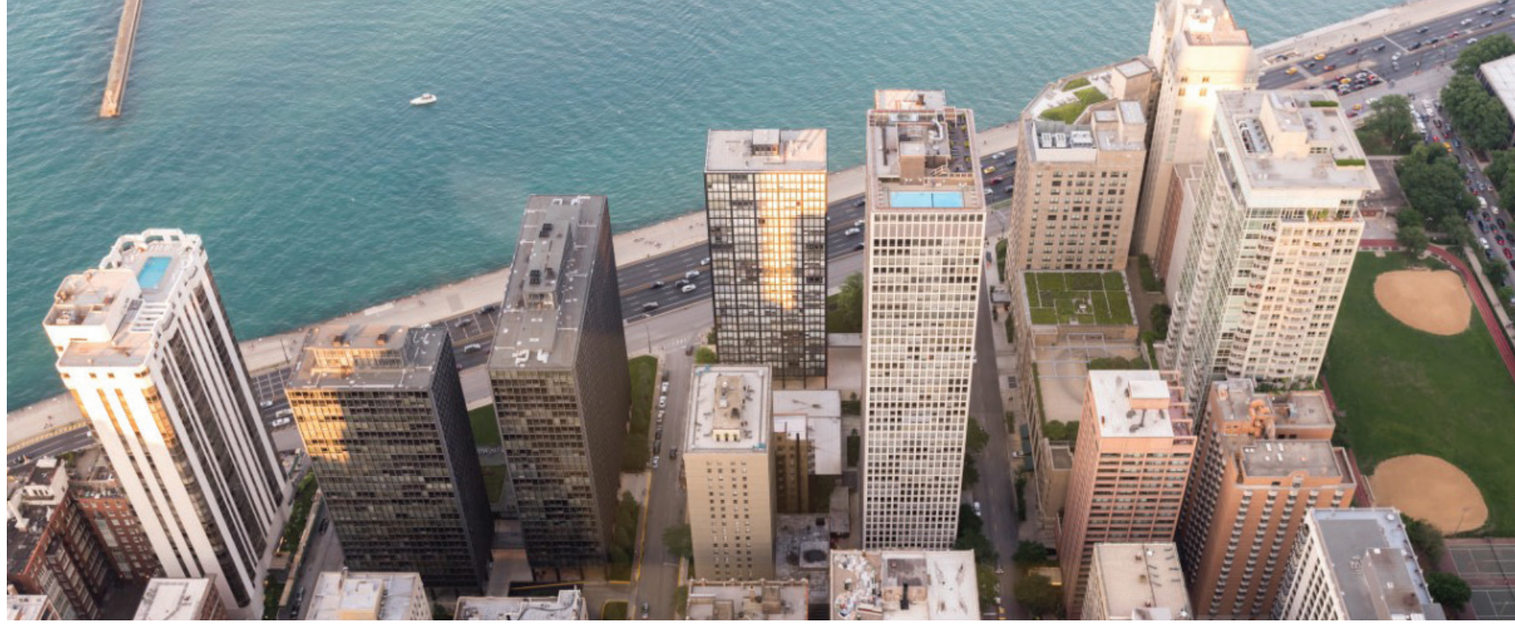
"ENABLING CLEANTECH INNOVATION GROWTH IN LOW AND MIDDLE INCOME COUNTRIES LOOKS DIFFERENT FROM HIGH INCOME ONES, given more nascent technology markets and basic challenges of attracting talent and finance. Yet there is an exciting opportunity in creating new business models, not just technologies, to scale."

– Jean-Louis Racine, infoDev Climate Technology Program Lead, World Bank

Table 2: Assessment of potential reduction in annual GHG emissions by 2030 and amount of investment by 2030 through disruptive innovation

CITY SECTOR	SUB-SECTOR	LEVEL OF POTENTIAL FOR INNOVATION		ADDITIONAL ABATEMENT THROUGH INNOVATION, $GtCO_2e$	INVESTMENT IN INNOVATION, $ TRILLION
		STARTUPS	CORPORATES		
BUILDINGS, RESIDENTIAL	New building heating efficiency	Low	Medium	0.18	0.68
	Heating retrofits	Low	Medium	0.12	0.82
	Appliances and lighting	Medium	Medium	0.16	0.02
	Fuel switching / solar PV	Low	Low	0.02	0.06
BUILDINGS, COMMERCIAL	New building heating efficiency	Low	Medium	0.09	0.85
	Heating retrofits	Low	Medium	0.06	0.51
	Appliances and lighting	Medium	Medium	0.12	0.07
	Fuel switching / solar PV	Low	Low	0.02	0.02
TRANSPORT, PASSENGER	Urban planning – reduced travel demand	High	Medium	0.10	0.00
	Mode shift and transit efficiency	Medium	High	0.20	1.48
	Car efficiency and electrification	Medium	Medium	0.08	0.43
TRANSPORT, FREIGHT	Logistics improvement	Medium	Medium	0.04	0.00
	Vehicle efficiency	Low	Low	0.02	0.09
WASTE	Recycling	High	High	0.10	0.00
	Landfill methane	Low	Low	0.00	0.00

4 Evaluating the barriers to and enablers for climate innovation in cities



THE GROWTH JOURNEY: FROM INNOVATION TO IMPACT

Growth of cleantech solutions in cities can provide more efficient mobility options, affordable quality housing for all and waste management that will stay viable into the future, alongside accelerating urban climate action. Yet as we saw with some of the examples, while adoption at scale is needed, it is certainly not a given.

To explore this, we have identified three phases of growth for climate innovation in cities to reach viable and commercial markets that also delivers positive climate impact. Whether a startup or corporate innovator, the phases of growth – discovery, scaling and amplification – are outlined in Figure 5 below, alongside expected business and climate outcomes.

