Decarbonising Road Freight: **GETTING INTO GEAR**

Industry Perspectives

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IN COLLABORATION WITH

Deloitte.

CONTENTS

FOREWORD

The world today is going through a period of intense change. There are tremendous challenges from the immediate shock of the pandemic to the longer-term effects of climate change. But if there is uncertainty, 2020 also showed what the world can achieve when it works together: the hope that vaccines can provide. And across the world, businesses and governments are setting goals in line with the Paris agreement on climate change.

Huibert Vigeveno
Downstream Director
Shell

Almost 1,400 businesses, more than 450 cities and more than 120 countries[1] are part of the largest ever alliance committed to stop adding to the amount of greenhouse gases in the atmosphere by 2050. In other words, achieving net-zero emissions and doing so in just a few decades. Such goals demand broad collaboration.

In April last year, Shell also announced our own ambition to be a net-zero emissions energy business by 2050 or sooner, in step with society and our customers[2]. This will require working with others in a way and at a scale we not seen before. In 2020, we published the Decarbonising Shipping: All Hands on Deck report. This amplified our work with customers and partners in sectors where it is hardest to reduce carbon emissions. The report helped to inform Shell strategy and encouraged carbon reduction commitments in the sector. It gives me great pleasure to introduce our second report, based on a second collaboration, this time with the road freight sector.

Trucks move almost everything that modern society depends on in daily life. During the pandemic, road freight played a vital role. With around 3 million companies operating about 217 million vehicles, the sector accounts for about 9% of global carbon dioxide emissions – and demand for road freight is set to double before 2050. So how can a sector made up of so many different parts jointly take the steps needed to reduce emissions?

This report is driven both by urgency and the need for collaboration. It is based on more than 150 interviews across the industry, from logistics companies to vehicle manufacturers and regulators. It identifies 22 solutions for the sector to start reducing emissions right now and increase the speed of the transition to low- and zero-emission vehicles.

The solutions include immediate action through the increased use of existing technology, such as battery-electric technology for the shorter-range, lighter vehicles used in cities. In the longer term, they include hydrogen as a fuel for heavier trucks that travel further with a greater load. The solutions include the need for greater regulation, increased production and improved infrastructure to sustain growth. The principle of collaboration runs throughout.

Shell uses a contracted fleet of around 3,000 heavy-duty trucks and delivers fuels to almost all of our 45,000 retail sites worldwide. As well as supplying fuels, lubricants and vehicle charging services, Shell is also expanding our hydrogen projects, from production to refuelling networks. In our companion report **Decarbonising Road Freight: Shell's Route Ahead**, we set out the actions we are taking to help reduce emissions in this sector.

The solutions provide a plan of action, a path towards net-zero emissions by 2050 in the road freight sector. I believe this is possible because of the steps the industry has already taken – and its will to go even further. The report shows an industry that is not only engaged and prepared to change, but ready to get into gear for the journey ahead.

RESEARCH OBJECTIVES

This research paper reflects the perspectives of over 150 executives and experts, representing 123 organisations across almost all segments of the road freight sector and 22 different countries (see Exhibit 01). It aims to:

- **Take a comprehensive view.** Many decarbonisation studies focus on specific challenges or stakeholder groups in isolation. Given the interdependency of factors, the sector needs a more comprehensive view, which includes economic, regulatory and organisational factors.
- **Reflect the voice of the industry.** No one stakeholder group can do this alone, and everyone will have a role to play. It is essential to understand the unique motivations and challenges of different groups and geographies, to develop solutions that will make an impact.
- **Clarify a practical way forward.** Road freight leaders who participated in this research are at a point where they need to make decisions around decarbonisation. We worked with them to converge on a set of solutions and a roadmap that can help the industry act now and clarify the path forward.

The primary driver for publishing this report is to highlight the insights participants shared with us through interviews and working sessions, not the views of Shell or Deloitte. All engagements with interviewees were conducted in a manner that respects competition law boundaries.

01 **Research interviewees**

158 road freight stakeholders...

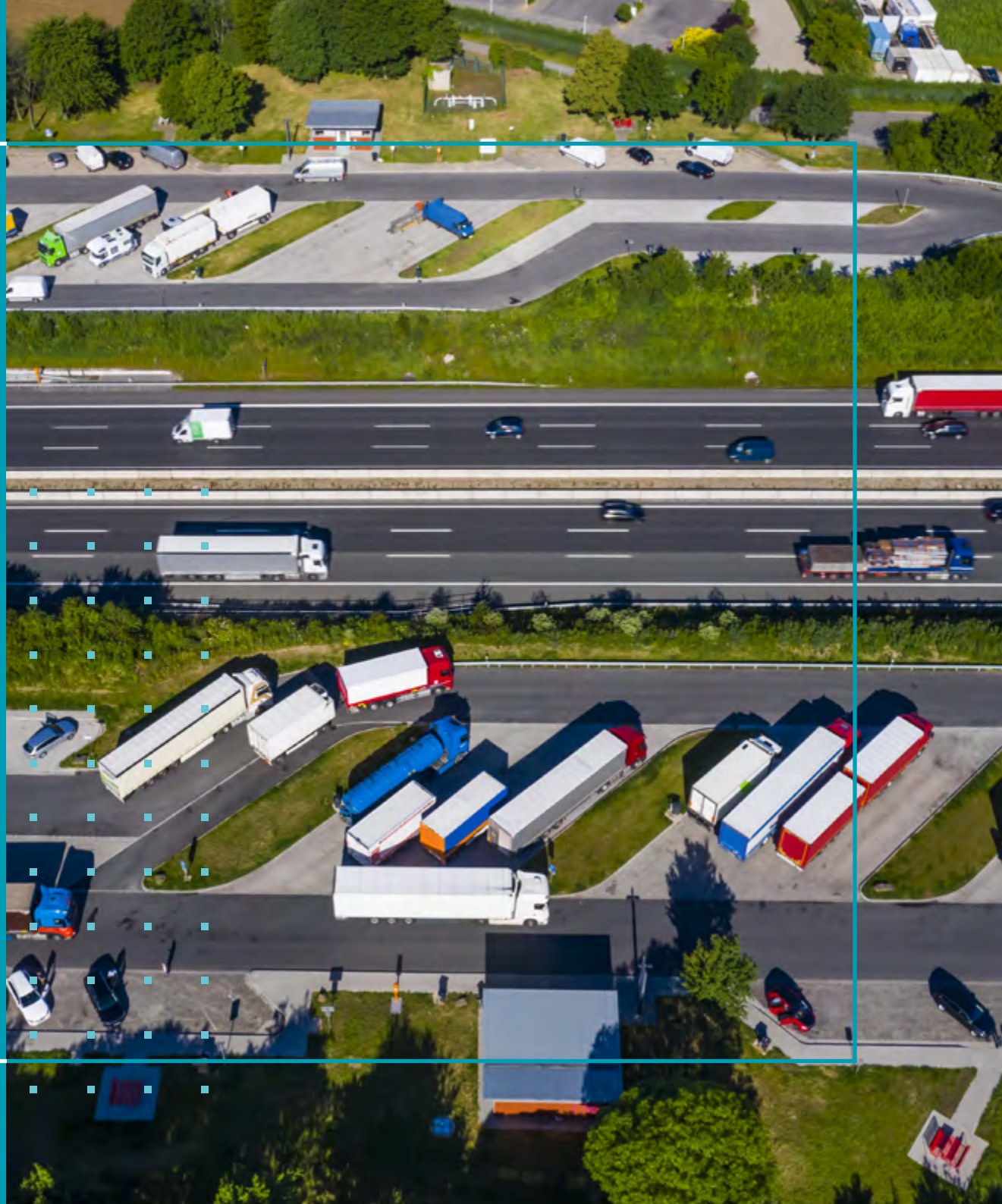
35 CEOs and senior executives	**49** Logistics leads and experts	**40** Sustainability leads and experts	**28** Strategists and innovation experts	**6** Policy and regulation specialists

...representing 123 organisations

3 of top **5** **Third-Party Logistics**	**3** of top **5** **Apparel**	**4** of top **5** **Truck OEMs**[1]	**2** of top **5** **FMCG**[2]	**2** of top **5** **Retailers**	**5** leading **NGOs**[3]
53 Europe[4]		**45** Asia		**25** North America	
39 3PL[5], logistics companies and couriers	**27** Shippers and private fleet owners	**35** CEOs and senior executives	**19** Technology and infrastructure providers	**26** Industry groups, NGOs, regulators and financiers	

Notes: 1) OEM refers to original equipment manufacturers, or for the purposes of this report it refers to truck manufacturers; 2) FMCG refers to fast-moving consumer goods companies; 3) NGOs refer to non governmental organisations; 4) regions indicate organisations' headquarters, but most participating organisations operate globally; 5) 3PL refers to third-party logistics companies.

Executive Summary



Road freight is the most visible and most flexible part of the global supply chain. Trucks move virtually everything modern society depends on for daily life. During the COVID-19 crisis, we have all experienced just how critical road freight is in bringing essential goods to where they are needed the most. However, road freight is a highly fragmented sector, and with around three million companies operating some 217 million vans, trucks and buses globally, it is also a major source of greenhouse gases (GHGs). The sector accounts for around 9% of global CO_2 emissions, with the US, Europe, China and India responsible for more than half of that total[3]. As the global economy returns to growth in the coming years and decades, so too will carbon emissions from road freight.

Around 60% of the sector's CO_2 emissions are generated by the around 63 million medium- and heavy-duty trucks (MDTs and HDTs respectively)[4], which are the main focus of this research. These large vehicles are well served by today's diesel powertrains, which allow them to carry loads that are many times their own weight, and over hundreds of kilometres each day. These characteristics mean emissions from MDT and HDT classes will be harder-to-abate.

To meet the targets set out in the Paris Agreement, absolute emissions from road freight will need to decline almost 60% by 2050, despite a possible doubling of road freight volume over the same period. This means that the sector will need to realise an emission intensity reduction of over 80% in less than 30 years[5]. More pressingly, the sector's emission intensity will need to decline by around 30% before 2030. On the current trajectory, the road freight sector will not meet the targets of the Paris Agreement. It is clear a concerted effort is needed to break down the challenge and co-ordinate the industry around meaningful solutions.

Through interviews with over 150 executives and experts across the global road freight sector, we have broken down what is often seen as an insurmountable problem into manageable components. We did that by applying a comprehensive, ecosystem-wide lens to decarbonisation, focusing on three core questions: "Why should the sector change, can the sector change, and how fast can the sector change?" The interviews generated six main highlights around the three core questions (see Exhibit 02).

02 **Research highlights**

Why should the sector change?	1. The sector is facing several barriers to decarbonisation – especially limited **infrastructure**, insufficient **regulatory incentives** and lacking **demand from shippers.**	2. Road freight decarbonisation is **close to an inflection point** due to increasing regulatory and market pressure, and will **evolve faster than many expect.**
Can the sector change?		3. To converge on a viable low- and zero-emission technology, the sector needs to adopt a **duty cycle perspective.**
		4. Through collaboration around a **catalogue of 22 solutions**, the sector will be able to **reduce emissions now** and **accelerate a shift** to low- and zero-emission trucks.
How fast can the sector change?		5. The sector has defined a **decarbonisation roadmap**, which allows it to **start deploying** low- and zero-emission trucks **at scale by the late 2020s.**
		6. Achieving significant emissions reduction requires a **concerted global effort**, with leading regions and companies **sharing knowledge and supporting others** to leapfrog ahead.

Barriers to Decarbonisation

1. **RESEARCH HIGHLIGHT**

The sector is facing several barriers to decarbonisation – especially limited **infrastructure, insufficient regulatory incentives** and lacking **demand from shippers.**

Relatively cheap trucks and diesel fuel, and near-universal access to fuelling infrastructure, underpin the current attractiveness and flexibility of the road freight sector. Around 80% of interviewees consider insufficient access to fast battery charging and hydrogen fuelling infrastructure as a limiting factor, because "no operator will take a chance on a new truck unless they are certain they will be able to fuel or charge it," in the words of one fleet owner. Interviewees highlight insufficient supply of renewable electricity as one of the key reasons for the lack of infrastructure. "We first need to overcome the shortage of green electricity and hydrogen. Otherwise, neither BEVs nor FCEVs will make a difference," noted a road freight financier.

Interviewees indicate also that alternative technologies required to decarbonise – namely battery electric vehicles (BEVs) and fuel-cell electric vehicles (FCEVs) – are still "prohibitively expensive to buy and use." Around 80% of interviewees believe that an absence of well-designed regulatory incentives to reduce this cost difference in the initial years of the transition will be a major barrier preventing fleet owners from investing in low- and zero-emission trucks at scale.

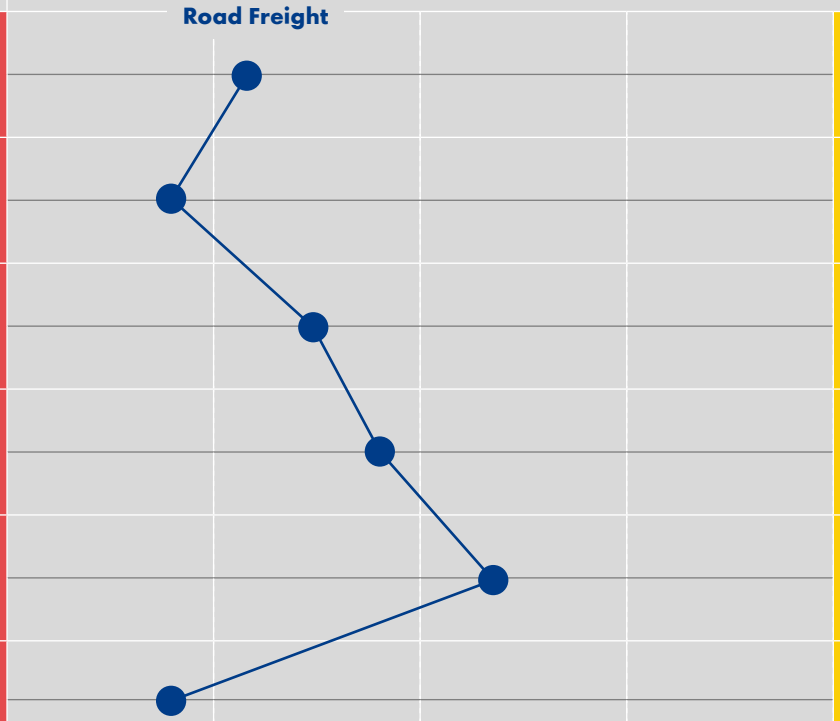
Around 70% of interviewees indicate that the shippers' willingness to incentivise lower-emission road freight services is critical to free up investment in decarbonisation. Although many shippers make sustainability commitments at the boardroom level, and sometimes even ask their logistic partners about low-emission trucks, when it comes to procurement criteria, these incentives are currently lacking. "There is a huge pressure on transportation to be cheap," noted an executive from a large logistics company.

These three barriers were mentioned most frequently by interviewees, but several other challenges were also identified. For example, many fleet owners pointed out that while alternative technologies are already available, original equipment manufacturers (OEMs) have been slow to produce new trucks at scale. These interviewees explained that OEMs are waiting for more certainty of demand – especially as they need to balance the needs of the dominant diesel business and short-term investor expectations. Some interviewees explained that demand for new trucks will be limited by uncertainty about their residual value, namely the ability of first owners to resell them at an attractive price in the secondary market.

Conversely, many interviewees noted that there are opportunities to reduce emissions even before alternative technology trucks are introduced – particularly as the way current fleets are managed is often inefficient, with "up to 50% of trucks driving empty", as noted by one logistics executive.

03 **Barriers to decarbonisation**

Readiness questions	**Readiness factors**	**Participants' view on criticality of barriers**		The line represents the relative criticality of the barriers, but its absolute position differs depending on the context in each region
Why should the sector change?	1. Market and Customer Demand	~70%	Major barrier 100%	Minor barrier 0%
	2. Regulatory Incentives	~80%	Major barrier 100%	Minor barrier 0%
Can the sector change?	3. Technology Alignment	~65%	Major barrier 100%	Minor barrier 0%
	4. Clarity on Roles and Decision Making	~55%	Major barrier 100%	Minor barrier 0%
How fast can the sector change?	5. Ease of Asset Replacement	~40%	Major barrier 100%	Minor barrier 0%
	6. Ease of Infrastructure Replacement	~80%	Major barrier 100%	Minor barrier 0%



A New Paradigm

2. **RESEARCH HIGHLIGHT**

Road freight decarbonisation is **close to an inflection point** due to increasing regulatory and market pressure, and will **evolve faster than many expect.**

Although sector stakeholders are acutely aware of the challenges ahead, a real sense of optimism is emerging. That optimism is underpinned by bold commitments to emission reduction made by business and political leaders around the world, such as the plans to achieve climate-neutrality in the European Union (EU) by 2050 and in China by 2060. Many interviewees indicated that over the past few years, unprecedented progress has been made in almost all aspects of decarbonisation, from increasing demand and accelerating regulation to maturing technology. The sector is entering a new phase on its decarbonisation journey, with some interviewees going as far as saying that "road freight is not 'hard-to-abate' any more."

On the demand side, large shippers of goods are under increasing pressure from their customers, investors and employees to tackle emissions in their supply chains. This pressure has started to translate into tangible action, with shippers that operate their own truck fleets in particular making flagship commitments and large-scale investments in low- and zero-emission technologies.

"We are now starting to really walk the talk on decarbonisation as it's clear that what is good for society is good for business,"

Global Shipper

Regulators are not standing still, and almost every week brings new announcements about even more ambitious decarbonisation pathways at a regional, country or even city level. Many interviewees welcome these developments because "while Fortune 500 companies might be able to do it themselves, everyone else will need policy support." Interviewees expect the next five years to bring further regulatory acceleration, with a possible convergence of targets across most geographies in the second half of the decade. The growing investment in green energy projects, such as the EU's Hydrogen Roadmap, also reflects a concerted move to lower the cost and create a more abundant supply of sustainable fuels.

Against this backdrop, over 70% of interviewees perceive road freight decarbonisation as a top or top-three priority for their organisation. Many stakeholders believe the sector is close to an inflection

point and that decarbonisation will evolve faster than many expect. Contrasting road freight with other sectors undergoing the transition, one interviewee pointed to studies that show that during major transitions "everything can look like a failure in the middle – even while significant progress is being made."

Although not yet commercially viable, the technologies to decarbonise road freight exist, and most OEMs are developing FCEVs and BEVs. Once the pieces start falling into place, with aligned incentives, trucks being produced at scale and visibly accessible infrastructure, the progress will become clear to the whole sector.

"There are a lot of opportunities that we couldn't have imagined 10 or 20 years ago."

Logistics Company

3. **RESEARCH HIGHLIGHT**

To converge on a viable low- and zero-emission technology, the sector needs to adopt a **duty cycle perspective.**

When analysing alternative technologies applicable for road freight, most studies focus on truck size. Looking through that simple lens, the bigger the truck, the more difficult it is to decarbonise. In reality, the around 63 million MDTs and HDTs are used in very different ways. They are part of an intricate logistical network in which their roles range from connecting production sites thousands of kilometres apart to delivering food to supermarkets in urban areas.

Developing a view on how the sector might decarbonise calls for a deeper understanding of the way trucks are used. We must apply different lenses, such as distance driven, geographical coverage, how predictable and repeatable the routes are, and number and length of breaks. This allows the sector to make progress in specific duty cycles early, instead of waiting for a solution that is optimal across the board. In some cases, the sector stakeholders may choose to fundamentally reorganise their supply chains to take advantage of the emerging technologies and make their fleets more efficient. It is also becoming clear that in the long-term "no one size fits all," and the sector will need to work with different technologies for different applications. Both battery electric and hydrogen trucks have a role to play.

Solutions

4. **RESEARCH HIGHLIGHT**

Through **collaboration** around a **catalogue of 22 solutions**, the sector will be able to **reduce emissions** now and **accelerate a shift** to low- and zero-emission trucks.

Interviewees recognise that the challenge of decarbonising road freight is too large for any one organisation or even one stakeholder group alone. Only a joint, collaborative effort will allow the sector to take advantage of the changing paradigm and make progress quickly, with one logistics company executive urging: "Let's not ponder about the chicken-and-egg problem of infrastructure and truck production, but start to collaborate and enable the ecosystem to make it happen."

The 22 solutions, or recommendations for actions, that emerged from research, interviews and workshops, provide more clarity on why and where the ecosystem should collaborate. These solutions demonstrate not only the breadth of ideas and initiatives already present in the sector, but also the variety of actions that must be undertaken and the range of stakeholders that must be involved. The sector stakeholders should work together by sharing the costs and benefits of the transition, to make sure the initiatives become self-sustainable, and to overcome the remaining decarbonisation barriers.

The 22 solutions fall under four main categories, based on their shared characteristics

- **Make impact now.** Solutions that can be started immediately, using existing technologies, leading to significant short- and medium-term reductions in emissions. Firstly, last-mile delivery and city buses can be largely electrified, reducing pollution and noise in cities. Secondly, the sector should focus on reducing emissions from the current fleet through proven cost-saving technologies. This can be done by implementing digital and data analytics tools to reduce the number of empty trucks on the road, or improving the efficiency of the trucks themselves through low-friction tires and lubricants, improved aerodynamics and driver assistance devices. Thirdly, where sufficient supply exists, the sector can deploy transition solutions such as liquefied natural gas (LNG), compressed natural gas (CNG), bioLNG and biodiesel to begin reducing tailpipe emissions. This may in some cases include offsets, in those situations where they do not substitute investment in zero-carbon technologies, and should be directed at programmes that contribute to decarbonisation pathways, like renewable electricity generation.

- **Create a snowball effect.** To deploy zero-emission vehicles at scale, fleet owners, infrastructure providers and OEMs should launch joint truck and infrastructure pilots in high-volume clusters and corridors. Demand for alternative technologies needs to be further stimulated by shippers putting greater emphasis on emissions in transport procurement, and by financiers creating green products – aimed at smaller fleet owners in particular. With fleet owners coming together to make joint purchasing commitments, OEMs will be more willing to invest. Through technology partnerships – for example, with fuel-cell and battery producers – OEMs can accelerate the commercialisation of trucks. And novel revenue models could reduce the risk for fleet owners by creating secondary-market certainty. More trucks on the road means more reliability, lower cost and yet more infrastructure, which in turn creates incentives to invest further. "If you build it, they will come," said one financier, indicating the need for decisive action and suggesting that the bold first-movers are set to reap disproportionate rewards.

- **Build conditions for success.** In parallel, the sector should give stakeholders incentives to move to widespread adoption of zero-emission trucks. Regulators will play a key role here, expanding incentives for OEMs, energy companies and truck owners, clarifying regulatory pathways and creating joint-city campaigns. Especially in the early stage of the transition, the role of regulatory incentives will be important because "we will need to invest in new trucks long before the market demand for green trucks scales. We need help to bridge that timing gap," in the words of one technology provider. Regulators will also work with energy companies and industry bodies to set standards for battery charging and hydrogen fuelling. Standards and certification programmes can also be set up by industry bodies to assess the carbon intensity of fleets and serve as a reliable metric in transportation tenders. Shippers will focus on increasing consumer awareness around low carbon transport, while OEMs will scale up research and development (R&D) in collaboration with other sectors. Finally, key sector stakeholders will share non-competitively-sensitive information to encourage uptake of alternative technologies.

