Net Zero Places

Innovative approaches to reducing emissions in and between places

Innovation Brief

Winter 2021

CATAPULT
Connected Places

Contents

Towards Net Zero Places

Achieving UK and global targets for net zero will be the defining challenge of the next three decades and a central driver of innovation and change across all sectors.

The UK has done well in reducing CO_2 emissions from 1990 levels through new forms of energy supply - most notably the switch from coal to gas and renewables. The mobility and built environment sectors have been slower to adapt however and are now the two largest contributors to emissions. Given the interdependencies between the way we live, work and travel, emissions reduction targets in mobility and the built environment will not be achieved by taking a sector-by-sector approach. This is a system-level problem, where place, energy, infrastructure, industry and people all influence each other. The transition to Net Zero Places therefore requires a combination of measures, including:

- Improving the performance of existing systems and assets through digitisation, retrofit and creative integrations with adjacent systems;
- New business models, services and spatial planning which manage down demand for carbon intensive activities, for example through behaviour change strategies;
- The introduction of new technologies to realise step changes in those sectors with the highest contributions, particularly in heavy transport and logistics.

We have organised this latest *Innovation Brief* around these three areas of need, with chapters looking at discrete market opportunities within each - from decarbonising ports and airports (a major theme in the EU Green Deal), to boosting active travel, retrofitting homes and other buildings, and overhauling the haulage industry (as featured in the UK Government's recent Ten Point Plan for a Green Industrial Revolution).

In the following pages you will find insight and analysis from domain experts across Connected Places Catapult, covering examples of pioneering practise, dispatches from the leading edge of research, and a showcase of brilliant British businesses with net zero propositions for places. Whether you are looking for ideas on how to deliver net zero commitments in your area or organisation, or an innovator seeking opportunities for collaboration and commercial contracts, this *Innovation Brief* will connect you to the insights you need to take action.

Contributors

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Tom is currently a Solutions Architect at the Connected Places Catapult working across new mobility technologies, including maritime and logistics, with a strong focus on digitalisation and decarbonisation opportunities for the sector, working across government, academia and industry. Tom also holds a BSc (hons) in Environmental Studies and has experience across the maritime, defence and engineering sectors through previous positions at Rolls-Royce and Lloyd's Register in innovation, clean maritime, materials, autonomous ships and digital twins/analytics for assets.

Andrew Chadwick

Andrew Chadwick has 20 years' experience in unmanned aviation, where he has successfully developed and delivered programmes for government departments, the emergency services, and industry clients in the UK and overseas. This includes working on the majority of UK MoD unmanned aircraft procurement programmes, including: Watchkeeper, Reaper, Protector, Desert Hawk, Scan Eagle, and Zephyr.

His experience includes technical evaluation of drones, air traffic integration, operations, certification and regulation, UAS pilot and maintainer training, plus the creation of one of the World's first drone test, evaluation and operations managed service.

Andrew is currently Chairman of the Royal Aeronautical Society UAS Specialist Group Committee, a member of the Industry Advisory Board for the Autonomous Vehicle Systems and Dynamics, MSc at Cranfield University, and a member of the Royal Academy of Engineering Working Group on the safety and ethics of autonomous systems.

Andrew joined the Connected Places Catapult in 2019 and is its' Aviation Technology Initiative Lead. Current work includes the Department for Transport Drone Pathfinder Programme and leading the Future Air Mobility and Sustainable Aviation initiatives within the Catapult.

Dr Richard Miller

Richard Miller has over 40 years' practical experience in innovation and sustainability across multiple sectors. He is a Director of consultants Miller-Klein Associates Ltd, and Associate Director of the Connected Places Catapult. He worked with Innovate UK, developing and implementing their built environment and urban living programmes. Richard's current focus with Connected Places Catapult is delivering homes and buildings fit for the future that are low-carbon, desirable, adaptable and resilient to climate change. Buildings that we help us achieve net zero by 2050.

Andrew Green

Andrew has 40 years' experience in the successful development and exploitation of technologies for process, energy and transport sectors, with the last 15 years spent focussing on the drive to decarbonisation and supporting the UK in meeting its net zero targets. This includes Carbon Capture, Use & Storage, Hydrogen, heavy duty vehicle decarbonisation and step-out chemical process technologies (process intensification). Andrew has worked at the interfaces between industry, academia and government, within a wide network in each of these.

Scott Cain

Scott Cain is an Associate of the Connected Places Catapult, leading on active travel and founder and CEO of the active travel business Active Things. He is also a Senior Research Fellow at UCL in the Bartlett School of Architecture and a Research Associate at King's College London in the Centre for Urban Science and Progress (CUSP).

Alan Nettleton

Alan is a Transport Planning Professional and Chartered Engineer. Prior to joining the Catapult in 2014, he worked for private transport consultancies for over 11 years.

Alan is a keen advocate for investing in technology and infrastructure that reduces the environmental impact of transport. He is leading Connected Places Catapult projects relating to transport decarbonisation, and is currently investigating how to accelerate the UK's transition to zero-emission long haul heavy goods vehicles. He was the primary author of Connected Places Catapult's published report on electric vehicles.

Alan also led projects related to connected automated vehicles (CAVs), including Connected Places Catapult's contributions to Flourish and HumanDrive, and the publication of a number of reports in this area.

Rimaljit Likhari

Rimal is a Senior Market Analyst at Connected Places Catapult and a biotech engineer by education. She has around 9 years of experience working for a number of research and boutique consulting firms in the UK and India. She is currently working on projects focused on Net Zero Places including market opportunity assessment for Electric Vehicles in India. Previously, she led Connected Places Catapult's work on collaborative street works and mapping underground assets. She was also the lead author of Connected Places Catapult's report on Global Cities and Future Opportunities for UK businesses.

Bob Burgoyne

Bob heads the Market Intelligence Team at Connected Places Catapult and is currently leading projects focused on net zero places and the levelling up agenda. His experience spans consumer research, brand and marketing strategy, secondary research, market opportunity analysis, designing digital transformation strategies, stakeholder mapping, social media analytics and organisational strategy development. Bob is energised by solving complex problems and bringing together multi-disciplinary teams to do so.

Ron Oren

Ron Oren is an innovation specialist with 10 years' experience in supporting innovation through strategy development, partnership creation and project design in a range of sectors including BioTech, MedTech and environmental engineering. His current role at Connected Places Catapult focusses on societal and technological trends to explore future risks, challenges and opportunities. Ron led the Strategic Initiative on Open Data for Transport at Connected Places Catapult, where he created data-driven services pilots to demonstrate the value of the underlying data and to generate the business case to share data wider.

Bin Guan

Bin is a Researcher at the Connected Places Catapult with a background in Built Environment. He plays a key role in conducting market research and communicating evidence-based insights to support the delivery of a variety of innovation projects in Connected Places's, covering areas of urban planning, housing, real estate, urban mobility, elderly healthcare, government digital transformation and smart cities. He also produced a series of research papers to support Connected Places strategy and thought leadership and helped set up Connected Places Catapult's Future of Housing programme.

James Datson

James Datson is an expert in the digitalisation of mobility. He helps transport companies innovate and advises policy makers on how to benefit from this innovation. He currently manages the Connected Places Catapult's relationships with Government departments. He is a Board Director for the MaaS Alliance and has 20 years' experience providing transport innovation expertise. Previous to his current role, James spent the majority of his career in consultancy.

Dr Patrizia Franco

Dr Patrizia Franco is Principal Demand Modeller with over 15 years' experience in transport planning and modelling. She has worked on R&D and innovation projects for new and emerging mobility services, agent-based and activity-based modelling to assess future policy interventions for greater sustainability and resilience in smart cities.

Former researcher in Transport Modelling and Data Analysis at Newcastle University (2008-2015), she applied integration of strategic transport modelling with agent-based to holistically assess regional carbon footprint and assess decarbonising transport policies and strategies.

Since she joined the Catapult in 2015, she has been technical lead of projects to improve the knowledge base around data-driven demand modelling tools and test policies and scenarios for urban and rural mobility. Over the last three years, she worked with the Department for Transport in a new initiative looking at establishing a new methodology for the next generations of tools for strategic transport modelling, looking at Demand agent-based modelling at large-scale to explore the new trends and technologies in the mobility sector. These projects led to two awards for Connected Places Catapult: Best Papers in 2017 for advancing the use of agent-based modelling in transport and more recently, the Hall of Fame Industry Award at the ITS World Congress 2019 for the pivotal role in establishing new markets for emerging mobility services using innovative data-driven transport modelling tools.

Chapter 1:

Optimising existing systems

‘Building back better’ is a fashionable phrase today. However, to achieve our net zero aspirations, starting from scratch is rarely the best option due to the sunk carbon costs of existing infrastructure. Instead, a better approach is often to look holistically at how current assets operate, and how they relate to other parts of the system and identify new technologies, operational approaches or other changes which can reduce emissions. In this chapter we consider recent thinking on how to optimise the operation of airports, buildings and seaports.

1.1 Net zero ports: multi-modal energy hubs

Thomas White

The UK is a maritime nation. Our maritime heritage and innovation have long been at the heart of our economic prosperity and global influence.

Globally, the maritime shipping sector contributes 2.9% to anthropogenic CO_2 emissions, with total emissions expected to grow 130% by 2050[1]. Even so, maritime transport remains one of the most efficient means of moving freight in terms of CO_2 emitted per tonne transported. It is more efficient by comparison to road, rail and air transport. However, as these alternative transport modes become greener, so too must shipping reduce emissions through cleaner solutions.

Significant efforts are underway globally to reduce maritime emissions, with the International Maritime Organisation (IMO) setting a target to halve 2008 emission levels by 2050 through increasing electrification and use of future fuels such as LNG (liquified natural gas), hydrogen or ammonia. The decarbonisation of shipping is a global challenge that requires a collaborative global effort.

The UK is well positioned to lead this effort with its significant influence on maritime issues globally - as well as being home of the International Maritime Organisation, the UK boasts world-leading regulators, academic institutions, industry associations and waterborne technology organisations.

Decarbonisation of ports - a triple opportunity

The UK also has the opportunity to make improvements in its own ports. There are currently more than 100 ports in the UK that process around 95% of UK trade and almost half a billion tonnes[2] of goods every year. In taking the lead in decarbonising the processes used at ports, the UK will not only make progress towards national net zero targets but could also build competitive 'first mover' advantage in developing the technologies and other innovations that enable this.

The market opportunity here is significant - the projected size of the ports equipment and smart ports markets is over 40BN USD by 2025[3] In addition, implementing changes at transport hubs like ports can help facilitate further change throughout the distribution network - as we will see below in the discussion of the Hydrogen Economy.

UK ports

Ports are multi-modal transport hubs that are vital to the effectiveness and resiliency of our national logistics networks and supply chains, and to the success of the industries on which they rely. As well as goods, over 1.8 million people pass through our ports each a year[4], on journeys ranging from international cruises to short sea ferry crossings that connect people, places and business on a daily basis.

"Whilst Brexit has dominated the headlines for years, sustainability has been the issue that affects all ports and it will be near the top of the political agenda for the next decade"
Mark Simmonds, British Port Association Head of Policy and External Affairs[5]

Ports are a complex mix of internal processes and wider stakeholder interactions that present significant challenges and opportunities in terms of reaching our national net zero targets. They incorporate a broad range of infrastructure, from dockside facilities built in the Victorian era to highly modernised automated cargo processing equipment.

Offshore Wind as an Enabler

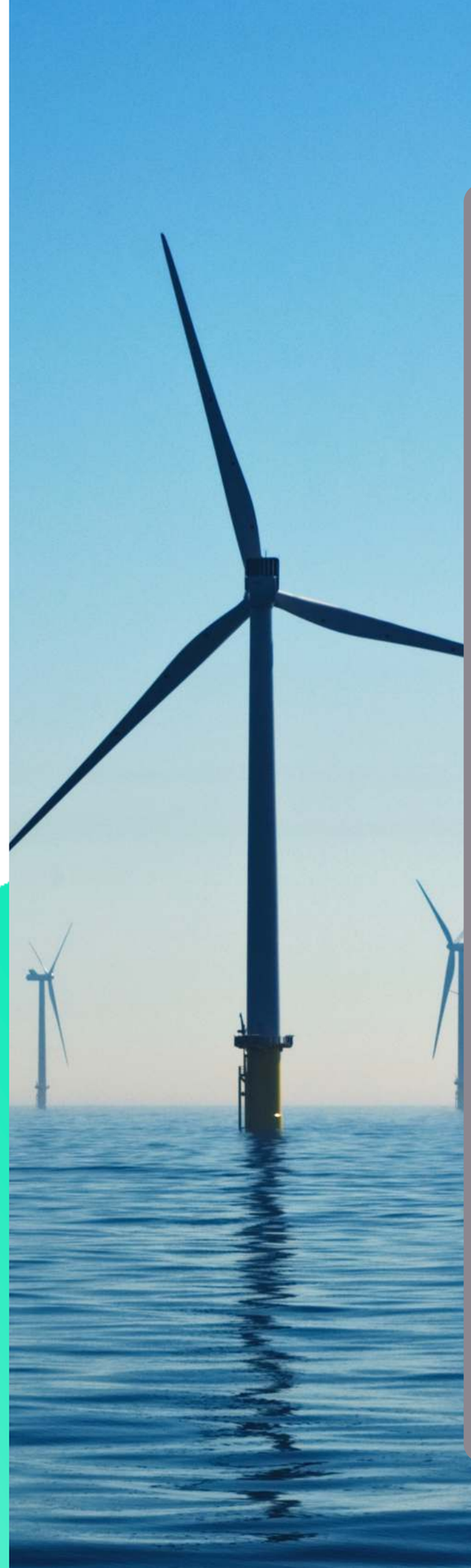
The offshore wind sector is growing rapidly in the UK, which has the largest installed offshore wind capacity in Europe (and is supported by one of our sister Catapults[6]). This growth in turn is creating significant opportunities for UK ports across the offshore wind supply chain, from maintenance and servicing to manufacturing. Greater integration of energy systems in and around ports, supported by offshore generating capacity, can offer cleaner energy solutions both to the port itself and to connected stakeholders such as warehousing and manufacturing sites. One such opportunity is in the generation, storage and supply of green hydrogen to a wide range of port stakeholders.

The Future Hydrogen Economy

Hydrogen, and derivatives such as ammonia, are being extensively explored in maritime as potential future fuels that meets the energy requirements of international shipping. A green hydrogen industry could generate £320bn for the UK economy by 2050, also creating and supporting 120,000 jobs[7] in manufacturing, maintenance and supporting industries. Hydrogen fuel conversion also offers attractive routes to energy storage and distribution, strengthening the case for further investment in offshore renewables.

A strong green hydrogen ecosystem through ports presents an incredible opportunity for the UK, not only to take a leading role in the transition to hydrogen fuels for international and domestic shipping, but also to stimulate and drive the transition to clean fuels for Heavy Goods Vehicles (HGVs) and mobile plant at ports, with significant cross-sector opportunities. HGVs as customers of hydrogen fuels at ports also adds new potential revenue streams that support the investment case for hydrogen as the fuel of choice for the international shipping.

Connected Places Catapult's recent work with the UK Department for Transport confirms that the majority of strategically viable hydrogen clusters currently being considered are in close proximity to ports. In this way ports and offshore energy present a clear and immediate opportunity to develop and showcase **whole system concepts as energy hubs for the future hydrogen economy** - from clean energy generation to fuel production, infrastructure integration, fuel supply and use.



Ports as Green Energy Hubs

Shell is developing a hydrogen hub through the Port of Rotterdam and the Hollandse Kust windfarm. Aiming to start production in 2023, the Shell plant will operate on land allocated by the Port of Rotterdam and produce up to 60,000kg of hydrogen daily, which in turn would be able to fuel approximately 2,300 hydrogen powered goods vehicles per day[8]. Shell is also planning to use the hydrogen produced to fuel its conventional refinery operations, leading to a reduction of 200,000 tonnes of CO2 emissions per year in itself.

"The energy transition calls for guts, boldness, and action... We want to develop a new value chain together with our partners and governments – from wind to hydrogen – to create a green hydrogen hub" Marjan van Loon, President-Director of Shell Nederland [9]

The Port of Amsterdam is also involved in a green hydrogen project [10] together with Tata Steel and Nouryon, with an aim of creating a 100 MW hydrogen plant using energy generated by offshore wind.

In the UK, the port of Aberdeen is an accredited EcoPort[11] and is playing a leading role in the region's transition to a hydrogen economy through the creation of an Energy Transition Zone focused on renewables and linked to the wider transport network including hydrogen fuelled buses and hybrid fleets.

Associated British Ports (ABP) (which operates 21 ports in the UK) is now running renewable energy projects in 17 of its ports. These projects provide clean electricity for ABP, its customers and the National Grid. Overall, in the last decade, ABP has invested around £50m in green technologies such as renewable energy, electric fleet, electric port equipment and fuel-efficient pilot vessels. For instance, around £7m has been invested at the Port of Hull to install Humber's largest roof-mounted solar scheme[12].

The time is now

In the UK we are also seeing an increase in coastal and short sea shipping interest, partly driven by impacts from Brexit and in the potential benefits in moving freight away from inland transport networks. These developments all present an opportunity to create a cleaner UK domestic maritime sector, with ports offering cleaner fuel options to a wider range of customers.

The UK has a sustainable, competitive advantage in our offshore wind sector. Making use of these natural resources through our ports in trialling and developing whole systems concepts for multiple port stakeholders has the potential to **transform UK ports from the transport hubs of today, to the multi-modal energy hubs of tomorrow.**

Helping to spark progress

Connected Places Catapult is currently engaged in several collaborative projects to connect the market, spark innovation and accelerate decarbonisation in UK ports and the maritime sector. We are leading on the **Transitioning to Smart Ports** project for the Department for Transport, which is taking a challenge-led, whole-value chain approach to understanding digitalisation and decarbonisation opportunities at ports and across wider stakeholders. And we are a founding partner at the **Innovation Hub 2050**, based at the Port of Tyne. In this project we are supporting the hub in maritime innovation through challenge setting, use case development and bringing cross-sector opportunities for collaboration.

If you are working on an innovative solution or services for ports or the maritime sector we want to hear from you. Likewise, if you are looking to leverage new approaches to improve your existing product, service or supply chain, please get in touch.

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1.2 Net zero airports – It's not just about aircraft

Andrew Chadwick

The airport industry accounts for around 5% of the air transport sector's total carbon emissions[1]. More broadly, the global aviation sector is responsible for 12% of carbon emissions from all transport sources (ATAG, 2019).[2]

Over the last decade, a growing number of airports have started implementing measures to reduce their carbon emissions. But when considering how to decarbonise airports, the focus tends to remain within the airport boundary. However, the opportunity - and imperative - for innovation is much wider, starting from the moment a passenger makes a flight booking and encompassing all the steps which take that passenger to the airport, what happens when they get there, and the airport's associated infrastructural and logistical ecosystem.

