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The second frontier

Why the transport sector is next in tackling climate change

Power generation has until now been at the centre of efforts to limit global warming

We think the next focus for reducing emissions will be on the transport sector

Our proprietary model shows how cleaner transport can cut emissions and meet Paris Agreement goals

Play interview with Ashim Paun

Did you know?

- **70% of greenhouse gas emissions (GHGs) from human activities are via burning fossil fuels – oil, gas and coal**
- **Fossil fuel related CO_2 emissions in 2018 are projected to be the highest yet, at 37GtCO_2**
- **For a 66% chance of limiting warming to 2ºC, the annual level of GHG emissions needs to be 43% lower than 2018 levels by 2040**
- **Globally, the transport sector is responsible for 24% of emissions from use of fossil fuels for energy, and 15.7% of the overall total from human activities**
- **Oil is the fuel feedstock for 92% of the transport energy mix, and 61% of oil supply is consumed by the sector**
- **Our autos team expects electric vehicles to take c.5-10% of market share in Europe in 2021. In Norway, EVs and plug-in hybrids accounted for half of all sales in 2018**
- **A growing 12% share of the global transport sector's GHG emissions come from aviation, and international air traffic is expected to grow at 5% per year**
- **Maritime transport accounts for 87% of global freight – emissions from ships are high in absolute terms, but it's an efficient way to move goods in relative terms of energy and emissions**
- **Unless costs fall, the use of biofuel and synthetic fuels for aviation could lead to a 10-20% increase in ticket prices (Energy Transition Commission)**
- **Improved and digitalised planning in shipping could lead to fewer km travelled, allowing for industry revenue benefits of USD1.5trn by 2025 (World Economic Forum)**

Executive Summary

Why transport is the second frontier

All countries signed up to the 2015 Paris Agreement aim to limit global warming in 2100 to well below 2^{0}C higher than in pre-industrial times, and ideally 1.5ºC. Now comes the hard work – bringing down greenhouse gas emissions (GHGs) to achieve this.

The power generation sector has, until now, been the focus of efforts to decarbonise economies – it's the first frontier. But even dramatic success there won't be enough to meet climate targets alone. So we think the next global focus will be on reducing emissions in the transport sector.

Closing the emissions gap

In this report, we have created a ***Clean-Power-and-Transport-2040* scenario**, which we abbreviate to **CPT-2040**. This scenario sees power generation fully decarbonised over the 2020 to 2040 period – as renewable technologies such solar and wind replace fossil fuels in generation mixes – the first major step down in closing the 'emissions gap', which exists between business-as-usual GHG emissions and emissions consistent with 2ºC of warming at century end. This is a substantial first step, given power generation is responsible for around 27% of manmade GHGs. Next, our scenario incorporates a transport sector in which emissions fall overall by 76%, a number built up subsector-by-subsector, as illustrated in Figure 1.

76%

Transport emissions reduction in our proprietary CPT-2040 scenario

Supportive policy, technological advances and cost improvements mean that electricity, hydrogen and biofuels can all replace oil as fuel feedstocks for different transport modes. Decarbonisation of transport is a crucial second step, given that the sector is responsible for over 15% of GHGs. Nevertheless, it is more challenging to achieve a low-carbon transition for certain means of moving people and goods – in particular, for trucks, aviation and shipping.

This is a collaborative note between HSBC Global Research's equity sector teams and the HSBC Climate Change Centre of Excellence. Analysts from across our autos, capital goods, transport & logistics teams have described how technology and regulation catalysts can drive change in their areas of transport and we have built these thoughts into the emissions computations for our CPT-2040 scenario. **Essentially, CPT-2040 combines zero-carbon electricity with low-carbon transport to demonstrate how the emissions gap can be substantially reduced. Overall, the gap for 2ºC is closed by 72% of maximum warming at the median case, as shown on the left-hand side of Figure 1. The larger emissions gap, for the more ambitious target of 1.5ºC of warming, is closed by 48% by CPT-2040 – a more detailed version of this emissions gap chart can be found on page 12.**

Investments and opportunities

Such a huge transition will make substantial new demands on infrastructure. This, in turn, will drive investments in many sectors – with new components, equipment and infrastructure needed for ships, trains, planes and road transport. The substantial investments required for clean transport form a core part of the trillions of dollars[1] needed for new infrastructure this century, whether aligned with limiting warming to 2ºC or not. However, these costs should be understood alongside the costs associated with *not* acting – a 2018 paper in *Nature* found that there is a 60% chance of such costs exceeding USD20trn by 2100[2].

> **"Supportive policy, technological advances and cost improvements mean that electricity, hydrogen and biofuels can all replace oil as fuel feedstocks for different transport modes**

CPT-2040 is not a projection for what we think is most likely to happen – it is a scenario to demonstrate what we think is a more likely approach to closing the emissions gap. But what is certain is that, if we don't go beyond clean power and also tackle some of the sectors which are harder to address – like transport − then climate impacts which we're already seeing, such as rising temperatures, altered water cycles and more severe extreme weather events, will worsen and associated socio-economic impacts alongside them.

*   *   *   *   *

The first section of this report looks at where GHGs come from globally (see flowchart on page 8) and we then explain the methodology behind the CPT-2040 scenario. We cover freight, road transport and aviation, respectively, covering the thoughts of our sector equity analysts for individual transport subsectors. We conclude by considering structural catalysts which we think can increase the urgency of the transition towards cleaner transport: (1) carbon pricing (2) strong action in countries which can't achieve emission cuts from other sectors (3) non-state actors (4) health concerns around air pollution (5) green bonds from public and corporate issuers to fund clean transport.