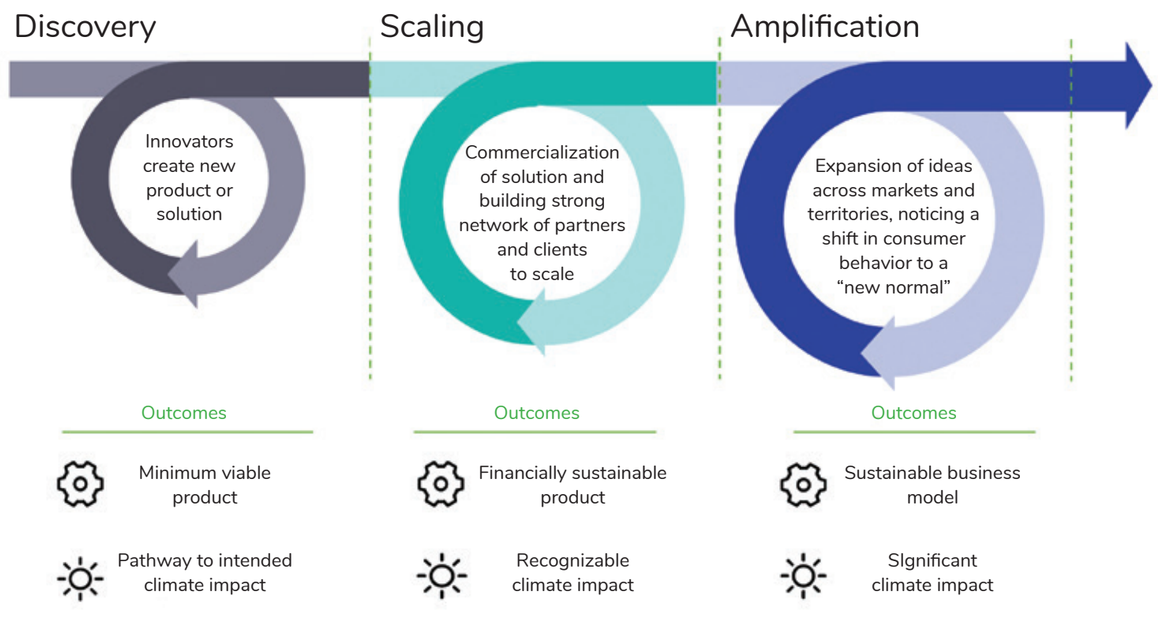
Based on findings from our interviews and research, much enthusiastic support around climate innovation in cities focuses on the discovery phase. However, the number of cleantech innovations then able to successfully commercialise and scale their solution declines, with even fewer innovations able to amplify impact across multiple cities.

Cleantechs face a number of barriers on their journey from innovation to climate impact. Some are similar to those experienced by other startups and innovators, however the specific nature of cleantech also brings its own set of challenges, which we outline next.

For cleantech innovators to establish sustainable business models and contribute to significant climate impact, a range of issues need to come together both at the macro-/city-level and the micro/startup-level. There is no silver bullet of course but a number of successful innovation cities and regions exist globally. Not just Silicon Valley but also, for example, Seoul, South Korea, Helsinki, Finland, the 'golden triangle' of Oxford-Cambridge-London in the UK, the 'Research Triangle' in North Carolina, US and Tel Aviv, Israel.

Each has a strong innovation economy to support both startups and corporate innovation, many with a cleantech angle. A review of the characteristics that these places exhibit helps us identify five common features of higher-performing innovation ecosystems, which are outlined in Box 4.

Figure 7: **The growth journey**



BARRIERS TO SCALE

Startups and corporate innovators pushing boundaries of existing policy frameworks and traditional markets share a range of barriers in developing their ideas into viable products, attracting the right talent and finance, finding customers and scaling their innovations.

We have identified seven challenge areas for cleantech innovators and cities to work together, based on our discussions with several city government officials and other actors in the cleantech space around the world. The challenges will look different depending on the innovator or city in question, as well as the stage of the innovation journey to climate action – see list below for an overview and Figure 8 below for an illustration.

Awareness and communication

- Cleantech poorly understood outside industry
- City governments challenged to effectively articulate needs and priorities for innovation
- Incumbent on startups to pitch to cities, but hard to know who key decision-makers are

Culture and pace of work

- Startups need speed and plan in terms of months; cities plan in terms of years
- Large corporates may lack urgency to innovate; employees not incentivised to do so
- Cities cautious in taking risks with untested new technology

Skills and motivation

- Core commercial skills thinly spread
- Missing support in skills transition from discovery to scaling/commercialization phases
- Livability and affordability of cities to compete globally for innovation economy talent

Financing and funding

- Few successful or lucrative cleantech startup exits, poor financial track record diverting investor interest
- Hardware-based innovations requiring higher initial investment, space, continued funding
- Constrained city government budgets to bet on startups and weak operating and maintenance capitalization for upgrades

Markets and networks

- Tech-led pilots struggle to get wider traction if not targeted at specific city problems
- New cleantech needs constant refinement, high research and development costs, supportive networks
- Lack of local manufacturing supply chains or clusters to scale/replicate cleantech solutions

Policies and regulation

- Existing, slow-to-change regulatory barriers hinder new tech implementation at pace
- Lack of clear city-focused incentives or abrupt changes in subsidies for cleantech
- Concerns of political instability, leadership or strategy shifts based on votes, public opinion

Public procurement

- Startups discouraged by high business development costs, cumbersome criteria of public procurement
- Inefficient to scale city engagements across cities as lack of standard procurement rules
- City tenders may lack innovation, dissuading long-standing suppliers from innovating

Figure 8: Common pitfalls for cleantech innovators through the three phases of growth