Each step in the process is part of a chain, with each link having its own carbon footprint. Broadening our scope of consideration to include these less immediate aspects of the airport experience, we can address deeper system efficiencies, introduce innovations to improve the process, and ultimately lower the overall carbon footprint.

There are several longer-term sustainable solutions being developed that are aimed at aircraft and aircraft operations themselves. These include cleaner engines, new fuels,

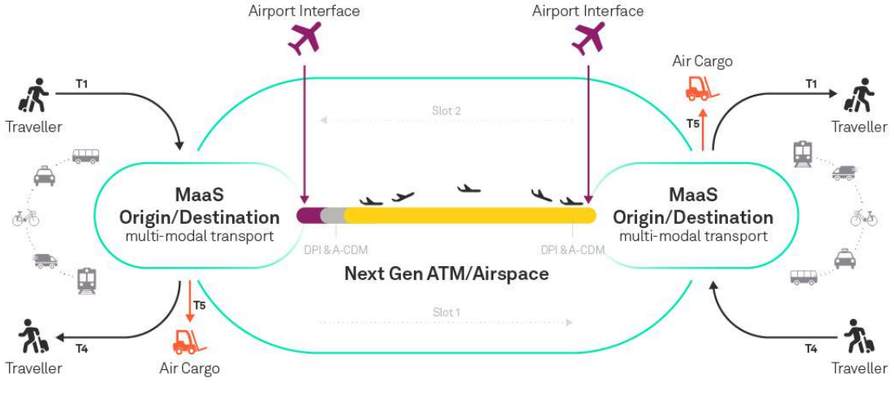


Figure 1: Door-to-door travel – not just the aircraft journey itself

electrification, and airspace usage change, but these take time to develop and to achieve regulatory approvals. There are, however, actions that airports can do in the shorter term to dramatically reduce their carbon footprint.

Short-term actions

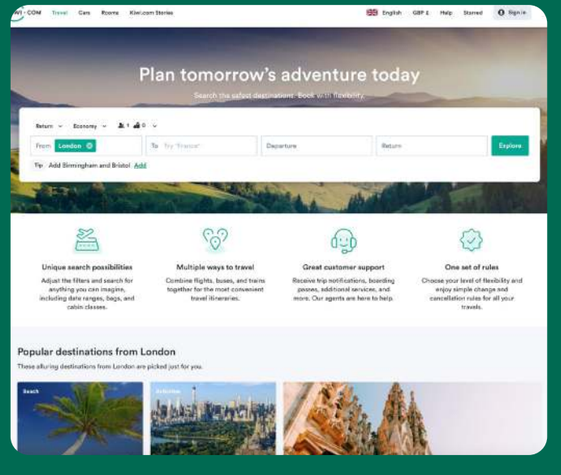
Most airline journeys are now booked online. This helps reduce airline costs, provides ease of booking, and presents a variety of journey-provider options. It also helps reduce the environmental impact as it reduces the need for paper tickets, with check-in and security clearance being enabled by digital technology on our phones.

However, one option not currently available to us is the ability to book an entire journey from doorstep to doorstep.

Imagine how much time and effort could be saved if rather than just booking the flight itself, the airline (or journey service provider) provided the option to book the entire journey - from home or the office to the airport, through the airport (check-in, security, shopping), the flight itself, security clearance at the destination airport, plus the onwards journey to a hotel or similar - all on one digital ticket.

Imagine the benefits of doing that if your journey provider also carried your bags, so you only see them once you safely arrive at your destination. Imagine the changes we could then make to our own journey choices to and from the airport, and how we might reduce our carbon footprint, by making our journey provider legally responsible for the environmental impact of our journey.

To make us vehicle agnostic - relying on our journey provider to deliver the most economical, efficient, and sustainable mode of transport, whether that be public transport, electric taxis, autonomous electric cars, or even electric-powered human-carrying drones - would help us achieve a reduced personal carbon footprint in our journey-making. With financial and legal incentives to drive these initiatives, we could make an impact in the short-to medium-term.



Case study

Kiwi.com

Czech company **Kiwi.com** (recently acquired by General Atlantic) claims to be the 'world's first global intermodal booking platform'. Using its 'Virtual Interlining' concept the online travel platform integrates flights with ground transportation including trains, cabs, rental cars, ride hailing operators, buses — into one itinerary. The platform's other USP lies in its Guarantee feature that claims to protect customers from missed connections caused by delay, schedule change, or cancellation.

Why are we not already doing this?

Sustainable practices at road level, associated with airport access, can reduce the environmental impact of airport infrastructure whilst at the same time creating financial and operational benefits. Surface level models where airports are part of a physically and digitally connected transport hub, as opposed to a stand-alone destination, have been proven to reduce an airport's environmental impact.

However, in order to achieve this, airports need better connectivity with public transport networks, and the public must have the desire to change their habits and take public transport rather than relying on their own cars or taxis. More crucially, such public transport connections services need to be more affordable than the ones currently offered. Indeed, it is possible to dramatically reduce our carbon footprint by focussing on the improvement and use of cleaner public transport to travel to and from airports.

Image credit: Airportr

Case study

Airportr

Travelling luggage-free allows us to opt for public transport or drive smaller, lower carbon-footprint cars for travel to airport. Doing so has long been possible but often involves high prices and next-day if not later service.

But this is changing. Companies, such as **Airportr**, provide same-day luggage delivery services, transporting bags to and from airports, as well as homes, hotels and offices fro just £15. Luggage is collected from home, delivered to the aircraft, then made available to collect at the destination airport. Service providers such as Sherpr even deliver luggage direct to the final destination.

With a vast number of airports located within or close to cities, integrated journeys to and from airports by greener transport modes will be key to reducing carbon emissions as well as road congestion.

We also anticipate an accelerated reduction in carbon footprint associated with ground transport access to and at airports if we take this integrated approach.

Leave the car at home

There are of course both challenges and potential solutions to making airports car-free zones, accessible only by public transport, electric/hybrid vehicles, or autonomous vehicles (including the use of autonomous vehicles for airport access and airside use, with much limited internal combustion engine car access to airports). To address the environmental challenges, we must explore these options, and engage with the public to gauge their response towards a move from reduced private car use to an eventual enforced use of public transport or to dedicated green transport corridors.

Connected Places Catapult previously explored the use of existing motorway infrastructure together with autonomous vehicles and new transport hubs near to motorways, to provide new or more frequent services between a wide variety of locations across the country. The 'Motorway Mobility' study[3] explored how frequent and convenient services of this type throughout the day and night could enable users to switch from the private car to public transport including, as a use case, airport workers' travel to work. This would give back to people some of their free time that was spent driving, during which they could catch up on work or simply relax - and would also lead to reduced congestion, reduced greenhouse gas emissions, improved safety, reduced public transport journey times as well as creating new business opportunities.

Perhaps one consideration would be to focus on more customer-centric transportation, rather than network-centric operations and services, particularly as an answer to the need for more contactless travel in response to the Covid-19 pandemic?

Case study

Dulas Ltd

Dulas Ltd recently managed the installation of solar PV at Heathrow Airport. Terminal 2's rooftop now has >100 integrated optisol solar panels installed; custom-made by Dutch firm Scheuten. The installation was one of the largest Optisol solar panel installations in Europe.

What about at the airport itself?

Consuming 9.7 kilowatt-hours (kWh) of electricity and 34.7 kBtu of natural gas per square foot annually on average, airports are large consumers of energy.[4] Energy accounts for a large share - 10% to 15% [5] - of operating costs for airports, providing a substantial financial incentive to find lower cost sources of energy. By cleanly generating and storing all their own energy to power operations, airports could be self-sufficient and green rather than relying on the national grid. The energy would be used for heating and lighting buildings, airside lighting, electric vehicle charging, waste recycling, baggage handling, electric aircraft battery charging, and also stored on site. Any unused energy could be shared to provide electric power to local communities and towns.

With so much roof space available on hangarage in airports, installing solar panelling is an obvious opportunity to do this. Heathrow Airport, for example, was able to reduce its carbon emissions by 14% with the installation of LEDs and a rooftop solar system in 2017.[6]

Additionally, airports should consider the introduction of hydrogen storage sites for hydrogen-powered HGVs and vehicles and future hydrogen-powered sub-regional aircraft, plus storage for biofuels and Synthetic Aviation Fuels (SAFs) in preparation for the widely anticipated growth in electric and sustainably fuelled aircraft - cleaner energy for our more demanding travelling needs.

Low carbon air freight

Of course, airports are not only passenger hubs - innovations in air freight also present opportunities for decarbonisation. We could optimise freight transport channels in favour of sustainable modes of transport (including goods shared space and reduced cost distribution) and also transform the movement of air freight which would help address our fragmented and inefficient supply chains for a variety of goods.

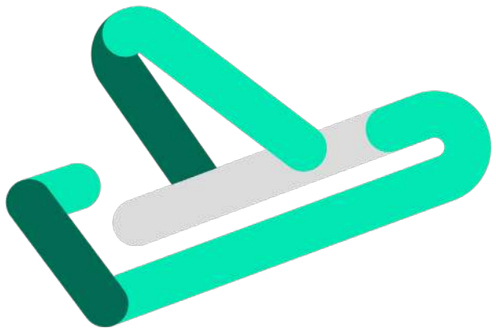
Currently, most of the air cargo flying from the UK is carried in the hold space of commercial passenger airlines. There are also several cargo-only commercial airlines which operate flights in and out of the multi-billion-pound market for UK air freight, carrying goods from all over the world.

The lack of industry-wide advance visibility of freight to be carried across the organisations involved (customers, freight forwarders and carriers) results in inefficiencies that translate into an increase of carbon footprint by those service providers. Airport hubs across the globe experience significant congestion in and around the cargo handling facilities. Indeed, more than 200 airports globally are now designated as "Level 3" slot-coordinated facilities by the International Air Transport Association (IATA).[7] This means that these airports are running at full capacity for runway and parking needs. Interestingly, more than half of these airports are in Europe, including London Heathrow, Paris de Gaulle, Frankfurt and Amsterdam. Such cargo congestion at airports stretches onto the surrounding shared-user road network and increasing the environmental impact of an airport - introducing poorer air quality and more emissions.[8,9] What's more, air cargo carriers also suffer through being unable to maximise their revenue-earning potential, by not fully utilising all their carrying capacity.

Better delivery planning, perhaps focused on the use of off-site hubs similar to that explored under the Motorway Mobility project, could dramatically reduce the environmental burden, lower the carbon footprint of air freight, and result in a financial benefit to the airlines, airports and industry.

To achieve net zero, airports will need to become truly connected places

Climate change is the greatest challenge of our time. Airports are slowly starting to respond to this challenge and finding that, with new technologies and the re-engineering of businesses processes, it is possible to significantly lower their carbon footprint. But they cannot do this alone. Like ports, airports are nodes in complex networks which reach far beyond their own boundaries. Net Zero Places will pioneer ever-closer collaboration in planning and investment across regional ecosystems to ensure that these high-impact, high-value nodes enjoy the right connectivity to enable new user behaviours and more circular, environmentally sustainable business processes.



Helping to spark progress

This is a time of significant opportunity and innovation in aviation. Connected Places Catapult is proud to have been at the leading edge of that wave, stimulating investment, shaping R&D-friendly regulations, and brokering high-value partnerships between industry, innovators and the research community. We are now building on those investments by establishing a new Air Mobility Directorate to enable us to create even more impact in this market.

If you are working on an innovative solution or service for the aviation industry, we want to hear from you. Likewise, if you are an asset owner or existing service provider looking to leverage new approaches to improve your existing product, service or supply chain, please get in touch.

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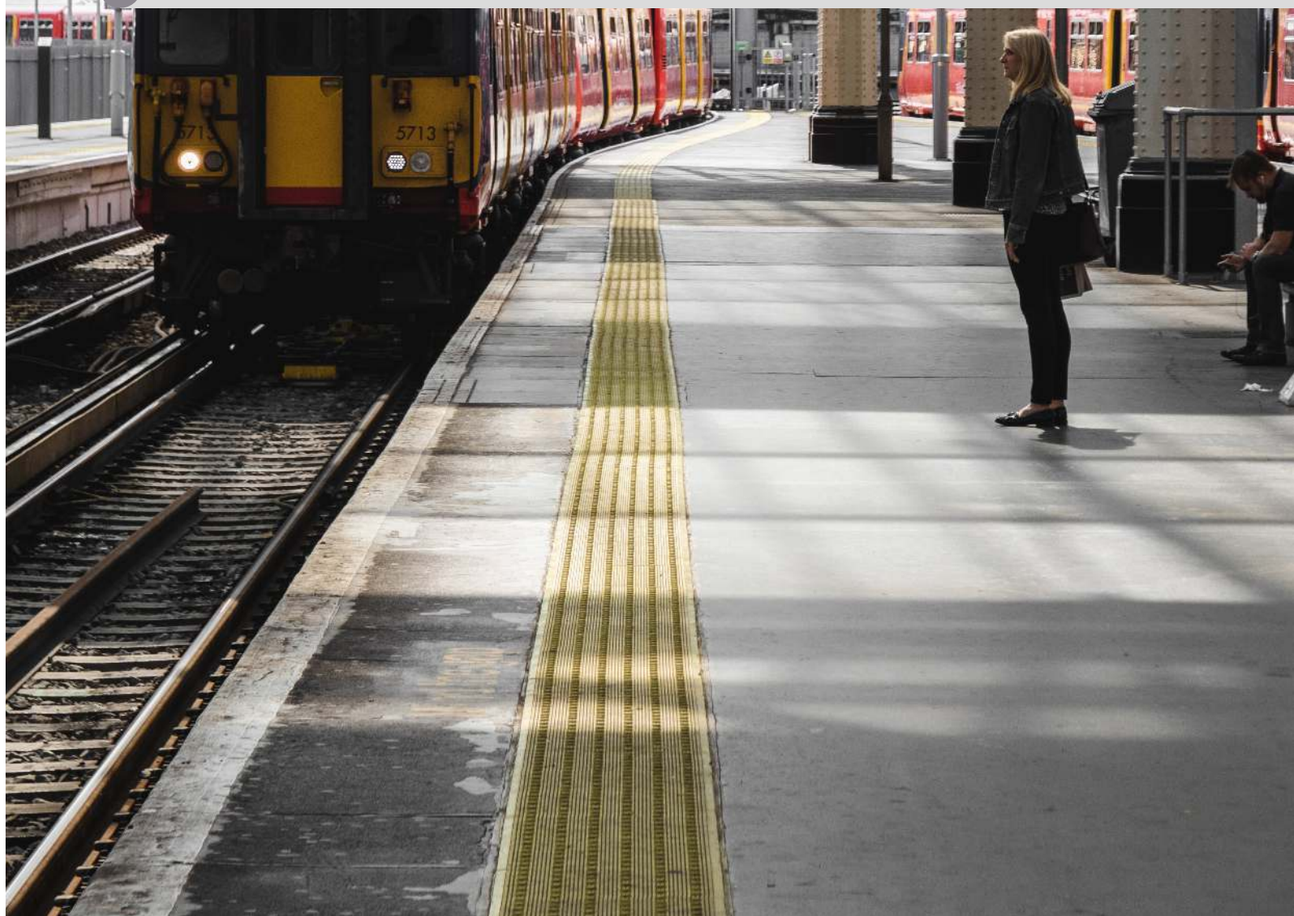


1.3 Building back is not enough – the critical case for retrofit.

Richard Miller

Twenty-seven per cent of total UK greenhouse gas emissions come from buildings [1]. There is no route to net zero for the UK without a dramatic cut in these emissions. Our homes, offices, schools, hospitals, warehouses, and factories must use less energy and switch to low carbon sources.

The biggest source of building emissions is our homes. They account for 67% of the buildings' total, with commercial buildings contributing 22% and public buildings a further 11%. The Committee on Climate Change says all of that must reduce to zero.

The UK has made excellent progress in reducing the carbon intensity of the grid[2]. In 2019 48.5% of the UK electricity generation was zero-carbon.

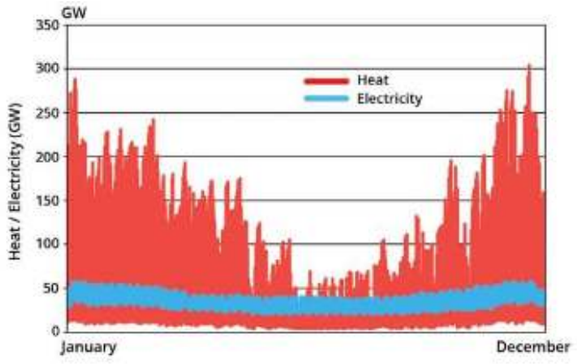


Figure 1 : Variation in Domestic Heat and Electricity Demand Across the Year [3]

Is simply going electric enough?

Can we convert all our building energy requirements to electricity and continue to decarbonise the grid? Unfortunately, about 63% of the total energy required by buildings is for space and water heating and it shows a big seasonal variation. Figure 2 shows heat and electricity demand[4] across the year for UK homes.

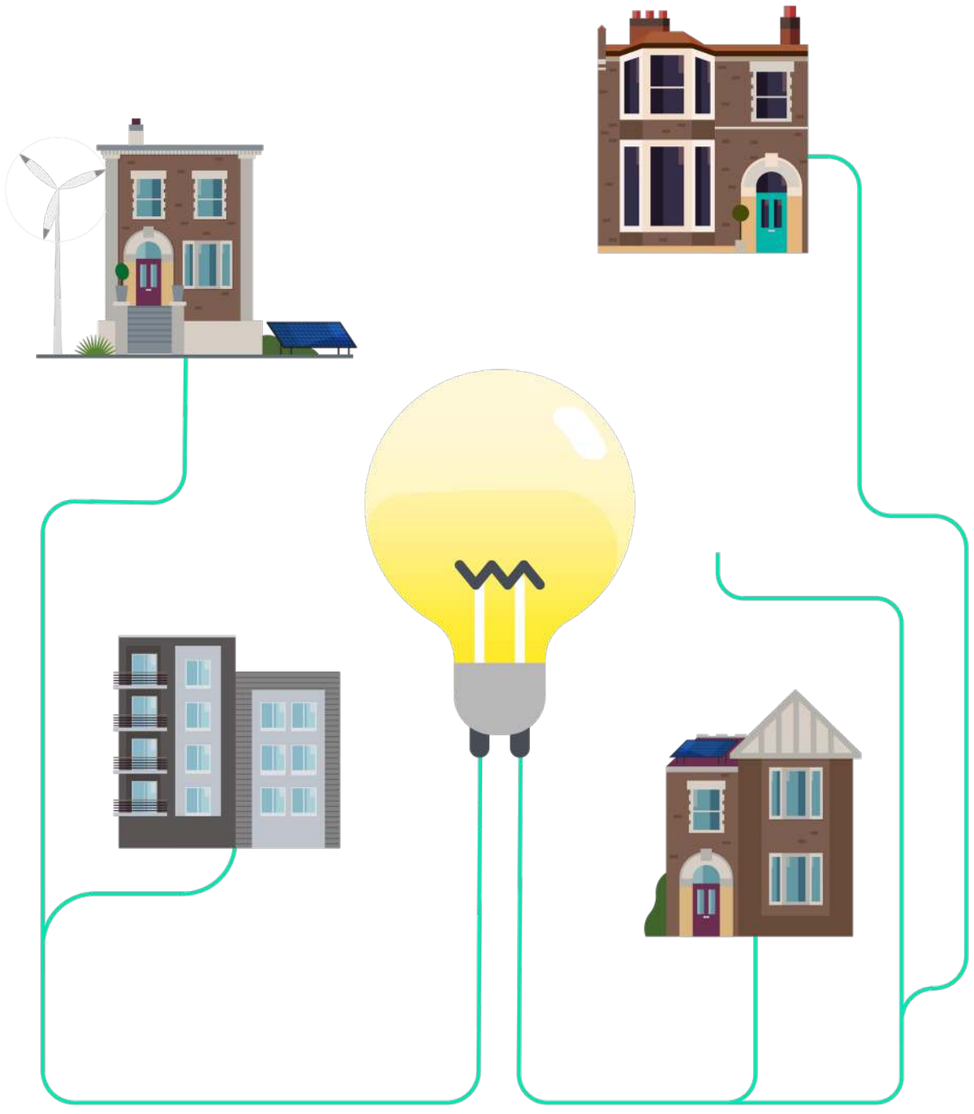
In the summer, the electricity and heat demand are about equal, but in winter we use six times as much heat as electricity. Some experts already worry that we cannot supply the future demand for electricity once we add in the projected number of electric vehicles. There is no model of a future National Grid based on renewables and nuclear that could meet the heating demand for our current buildings. Heat pumps can generate more heat energy than they consume electricity, and that can help to bridge the gap. The Coefficient of Performance (COP), how much heat energy you get out for the electricity you put in, is typically 2 to 4. Assuming a COP in the winter of about 3 we could halve the demand gap, but it is still too big.