- **Scale.** As demand and supply grow, the sector will focus on mass production of trucks and fuels, ensuring maintenance capability and integration with other technology roadmaps.

5. **RESEARCH HIGHLIGHT**

The sector has defined a **decarbonisation roadmap**, which allows it to **start deploying** low- and zero-emission trucks **at scale by the late 2020s.**

Road freight decarbonisation has already started. Sector stakeholders have at their disposal the products of enormous technical, market and regulatory progress made to date. Importantly, in comparison with other, harder-to-abate sectors, like shipping, road freight trucks are small, less expensive and have shorter lifespans. This allows the road freight stakeholders to iterate through technology cycles faster – for example, by making investments in LNG, CNG, bioLNG or biodiesel now, and changing to BEV and FCEV when they become viable.

To meet the Paris Agreement targets, zero-emission trucks must be commercially viable and must enter the fleet at scale by the late 2020s. Many interviewees believe this can be done, but it requires the sector to act decisively, starting to work on the first ten solutions within the next two years. In these initial years, the goal is to take maximum advantage of existing technologies to reduce emissions quickly, while dramatically expanding the reach and scope of alternative technology pilots. Simultaneously, the shippers need to start translating board-level decarbonisation commitments into consumer propositions, while the regulators at all levels need to chart the policy pathway for the next decade.

"Don't wait for the perfect solution; pilots, learning fast and deploying is the way to go."

Shipper

Understanding the triggers and behaviours of different stakeholders will be a key to success. For example, shippers with their own truck fleets already play an important role in kick-starting decarbonisation, as they have greater control over the technology used and see greater benefits from sustainability investments. Conversely, for financiers to fund alternative technology trucks, they will require additional assurances that debts will be repaid. These could include longer-term contracts between shippers and transport companies, or truck value guarantees. Targeted incentives from the regulators will also go a long way toward stimulating technology uptake.

Before the mid-2020s, the sector will need to step up its R&D efforts and start deploying FCEV and BEVs to commercial operations. Incentives provided by shippers, financiers and OEMs will be critical to stimulate initial

demand. At that stage, battery charging and hydrogen fuel cell infrastructure will also need to be standardised, to enable wider roll-out and cross-operability.

In the late 2020s, as infrastructure providers and OEMs scale up production, low- and zero-emission trucks will get close to cost parity with diesel and will start entering the fleet at scale.

6. **RESEARCH HIGHLIGHT**

Achieving significant emissions reduction requires a **concerted global effort**, with leading regions and companies **sharing knowledge and supporting others** to leapfrog ahead.

Road freight decarbonisation is a global challenge. Europe and the US together account for 30% of global emissions, and as the other markets grow, this share will further decline. Although Europe has historically been seen as a champion of sustainability, in many respects China already leads the road freight decarbonisation agenda, with one industry group representative noting that "China is heavily investing in alternative technologies for buses, and leading the hydrogen economy for heavy trucks." To achieve significant emissions reduction at a global level, other large countries such as India – and increasingly those in Africa and South America – will need to accelerate their efforts.

Although the solutions identified in this study are globally applicable, each market has unique conditions and challenges that must be addressed as part of the transition. Fuel supply, technology maturity and access to infrastructure will determine which solution is the best to start with. For example, in some countries or regions, like India, transition fuels and even modernisation of diesel engines might play an important role longer, while in others, like China and the EU, hydrogen forms part of the industrial strategy and as such will be favoured early on.

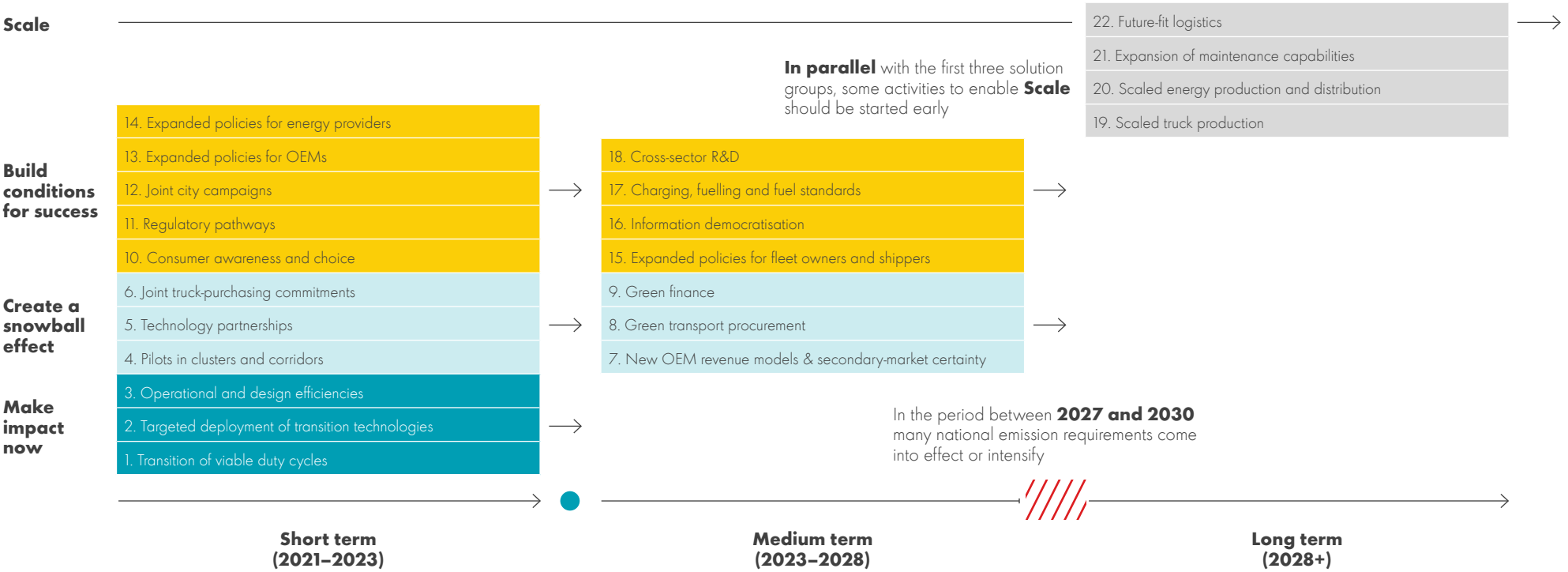
In all cases, cross-border collaboration and multinational actors will be key to accelerating learning, so that as solutions mature in one geography, they can be applied in others, allowing them to leapfrog ahead to a decarbonised future.

At the start, it will likely be a very small group of like-minded companies that will lead the charge and work together to create momentum around the transition. These first-movers will reap the benefits of early access to differentiated insights, and will have the ability to share risks and investments and to influence the direction of the transition in their favour. The engagements they make with their customers and other ecosystem players during the early phases of the transition can reconstruct and strengthen these relationships into the future.

As these early initiatives bear fruit, more companies will join to create the necessary scale and make impact across the sector.

The path forward is clear, and it is time to **'get into gear'**.

04 **Solutions Roadmap**



Note: Timing of solution is related to period in which most activities are expected; however, most solutions require effort across short, medium and/or long term

Where We Are Today

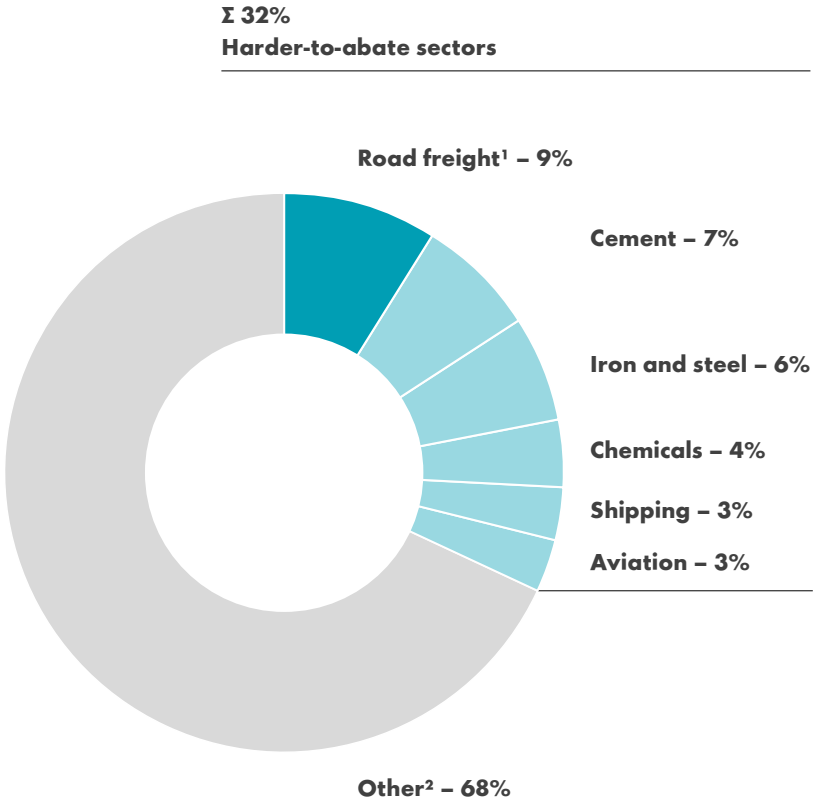
THE DRIVE TO DECARBONISE

The 2015 Paris Agreement defined a bold ambition to limit global warming to below 2°C above pre-industrial levels and pursue efforts to limit it to 1.5°C – in part by pursuing net carbon neutrality by 2050. In response, many countries, industries and individual organisations set targets to limit their carbon emissions, and began developing plans on how to reach them.

Action is happening at global, national, regional, sector and local levels, and there are many positive signs, but more can be done to address climate change. The United Nations Environment Programme notes that: "On current unconditional pledges, the world is heading for a 3.2°C temperature rise." A more focused, sector-specific and action-oriented approach is required to facilitate and accelerate decarbonisation efforts.

The challenge is particularly pronounced in six harder-to-abate sectors that, according to the International Energy Agency (IEA), currently account for around 32% of global CO_2 emissions (see Exhibit 05). These sectors share common characteristics, such as long asset lifespans, high energy dependency and complexity of electrification. As a result, decarbonisation of these industries will be slower, more investment-intensive and more technically demanding than other sectors. As decarbonisation happens more rapidly elsewhere, pressure and focus on harder-to-abate sectors is expected to increase.

05 **Global CO_2 emissions by sector 2018**



Sources: IEA, CO_2 emissions by sector, World 1990–2018; CO_2 emissions from industry, transport and heavy-duty vehicles in the Sustainable Development Scenario 2000-2030; Deloitte analysis
Notes: 1) Including LCVs, MDTs, HDTs and 1.5% from buses; 2) Including power (46.5%), other transport (10.8%), buildings (8.6%), feedstock (1.9%), and other industry (1.6%)

GHG EMISSIONS IN ROAD FREIGHT

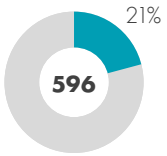
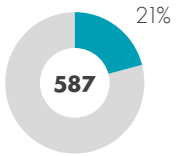
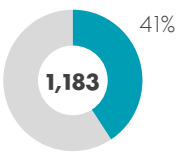
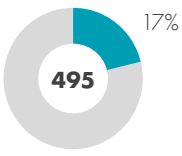
Where we are: Road freight is fundamental to the global economy and our day-to-day lives. It accounts for around 9% of global emissions of which more than half comes from the US, Europe, China and India.

Trucks are used to transport virtually everything modern society depends on for daily life, from the milk on supermarket shelves, to the cement needed to build our homes, and everything in between. "Whatever product you can think of, just name it, we have had it on our trucks, and most likely quite recently," noted a large logistics operator. The road freight sector is critical to the global supply chain because trucks are the most flexible mode of transport – able to access urban areas, and sharing the fuelling and road infrastructure with personal vehicles, rather than requiring tailored resources. The COVID-19 crisis has emphasised the central importance of road freight. The sector transports essential goods to where they are needed most, and enables the increase of home deliveries, allowing people to avoid unnecessary trips out to buy the items they need.

Globally, around three million companies are engaged in road freight[6]. Many of them are small or very small businesses, making the sector highly fragmented and competitive with low profit margins. These companies are responsible for transporting almost 22 trillion tonne-kilometres of cargo each year[7]. In other words, it is roughly equivalent to a large truck with 20 tonnes of cargo travelling around the equator 30 million times.

Because of their prevalence, trucks, together with an adjacent segment of buses, account for around 9% of global CO_2 emissions – almost three times as much as shipping. However, while shipping emissions are generated by around 50,000 vessels, there are some 217 million van, trucks and buses in the global fleet (see Exhibit 06). Around 63 million of those are MDTs and HDTs, which together account for around 60% of road freight CO_2 emissions.

06 **Global road freight fleet, including buses and coaches**

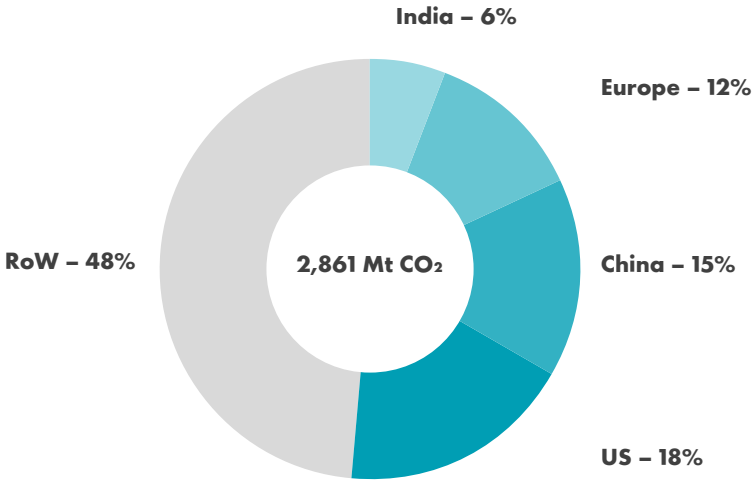
	Light Commercial Vehicles (LCVs)	Medium-Duty Trucks (MDTs)	Heavy-Duty Trucks (HDTs)	Buses and coaches	
					
Max. tonnage[1]	**<3.5 tonnes**	**3.5–15 tonnes**	**>15 tonnes**	**variable**	**Σ (M)**
Europe[2]	28	2	4	1	35
US[3]	20	5	3	1	29
China	21	4	7	3	35
India	5	3	2	1	11
Rest of World	70	22	11	4	108
Total	144	36	27	10	217
Road freight emission ($Mt CO_2$)[4]		  **MDTs & HDTs**			**2,861 Mt CO_2**

63 million trucks account for **62% of global road freight emissions**
MAIN FOCUS OF THIS RESEARCH

Sources: IEA Future of Trucks, OECD; IEA Energy Technology Perspectives; IEA Tracking Transport 2020; Deloitte analysis
Notes: 1) Tonnage main driver for future fuel choices, although some exception; Tonnage (1,000 kg) for GVWR = Gross Vehicle Weight Rating; 2) Eurostat numbers account for 40 M trucks, largest difference are an additional 5 M light commercial vehicles, 3 M special purpose trucks and 2 M others; 3) US bureau of statistics numbers differ mainly due to large number of privately owned pick-ups and vans that are not included in above road freights number but are included in US statistics (41 M); 4) Emissions for LCVs, MDTs and HDTs are taken from IEA Future of Trucks; emissions for buses is taken from IEA Tracking Transport 2020

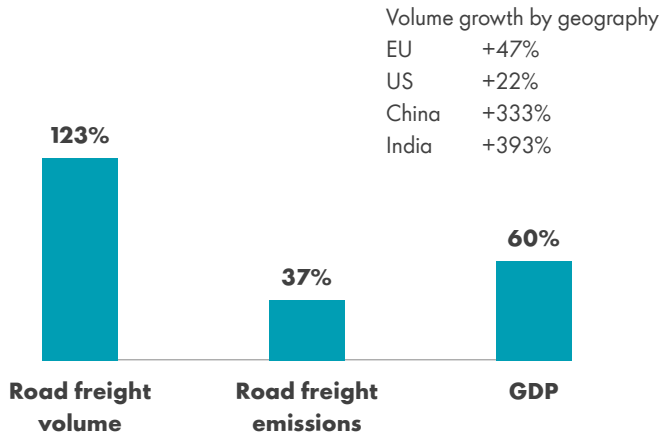
The fundamental role of road freight in the transportation of goods, and trade more broadly, means that emissions are highly correlated with population size and economic activity. Countries such as China and India have been particularly dependent on trucks to fuel their rapid economic growth. Today, the US, Europe, China and India generate more than half of all road freight emissions (see Exhibit 07). In the coming decade, absolute and relative emissions in other parts of the world will also grow as economic development intensifies, particularly in regions like Africa. As such, the imperative to decarbonise road freight will gradually expand beyond those regions traditionally leading emission reduction efforts, requiring a truly global approach.

07 **Road freight CO_2 emission per region (2018)[1]**



Sources: IEA (2017) Future of Trucks; IEA (2020) CO_2 emissions from transport and heavy-duty vehicles in the Sustainable Development Scenario 2000–2030; OECD; Deloitte analysis
Note: 1) Total emissions are divided over the countries by making use of number of trucks per country and average emission per stock vehicle, including buses

08 **Global road freight volume[1], emissions[2] and GDP[3] (2000–2017)**



Sources: IEA (2020) Transport sector CO_2 emissions by mode in the Sustainable Development Scenario 2000–2030; OECD; World bank; IMF
Notes: 1) Road freight volume indicates tonne-kilometre (how many tonnes of cargo were shipped over how many kilometres); 2) Road freight only, excluding buses; 3) World GDP in constant 2010 $, to eliminate effect of inflation

Where we are: Road freight is rapidly improving its emission efficiency, but it nears the limits of current technology. If the industry continues with the current trajectory, CO_2 emissions are expected to grow.

"Home delivery volume has tripled in recent years, and with it the need for trucking"

Shipper

Global road freight volume has more than doubled over the past 18 years (see Exhibit 08), driven by economic development- especially in China and India- and the adoption of e-commerce. A fleet owner noted: "the COVID-19 crisis has further increased our volumes, even after lockdown measures were lifted in the summer."

Despite the dramatic increase in volume, road freight emissions have increased significantly less over the same time frame, as diesel engines have become more efficient, in line

with stricter emissions regulations. Around half of trucks driving in Europe in 2000 were running on engines complying with Euro I regulation, emitting up to 8 g/kWh of nitrogen oxide (NOx). Estimates now suggest that more than 60% of trucks in Europe run on Euro V or VI engines, which emit less than 0.4 g/kWh 0.4 g of NO[8]. Moreover, the relative decline in emissions has been even more pronounced with regard to other GHGs, such as nitrogen dioxide and nitric oxide (collectively NOx).

However, there is a limit to how much further emission reduction can be achieved with improvements to diesel engines. Most participants in this research indicated that the limit is near, with one fleet operator stating: "I don't think there is a lot more room to go on how much more efficient diesel can be; some changes on the powertrain maybe, but not much more than that."

Significantly, the industry will need to address some of its core structural characteristics to accelerate progress. Value chain fragmentation and low margins in particular have historically limited the sector's ability to achieve its full potential in terms of emission efficiency. Interviewees cite factors such as manual processes, limited use of digital technologies and many empty trucks on the road as examples. A large fleet owner summarised it by saying, "the underlying problem is that operationally nothing has changed in the trucking industry since the 1970s; 90% of companies own fewer than 10 trucks."

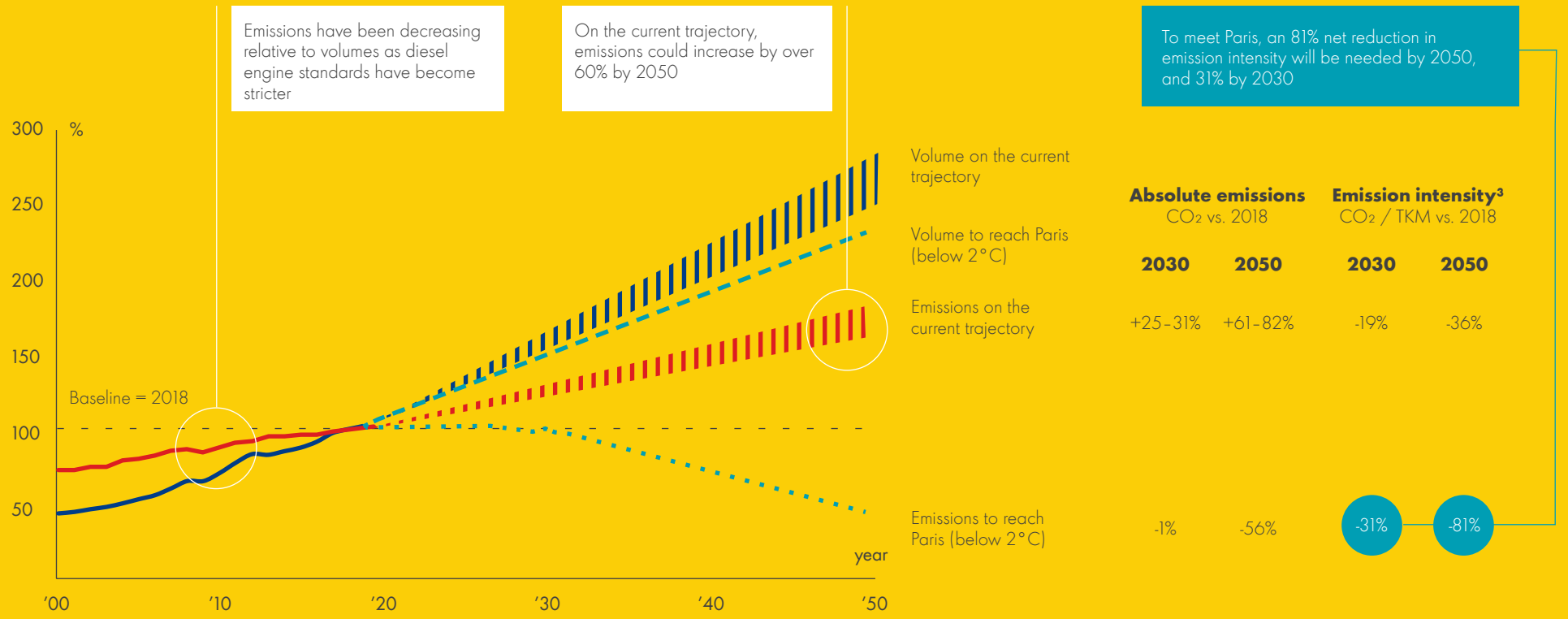
In the coming decades, economic development – especially in emerging markets – and increasing demand for e-commerce will drive further growth in road freight volumes (see Exhibit 09). For example, as the population of Africa is set to grow from 1.3 billion today to over 2 billion by 2040[9], demand for transportation services will also grow rapidly. Because rail and inland waterway infrastructure is limited and it will take longer to develop, road freight volume in Africa is expected to increase by as much as 70% towards 2030. Although in some regions, modal shift to waterways and rail, digitally enabled route and network optimisation, and, in the longer term, autonomous technologies might slow the pace of growth, the net effect will almost certainly be more trucks on the road. On the current trajectory, these trucks will also mean more emissions (see Exhibit 10). One logistics executive summarised it by saying: "We might improve the efficiency in the industry, but the challenge will remain huge."