SEVEN ENABLERS TO GROWTH

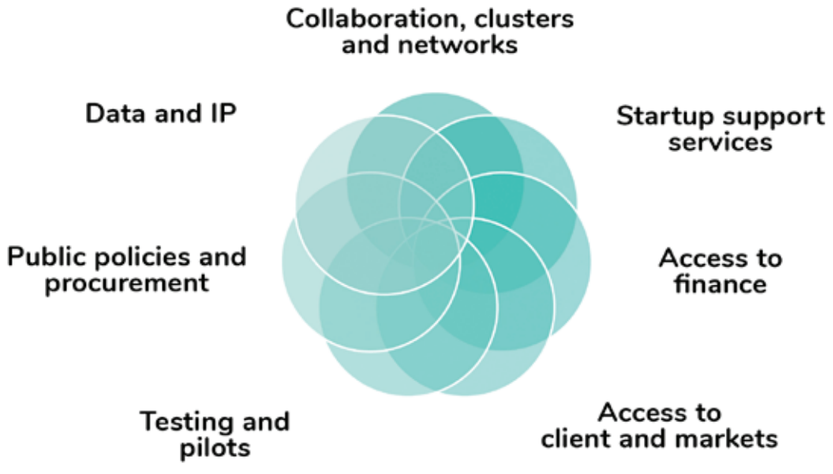
Barriers to startups and innovation are generally well known, and several tools and instruments have emerged as a result, ranging from new financing mechanisms and basic entrepreneurial skills programs to incubator spaces and wider innovation policies.

With cleantech coming into greater focus over the last decade, new initiatives have sprung up to cater for specific innovation challenges in the space. The issue with this budding support is that it is often ill-defined and incomplete. Some cities provide support directly, some initiatives are national or private. Not all initiatives provide support across the urban innovation journey, which means that startups and innovators need to jump between different support services, distracting them from their core mission and adding to costs. What is needed is a clearer, more structured and comprehensive ecosystem of support, focused on both scale and networks, ideally opening up multi-city markets and important knowledge transfer.

Through our research and interviews, we identified seven areas of existing tools and instruments to support climate innovation in cities – see Figure 9 and a non-exhaustive list in Table 3 starting on page 28. The vast number of emerging examples gathered in Table 3 show just how busy and fast-moving this space is, and that it is only likely to continue growing at both the national and global scale. Many of the tools listed are being embraced by different actors (e.g. hackathons led by either the city government, academia or the private sector), which makes coordination between these actors to align objectives and benefits even more vital.

Collaboration, clusters and networks provide some of the most exciting and impactful ways forward for scaling cleantech, yet many of the existing enablers are still focused on early-stage support. Startup Genome's recent review of 15 types of policy actions also supports these findings, which noted that government support has mostly focused on access to capital and startup support organisations and programs, while the least focus has been given, among others, to scale-up support, regulatory reform and procurement.[xxiv]

Figure 9: Enablers: Scaling city cleantech innovation



4 EVALUATING THE BARRIERS TO AND ENABLERS FOR CLIMATE INNOVATION IN CITIES

In emerging markets where cleantech is a budding sector, such as large parts of Sub-Saharan Africa and South East Asia, raising awareness of the sector, facilitating grant funding and supporting innovation on a national level in more traditional cleantech areas such as solar power remain the focus. In more mature markets, from Helsinki to Los Angeles, cleantech support services and ecosystem actors are already relatively well connected and operating at city-level.

Improving the business environment at a local level is a challenge for scaling climate innovation in cities in both emerging and mature markets. While favourable urban policies and regulations can enable development of climate innovation in cities, few such innovators target products for cities due to the high barriers of accessing government tenders, particularly for startups and smaller companies. These procurement challenges, however, are slowly changing – see Box 4 on the following page.

"THE MEMBER-BASED CLUSTER MODEL WORKS IN THE DANISH ECOSYSTEM AS IT ALLOWS BROAD COLLABORATION, with the Nordic Council of Ministers supporting coherence regionally. We are still learning how to get the most relevant parties to the table at the global level, however, to connect on solutions and finance - pooling together smaller organizations can help create the umbrella partners needed to coordinate and accelerate action."

– Henrik Bjørnager Jensen, International Director, CLEAN

Box 4: **Transforming cleantech procurement in cities**

Scaling climate action in cities requires bold action from local governments, not just reacting to new technologies being implemented in the city, but proactively changing own rules and processes to expand access to government contracts and boost cleantech innovation. **Representing 12% of GDP in OECD countries**,[xxv] public procurement is both a huge market and a key GHG reduction opportunity.

Changing cautious and complex public procurement is a slow process, but new tools are being developed to lure more startups from the B2B and B2C markets into providing solutions directly to city governments.

The first, simple steps cities can do to engage directly with cleantech innovators include **reverse pitches** and **requests for information** (RFIs), e.g. on the latest market progress in battery storage technologies. In fact, a number of startups, and more mature outfits, are supporting cities in doing just that. Examples include Citymart's RFI generator launched in August 2018,[xxvi] Avisare's platform for collating and simplifying public procurement processes, UrbanLeap's workflow tool for local governments to evaluate, pilot and accelerate scaling of innovation,[xxvii] and Startup in Residence's 16-week program for startup and city government co-development. **'Triple helix' partnerships** with corporates and academia, as well as **designated zones for piloting** in city environments can also help identify relevant innovations.

Building skills and awareness is important among startups and corporate innovators - to understand the opportunities and ways of working with municipalities - and within city hall - so that the existing landscape of cleantech solutions is clearer to enable better evaluation of technologies presented. This is key before committing to working with a specific innovator, given city governments often operate with tight budgets and with high requirements for transparency in spending taxpayer money. Startups will also want to ensure their prototyping or piloting efforts with a particular city government would have a clear path to forward, given limited investment budgets and long development cycles for cleantech.