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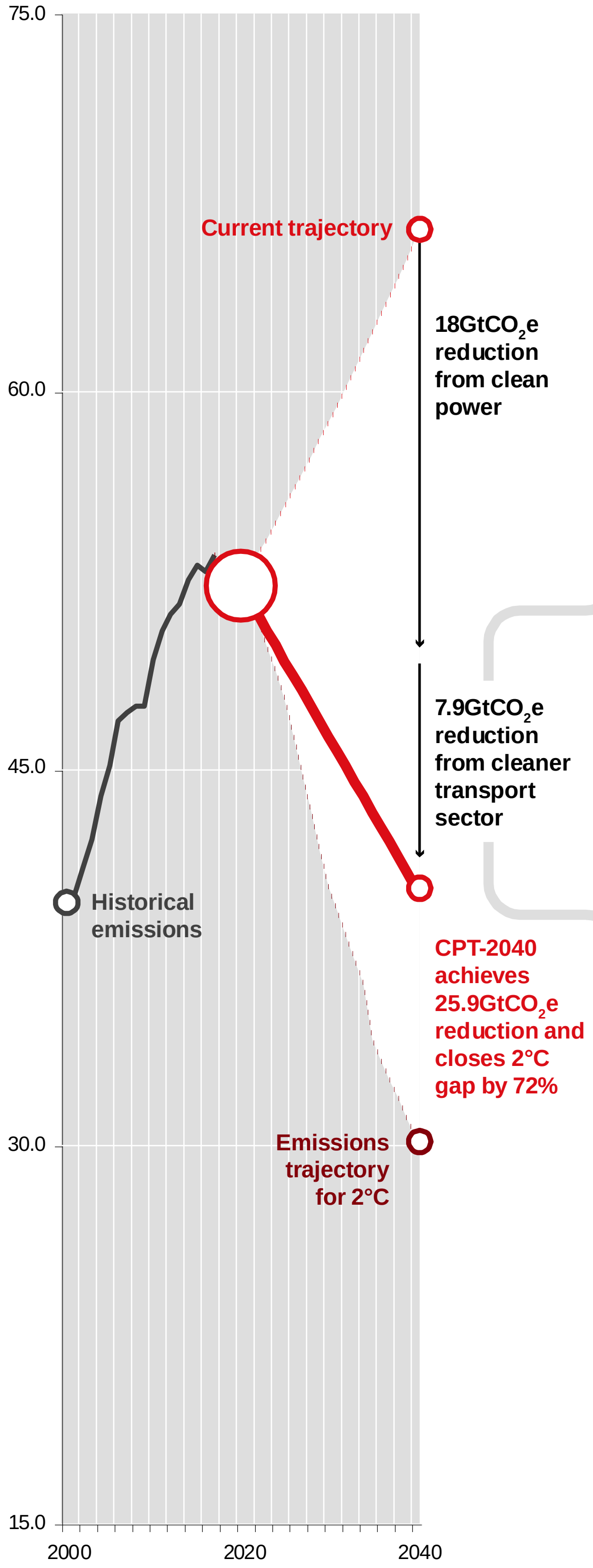
[1] Such estimates have been provided by a number of institutions including the World Bank, United Nations Environment Program and International Energy Agency.

[2] Details of probabilities and discount rates applied found here: Large potential reduction in economic damages under UN mitigation targets, Burke M., Nature, 24 May 2018 (vol 557, pp. 549)

Figure 1: Closing the emissions gap with clean power and transport

Greenhouse gases in gigatonnes of equivalent carbon dioxide ($GtCO_2e$) p/a



How to make the transport sector cleaner

	Technological change	Catalysts	Energy switch	Emissions in CPT-2040
Heavy goods vehicles (HGV)	Diesel alternatives	• Policy • Cost • Technology	Diesel to hydrogen, natural gas and power	66.6% lower than 2040 BAU
Light goods vehicles (LGV)	EVs	• Policy • Cost • Technology	Diesel to power	0%
Rail	–	• Policy	Diesel to power	0%
Shipping	Modular design and new engines	• Policy • Cost • Technology	Bunker to LNG and hydrogen	38% lower than 2008
Cars	Electric vehicles	• Policy • Cost • Technology	Diesel/ gasoline to power	0%
Buses	Battery operated	• Policy • Cost • Technology	Diesel to power	0%
2 & 3 wheelers	e-bikes	• Policy • Cost • Technology	Gasoline to power	0%
Aviation	–	• Policy	Kerosene to kerosene and biofuels	Same as 2020

Source: UNEP, HSBC estimates

In the fast lane

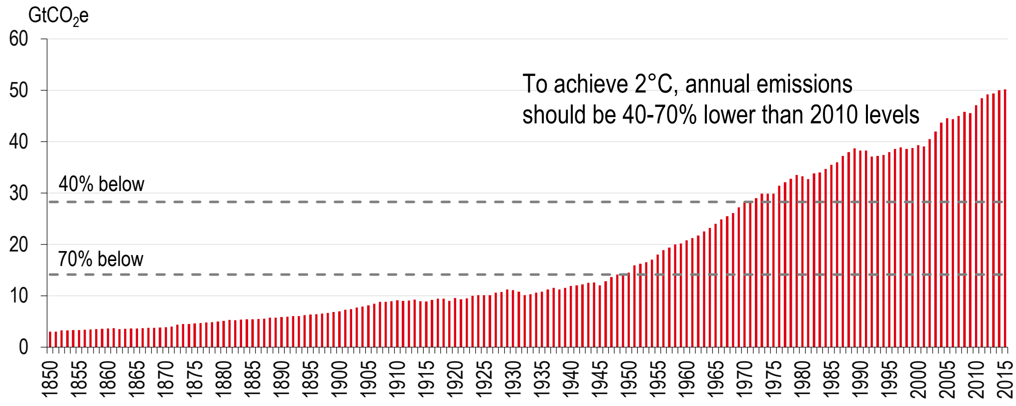
- Deep emissions reductions are needed to achieve global climate goals, requiring a shift away from using fossil fuels
- Transport, which depends chiefly on oil as feedstock, has come into focus as technological alternatives become more viable
- Our proprietary CPT-2040 scenario shows how the 'emissions gap' can be closed by cleaner transport and power generation

The need to reduce emissions

85% of energy comes from fossil fuels

To limit global warming, the world must lower its greenhouse gas emissions. GHGs are still rising, with the International Energy Agency (IEA) predicting that 2018 emissions were the highest yet (Chart 1 shows annual GHGs since 1850).

Chart 1: Global historical annual greenhouse gas emissions (1850-2015)

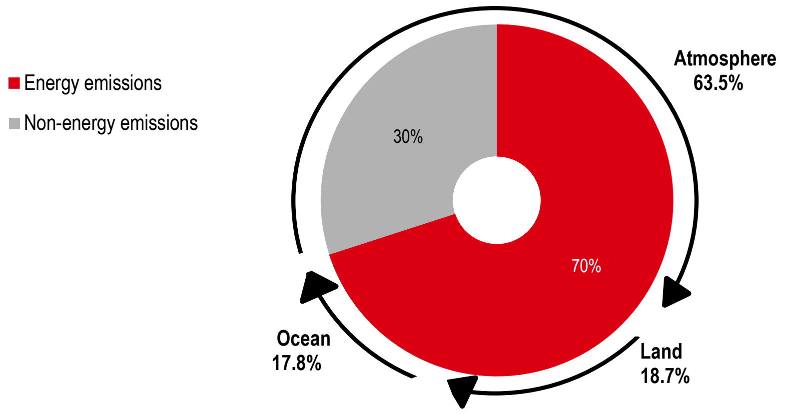


Source: PRIMAP Dataset

All 197 parties to the United Nations Framework Convention on Climate Change (UNFCCC) have either signed or ratified the Paris Agreement. The most important goal of the Paris Agreement, in our view, is the following:

- **Holding the increase** in global average temperature to **well below 2°C** above preindustrial levels (in 2100) and to **pursue** efforts to limit the temperature increase to **1.5°C** above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change

Chart 2: GHG emissions – sources and sinks



Source: HSBC, IEA, EDGAR

70% of emissions are from using fossil fuels for energy

To pursue these goals, virtually all countries around the world will need to remove carbon and other GHGs from their energy systems and broader economies. Chart 2 shows where emissions come from, with around 70% coming from burning fossil fuels − coal, oil and gas − for energy. All countries consume energy, for use in homes, services, industry and transport. A high proportion of energy consumed – over 85% – comes from burning fossil fuels. In terms of which users of fossils generate emissions, Figure 2 shows that, after the power generation sector, the transport sector was the next highest emitter, accounting for 15.7% of total emissions, almost entirely via oil use.