To address the climate imperative, the current trajectory cannot be maintained. The IEA estimates that to meet the targets set by the Paris Agreement, absolute emissions from road freight will need to decline almost 60% by 2050, despite a possible doubling of road freight volume over the same period. Therefore, the sector will need to realise an emission intensity reduction of over 80% in less than 30 years. More pressingly, the sector's emission intensity must decline by around 30% before 2030 – an unprecedented challenge.

09 **Trends in road freight volume (tonne-kilometres)**

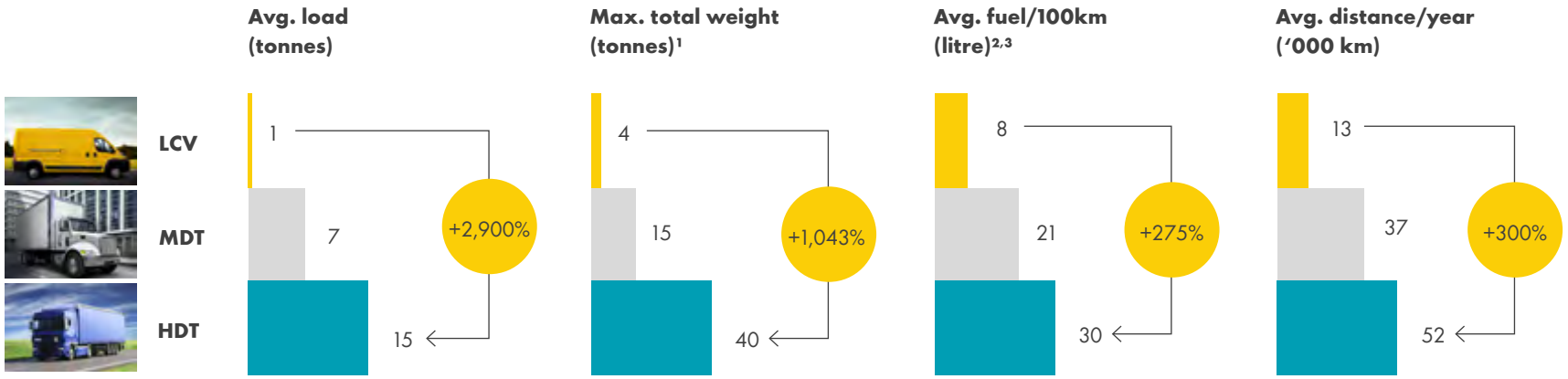
	Impact on road freight emissions
Global economic growth (particularly from developing regions)	↗
Growth in eCommerce and growing expectation of increased **delivery speed**	↗
Modal shift enabled through increased waterway and rail infrastructure availability (particularly developing countries)	→
Route and network optimisation enabled through analytics and connectivity	→
Long term: **Autonomous driving**	→
Short term: Recovery rate of trade growth **post-COVID-19**	→
NET IMPACT	↗

10 **Global road freight volume and emissions[1,2]**



Sources: IEA (2020) Transport sector CO_2 emissions by mode; OECD (2020) Road Freight Transport TKM, IEA (2017) Energy Technology Perspectives; Deloitte analysis
Notes: 1) Current trajectory and targets based on IEA's scenarios for heavy-duty road freight. Current trajectory based on Reference Scenario. Targets to "reach Paris" based on Beyond 2°C Scenario (B2DS; commonly referred to as Sustainable Development Scenario); 2) Volumes are depicted as tonne-kilometres (TKM); emissions as CO_2. Both volume and emissions exclude buses; 3) The beyond 2°C scenario assumes a slight decline in volume, which has been used to calculate respective intensity factors

11 **Comparison of truck types**



Sources: IEA Future of Trucks; Deloitte analysis
Notes: 1) GVWR = Gross Vehicle Weight Rating = maximum operating weight of vehicle including vehicle weight and cargo; 2) Fuel consumption assumed to be under loaded conditions, determined using Worldwide harmonised Light vehicles Test Procedure (WLTP); 3) Fuel consumption for LCVs based on Vauxhall Vivaro, Ford Transit, Volkswagen Transporter and Mercedes Sprinter; For MDTs, based on Mercedes Atego and Kenworth T270; For HDTs, based on Mack Anthem, Kenworth W990 and Scania S500

Interviewees question whether emissions from HDTs and MDTs – the focus of this research – can be addressed in time, given their characteristics. These trucks are not just "more of the same" when compared with Light Commercial Vehicles (LCVs), but rather a different type of technology with very different characteristics (see Exhibit 11). They principally carry loads that are many times the weight of the truck itself, and their energy needs are dramatically greater than those of LCVs. "HDTs are real workhorses," said one interviewee.

"They drive around the clock, hundreds of thousands of kilometres – the whole supply chain depends on them being able to carry these loads, over these distances in a reliable way."

Technology Provider

This makes MDTs and HDTs much harder-to-abate, and means a novel approach is needed to scale.

Where we are: Policy-makers around the world are setting targets to reduce CO_2 emissions from road freight, at national and local levels.

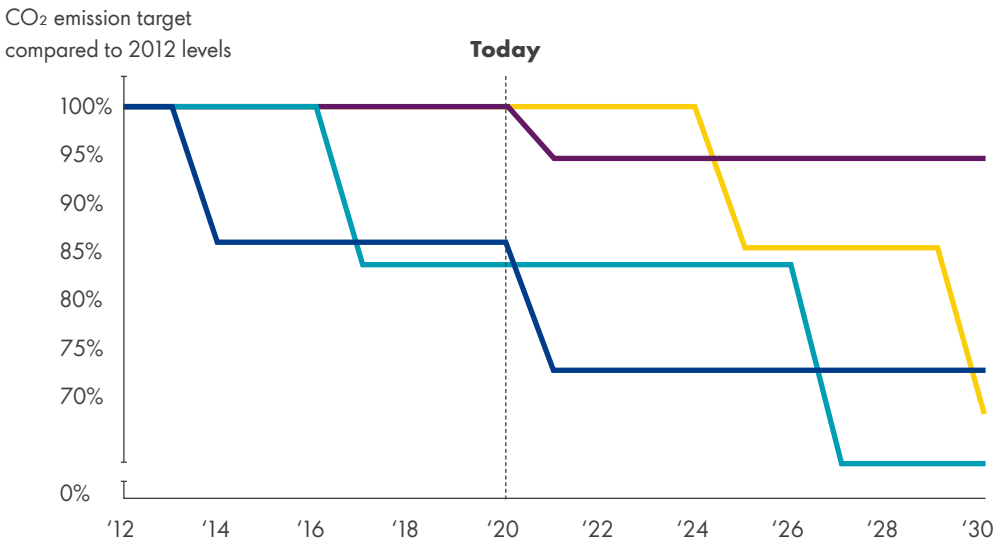
In 2019, the EU agreed legislation to restrict CO_2 emissions from new trucks by 30% by 2030 and 15% by 2025 compared to a 2019 baseline. With this action, the EU joined other large global markets setting a goal for a significant reduction in emissions from road freight. Between 2013 and 2018, Canada, the US, China and India implemented mandatory limits on new trucks, with short-term reduction targets ranging from 5% in India to 38% in the US. As a result, around 70% of HDT sales globally are now covered by some form of CO_2 regulation or standards[10]. More measures – including the next targets in China – are expected to be introduced by 2025[11]. The starting points in terms of engine-emission intensity are different depending on the country, and the net impact of these measures will also differ. However, it is clear the regulators intend to reduce road freight emissions significantly across key markets (see Exhibit 12). "The EU and US plans are already under revision for potential acceleration, and we expect Asia to make another move soon," stated an industry group senior executive.

Most interviewees believe that the first zero-emission trucks will need to start entering commercial operations by 2025 at the latest if countries and regions are to meet their targets.

Alongside national and regional governments, many local and city authorities have implemented or announced road freight decarbonisation schemes. Prominent examples include China's Clean Diesel Action Plan – which accelerates the adoption of strict China VI emission standards in key provinces[12] – and London's Ultra Low Emission Zones, which requires all trucks in the city to meet strict Euro VI emission standards or face fines[13]. Arguably, the most ambitious local regulation is California's Advanced Clean Trucks rule, which mandates that by 2025, 7% of HDTs sold must be zero-emission, rising to 40% by 2035[14]. "Massive city regulation is the single most important thing that makes the sector move," stated one interviewee.

Importantly, regulators are moving forward at all levels and in some cases bringing forward emission-reduction targets. For example, in November 2020 the British government announced that the UK ban on new diesel vehicle sales will come into effect in 2030, ten years earlier than originally planned[15].

12 **CO_2 emission-reduction regulation for new heavy-duty trucks – Illustrative**



	Liter /100 km[1,2]	Δ 2012–2025	Δ 2012–2030
India	45	5%[3]	5%[3]
China	39	14%[4]	27%[4]
EU	35	15%	30%
US and Canada	41	16% (9–23%)[5]	38% (24–50%)[5]

Sources: ICCT (2017) Fuel consumption standards heavy-duty vehicles India, (2018) CO_2 emissions and fuel consumption standards for heavy-duty vehicles in the European Union, (2016) Stage 3 China fuel consumption standards for heavy-duty trucks, (2018) Second-phase GHG emissions heavy-duty vehicles Canada, (2016) US Efficiency and GHG Regulations for Model Year 2018–2027, (2013) GHG Emissions Standards Heavy-Duty Vehicles Canada; IEA (2017) Future of Trucks
Notes: 1) Typical average fuel consumption of new trucks in 2015 at representative payloads litre diesel equivalent per 100 km; 2) India and China calculated as maximum fuel consumption per km for each new truck sold; EU and US calculated as average fuel consumption per km of all new trucks sold; 3) Tractor-trailer with GVW between 35.2–40; 4) Tractor; 5) Combination tractors Class 7 and 8 (incl. heavy haul) that range of over 45 heavy-duty subcategories that depend on type, duty cycles and requirements

The Deadlock: Barriers to Decarbonisation

DECARBONISATION READINESS FACTORS: SUMMARY

Using the views and research gathered in interviews and workshops with sector executives and experts, we developed a systematic approach to assess the industry's readiness to decarbonise. Focusing on three core questions (see Exhibit 13), this research looks at decarbonisation through a comprehensive, ecosystem-wide lens, and breaks down what is often seen as an insurmountable problem into manageable components. Based on a wide range of responses, we assessed road freight decarbonisation readiness against six factors.

Most findings from the assessment are globally applicable. Alternative technology trucks and infrastructure are yet to be deployed at scale, which means that in many respects barriers to decarbonisation are the same across the world. However, geographical differences do exist. Some regions, namely the EU, China and parts of the US, are slightly ahead on the decarbonisation journey – especially in terms of regulatory targets. Because we intend to learn from the progress made so far, many examples included in the following sections represent the perspective of those regions. We provide an additional view on the key regional differences in the last section of this report.

13 **Decarbonisation readiness questions and factors**

1. Why should the sector change?
Considers the factors that may trigger stakeholders to act.

- **Market and Customer Demand:** Pressure and incentives from society, customers, financiers and investors, which creates motivation for truck manufacturers, owners and operators to invest in lower-emission technologies.
- **Regulatory Incentives:** Instruments applied by regional and local authorities. These can include incentives such as grants and tax cuts, and disincentives such as fines, carbon credits and carbon levies.

2. Can the sector change?
Considers whether decarbonisation is feasible in the foreseeable future.

- **Technology Alignment:** Technical and commercial viability of alternative fuels and other lower-emission technologies, and clarity on development pathways.
- **Clarity on Roles and Decision Making:** The ease in making decisions, clarity on roles and responsibilities, and alignment of priorities for key stakeholder groups in the sector.

3. How fast can the sector change?
Considers the degree of effort required to implement change at scale.

- **Ease of Asset Replacement:** What it takes to replace or upgrade the truck fleet. This depends on truck cost, complexity and lifespan, the rate at which alternative technologies are developed, and the impact alternative technologies have on fleet operations.
- **Ease of Infrastructure Replacement:** What it takes to set up production of renewable electricity and green fuels at scale, and deliver them to areas where trucks operate and prepare for charging or fuelling. The more production capacity needed, the more dispersed the infrastructure, the greater the challenge.

Overall, road freight scores on the low side in terms of its readiness to decarbonise, facing barriers across all factors – especially insufficient regulatory incentives, limited infrastructure and limited demand from shippers (businesses that use road freight to move goods).

Exhibit 14

1. **RESEARCH HIGHLIGHT**

The sector is facing several barriers to decarbonisation, especially **insufficient regulatory incentives**, lacking **infrastructure** and limited **demand from shippers.**

Firstly, interview participants identified the significantly higher cost of alternative technologies compared to diesel-powered trucks as a major barrier preventing fleet owners from investing in low- and zero-emission trucks at scale. Many cited the lack of well-designed regulatory incentives to reduce this cost difference in the initial years of the transition as an issue.

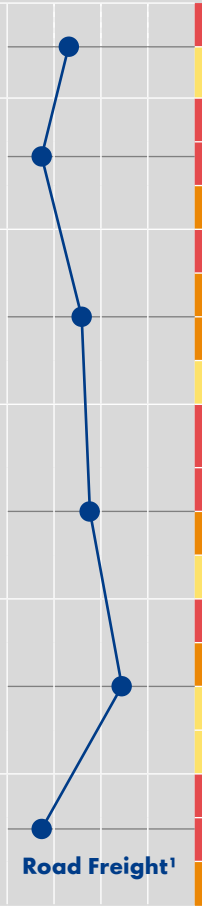
Secondly, interviewees regarded access to fast battery charging and hydrogen fuelling infrastructure as insufficient, further prohibiting alternative technology adoption. One of the key reasons for the lack of infrastructure is insufficient supply of renewable electricity.

Thirdly, although many shippers make sustainability commitments at the boardroom level, and sometimes even ask their logistics partners about low-emission trucks, when it comes to procurement criteria, clear operational or financial incentives for operators are currently lacking.

These three barriers were mentioned most frequently, but interviewees identified barriers across all six framework factors. We further refined them in workshops with sector executives and experts from around the world, which we have summarised in (see Exhibit 15). The following sections focus on each of the six factors and associated barriers in greater detail.

15 **Decarbonisation readiness assessment**

Readiness questions	Readiness factors	Participants' view on criticality of barriers	Main barriers
Why should the sector change?	1. Market and Customer Demand	~70%	Shippers continue to prioritise the lowest cost in heavy-duty trucking, as consumer pressure to reduce emissions is limited
			Financing options for alternative technologies are limited, especially for small fleet owners, as bankers find it challenging to de-risk the business case
	2. Regulatory Incentives	~80%	Long-term emission targets are not specific, with limited clarity around transition pathways and technology
			Financial incentives are insufficient and too focused on OEMs to overcome the cost difference between diesel and alternative technologies
			Regulations are inconsistent and fragmented between regions, countries and cities, which complicates operations and increases the overall cost of decarbonisation
Can the sector change?	3. Technology Alignment	~65%	Battery and hydrogen technologies are both immature, and neither provides the efficiency, scale, reliability and flexibility of diesel trucks
			It is unclear how much alternative technologies may improve over time, which hinders investment decisions
			Drop-in fuels have limited supply, which is structurally difficult to scale up, and they are likely to remain prohibitively expensive
			There are inefficiencies in the existing fleet, driven by suboptimal asset usage and low adoption of digital solutions
	4. Clarity on Roles and Decision Making	~55%	The value chain is fragmented, with shippers having limited control over what trucks are used, and truck owners having limited incentives to make early investments in alternative technologies
			Trucks are produced by a handful of OEMs that have contradicting priorities between developing alternative technologies and extracting value from traditional businesses
			Current TCO calculation methods make it difficult to create like-for-like comparisons between diesel and alternative technologies
			The sector has relatively few mechanisms for information and best-practice sharing, resulting in fragmentation of decarbonisation initiatives
How fast can the sector change?	5. Ease of Asset Replacement	~40%	It will take a long time for OEMs to scale up production capacity for alternative technologies and replace millions of trucks in the global fleet
			Fleet owners delay investment decisions and extend truck lifespans to avoid the risk of resale value loss
			Transitioning fleets to alternative-technology trucks creates complexity in operations, reducing efficiency and flexibility
			New technologies will require new maintenance capabilities, which will take time to develop, have an impact on operations, and may create bottlenecks
	6. Ease of Infrastructure Replacement	~80%	The renewable electricity required for alternative technologies is lacking, and requires significant investment and time to develop
			The distribution and charging/fuelling infrastructure for battery and hydrogen technologies will require major investments and near universal coverage
			Depot ownership and configurations complicate adding new charging/fuelling technologies and complicate operations



Severity
- Major
- Moderate
- Minor

Note: 1) See section "Regional differences " for barrier differences per country or region

1. MARKET AND CUSTOMER DEMAND

The willingness of shippers to incentivise lower-emission road freight services, and broader supports from the financing community were flagged by 70% of interviewees as critical to free up investment in decarbonisation (see Exhibit 16). Such incentives are currently limited.

Industry perspective: Shippers continue to prioritise the lowest cost in heavy-duty trucking, as consumer pressure to reduce emissions is limited.

Shippers – such as consumer goods companies and supermarkets – are increasingly making commitments to reduce the environmental impact of their supply chains. However, "shippers tend to follow the consumers and look for the biggest bang for the buck," said one fleet operator. This trend helps to explain why more "visible" sustainable attributes, such as packaging and green last-mile delivery, are often prioritised over investments in low-emission HDTs which, tend to be used outside urban areas away from the public's gaze, often at night, and represent a relatively small share of product costs.

Developments in e-commerce have led to consumers expecting faster delivery, increasingly without additional shipping charges. This makes it more difficult to offer lower-emission road freight options, which tend to be more expensive. Interviewees from logistics companies in particular indicate that although many shippers make commitments at the boardroom level, and sometimes even ask about low-emission trucks, when it comes to their procurement criteria, they almost always prioritise lower price. "If I provide a freight quote that is 5% above the standard industry rate, shippers are never going to pick us. They are going pick the diesel quote every time," said a large fleet operator.

However, some interviewees note positive signs of demand for low-emission road freight. Firstly, representatives of the long-distance bus (coach) segment say there is growing interest in emissions reduction among their customers, noting that "around 10% of our customers already choose to pay extra for carbon offsetting." Secondly, several fleet operators pointed out that their customers increasingly require emission information to be provided in tenders – particularly in the automotive sector. "Car makers sometimes even let us use trucks made by their competitors, as long as they are more emission efficient," said a fleet director at a European logistics operator. Thirdly, some interviewees indicate that consumer goods shippers with their own large fleets of branded HDTs are increasingly willing to make decarbonisation investments. They cited pressure from shippers' own workforce as an important driver of increased willingness to change, noting recent news about "climate strikes" to make the point.

Exhibit 16

INTERVIEW INSIGHTS

70%

Research participants perceive a **lack of market and customer demand** to be a major barrier to decarbonisation.

Industry perspective: Financing options for alternative technologies are limited – especially for owners of smaller truck fleets – as bankers find it challenging to de-risk the business case.

The road freight market is highly commoditised and competitive and generates low margins[16]. Small fleet owners and individual drivers in particular rely heavily on leases as a method of truck financing, which is considered cheaper than servicing loans, but slows down capital accumulation.

Several interviewees noted that truck owners often lack financing options to invest in lower-emission technologies, such as Euro VI engines. As a result, they tend to delay investments until external pressures, such as

regulation or customers, force them to act. "Financial support is designed for large fleet owners, not for the small ones. Smaller truck owners are cut off from financial support," noted an executive from an industry group.

Alternative technologies such as FCEVs will initially require higher upfront capital compared to diesel trucks, and will carry higher uncertainty around residual value and total cost of ownership (TCO) – the main metric used to inform purchasing decisions. For owners of small fleets, such new trucks will account for a disproportionate share of the fleet, and could increase financing cost and margin pressure beyond acceptable levels.

Financiers themselves acknowledge that they find it difficult to create financing options for alternative technologies. First, they note that the current financing models are based on a vehicle's lifetime value, which is highly uncertain in the case of BEVs and FCEVs. Second, they point out that most contracts between shippers and logistics providers last less than a year, reducing certainty that the new trucks will be used enough to pay back investments. Third, they are uncertain about the direction in which regulation will develop – particularly which technologies will be allowed in which cities, and when. "The sector needs long-term contracts and stable government policies to innovate," indicated a road freight banker.

2. REGULATORY INCENTIVES

Regulation of road freight emissions is evolving, but needs to be accelerated to achieve the 2050 Paris targets. Given the magnitude of investments required, 80% of interviewees, especially those based in the US and Asia, believe more incentives are needed to kick-start decarbonisation (see Exhibit 17).

Industry perspective: Long-term emission targets are not specific and there is limited clarity around transition pathways and technology.

Road freight emission regulation has historically centred on stimulating incremental improvements in diesel engine efficiency. Each new engine standard built on the previous one, following what one technology company describes as a "more of the same" approach. The long-term emission-reduction targets announced in Europe, the US and China in recent years represent a step change and require a deviation from that approach. Most interviewees consider them significantly more ambitious, but these targets are less specific about how the transition will be phased and how specific technologies will be impacted. This ambiguity makes long-term planning difficult, and means sector executives are less likely to make early investments. "Emission regulation without a playbook will create complexity for smaller organisations that do not have the capacity and means to seriously assess pathways of decarbonisation," indicated a global shipper.

Industry perspective: Financial incentives are insufficient and too focused on OEMs to overcome the cost difference between diesel and alternative technologies.

Almost all interviewees agreed that improvements in diesel engine efficiency must be combined with large numbers of alternative technology HDTs – such as, FCEVs or BEVs – to achieve 2030 emission-reduction targets. However, most interviewees do not consider the current financial incentives to be sufficient when comparing to the additional cost of buying and operating an FCEV or a BEV to a diesel-powered truck. The role of incentives will be important in the early stage of the transition, because "we will need to invest in new trucks long before the market demand for green trucks scales. We need help to bridge that timing gap" said one technology provider.

That said, some interviewees note that the EU is a positive exception, as it has implemented measures such as an additional weight allowance for electric trucks (FCEV, BEV), and the possibility for truck makers, or OEMs, to reduce their overall CO_2 targets by accelerating electric-truck deployment[17]. However, participants point out that the incentives are primarily focused on OEMs, and provide few benefits for fleet owners to buy alternative technology trucks, shippers to decarbonise supply chains or energy companies to set up new infrastructure. As such, most research participants remain convinced that the sector will be unable to transition to alternative technologies at scale without additional incentives.

"OEMs are announcing new trucks, but even if they start producing them at scale, they will be prohibitively expensive for us to buy and use."