The potential of hydrogen and solar

One option is to switch from fossil fuels for heating to hydrogen [5]. You can either burn it directly or use a fuel cell to generate both electricity and heat. The problem with this idea is that the only current way to get clean and green hydrogen is through electrolysis using renewable electricity. That will put another major load on our decarbonised grid.

Another idea currently in its infancy is to use solar thermal collectors with a heat store, such as the 'heat battery' from Sunamp [6]. Solar radiation is converted to heat in a working fluid and then transferred to an insulated heat store. The stored heat energy then provides domestic hot water or can be used for space heating. These systems lack the heat output required for conventional central heating in the colder months unless the building is extremely well insulated and only needs low temperature heating.

The only practical option for the tens of millions of buildings in the UK is to reduce their energy consumption as much as possible, and to decarbonise what remains.



The existing building stock is not energy efficient enough. Our housing stock is old and in poor condition.

A tired and outdated housing stock

The existing building stock is not energy efficient enough. Our housing stock is old and in poor condition. Over half our homes predate any meaningful building regulations, and 70% had no requirement for effective insulation. Only one third of the housing stock is adequate by today's standards [7], and a tiny percentage are ready for a net zero future. Even amongst homes built in 2020, only 13% meet the highest standards of energy efficiency recognised by the UK Government and that is way below the requirements for 2050.

For public and commercial buildings, it is a similar story. There are more properties below today's standard than meet or exceed it.

We cannot simply build our way out of the problem as the turnover rate for both domestic and non-domestic properties is slow. About 80% of homes and 70% of commercial and public buildings in use today, will still be in use in 2050. So, we must do two things:

- make sure all new buildings meet the highest energy standards, and
- retrofit existing buildings to meet the same efficiency standards.

A roadmap to success

We know how to do that - at least technically. Standards such as Passivhaus [8] and projects like AIMC4 [9] have shown that is possible to create new homes with the required energy efficiency. Energy positive [10] non-domestic buildings that create more energy than they use are becoming available.

It is the same with retrofit. The Passivhaus trust has its EnerPHit [11] standard and Energiesprong [12] an integrated approach and business model. Demonstration projects covering large numbers of dwellings show it is possible to retrofit a wide variety of properties to a high level of performance. Two good examples from the UK are Retrofit for the Future [13] and the REMOURBAN [14] project in Nottingham.

Despite the need for net zero buildings, and evidence from successful projects, the transition is not happening fast enough. The major barriers [15] are:

- Low user demand. The economic case for energy efficiency is poor for the building owner, and the knock-on benefits are not clear
- There is no clear government policy driving energy efficiency in buildings. Where policy exists, it lacks the ambition required to meet 2050 targets
- Costs are too high, and we don't have a supply chain that can deliver in volume and at speed
- Because the transition to net zero buildings involves many small and distributed projects, it is hard to raise finance. It is easier to understand the risks and rewards of investing in a wind farm, and the whole process is standardised.

Finding the confidence to deliver

To break the logjam, things need to change for both building buyers and suppliers. Both need confidence. Buyers need to believe that the buildings will perform as advertised, and suppliers need to know there's a sustainable market. Both need better access to information, evidence, and knowledge. Everyone needs clear policy and regulatory alignment.

Case studies

Naked Energy[21], Powervault[22], Ventive[23], Factory Zero[24]

Innovators are coming up with many new components and systems to help deliver net zero buildings.

Naked Energy combines photovoltaic electricity with solar thermal heating. Their panels are water-cooled. This improves the energy conversion efficiency and provides the building with all the hot water it needs.

Powervault produce domestic battery systems that manage the peaks and troughs of electricity demand to squeeze the last drop of performance out of photovoltaic panels.

Ventive has produced a passive ventilation system with energy recovery. It provides excellent indoor air quality while cutting energy requirements for heating.

Factory Zero manufactures complete energy modules off-site for quick and easy installation in any building. This is cutting the cost of sophisticated energy systems, bringing them into the domestic market.

Buyers need a good business case for investment and an offer tailored to their specific needs, while the supply chain needs better skills and ways of guaranteeing performance. We will not solve these problems without innovation. We need:

- A diversity of solutions to cover all building types - new build or retrofit
- Mass-customisation to adapt solutions quickly and cheaply for any specific building
- Reproducibility and reliability. Designs must work first time and every time
- Speed and efficiency. With an enormous amount of construction delivered over the coming 30 years, we will need industrialised solutions.

This would transform the way most construction is done. It means changes to building design, the materials used and the construction methods.

Designers will integrate energy-efficient fabric with energy generation and management. Digital twins[16] and building passports [17] will help ensure that the building performs as designed when construction work is completed, and performance is maintained as the building evolves through its life.

New business models will emerge. Energiesprong [18] guarantees building performance for 30 years. That gives confidence to buyers to invest. Businesses are experimenting with 'Heat as a Service' [19] or comfort plans as an alternative to the consumer handling all the capital, operational costs and maintenance themselves. Companies like RetrofitWorks [20] are positioning themselves as one-stop shops for the customer - bringing together advocates, practitioners and finance - to find and deliver the right solutions for building owners.

Challenging conventional methods of construction

The story of Q-Bot [25] is an example of the way innovators are challenging conventional methods of construction. Older homes often have suspended wooden floors that are uninsulated. That means the homes are cold, draughty and expensive to heat. The traditional solution is to rip up the floorboards and insert insulation. This is very disruptive, and very unpopular. The Q-Bot solution is to cut a small access slot in the floor and insert a small robot that crawls around under the floor spraying insulating foam onto the floorboards and joists. Good insulation with minimum disruption. A solution that makes retrofit for energy efficiency as painless as possible.

QBot in operation. Source: borntoengineer.com

The transformation extends to construction. Digital scheduling of work, management of materials and digital twins are all helping to increase speed and reduce waste, errors and rework. This goes together with Modern Methods of Construction [26] that focus on off-site factory-built components and modules. It is the beginning of a transition from construction as a craft to full industrialisation. Modern production line flexibility allows the mass customisation necessary to meet the diversity of building types.

Innovators are developing alternative solutions for net zero buildings. We need more innovation to continue to drive down costs and increase the range of buildings that can reach net zero. We also need society to insist that all buildings must achieve the levels of energy efficiency required. With confidence from the buyers that excellent performance is deliverable at a reasonable cost, and confidence from the supply chain that the market is sustainable, the industry will find the new designs, materials and methods to transform and decarbonise construction.

Helping to spark progress

Delivering net zero buildings and built environments will require innovation across the value chain. In January 2020, Connected Places Catapult published Retrofit: Towards a Sector-Wide Roadmap 2020 [27] in partnership with industry, government and investors. We are now working to implement the recommendations of that report to stimulate demand for retrofit solutions and dismantle barriers to commercial applications at scale.

If you are working on an innovative solution or services for the built environment, we want to hear from you. Likewise, if you are looking to leverage new approaches to improve your existing product, service or supply chain, please get in touch.

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Chapter 2:

Reducing demand

Many aspects of the way we live, work and travel today contribute to carbon emissions. Indeed, our towns and cities have largely been designed to accommodate behaviours we now understand to be environmentally harmful – optimised, for example, for private vehicles rather than public transport. While some impact on reducing emissions can be achieved through improving the operation of existing systems and infrastructure, it will also be necessary to change behaviours and reduce underlying demand.

In this section we examine the market trends and innovation opportunities related to reducing demand for carbon-producing activities – both at a system level, and at the level of individual behaviours.

2.1 Mobility as a Service – Time to Sell it Right

James Datson

The full potential of Mobility as a Service in terms of customer convenience and making travel more carbon efficient has yet to be realised - why is that, and what can be done?

The decarbonisation imperative and the role of MaaS

Transport is now the UK's largest source of carbon emissions and accounts for 33% of domestic emissions in 2018.[1] Cutting transport emissions remains a significant challenge as the UK aims to bring all greenhouse gas emissions to net zero by 2050.

The Department for Transport's Decarbonisation Strategy clearly outlines the challenge and areas which need to change in order to deliver a net zero transport system in the UK.

Accelerating modal shift to public and active transport

- Help make public transport and active travel the natural first choice for daily activities
- Support fewer car trips through a coherent, convenient and cost-effective public network; and explore how we might use cars differently in future
- Encourage cycling and walking for short journeys
- Explore how to best support the behaviour change required

Decarbonisation of road vehicles

- Support the transition to zero emission road vehicles through:
  - regulatory framework
  - strong consumer base
  - market conditions
  - vehicle supply
  - refuelling and recharging infrastructure
  - energy system readiness
- Maximise benefits through investment in innovative technology development, and development of sustainable supply chains

Decarbonising how we get our goods

- Consider future demand and changing consumer behaviour for goods
- Transform 'last-mile' deliveries – developing an integrated, clean and sustainable delivery system
- Optimise logistics efficiency and explore innovative digitally-enabled solutions, data sharing and collaborative platforms

Place-based solutions

- Consider where, how and why emissions occur in specific locations
- Acknowledge a single solution will not be appropriate for every location
- Address emissions at a local level through local management of transport solutions
- Target support for local areas, considering regional diversity and different solutions

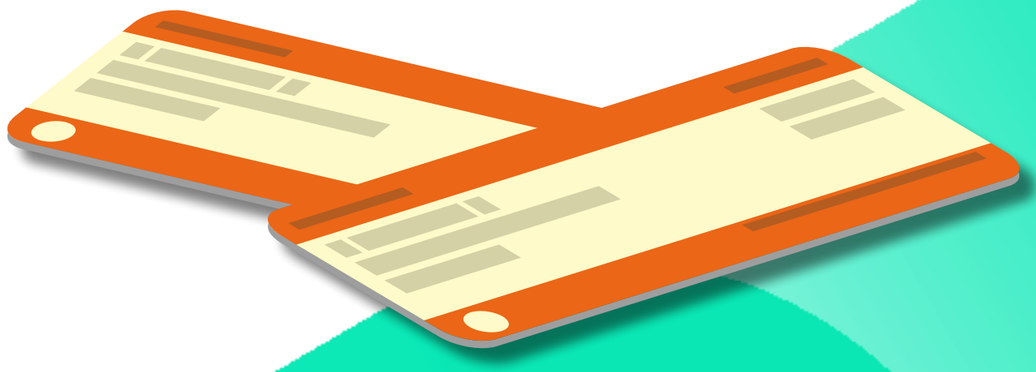
UK as a hub for green transport technology and innovation

- Utilise the UK's world-leading scientists, business leaders and innovators to position the UK as an internationally recognised leader of environmentally sustainable technology and innovation in transport
- Build on expertise in the UK for technology developments and capitalise on near market quick wins

Reducing carbon in a global economy

- Lead international efforts in transport emissions reduction
- Recognise aviation and maritime are international by nature and require international solutions
- Harness the UK as a global centre of expertise, driving low carbon innovation and global leadership, boosting the UK economy

Figure 1: Six strategic priorities for the Transport Decarbonation Plan, to deliver a vision of a net zero transport system
Source: Department for Transport, 'Decarbonising Transport', 2020



Behaviour change among travellers is one such area of opportunity. Four types of behaviour change can help lower emissions:

Re-mode: Shift popular modes of travel to zero or low emission ones such as walking, cycling, public transport or car-pools with higher vehicle occupancy

Re-route: Organise the transport network more efficiently, ensuring it avoids congested areas

Re-time: Encourage travel in non-peak hours, reducing journey time and emissions

Reduce: Encourage change that reduces the need to travel, such as working from home. [2]

Changing behaviours is hard because most of our behaviours are habitual. Simply knowing that an alternative is in some way 'better' doesn't make it easy to change - as anyone who has ever made a New Year's resolution to give up junk food or exercise more well knows. In reality, behaviours change in response to a range of factors, from big public information campaigns designed to instil new social norms (e.g. 'wear a seat belt') to softer 'nudges' such as making a more socially beneficial choice the default option one (e.g. auto-enrolling people into pensions).

In a market driven society, consumer behaviours are influenced by how well competing alternatives meet user needs. Relatively few people would willingly pay a premium for a sub-optimal product or service, regardless of the social good that might go with it. In the context of transport, many people still own and habitually travel by car for the convenience it offers. As a recent study by Urban Institute of Transport Planning (UITP) illustrates, car ownership is the biggest barrier to a multi-modal and sustainable transport.[3]

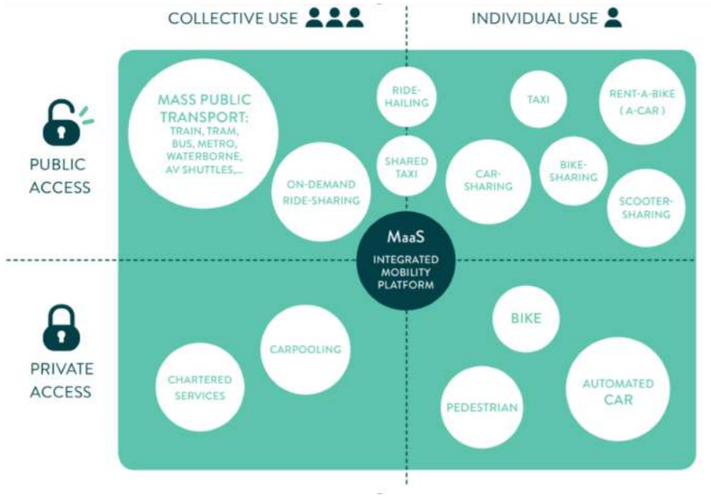
While intra-city travel might be possible through the stitching together of multiple public transport options, who has the time to work all that out? Especially when the consumer would 'feel' the cost of each mode adding up.

Mobility as a Service (MaaS) offers policy makers a new tool for change. MaaS has the potential to make behaviour change easier by delivering what customers need (i.e. to get from point A to point B) in a convenient way, when it suits them, and at a reasonable cost. Truly integrated multi-modal MaaS has significant potential to lower transport emissions by switching journeys to combinations of more sustainable modes including public transport, active travel and shared mobility.

While fully integrated MaaS solutions are currently rare, there is evidence that even the building blocks of MaaS can change behaviours. For instance, a 2015 study of New York City found that real-time information increased weekday ridership on long route buses by 1.7%.[4]

MaaS combines travel offerings from different transport providers into a single service, with the potential to offer bespoke journey options customised to individual preferences. Net Zero Places will use such services to make transport without a private car more convenient and attractive for travellers than driving.

Figure 2: MaaS Value Proposition for Primary Stakeholders; Source: UITP, 'Mobility as a Service, April 2019

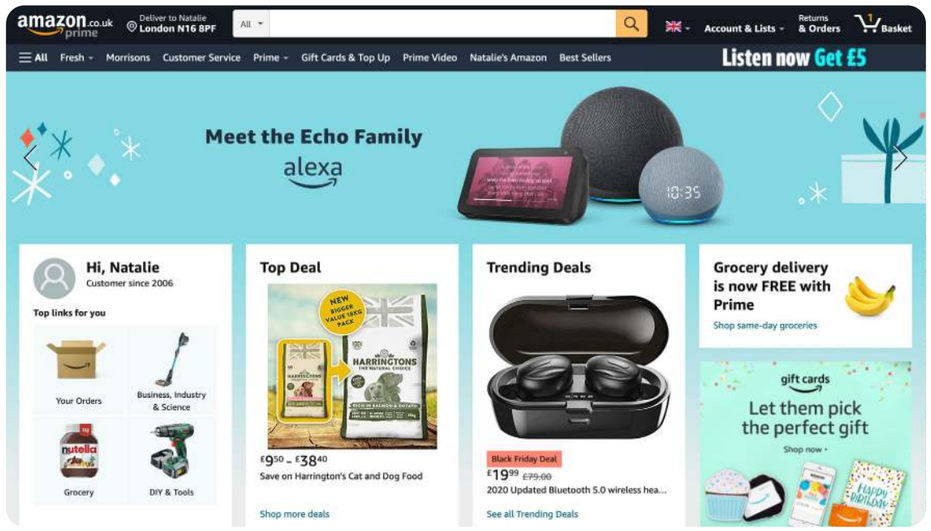


Case studies

Transport for Greater Manchester (TfGM) and Atkins/SNC-Lavalin

Transport for Greater Manchester (TfGM) and **Atkins/SNC-Lavalin** in 2018 tested the hypothesis that MaaS could drive modal change from private cars to either public transport or active travel modes such as walking and cycling. Researchers carried out extensive research including in-depth interviews and ride-alongs to find out the key day-to-day issues affecting commuters. Seven modes of travel were offered in the personalised journey plans: buses, trams, carshare, taxi, bike share, on-demand shared mini-bus and walking. The results showed that MaaS could be a significant tool in driving modal shift with over a quarter (26%) of participants more willing to use public transport and 21% were more willing to cycle and walk.

Source: UITP, 'Mobility as a Service', April 2019



Amazon dominates the world of online retail

Reducing the friction that consumers face in choosing and using different modes of transport gives MaaS providers a new opportunity to influence who travels where, when and by what means. There is another sector which has specialised in this sort of customisation and driven behaviour change on a mass scale - online retail.

Lessons from the jungle

Amazon's dominance in the world of online retail is driven by two complementary forces - convenience and customization.