The first frontier: power has been the focus

Policy and falling costs have been catalytic

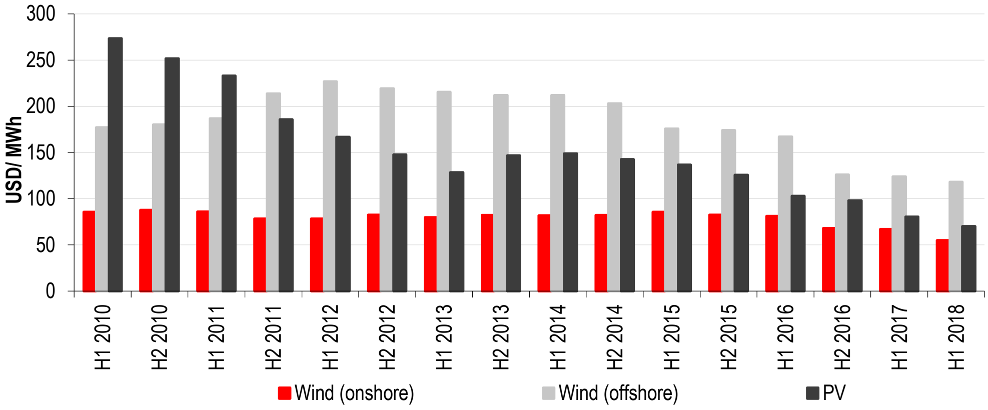
Many countries have focussed to date on reducing emissions from their power sector. The main way to do this has been through encouraging replacement of fossil fuels in power generation. Policy has been an effective tool, in our view, and used in many big and small economies around the world. In the EU, there is a target of 20% of final energy from renewables by 2020 and at least 27% by 2030. In China, targets include 110 GW in Solar, 210 GW in wind and 340 GW in small hydro by 2020, equivalent in total to over 7.5x the UK's total installed power generation capacity.

> **"Climate policy ambition has been supported by improving economics of clean power… and these improving economics in turn mean policy can be more ambitious**

Synergy

Policy ambition has been supported by the improving relative economics of clean power generation technology (Chart 3). Costs are therefore the second driver for decarbonising power – we have seen many examples now of renewable energy winning auction bids. Meanwhile, improving economics in turn mean policy can become more ambitious. In our view, the fact that renewables have come down so much in price has been a key factor in making possible greater levels of ambition on mitigating climate change in countries all over the world. Thus policy supports economics, and economics supports policy.

Chart 3: Renewables keep getting cheaper



Source: Bloomberg New Energy Finance

The global policy focus on decarbonising the power sector has been a rational first phase of decarbonisation, in our view, given that low carbon alternatives to using fossil fuels – in particular solar and wind generation technologies − have become more advanced and more commercially viable in this sector than in other major emitting sectors.

The second frontier: why transport is next

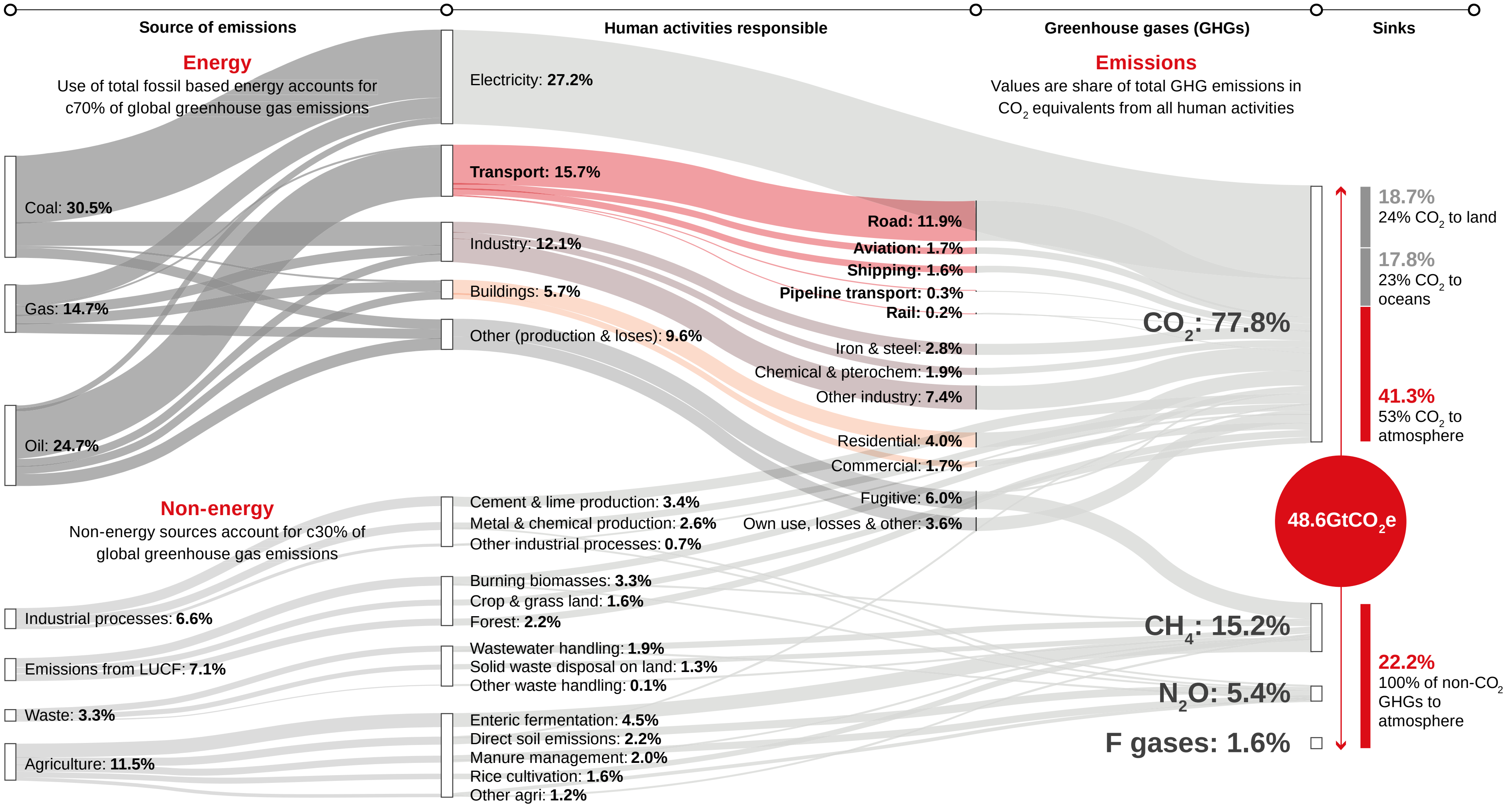
Decarbonising power is a huge first step in combatting climate change. But even a massive transition toward zero carbon power generation would not be sufficient in delivering the emissions reductions consistent with limiting warming to 2°C in 2100.