Fleet Owner

Industry perspective: Regulations are inconsistent and fragmented between regions, countries and cities, which complicates operations and increases the overall cost of decarbonisation.

Cities such as London and Berlin and regions like California have responded to demands from residents for cleaner air and less noise by implementing schemes designed to limit the use of older, higher-emission vehicles. Participants in the research note that most of these schemes follow individual timelines and have differing technology requirements. For example, London has a daily penalty charge for trucks entering the city centre that do not meet Euro VI standards, while Paris only penalises those who do not meet Euro V; however, Paris plans to restrict all diesel vehicles entering the city centre starting in 2024, while London has no such plan[18, 19]. This complicates matters for fleet owners, and creates additional inefficiencies in the sector as a whole. For instance, cargo destined for delivery in a low-emission zone needs to be repacked and moved from one truck to another before entering such a zone.

Many interviewees raise concerns that this challenge will increase in years to come, as different countries follow different pathways and favour different technical solutions. For example, one participant noted that while European regulators support hydrogen fuel

Exhibit 17

INTERVIEW INSIGHTS

80%

Research participants perceive a **lack of regulatory incentives** to be a major barrier to decarbonisation

cells for long-distance transport[20], some individual governments are supporting more BEV-oriented technologies such as overhead contact lines[21].

"In cross-border freight, the challenge will be the biggest. It can be more expensive to comply with different local regulations than to comply with the most stringent single standard."

Industry Group

Despite their downsides, most interviewees agree that city and regional schemes are an effective tool to stimulate the adoption of alternative technologies. Metropolitan areas can create a snowball effect, empowering smaller cities to implement zones themselves, and expanding regional zones across multiple cities. California is an example of the disproportionate impact one region or city can have, with one technology provider noting "California's economy is a powerhouse, so their actions will surely impact what other states do."

3. TECHNOLOGY ALIGNMENT

Both the performance and emission intensity of diesel engines used in most HDTs have improved significantly since the introduction of emission standards half a century ago. Nonetheless, the road freight sector is trying to shift focus towards low- and zero-emission energy carriers, but 65% of interviewees indicate that more alignment around which technology will be used for HDTs is needed to kick-start the transition.

In the longer term, around 75% of interviewees cite hydrogen FCEVs as the most viable alternative HDT technology from a performance perspective, with many also expecting a role for BEVs in specific applications. Biodiesel, bioLNG and synthetic fuels are less often mentioned because of concerns about the pathway to large-scale production. A quarter of interviewees regard liquid and compressed natural gas (LNG, bioLNG and CNG) as important transition fuels, citing their positive impact on reducing air pollution (see Exhibit 19).

Industry perspective: Today, battery and hydrogen technologies are both immature, and neither provides the efficiency, scale, reliability and flexibility of diesel trucks.

Participants mentioned truck characteristics such as range and charging time, as well as the lack of infrastructure, as key barriers to BEV and FCEV adoption. In this section, we focus on truck characteristics, and cover the infrastructure barriers later in the document.

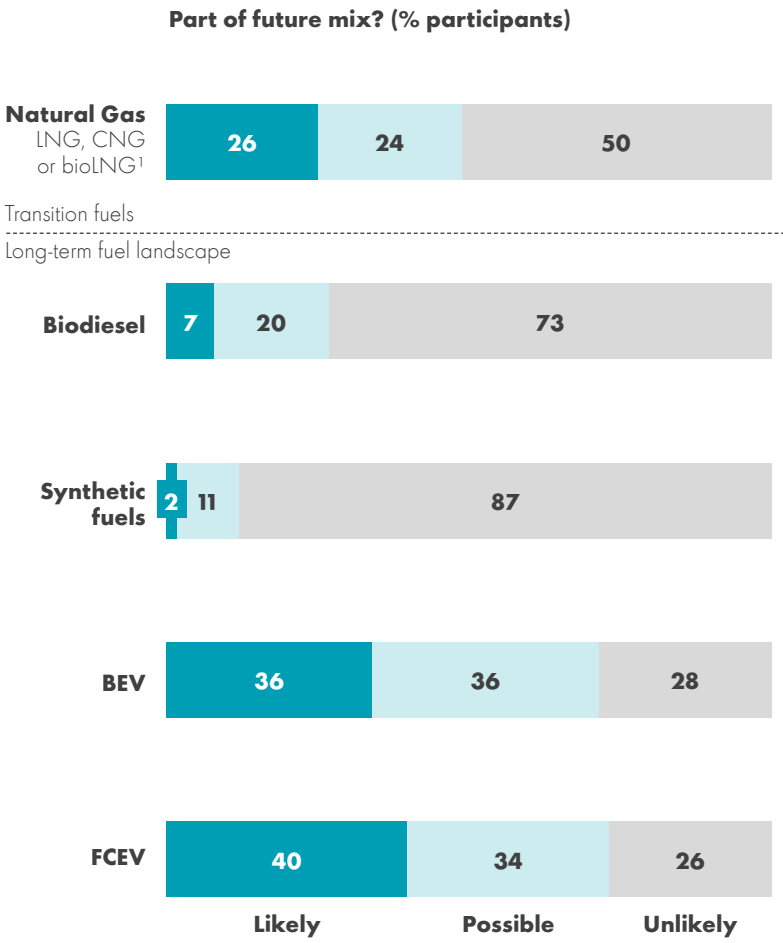
Exhibit 18

INTERVIEW INSIGHTS

65%

Research participants perceive a **lack of technology alignment** to be a major barrier to decarbonisation

19 **Sector perspective on alternative technologies**



Engine type	Advantages	Disadvantages
Combustion (drop-in fuels)	Lower emissions; immediately available in many locations; less local air pollution compared to diesel (fewer particulates)	Emits CO_2; emission benefits are less than alternative fuels; risk of methane leakage; engine has less power
Combustion (drop-in)	Easy to use in current engines; can use existing distribution infrastructure	Limited feedstock; unlikely to be available in sufficient quantities for road freight; difficult to trace origins to confirm it is green
Combustion (drop-in)	Easy to use in current engines; can use existing distribution infrastructure	Costs significantly higher than alternatives, with limited short-term improvements expected; uses hydrogen as feedstock
Electric motor	Relatively mature technology; reduced maintenance due to fewer moving engine parts; quiet and smooth for drivers	Short range, long charging, heavy weight – not applicable to many duty cycles; production limited by rare metals and cradle-to-grave environmental impact; major upgrades in grid required
Electric motor	Range and fuelling time similar to diesel; reduced maintenance due to fewer moving engine parts	Fuel cost higher than electricity, which is used as feedstock; limited production and distribution

Note: 1) BioLNG is not a transitioning fuel, but has been grouped with LNG and CNG because it is not a drop-in fuel for diesel engines. However, bioLNG shares many advantages and disadvantages with Biodiesel

Battery Electric Vehicles

Electric vehicles with battery technologies have grown in popularity, both for personal use and, increasingly, in the LCV segment. Their CO_2 credentials improve further when powered by electricity generated from renewable sources such as solar or wind power.

To complement these LCVs, several OEMs have announced the forthcoming release of battery electric HDTs. However, interviewees tend to believe that BEVs have major structural limitations – especially related to battery range and charge time. Virtually all trucks announced to date have a maximum battery range of under 350 km, and most under 250 km. Using the existing "fast charger" infrastructure, it would take around five hours to fully charge a battery for another 250 km, making it hard if not impossible for most truck owners to operate such trucks economically. While some manufacturers have claimed trucks with ranges over 800km, and charging times under 30-minutes would be available in the near future, interviewees were sceptical, as noted by one logistics company: "Some OEMs claim their BEV trucks will go for 800 km, but we are somewhat sceptical about what is marketing and what is reality."

In a comparison of truck characteristics (see Exhibit 20), it is apparent that most alternative technologies can compete with diesel on range and refuelling time, with the exception of BEVs. Increasing battery size to extend the maximum range is in turn limited by legal and economic limits on truck weight. "Travelling 800 km from Hamburg to Munich with a 40-tonne truck, we would need a battery that weighs almost 15 tonnes," said one fleet owner illustrating the point. "If you want to have a battery truck at this moment, you lose transporting capacity." With the current technology, bigger batteries will also result in even longer charging times, further complicating operations.

Despite the limitations, some participants still recognise the future potential of BEVs. They consider the technologies to be a natural extension of an electrified LCV fleet for those applications that involve limited daily distances, on predictable routes and with a relatively long downtime (e.g. overnight). Some markets, like Germany and Sweden are also piloting overhead charging networks, which would significantly extend the range of BEVs traveling along electrified corridors.

20 **Comparison of HDT characteristics[1]**

	Diesel	Natural gas[2]	Biofuels	Synthetic fuel	Battery electric		Fuel cell electric[3]
Energy carrier	Diesel[4]	LNG or CNG	Biodiesel(from biomass)	Synthetic diesel (Hydrogen and CO_2)	Battery pack		Hydrogen
Powertrain	ICE	ICE	ICE[5]	ICE[5]	Electric motor		Electric motor
Drop-in fuel	n/a	✗	✓	✓	✗		✗
Zero-carbon	✗	✗	✓ (Possible)	✓	✓		✓
Range (km)	>1,500	~1,000	>1,250[6]	>1,500[6]	~200	~800[7] (planned)	400-1,200
Refuel time (h)	0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4	>3[8]	>7[8]	0.3-0.4
Weight powertrain (kt)[9]	~ 3.0	~ 2.2	~ 3.0	~ 3.0	~2.2[10]	~ 4.9[10]	~2.6[10]
TCO and initial truck cost				n/a	TCO declining to parity fast; truck cost currently 1-3x higher		TCO declining but still high; initial truck costs 2-3x higher

Relative performance vs. diesel (illustrative):

- On/above par
- Slightly below par
- Below par

Sources: IEA (2017) Future of Trucks; ETC (2019) Mission possible heavy road transport; T&E Comparison of hydrogen and battery electric trucks; Earl et Al., Analysis of long-haul battery electric trucks in EU; Energy.gov; Truckpaper.com; Cleantechnica.com
Notes: 1) For simplicity, hybrids and mixing of fuels are excluded from overview; 2) Based on Scania R410 LNG; 3) Based on Nikola truck; 4) Possible in combination with CCS; 5) Possible modification needed; 6) Energy density of biodiesel is ~15% lower than that of diesel (~38 vs. ~45 MJ/kg), for synthetic fuel a diesel energy density is assumed; 7) Based on Tesla Semi; 8) Values shown assume fast charging at 150kW. If more common slow chargers of 20kW were used, the charging time would be more than seven times longer; 9) kilo tonnes, incl. engine, cooling system, transmission and fuel/batteries; 10) 270 kWh and 1,100 kWh batteries assumed for BEV, a 250 kWh battery pack is assumed for FCEV, battery pack energy density 0.25 kWh/kg and energy consumption 1.15 kWh/km and 85% battery use. Electric motor and gearbox is assumed 600 kg, and fuel cell electric is assumed 470 kg

Hydrogen Fuel Cell Electric Vehicle

Most interviewees consider the performance characteristics of FCEVs to be similar to diesel trucks. Recently announced FCEVs are set to have ranges of over 1,000 km and will take less than 20 minutes to fuel. Many interviewees therefore see hydrogen trucks as the only viable zero-emission option in the coming decade – both technically and economically.

"As you get to longer, heavier transport with more utilisation, fuel cell technology is the only solution."

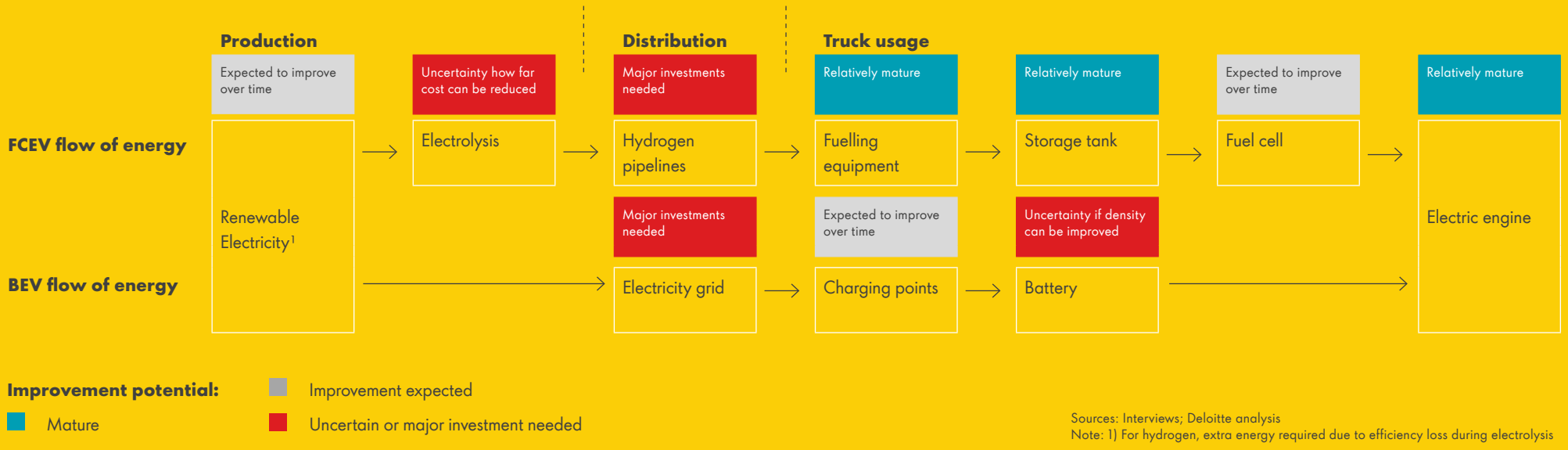
Component Manufacturer

As with BEVs, FCEVs have a near zero-carbon footprint when renewable electricity is used to make hydrogen (some emissions will still come from the manufacture of wind turbines, etc.). The main concern about FCEVs centres on their energy efficiency. Compared to BEVs, twice as much renewable electricity will be needed to move the same amount of cargo, making the cost of producing hydrogen a prohibitive factor.

Industry perspective: It is unclear how much alternative technologies may improve over time, which hinders investment decisions.

Despite decades of developments in FCEVs and BEVs, neither solution is yet commercially competitive with diesel, with some exceptions such as BEV applications for last-mile delivery. Most interviewees expect the technology to improve in the coming decade, which could drive down costs and make them more viable for some applications. However, views differ on the expected pace and scope of improvement (see Exhibit 21). Bullish OEMs such as Tesla are confident ranges will exceed 1,000 km[22], while the majority of OEMs predict short-term ranges around 250–300 km[23]. There is also uncertainty around how long it will take to achieve such ranges and improve charging speeds, once infrastructure is put in place. As a result, sector stakeholders are less likely to invest until they have more foresight on developments in technology performance and cost.

21 **Sector perspective on BEV and FCEV improvement potential**



Sources: Interviews; Deloitte analysis
Note: 1) For hydrogen, extra energy required due to efficiency loss during electrolysis

"In the past 50 years, hydrogen has always been 10 years out. We are worried that it is the same today."

Industry Group

While most interviewees recognise that ramping up renewable energy production will likely move at an ever-greater pace in the coming decade, there is less certainty about the industry's ability to produce enough affordable clean hydrogen. Developments in distribution networks, such as hydrogen pipelines and electricity grid, remain equally uncertain, although most interviewees see them as expensive but solvable problems. "Once the trucks are available, there is money to be made on fuelling or charging, so someone will build the infrastructure," said one fleet owner.

Most interviewees were unclear about the potential for improvements in battery energy density. Some cited studies showing that although the cost of batteries has been declining at around 20% per year over the past decade due to a dramatic increase in production, the improvements in energy density have been a more modest 5 to 7% a year over the same period – and even less in the past five years[24]. Energy density is a key metric, as it allows OEMs to extend a truck's range without increasing the battery size and weight, and therefore having no impact on loading capacity. Some interviewees indicated that even if further improvements are possible, at historical rates, it could take another 15 years until batteries have sufficient density to provide the range required for many HDTs.

A number of interviewees also raised concerns about the potential long-term cradle-to-grave environmental impact of batteries, given how little is known about battery disposal and recycling. These factors extend beyond the point of energy use to the sourcing and production of batteries, and their disposal at end of life. Their worries centre primarily on the negative social and environmental impacts of large-scale extraction of minerals used in

batteries, the majority of which are found in developing nations with fewer environmental and labour protections in place. Studies cited by interviewees also note the need to store, disassemble and chemically separate what will likely amount to tens of millions of cubic metres of battery pack waste every year[25]. "If we have to build batteries for 200 million trucks, in addition to all the personal vehicles, and again each 10 years, the amount of materials needed will be unbelievable," said one technology provider.

While not frequently mentioned, some interviewees also pointed to the potential negative atmospheric impact of hydrogen as a result of leakage and its role as an "indirect" GHG. Industry literature also substantiates this point[26].

Industry perspective: Drop-in fuels have limited supply, making them structurally difficult to scale up, and they are likely to remain prohibitively expensive.

"Biofuels have a role to play in the short term, but for full decarbonisation, their supply is highly constrained.,"
OEM

Biodiesel is a type of biofuel typically derived from vegetable or animal fats and alcohol. In many countries, it is already blended with traditional diesel in small quantities. Biodiesel is often considered a net-zero-emission fuel because the CO_2 released during the combustion is previously absorbed by the plants from the air. But interviewees raised concerns about the availability of biofuels in sufficient quantity given the large volume of fuel needed for the industry, as well as the land and biomass required to produce it. Interviewees also raised transparency concerns, with one logistics company executive noting "if we use a blended fuel, it is difficult to verify the bio content, and whether it comes from sustainable sources."

As with biofuels, synthetic fuels – or efuels – are relatively easy to adopt because they can largely use existing infrastructure and existing engines. Synthetic fuels are produced using a combination of hydrogen and carbon dioxide, making the renewable energy required to produce them even greater than that needed to produce green hydrogen. While the CO_2 is captured from point source emitters today, it may be captured directly from the air as technology evolves. Interviewees indicate that although efuels might play a role in the transition fuel mix, they are unlikely to be to prevalent in road freight in the long run.

Industry perspective: There are inefficiencies in the existing fleet, driven by suboptimal truck usage and low adoption of digital solutions.

The fragmentation of road freight, with a large share of trucks owned and operated by small companies, has created inefficiencies in how

trucks are used. Additionally, interviewees indicate that outdated manual processes, as well as limited use of truck connectivity and analytics for operations management result in a high number of less-than-truckload (LTL) shipments and suboptimal routing. "The industry is very manual. Booking a truck for a shipment happens over back-and-forth emails. We load a truck 2,000 times a day, and there is always a person involved," said a fleet owner.

To illustrate the point, interviewees cited analyses indicating that between 30% and 50% of all truck journeys are empty[27]. Some participants shared anecdotes of half-filled trucks – sometimes belonging to the same operator – travelling between the same cities at the same time. Increasing consumer expectations around short delivery times further increase the number of trucks on the road and the number of empty kilometres driven. Interviewees also noted inefficiency in how trucks are designed and operated. The wrong tyres, suboptimal speeds and unnecessary breaking were just a few examples mentioned.

Developments in connectivity and autonomous driving will likely increase sector efficiency in the coming decade. "Transportation today depends on bringing the driver back home with an empty truck. If we can eliminate the human element, this could make operations more efficient, with a big emission impact too," noted a major shipper. However, several executives indicated that most companies still consider the impact of these technologies as separate from decarbonisation, despite the clear interrelationship between the two trends.

4. CLARITY ON ROLES AND DECISION MAKING

Although most trucks in the global fleet are produced by just a handful of OEMs, there are around 3 million truck owners and operators[28]. With many complex, interdependent decisions that must be made, and occasionally misaligned priorities between stakeholders, 55% of interviewees consider the resulting lack of clarity on roles and decision-making to be a major barrier to decarbonisation (see Exhibit 22).

Industry perspective: The value chain is fragmented, with shippers having limited control over what trucks are used, and truck owners having limited incentives to make early investments in alternative technologies.

Of the around 3 million truck owners and operators engaged in road freight globally, many are small or very small. For example, in Asia, 90% of trucks are owned by individual drivers, and only 0.1% are owned by companies with more than 100 trucks[29]. The level of fragmentation is equally high in Africa and South America, although some sub-regions are dominated by larger organised groups[30]. The industry is marginally more consolidated in Europe, the US, Canada and Australia. Small fleet owners often work as subcontractors for larger fleet operators, who provide services for third party-logistics (3PL) companies, who in turn co-ordinate road transport on behalf of shippers.

The fragmentation is largely intentional because many shippers and logistics companies want to minimise their fixed costs and balance sheets, and continuously seek new service providers that can offer the lowest cost.

In this model, shippers – and sometimes logistics companies – have limited control over what trucks are used in their fleets, while truck owners are several steps removed from the shippers. This makes it difficult to achieve any commercial benefits from investments in lower-emission trucks. A global shipper explained that "the biggest problem in electrifying the trucks is that nobody actually owns this equipment. We as shippers do not, and logistic companies do not either." Decision making is further complicated through the use of LTL services, where cargo from multiple shippers is bundled on one truck. As a result, owner-operators may not be able to provide a lower-emission solution easily even if a shipper was willing to pay extra for it. This is illustrated by a global shipper: "Two-thirds of trucks are owned and operated by independent LTL carriers, who will not invest in alternative technologies if only one of their customers asks for it."

Moreover, early investments in alternative technology trucks inevitably carry higher costs and greater risk for fleet owners. The risk of testing a few dozen BEVs or FCEVs may be relatively insignificant for an international company with a fleet in the thousands but small and often family-owned truck operators would struggle to buy a single low- or zero-emission truck. The risk is such that a single wrong investment could threaten the future of the entire business as such companies are unable to spread the extra cost across a large revenue base. In the words of one interviewee, "Smaller companies lack the capabilities and financial means to invest in untested technologies."

Industry perspective: Trucks are produced by a handful of OEMs that have contradicting priorities between developing alternative technologies and extracting value from traditional businesses.

Although the trucks in the global road freight fleet are owned by millions of companies, most are produced by fewer than 20 OEMs. The top three OEMs account for around 30% of the approximately 3 million MDTs and HDTs produced globally each year, with the top six manufacturing over 50%[31].

These OEMs derive virtually all commercial revenues from diesel trucks. In recent decades, they have made major capital investments to improve diesel performance and adhere to increasingly strict emission regulations. Interviewees recognise that most OEMs have accumulated tremendous capabilities and institutional knowledge in their core diesel business. Transitioning to alternative technologies will require significant investment in new capabilities, new supply chains and new manufacturing lines. In the absence of proven demand, OEMs are naturally reluctant to make large investments quickly. As one OEM executive noted "The level of uncertainty is very high. It would be very

Exhibit 22

INTERVIEW INSIGHTS

55%

Research participants perceive a **lack of clarity on roles and decision making** to be a major barrier to decarbonisation

risky for us to already make a bet on one technology." One infrastructure provider explained that "OEMs need a minimum number of orders to be guaranteed before they start producing at scale."