The company has invested huge sums in reducing friction in the consumer purchase journey - from the moment of 'ooh I think I might want that' to a parcel arriving on the doorstep. It has also built a significant data-driven advantage through extensive '360 degree' customer data collection and people-based marketing.[5]

The company collects and uses a wide range of customer data including their purchase history, items in the shopping cart, wish-lists, addresses, reviews and website searches, to build and streamline its recommended products and advertisements for individuals.

"I made up my mind at this point that I would never try to reform man — that's much too difficult. What I would do was to try to modify the environment in such a way as to get man moving in preferred directions."

Buckminster Fuller

Furthermore, it uses customisation to drive convenience by using big data for its patented 'anticipatory shipping model' that helps it cut delivery time and costs. The model predicts the products you are likely to purchase and when and where you may buy them. Based on these predictions, the items are sent to a local distribution centre to be ready for shipping once you order them.[6]

Whether Amazon's platform-level dominance creates a net social good or not is a matter for debate, but what is clear is that there is no equivalent multi-modal player in the world of transport. Digitally native ride-sharing companies such as Uber and Lyft which offer limited versions of MaaS have seen widespread adoption due to venture-capital subsidised travel costs[7] but not necessarily for the 'greener good'.[8] Recent studies suggest that Uber, Lyft and similar services are adding car miles to city and suburban roads.[9] Partly this is due to drivers spending a lot of time travelling to pick up passengers, but in many cases the car trips are also replacing trips that would otherwise have been made by public transport, walking, or cycling.[10]

For MaaS to contribute to positive consumer travel behaviour change there is a lot to learn from Amazon. A compelling MaaS platform would offer both enhanced convenience and a customized experience. The data which might facilitate customisation are available and proliferating. If a customer uses a performance-tracking app like Strava or a calorie-counting app, a MaaS algorithm might infer that they would be open to a larger proportion of their journey being 'active'. Contextual cues (for example a calendar appointment) might override this to offer greater speed. Users could adjust their explicit preferences within the platform itself - perhaps, for example, to look for a glitzier mode of transport when going on a date.

All of which is to say that MaaS operators have an opportunity to create better and more responsive services, which, once adopted, become habitual, displacing private vehicle usage and reducing emissions.

Recent studies suggest that Uber, Lyft and similar services are adding car miles to city and suburban roads.

Delivering on the promise

The potential for integrated, customised MaaS services is clear and the data 'raw materials' are being generated at unprecedented speed and volume. But despite years of anticipation, MaaS is not rolling out at the pace many expected. Entrants are still struggling to identify successful business models, and most of the financing is coming from either research grants, venture capital, or the public sector.

The reach of current MaaS platforms is limited both in terms of physical areas and demographics covered. Existing services are primarily targeted towards younger urban dwellers[11] and wealthy neighbourhoods[12]. Most manifestations of MaaS today are simply taxi services. Where smarter journey planning is offered, services a lack unique selling points such as lower pricing or extra convenience. 'Last mile connectivity' also remains a barrier to adoption. Public transport networks connect fixed locations and can't compete with the car's ability to deliver passengers anywhere they choose.[13]

For MaaS to make a meaningful contribution to net zero, it needs to integrate the full suite of transport options. To date, bringing together a critical mass of competing providers has proved a Herculean ask. Opening up their customer data and collaborating in this way represents a step change in the business model of transport operators that few have been willing to take. Shifting more journeys from car to public transport would be a huge prize for transport providers, but the risk of going it alone and ceding their commercial advantage to competitors has stymied progress towards MaaS.

Causes of MasS inertia

Forces	Appetite	Ability
Prevent	• Commercial **business case** not clear. • **Internal digitalization** of a transport operator's systems takes priority.	• Absence of **technical capability.** • **Regulatory issues e.g.** franchise/ subsidy.
Support	• Recognition of **customer experience benefits**. • Recognition of the **the fact that other sectors are getting digitalized**.	• Vertical innovation is **foundational**.

MaaS apps and market offerings

Major MaaS offerings currently in the market include the WHIM app (developed by MaaS Global) and Swedish UbiGo app. The WHIM app is now used in several European and UK cities including Helsinki, Vienna, Birmingham, and Antwerp. Residents use the app to select their favoured mode of transport from a list including trains, buses, bikes, trams, or taxis. The user can pay for the various journeys individually or buy a monthly subscription. The company recently saw an investment of £8.6m by BP to help it expand its global expansion with immediate plans including Singapore and the US.

With around 70,000 users in Helsinki (as of late 2018) the impact of MaaS on driving modal shift to public transport is becoming more apparent. Data by MaaS Global shows WHIM users prefer public transport much more than average Helsinki citizen (92% of WHIM users versus 34% of all Helsinki passengers).

Driving behaviour change to more sustainable modes

The UK has some remarkable history of driving behaviour change to more sustainable modes. In the 2000s, governments and regional bodies invested significant sums in travel behaviour change initiatives and programmes. These include the Cycle Demonstration Towns Programme (2005-2011), Sustainable Travel Town (2004-2009), a large-scale personal travel planning programme, and public transport information and marketing initiatives.

Despite some critique, there is strong evidence that these investments generated returns. The Sustainable Travel Towns programme, implemented in the towns of Darlington, Peterborough and Worcester, led to a decline in the number of trips made by car by 9% per person and car driver distance by 5% to 7%, according to aggregated household survey results for the three towns. This compares with a fall of about 1% in medium-sized urban areas over the same period, based on NTS data.

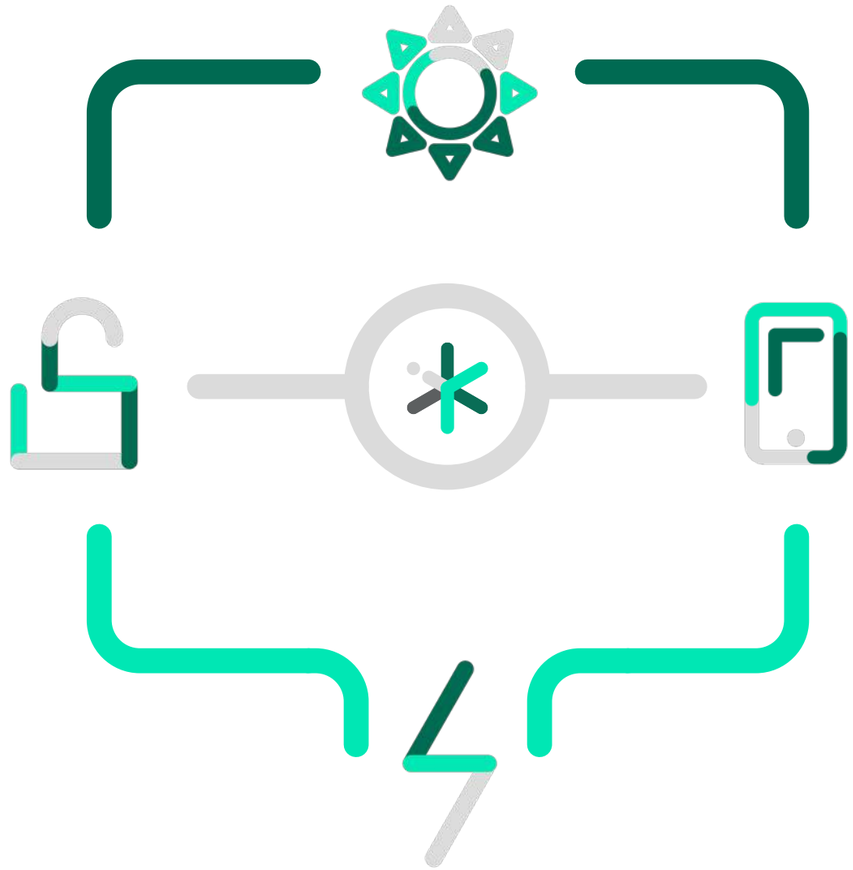
Stimulating "co-opetition"

Transport authorities in the UK have a track record of intervening to influence travel behaviour. The levers they use include speed limits, traffic calming, zero emissions zones, congestion charges and so on.

Net Zero Places will need to tackle the disincentivises which keep individual operators from participating in MaaS platforms. In practise, this will mean transport authorities and regulators shaping the market in one of two ways:

- Requiring transport operators to integrate services with a MaaS platform owned by a public body (such as in Île-de-France).
- Requiring transport operators to share their data and access to their ticketing and payment interfaces to allow competitive MaaS offerings to achieve scale (such as WHIM in Helsinki, Antwerp and Birmingham).

Either way, the experience of cities such as Helsinki make it clear that local authorities need to actively legislate to create a market for MaaS. This will take time and political will. In the meantime, the increased usage of micro-mobility solutions and trialling of e-scooters in many places across the UK will help create traveller demand for more flexible journey options. Once rolled out nationally and integrated into MaaS platforms, these micro-mobility services will also help solve the first and last mile problem which keeps so many of us reaching for the car keys.



Legislation to facilitate new market creation

Smartphone-based MaaS platform

Helsinki was the first large city to introduce the smartphone-based MaaS platform (WHIM – see previous box) as a way to reduce the use of cars within the city.

But the success of WHIM was reliant on a market shaping intervention: the Finnish Act on Transport Services (2017) that brought together transport market legislation. Operators are forced to share their data and to use interfaces in their applications that allow access to their ticketing systems.

"Opening up this kind of information in real-time enables new services to emerge, like has been the case in the hotel business and aviation." Anne Berner, Finish Minister of Transport

Another law has helped to open and streamline all the different payment interfaces. This means that a ticket bought from one bus operator for a bus journey can and will be integrated into other services too.

Helping to spark progress

The way that people and goods move in the future will be a key determinant of achieving net zero targets. Through our Intelligent Mobility Accelerator and strategic partnerships with the Department for Transport, HS2 and others, we are creating opportunities for UK businesses to develop, demonstrate and scale innovative mobility solutions in the UK and globally.

We are also supporting place leaders to plan and commission integrated mobility services of the kind outline above by developing advanced data modelling tools in collaboration with industry and academia to simulate demand for new mobility services, informing investments and spatial planning.

If you are working on an innovative mobility solution or service, we want to hear from you. Likewise, if you are looking for help to identify and introduce the right innovative mobility solutions in your area, please get in touch.

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2.2 Making better decisions through data-driven integrated place planning

Bin Guan, Bob Burgoyne

Planning decisions are too siloed. Choices about how to use land affect and interact with the ways our energy and transport systems operate - with potentially huge implications for emissions.

The dance of development

The places where we live, work, and play are complex, comprising (among other things) buildings, transport systems, energy grids, waste management, and ICT networks. Each of these is deeply interdependent upon the others - for instance, the location of transport hubs is determined by the volume of demand for travel between places, while the development of said places is influenced by the availability of transport and utility infrastructures. These physical assets and services are planned, developed and managed by an equally complex mix of public institutions and private entities with different geographic scales and coverage. Planning, developing and managing places is therefore a constant dance between the now and the new, the needs of different parts of different systems, and balancing the impacts across all.

When it comes to reducing carbon in the ways we live, work and travel, spatial and systems planning plays a critical role. As discussed in the chapter on reducing emissions through behaviour change, the design of our towns and cities influences the choices we make. We can engineer out unwanted behaviours by designing for different ones. But there are also structural reasons why places have the environmental impacts they do, grounded in the interplay between the different systems which make a place work. At present, few developers or planning authorities have the tools needed to understand this complex interplay or model the impact of different choices. This will have to change if we are to realise net zero ambitions.

Net Zero Places will harness the growing power of data modelling to guide decisions about the development of assets, infrastructure and services in their areas to shape environments which engineer out carbon intensive activities at the systems and individual level.

Towards data-driven integrated planning

In recent years, the UK land use planning system has been the focus of significant digital innovation. This 'Plantech' revolution was catalysed by Connected Placed Catapult but is now widespread, with a growing ecosystem of innovative businesses developing new tools and services for developers and planners alike. Because of this, the Ministry for Housing, Communities and Local Government (MHCLG) now has a Digital Land team and the Government recently published a white paper on Planning for the Future, which featured digital tools and approaches heavily.

The idea of bringing the right data together to support better decisions in land use planning has been central to Plantech. Now is the time to expand the reach of the new tools to integrate data and decisions about transport and energy planning.

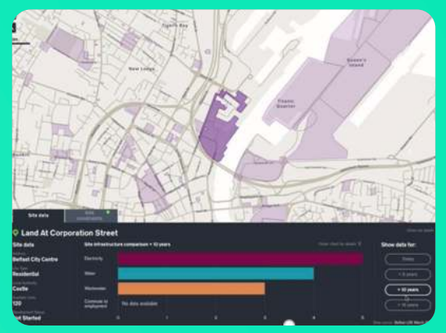
The idea of integrated planning is not new. John Prescott announced a 'blueprint' in 1998 but it failed to get traction.[1] One of the main technical barriers has been the lack of available data and appropriate tools to integrate and process them. That is changing rapidly. Today there is much more data available and the techniques available to mine and model that data are more sophisticated.

At the most basic level, better data allows for improved visualisation (including through maps), enabling decision makers to literally see the implications of different scenarios. Better data also allows for better modelling, to project or predict the impact of decisions with more accuracy. And finally, under the right circumstances and with the appropriate feedback loops and 'actuators' in place, better data can input into systems which self-optimise.

First steps in integrated planning platforms

In 2015, Connected Places Catapult (in the guise of Future Cities Catapult) worked with developers and the Greater Manchester Combined Authority to explore how bringing otherwise disparate data together into a shared view could benefit all parties. The result was a concept called GrowthPlanner (originally GrowthMapper). The idea behind this tool was to overlay data about capacity across a range of utilities on a map of approved and in-progress planning applications. Inspired by Transport for London's Public Transport Access Level (PTAL) rating for land, the tool generated a three-way benefit:

- Swift access to clear information for developers about current and future spare utilities capacity on potential sites;
- Early warning for utilities providers on future demand, directing investments in additional capacity to the right locations;
- Oversight of the whole picture to planning authorities, enabling them to guide all parties and deliver better outcomes for the place.



Further work for Belfast City Council transformed this proof of concept tool into a working prototype and a range of commercial suppliers such as LandTech, Landmark and Magic Map have now picked up the baton to further develop the concept and expand Plantech into new areas of land use planning. A whole ecosystem of innovative companies now exists to provide data, combine, visualise and interrogate data over the cloud.

Taking it to the next level: Transport planning

Transport planning has historically relied on very limited datasets which allowed for system optimisation on a narrow range of dimensions. For example, origin-destination surveys amongst a sample of the population to understand where people are travelling, traffic counters on junctions to measure how many vehicles are passing.

Today, a much more extensive, richer set of data are available which provide a more granular and complete view of how people (not just vehicles) move around, and the emissions impact of specific vehicles moving in particular ways. For example, by analysing anonymous mobile

phone location data (either GPS or through triangulation from multiple cell towers) an almost complete and real time picture can be built up of how people move, and by accessing individual vehicles' telematics data as they travel on a stretch of road, an accurate and dynamic picture of congestion can be built up.

This increased availability of data has enabled the use of new analytical techniques to plan transport systems with a view to optimising more than simply the flow of vehicles around the network. Agent Based Models offer the potential to 'road test' different modal choices (for example, adding a new bus stop) in a virtual environment which simulates system-level complexity and could help make cleaner modes a more attractive consumer choice. Digital Transport Twins can be used to more accurately model the impact of events on traffic flows, allowing more rapid interventions by highway authorities, smoothing flows and minimising the emissions spikes caused by 'stop-start' traffic. Connected Places Catapult has pioneered the use of digital twins in traffic planning and management through supporting Highways England in digitising the Strategic Road Network. This has, amongst other things, helped evaluate air quality measures in relation to speed and/or traffic restrictions.

The last piece of the puzzle: Local Area Energy Planning

The third strand of integrated planning is energy. The emergence of more efficient, distributed means of energy generation, and improvements in energy storage could soon allow for significantly different energy systems. Understanding and planning for these changing solutions and the changing needs of a more heavily electrified economy is a critical task for those planning new infrastructure and investments.

Agent Based Modelling to Understand and Incentivise Greener Travel Choices

Patrizia Franco

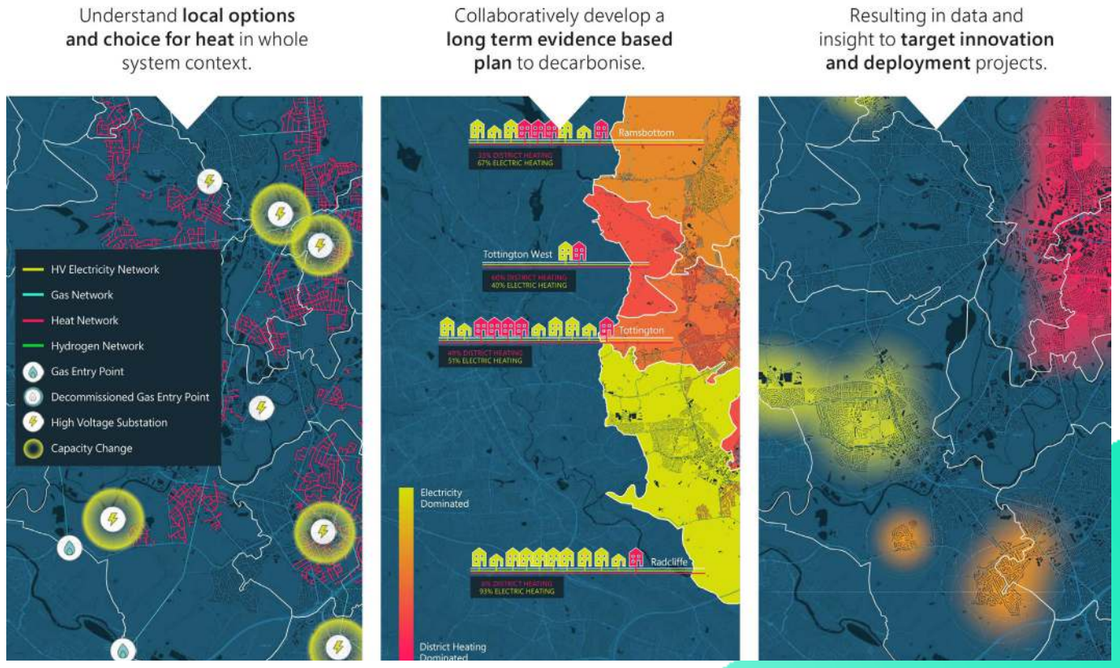
In the 2019 “Demand Modelling and Assessment through a Network Demonstrator” project, Connected Places Catapult in collaboration with the UK Department for Transport developed a large-scale agent-based model (ABM), representing the North East of England in order to investigate the impact of new technologies or modal options on travel behaviours and transport choices.

The DeMAND ABM comprises a synthetic population of nearly 650,000 agents (individual people) replicating the transport choices and preferences within Tyne and Wear (population 1.136 million in 2018). Each agent has its own socio-demographics characteristics, spatial information, and daily activity schedules. These are informed by real world but anonymised and aggregated mobile network data (MND) sourced from O2Motion (Telefonica) along with travel surveys and behavioural models which allow the ABM to simulate the demand for travel.