> **“ the transport sector will be the next part of the energy system where the virtuous circle of policy and economics will catalyse clean technologies**

Thus all actors across the wider economy will need to focus also on achieving low-carbon energy mixes in *non*-power sectors. The problem is that in many of these sectors, it is more technologically complex and expensive to replace or even reduce fossil fuel usage. The Energy Transitions Committee (ETC), an institution peopled from across the energy landscape, aims to accelerate change towards low-carbon energy systems. The ETC published a report in 2018 which looks at possible routes to decarbonise what it identifies as the ‘harder-to-abate sectors’: including trucking, shipping and aviation, as well as the major emitting industrial sectors.

Industrial processes generate just under one fifth of CO_2 emissions from fossil fuels (Chart 5) – but there are major technological difficulties in decarbonising high-emitting parts of industry, such as petrochemicals and virgin steel making. The next major areas of focus then for decarbonisation are transport and buildings. And decarbonising transport is crucial because the sector generates a similar amount of total global emissions as industry (see Chart 5) but where lower carbon alternatives are becoming more viable.

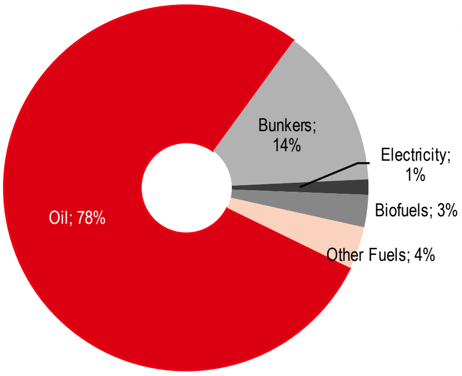
Figure 2: Global GHG emissions share in 2012



Source: HSBC, IEA, EDGAR, Global Carbon Project; Note: values for sinks adjust calc. error; F-gases sources are not shown here but typically include refrigeration, air conditioning, aerosols and high voltage switchgear ; LUCF is Land Use Change and Forestry

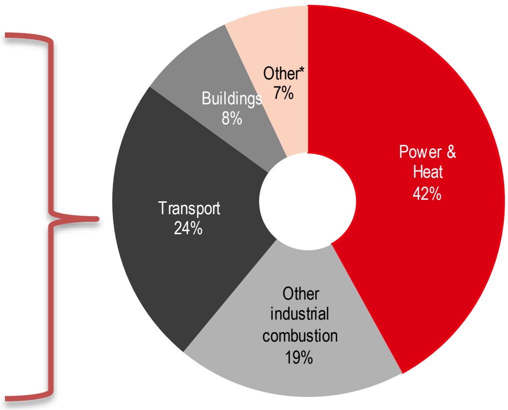
And so we think that the transport sector will be the next part of the energy system where the virtuous circle of policy and economics will catalyse clean technologies.

Chart 4: Oil dominant in the transport fuel mix….



Source: IEA, World Energy Outlook 2017. Data for 2016

Chart 5: …leading to 24% of CO_2 emissions from fossil fuels



Source: IEA CO_2 emissions from Fuel Combustion, 2018. Note: *Others includes agriculture/forestry, fishing and other non-specified. Data for 2016

Hooked on oil

Transport sector energy consumption

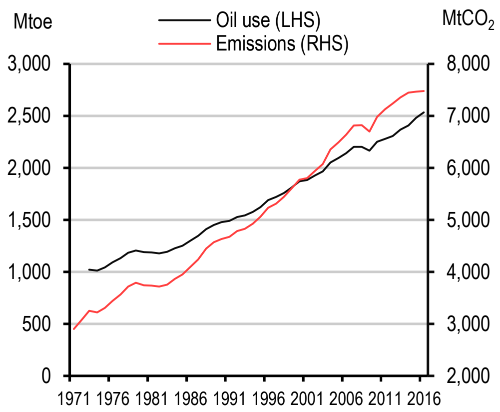
Currently, the transport sector uses oil derivatives (mostly diesel and gasoline) for 78% of its fuel consumption, and bunkers – the heavy, residual oil left over after gasoline, diesel and other light hydrocarbons are extracted from crude oil during the refining process – for another 14%. Thus **overall, the transport sector relies on oil for around 92% of its total feedstock**. Typically, oil is sprayed into a combustion chamber, where it ignites, causing high pressure from combustion gases produced, which pushes pistons, and these drive shafts which cause wheels or propellers to turn. Indeed, oil to transport is the single biggest supply-to-demand flow in the global energy system. This flow is therefore a major source of emissions.

> **“ oil to transport is the single biggest supply-to-demand flow in the global energy system**

Transport *share* of emissions increasing in many economies, as other sectors decarbonise

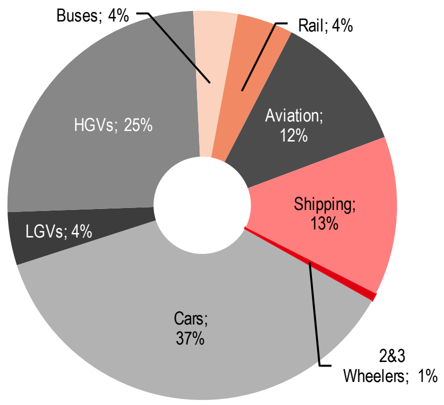
As the global population increases, and affluence rises in many geographies, so have transport oil consumption and emissions, both due to increased personal and business travel and given increased trade volumes with greater enabling laws, globalisation and infrastructure. Chart 6 illustrates these trajectories on a global basis. **In economies where transport emissions have decreased in absolute levels, they have often increased in terms of their relative share of the total.** For instance, transport is the largest emitting sector in the UK, making up 27% of total GHG emissions in 2016, according to the UK Department for Business, Energy and Industrial Strategy. This is up from 16% of total emissions in 1990, although absolute levels have decreased to a degree, in a broadly decarbonising economy. The drivers for this phenomenon can typically include decarbonisation of power and economic rebalancing away from heavy-emitting industrial production. Meanwhile, in California, where transport emissions are down by c.27% versus 2000 levels, the sector accounts for an increasing share of the total, at 41% of total emissions in 2016, vs 35% in 1990.