Shifting production to alternative technologies – while protecting the OEM workforce and subcontractors – will take years, perhaps decades. As such, short-term investor expectations might play an equally important role in slowing down the transition: "It is a capital allocation issue. When you have a dollar to invest, you put it where it will generate the biggest return. And that is still the diesel business," said a financier.

Replacing diesel with electric engines, whether BEVs or FCEVs, may also decrease the ability of OEMs to differentiate their products in the market. "OEMs profit from engines and gearboxes, which is exactly what electric vehicles remove," said a representative of a financial institution. In this context, geopolitical considerations might also play a role – especially in Europe and the US – as battery and fuel-cell technology is currently developed in Asia. Labour unions are also expected to play a significant role in some markets as job profiles and capability requirements change.

Industry perspective: Current TCO calculation methods make it difficult to create like-for-like comparisons between diesel and alternative technologies.

Regardless of the brand, most trucks produced today are based on similar technologies and have similar lifespans and operating and maintenance requirements. Comparing diesel trucks is therefore relatively simple, especially as the cost of fuel accounts for around half of a truck's TCO[32].

"TCO is the single most important factor in deciding which truck to buy."

OEM

Interviewees note that calculating the TCO for alternative technologies will require a different approach. Not only are there more uncertainties about the pace of technology development and residual value of trucks, but some cost elements may also need to be considered in a structurally different way. For example, electric drivetrains typically have fewer moving parts, and may require less maintenance. Conversely, the greater weight of a BEV may increase the wear and tear on truck tyres and chassis. In addition, deploying BEVs or FCEVs might require changes to how trucks are used, which in turn might impact truck utilisation. In the absence of generally accepted TCO calculation methods, such complexities make it difficult to make a like-for-like investment comparison between current and alternative technologies.

"Hydrogen or electric trucks might soon be more attractive from a TCO perspective for

some applications than diesel, but we have no accepted way of proving that," noted an interviewee. As a result, truck owners – many of whom rely on external debt or lease financing – tend to make the safe choice of investing in what they already know and with a lower upfront cost. A freight director of a European industry group summarised it in the following way: "High upfront capital investments for new technologies deter logistics companies from considering TCO."

Industry perspective: The sector has relatively few mechanisms for information and best-practice sharing, resulting in fragmentation of decarbonisation initiatives.

The road freight sector does not have a co-ordinating international body to oversee and organise decarbonisation activity within the sector, unlike aviation and shipping, which have the International Air Transport Association and Global Maritime Forum respectively. Some promising coalitions and initiatives have been formed, including the European Clean Trucking Alliance. And some interviewees mentioned the recent launch of the Road Freight Zero initiative at the World Economic Forum as a sign that the industry is coming together to tackle decarbonisation. However interviewees said there were currently few mechanisms to coordinate activity across these and smaller partnerships to focus resources. "Everyone is piloting the same technologies independently, which creates redundant investment," said one international shipper. This results in a lack of awareness, fatigue and scepticism around technology applicability and has a detrimental impact on a possible roadmap for development.

5. EASE OF ASSET REPLACEMENT

Once incentives are in place and technology matures, the sector will need to start producing at scale and replacing the millions of trucks in the global fleet. That will require fitting them into an intricate operations network and managing uncertainty around resale values and maintenance of alternative technology. Around 40% of all interviewees consider the issue of replacing the current fleet for alternative technology trucks a key barrier to decarbonisation (see Exhibit 23).

Industry perspective: It will take a long time for OEMs to scale up production capacity for alternative technologies and replace millions of trucks in the global fleet.

Exhibit 23

INTERVIEW INSIGHTS

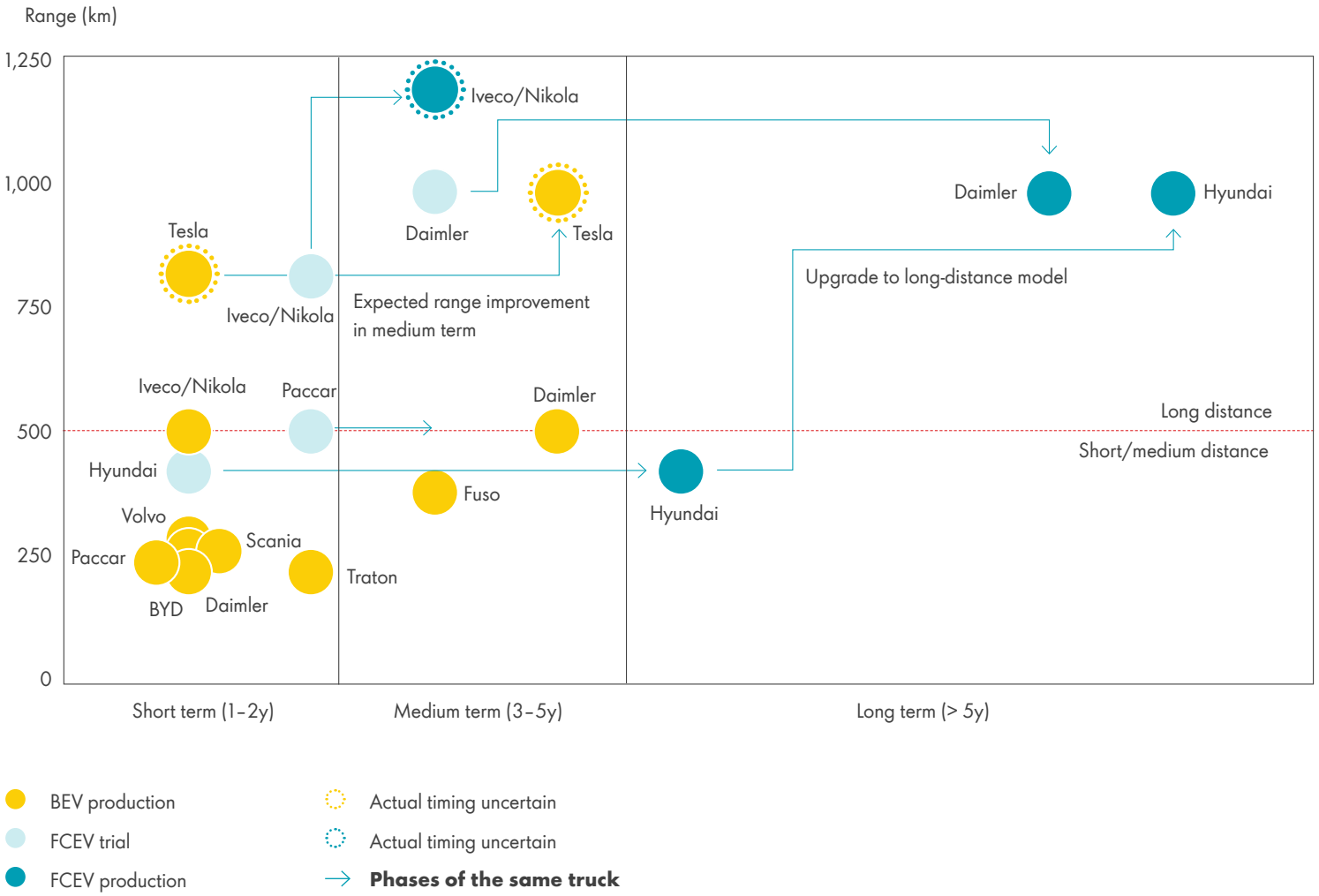
40%

Research participants perceive **complexity of asset replacement** to be a major barrier to decarbonisation

Over the past two years, several major OEMs announced plans to add FCEVs or BEVs (or both) into their product portfolios. However, most plans involve only small-scale production intended for customer trials, and interviewees indicate that demand for alternative technology already often exceeds supply. Several fleet owners interviewed for this research paper indicated that they tried ordering small numbers of battery and hydrogen trucks for testing, but were unable to do so. "I read about OEMs launching hydrogen trucks, but if I call them today, they will not be able to sell me one, not even for testing," said an executive at a European logistics company.

Only two major OEMs have so far announced plans to move beyond trials and scale up production of HDTs with ranges exceeding 800 km. Those OEMs indicate the second half of this decade as a realistic time horizon for when first manufacturing plants can be built, supply chain networks established and production at scale can begin (see Exhibit 24).

24 **OEM roadmaps for FCEV and BEV HDTs**



Sources: Company websites and press; Deloitte analysis

Interviewees noted that replacing the current fleet of around 30 million HDTs – with around 3 million added every year – would take a decade at the very least. More realistically, current and new technologies will co-exist for many years, so full replacement would more likely take 20 or 30 years.

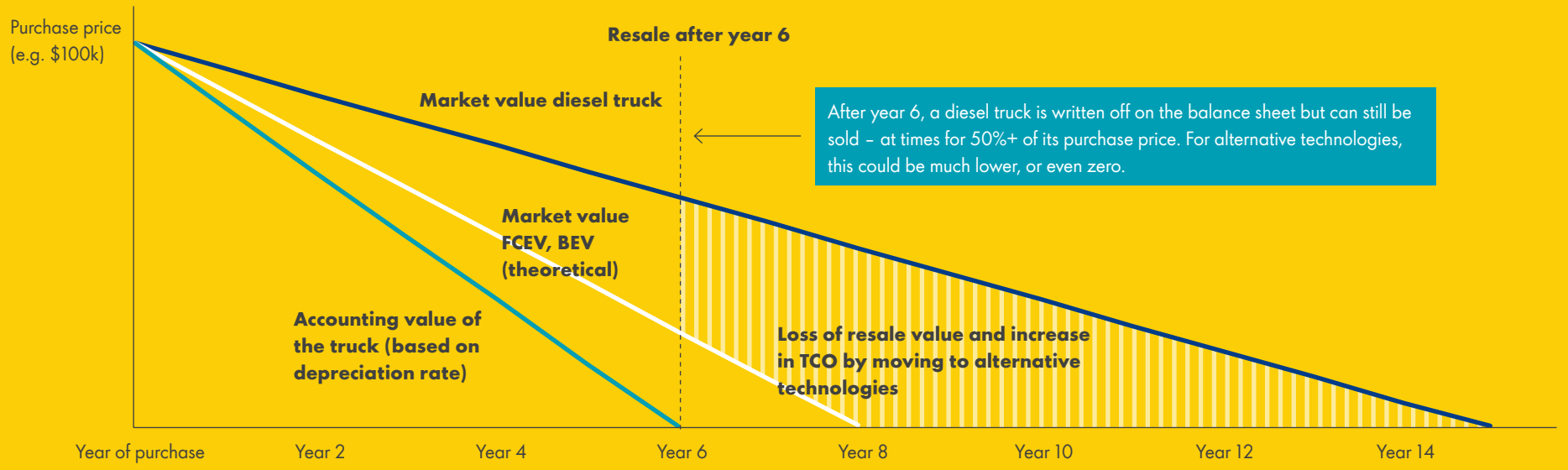
"It will take well into the 2040s and maybe 2050s before most of the trucks on the roads are FCEVs or BEVs."

Fleet Owner

Industry perspective: Fleet owners delay investment decisions and extend truck lifespans to avoid the risk of resale value loss.

A diesel truck is typically depreciated by its first owner in under six years, after which the truck either continues to be used with a lower associated accounting cost, or, more often, is sold in the secondary market directly or through dealer buy-back terms. Some fleet owners indicate that the depreciation period can be as short as three years. As a result, a significant part of the first owner's TCO – and therefore profit – relies on the trucks maintaining their resale value beyond the initial ownership period (see Exhibit 25).

25 **Financial impact of resale value uncertainty – ILLUSTRATIVE**



Sources: Interviews; Deloitte analysis

Interviewees indicate that the resale value for alternative technology trucks will be highly uncertain – especially in the initial years of the transition. New technologies tend to improve faster than the established ones, and as such the market value of BEVs and FCEVs might decline dramatically faster than that of diesel trucks, further increasing the TCO for the first owner. "I do not know how much I can reasonably get for the hydrogen or electric truck after four years. I don't even know if anyone will be willing to buy it," said one fleet owner. Interviewees also noted that while engine repairs and rebuilds are common today to extend the life of trucks, the significantly higher battery pack cost as a proportion of total truck cost would make extending the life of BEVs less feasible, thus reducing their secondary-market value.

A number of interviewees expect that without additional regulation, financial incentives, or guarantees from OEMs, many fleet owners – especially smaller ones – will minimise the resale-value risks by continuing to buy diesel-powered trucks, even as alternative technologies reach cost parity. Even when new diesel truck sales are phased out, a simple way to avoid investments in FCEVs and BEVs will be to extend truck lifespans.

Industry perspective: Transitioning fleets to alternative technology trucks creates complexity in operations, reducing efficiency and flexibility.

Road freight operators are under continuous pressure to provide fast and reliable service at low cost, especially as consumer expectations and the take-up of e-commerce are increasing. HDTs form part of an intricate and highly integrated international supply chain network, running on tight schedules between ports, production sites, distribution centres and other loading and unloading sites. Truck utilisation and reliability are therefore key to competing in this market. "Trucks should perform like a tool. They need to be reliable vehicles that perform

without stranding and are well integrated into the network of depots," noted one executive from a major truck technology provider.

Interviewees indicate that making early investments in alternative technologies means sacrificing a lot of the operational efficiency that characterises the sector, whether time is lost through recharging batteries or rerouting trucks to the next hydrogen fuelling station. It may also create additional risks and costs – for example, those related to training drivers and other personnel on how to safely use the new technology. The fleet director of a courier company illustrates the point: "If a driver forgets to fuel a diesel truck before going to sleep, we lose 20 minutes in the morning. If he forgets to charge a battery, the truck is unusable for the next half-day."

Operating multiple technologies within one fleet is particularly detrimental to efficiency, because it reduces flexibility by making it more difficult to swap trucks between routes, and increases the co-ordination effort required. "Having a fleet with mixed technology adds a whole new dimension of complexity to network planning," summarised an executive of a major European fleet operator.

Industry perspective: New technologies will require new maintenance capabilities, which will take time to develop, have an impact on operations, and may create bottlenecks.

Many large logistics companies have developed in-house maintenance and repair capabilities to ensure their fleets are reliable. Routine repairs on diesel engines can often be done in the depots, and it is relatively easy to bring in external assistance in the event of a breakdown en-route.

Inevitably, maintenance requirements will change when owners and operators replace diesel trucks with FCEVs or BEVs. This could result in fewer repairs on some components, such as the drivetrain, and more on others, such as the chassis. Regardless of the specific differences, alternative technologies will require fleet owners to develop new capabilities, and possibly implement higher safety standards. "BEVs come with high voltage, which means that we have to train and certify workshops in the future if we want to do our own maintenance," said one OEM executive. This transition will require time and investment, and might further limit the flexibility of fleets. Some interviewees also noted that maintenance and repair capabilities will initially be concentrated with the OEMs, possibly resulting in bottlenecks and cost increases.

6. EASE OF INFRASTRUCTURE REPLACEMENT

The road freight sector consumes around ~38 EJ (11 million GWh) of energy annually – mostly in the form of diesel fuel[33]. Transitioning the fleet to electric motors will require unprecedented investments in renewable electricity, hydrogen production (where applicable) and transport networks like pipelines and utility grids. Charging and refuelling points will also need to be made available in almost all corners of the world to maintain sector flexibility. 80% of interviewees consider infrastructure replacement as the key barrier to decarbonisation (see Exhibit 26).

Exhibit 26

INTERVIEW INSIGHTS

80%

Research participants perceive **complexity of infrastructure replacement** to be a major barrier to decarbonisation

Industry perspective: The renewable electricity required for alternative technologies is insufficient, and requires significant investment and time to develop.

Renewable electricity will play a key role in decarbonising road freight, either directly powering batteries or indirectly to produce green hydrogen or synthetic fuels. Today, just 25% of the total global electricity production comes from renewable sources (around 23 EJ)[34]. If all trucks in the global fleet were transitioned to BEV today, they would need 94% of all renewable electricity generated around the world to charge their batteries (see Exhibit 27). "We first need to overcome the shortage of green electricity and hydrogen. Otherwise, neither BEVs nor FCEVs will make a difference," noted a road freight financier.

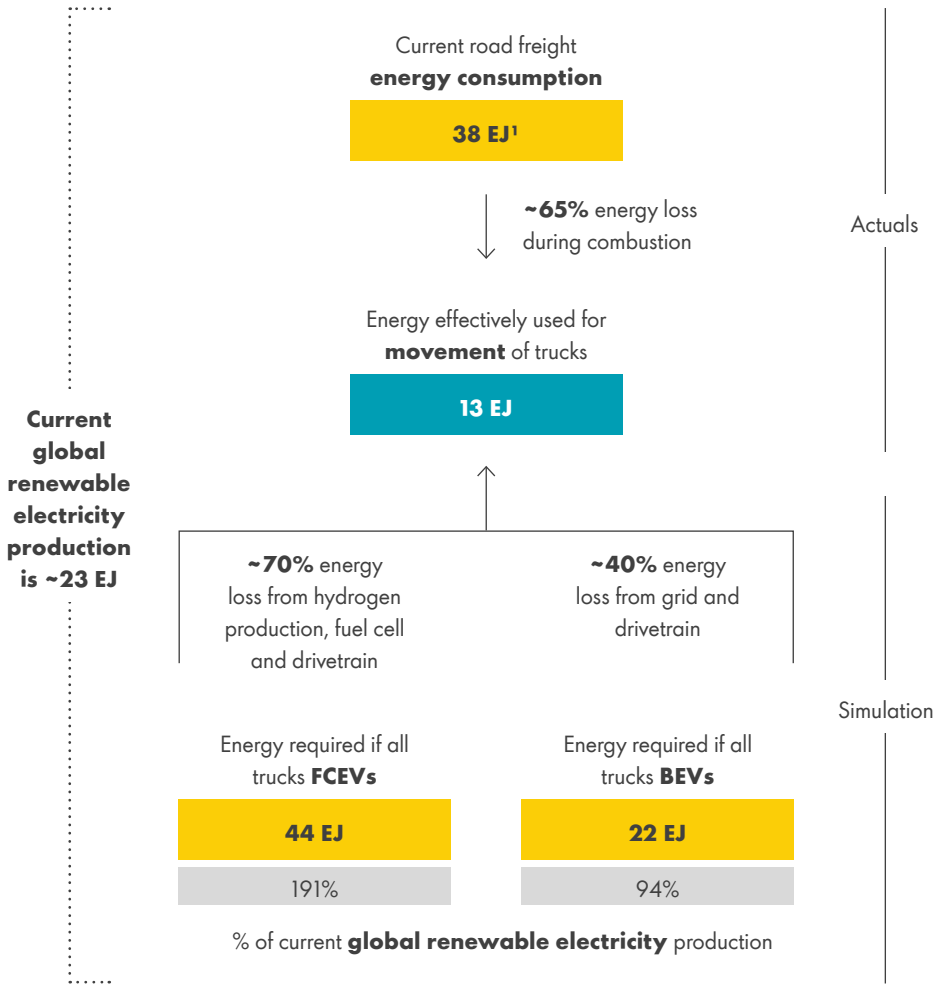
Anywhere between 22 and 44EJ in renewable electricity will need to be produced annually for the road freight sector alone, depending on the final mix between battery and hydrogen trucks. That is double the amount of renewable electricity currently generated. Additionally, this demand does not factor in the growth in road freight volume or – more importantly – the needs of industrial and residential users, and other sectors undergoing the transition. Interviewees considered this a major barrier that will take an unprecedented effort and several decades to address.

"We are, at the very least, 10 years away from producing the electricity needed to charge batteries or to generate hydrogen on significant parts of the fleet."

Logistics Company

Interviewees also noted that the scarcity of renewable electricity will likely result in an increase in electricity prices, making BEVs and FCEVs even less economically viable in the transition period. "If demand goes up, price goes up, and achieving break-even for new trucks becomes challenging," noted one shipper.

27 **Energy required for BEV or FCEV trucking (2017)**



Sources: Shell (2018) Sky Scenario; IEA (2019) World electricity generation by source 1990–2018; Zang et al. (2015), Towards a smart energy network: The roles of fuel/electrolysis cells and technological perspectives
Note: 1) Shell Sky Scenario road freight energy consumption 2015 (34 EJ) is adjusted with 11% based on the TKM increase between 2015 and 2017

Industry perspective: The distribution and charging/fuelling infrastructure for battery and hydrogen technologies will require major investments and near universal coverage.

One of the key characteristics of road freight is its flexibility, namely the ability of trucks to go virtually anywhere, without the need for waterways, rail tracks or other purpose-built infrastructure. This flexibility is possible because trucks share roads and fuelling stations with personal vehicles. Creating universal access to battery charging and hydrogen fuelling will therefore be critical if the sector is to shift to BEVs and FCEVs at scale.

This creates a chicken-and-egg dilemma. Given the early stage of BEV and FCEV technology, governments, energy companies and financiers are on one hand hesitant to make large infrastructural commitments. On the other, OEMs are hesitant to scale up production, and fleet operators are reluctant to buy new trucks, due to the lack of infrastructure. "No operator will take a chance on a new truck unless they are certain they will be able to fuel or charge it," said a fleet operator.

Some very large fleet operators might be in a position to build their own fuelling facilities, but most medium-sized and small companies will rely on public infrastructure. Interviewees noted that companies operating on changeable routes that are driven by customer demand, will especially need a high density of fuelling stations before they are able to switch to alternative technologies. "We don't need to refuel on every corner, but almost. For many of our journeys, we need a dense network that connects Europe," said a large fleet operator. These constraints apply to all alternative technologies, but are most critical for battery charging and hydrogen.

Battery charging

The current electricity grid is designed for highly decentralised industrial and residential use, where individual units of equipment have relatively small energy needs. Installing ultra-fast charging points for HDTs – something that most interviewees consider necessary to make BEVs economically viable – will put a heavy toll on the grid. For example, a typical personal vehicle charging station uses around 0.1 MW of electricity, increasing to 0.2 MW with a "supercharger". Recent announcements around BEV trucks indicate that to charge batteries in an acceptable timeframe, the industry will need to develop "mega-chargers" of up to 1 MW, five to ten times the current levels.

Many interviewees doubt whether this is possible before electricity companies implement major upgrades in electricity transmission and distribution networks. An executive working at a major European logistics provider outlined the situation in blunt terms: "If we moved our fleet to BEVs and started charging it all in our main depot, the whole city around us would have a power outage immediately."

Even with extra grid investments, fully charging a battery will take several times longer than fuelling a diesel or a hydrogen truck, both in the foreseeable future and possibly for ever. This means additional parking spaces – possibly in multiples of current numbers – will need to be created at service stations, along the highways and throughout the urban environment to accommodate trucks parked for 60 minutes or longer at a time, instead of the current 15 to 20 minutes.

Hydrogen fuelling

The fuelling time for a hydrogen truck, at around 15 to 20 minutes, is comparable with diesel-powered trucks. However, moving hydrogen from the production sites to the fuelling stations will require a new network of pipelines and tank trucks. The technology to transport hydrogen safely and reliably has been used in industrial applications for decades but interviewees say that the scale of investment required to ensure widespread supply for road freight applications is without precedent. Some interviewees indicated that the existing gas infrastructure could be partially repurposed for hydrogen use, but not without a change in pipeline material and considerable investment. As a result, virtually all interviewees agree that universal access to green hydrogen is still a long way off.