The tool can be used to assess and evaluate the potential impact of various policy choices and investment decisions – to help support the roll-out and uptake of more sustainable choices such as multi-modal mobility-as-a-service, shared mobility and electric micro-mobility solutions.

Given the deeply connected relationship between how land is developed and used, how people and goods move about, and the energy required to power all of that, the need for more granular understanding among decision makers about the impact of the choices they are making is obvious.

Connected Places Catapult is part of a consortium of stakeholders including local authorities, asset owners and managers, engineering firms and academics who are contributing to the Zero Carbon Rugeley project which incorporates a new housing development, alongside and integrated transport and energy system. Through this project we will be supporting the roll out of electric vehicle charge points across the area, with decisions on the best location incorporating both the flows of people around, to and from the area and also the impact on the local grid. Companies like PTV and Energeo are also actively commercialising similar approaches.



Source: Energy Systems Catapult (2020). Local Area Energy Planning: Building robust plans to meet net zero

From Digital Planning to Digital Twins

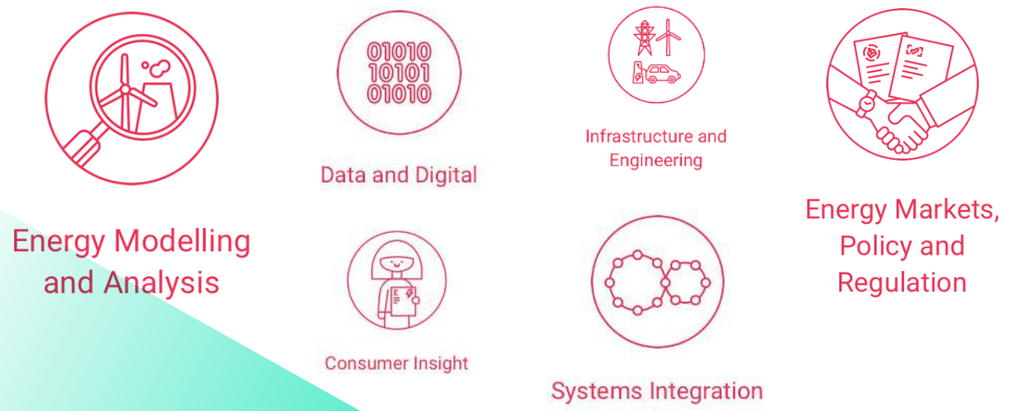
Ron Oren

A digital twin is a digital representation of a real-world asset, system or process, which is updated in near-real time and can be used to inform decisions about interventions in the real-world twin. According to Navigant, digital twins "potentially offer a much richer capability to model and analyse real-world systems and how they change over time"[2]. In its purest form, digital and physical twins are connected through a direct feedback loop (i.e. a change made in the digital twin causes an equivalent change to happen on the physical one). In practice, however, that feedback may be indirect: e.g. insights from the digital twin can inform a planning decision alongside data and inputs from other sources.

Digital twins of individual assets are in use in the market, albeit not very commonly. Where digital twins can truly make a difference is in complex systems of interlocking assets, infrastructure and processes, where a change in one part of the system can have unexpected (and sometimes negative) consequences elsewhere. Places are complex systems at the best of times and achieving net zero places far more so. So, a network of interoperable digital twins would be a key enabler to achieving net zero targets. By combining IoT, ubiquitous computing and advanced data analytics to explore in near-real time how interventions (e.g. installing local energy generation, implementing low-emission zones or changing working hours in selected businesses) would play out across different domains, digital twins allow optimisation of the whole system for the greatest good.

The technology for this already exists but needs to be applied to the city context. For example, the digital twins that Rolls Royce uses for remote engine management can be applied to optimise energy consumption in buildings. Extending this to neighbourhood level then allows intelligent decisions on both building design and microgeneration to move whole districts towards net zero. The hurdles to overcome are not technological but around business models and culture: meaningful change will require sharing of data between organisations and domains (e.g. energy systems and buildings management). This in turn requires common standards for the data, a shift towards sharing by default and increased willingness by organisations to adopt data-driven insights (especially when the data in question was generated outside the organisations).

Another key barrier is legacy infrastructure, which often does not have the sensing or remote management capabilities needed to make the city smart. Infrastructure operators are beginning to work closely with technology providers (some transferring from other sectors or even disruptive start-ups) to make intelligent decisions on where to invest in retrofitting technologies and where to wait for the next planned maintenance cycle to invest in upgrading the infrastructure. Either way, the investment required is significant; to build a solid business case it should be prioritised in areas where a digital twin would have the most impact (on net zero targets, cost reduction, revenue generation; or indeed all of the above). Connected Places Catapult is working to assess and prioritise use cases for digital twins in the connected places market to inform potential investments and unlock the potential of place-based digital twins.



Helping to spark progress

Since late 2019, Connected Places Catapult and Energy Systems Catapult have been working together to leverage mutual expertise in land use, transport and local area energy planning (LAEP) to form the basis of an integrated approach to place planning, with a view to catalysing a further surge in digitised planning tools and a focus on supporting places to achieve net zero.

If you are working on an innovative solution or service for land use, transport or energy planning, or any combination of the three, we want to hear from you. Likewise, if you are a planning authority, infrastructure provider or develop looking to understand better how changing demand, potential investments and future technologies might impact your assets or area, please get in touch.

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2.3 Active Travel: delivering a gear change and a step change

Scott Cain

Cities worldwide are rapidly adapting to accommodate more journeys by foot and bike, inspired both by public health needs and net zero goals. Because of this, the market opportunity for active travel has never been greater.

A handcyclist on a residential road. Image credit: Transport for London

Further innovation by businesses supporting place leaders to plan and implement effective infrastructure for walking, cycling and running, will help ensure that positive progress and momentum isn't lost.

Perhaps a good place to start is with what we actually mean when we say 'active travel'. Usually it's simply the collective term for cycling and walking. But what if we were to think more broadly and inclusively? Should it not include all human-powered mobility? Could we consider sustainable freight as a potential beneficiary of active travel?

Once we start thinking beyond everyday walking and cycling, the full diversity of pedal-powered design opens up a whole spectrum of new solutions. Consider the range of form factors, not least those used by disabled cyclists and wheelers (people in wheelchairs) as well as scooters and skaters. Picture the growing array of e-cargo and electric bikes, which are partly assisted but principally human-powered, as well as all kinds of journeys on foot - including running - as legitimate forms of healthy, active travel. The potential benefits of active travel-centric places are both wide-ranging and achievable.

A wonder drug

As Public Health England put it, "Switching more journeys to active travel will improve health, quality of life and the environment, and local productivity, while at the same time reducing costs to the public purse. These are substantial 'win-wins' that benefit individual people and the community as a whole".[1]

Active travel aligns the needs of people and place. If you plan and design for active travel and healthy streets, the benefits reach far beyond transport - in terms of health, wellbeing, reduced social isolation, improved air quality, reduced environmental and carbon impacts - the list goes on. It is why one former Chief Medical Officer referred to it as 'a wonder drug'.[2]

A profound and immediate opportunity

There is an immediate, growing and profound opportunity in active travel. Active travel is every bit as central to decarbonising transport and Net Zero Places, as it is pandemic recovery. The opportunity is truly global in scale. It is being enabled through policy and regulation and is high up on the agendas of leading city, regional and national governments,[3] as well as employers and business groups.

At Connected Places Catapult, we recognise that it is a market opportunity for UK plc - from urban design, engineering and placemaking, to innovative finance and insurance, industrial design and high value manufacturing, through to digital services, advanced modelling and simulation.

And it is an opportunity right now. Technically and, perhaps most tantalisingly, culturally. With travel patterns and life's regular rhythms disrupted, such flux presents opportunity. One for forward-thinking place leaders and private sector innovators alike.

The winds of change

Active travel has been given fresh impetus and increased priority by both the UK government and the Department for Transport as an enabler for getting the economy moving again whilst maintaining safe, social distancing. This includes the 'Gear Change' announcement of £2bn investment for active travel including a £250m Active Travel Fund, and £200m Active Travel for Schools Fund. [4]
This is leading to many more instances of road space reallocation, 'filtered permeability', Low Traffic Neighbourhoods (LTNs) and traffic calming to give preference to modes other than the private car.[5]

A new public body called Active Travel England has been announced. Described as an active mobility equivalent to Ofsted, this inspectorate will have powers to withdraw funding if standards are not met or projects are subject to delays.[6] Active travel is also central to the UK's Decarbonising Transport Plan.[7] And it is prominent in the push to reduce obesity,[8] spearheaded personally by Prime Minister Boris Johnson.[9]
This includes what Downing Street has called "the biggest ever step change in cycling and walking".[10] Among the policy measures are pilots to encourage GPs to prescribe cycling (and park runs) in areas with poor health and low physical activity rates, as well as further investments in secure bike parking and additional infrastructure.

Trials to allow e-scooters to be legally ridden on UK roads have also been fast-tracked.[11] Active travel combined with public transport is now central to the strategies of UK city regions and devolved administrations. Each has a Cycling and Walking Commissioner, as exemplified in Greater Manchester by Chris Boardman, who has evolved the narrative for cycling and walking to be one of social justice and inclusivity.[12] Furthermore, a new Acceleration Unit, working directly to The Department for Transport Secretary of State will from October 2020 be headed by sustainable travel champion, Darren Shirley, latterly CEO of Campaign for Better Transport.[13]

Active travel

Active travel is the collective term used for cycling and walking. More broadly think of it as 'human powered' travel, which includes cargo bikes, electric bikes and all journeys on foot.

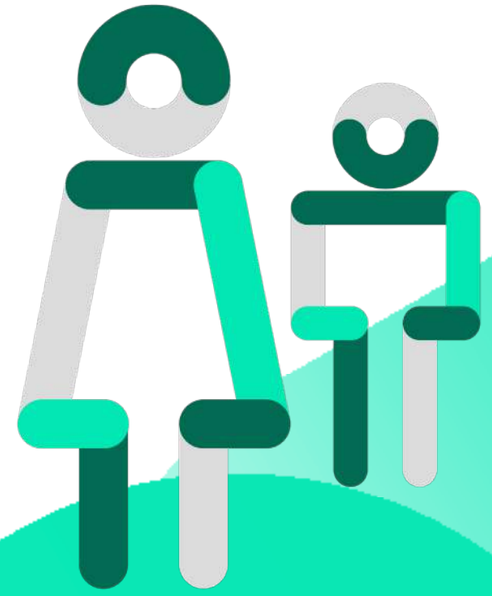
There are also new initiatives from bus and train operators to enable active travel in combination with public transport. This includes a new 'bikes aboard' facility by East Yorkshire buses and Go North East, whilst the Go-Ahead Group and Stagecoach have introduced technology that, via apps and AI, allows customers to plan journeys for quieter times and understand how busy the next bus will be in real-time.[14]

The insurance market, which itself is seeing innovation from UK start-ups like Laka and Bikmo, provides a useful barometer. "Sales are up 315% on the back of COVID," observes Cycleplan CEO Paul Williams "and whereas 18 months ago we had electric bikes representing around 10% of our policies taken, that tally is now closer to 19%. This buying profile has altered our typical customer base and we're learning a lot from that."[15]

Data insights and modelling, which help us understand how we move today and how we might optimise our journeys in future, is steadily maturing. Examples include Strava Metro, now available at no cost to UK cities and transit authorities, the smart cameras and AI of Vivacity Labs, and data from mobile phone operators like Telefonica (used in the DeMAND agent based models mentioned earlier) .

Innovations in the design of hard infrastructure are also underway - in Cambridge, a new style roundabout is being tested which slows traffic and gives priority to pedestrians and cyclists. [16]
If successful, the new (for the UK) style roundabout could become a template for replication elsewhere.

Trials to allow e-scooters to be legally ridden on UK roads have been fast-tracked



In terms of vehicles, innovative UK companies like Pure Electric are growing rapidly.[17] Pure Electric, which took over 11 Cycle Republic stores in April 2020, sells electric bikes, e-cargo bikes and e-scooters and has already begun its European expansion. Ambition, intent and expertise are not lacking, with it now designing and developing its own e-scooter.

A global market

City and national governments globally[18] are introducing their own temporary measures to support active travel, including re-allocating road space away from private vehicles. This is resulting in comparable upticks in active travel, including in even the most car-centric of nations like the US.[1]

This is combined with significant government funding to invest in infrastructure and develop markets for innovation. International efforts to enable modal shift at scale are also taking root across every continent. India, for example, has 44 Bicycle Mayors, 40% of the global total. The UK, meanwhile, has just one - Adam Tranter in Coventry. As the Bicycle Mayor for Bangalore, Sathya Sankaran, puts it:

"We now have the tech workers who can afford a car but instead ride to commute, for pleasure and for recreation. They are redefining cycling, giving up on the car commute, which is terrible. In Bangalore the car is overwhelmingly bad for everyone. The opportunity is enormous here - just 15% of people own a bike and it's just 3% of mode share."

Fleet of foot

UK plc will need to act swiftly to capture market opportunity. Cycling is now on the EU Green Deal Agenda of the European Commission, with something of the order of 20 billion euros earmarked for investment via EU regional funds alone[19]

At the national level in Europe, there's a multi-billion euro investment in Germany, as well as a deliberate deepening of its knowledge and research base, with support for cycling professorships, akin to those in the Netherlands and Denmark.[20] There are positive market developments in terms of cargo bikes[21] and electric bikes.[22] Using Germany by way of example again, sales of e-bikes grew year-on-year to almost 40%.[23] In the Netherlands, a global leader in inclusive cycling, over half of new

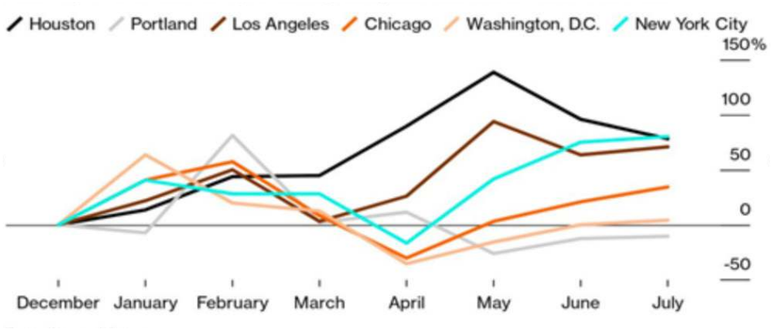


Figure 1: Bike trips on strava surged during the pandemic in several U.S. cities. Chart shows year-on year percent change in Strava bicycle trips each month, 2019 vs 2020
Data: Strava Metro Source: City Lab

[1] https://www.bloomberg.com/news/articles/2020-09-23/how-the-coronavirus-affected-biking-in-u-s-cities?srnd=citylab-transportation

adult bikes sold were electric in 2018.[24] With the UK's heritage in bike design and manufacture, combined with its high value engineering, consulting and advanced digital ecosystem, plus its globally admired science and research base, there are large and growing domestic and international opportunities. Yet this will only be realised if the UK is agile and coordinated in its innovation response.

Whilst it is too early to see which shifts in behaviour that have emerged during the early months of COVID-19 will persist - remote working, fewer commutes, more localised journeys, reductions in business travel - analysts at Arup, Connected Places Catapult and elsewhere argue that long term trends have been accelerated.[25] These dovetail with the increasingly urgent imperative to create viable conditions for Net Zero Places.

Net Zero Places will be engineered for active travel

There is a new timeliness to the active travel agenda for society and as a market opportunity for UK firms.

Exactly what we include in the scope of this market, how big it is now and how fast it is growing is still an emerging picture - yet there is enough evidence to suggest that it is large enough, growing at pace, based on long-term fundamentals and strategically aligned with decarbonisation and public health agendas.

Connected Places Catapult research has identified nine principal market opportunities in active travel. Here we outline three and their relevance to Net Zero Places:

Cargobikes as a System

There is the opportunity to build a deliberate value chain around the design, production and deployment of electric cargo bikes. These vehicles are totemic for clean growth and operate at a human scale. There is an opportunity to combine urban planning and regulatory-led policies to enable electric cargo bikes (of various scales combined with micro-consolidation centres) to support the current 90% of goods in the UK being moved by road[26] whilst considering the last mile. There are road-user charging and other innovations for pricing regulation to deter high-carbon, less sustainable options.

The UK has emerging pioneers in new cargo-bike design and production (www.eav.solutions) and in new business models (https://pedalme.app/), alongside its most established yet innovative firms like Raleigh and Pearson. Cargo-bikes and electric cargo-bikes offer, for the consumer market, more inclusive options (e.g. parents of young children and in particular mothers who do a disproportionate number of multi destination trips). And increasingly as an integrated freight solution, with particular last mile advantages relative to road freight when combined with rail, as evidenced by GWR data[27].

A recent LGA report makes the case for replacing conventional delivery vans with cargo bikes, at scale, in order to reduce current urban delivery carbon emissions by 73% without changing the overall network efficiency.

What opportunities exist to accelerate the value chain around electric bikes and cargo-bikes - from design to new business models? What adjacent insights and opportunities build on the UK's high value manufacturing expertise? Could mechanisms like SBRI or challenge programmes pull through, with regional hubs/clusters forming around existing car-centric innovation in, for example, Coventry/Warwick and Sunderland? Some of these were, after all, the original clusters behind the birth and production of the modern bike itself.

Fifteen Minute City

This simple yet powerful concept is rapidly gaining traction, which rethinks amenity to be accessible on foot and by bike within 15 minutes from where we live. Think local shops, doctors, schools, parks, sports facilities and the like. Popularised in Paris by Mayor Anne Hidalgo, it is promoted by the C40 cities among its network.

The brainchild of French-Columbian scientist, Carlos Moreno, it opens up opportunities for place leaders, developers and technical innovators - including complex system models and digital engagement and planning tools. The concept is sometimes referred to as 'Twenty-minute neighbourhoods', based on learning coming from Melbourne, Australia. Sport England and the TCPA (Town and Country Planning Association) have emerging programmes to design active environments - further supporting the realisation of the 15-minute concept. This may become a big idea for Net Zero Places.

Seeking to meaningfully reduce carbon emissions from the strategic road network is enormously challenging, never mind legacy vehicles and the embedded carbon in new vehicles, whether electric or not. With remote working and local work hubs, suitably accessible on foot or by bike or electric bike - such as the UK's AnalogMotion - this vision would enable people to connect with each other and do almost everything they need to do in their daily lives without even getting onto the strategic road network.

Combo travel

Inspired by Innovate UK's Karla Jakeman, this focuses on unlocking more active travel trips, and in particular human-powered mobility combined with one other mode such as bus, train, tube etc.

'Combo travel', as it may yet become known, is distinct from the larger concept of Mobility-as-a-Service (MaaS) in a variety of ways, not least in that it is specifically focused on enabling active travel. This opens up user-centric and system design with, for example, bus and train station designs, bike provision and secure storage at interchanges, potential for active travel alternatives to park and ride (with e-bikes replacing or complementing buses).