Chart 6: Transport oil consumption and emissions



Source: IEA, WRI

Chart 7: CO_2 emissions by transport type (2015)



Source: UCL; HBSC

Reducing emissions from the transport sector

Transport is a major emitter but also, theoretically, presents a major decarbonisation opportunity

Heterogeneity means complexity

The transport sector is far from homogenous. **Unlike power generation, where ultimately the product one needs is watt-hours of electricity, in transport it is more complicated, as the objective is to move people *or* goods over different distances, with varying time constraints and geographic conditions, cleanly, safely and cost effectively.** Hence we have many different types of transport technology which move through water, land and sky – including ships, trains, planes, cars, vans, trucks and bikes. And as the technology advances, we believe that, in the battle against climate change, transport follows power as the second frontier for reducing greenhouse gas emissions in scale.

Chart 7 shows where CO_2 emissions come from *within* the transport sector. Cars take the highest share, with 37% of transport emissions. Heavy goods vehicles (HGVs) or trucks, account for a quarter of emissions, while light goods vehicles (LGVs) and buses account for another 4% each. Add in 2&3 wheelers and you get to a total of 71% of emissions from road transport. The balance comes from rail, shipping and aviation. Working through these mode-by-mode, we believe there exists considerable potential in this sector to contribute to closing the 'emissions gap' – the gap which can be seen between a business-as-usual case of the Paris Agreement as the extent of climate policy and the emissions trajectory consistent with limiting to 2°C warming in 2100, at a given probability.

HSBC's 'CPT-2040 Scenario'

Some transport subsectors offer strong decarbonisation potential, in our view. In this report, we consider what will happen to transport subsectors in a world which is trying to limit warming to 2ºC. *This is an important point to stress – it is not our projection for the most likely outcome.* Instead, we are using a scenario – which we call our ***Clean-Power-and-Transport-2040*** **scenario** (**CPT-2040**) - to demonstrate the extent to which deep transition in the sector can close the emissions gap between business-as-usual and strong climate policy trajectories.

22.1%

Proportion of the 2ºC emissions gap which can be closed by low carbon transport solutions

A 20-year clean transport transition

The world has signed up to the Paris Agreement, and has now finalised a rulebook to implement it, and the period for the Agreement starts from 2020. So we assume the transition starts from next year - 2020. Corresponding to the Paris Agreement, certain key transport legislative measures such as CORSIA and the IMO rules covering shipping use 2020 as their baseline date against which to regulate emissions. We then use a date of 2040, to achieve this low-carbon transport transition by, for a number of reasons:

- It is the mid-point between the 2030 date when global carbon dioxide (CO_2) emissions must decline by 45% and when they must reach 'net zero' by 2050 – in order to avoid 1.5°C of warming by 2040 threshold as described by the Intergovernmental Panel on Climate Change.
- Many system forecasters currently offer scenarios for energy supply and demand flows through until 2040, including the International Energy Agency and BP.
- 2040 is ten years after the end date for most of the current pledges under the Paris Agreement. Any future pledges which will cover the 2030-2040 period will, in our opinion, need to take a much stronger line on economy-wide decarbonisation if headline warming targets are to be met, and this will include transport.

In terms of transport subsectors, we have worked with HSBC's global equity teams and reached the following conclusions, which we build into CPT-2040:

Freight

Shipping

13.2% of 2015 transport emissions. The International Maritime Organisation (IMO) has set out a target of a 50% cut of 2008 emissions from the sector by 2050. To put this into perspective, if the global shipping industry was a country, it would be bigger than Germany in terms of CO_2 emissions from fuel combustion.

Decarbonisation will be achieved by switching from bunker fuel to alternatives, including natural gas and possibly hydrogen, as well as by designing more fuel efficient ships and potentially controlling shipping speeds. We assume a linear rate of improvement here under IMO rules, giving us a reduction of 38% in 2008 levels in 2040.

Heavy goods vehicles

24.8% of 2015 transport emissions. To date, progress on decarbonising this heavy emitting sector has been limited. However, three technologies are competing to replace diesel, with no clear winner apparent from innovation and regulations.

Overall, given that the alternatives are all still relatively nascent, we think it is hard to project which technology will win out in replacing diesel in trucking, which is further supported by a number of factors:

- infrastructure constraints
- raw material constraints, not least in providing for batteries projected by Tesla to be 40-50x larger than those used in cars
- geographical factors: e.g. we think certain geographies may prefer to focus on natural gas where it is cheap and locally abundant, while in others which aim for greater GHG reductions, the focus may be more on electric and hydrogen.
- '*sub*-sub-sectors' – within trucking and haulage, some technologies may be more applicable, for instance between construction, mining, long-distance freight, shorter-range delivery, diggers, and agricultural vehicles including tractors. Also some industries use vehicles more of the time – for e.g. construction vehicles may sit idle at night and be used less than haulage vehicles.

We assume a mix of hydrogen, electricity and natural gas by 2040. With equal shares, and given that natural gas is not necessarily more efficient in terms of GHGs than diesel, this means we utilise a 67% reduction in trucking emissions.

Light goods vehicles

4.4% of 2015 transport emissions. Light goods vehicles mostly run on diesel. Although replacing this feedstock presents some challenges, if the transport sector is to make a substantial contribution to climate goals, then we believe LGVs will need to quickly build on lessons learned from electric cars and indeed buses. In our scenario, we assume total electrification of the global LGV fleet by 2040.

Rail

4.6% of 2015 transport emissions. Given electric trains are a long-proven technology – around two-fifths of trains globally run on electricity - for a climate-ambitious scenario like CPT-2040, we assume all trains are electric by 2040 (involving only electric lines built in future and replacement of diesel engine stocks).

Road

Cars

Responsible for 36.8% of 2015 transport emissions. Cars can be electrified, replacing the need to burn oil. The technologies are proven and increasingly commercially viable. Policy is generally supportive too; a number of countries are using incentives to get oil off the road. Norway has, more than any other country, subsided electric vehicles. 2018 sales of EVs and plug in hybrids the country made up 50% of total car sales. We assume total electrification of the global car fleet by 2040.

2&3-wheelers

0.7% of 2015 transport emissions. E-bikes are, in our opinion, a technologically non-complex extension of using electricity in other heavier transport applications and so we assume an electric bike stock globally in 2040.