Industry perspective: Depot ownership and configurations complicate adding new charging/fuelling technologies and operations.

In some cases, the time spent loading and unloading trucks could be used for what has been dubbed "opportunity charging". BEVs in particular are likely to rely on this method of extending their range, with a technology provider noting that "for BEVs to have an acceptable range, they will need to charge whenever they stop at the depot. Hydrogen trucks can probably just use public infrastructure once a day."

In many instances, the companies that operate trucks are not the same as the ones that own the depots. Depots sometimes belong to the shipper, but in many cases they are owned by a third-party warehousing company. Interviewees note that if truck owners invest in electric vehicles, they need to rely on these third parties to equip their depots with charging points. However, there are limited incentives for depot owners to make these types of investments, with one shipper noting: "It is unclear who will pay for the chargers: depot owners, who do not benefit from it; or fleet operators, who unload at many different depots."

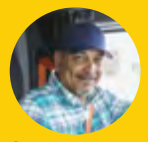
Moreover, even when depot owners are willing to build charging points, they might be concerned about the impact on available space, operations and safety. "Charging points need to be installed close to the walls to avoid them being constantly knocked over. This significantly complicates the organisation of vehicles at the depot," said one coach operator. Reduced parking space and the need to co-ordinate charging timeslots might further increase the cost for depot owners.

STAKEHOLDER VIEWS ON DECARBONISATION BARRIERS

Barriers identified in the previous section reflect an industry-wide perspective on decarbonisation. However, each barrier is more applicable to some stakeholder groups than others, and they are perceived in different ways. It is important to understand how each stakeholder group perceives the barriers, and their underlying triggers and motivations, in order to identify practical solutions.

Working with research participants, a series of stakeholder perspectives were developed (see Exhibit 28) to illustrate these differences and build a deeper understanding. These perspectives are also used to help shape the solutions set out later in the report.

28 **Example perspectives on barriers to decarbonisation – ILLUSTRATIVE**



Sam
Truck Driver

I've been on the road for many years and my truck has become part of my life, although I try to be home at least three nights a week. I need my truck to be safe, comfortable and, above all, reliable. I don't know much about electric or hydrogen trucks – I've only heard they are quiet and have great torque, but that there is no way to fuel or charge them. I really don't want to get stranded in the middle of nowhere because I have no charge or fuel. I don't know how the market will evolve, and I don't want to end up with the wrong truck.

Alyssa
EVP Commercial Vehicles at an OEM

We are proud of how each new generation of our diesel trucks has been more emission-efficient than the previous one. We are developing BEVs and FCEVs, but producing them at scale will require new engineering capabilities and significant investment in production capacity and R&D. This will be a major shift for our business, and we don't know which way the market will go. Besides, so far, there are not a lot of fleet owners asking for these trucks.

Petra
Supply Chain VP at a Shipper

My job is to ensure our materials and products are delivered quickly, cheaply, and in perfect condition. Of course, we want to help tackle climate change and I think our customers would appreciate us using green trucks, but speed and cost of delivery seem to be their priorities. I think we could pay a small premium because we have committed to do our part, but we need to stay competitive.

Samuel
GM Fuel Stations at an Energy provider

As part of our decarbonisation commitments, we are putting a lot of effort into the production of renewable electricity and hydrogen. However, the upfront investments are significant, and the benefits will take time to materialise; we definitely can't do it alone. Additionally, to build a widespread network of charging or fuelling stations we will need some certainty around the demand. If we know when the FCEVs or BEVs will start hitting the road and where, we will make sure the infrastructure is ready.

Sahana
Owner of a Logistics company

Margins in our business are small and they depend on asset utilisation. Our priority is to have trucks full and constantly on the road. We do this by responding to shipper requirements and keeping our costs to a minimum. I haven't seen many zero-emission trucks for sale, but even if they were I doubt my customers would pay more to cover the extra cost, and we don't have a lot of financing options. Plus, there aren't many charging or refuelling points, we are unsure about maintenance, and can't afford to lose flexibility.

Jacques
Transport Sector Lead at a Bank

Fleet owners increasingly ask us about financing options for FCEV and BEV trucks. I think the sector will move there, especially as regulation gets stricter, but we are not yet ready. We are committed to reduce carbon from the sector, but feel most comfortable doing that with proven technologies. Zero-emission trucks are too expensive, we do not know how to estimate the TCO and there is too much uncertainty around the resale value. In short, the risk of the loans not being paid back is too high for us at this stage.

Lin
Director at a Road Regulatory Authority

There is a lot of momentum behind the work we are doing, but it can be difficult to align with other authorities. We have so many interests to consider when designing a policy that it can be difficult to set realistic timelines and remain technology agnostic while still meeting our mandate. For example, we cannot stifle trade by making transport too expensive, or force OEMs to move manufacturing jobs overseas. Also, the budget we can spend on incentives is limited and it is often not clear where it will have the biggest impact.

Zoe
Consumer

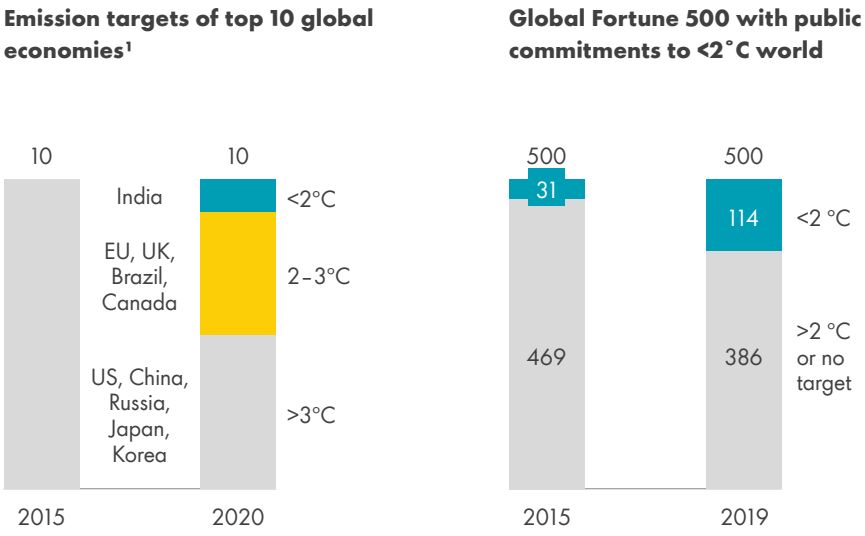
I do a lot of shopping online; even more since the COVID lockdown – it's just so convenient. I really like that my packages are delivered so quickly – next day in most cases. Of course, I care about the environment and want to do my part to help, but I don't think as one person I can do much – my carbon footprint is probably very small, but I don't really know. In any case, I don't get much choice around delivery options.

A New Paradigm: Solutions for Decarbonising

SIGNALS OF CHANGE

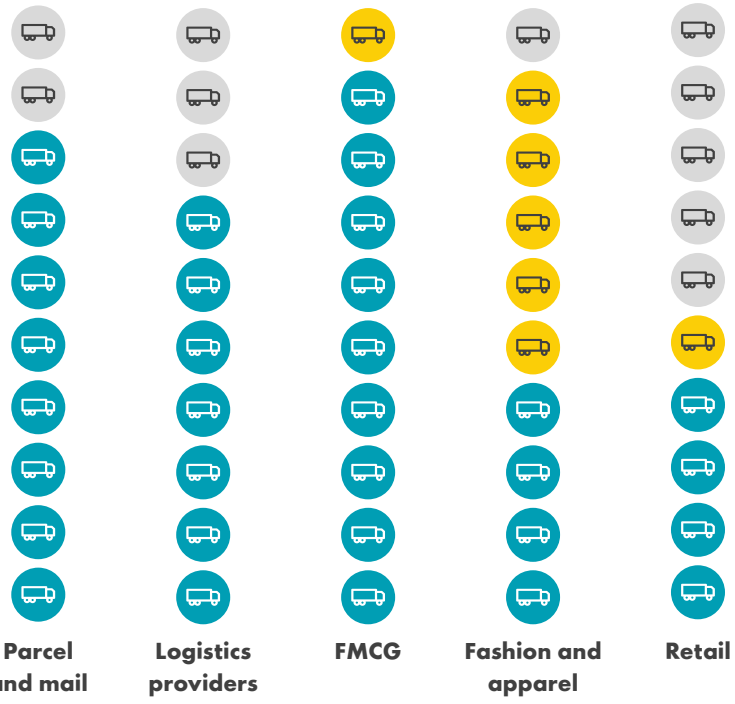
Around the world, business and political leaders are responding to the decarbonisation challenge, with a growing number of commitments to reduce their emissions. Plans to achieve climate-neutrality across the EU by 2050 and in China by 2060 are two notable examples. Increasingly, these commitments include road freight, both directly, as Scope 1 and 2 targets for logistics companies looking to reduce emissions from their own operations, or indirectly, as Scope 3 targets for shippers looking to reduce emissions from their supply chain (see Exhibit 29 and 30).

29 **Climate targets and commitments**



Source: Climate Action Tracker (Nov 2020); Natural Capital Partners; Deloitte analysis
Note: 1) Before 2015, targets were often not reported in relation to global temperature – targets inferred based on absolute emission-reduction targets by country

30 **Companies with road freight commitments (top 10 players per sector)[1]**



Sources: Corporate websites and Deloitte analysis
Notes: 1) Top 10s used from Forbes (retail), 3PL Logistics (logistics providers), FirmsWorld (FMCG), BizVibe (fashion) and Value Today (parcel and mail); Top10s based on 2019 revenue, except for parcel and mail where market cap. at end of 2019 is used; 2) For parcel & mail and logistics providers, scope 1 and 2 commitment in latest annual (sustainability) report was interpreted as a road freight commitment. For other sectors, scope 1 and 2 commitment in annual (sustainability) report was interpreted as owned fleet only, if a scope 1, 2 and 3 commitment was given and/or there was an explicit reference to third-party (road) logistics, this was interpreted as full road freight commitment

31 **Employees are becoming increasingly focused on decarbonisation**

The first global climate strike took place in September 2019, with over six million students and employees taking part across 150 countries. The purpose of the demonstration was to speak out against company and government environmental impacts, and to demand more action be taken, including curtailing the use of fossil fuels, and stopping donations to climate-denying politicians and think tanks. Employees from Amazon and Google participated in the first strikes, a move that is credited in part for recent environmental initiatives from both companies. These strikes are not an anomaly, as companies report an increase in employee activism and increasingly use climate commitments to attract and retain talent.

Sources: The Wall Street Journal, The Guardian, CNBC and Wired

On the demand side, customers, investors and employees are putting increasing pressure on large global shippers to tackle the emissions generated by their supply chains. This pressure has started to translate into tangible action, for example through employees demanding their employers make greater efforts to decarbonise (see Exhibit 31). Notably, those shippers that operate their own truck fleets have made major commitments and large-scale investments in low- and zero-emission technologies. "We are now really starting to walk the talk on decarbonisation as it's clear that what is good for society is good for business," said a global shipper.

Regulators are not standing still, and almost every week new announcements are made about more ambitious decarbonisation pathways and targets. Markets such as the EU, Canada and the US have all announced targets to reduce tailpipe emissions by 20% to 30% before 2030. Existing targets are also intensifying, with the UK recently moving forward its ban on the sale of petrol and diesel passenger vehicles to 2030. Many interviewees expect the next five years to bring an acceleration in regulation, with a possible convergence of targets across most geographies in the second half of the decade.

"Regulations are only going in one direction; they are getting tighter, and the transition is moving faster than we anticipated."

OEM

Exhibit 32

INTERVIEW INSIGHTS

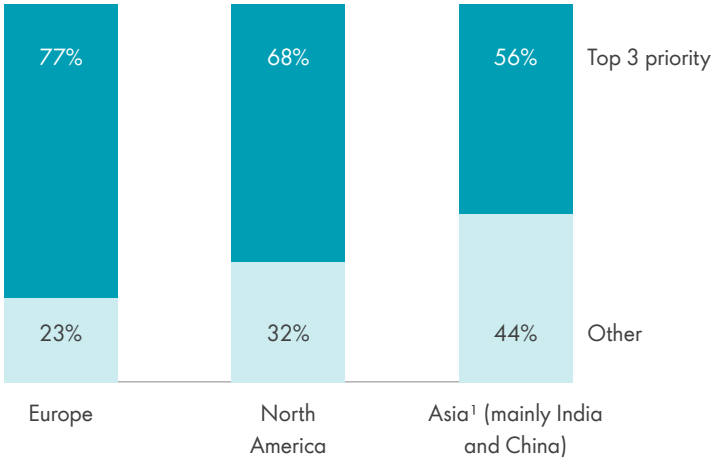
70%

Research participants perceive **decarbonisation as a top 3** priority for their organisation

Meanwhile, investment is growing in green energy projects. Africa's Renewable Energy Initiative (AREI) – which is making progress in achieving at least 300 GW of new renewable energy generation capacity by 2030[35] – reflects a concerted move to lower the cost of sustainable fuels and create a more abundant supply. The development of BEV charging and hydrogen fuelling stations is also under way – principally in Europe and the US. For example the number of hydrogen fuelling stations has more than quadrupled between 2015 and 2019[36], albeit from a low base.

Importantly, in the past 12 months alone, almost all major global OEMs have announced plans to develop and commercialise alternative technology trucks. New industry alliances are also emerging,

33 **Importance of decarbonisation across geographies**



Note: 1) Although participants in Asia noted decarbonisation was a priority for their organisation, they flagged that the importance of the topic was growing, but not yet high in either market

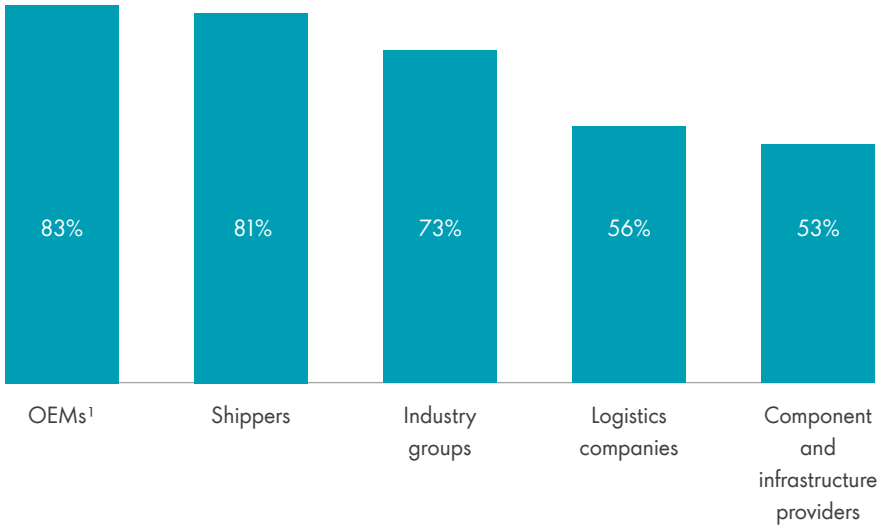
such as Road Freight Zero, a multi-stakeholder coalition of the World Economic Forum that aims to advance the deployment of zero emission fleets and infrastructure.

Against this backdrop, around 70% of interviewees perceive road freight decarbonisation as a top or top-three priority for their company or organisation (see Exhibit 32). Geographically, this sentiment is most pronounced in Europe, with the US and Asia closely behind (see Exhibit 33).

Interviewees representing industry groups (such as trade bodies, coalitions and NGOs), shippers and OEMs were the most positive about their organisations' commitment to decarbonisation, while those representing logistics companies were more reserved (see Exhibit 34). Several interviewees explained this difference by pointing out that logistics companies – especially those with their own fleets – will be the ones having to make early investments in alternative technologies. As such, these stakeholders are careful not to make promises about how much progress they can make, before they are confident that the technology and market environment are ready. "We do believe decarbonisation is critical, but we cannot do it alone or before the technology is ready. So, for now, we are waiting," said one fleet owner.

Virtually all interviewees indicated that the COVID-19 crisis will likely result in more attention given to the decarbonisation of road freight. During the months of lockdown, people living in many cities experienced cleaner air and less noise, thanks to far fewer vehicles on the roads. This was reinforced by the psychological link between a respiratory illness and the need for clean air. Simultaneously, the critical role of road freight became even more apparent, as society depended on timely delivery of essential goods to homes and nearby shops. As one interviewee summarised it: "The pandemic has shown that the trucks are essential, and the future is decarbonised – there are no doubts."

34 **Participants that consider decarbonisation as top 3 priority**



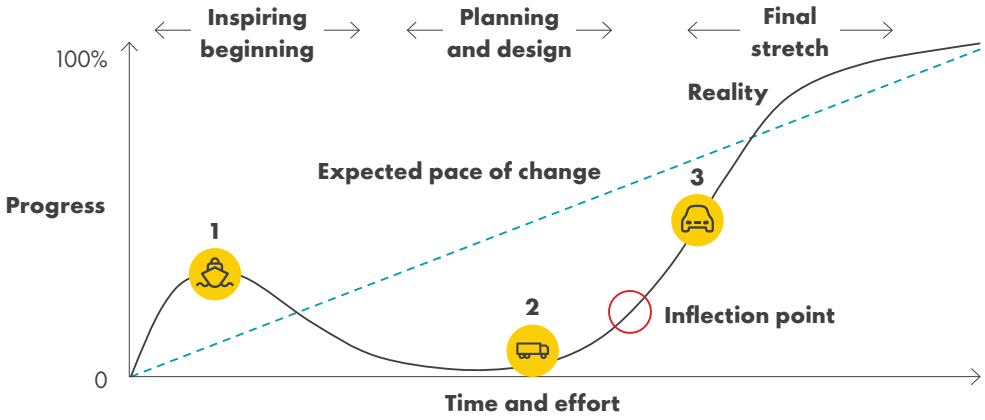
Note: 1) OEM interviewees view decarbonisation as key to future-proof their core business

INFLECTION POINT – MOVING BEYOND PLANNING AND DESIGN

To accelerate decarbonisation and demystify the transition, it is useful to compare road freight with other sectors undergoing a similar change. Building on the Decarbonising Shipping: All Hands on Deck report published by Shell and Deloitte in July 2020, and analysis of several other sectors, we can contextualise where road freight is on its journey towards a zero-emission future.

Some interviewees have noted that there is often a difference between perceived and actual pace of change and this holds true with decarbonisation (see Exhibit 35). In the early stages, a joint ambition to decarbonise and the success of initial pilots unite stakeholders, inspire optimism and create an expectation that a sector-wide solution is just around the corner. Over time, this optimism often declines as efforts intensify around the planning and design of improvements to technology and infrastructure, in preparation for widespread deployment. One interviewee pointed to studies that show that during major transitions "everything can look like a failure in the middle," even when significant progress is being made. The interviewee also noted that the range and specificity of identified barriers are a testament to how much attention is now given to decarbonisation.

35 **Decarbonisation vs. typical change-adoption phases – ILLUSTRATIVE**



1. Inspiring beginning – e.g. shipping

- Optimism that over next 20+ years "the sector" will find a way to decarbonise.
- Demand and technology alignment are key barriers – things that seem abstract.
- Most investments are in the future

2. Planning and design – e.g. road freight

- Progress seems slower than expected.
- Practical barriers of infrastructure and scaling asset production seem daunting
- New assets are still very expensive, but investments need to be made now ("which truck do I buy?")

3. Final stretch - e.g. personal vehicles

- Progress is visible.
- Infrastructure is being built at scale, and assets are being replaced.
- Cost of new assets is close to parity – investments are "easy"

Sources: Deloitte analysis based on Ryan Raffaelli (2018) "Leading and Managing Change" and Kanter, Rosbeth (2006) "Confidence: How Winning Streaks and Losing Streaks Begin and End"

Many interviewees believe the road freight sector is nearing an inflection point and will evolve faster than expected (see Exhibit 36). Most technologies to decarbonise road freight already exist – even if they are not yet commercially viable – and most truck manufacturers already have FCEVs and BEVs in development. And progress is likely to become clearer once some of the key pieces of the puzzle start falling into place, namely aligned incentives, trucks being produced at scale and visibly accessible infrastructure.

"There are a lot of opportunities that we couldn't have imagined 10 or 20 years ago."

Logistics Company

To decarbonise, the road freight sector needs to move beyond planning and design, and start deploying alternative technologies to operations, where they can be stress-tested and refined. The goal is to create a snowball effect, where more trucks on the road mean more reliability, lower cost and more infrastructure – which in turn creates the incentive to invest further. Several interviewees indicated that achieving the economic viability of alternative technologies through scale will be critical, because a sector as large as road freight will not be able to rely on regulatory or customer subsidies for long.

There is no need to wait for a perfect solution. Road freight stakeholders have at their disposal the products of the enormous technical, market and regulatory progress made to date. Therefore, existing technologies need to be quickly put to commercial use, so that learnings can be captured, and further improvements made.

Exhibit 36

2. **RESEARCH HIGHLIGHT**

Road freight decarbonisation is **close to an inflection point** due to increasing regulatory and market pressure, and will **evolve faster than many expect.**

APPLYING A DUTY CYCLE PERSPECTIVE

Developing a view on how the sector might decarbonise calls for an understanding of the way trucks are used. The around 63 million MDTs and HDTs are part of an intricate logistical network in which their roles range from connecting production sites thousands of kilometres apart, to delivering food to supermarkets in urban areas. To identify the right solutions, we must apply different lenses, such as distance driven, geographical coverage, how predictable and repeatable the routes are, and number and length of breaks (see Exhibit 37). We summarise the most important of these lenses into four "duty cycles" (see Exhibit 38).

MDTs and HDTs are used for both medium- (<500 km per day) and long-distance duty cycles. The view from within the industry is that each of these two cycles accounts for around half of all MDT and HDT activity. The shortest daily distance of under 250 km is covered when trucks operate on "milk runs", staying in and around urban areas, typically delivering goods from local depots to retail points such as supermarkets. In this instance, they often stay idle for the night. Trucks operating in the second duty cycle – "24/7 regional operations" – typically cover slightly longer daily distances (up to 500 km), and have significantly less downtime.

There are also two long-distance duty cycles. The first, "multi-day trips", involves journeys between regions or countries, where distances reach up to 1,200 km per day, constrained by fuelling time, driver breaks and driving time regulation. The most intensive duty cycle is "24/7 long-haul", where trucks are in near constant use across regions and countries. This duty cycle involves multiple drivers, and is characterised by up to 2,000 km of daily distance and very few periods of extensive truck downtime.

An additional consideration across all duty cycles is whether the journeys are planned and repetitive – otherwise called "engineered routes" – or entirely flexible. Interviewees indicate that this has major implications on how much infrastructure will be needed, and where. The duty cycles also evolve over time as technology and supply chains mature. For example, improvements in network planning and developments in autonomous driving increase the ability of logistics companies to keep trucks occupied, thereby shifting volume from milk runs to 24/7 operations.

A common perspective among interviewees is that "no one size fits all," and the industry will need to work with different technologies for different applications. Understanding duty cycles is therefore critical to converging on viable low- and zero-emission technology. It allows the sector to make progress in specific duty cycles early, instead of waiting for a solution that is optimal across the board.