A number of bus and train companies, including Southern and Govia Thameslink, are engaging with this topic and pulling through solutions from the market. Likewise, ITS via its newly formed Active Travel working group.

Taken together, all this suggests we have the opportunity, if properly understood and strategically enabled, to deliver both a gear change and a step change - by bike and by foot - to change how we live and move, with all the health, wellbeing and carbon-reducing benefits this brings.

Helping to spark progress

The way that people and goods move in the future will be a key determinant of achieving net zero targets. Through our Intelligent Mobility Accelerator and strategic partnerships with the Department for Transport, HS2 and others, we are creating opportunities for UK businesses to develop, demonstrate and scale innovative mobility solutions in the UK and globally.

We are also supporting place leaders to plan for active travel and commission new mobility services by developing advanced data modelling tools in collaboration with industry and academia to simulate future demand, informing investments and spatial planning.

If you are working on an innovative mobility solution or service, we want to hear from you. Likewise, if you are looking for help to encourage active travel or introduce other innovative mobility solutions in your area, please get in touch.

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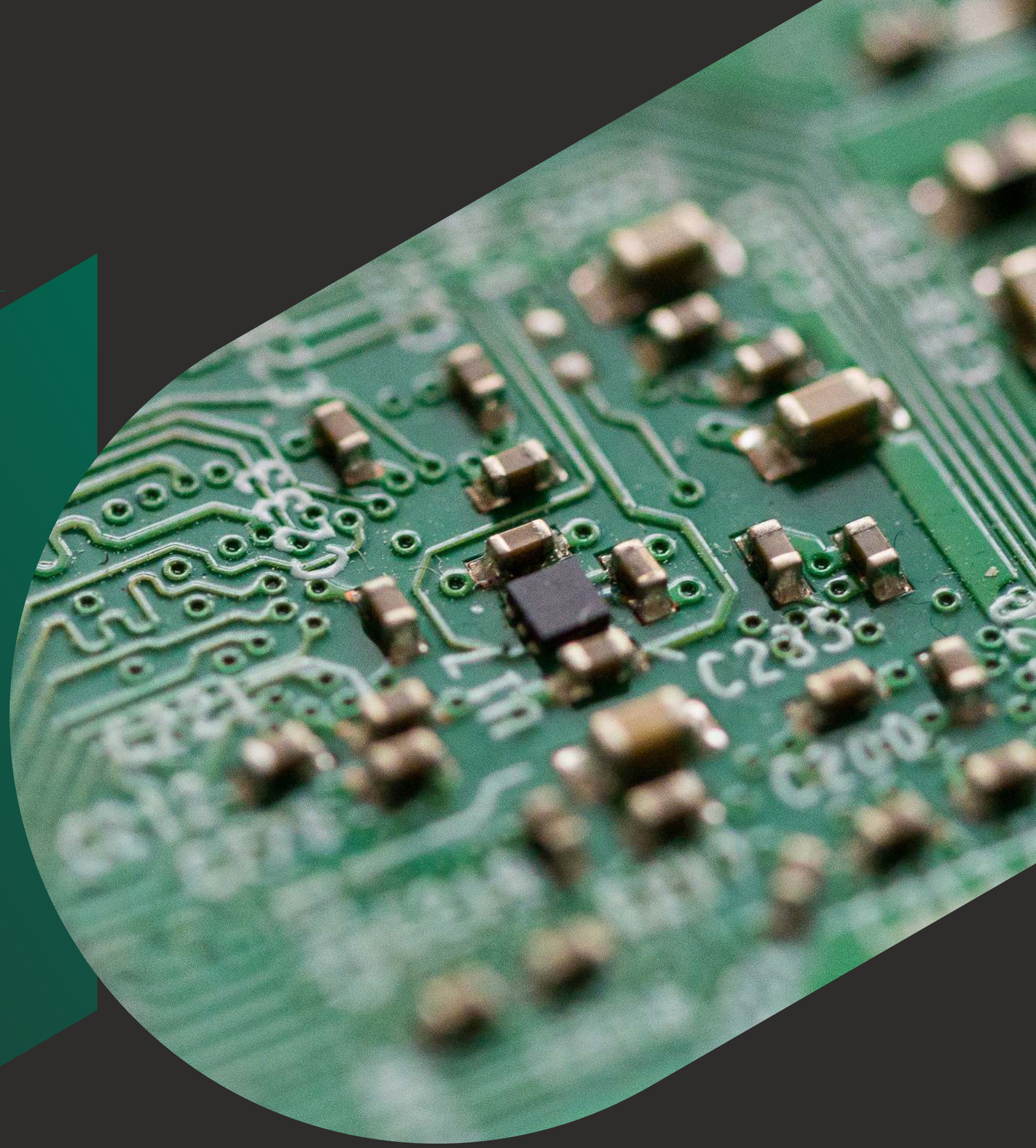
Chapter 3:

New Technologies



In this third and final chapter we look to the future and the emerging technologies which promise to have a transformative impact on the ways people and goods travel. Securing the benefits of these new solutions is only partially about refining and proving the technologies themselves. Deploying them at the scale needed to deliver net zero will also require significant innovation in the planning and development of our towns, cities and national infrastructure, all of which represent market opportunities.

3.1 Transitioning Road Freight to Net Zero

Andrew Green and Alan Nettleton

Building a roadmap for heavy freight decarbonisation – from demonstration to commercialisation.

Decarbonising Heavy Freight - the next technological frontier?

In response to the Committee on Climate Change's (CCC's) proposals for net zero, the Government has legislated and is now committed to developing a plan in 2020 to achieve net zero emissions across every single mode of transport by 2050.

After cars and other light vehicles, heavy goods vehicles (HGVs) are the largest contributors to greenhouse gas emissions, representing 4% of total UK emissions. Great strides have been made over recent years on incremental improvements to both decreasing vehicle emissions per mile travelled and improving logistics efficiency to reduce the number of vehicle miles. Continuing emissions reductions are expected, driven by improved vehicle technologies, lower net-emission fuels and digitalisation of logistics but, by themselves, these will be insufficient to hit the net zero emissions target.

New solutions will be required for every road freight vehicle type - from e-cargo bikes to 44-tonne articulated lorries. Alongside addressing Greenhouse Gas (GHG) emissions there is growing pressure to reduce atmospheric emissions (e.g. NOx and particulates), so any solution is likely to require zero-tailpipe emissions.

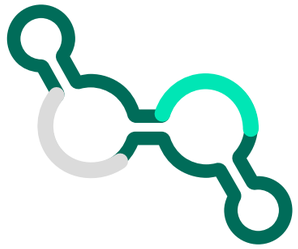
The HGV market is heavily fragmented with a wide range of vehicle sizes and body types serving different sectors. Different operations require different vehicles and duty cycles. Larger articulated vehicles, which dominate long-haul freight operations, are driven significantly further than rigid vehicles which tend to be used for local and regional deliveries.[1] Moving to zero emission vehicles will require not just a step change in vehicle technology, but substantial, national-scale investment in the infrastructure to provide fuel to the vehicles. This fuel could be electricity, hydrogen or some other alternative zero-emission fuel.

[1] An articulated vehicle is a vehicle which has a permanent or semi-permanent pivot joint in its construction, allowing the vehicle to turn more sharply.

Key 'Green Initiative' by Parcel Delivery Companies in the UK

DPD	DPD plans to cut its CO2 emissions by 89% and pollutants by 80% by 2025. Around 75% of DPD's road fleet are at least Ero 5 compliant. For their last mile operations, it now mainly uses electric vehicles and cycle couriers.
DHL	Plans to reduce local air pollution emissions by operating 70% of its own first and last mile services with "clean pick-up and delivery solutions, such as bicyles and electric vehicles."
Green Courier	UK-based Green Courier claims to use one of the lowest carbon emitting fleets in the industry, including bicycles, electric vans, motorcycles and ultra-low emission vehicles.
Yodel	UK's independent parcel delivery company Yodel recently invested £15.2m in new 'greener' vehicles as well as technology to improve efficiency and safety.

For local and regional freight, there is already a movement towards battery electric vehicles, the development of which can piggy-back on developments in the passenger vehicle space and the growing recharging infrastructure for cars and other light vehicles. The UK is well-placed to service these opportunities with innovative vehicle supply companies such as Tevva and Arrival, integrators such as Ricardo and Arcola and many 'Tier 1' component suppliers. However, the biggest emitters are the largest, long haul vehicles and they also represent the greatest challenge. Transitioning such vehicles to net zero emissions represents one of the largest technological, market and infrastructure challenges of all transport modes.



Hydrogen fuelled HGVs

Energy is stored on board the vehicles as compressed hydrogen gas, which can either be used in an internal combustion engine or converted to electricity in fuel cells to power an electric motor. Vehicles will need to refuel at hydrogen refuelling stations: and distribution of hydrogen to those stations is a key factor to be considered with this solution.

Electric Road System (ERS) enabled HGVs

This option is based on a solution proposed by Siemens and other stakeholders known as 'eHighway'. A pantograph is fitted to the vehicle roof and transmits energy from overhead electric lines to the motor of the HGV. This can be automatically or manually raised or lowered. An additional energy source will be required for when the vehicle is not in contact.

Battery Electric HGVs

Pure battery electric HGVs store all of their energy within batteries on the vehicle. This electric energy feeds the motor. Batteries must be charged whilst the vehicle is stationary at a charging station. Given the large energy requirements of the vehicle and typically very high utilisation of HGVs, charging may be overnight at a depot and/or with extremely high-powered chargers at service stations during short driver rest breaks.

Three possible routes to net zero HGVs

Various potential solutions are in development around the world but are not yet in widespread use anywhere. Each solution has their own strengths and weaknesses - not to mention their own passionate advocates, who are usually motivated by commercial and/or operational interests in the adoption of their preferred solution. Because each option requires its own significant infrastructure, investment, and a lengthy and expensive vehicle development process, it is unlikely that the transition to a single solution will be driven by market forces alone.

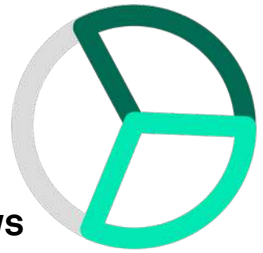
Over the last two years Connected Places Catapult has been working closely with the Department for Transport on the Transitioning to Zero-Emission Transport project (TranZET). TranZET aims to bring together stakeholders who would need to be involved in the transition to zero emission long haul HGVs, independently review the options, develop a business case and plan for a commercial demonstration project and set out a potential transition roadmap. Key outputs of the TranZET project to date have been:

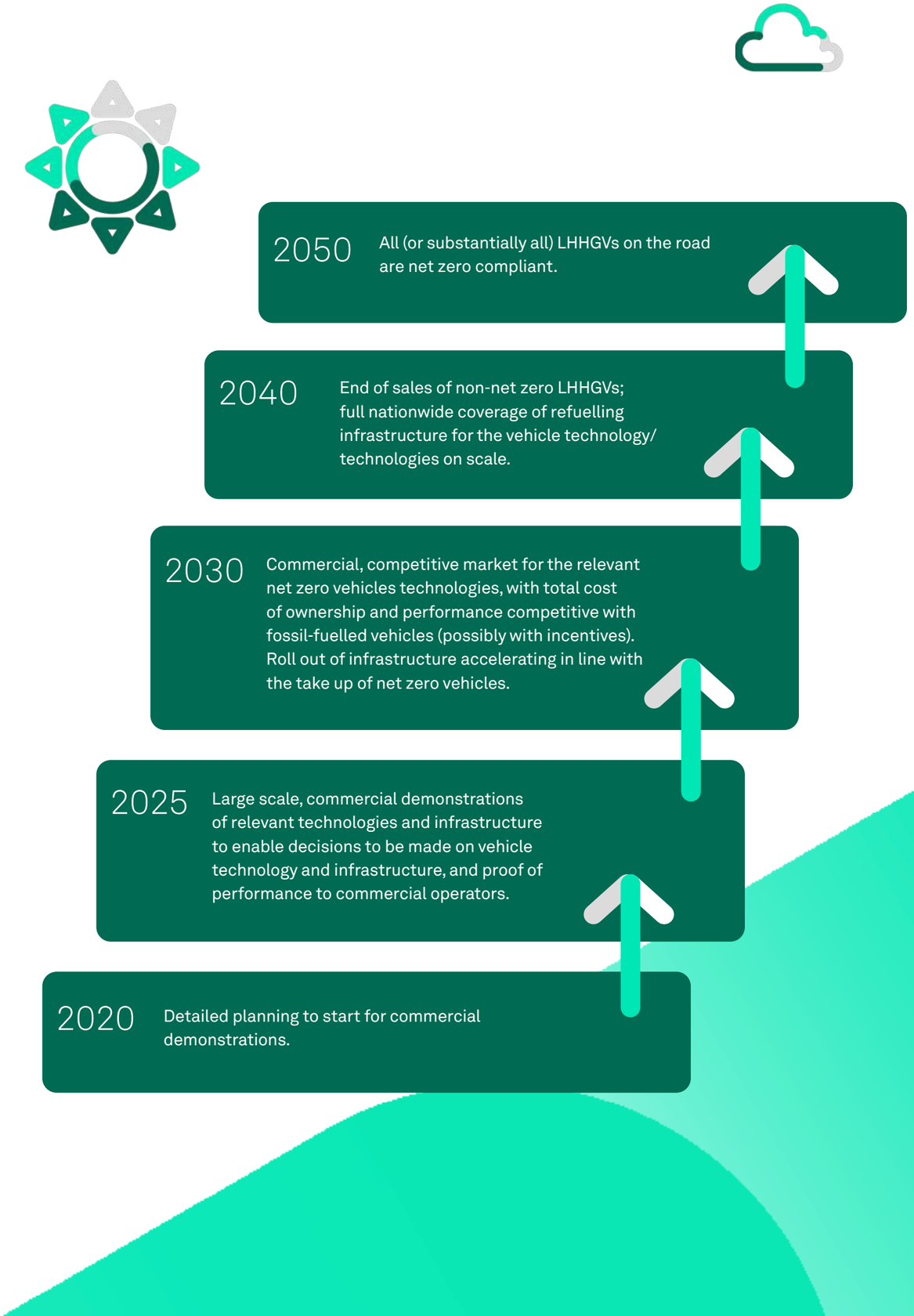
- Development of a Strategic Framework to identify key barriers to transition and how they might be overcome
- Analysis of the expected future cost of ownership of the options. This used a cost model developed in collaboration with Element Energy, which drew on best-available cost data. This has been benchmarked against a range of other models. The bottom line of this analysis was that there is no clear winner on this basis, with any differences well within the bounds of uncertainties in future costs
- Analysis of Strengths, Weaknesses, Opportunities and Threats. In many ways the different options complement each other. For example, ERS has the highest 'windmill to wheel' efficiency (claimed to be greater than 80%[1]), but the highest infrastructure requirements, whereas hydrogen offers short refuelling time and long range, but lower efficiency

- Development of a Strategic Outline Business Case for large-scale, commercial demonstration of the options, supported by in-depth stakeholder engagement. Connected Places Catapult's work has shown that proving commercial operation and starting establishment of the refuelling infrastructure are essential prerequisites for deciding on options and enabling market forces to take off.

The target of full decarbonisation of HGVs by 2050 sounds a long way away but working backwards from that shows that there really is no time to lose. If vehicles need to all be zero emission by 2050, sales of non-compliant vehicles will need to stop ten years earlier. It will take ten years to develop a fully competitive vehicle marketplace and build all the required infrastructure. Key decisions on which routes to follow must be taken early in the second half of this decade. A large-scale, commercial demonstrator with 50 or 100 vehicles and substantial refuelling infrastructure cannot happen overnight.

The target of full decarbonisation of HGVs by 2050 sounds a long way away but working backwards from that shows that there really is no time to lose.





The UK Supply Chain and Commercial Opportunity

The HGV manufacturing industry has been valued at over $360 billion and is growing by 4% per year. [2] Achieving the transition required for net zero will have a major impact on the sector. The UK currently has only a single Original Equipment Manufacturer (OEM) in this area - Leyland DAF - which is focused on smaller, rigid vehicles. Any solution developed needs to have the buy in of the major OEMs - and be compatible across Europe, since a high proportion of HGV journeys involve passing through multiple European countries.

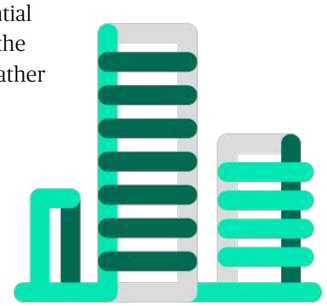
Currently no other country has made a definitive decision on the approach to decarbonisation. Germany has thus far led on ERS with three demonstrator projects covering around 15km in mixed-use environments with real traffic.[3] Sweden is also testing ERS and Switzerland recently announced a big hydrogen trial with Hyundai.[4] Through building on these experiences with a more substantial demonstrator programme, the UK has the opportunity to take a leadership position and create first mover advantage for its businesses, as well as making vital progress towards net zero.

While there is not as much HGV manufacturing in the UK as in some other countries, the UK does offer a vibrant, innovative supply chain. Recent research for the TranZET project by the Advanced Propulsion Centre identified over 60 organisations which could support and benefit from the transition to net zero emission HGVs. The proposed demonstrator is likely to need the support of one or more major OEMs to ensure that well-developed, reliable vehicles are made available to the commercial operators, but the UK supply chain is well-placed to benefit and the demonstrator could provide an invaluable opportunity to provide a test bed for more innovative offerings alongside commercial vehicles.

As well as vehicle supply there will be opportunities around development of infrastructure. For example, if ERS is adopted it could result in 1000s of kilometres of overhead wires being built on the UK's major routes, which could benefit from learnings from rail electrification and other major infrastructure projects. The UK could benefit from the fact that one of the world's leading suppliers of Hydrogen Refuelling Stations is based in Sheffield (ITM Power) - and as discussed in the chapter on green ports, there is an opportunity for UK ports to become hubs for the creation of hydrogen fuel from off-shore renewables.

Demonstrations that drive decisions

Moving the whole of UK road freight operations to net zero emission vehicles by 2050 represents a major challenge, but equally an opportunity for the UK supply chain. This transition is unlikely to be achieved in the required timescale by market forces alone, even with financial incentives. A large-scale commercial demonstration programme in the mid-2020s is essential to provide confidence for operators, the right signals for manufacturers and gather the real-world data needed to inform the major infrastructure investment decisions that lie ahead.



Helping to spark progress

Decarbonisation of heavy transport is a key imperative in the wider sector landscape - and an area with huge commercial potential for successful approaches which are adopted at scale. Connected Places Catapult is bringing together leading edge players in the logistics sector, having hosted the 2019 International Physical Internet Conference and recently contributed to the 2020 Future Logistics event. If you are working on an innovative solution or service for the logistics industry, we want to hear from you. Likewise, if you are a distributor or supply chain manager looking to introduce innovation into your process, please get in touch.