Over time, city municipalities may want to work on changing own procurement processes to enable more agile and consultative public tenders as a standard practice. Barcelona can serve as a benchmark, having won the European Procura+ sustainable 'procurement initiative of the year' award in 2018.[xxx]

Environmental clauses are required in each city contract, and it has also developed trailblazing toolkits for innovation procurement.[xxxi] In 2015, a **48-month pilot rental contract of 30 e-scooters for city police yielded 88 tCO_2 savings**, with the program planned to expand to 198 e-scooters in 2018.[xxxii] City government leadership played a key role in transforming cleantech procurement.

"A CHAMPION IN CITY GOVERNMENT WHO BELIEVES IN AN IDEA, can navigate internal politics and sets clear goals upfront for pilot programs while being committed to its long-term success is the most promising way to make public procurement work for startups, cleantech or otherwise – but finding those in power or willing to stick their neck out can be tricky."

– Sky Kelley, founder, Avisare

Table 3: Tools and instruments enabling innovation and scaling of urban climate innovation (list not exhaustive)

TOOLS AND INSTRUMENTS	DESCRIPTION	STAGE MOST NEEDED AT	RELEVANT CLEANTECH/CITY EXAMPLES
COLLABORATION, CLUSTERS AND NETWORKS			
Co-creation spaces	Dedicated spaces for cleantech startups to work closely with peers, get access to business services and networks to accelerate knowledge- sharing, collaboration through economies of scale.	Discovery, scaling	Brooklyn Navy Yard in New York combines urban art and advanced manufacturing co-production spaces, including for cleantech innovators.[xxxiii]
Co-creation platforms	On-/offline platforms for collaboration between different stakeholders, including hackathons, to come up with new approaches to solving problems or forming new ideas.	Discovery, scaling	C40 City Solutions platform supports early engagement for solutions;[xxxiv] Climate-KIC's annual 1-day solutions- focused Clima-thon in 113 cities.[xxxv]
Innovation Clusters	An aggregate of multiple enablers, often managed with geographical focus and based on 'triple helix' innovation cooperation between industry, government and academia.	Discovery, scaling, amplification	Greencape promoting cleantech in South Africa's Western Cape;[xxxvi] Denmark's national CLEAN cluster including smart city focus.[xxxvii]
Innovation Networks	Formalised cooperation between cleantech incubators, accelerators or other intermediaries through bilateral or multilateral partnerships for faster spread of viable disruptive ideas.	Discovery, scaling, amplification	ICN;[xxxviii] Climate Business Innova-tion Network connecting cleantech entrepreneurs in developing coun-tries with global resources.[xxxix]
Corporate Partnersips in Cleantech	Corporate investment, programs, acquisition or sponsorship to scale cleantech startups in own sharing - risk-sharing, faster development and wider implementation of solutions.	Discovery, scaling, amplification	BMW Innovation Lab's 16-week acceleration program for startups;[xl] LACI's network of corporate (and other) partners.[xli]
Peer-to-peer industry networks	Collaboration between large corporates to exchange knowledge and facilitate corporate innovation to reduce carbon footprints, often with sector focus.	Scaling	World Business Council for Sus-tainable Development, a global, CEO-led organization with program on cities and mobility.[xlii]
STARTUP SUPPORT SERVICES			
Incubators	Support development of disruptive ideas with aim of building out business model/ company through access to wide range of early-stage startup support, physical spaces.	Discovery,	Range of examples inlude LACI in Los Angeles, MaRS in Toronto, ACRE in New York CIty, TechStars Energy in Norway, Station F in Paris
Co-creation platforms	Accelerate growth and scaling of startups after initial business development support. Fixed term, cohort-based programs, Public, private, university, corp. or intermediary- driven.	Scaling	Cleantech Open, major accelera-tor in US[xliii]; New Energy Nexus Southeast Asia supporting accel-eration of smart energy startups in region.[xliv]
Innovation Clusters	Training in cleantech areas for entrepreneurs to enable scaling. Corporate-, university-, vocational school-, recruiter- or incubator-led that can take various forms.	Discovery, scaling	Climate KIC's Greenhouse pre-incubation program for aspiring entrepreneurs with climate-related business ideas.[xlv]
Innovation Networks	Matchmaking of corporate or other volunteers sharing expertise/specific skills with entrepreneurs leading to potentially higher success rates for startups.	Discovery, scaling	Rainmaking's '+impact' initiative (private sector broker, all SDGs); C40's Women4Climate mentorship scheme for female entrepreneurs.[xlvi]
Corporate Partnersips in Cleantech	Supporting entrepreneurs to find co-founders, build team through ad hoc/specialist support or focused pro-grams/platforms to access finance and the right skills.	Discovery	Inco.org network, mentorship for social/environmental startups in cities across 35 countries, including for minorities and refugees.[xlvii]