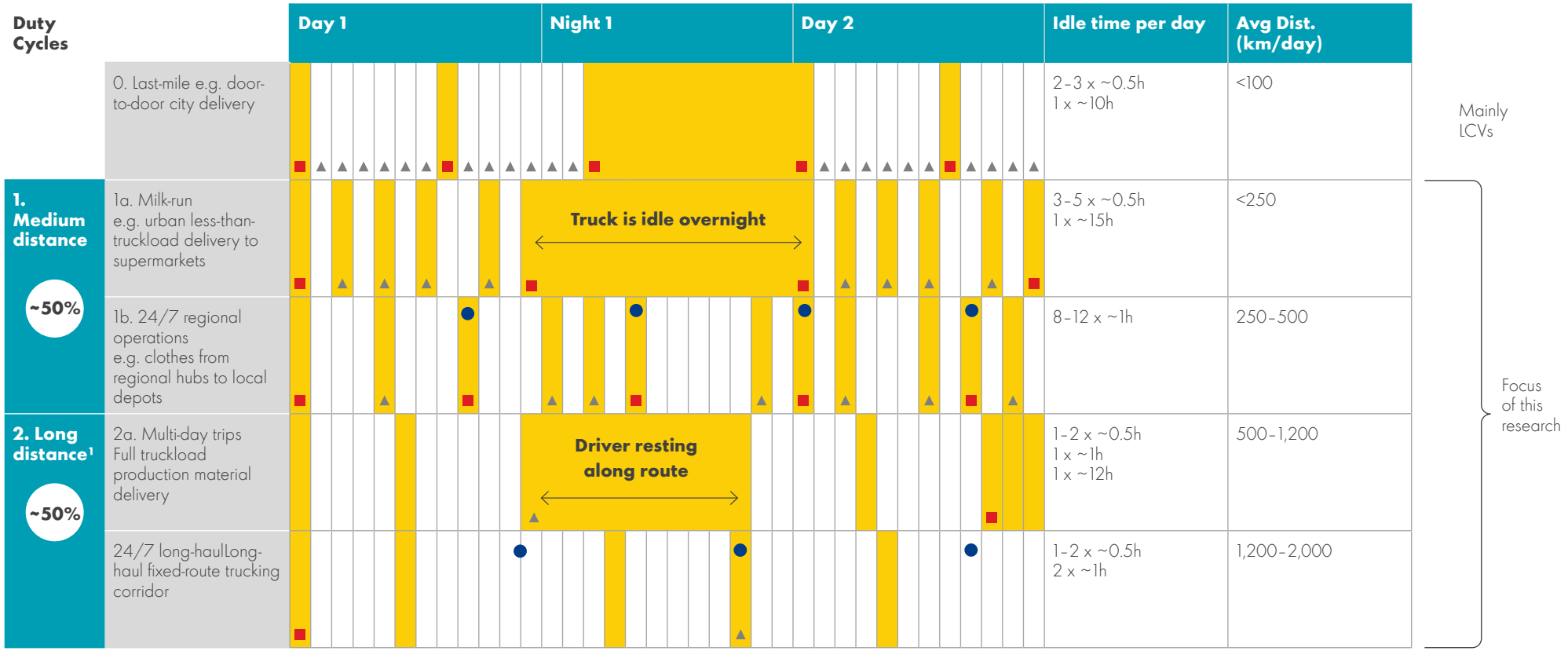
Exhibit 37

3. **RESEARCH HIGHLIGHT**

To converge on a viable low- and zero-emission technology, the sector needs to adopt a **duty cycle perspective.**

In some cases, the sector stakeholders may choose to fundamentally tailor the way the supply chains are organised to take advantage of the emerging technologies and make their fleets more efficient.

38 **Typical truck duty cycles**



Notes: 1) Driver rests for 45 minutes every 4.5 hours; typical driving day is assumed to be 9 hours of driving (can be extended in certain situations to 10 and 11 hours in Europe and US respectively); 2) TKM for Europe, China and US extrapolated to rest of world

SOLUTIONS

A wide range of initiatives were identified to address the barriers to decarbonisation, and move road freight past the planning and design stage of the transition. These initiatives were refined into a catalogue of 22 solutions through industry workshops and review sessions.

The large number of solutions demonstrates both the volume of ideas and initiatives already present in the industry, the variety of actions that must be taken and the stakeholders that must be involved. Although each solution is individually important, none will be enough on its own. Integration between them, and collaboration across the ecosystem is essential to accelerate progress.

The 22 solutions fall under four main categories, based on their shared characteristics.

Make impact now

This category comprises three solutions that can be started immediately to reduce emissions with existing technologies:

1. **Transition of viable duty cycles:** scale up replacement of small and medium-sized trucks and buses in viable short-range and urban duty cycles using existing BEV and FCEV solutions.
2. **Targeted deployment of transition technologies:** commercialise LNG-, bioLNG-, CNG- and biodiesel-powered trucks around existing points of supply, and expand natural gas supply where it does not substitute from investment in zero-emission technologies.
3. **Operational and design efficiencies:** reduce the existing fleet's emissions by using digitisation and analytics tools to improve usage at a company and sector level, and through other operational improvements such as aerodynamics, driver assistance devices and fuel and lubricant quality.

Create a snowball effect

This category comprises six solutions designed to activate the ecosystem, tackle the chicken-and-egg dilemma, start building demand for heavy-duty zero-emission trucks and bring down their cost:

4. **Pilots in clusters and corridors:** use coalitions and partnerships to deploy zero-emission trucks in regional or duty-cycle clusters and along high-traffic corridors, with shared infrastructure and a dedicated fuel supply.
5. **Technology partnerships:** minimise technology and production risk by establishing partnerships and joint ventures between OEMs and component providers for early production of zero-emission trucks.
6. **Joint truck-purchasing commitments:** increase demand certainty while reducing unit price and risk by consolidating orders from multiple fleet owners.

7. **New OEM revenue models and secondary-market certainty:** reduce fleet owners' capital cost and residual value through new OEM revenue models (such as truck-as-a-service), purchase commitments and secondary-market development.

8. **Green transport procurement:** incentivise fleet owners that invest in emission reduction by including efficiency and reporting requirements in tender criteria – with weighting increasing over time – and by awarding longer contracts.

9. **Green finance:** establish green lending portfolios, and develop new financing instruments to support alternative technology trucks and infrastructure purchases – particularly for small owners.

Build conditions for success

This category comprises nine solutions to give the sector stakeholders incentives and information required to move to widespread adoption of zero-emission trucks:

10. **Consumer awareness and choice:** increase consumer demand for products shipped with lower-emission vehicles, through carbon labelling, and branding and marketing of green trucks and products.

11. **Regulatory pathways:** develop and communicate principles for future regulation and medium-term policy milestones.

12. **Joint city campaigns:** unify clean air and low-emission-zone policies and timelines between major cities and industrial hubs within each region.

13. **Expanded policies for OEMs:** define policy measures and incentive schemes for OEMs, including fleet emissions requirements and production incentives.

14. **Expanded policies for energy providers:** create renewable fuel requirements and grant programmes for energy providers to expand green energy production, and charging and refuelling networks.

15. **Expanded policies for fleet owners and shippers:** define emission reporting standards, targets and incentives for owners, operators and users of large truck fleets, including purchase incentives and tax breaks.

16. **Information democratisation:** create knowledge hubs and sector fora to share non-competitively-sensitive information on technology development, and provide a platform to debate differing pathways.

17. **Charging, fuelling and fuel standards:** establish industry standards for fleet emissions, battery charging, hydrogen fuelling applications and hydrogen quality, to de-risk asset investments.

18. **Cross-sector R&D:** engage with adjacent sectors working on similar technology challenges to share and scale R&D resources, including hydrogen infrastructure and industrial batteries.

Scale

This final category comprises four solutions that focus on the mass production of trucks and fuels, ensuring maintenance capability and integration with other technology roadmaps:

19. **Scaled truck production:** expand production capacity of BEV and FCEV trucks, and gradually scale down production and investments in diesel technologies.

20. **Scaled energy production and distribution:** expand production and distribution infrastructure, including charging and fuelling for renewable electricity and hydrogen, starting in areas around pilot clusters and corridors.

21. **Expansion of maintenance capabilities:** develop maintenance capability at scale – including third parties – to support the growing fleet during the transition period.

22. **Future-fit logistics:** integrate decarbonisation pathways into broader technology roadmaps, including autonomous driving, connectivity and analytics.

MAKE IMPACT NOW

1. Transition of viable duty cycles

Many fleet owners have already started using smaller alternative technology trucks. For instance, BEVs are technically and economically viable in urban last-mile duty cycles where driving ranges are relatively short, vehicles idle overnight and there is easy access to charging infrastructure. Notable recent examples include Amazon's order of 100,000 electric trucks from US start-up Rivian[37] and IKEA's commitment to use electric vehicles for all of its home deliveries globally by 2025 – having reached that goal already in cities such as Shanghai[38].

City buses have also been at the forefront of a shift to hydrogen and battery technologies for some time. In addition to having fitting duty cycle characteristics, buses benefit from the willingness of some authorities to bear higher upfront costs to help reduce noise and emissions within their cities. For instance, Shenzhen is the first major city with an entire bus fleet – comprising around 16,000 vehicles – running entirely on electricity[39].

LCVs and buses are not the primary focus of this research, but their impact on other segments cannot be overlooked. Accelerating the transition of viable vehicle types and duty cycles to BEV and FCEV (see Exhibit 39) will help the sector to "make an impact today, and allow technologies and infrastructure to evolve," says one fleet operator. In doing so, the sector will improve technology maturity, bring down costs and create conditions for investments in renewable electricity, grid upgrades and charging point installations. It will also help to promote the benefits of alternative technologies and build momentum in the market.

"If we made minor adjustments to how we do deliveries, we would be able to transition the majority of our delivery fleet today."

Fleet Operator

In addition to transitioning duty cycles that can be addressed with today's technology, fleet operators should look for opportunities bring more of their fleet within scope by making minor adjustments to operations. For example, this could take the form of planning breaks in places where opportunity charging is possible like specific depots or stores.

Transitioning viable duty cycles will take time and focus, but should not distract from progressing harder-to-abate segments such as HDTs.

39 **Duty cycles transition**

Duty Cycles		Idle time per day	Avg. Dist. (km/day)	LCV	MDT	HDT	Summary
	0. Last-mile e.g. door-to-door city delivery	2-3 x ~0.5h 1 x ~10h	<100	BEV	BEV		▪ Short distances make BEV more applicable ▪ Possible use of personal vehicle charging infrastructure ▪ Low-emission zones in cities require faster transition
1. Medium distance ~50%[1]	1a. Milk-run e.g. urban less-than-truckload delivery to supermarkets	3-5 x ~0.5h 1 x ~15h	<250		BEV	BEV and/or FCEV	▪ Medium distances and enough breaks for MDTs to use BEV ▪ In HDTs, battery size and charging time may be impractical
	1b. 24/7 regional operations e.g. clothes from regional hubs to local depots	8-12 x ~1h	250-500		BEV and/or FCEV	BEV and/or FCEV	▪ BEV may be viable in the longer term if opportunity charging infrastructure is widely and densely available ▪ FCEV may be viable sooner, with less need for a dense fueling infrastructure, if price of hydrogen declines
2. Long distance ~50%[1]	2a. Multi-day trips e.g. full truckload production material delivery	1-2 x ~0.5h 1 x ~1h 1 x ~12h	500-1,200			FCEV	▪ FCEV likely more viable given long distances and few breaks ▪ BEV only if batteries significantly improve density or if very fast charging becomes available
	2b. 24/7 long-haule.g. long-haul fixed-route trucking corridor	1-2 x ~0.5h 2 x ~1h	1,200-2,000			FCEV	▪ FCEV likely the only option in foreseeable future

Likelihood of alternative technology

BEV more likely

FCEV more likely

Source: Deloitte Analysis
Note: 1) Estimated share of total MDT and HDT truck volume (tonne-kilometres). Illustrative, based on interviews with fleet operators

2. Targeted deployment of transition technologies

Interviewees highlighted the role of LNG, CNG, bioLNG and biodiesel in reducing road freight emissions while zero-emission alternatives for MDTs and HDTs are being developed. Although LNG and CNG do not bring emissions to zero, and bioLNG and biodiesel have supply constraints, they are technically mature and can improve the tailpipe emission profile of today's trucks.

"They aren't perfect, but they are better than nothing and are the only option available to us today," says one fleet operator. Across geographies, fleet owners in search of short-term decarbonisation measures are starting to commit to biofuels. As a notable example, the UK's John Lewis Partnership has announced it will switch all heavy delivery trucks to biomethane-powered versions by 2028[40]. Hybrid trucks were also frequently mentioned as a viable interim solution, to reduce emissions while maintaining flexibility.

Importantly, to avoid a lock-in effect, transition fuels should be used when and where they will not be disruptive to investments in zero-emission technologies. For example, several interviewees noted that India will likely take longer than Europe or the US to adopt BEVs and FCEVs in road freight due to infrastructure and economic constraints, but that in the interim there may be potential to increase the use of biofuels or CNG.

Transition fuel projects can also serve as a blueprint on how to scale zero-emission technologies through targeted pilots. For example, Eco-Gate, an EU-supported project made up of over 50 consortium partners and stakeholders, aims to install natural gas supply points and a network of stations along a strategically positioned transport corridor in southern Europe.

Several interviewees noted that carbon offsets – as used by most courier companies and many logistics operators – will continue to play an important role in reducing net emissions until a viable alternative technology becomes available. Although most interviewees recognise offsets as a valuable interim solution, some noted concerns: "Offsets risk taking focus and investment from the actual problem, and give an excuse to not take action," said one executive working for a large shipper. Not only should offsets avoid diverting investment from decarbonisation pathways, where possible they should also be focused on programmes that contribute to sectoral decarbonisation, such as renewable energy production.

3. Operational and design efficiencies

Most interviewees indicated that there are still opportunities to reduce emissions from the current fleet by improving truck design and operations. One technology company noted that "many companies in the sector could reduce 30% of emissions just by adopting existing technologies and using trucks better" (see Exhibit 40). Crucially, these improvements are often ROI-positive, as they result in lower fuel consumption and cost.

Design improvements relate primarily to reduction in vehicle drag, friction and rolling resistance, such as using automatic tyre pressure control and energy-efficient lubricants. Large fleet operators already adopt many of the latest technologies, but many interviewees believe there remain significant opportunities among the many smaller companies that make up a large proportion of the sector. These companies will need help to recognise and capture the longer-term savings resulting from investments in newer truck models and retrofitting old ones. This can be achieved through measures such as building key technologies into standard truck models, designing financing options for truck upgrades and retrofitting, and increasing awareness around TCO.

"30 to 50% of trucks at some companies run empty; this is where you start decarbonisation."

Fleet Owner

Interviewees see even more potential to reduce emissions through operational efficiencies, especially by reducing empty or under-laden kilometres. Addressing empty kilometres may also accelerate zero-emission pathways simply by reducing the number of trucks on the road and shrinking the scale of the challenge. Conversely, empty kilometres and truck volumes may continue to grow if nothing is done to mitigate the rise of e-commerce and growing consumer expectations around delivery times. The largest opportunity for improvement is in domestic transport and developing markets where empty kilometres are often twice as high as on international routes in developed markets[41].

Finally, greater use of connectivity and analytics can drive truck efficiency, while using digitally-enabled aggregators can help better match supply and demand. This would help to optimise the network at both the individual company and sector level. Interviewees also mentioned opportunities to reduce emissions within individual journeys, citing solutions such as platooning and driving assistance.

40 **Example efficiency measures – heavy-duty trucks[1]**

	Design efficiencies			Operational efficiencies		
	Aerodynamics	**Tyres**	**Driveline**	**Route optimisation**	**Platooning**	**Driver assistance**
Description						
	Drag reducers (e.g. gap seals and boat tails)	Low resistance tyres and automatic pressure control	Transmission gear and friction reduction (e.g. better lubricants)	Optimise (partially) empty kilometres with digital solutions[2]	Close driving at constant speed, with fewer speed changes	Predictive cruise control and automated eco-driving
ICE fuel savings potential (%)	6-14	1-9	1-4	1-25[3]	4-17	1-10

Sources: ICCT (2012) Reducing aerodynamic drag and rolling resistance from heavy-duty trucks; ICCT (2017) Fuel efficiency technology in European heavy-duty vehicles; ICCT (2018) Automation in the long-haul; Torabi and Wahde (2018) Fuel-efficient driving strategies for heavy-duty vehicles; UK Government Office for Science (2019) Decarbonising road freight; Commercial Fleet (2019) Load sharing: how to avoid running on empty; Transport and Environment; RTS; ACEA; Deloitte analysis

Notes: 1) Excl. non-truck optimisations (e.g. tarmac on highway has a 6% fuel-efficiency improvement potential); 2) Empty truck kilometres and unutilised weight capacity is estimated at 20–28% and 37–39% respectively; 3) Assumed that both empty and partially-empty can be optimised in parallel

CREATE A SNOWBALL EFFECT

4. Pilots in clusters and corridors

Before fleet owners invest in alternative technology trucks, they will want to be assured that those trucks can be charged or fuelled close to their normal area of operation. But investments in charging and fuelling infrastructure are not viable if there are too few BEV and FCEV trucks on the road around them.

The sector can start solving this chicken-and-egg dilemma if fleet owners, infrastructure providers and OEMs jointly pilot alternative technologies in clusters or transportation corridors that are geographically small and have a high volume of road freight activity. In these carefully selected areas, pilot partners can ensure sufficient infrastructure density and truck numbers to justify investments on both sides. One interviewee illustrated the point, saying that: "There are regions close to the North Sea where dozens of livestock and dairy shippers operate on short, dense routes. We could move this whole operation to hydrogen with just a few stations."

Pilots that involve real commercial operations and multiple fleet owners in contained geographical areas will have a greater impact on technology development than the technically-focused pilots largely used today. Fleet operators will share the costs and operational risks, and generate large amounts of data on how the new technologies behave in real duty cycles, carrying real cargo, and fuelled at real stations. Such data will be invaluable for OEMs to increase the reliability of BEVs and FCEVs while bringing the cost down. Large shippers will also have a key role to play by investing early in trucks that help them meet their own emission reduction targets, and by maturing these new technologies so that smaller logistics companies can use them later.

"Coalitions are a win-win situation for ecosystem partners to scale and benefit from a new technology while mitigating risk."

Financier

Initiatives that bring together multiple operators are still scarce in the road freight sector, but several pilot projects involving trucks and infrastructure have been launched recently. Notable examples include the partnership between Scania and ASKO to use hydrogen trucks in operations in Norway[42], and the West Coast Electric Highway project in the US[43] (see Exhibit 41). Overhead charging pilots have also been established in both Sweden and Germany to accelerate BEV transitions along certain corridors[44].

It will become progressively easier to expand regions and corridors as pilots are scaled. These first pilots will help lower technology costs, expand infrastructure networks and build operational confidence.

41 **Interstate 5 highway**

The Interstate 5 highway is the main north-south corridor running from Canada to Mexico through several large cities on the US West Coast. The aim of the West Coast Electric Highway project is to electrify both passenger and cargo transport along the route and its connecting highways.

The aim is to install 27 stations for LCVs and MDTs at roughly 80-kilometre intervals by 2025, of which 14 will be upgraded to facilitate HDT charging by 2030.

Although this project will require investments for grid upgrades and real estate , the high volume of traffic strengthens the business case. This project will also be able to take advantage of government support and existing passenger vehicle networks. These factors create the conditions to begin scaling up infrastructure, which will in turn lower technology costs and improve maturity.

Source: Greencarreports.com

5. Technology partnerships

OEMs have been reluctant to scale up production of FCEVs and BEVs to date given uncertainty around demand for alternative-technology trucks and the regulatory environment. Currently, most OEMs still focus their decarbonisation efforts on refining and testing concept vehicles at small-scale. As a result, the market remains constrained on both the demand and supply side.

Joint ventures and other partnership schemes are an effective way of spreading the risk and investment associated with acquiring key technical components, re-designing the supplier networks, upgrading production facilities and retraining the workforce. This will allow OEMs to innovate "at the edge" of the current business and gradually move them into the core business as they mature. Interviewees see three main models for such partnerships.

Firstly, collaborating on R&D with key component providers, such as hydrogen fuel cell or battery manufacturers, can help OEMs gain access to critical technologies faster while managing the risks of integration with other elements of the truck. One OEM noted that "collaboration with battery suppliers is a must if we want to bring reliable BEVs to market quickly. Partnerships will be more valuable than investing in technology ourselves."

Secondly, partnerships between OEMs can help to accelerate the time it takes to make alternative technologies market-ready and scale up production. One OEM highlighted that "partnerships allow us to scale R&D investments, manage technology risk, and leverage core competencies around a common goal." There have been important examples of this approach in recent months – notably IVECO's recent joint venture with Nikola to accelerate the development of hydrogen HDTs, and other OEMs forming partnerships[45], as shown in Exhibit 42. The Daimler and Volvo fuel-cell joint venture[46] may provide a blueprint for such collaboration, with the two global OEMs planning to work jointly to "develop, produce and commercialise fuel-cell systems", while they "continue to be competitors in all other areas, such as vehicle technology and fuel-cell integration in trucks."

Thirdly, to accelerate market development, OEMs can form partnerships with other ecosystem stakeholders such as infrastructure providers. Ionity provides a notable example of this solution in the passenger electric vehicle market. It is a joint venture between leading vehicle manufacturers to build a high-power charging network for electric vehicles along major highways in Europe (see Exhibit 43)

42 **Example technology partnerships – OEMs**

	Hyundai Cummins	Traton Hino	BYD Toyota	Daimler Volvo
Truck type	BEV and FCEV	BEV and FCEV	BEV	FCEV
Shared development	Integrate components from both players into one truck	Truck and platform development, including software and interfaces	Truck and platform development	Development of fuel cell technology
Starting year	2019	2020	2020	2021
Regional focus	North America	Global	China	Global

Sources: Hyundai (2019) Hyundai Motor Company and Cummins to Collaborate on Hydrogen Fuel Cell Technology; Volkswagen AG (2020) TRATON and Hino start E-Mobility Joint Venture; Toyota (2019) BYD, Toyota Agree to Establish Joint Company for Battery Electric Vehicle Research and Development; Daimler (2020) Fuel cell Joint Venture. Volvo Group and Daimler Truck AG sign binding agreement
Note: "Platform" refers to the truck's main body, including the chassis, drivetrain, steering and suspension

43 **Ionity: high-power long-distance BEV charging infrastructure**

The Ionity project, initiated in 2017, is a joint venture between seven OEMs (BMW, Ford, Hyundai, Mercedes-Benz, Volkswagen, Audi and Porsche) to deliver a high-power long-distance charging network for EV passenger cars across Europe. The additional charging infrastructure was required to further scale the broad adoption of electric passenger cars in Europe.