According to Statista, global E-bike sales volume was about 34m units in 2016, while Navigant Research believes volumes could reach 40.3m units by 2023. China is the largest E-bike market with approximately 29.m units.

Buses

3.7% of 2015 transport emissions. Buses can be electrified – indeed, there is already a large uptake of electric buses in China as a result of government policy, with heavy subsidies overcoming the key barrier of high battery costs. Other countries, including the UK, have increasing fleet sizes. Worldwide, 13 global cities have a target of a zero emission bus fleet by 2025. We assume electricity replaces diesel, resulting in a zero-carbon global fleet by 2040.

Aviation

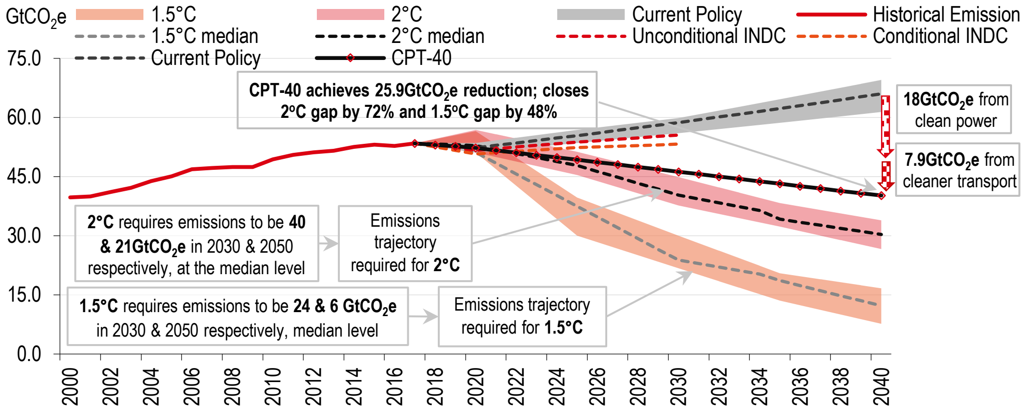
Planes: *11.7% of 2015 transport emissions*. Technological advances to date do not currently point at a move away from burning liquids in planes. However, continued use of liquids could involve a move towards greater use of biofuels, instead of only kerosene. However, it is near impossible to envision a zero carbon aviation fleet, so instead for CPT-2040, we assume the CORSIA regulations, designed to reduce international aviation emissions, are successful in capping emissions at 2020 levels, and so we use this estimated number in our scenario-building. CORSIA is based around an expectation that offsetting will be a central part of airlines reducing their net emissions.

TOTAL transition under the CPT-2040 scenario

Overall, adding together where technology and regulation can drive emissions cuts across these transport subsectors gives us a total reduction of c.76% of transport emissions, or 11.9% of the global total from human activities. That 100% sectoral decarbonisation is not achieved reflects the greater challenge of replacing oil in trucking, aviation and shipping.

Chart 8 shows the effect of the power generation and transport transition in our CPT-2040 scenario on the emissions gap. In effect, it first shows the extent to which zero-carbon power can close the 'emissions gap' to an emissions trajectory limiting warming to 2ºC. Add in 'best-practice' low-carbon transport technologies as well and one can see how the sector can make a significant contribution to closing the emissions gap.

Chart 8: Closing the emissions gap with clean power and transport



Source: HSBC, UNEP

This trajectory is even allowing for the effects of a growing global population and greater affluence, in emerging markets in particular, which drive demand for mobility and freight. CPT-2040 closes the gap for 2ºC by 72%. The larger emissions gap, for the more ambitious target of 1.5ºC of warming, is closed by 48%.

We are highly cognisant of the challenges involved in achieving a transport mix which decarbonises to this extent. Huge new power generation requirements will be required, along with substantial building out of charging infrastructure. Some sectors may see different cost challenges – the Energy Transition Commission believes that if biofuels or synthetic fuels remain significantly more expensive than conventional jet fuel, zero-carbon international flights may require a 10-20% increase in ticket prices. Large quantities of natural resources will be needed for batteries – lithium, cobalt, nickel and others. Additionally, there will be supply chain requirements relating to natural gas and hydrogen, where these replace oil derivatives.

No biofuels outside aviation

It is worth noting also that biofuels do not form part of the future energy mix for land or sea transport in CPT-2040. Although currently part of the mix for cars already in many countries, we believe that in future, the sector will face headwinds to growth, given competition for crop-growing land with food production needs for a growing global population. Indeed, truck manufacturer Scania talks about a maximum possible global capacity of 20% of vehicle demand being met by biofuels, which in turn is supportive of battery electric vehicles instead emerging as dominant[3]. Furthermore, if aviation emissions are effectively kept constant, as per the CORSIA regulation targets, then we believe biofuels will need to play a significant role here, which may divert much supply away from land and sea, where other technologies can replace oil.

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Transitioning transport

Transport can be transformed in order to play a key role in delivering reductions in global greenhouse gases. Whether catalysts for transition come from country level policies, or from non-state actor measures, or from technological advancement, we believe that some transport subsectors will see a rapid change in their fuel feedstocks in coming years, even as populations increase and mobility drivers change with growing affluence, particularly in emerging markets. In many cases, this transition will lead to substantial new infrastructure requirements. All of this transition will drive opportunities and risks for companies operating in the resources, energy, aviation, logistics and capital goods sectors. Next we look at other structural and systemic factors that may drive change in the sector.

Transition already happening? …clean transport in the news

- The German Aerospace Centre (DLR) has found that use of petrol and diesel cars must be phased out before 2030 across **Europe** in order for the Paris Agreement goals to become an achievable target. From February, all diesel vehicles − except the most recent models − will be banned from the streets of Frankfurt. A similar ban has been in place in Hamburg for a number of months, and in Stuttgart since the start of the year. Berlin is likely to introduce a ban this year, and they are being considered in other German cities too.
- In November 2018, the **US** Environmental Protection Agency announced their *"Cleaner Truck Initiative",* a rulebook that aims to cut emissions from trucks, which are forecast to contribute to one-third of NOx emissions from transport in the country in 2025.

[3] *https://www.scania.com/group/en/wp-content/uploads/sites/2/2018/05/white-paper-the-pathways-study-achieving-fossil-free-commercial-transport-by-2050.pdf*

- In 2018, **China** released its three year 'Blue Sky Plan', which aims to address China's air pollution challenges in highly polluted, densely populated regions, including via promoting greener transportation and higher EV uptake. The Ministry of Ecology and Environment claims that diesel trucks account for 7.8% of vehicles, but contribute up to 57% percent of total nitrogen dioxide emissions and over 75% of particulate matter, both harmful to human health. In January 2019, the Ministry announced guidelines for addressing trucking emissions in the short term, with tougher fuel and engine standards, higher rail freight volumes and stronger monitoring capabilities.
- **Rolls-Royce** is trialling conversions of trains from diesel to hybrid-electric engines across the UK. If successful, this would be rolled out across the country from 2020. Rolls-Royce plans to fit PowerPacks to the trains, allowing for an easy switch to hybrid; lowering emissions as well as noise pollution. The UK aims to completely phase out the use of diesel powered trains by 2040.
- All **IKEA** deliveries within the cities of Amsterdam, Paris, Los Angeles, New York and Shanghai will be made by zero-emission vehicles by 2020. The company reports that this will account for a quarter of all deliveries made.
- A number of large companies – including FedEx, DHL, UPS, Walmart and Pepsi - have placed advance orders for the "**Tesla** Semi", Tesla's new electric truck.