TOOLS AND INSTRUMENTS	DESCRIPTION	STAGE MOST NEEDED AT	RELEVANT CLEANTECH/CITY EXAMPLES
ACCESS TO FINANCE			
Blended finance for innovation	New finance mechanisms blending public and private finance, e.g. through focused loans, grants and startup funding for new innovative public-private partnerships (PPPs).	Discovery, scaling	P4G funding e.g. for city-related innovative projects in developing countries (up to $100,000 for startup PPPs, $1 million for scale-ups).[XLVIII]
Cleantech-focused funds	Funding earmarked for cleantech and environmental innovation for cities, e.g. by patient capital by specialist funds, often supported by public sector and/or donors.	Discovery, scaling, amplification	Multi-donor Climate Technology Fund ith funding, e.g. for public transit;[XLIX] Global Environment Facility (GEF) inc. sustainable cities focus.[L]
Microfinancing	An aggregate of multiple enablers, often managed with geographical focus and based on 'triple helix' innovation cooperation between industry, government and academia.	Discovery	USAID's Renewable Energy Microfinance & Microenterprise Program (REMMP).[LI]
ACCESS TO CLIENT AND MARKETS			
Scale-up programs	Helping startups scale beyond early years with specific skills training, corporate introductions and wider networks.	Discovery	Alarcity, scale up program internationalization program for Canadian cleantech companies, e.g. in waste.[LII]
Online marketplace	Digital marketplaces connecting cleantech solutions and clients to speed up matchmaking and procurement process.	Scaling, amplification	Solved online on-demand cleantech expertise, e.g. San Diego Water Authority hired expert evaluation panel to assess technology bids.[LIII]
Startup markets	In person/online marketplace e.g. conferences with concentration of cleantech entrepreneurs pitching to potential investors, led by corporate or other broker for time-efficient fundraising.	Scaling, amplification	Ecosummit conferences across cities in Europe bringing together startups, investors and corporates on smart, green cities, energy and mobility.[LIV]
TESTING AND PILOTS			
Living Lab/ Test Bed	Specific area in city designated for testing cleantech innovations for better fit solutions, e.g. through joint venture between city and university or broader network of collaboration.	Discovery, scaling	LADWP and Bureau of Street Services experimentation with cool pavement technology on the LKIC campus in Los Angeles.[LV]
Innovation park/district zoning	Special economic zone with own rules and regulations to advance city-specific solutions to achieve maximum impact. Targeted government support through policy, incentives, networks.	Scaling, amplification	Singapore National Environmental Agency's Regulatory Sandbox relaxes certain rules for experimentation, within certain parameters.[LVI]
Citizen showcasing	Showcasing new technology for citizens to test functionality and indicate adoption rates. Can be led by innovator, enabler or e.g. city/ corporate customer.	Discovery, scaling, amplification	CicLAvia's bike lane testing in Los Angeles; [LVII] Citymapper's Project Grasshopper experimental pop-up smart bus route in London.[LVIII]
Co-piloting	Collaboration to mainstream process for pilot testing by agreeing success metrics upfront e.g. among cities/with universities, to enable quicker scaling of successful pilots across city assets.	Discovery, scaling	The Green & Digital Demonstration Program (GDDP) gives innovators access to Vancouver's assets to test technologies and attract finance.[LIX]

TOOLS AND INSTRUMENTS	DESCRIPTION	STAGE MOST NEEDED AT	RELEVANT CLEANTECH/CITY EXAMPLES
PUBLIC POLICIES AND PROCUREMENT			
Online procurement platforms	Facilitation and aggregated digital services for innovative public procurement to enable more efficient public procurement of innovation.	Scaling, amplification	Several examples, many of which are North America-focused: Citymart;[LX] Avisare;[LXI] UrbanLeap;[LXII] Startup in residence.
Open calls/ competitions	Showcasing cleantech innovations to specific clients or investors/industry e.g. city-led requests for information (RFI) for tailored solutions.	Discovery, scaling	New York City's 'moonshot' Climate Action Challenge; [LXIII] C40's Women4Climate Tech Challenge.[LXIV]
Innovative procurement methods	Agile public procurement through replicable toolkits, methods, where city takes active role in changing own processes.	Scaling, amplification	Barcelona's procurement best practices;[LXV] lessons on cleantech procurement in Finland;[LXVI] European Procura+ network [LXVII]
Reverse pitching	Set a clear challenge or problem and then invite innovators to bring solutions to these. .	Discovery, scaling,	Amsterdam's Startup in Residence program.[LXVIII]
City innovation identification	National or local government policies supporting e.g. writing a city's long-term vision to galvanise action from all stakeholders.	Discovery, scaling, amplification	Morgenstadt City Labs initiative assessing city challenges for sustainable development;[LXIX] Bloomberg Philanthropies funding innovation to tackle urban issues.[LXX]
DATA, INTELLECTUAL PROPERTY AND INFORMATION SHARING			
Open data programs	City government open data platforms to broaden access to knowledge of existing solutions and spur new data-based innovation opportunities.	Discovery, scaling, amplification	Sharing City Seoul project for wider resource and information sharing in the South Korean capital.[LXXI]
Increased corporate transparency	Voluntary or mandatory frameworks for corporate CSR reporting and carbon disclosures, potential for increased innovation.	Discovery, scaling, amplification	Global Reporting Initiative driving transparency in sustainability reporting. [LXXII]

TOWARDS MORE COHESIVE URBAN INNOVATION ECOSYSTEMS

For cleantech innovators to establish sustainable business models and contribute to significant climate impact, a range of issues need to come together both at the macro-/city-level and the micro/startup-level. There is no silver bullet of course but a number of successful innovation cities and regions exist globally. Not just Silicon Valley but also, for example, Seoul, South Korea, Helsinki, Finland, the 'golden triangle' of Oxford-Cambridge-London in the UK, the 'Research Triangle' in North Carolina, US and Tel Aviv, Israel.

Each has a strong innovation economy to support both startups and corporate innovation, many with a "climate innovation angle. A review of the characteristics that these places exhibit helps us identify five common features of higher-performing innovation ecosystems, which are outlined in Box 5.

"AS A CITY, OUR CONTRIBUTION TO VANCOUVER'S BURGEONING CLEANTECH GROWTH IS LARGELY DRIVEN BY OUR POLICY WORK. Introducing greener requirements for construction materials has, for example, prompted local manufacturers to upgrade their technologies to meet local demand. Alongside this, we work with the Vancouver Economic Commission to leverage city assets for cleantech pilots, as part of the Green and Digital Demonstration Program."

– Sadhu Johnston, City Manager, City of Vancouver

Box 5: **Five characteristics of higher performing urban innovation ecosystems**

1. Clear market signals: Municipal and national governments can make clear commitments to being places that support innovation and innovators, e.g. via policy, strategic, institutional, and funding interventions. Places with clear propositions such as Seoul and Tel Aviv create the leadership, confidence and inspiration innovators and investors need and can respond to.