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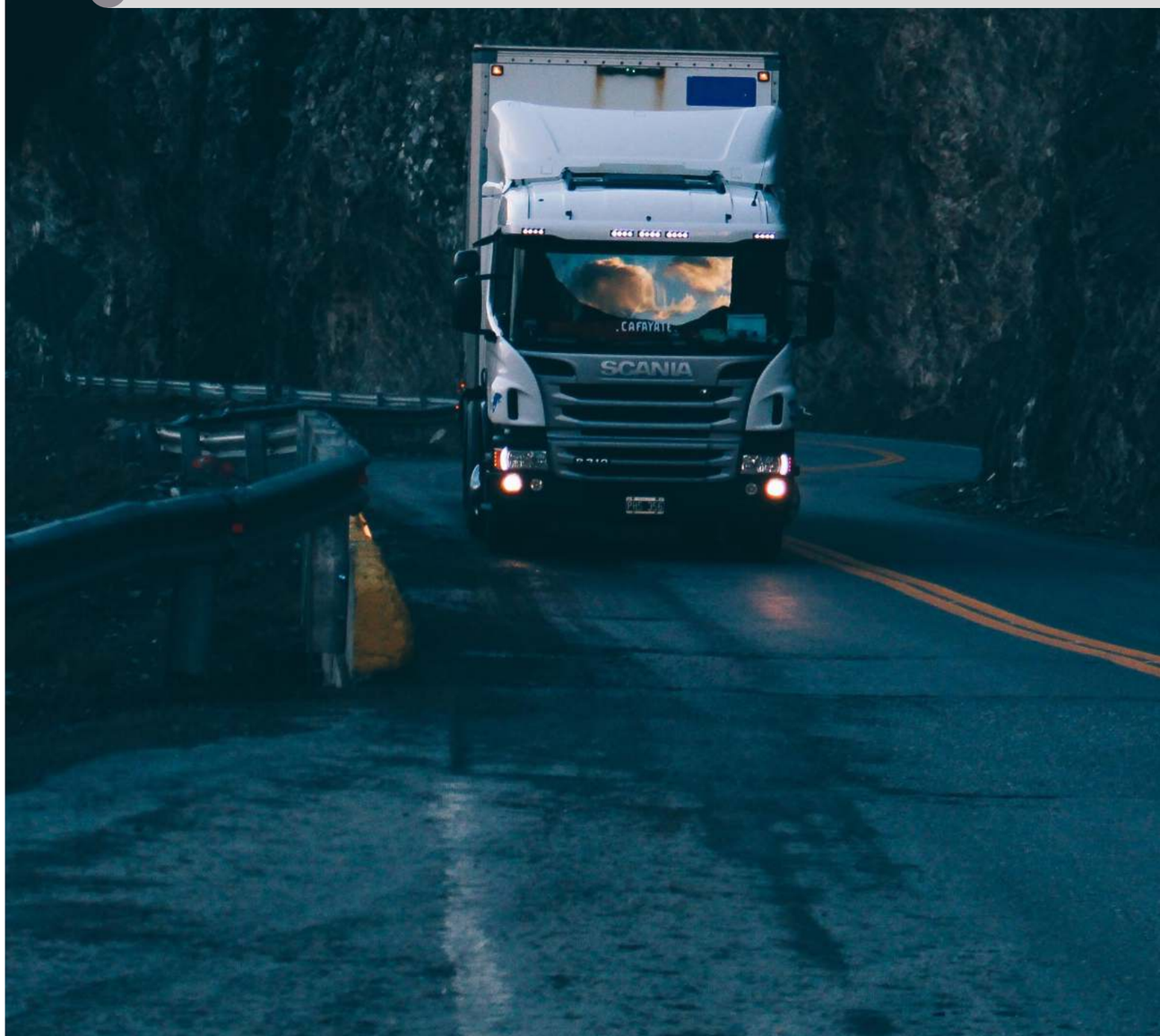


3.2 Drones and the Electric Aircraft Revolution

Andrew Chadwick

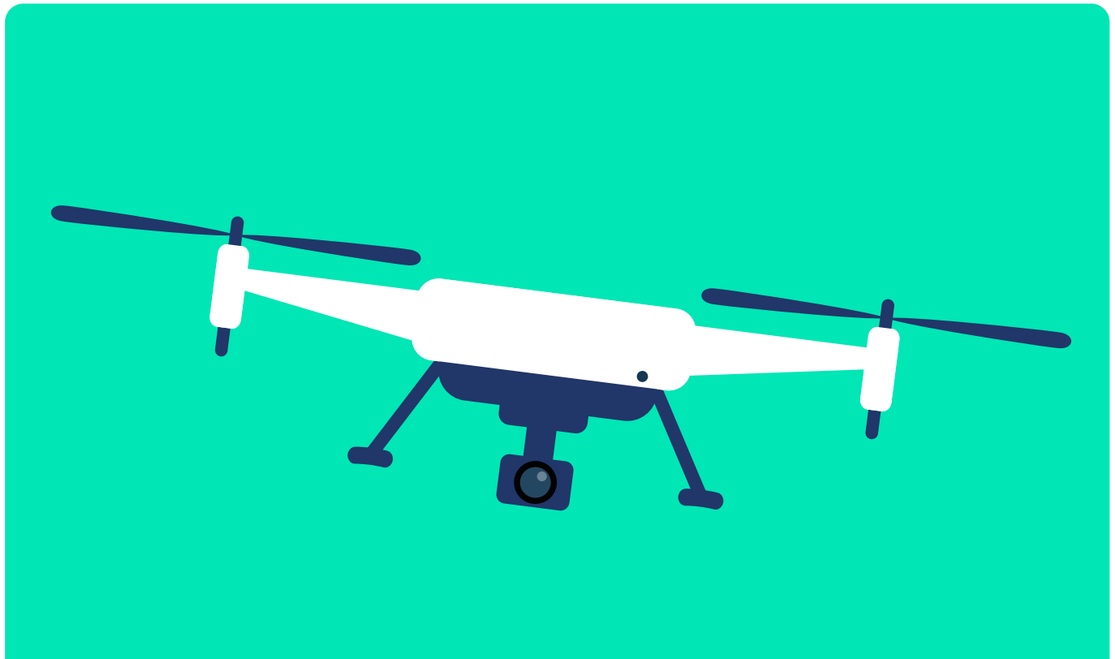
Improvements in battery technology and materials science, incubated in the drone sector, are accelerating progress towards commercially viable electric planes.

The aviation industry contributes 2% to 3% of global greenhouse gas emissions. Electrification promises to render commercial aircraft almost carbon neutral. What's more, since electricity is cheaper than traditional fuel, it will also reduce the cost of flying. Fortunately, electric planes are no longer a far-flung idea; building on technologies developed in the drone industry, they have the potential to become commonplace in the near future.

From net zero to Jet Zero

The UK is taking the lead in developing green aircraft solutions. In June 2020, the UK's Transport Secretary, Grant Shapps, announced the creation of the Jet Zero Council, a group that will be responsible for making net zero carbon emissions a reality for all flights in the future. Leaders from aviation, environmental groups and government are being brought together to form the Council. Their goal is to demonstrate - within a generation - flight across the Atlantic without harming the environment.

Similarly, in July, the Aerospace Technology Institute (ATI) launched FlyZero, an ambitious project to help UK aerospace develop a zero-carbon emission aircraft by 2030, backed by the UK Government's Department for Business, Energy & Industrial Strategy (BEIS). The FlyZero programme will pull together expertise from across the UK supply base and universities in an initial 12-month programme to look at the design challenges and market opportunities of potential zero-emission aircraft concepts. The FlyZero vision is for the UK to realise zero-carbon emission commercial flight by the end of the decade. Funded by a £15 million grant from BEIS, FlyZero will utilise the expertise of around 100 secondees from industry and academia.



Introducing the Future Air Mobility Innovation Centre

Connected Places Catapult is also investing in sustainable aviation. We have recently announced the launch of the Future Air Mobility Innovation Centre. It will provide a centre of focus for R&D and investment activity and a focus for investors and funders. Its aim is to position the UK at the forefront of Future Air Mobility research, development and use, and contribute to UK economic growth. In addition, it will help the industry develop safe, efficient, and sustainable systems to move both goods and people. Amongst its many services, it will also provide independent advice to government and decision makers across the UK, taking advantage of the Catapult's wide network of city, local authority, devolved and central government contacts.

One of our first projects within the Future Air Mobility Innovation Centre will be to help the aviation industry identify and deliver near and medium-term opportunities to address sustainability of the air transport system. In this we will not only focus on the aircraft but the entire aviation eco-system itself - each link in the chain.

Sustainability across aviation is a natural progression from the introduction of drones across many sectors worldwide. Being recognised as a new business work horse, drones are increasingly becoming electrically powered, and are leading the carbon-free cause. Indeed, as one collaborator recently commented, "drones are born green".

The benefits of drones

Drones were originally developed for military purposes. However, from the beginning of the twenty-first century, as battery and control technologies were significantly developed and miniaturised, particularly by companies such a DJI in China, drones have increased their performance and become much more cost effective, resulting in a significant shift in the use of drones. Now drones are deployed across a variety of sectors globally, from agricultural and entertainment to educational.

Connected Places Catapult leads the UK Government's Drone Demonstration and Development Pathfinder. This programme explores and develops the safe use of drones Beyond Visual Line of Sight (BVLOS) across the UK, and also develops use and business cases for drones across industry sectors, regionally and nationally. Use cases vary from media use, parcel delivery, search and rescue operations, agriculture, wildlife protection, environmental monitoring, infrastructure maintenance, even tree planting. We are increasingly receiving enquiries from industries considering this new technology because of its green credentials, reduced cost and increased safety.

Cessna Skymaster

The retrofitted Cessna Skymaster, which can travel up to 200 miles on a single charge, uses 55% less fuel than an unmodified aircraft, and costs up to 50% less to maintain[1]

Powering the green aviation revolution

Linked to this is our work on supporting aviation infrastructure - both physical and digital - to enable the new green aviation revolution. We are leading the development of the Open-Access Unmanned Traffic Management (UTM) framework in collaboration with the UK Department for Transport and industry. This government-funded initiative explores the steps the UK has taken to be at the forefront of commercial drone development and identifies the steps to be taken in order to remain in the global race towards unmanned traffic management. This year we are developing, building and testing the UTM framework, with a series of physical trials in the UK in early 2021.

Adoption of a UTM system, integrated with the entire air traffic network, will provide a more energy and cost-efficient process for managing our airspace, and will significantly help to reduce greenhouse gases and aviation's carbon-footprint, whilst at the same time increasing air safety.

In the future, electric aircraft, such as eVTOL (electric vertical take-off and landing) and multicopters - drones with multiple rotors - will become a common sight. Electric aircraft will increase accessibility in large parts of the country, particularly in outlying regions, where today it is too expensive to maintain a well-functioning transport infrastructure. Drones will likely find niche applications such as delivering vital medicines to remote areas that other vehicles cannot reach. It is expected that drones and electric aircraft will more than halve the operating costs compared to conventional combustion engine flights. Primarily, because of their lower maintenance and energy costs, electric aircraft will have a long-term cost advantage on short regional routes with limited passenger bases.

Image credit: Vertical Aerospace - VA-1X

UK Companies Leading the Development of Electric Aircraft

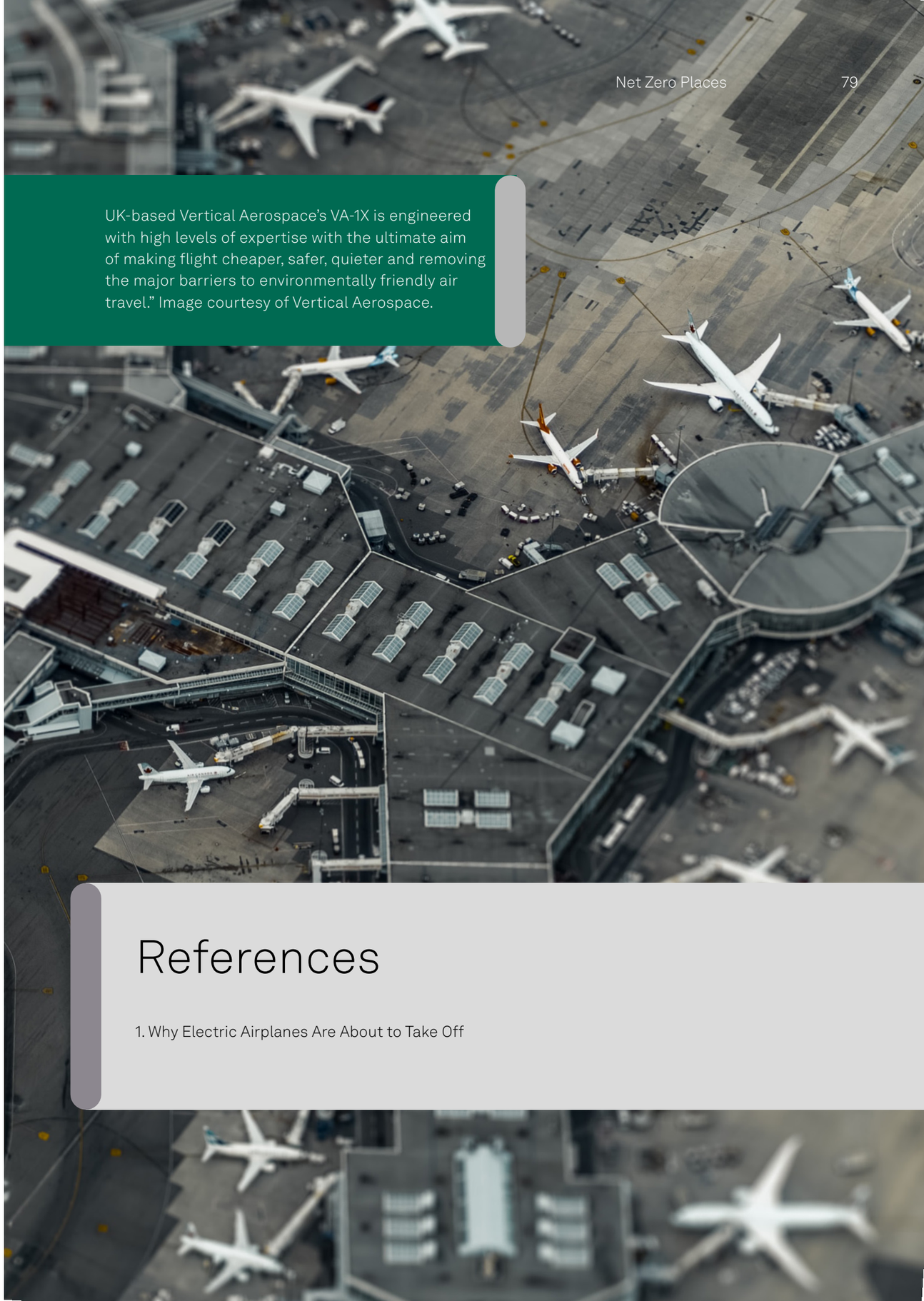
Vertical Aerospace	Based in Bristol , a globally leading aerospace hub, Vertical Aerospace is jointly working with global players such as Honeywell, to develop a certified all-electric winged vertical take-off and landing aircraft.
VRCO	Based at Infinity Park Derby, VRCO is leading global efforts in designing the world's finest electric personal aircraft, AirVolution, which can vertically take off and land.
SAMAD Aerospace	Based in Cranfield Technology Park, SAMAD Aerospace is a British tech start-up that aims to improve connectivity and civilian air transportation globally. Its Starling Jet is a VTOL hybrid-electric propulsion aircraft for civil aviation use.
Aston Martin	Based in Warwickshire, Aston Martin is targeting the aircraft market for the urban cityscape of 2030, Aston Martin's Volante Vision Concept will be a luxury personal eVTOL vehicle; produced in partnership with Cranfield Aerospace Solutions, Cranflield University and Rolls-Royce.

It is anticipated that programmes such as FlyZero, Jet Zero, plus the recent UKRI Future Flight Challenge will accelerate the development of drones, electric aircraft, and supporting infrastructure and services in the UK, and this new technology will account for a significant share of the aviation market. So, perhaps it's time to expand the ambition of my colleague's comment: if all drones are born green, is it not possible that one day so too might all aircraft be?

Helping to spark progress

This is a time of significant opportunity and innovation in aviation. Connected Places Catapult is proud to have been at the leading edge of that wave, stimulating investment, shaping R&D-friendly regulations, and brokering high-value partnerships between industry, innovators and the research community. We are now building on those investments by establishing a new Air Mobility Directorate to enable us to create even more impact in this market.

If you are working on an innovative solution or service for the aviation industry, we want to hear from you. Likewise, if you are an asset owner or existing service provider looking to introduce innovation into your product, service or supply chain, please get in touch.



UK-based Vertical Aerospace's VA-1X is engineered with high levels of expertise with the ultimate aim of making flight cheaper, safer, quieter and removing the major barriers to environmentally friendly air travel." Image courtesy of Vertical Aerospace.

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1. Why Electric Airplanes Are About to Take Off

3.3 Home Deliveries: A Commonplace Convenience or a Complex Conundrum?

Rimaljit Likhari, Bob Burgoyne

A last-mile home delivery made successfully in the first attempt currently generates around 181g of CO2 per km per item, significantly higher than the 175mg per km target for vans set by the EU in 2017.

Online sales in the UK neared £76 billion in 2019 - around 20% of total retail sales in the country.[1] Sales are expected to continue growing at a rapid rate of 35% until 2023.[2] This is hardly surprising. We are all awed by the speed and convenience of e-commerce. But without significant changes to the way fulfilment happens today, this growth will continue to have a negative environmental impact.

The World Economic Forum suggests carbon emissions from last mile deliveries in urban areas will increase by 30% by 2030. In addition, traffic congestion could rise by 21% alongside a 36% increase in delivery vehicles in inner cities[3]. Most of us are already witnessing (quite literally) the effects of this. Delivery vans passing our streets several times a day has become a common occurrence - and one which we increasingly witness due to the increasing amount of time we now spend at home during the COVID-19 pandemic.

Last mile delivery is defined as the movement of goods from a transportation hub to the final delivery destination. The final delivery destination is typically a personal residence. The focus of last mile logistics is to deliver items to the end user as fast as possible.

Is this emerging new status quo positive or negative in terms of emissions as compared to the traditional bricks and mortar retail environment? The jury is still out. Researchers remain uncertain as to whether online shopping is more eco-friendly than traditional shopping.[4] This is because measuring emissions from e-commerce is challenging: it involves several variables such as order size, type and amount of packaging, type of vehicle used and the last mile distance. Interestingly, several of these variables depend on consumer habits.

Measuring total carbon emissions from e-commerce is challenging but irrespective of this, last-mile delivery and packaging are generally considered to be two key sources of carbon emissions from e-commerce.[5] Last mile delivery constitutes the most expensive (50% of a product's total transportation cost), least efficient and most polluting part of the supply chain.[6]

"The complexity is tremendous. Buying online or not doesn't account for the main variable. The main variable is how far away did something come from. And then how quickly did you demand that it get to you."