The road ahead

- Technological advances and clean transport-supportive regulation can catalyse the transition, carbon pricing can further help
- It's not just countries who are driving change − non-state actors, in particular cities, are catalysing transport change…
- …which makes sense as urban dwellers are often most at risk from a health point of view, given air pollution from diesel and gasoline

For the transport sector to make a material contribution to achieving the global target of limiting warming to 2ºC at century end, considerable investment is necessary. Nevertheless, we do think this transition is possible and plausible. *In this section, we look at structural catalysts which can help ensure the transition begins.*

Would a carbon price help drive down emissions in transport?

Transport sector marginal in existing schemes

We think carbon pricing is an important tool in limiting GHG emissions and has the potential to be effective, if broadly implemented and priced appropriately. However, coverage of the transport sector in the carbon pricing regimes globally is very sporadic. The largest scheme, the EU-ETS, covers over 11,000 installations across the power generation sector, industrial units and domestic airlines. However, here and with most other carbon pricing schemes, the transport sector is largely omitted. This is partly due to the logistical difficulties around charging individual operators of vehicles – car owners, truck drivers etc.

Some innovation has been taken in terms of bringing the transport sector under the auspices of carbon pricing, which may allow carbon pricing to be charged to the supplier rather than the user − the Californian cap-and-trade scheme holds fuel suppliers liable to report the carbon pollution produced when the fuel they supply is burned. If this reporting leads to pricing, then this could be an effective market based mechanism to incentivise the upstream supplier to invest in clean fuel and may be easier to implement, in our view. In Sweden, suppliers of fuels are levied carbon tax in proportion to the carbon content of the fuel and consumers (including transport) are levied energy tax in proportion to the energy content. Additionally, there is a value added tax (VAT) levied during the production phase. Details on major carbon pricing schemes globally and their covered sectors are in Table 7.

Transport crucial to climate ambition in countries with low carbon power generation

Some countries with low-carbon power are targeting transport already

In those countries where power generation is already low carbon, we believe decarbonising other sectors takes greater urgency, in order for national emissions reduction targets to be met. Where electrification of modes occurs, this not only lowers emissions by reducing use of oil derivatives, but also given the power generation is low carbon. Indeed, we have seen strong climate policy on transport already in several such countries:

France: 92% of electricity generation had a zero carbon footprint in 2016 (73% from nuclear, 11% from hydro, 4% from wind, 2% from each of solar and bioenergy). The transport sector is the largest source of GHGs (29% of energy related GHGs). The country has pledged to ban petrol and diesel cars sales from 2040. Although the country is looking to reduce the nuclear share to 50% by 2035, the share of renewables, is targeted to rise to 40% by 2030, keeping power generation emissions low.

Norway: 95% of power generation from hydropower, 3% from wind and the balance is thermal. Meanwhile, road transport emissions accounted for 17% of the total in 2017. Sales of new EV and hybrid vehicles reached 50% last year and the country is targeting 100% by 2025. The government provides EV vehicles exemptions from direct taxes, like VAT and import tax and indirect levies like road tolls, charges for access to bus lanes and road ferries. The country is also fast developing charging infrastructure which will help in easy adoption of EVs by the consumers.

Sweden: Power generation is very low carbon, with 47% hydro, 35% nuclear and 9% wind. Most of the balance comes from biofuels and waste-to-energy. This leaves the transport sector as the largest emitting sector, with 32% of GHG emissions (in 2017). Sweden has pledged to reduce transport emissions (ex-aviation) by at least 70% by 2030 compared to 2010 levels. In July 2018, the government introduced higher taxes for petrol and diesel powered vehicles and made it cheaper to own plug-in vehicles.

However, for *some* countries where power is low carbon, we have *not* seen corresponding strong transport policy. We believe, as the urgency of climate action increases, technologies improve and costs fall, such countries are likely to adopt stronger clean transport policies.

Table 7: Key carbon pricing schemes and their covered sectors

Scheme	Type	Operational since/ Scheduled for	Region covered	GHG covered	Sectors covered	Value (USD bn, in 2018)
EU ETS	ETS	2005	EU, Norway, Iceland, Liechtenstein	45%	Power gen, industry (incl. processes), aviation	31.8
Korea ETS	ETS	2015	South Korea	68%	Power gen, industry, buildings, aviation, waste	11.0
France carbon tax	Carbon tax	2014	France	35%	Industry, buildings and transport	9.6
California cap-and -trade	ETS	2012	California	85%	Power gen, industry (incl. processes), transport, buildings	5.4
China Pilot ETSs	ETS	2013-2016	Beijing, Chongqing, Fujian, Guangdong, Hubei, Shanghai, Shenzhen, Tianjin	50%	Power gen and industry (incl. buildings, aviation and transport in some of them)	4.4
Sweden carbon tax	Carbon tax	1991	Sweden	40%	Transport and buildings	2.8
Japan carbon tax	Carbon tax	2012	Japan	68%	All sectors incl. fossil fuels	2.5
Norway carbon tax	Carbon tax	1991	Norway	62%	All sectors incl. fossil fuels	1.7
Finland carbon tax	Carbon tax	1990	Finland	36%	Industry, transport, buildings	1.6
UK carbon price floor	Carbon tax	2013	UK	23%	Power generation	1.1
Regional Greenhouse Gas Initiative (RGGI)	ETS	2009	Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont	21%	Power generation	0.2
Argentina carbon tax	Carbon tax	2019	Argentina	20%	All sectors	-
Canada- federal carbon tax and ETS	Carbon tax and ETS	2019	Canada	-	Fuel producers & distributors and industry	-
China National ETS	ETS	2020	China	25-30%	Power gen, aviation, building materials, chemicals, iron & steel, non-ferrous metals, pulp and paper, petrochemicals	-
Singapore carbon tax	Carbon tax	2019	Singapore	80%	Industry, power generation	-
South Africa carbon tax	Carbon tax	2019	South Africa	80%	Industry, power gen, buildings, transport	-

Source: World Bank; Note: value is based on the carbon tax/ price and the total emissions covered

The crucial role of non-state actors

In many cases, it is not just countries which are driving forward with measures designed to catalyse clean transport. Cities, states and even companies – collectively non-state actors – are also introducing policies and measures which can genuinely and materially catalyse transition. Non-state actors are continuing to support the Paris Agreement and in many cases are going beyond the ambition levels within climate pledges, in our opinion. Table 8 shows 202 commitments made by transport companies, Table 8 shows a selection of prominent examples.