2. Living laboratories: Startups and innovators need to be able to prototype and test solutions. Thus, cities like Helsinki, where demonstration areas such as Kalasatama Urban Lab allow companies, residents and the city government to co-develop and pilot new, climate-positive innovations, tend to offer better operating environments for startups. This is particularly the case for hardware-based cleantech where testing often requires practical real-world environments.

3. Entrepreneurial culture: The underlying business culture of a place creates a foundation for its economic condition. In some countries, more liberal and modern economic policy coupled with pragmatic deregulation will support greater risk-taking and private investment. Primarily due to its track record, Silicon Valley now has a clear reputation for attracting ambitious and determined types of people. In other parts of the world, the demand to be a leader in innovation from national government drives innovation at the local level. This is notable in China, where innovation policy has led to heavy investment in electric vehicles and cleantech.

4. Magnet for top talent and skills: Talent is absolutely key to this market. Cities have to be places where footloose talent wants 'to be' – sometimes it is a lifestyle proposition, sometimes the co-location of talent from other industries with whom to collaborate and share ideas. More than that though, the talent that creates the new ideas need to be supported by a wide range of 'B-players' that provide the business nous, the legal, financial, commercial, practical and scaling attributes that these new businesses will need.

5. Bankable prospects: While London and Helsinki are not as prolific as Silicon Valley in terms of their production of so-called 'Unicorn' firms (i.e. rapid growth $1bn valuation businesses), they are producing a steady stream of investable propositions at scale - thus improving both the investor and talent proposition. Success in markets other than cleantech can boost the reputation of these locations as places to do business. This final characteristic is often influenced by the previous four and provides a critical link to scale.

5 How we can act to support climate innovation in cities

Many cities are making strides on the zero-carbon path, but collectively have a long way to go in meeting the goals of the Paris Agreement. City governments cannot solve the challenge alone.

Climate innovation in cities can realise part of the challenge - we found it could deliver 1.3 $GtCO_2e$ GHG reductions and a $5 trillion market opportunity alongside wider co-benefits. More importantly, as time is running out on keeping global warming to a maximum 1.5°C, climate innovation in cities has potential to scale quickly thanks to the speed of technological innovation and its reliance on private capital, which is abundant compared with that of government budgets.

Yet realising this potential is not a given. As we saw with the complex range of actors and activities involved in climate innovation ecosystem, finding alignment between intermediaries, innovators, city policy and the enabling environment is a challenge. Ecosystem actors are still working in geographical, sectoral or other siloes, and have yet to come together to form the critical mass required to move from early stage piloting to scaling cleantech and amplifying its climate impacts across urban areas.

To help cities deliver these outcomes and meet the urgent climate challenges of today, we set out three overarching recommendations for enhancing city climate innovation and scaling. All three are interlinked and help bridge the gaps in knowledge and practice between actors at the city, regional and global levels. The recommendations do not necessarily fully relate to each city, which should evaluate its own situation.

Our key recommendations as follows:

1. **Transform city enabling environments for private sector innovation**: help city governments to accelerate action on their climate goals by enabling innovation
2. **Unlock the full potential of urban innovation ecosystems**: make it easier for innovators to work with cities and eachother to attain climate goals
3. **Create a global platform and partnerships to drive international leadership**: Create global partnerships and platform to drive innovative climate action in cities

These three recommendations are summarised in Table 4, mapped against the barriers, enablers, and success factors presented earlier in this report.

Table 4: Our recommendations to realise the potential of climate innovation in cities

RECOMMEN-DATIONS	1: HELP CITIES TO DRIVE CLEANTECH STARTUPS AND CORPORATE INNOVATION	2: HELP ENTREPRENEURS AND INNOVATORS SUCCEED BY UNLOCKING THE POTENTIAL OF URBAN INNOVATION ECOSYSTEMS	3: CREATE A GLOBAL PLATFORM AND PARTNERSHIP TO DRIVE INTERNATIONAL LEADERSHIP
Why needed?	Cities with climate-conscious leadership, proactive policymaking, and learning from each other inspire action among innovators and consumers alike.	Integrated intermediaries within cities help validate cleantech business opportunities, and support startups and corporate innovators move pilots to scale.	A global platform for climate action through the urban innovation ecosystem creates a common agenda for change and coordination to amplify impacts.
Aimed at...	City governments, innovators and consumers within cities	Cleantech ecosystem intermediaries within cities	Global city networks and cleantech ecosystems
...to address the following barriers...	• Knowledge and awareness • Culture and pace of work • Skills and motivation • Markets and networks • Policies and regulation • Procurement • Needs of underserved communities	• Knowledge and awareness • Culture and pace of work • Skills and motivation • Finances and funding • Markets and networks	• Knowledge and awareness • Culture and pace of work • Finances and funding • Markets and networks • Policies and regulation
...using the following enablers...	• Collaboration, clusters and networks • Pilots and testing • Access to clients and markets • Public policies and procurement	• Collaboration, clusters and networks • Startup support services • Access to finance • Access to clients and markets • Pilots and testing	• Collaboration, clusters and networks • Access to finance • Access to clients and markets • Data, IP and information sharing • Public policies and procurement
...to achieve key positive characteristics of ecosystems.	• Clear market signals • Magnet for top talent and skills • Entrepreneurial culture	• Living laboratories • Magnet for top talent and skills • Bankable prospects	• Clear market signals • Magnet for top talent and skills • Bankable prospects

RECOMMENDATION 1: Help cities to drive cleantech startups and corporate innovation

From Paris to Vancouver and Cape Town several city governments around the world are already leading the way in enabling cleantech innovation. Cities like Los Angeles have not only laid out a bold plan, but also built a physical campus and invested in accelerating innovation via LACI to support startups, implement zero emissions pilots, and help remove barriers and set market signals with partners.