Dr. Anne Goodchild, Founding Director, Supply Chain Transportation and Logistics Center, University of Washington

No dearth of possible solutions

But it is not all gloomy. There are at least two rays of hope here.

Firstly, with the 'right' mix of conditions and behaviours, online shopping or a hybrid of online and physical (termed as bricks and clicks by some) can be more carbon efficient. In the US, for example, some estimates suggest shopping online is 17% more carbon-efficient than visiting traditional stores.[7] This however strongly depends on factors such as the number of items purchased, return rates, amount of packaging used by retailers and the last-mile travel distance.

Secondly, some large e-commerce players are gradually adopting measures to cut their last mile delivery costs - and with reduced costs usually come reduced emissions. Consulting firm McKinsey classifies these measures into four broad categories: suppliers, warehousing and sorting facilities, transportation, and delivery destination (figure 2). The impact of these measures on reducing emissions ranges widely but there are some key measures (e.g. EV adoption) which provide benefits across multiple variables. These measures are discussed in depth by several thought leaders and research bodies including the WEF, McKinsey and Bain.

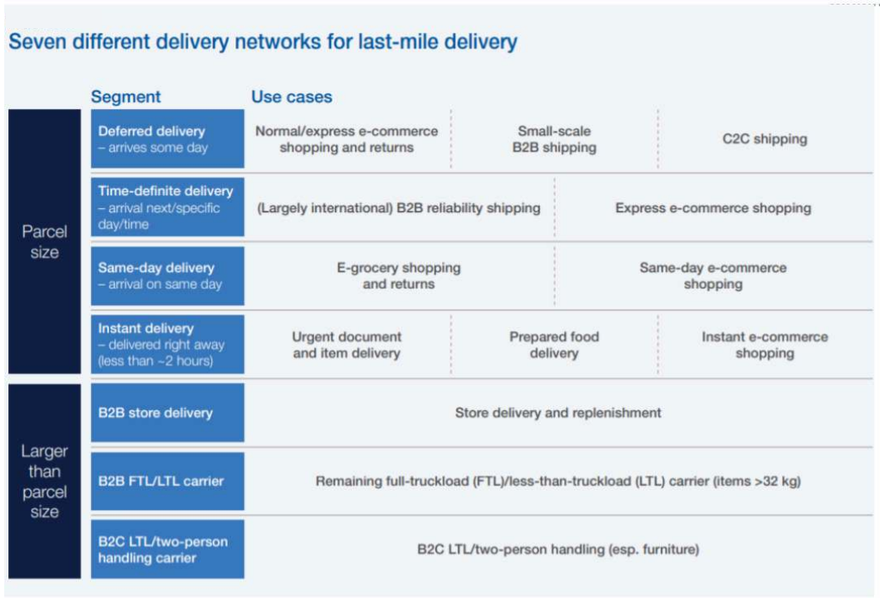
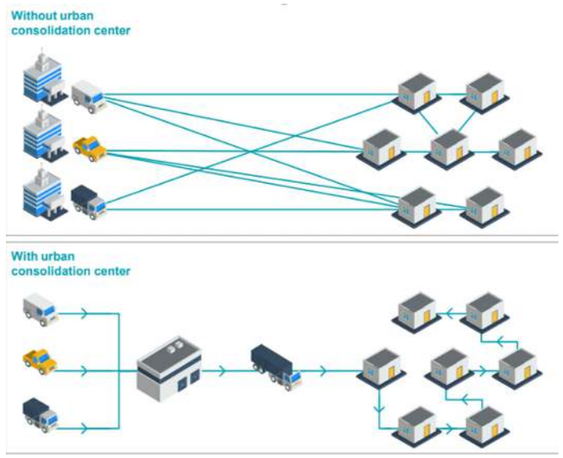


Figure 1: Different delivery networks for last-mile delivery;
Source: World Economic Forum, The Future of the Last-Mile Ecosystem, January 2020

Figure 2: Decarbonising Last Mile Deliveries: 20 potential measures and their Potential Impact; Source: McKinsey, 'An integrated perspective on the future of mobility', September 2017

Figure 3: With and without urban consolidation centres



Innovative technologies and approaches

Urban consolidation centres (UCCs)

Urban consolidation centres (UCCs) are buildings typically located at city fringes where parcels from multiple suppliers are brought together, sorted and dispatched. UCCs help to optimise loads, delivery vehicle sizes and routes by consolidating packages from multiple suppliers into fewer shipments. UCCs have been around for years but their uptake in the UK has been low.

Financial sustainability has been a key barrier to mainstream adoption with UCCs often requiring government subsidy to maintain operations. But with new technologies making implementation easier, the business case is getting stronger.

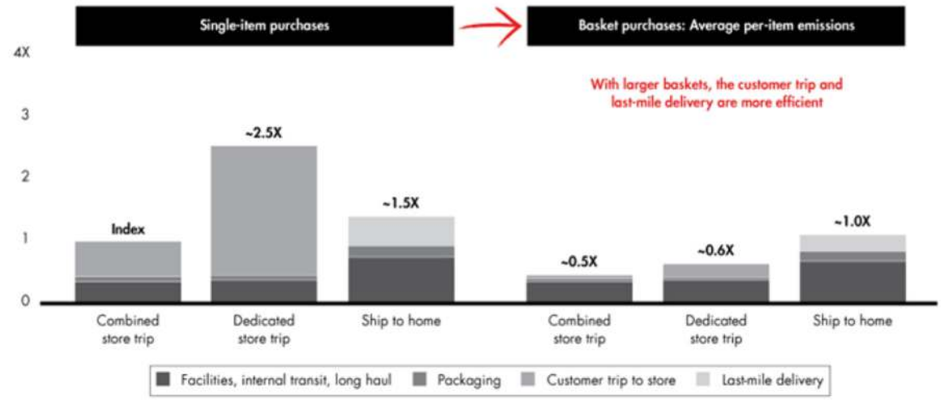
UCCs are also seeing better adoption in cities that almost mandate their use, either through direct intervention or indirect standards and guidelines that help enable the necessary economies of scale.

Clustering purchases

Clustering purchases is another significant lever that can be used to cut the number of delivery trips made in cities. Analysis shows that if we double the average number of items purchased per e-commerce transaction and ‘ship’ them together, it will reduce average per-item emissions by 30% and shipping costs by more than 50%.

However, clustering purchases would entail the regression of many people’s purchasing behaviours to a time where a slower gratification of desire was the norm. Companies such as Amazon have invested huge sums to rapidly satisfy desires through same-day deliveries and one-click orders. This has led customers to make frequent, smaller orders, driving up emissions. Expecting consumers to actively change their behaviours wholesale away from convenience is not realistic, so instead it would seem the imperative for action sits with the large e-commerce players themselves.

Figure 4: Lower carbon emmissions from cluster purchases. source Bain & Co
Emissions comparison across fulfillment channels (measured in carbon equivalents and indexed

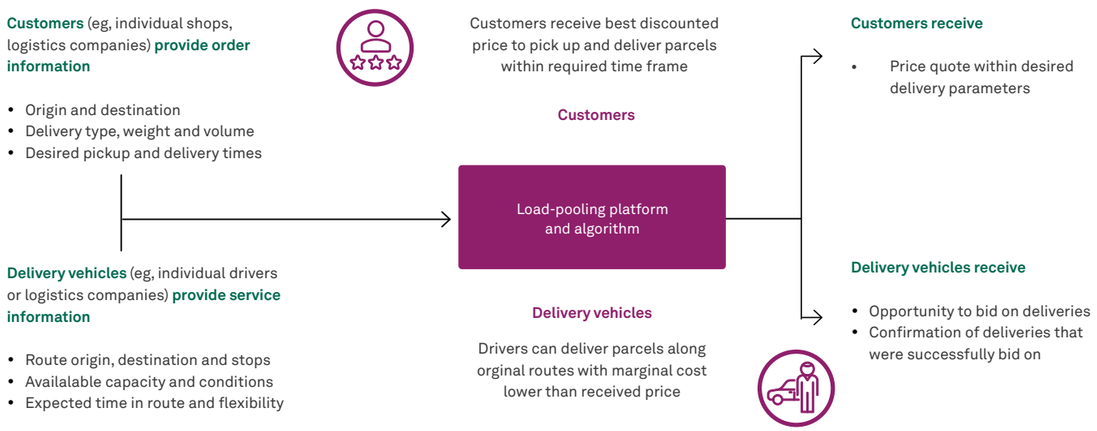


Amazon has the opportunity to take a leadership role here. A bold move would be to cluster deliveries for customers as a default (while pointing out the emissions benefits) and require proactive opt-out from this. This classic ‘changing the default’ nudge would likely have a huge impact. A more tentative option would be to offer clustering as an explicit opt-in choice, perhaps linked to a customer’s Amazon Smile (charitable giving) account. Given Amazon has pledged to be net zero by 2040 it will be interesting to see what action they take here.

Load Pooling

Load Pooling, in simple terms, pairs delivery vehicles with spare capacity with retailers/ logistics companies who need delivery space. This pairing up is done using digital platforms that use advanced technology including IoT[1] to determine capacity in use. Load pooling can be used for both B2B (business to business) and B2C (business to consumer) deliveries. Load pooling enables logistics companies to maximize the use of their fleet and benefit from higher drop density or number of deliveries within a given area. Load pooling in cities could reduce delivery costs by up to 25% and vehicle emissions by up to 30%.[8]

Figure 5: How Loading Pooling works Source: Mckinsey



[1]Internet of Things

Parcel lockers

Parcel lockers allow people to pick up packages from convenient locations such as apartment buildings, supermarkets, offices, and shopping malls, often using individual access codes. This offers multiple advantages from operational efficiency, costs and carbon emissions points of view. They reduce delivery time as well as mileage, with more efficient routing and fewer failed deliveries. Parcel lockers, when located in high-footfall locations, offer greatest potential in densely populated cities. In such cities, they could cut vehicle emissions as much as 70%.[9]

Electric and hydrogen-powered vehicles before the shift to electric

The shift to electric/hydrogen vehicles is one of the most 'visible' and potentially impactful measures to decarbonise delivery fleets. Estimates suggest that in a government-mandated scenario, battery electric vehicles and hydrogen electric vehicles alone can reduce emissions by 60% and 40%, respectively.[10] In 2020, several e-commerce and omni-channel retailers including Amazon and Ikea, and logistics companies such as FedEx have commenced the switch to eco-friendlier vehicles including electric delivery vans, e-cargo bikes and scooters (which is explored in greater detail in the previous chapter of this report). [11, 12]

Autonomous Delivery Vehicles

Autonomous Delivery Vehicles, mainly robots and drones, are seeing accelerated adoption since the pandemic. In Milton Keynes (UK) for instance, robots from Starship Technologies are being used to deliver groceries to residents.[13] In the US, Google's Wing drone delivery system has been used to deliver essentials to residents in Virginia.[14]

E-commerce and logistics giants including Amazon and FedEx too are developing delivery robots and backing state bills that would make delivery robots legal. Although most deployments are still at the pilot(less) stage and will need to overcome technical and regulatory obstacles, these autonomous delivery vehicles (robots and drones) will likely soon become mainstream.

Both delivery robots and drones have been shown to substantially reduce carbon emissions when compared to traditional vans with internal combustion engines (ICE), though the extent varies by type and scenario of use. For instance, Sidewalk Autonomous Delivery Robots (SADRs) generate lower carbon emissions compared to ICE vans when the robot doesn't require a mothership to operate (i.e. where the delivery area surrounds the depot). Road Autonomous Delivery Robots (RADRs) prove to be more efficient than electric vans when it is delivering to relatively low numbers of customers. Drones are more efficient in time-constrained and low-density delivery scenarios.[15]

With all these solutions available, it seems we should be well on the path to making last mile deliveries greener. Yet we are far from it.

Realising the economic and environmental opportunity

On their own these solutions work to some degree but a sizeable real impact will only be made by introducing them in combination, tailored for different places based on their varying market dynamics. For example, making deliveries at night using 'larger' electric vehicles to and from consolidation centres will reduce delivery time and carbon emissions - but will only be possible where there is sufficient critical mass to justify such a facility.

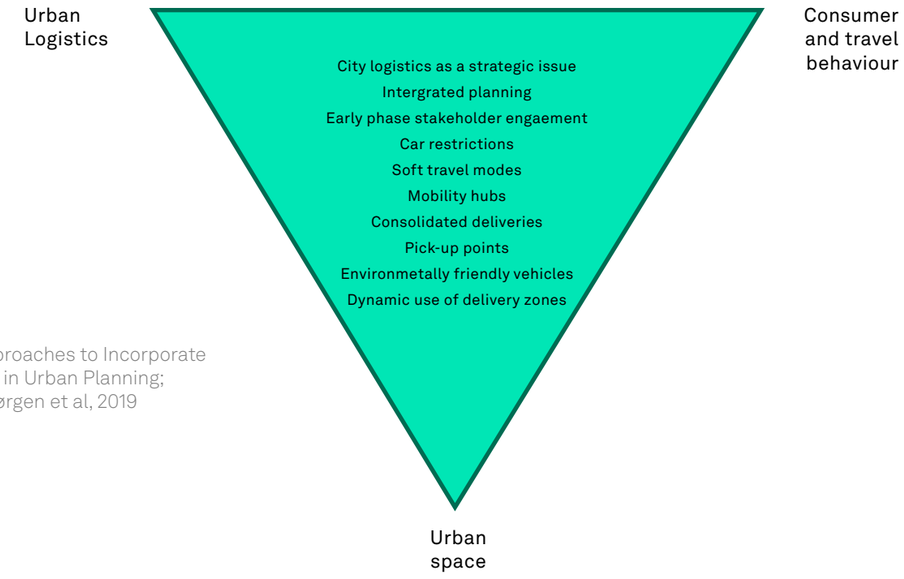


Figure 6: Approaches to Incorporate E-commerce in Urban Planning; Source: A. Bjørgen et al, 2019

Despite a range of available solutions, financial and operational constraints mean that the change has only just started and only amongst dominant players. For these measures to be adopted widely and at pace, and to avoid giving these players yet another size-driven advantage, cities and governments will need to take action. If both public and private players work together, delivery emissions and congestion could be reduced by 30% by 2030 when compared to a 'do nothing' scenario, and technology can help to bring delivery costs down by 25% at the same time.[16]

Figure 10 above highlights the relationships between urban logistics, consumer behaviour and urban space (A. Bjørgen et al, 2019). It also highlights some of the tools that cities could adopt to create a sustainable urban mobility landscape in a way that accounts for the local needs. The potential tools range from strategic approaches to physical planning.

Local authorities are accelerating the transition to net zero mobility through the introduction of a range of measures such as regulatory incentives and the roll out of EV charging infrastructure.

London, Amsterdam and Berlin have already established emissions-free zones in city centres. Such zones appear to be yielding results: since introducing the ULEZ (Ultra Low Emission Zone) in London, nitrogen dioxide levels dropped by 29% (February 2017 to September 2017) [17]. So far the arguments for such interventions have included without any specific plans for last mile deliveries specifically. Given the accelerated growth in e-commerce and the resulting impact on emissions - and the relative ease with which delivery fleets could switch to net zero vehicles and modes - that ought to change.

Growth in e-commerce will also drive unprecedented demand for warehouses, hubs and consolidation centres in and around cities. This will mean further intensification of urban land use over the next few years (although perhaps counter-balanced by changing needs resulting from COVID-19). Multi-storey warehouses that maximise logistics spaces - already common in Asian cities like Tokyo, Shanghai and Singapore - will become commonplace in urban areas. To manage this shift, place leaders will need to account for these new demands in local infrastructure and energy systems in strategic development plans. As an example, the New London Plan offers support to increase or retain industrial floorspace capacity. This is essential for congested high density cities like London where competition for floorspace usage has been fierce and will continue to be in the future.

As we discuss at length in the chapter on Integrated Planning - planning that considers infrastructure including buildings, transport, energy, waste and ICT - is an essential tool to achieving net zero targets. Net Zero Places will include city logistics and freight as a strategic issue in planning for transport and land use, as well as wider policies.

Greening the last mile

Addressing the carbon emissions and traffic congestion from last-mile deliveries requires co-ordination across the delivery ecosystem including consumers, retailers, logistics firms, cities and regulators.

Many of the available and emerging solutions for lowering emissions in last mile deliveries also cut costs, thereby offering a double incentive. Some of these (transitioning to low carbon delivery vehicles for example) are relatively easy for commercial players to implement directly, so for e-commerce giants with substantial capital available we would expect to see rapid adoption. Other changes will require more proactive consideration, engagement and planning by place leaders and policy makers as part of wider system-level reviews of how to achieve net zero. Trials and experimentation will show how innovations like consolidation centres and parcel lockers work most effectively, and which policy interventions stimulate the right kind of reactions. The responsibility for achieving net zero is shared across the ecosystem, but in last mile delivery at least, the building blocks of a greener future are there.

Helping to spark progress

Last mile deliveries are an increasingly prominent component of transport emissions - but also an area with rich possibilities for innovative new approaches. Connected Places Catapult is bringing together leading edge players in the logistics sector, having hosted the 2019 International Physical Internet Conference and recently contributed to the 2020 Future Logistics event. If you are working on an innovative solution or service for the logistics industry, we want to hear from you. Likewise, if you are a distributor or supply chain manager looking to introduce innovation into your process, please get in touch.

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7. The Carbon Footprint of Retail:Ecommerce vs Bricks & Mortar
8. An integrated perspective on the future of mobility, part 2: Transforming urban delivery
9. An integrated perspective on the future of mobility, part 2: Transforming urban delivery
10. Urban Deliveries Expected to Add 11 Minutes to Daily Commute and Increase Carbon Emissions by 30% until 2030 without Effective Intervention
11. Amazon hands Mercedes-Benz its biggest electric vehicle order to date
12. How IKEA plans to deliver its goods via electric trucks and vans
13. Robots deliver food in Milton Keynes under coronavirus lockdown
14. Google's Wing drones deliver essentials during coronavirus pandemic
15. Carbon emissions reductions in last mile and grocery deliveries utilizing air and ground autonomous vehicles
16. Last mile emissions set to grow 30% as inner-city vehicles rise 36%
17. ULEZ reduces 13,500 cars daily & cuts toxic air pollution by a third

Connect. Spark. Accelerate.

Connected Places Catapult provide impartial ‘innovation as a service’ for public bodies, businesses, and infrastructure providers to catalyse step-change improvements in the way people live, work and travel. We connect businesses and public sector leaders to cutting-edge research to spark innovation and grow new markets. And we run technology demonstrators and SME accelerators to scale new solutions that drive growth, spread prosperity, and eliminate carbon.

We hope that the market intelligence and insights in this Innovation Brief have deepened your understanding of what is happening across the connected places market to enable the transition to net zero. We will be publishing further analysis and information in the coming months on market opportunities in this space, as well as delivering a wide range of projects in the areas described in this report -from green ports and airports to active travel, integrated place planning to decarbonised road freight. To keep up to date with news and opportunities on these and more, visit our website and sign up to our mailing list.

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