Table 8: Transport company commitments

Sector	No. of Companies
Railroad transportation	20
Automobiles and Components	128
Trucking	24
Airlines	18
Tyres	12

Source: NAZCA Portal; HSBC

Meanwhile, cities around the world have also taken up the mantle for introducing clean transport policies. Transport infrastructure is key to managing the emissions profile around urban development. Reducing emissions is targeted by climate-smart cities in two ways, through mass public transit and by replacing oil-feedstock vehicles with alternative fuel vehicles. In some countries, for instance Canada where city level ambition is strong, it may be that non-state actor ambition is what drives clean transport take up, rather than any federal regulation.

> **Reducing transport emissions is targeted by climate-smart cities through mass public transit and via alternative fuel vehicles**

Health – urban air pollution is a further driver for cleaner transport

Transport is a policy focus for cities, being relatively effectively influenced by local policymakers as it is fixed to its urban location. As urban populations grow and affluence increases, a key health risk is air pollution.

A significant mortality risk

In total, air pollution is responsible for 7 million deaths a year globally, according to the World Health Organisation, of which 95% is linked to high concentrations of smaller particulate matter - $PM_{2.5}$. Additionally, it is an economic disruptor as people heed health warnings by staying at home or become ill and unable to work. Air pollution is caused by the release into the atmosphere of SOx, NOx and particulate matter through fossil fuel use – vehicle exhaust emissions, oil use in residential cooking and heating, coal-fired power generation and industrial activities such as petrochemicals and metal-making. It is also caused by airborne dust particles from drying wetlands, deforestation and land erosion.

7 million

Deaths pa attributable globally to air pollution (WHO)

Air pollution is a *local* environmental risk and should be understood, and addressed, as distinct to global climate change. However, it is causally also closely coupled with climate change – as the sources are largely the same, i.e. via burning oil and coal. On the one hand, air pollution can contribute to climate change – ozone and nitrous oxide (NOx) are both emitted in high levels in some areas, by road transport, industry and coal-fired power generation, and both are short-lived warming pollutants as well as localised air pollutants. Reciprocally, climate change can also exacerbate air pollution, whereby higher temperatures increase local levels of air pollutants such as ozone and particulates, and so exacerbating cardiovascular and respiratory disease levels. Air pollution causes many deaths through respiratory and heart complications, and can lead to lung cancer. In addition, dust storms associated with drought conditions contribute to degraded air quality due to higher airborne particulate counts and have also been associated with increased incidence of coccidioidomycosis (Valley fever), a serious disease caused by a fungal pathogen, endemic in Arizona and California.

More pollution in EM cities

The transport sector can be a key contributor to airborne pollutant levels. NOx is the third largest GHG by volume, so air pollution measures that reduce NOx have a co-benefit towards climate targets. Where these measures avoid burning fossil fuels, an additional climate benefit is less CO_2 emissions (CO_2 is the most prevalent GHG). Data shows EM cities to be the most polluted globally. We expect cities in these and all regions to prioritise air pollution from transport congestion, including by banning diesel vehicles from cities, as we are already seeing in Europe. Additionally, as more data becomes available and is widely distributed on social media, we think this will drive popular support for preventative measures.

Financing the transport transition

Public and corporate issues of transport green bonds

Green bonds increasingly are being used to fund greener forms of transit. We have seen a rise in green bond issuance by public transit entities like MTR and Transport for London. Public transit or electric rail systems are particularly attractive if they are located in clean green countries, where the power sector has been decarbonised.

Some auto manufacturers have issued green ABS bonds. Of particular interest to ESG focussed investors are 'green on both sides' auto ABS securities. In such a deal, the auto manufacturer lends money to clients to buy electric vehicles. These green loans are parcelled up and sold as ABS. The proceeds of the bond sale are then invested in green auto manufacturing. The 'green on both sides' ABS is seen as more environmentally friendly as the loans themselves were extended for EVs (as opposed to loans which have been extended to purchase non green vehicles).

Future technological disruption

Technology is constantly changing. It is not always clear which new technologies will prove to be the most disruptive to the transport sector over the course of the next twenty years. Indeed many will likely fail to live up to the potential ascribed to them. However, we believe that it is equally likely that something, or things, will indeed achieve their potential. Looking into the future 'pipeline' of disruptive technologies, a few stand out which have potential to disrupt transport.

- **Autonomous vehicles**: Self-driving vehicles, including cars, could change the way we travel (and indeed the model of car ownership). With no driver, the costs are reduced to fuel and vehicle maintenance, meaning this could potentially be disruptive from an economic point of view. This has the potential to reduce demand for rail, buses and even short-haul flights. The energy and emissions implications are dependent on what fuels the vehicles – electricity or oil derivatives - and indeed on factors such as car-sharing.

- **Drones:** In our view, the development of drones (unmanned aerial vehicles) suggests they could also be used to autonomously deliver physical goods, particularly over shorter distances and for lighter items, reducing demand on deliveries via road vehicles.
- **Hyperloops**: multiple 3D layered underground and overground transport systems like the Hyperloop, if they become economically and technologically viable, could disrupt demand for other transport types, including aviation. The US Department of Transport estimates that Hyperloops could be six times more energy efficient than air travel on short routes and three times faster than the world's fastest high-speed rail systems.
- **Virtual reality:** We believe that the potential impact of VR on transportation could be substantial, especially if the technology matures, becomes affordable and is adopted by business and consumers alike. Advanced VR offerings could obviate the need to travel for meetings as well as leisure and tourism.
- **3D printing:** We believe that 3D printing has the potential to revert society back to the production of bespoke goods locally and on-demand, in turn reducing the demands on traditional freight, and thus the energy system and emissions.

Final thoughts…

Overall, carbon pricing in the transport sector, strong action from countries with low-carbon power, and non-state actor climate ambition are key structural drivers for cleaner transport in our view, while the negative effects of air pollution will greater increase the urgency. Such drivers will further support the transport sector in becoming the next part of the energy system where the virtuous circle of policy and economics will catalyse better clean technologies. And we believe investment capital will flow not far behind.

Our CPT-40 scenario demonstrates how a dramatically lower-carbon transport sector can play a full part in closing the emissions gap between the emissions trajectory which can be achieved by current policies, and what is needed in order to achieve a maximum of 2ºC of global warming by century end.

Disclosure appendix

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