Many city governments do need help to engage and enable private innovation. Even cities that are further ahead today may find it challenging to support innovation at real scale if they do not have the right governance structures, skills or mandates for innovation. Local governments with complex mandates and limited resources are under pressure from many angles and may risk feeling overwhelmed by the range ideas, implications and the pace of progress and change.

Our first recommendation is for climate and development assistance to be channeled into targeted support to city governments to help them better identify, commit, plan, prepare and cater for startup and corporate innovation that helps meet their climate goals. Over time, tackling some more difficult 'bottlenecks' such as areas of procurement and regulatory reform can help unlock further growth and climate impact. Supported cities will demonstrate solutions so that others can replicate and learn from their experience and solutions as per the peer learning model successfully supported by C40 globally.

We need to create policy environments that have the necessary checks and balances in place to direct innovation that achieves the necessary GHG emissions reductions, whilst maximising co-benefits (such as increased air quality and social mobility) and minimising any potential tradeoffs.

Quick wins for city governments could include:

- Engage local government leadership to inspire commitment in supporting the role of innovation and technology in tackling climate challenges
- Articulate specific city challenges that need solving for climate impact, and proactively communicate it to the market
- Set out bold policy solutions that provide market signals to meet ambitious yet critical climate action goals without jeopardizing public procurement rules
- Engage with the local innovation community to build awareness of cleantech opportunities and solutions in the municipality
- Appoint champions in the municipality to drive the climate innovation in cities agenda internally, e.g. some departments may already be well-connected with the local innovation community and could inspire change in other departments

Over the next 3-5 years, city governments could also:

- Build ties with national and regional umbrella initiatives that bring cities together to share lessons and inspire action specifically around innovation and cleantech for climate action – e.g. finding what has worked for cities in similar geographies and economies is crucial to scale climate action and avoid re-inventing or adopting solutions unfit for context
- Review their own procurement processes to expand innovative and accessible public tenders and explore ways to harmonise certain rules and processes, within the city/region in the first instance, to enable replication of successful cleantech innovations at pace across several cities
- Identify incentives to drive positive change in consumer and corporate behaviour in sectors with the biggest potential to deliver climate impact in the specific city

RECOMMENDATION 2: Help entrepreneurs and innovators succeed by unlocking the potential of urban innovation ecosystems

The speed and scale of innovation means there is a strong opportunity for agile intermediaries to play a role in connecting the ecosystem. We need to make it clearer and easier for innovators to work in cities to deliver business and climate goals. From LACI in Los Angeles to Climate KIC in Europe, several intermediaries already exist to support cleantech startups, help cities work with such, or drive growth and collaboration in the wider ecosystem.

Our second recommendation is that every city with a budding or existing climate innovation ecosystem identifies an existing intermediary or new and independent aggregators to provide linkages and facilitate connections across the ecosystem at the city- or city-region scale. The objective of such a city intermediary would be to close support gaps along the innovation journey and accelerate cleantech market development so that innovative solutions can move quicker from pilot to scale – whether through financial matchmaking, skills for scaling or facilitating productive conversations between municipalities and innovators.

This does not mean that an incubator needs to be set up everywhere; the important thing is ensuring that there is easy access to support for research, innovation and scaling of viable climate innovation ideas in a city. We believe a convening intermediary should avoid too narrow sectoral alignments at the start to build critical mass and economies of scale for cleantech in cities. Local governments may choose to fund such a new aggregator, in which case it would benefit from an exit strategy, for when an ecosystem has matured and key bottlenecks have been addressed.

Quick wins for ecosystem intermediaries could include:

- Identify other cleantech intermediaries and cleantech innovation enablers, including academia, in own city region to link up with
- Direct funding to new forms of aggregator, city-level entities that can bring ecosystem intermediaries together and that, through online and physical resources, can enable startups and other ecosystem actors to quickly know who to turn to for specific support or collaboration for scale
- Flexibly design startup and business 'services' to fit with existing context e.g. by providing more city-level support and prototyping in developing areas versus scale-up services and internationalization in more mature city cleantech ecosystems
- Articulate cohesive local cleantech market opportunity and identify risks, in collaboration with the city

Over the next 3-5 years, ecosystem intermediaries could also:

- Drive formation or join existing clusters of cleantech actors focusing on city sectors to bring a wider range of intermediaries nationally and regionally together
- Promote cleantech across the urban innovation ecosystem, e.g. communicating ways to 'green' existing startups
- Create mechanisms for connecting cleantech startups in different cities to facilitate peer-to-peer learning
- Explore creation of third-party vehicle(s) to house and secure data that cities want to publish and innovators want to protect to mediate challenge of who owns data and how it is presented in public domain

RECOMMENDATION 3: Create a global platform and partnership to drive international leadership

Climate innovation lacks visibility, is poorly understood and is underrepresented as an opportunity. The innovation ecosystem that supports it currently lack a coherent identity, voice and common agenda that would lend it global credibility, momentum and space to grow. A global entity could stimulate much greater levels of international action similar to how the SDGs spurred action for development, Habitat III for cities and the Paris Agreement for climate.

From the local level to the global, various actors need to come together to scale climate innovation in cities to support more collaboration, access to capital and knowledge sharing across borders for accelerated climate action. Despite great enthusiasm this is not yet happening in a coherent or scaled way.

Our final recommendation is therefore to create a new global champion that would bring the trinity of cities, finance and the climate innovation community together internationally. It would act to provide, leadership and coordination; develop and share evidence, identify knowledge and learning plus convene and facilitate connections and mentorships between cities. It could also take on market level tasks such as using its position a central actor to operate as a 'clearinghouse' of urban climate innovation meaning that cities and ideas can be connected and exported from one to another. Its greater independence means that it could assess and access markets or explore the viability of a pilot innovation fund to reduce risk, facilitate early investment packages and assist interactions with patient investors and blended funds.

A global platform and partnership could initially:

- Provide better go-to support on market, knowledge, finance and network activities for both developed and developing countries
- Build connective tissue and soft infrastructure between these cities to support and share their activities
- Bring diverse financiers into the discussion, not only venture capitalists but particularly multilateral development banks, foundations and global initiatives willing to fund cleantech, that understand the urgency to invest now and the patience needed to see cleantech innovations through to scale
- Drive development of a 'pilot to scale' fund that allows to 'hack' procurement to demonstrate, learn and provide proof of concept at one end, with a clear line to scaling on the other end

Over the next 3-5 years, a global platform and partnership could also:

- Enhance the way global learnings are shared and trickled down to the local level, and vice versa, e.g. through city-to-city mentorship relations or sector focused connections
- Work with investors to identify and support new financial market access and instruments to drive growth in climate innovation in cities
- Build open, digital platform to share knowledge, contacts and drive global climate action at city level through cleantech

6 A Call to Action

As climate scientists, activists, policymakers and young people remind us, now is the time to act. We have seen a growing need for climate action in cities to reach the ambitious and necessary targets of the Paris Agreement and we know that we are falling behind; but this isn't a hopeless or necessary conclusion.

Yes, more work is needed to understand the nuances of cleantech development in cities, the actual scale of the market opportunity using new and comprehensive data, of what works and what doesn't. But we should not hesitate. Innovation is a clear lever and opportunity that can accelerate climate action at the pace required to get back on track.

We have presented our initial but encouraging estimates of GHG emissions reductions and investment opportunity that might be possible in cities, but the true potential is likely greater and **we have every expectation that we have underestimated the potential of innovation to contribute to climate action**.

Technology keeps surprising us with what it can achieve, with small ideas that can benefit the climate turning into mainstream innovations that can play a big role in catalysing climate action, for example as seen with e-scooters' sudden popularity and rapid growth.

To deliver this, **what is needed is a clearer, more structured and comprehensive ecosystem of support,** focused on both scale and networks, ideally opening up multi-city markets and essential open knowledge transfer. Policy signals, inspiring leadership and connective infrastructure are key as startups and corporate innovators design new business models and link with private capital to accelerate urban climate action. Our recommendations set this out and are looking for owners.

The real question is, how fast can we act? We call on:

City governments who need to foster innovation economies through vision and leadership, articulate needs better to ensure cleantech innovations are aligned with real demand, and adapt public procurement processes to improve access to startups and corporate innovators.

Ecosystem intermediaries that need to come together in a more cohesive way, articulate the market opportunity for climate innovation in cities and act as champions for increased innovation, talent and finance in the urban cleantech ecosystem, locally and regionally.

Investors who need to be at the table with city officials and intermediaries to support scaling of climate innovation in cities, find ways to balance return expectations and timelines of cleantech innovation, and develop new, potentially blended, finance tools to address investment gaps.

Academia that needs to connect better with the needs of city innovators and intermediaries and create partnerships with enterprising corporates and startups to commercialize viable ideas and move from piloting to scaling.

Startups and corporate innovators who need to communicate more with each other, and with city governments, to avoid costly failures and innovations misaligned with demand, focus on lessons learnt and key successes from others, and partner to scale innovations.

Citizens and communities who need to maintain public pressure around the urgency of climate action so that policymakers know to keep it on the agenda, and take steps to change behaviors, particularly around consumption, to realise the potential of climate action in cities. Citizens, cities and entrepreneurs also need to meet the needs of underserved communities through climate innovation solutions, while reducing the disproportionate burden they experience from climate impacts and air pollution.

GLOSSARY OF TERMS

Advanced mobility - electric, autonomous, optimised and data-enabled mobility solutions that reimagine the way we move within cities.

Cleantech - Cleantech refers to technologies that optimise the use of natural resources, be that energy, water or materials, reduce pollution and GHGs and help us adapt to the impacts of a changing climate.

Cleantech / innovation cluster - An aggregate of multiple enablers, often managed with geographical focus and based on 'triple helix' innovation cooperation between industry, government and academia.

Conscious consumption - cities, businesses and individual consumers supporting a circular economy that radically reforms how we use innovative construction techniques and materials, eliminate waste in a circular economy, grow and process food products and manufacture consumer products.

Disruptive innovation – The process of developing new products and/or services that challenge existing technologies and business models, disrupting markets and industries.

Ecosystem intermediaries - organisations and initiatives that can act as the 'glue' of the ecosystem, such as incubators, accelerators and co-working spaces.

First- and last-mile problem (FMLM) - a term used in supply chain management and transportation planning to describe the movement of people and goods from a transportation hub to a final destination in the home.

Innovation ecosystem - an innovation ecosystem models the dynamics of the complex economic relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation.

Intelligent energy - solutions in virtual grids combining several supply sources, micro generation and advanced demand management across multiple sectors.

Internet of Things (IoT) - a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

Living laboratories - A designated area in a city for testing cleantech innovations for better fit solutions, e.g. through joint venture between city and university or broader network of collaboration.

Rebound effects - the reduction in expected gains from new technologies that increase the efficiency of resource use, because of behavioural or other systemic responses. These responses usually tend to offset the beneficial effects of the new technology or other measures taken.

Reverse pitch – Buyers, e.g. city governments, set a clear challenge or problem and then invite innovators to bring solutions to these.

Smart cities - Smart cities is a process to grow citizen engagement and one which integrates hard infrastructure, social capital and digital technologies to make cities more responsive, resilient and 'liveable'.

Triple helix partnership - a set of interactions between academia, industry and governments, to foster economic and social development representing a shift from the dominating industry-government dyad in the Industrial Society to a growing triadic relationship between university-industry-government in the Knowledge Society.

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