The project is a close collaboration between the OEMs and 20 large highway service station brands that are conveniently located on or close to major European highways. By the end of 2020, Ionity will have 400 fast-charging stations operational, which all have standardised charging procedures to facilitate fast charging for participating OEMs.

Source: Ionity.eu

6. Joint truck-purchasing commitments

In a market dominated by small fleet owners, no single company will be able to create enough demand for alternative trucks to move the technology down the cost curve. Fleet owners should therefore form joint purchasing commitments to convince OEMs to invest in scaling up production. With increased order sizes, the unit price for fleet owners is likely to reduce, resulting in a more competitive TCO.

Joint purchasing commitments covering specific regions or road freight corridors will also incentivise infrastructure players to invest in such locations because of the greater demand certainty. If desired, the joint purchasing commitment can be extended to include the fuel of the vehicle.

7. New OEM revenue models and secondary-market certainty

Many interviewees suggested that OEMs will need to help fleet owners reduce high upfront costs of alternative-technology trucks, and mitigate the risks related to truck residual value and maintenance, to stimulate demand. Without such measures, the economics of adopting alternative trucks will not be viable for fleet owners – particularly the smaller ones – as illustrated by the executive of a shipping company: "If I buy the best available electric truck today, and my competitor buys a truck next year with twice the range, my business is in trouble."

To lower the upfront capital required and address the risk that rapidly advancing technology puts an owner at a disadvantage, OEMs could implement temporary truck-as-a-service business models. Instead of buying a truck, operators would pay a usage fee – for example, based on the distance driven – and would be able to exchange for a new model after a certain period. Other possible solutions to reduce the risk of residual value include secondary-market purchase commitments, government-backed truck values, and extended component warranties.

"My business case will be much clearer if I know I will be able to sell the truck in three years at a reasonable price."

Logistics Company

OEMs can further strengthen the business case for alternative trucks by including additional services in the purchase price. Notably, interviewees mentioned maintenance services and preferential or discounted access to charging or fuelling infrastructure networks as attractive incentives.

8. Green transport procurement

Interviewees noted that although some large shippers have recently started including emission-related questions in road freight tenders, these questions often have limited influence on which logistics company is selected. To accelerate decarbonisation, shippers should increase the importance of emission criteria in tenders. "Shippers have a key role in convincing fleet owners to buy the latest, most emission-efficient trucks," said one shipper.

The first step is to increase transparency. As a condition to enter a tender, shippers should require suppliers to provide data on the emission performance of their fleets, and on their plans to improve it. Although initially not treated as a selection criterion, this requirement will send an important message to fleet owners, and give them time to prepare for more substantive actions.

As a second step, shippers should include emission-efficiency criteria in the tenders. A common mechanism some already use is setting a minimum share of the truck fleet using Euro VI or equivalent engines. Shippers should also make it clear that the criteria themselves, as well as their relative weights, will become stricter over time, and that zero-emission requirements will be included when FCEVs and BEVs become more widely available.

Thirdly, shippers with predictable road freight volumes should increasingly offer multi-year contracts to those suppliers that operate the most emission-efficient fleets. This will help to increase fleet operators' access to external financing and reduce the risk of them misplacing investments. It can also open up the possibility of sharing the benefits – such as fuel savings – of more efficient trucks more equally with the shipper

9. Green finance

An alternative technology truck may initially cost three to four times the price of a diesel equivalent, but is likely to have a lower operating cost, especially when taking subsidies into account. Interviewees noted that traditional road freight loans do not account for these differences in cost. This limits the sector's ability to use external financing for investments in transition fuels – such as LNG, bioLNG or biodiesel – and at a later stage, in FCEV or BEV technologies.

Banks and other financiers should therefore commit to sustainability targets for their loan portfolios, and develop financial products designed specifically for alternative technologies. The focus should be on small and medium-sized fleet owners who find it difficult to self-finance new trucks, or access government support schemes.

To spread the risk of financing early-stage technologies, financiers might need to create shared investment portfolios or separate investment vehicles with higher risk-and-return thresholds. Additionally, new assurance schemes might be needed to account for the more uncertain asset values – potentially with regulatory guarantees.

The World Green Building Council's Green Mortgage Initiative is a relevant example from the housing sector. It allows homeowners seeking a mortgage with 37 leading European banks to secure preferential interest rates when purchasing more energy-efficient homes or undertaking measures which improve a property's energy efficiency[47]. This has enabled homeowners to lower their purchase costs and expenses and banks to meet green portfolio targets. It has also expanded demand for energy efficiency technologies in the home.

BUILD CONDITIONS FOR SUCCESS

10. Consumer awareness and choice

Shippers – especially those that sell products to end consumers – can make the carbon footprint of product delivery more visible. This would allow consumers to make more conscious decisions about choosing more sustainable products and delivery options. Shippers who follow such a course could stand to benefit by differentiating their brands and products in the eyes of consumers.

Carbon labelling of products is one possible measure to increase consumer awareness, as demonstrated recently by several notable companies, including Unilever[48], Oatly[49] and Allbirds[50]. The next step is to provide consumers with a choice between products with different carbon footprints. In some market segments, sustainable products may even be able to command premium prices – just as some consumers already choose more expensive fair-trade coffee and free-range eggs and chicken.

Beyond the product itself, companies can make it easier for consumers to choose lower-emission delivery options. "If a customer is shopping online, they want their goods as fast as possible. However, some customers would probably agree to a slightly slower delivery if we made it transparent that it lowers emissions," highlighted an executive from a large consumer goods business.

Trucks themselves can be an important marketing instrument. By using more branded trucks and labelling those that use lower-emission technologies, shippers gain an additional instrument through which they can turn decarbonisation investments into brand equity.

"We are definitely going to start decarbonisation with our own fleet. That is how we build goodwill."

Global Shipper

11. Regulatory pathways

Since policy makers have a range of instruments at their disposal (see Exhibit 44), it is important they identify and communicate which of those instruments will be used, and how they will be integrated with each other to achieve overall decarbonisation targets.

Authorities at all levels – particularly national and federal governments – should clearly outline the type of regulations that can be expected towards 2030 and beyond, what principles will be used to set targets and any interim milestones. "In the US, we have individual states setting aggressive targets, but it would help a lot to have clarity at the federal level," said a US-based global shipper.

The approach taken by the International Maritime Organisation (IMO) in the shipping sector is a relevant example. In 2018, the IMO announced an initial strategy to reduce GHG emissions across international shipping, with absolute and relative emission ambitions set for 2030 and 2050. The IMO is set to announce more specific measures in 2023. The principles should be sufficiently robust that they withstand potential government changes.

By creating a common pathway and timeline, road freight regulators can help fleet owners, OEMs and energy companies more effectively work towards a common goal. Having long-term clarity on what is expected, stakeholders will be more likely to develop alternative technologies in a gradual and economically viable way, break the

44 **Possible regulations, policies and incentives – PRELIMINARY and NON-EXHAUSTIVE**

	What gets regulated	How it is regulated			
Logistics companies / fleet owners	**Trucks bought**	Rebates/feebates to equalise TCO (including VAT reductions)	Loans to overcome high upfront investment costs		
	Truck usage	Weight and dimensions (e.g. add. weight allowance for ZEV)	Low-emission zones in cities and urban areas[1]	Reduction or exemption in road tolls based on emissions	Carbon-based fuel taxation to equalise cost price of alternative fuels
	Fleet ownership	Scrappage of trucks, with buy-back to avoid life extension in other countries	Time-limited tax credits for cleaner trucks	Optimisation packages for truck and trailer (e.g. drag-reduction package)[2]	Periodic real-world emission compliance testing
OEM/component manufacturer	**Trucks produced**	Tailpipe emission (pollution and engine efficiency)[3]	Well-to-wheel emission (pollution, engine efficiency and type of fuel)[3,4]	Lifecycle emissions (includes emissions during construction and recycling – cradle-to-grave)[3]	
Infra suppliers/ energy companies	**Fuel mix sold**	Fuel blending (e.g. % of biofuels added to diesel) and quality (e.g. % sulphur)	Percentage of net-zero or low-carbon fuels sold		Incentives for renewable fuel/ energy production for better cost-competitiveness
	Infrastructure development	Prescribe infrastructure development to ensure minimum network density and availability	Develop standards (safety/ fuelling/charging)		
Shipper/customers	**Logistics footprint**	Tailpipe operational target (potentially including offsetting)	Include transport emissions in emission trading scheme (ETS)	R&D incentives (e.g. funds for trials)	
Financiers	**Portfolio composition**	% green trucks in portfolio	Guarantees to de-risk investment – e.g. to decrease residual value uncertainty	Minimal sustainable finance criteria before providing a loan	

Often mentioned as high priority

Sources: Interviews; Deloitte analysis
Notes: 1) Including parking, (un)loading time windows, or specific low- or zero-emission vehicle lanes; 2) Including aerodynamic improvements and rolling resistance reduction; 3) Potentially including trailer of the truck; 4) Potentially also for infrastructure suppliers or energy companies

chicken-and-egg dilemma between trucks and infrastructure, and minimise the risk of misplaced investments.

"Embracing a well-to-wheel approach would favour the uptake of renewable fuels, while allowing for technology neutrality."

Industry Group

Regulators should adopt an approach to target-setting that spans the entire lifecycle of energy carriers. The scope of this well-to-wheel approach includes the production of a fuel or energy source, its transportation and how it is ultimately used in trucks. A step further would include the environmental footprint related to production and disposal of truck components, such as batteries and fuel cells, but most interviewees consider this highly complex. Other measures interviewees prioritised include truck purchase incentives, carbon-based fuel taxation, and standards around safety, fuelling and charging.

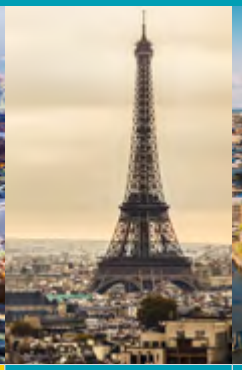
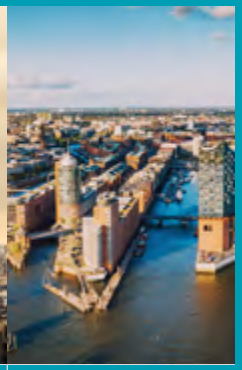
12. Joint city campaigns

To reduce air pollution and noise, city and municipal regulators are increasingly implementing measures limiting access of trucks using older technologies into urban areas or parts of them. Cities, such as Paris, plan to go as far as entirely banning non-zero-emission vehicles in the coming years. Many interviewees see these low-emission zones as an important catalyst for decarbonisation, with one fleet operator explaining that "city bans are very effective because they are simple. The truck either meets the requirements and goes in, or it doesn't and needs to be switched."

Different cities – even those within close proximity to one another – currently take very different approaches to emission regulation (see Exhibit 45). Interviewees noted that the impact of low-emission zones could be greater if they were more widely and consistently applied. Top cities and industrial hubs within each region should therefore set common targets and timelines. This would create a level playing field for companies operating across a particular region, strengthening incentives to invest in more emission-efficient trucks.

Importantly, because fleet owners try to avoid the effort and costs associated with switching trucks before entering cities, low-emission zones often lead to widespread improvements in the fleet, and as such "have a snowball effect on transport in the regions surrounding it," in the words of one industry group representative. With a more unified approach, this effect will be even more pronounced. As a second interviewee put it: "All trucks will have to change, including those that do not enter the city centres." The impact of this solution will increase over time as cities grow, at-home delivery increases and developing countries see greater urban development.

45 **Low-emission zones for heavy-duty trucks – ILLUSTRATIVE**

	London, United Kingdom	Paris, France	Hamburg, Germany
			
Area	Greater London area[1]	City centre	2 streets
Coverage	24/7	Between 8am – 8pm	24/7
Required Euro norm	Euro VI	Euro V	Euro VI
Expected changes	To be determined	2024: No diesel vehicles 2030: Only ZEVs[2] allowed	To be determined
Penalty for violation	Daily charge	Fine	Fine

Most-stringent regulation

Sources: Transport for London (2019), Urban Access Regulations
Notes: 1) From 2021, low-emission zones increased from the city centre to Greater London area;
2) Zero-emission vehicle

13. Expanded policies for OEMs

When a regulator commits to reducing truck emissions, it typically does so by setting stricter rules on OEM engines. These rules include either minimum emission efficiency levels that all engines must meet, or mandating average emission levels across all the trucks that any given OEM sells.

Interviewees noted that in some geographies, targets for HDT emissions were set more than a decade ago. Now is a good time to accelerate and unify these targets given that the outlook for alternative technologies has significantly improved in recent years and many OEMs have announced plans to produce zero-emission trucks. Interviewees noted that places such as California, which will require 40% of HDT sales to be zero-emission by 2035, could serve as an example for what the sector could achieve. "We have to change anyway to continue driving in California, so we could just roll it out nationwide," said one shipper.

Regulators should also strengthen incentives to help OEMs make earlier, more substantial investments in alternative technologies. Interviewees cited the EU's "super credits" system as a way to reward OEMs with lower overall emission requirements if they achieve a higher share of zero-emission vehicles in the initial years of the transition.

14. Expanded policies for energy providers

Policy and incentives will be needed to accelerate the development of energy infrastructure, including the generation of renewable electricity, hydrogen production, energy transport, and charging and refuelling networks. With the right levels of support, governments and regulators can help address demand uncertainty and the significant upfront investments required for this infrastructure.

"One of the biggest bottlenecks will be green electricity," noted a fleet operator. Regulators may choose to stimulate investments by requiring energy companies to produce a specified share of their electricity from renewable energy sources. For example, California requires utilities to produce at least 50% of electricity from renewable sources by 2030[51]. In the EU, the Renewable Energy Directive II defines criteria that bioliquids used in transport must comply with to be eligible for financial support[52]. Governments typically provide incentives through tax breaks, subsidies or direct investments. For instance, authorities in Japan, China and the EU have all committed to significant investment in green hydrogen production to build early momentum.

Policy will also have a key role in setting up battery charging and hydrogen fuelling networks. This support can take a similar form to electricity production, where a minimum fraction of the total fuel sold must be from renewable sources. Alternatively, regulators can mandate service stations to offer certain types of alternative fuels. Governments can also provide excise duty cuts, as well as subsidies and direct investments. For example, the Chinese government is investing CNY 10 billion (approximately $1.5 billion[53]) to expand the country's charging network by 50% in 2020[54]. Funding support will also likely be needed to upgrade electricity grids to enable battery charging and gas pipelines to distribute hydrogen. For example, the UK government has pledged £28 billion (approximately $37.8 billion[55]) to replace the existing low-pressure iron gas pipelines with a hydrogen- and biomethane-ready network[56].

Early regulation and funding should be concentrated around specific clusters and transportation corridors where pilots will be conducted. However, energy companies and governments need to look beyond the pilot phase, and plan investments to ensure adequate charging and fuelling coverage once alternative technology trucks start entering the fleet at scale – likely around 2025.

"We cannot start everywhere. We need to start in clusters near renewable resources and transport demand where you have political willingness, energy providers, and a large customer network."

OEM

15. Expanded policies for fleet owners and shippers

Alternative-technology trucks will likely be more expensive to buy and use than diesel-powered trucks when they enter mass production. To stimulate early demand, regulators will need to implement measures that help fleet owners and shippers lower TCO to levels comparable with diesel. As old and new technologies reach cost parity, these measures can be withdrawn. One OEM executive comments: "It's all about creating favourable conditions to kick-start demand for these new trucks, so they can hit the roads quickly."

Interviewees cited the relevance of tax breaks and financing incentives on the purchase price of new vehicles, noting the success such measures have had in some countries in stimulating the transition to electric passenger cars.

Regulators can also deploy instruments that lower the operating cost of new vehicles, with targeted and time-bound tax breaks and subsidies for hydrogen or biodiesel being the most mentioned options. To illustrate the effectiveness of such instruments, several interviewees noted that subsidies in the past decade have been used to stimulate investments in renewable electricity. Some also pointed to studies indicating that wind electricity has now become one of the cheapest sources of electricity[57].

Toll and congestion-fee exemptions for alternative technology trucks can be an additional way to lower the TCO. Several interviewees pointed out that in Germany, there is already a toll exemption for trucks running on natural gas[58].

"The toll approach is an example of how to incentivise where it really matters. Long-haul trucking companies benefit daily from toll exemption."

Industry Group

16. Information democratisation

The road freight sector can accelerate the adoption of alternative technologies if more stakeholders have comparable access to information about the latest trends and developments. Currently, such information mostly resides with a handful of large companies, while small fleet owners lack resources to identify and implement best practices. Interviewees noted that small companies are therefore typically the last to invest in new truck engines and connectivity solutions, even though some of these investments already offer attractive financial returns. "Small truckers have businesses to run; they do not have time to think about what will happen in five years," said an industry body representative.

To reduce the information asymmetry and accelerate decarbonisation, the sector should increase the use of tools and industry fora to share non-competitively-sensitive knowledge related to decarbonisation. As an example, some interviewees suggested a digital knowledge platform administered by an industry body, which could include information on the latest pilots, joint purchasing agreements, TCO estimates and operational best practices. Existing industry associations, such as the European Clean Trucking Alliance could be used as a starting point.

17. Charging, refuelling and fuel standards

One of the main advantages of a diesel truck is that it can be fuelled virtually anywhere in the world regardless of which OEM produced it and with no concern about incompatible fuel and equipment. Despite concurrent development of alternative technologies and infrastructure by multiple parties, the road freight sector needs to strive for a similar level of interoperability for FCEVs, BEVs and transition technologies. "The interaction between truck, infrastructure and operational procedures has to function smoothly everywhere," stated an executive of a major OEM.

For BEV trucks, interviewees call for standardisation around the amount of electricity (kW) and the type of outlets used in chargers. These decisions have a direct impact on the type of technology used within the trucks, with one OEM executive noting the following: "We heard about 3 MW chargers for trucks. The problem is if we plugged it in now, it would just burn the battery."

To make FCEV trucks widely operable, interviewees note the clear need to standardise the filling process and hydrogen transportation and storage, especially given both liquefaction and pressurisation options. Interviewees also noted that the sector would benefit from more clear standards around what constitutes green, blue and other colours of hydrogen.

Standardisation is also important for transition fuels, such as LNG, bioLNG, CNG or biodiesel, particularly in geographies where the path to FCEV and BEV will be longer. An executive of a fleet operator in India highlighted that trust in a new fuel or vehicle technology is tightly bound to government rules: "We have doubts about biofuels as there is no assurance by the government, and the quality at the station can differ from day to day."

Several interviewees also noted a standard or certification system could be defined to help assess the carbon intensity of fleets against a common frame of reference. This would help shippers identify and select the most efficient operators in tendering processes.

18. Cross-sector R&D

Many alternative technology components required to decarbonise road freight – such as batteries, chargers, hydrogen fuel cells and electrolysers – have extensive applications in other sectors. This creates an opportunity for technology providers to form R&D partnerships that include road freight stakeholders – particularly OEMs – as well as companies in other harder-to-abate sectors, such as shipping and aviation.

Thanks to their scale and broad expertise, cross-sector partnerships could shorten the technology development timeframe, kick-start demand for renewable electricity or green hydrogen, and possibly negotiate more regulatory support. Technology and infrastructure providers would benefit from a joint approach by gaining more testing data and an early set of launch customers, while OEMs would gain preferential access to key components required to produce BEVs and FCEVs. Also, interviewees mentioned increasing battery density and electrolysis in the hydrogen production process as important areas where cross-sector R&D would be most beneficial.

"Everyone is looking at moving hydrogen down the cost curve; we should be doing it together."

OEM

SCALE

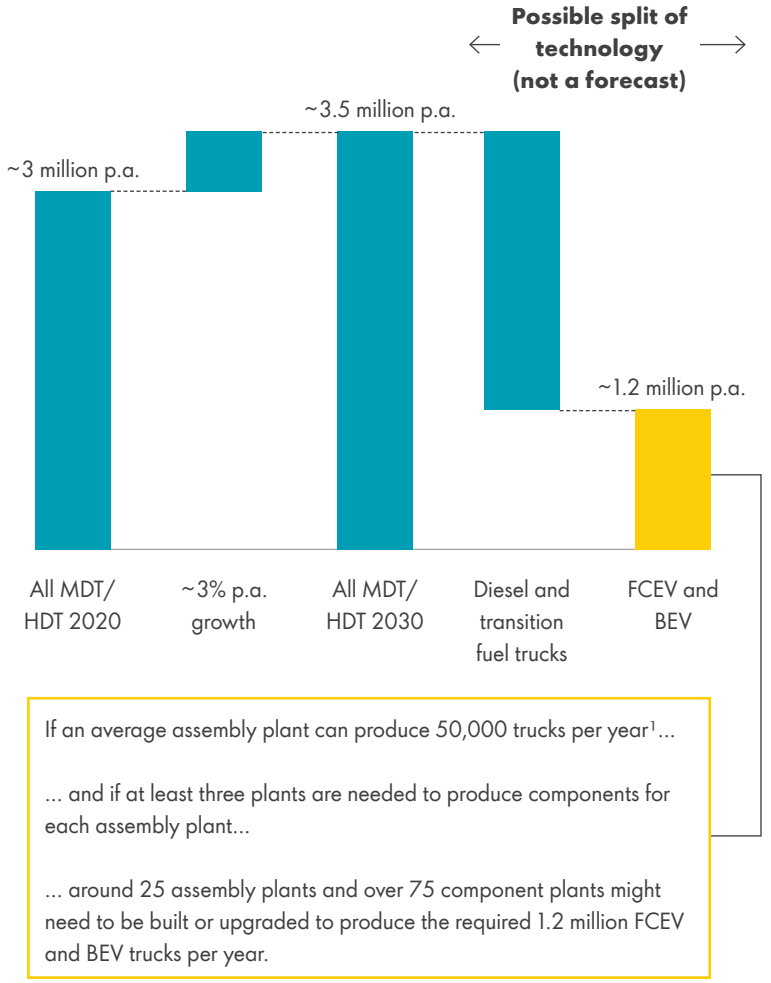
19. Scaled truck production

Virtually all the zero-emission MDTs and HDTs that OEMs have announced to date are at a concept or pre-development stage, with only a few vehicles tested on the road[59]. However, as fleet owners increasingly make orders involving tens[60] or even hundreds of FCEV and BEV trucks[61] to be delivered in the coming years, the OEMs need to start scaling up production capacity.

Some industry executives estimate that up to a third of all trucks sold in 10 to 15 years will have alternative drivetrains[62]. To reach that level, the OEMs will need to produce an estimated 1.2 million FCEVs and BEVs per year – an equivalent of 25 dedicated assembly plants and over 75 component plants (see Exhibit 46). The associated investment will likely be in the tens of billions of dollars. Because of the cost and time required, OEMs need to start making concrete plans for these investments now. As noted by an OEM executive: "We are not where we need to be, but we all have products in the pipeline and are preparing to scale up production."

The technical components in BEVs and FCEVs differ from diesel-powered trucks, and OEMs will need to redesign their supply chains and develop new engineering capabilities to scale production. By entering production partnerships and securing early purchasing commitments, OEMs will be able to reduce the investment risk associated with these changes. Financiers will play an important role in facilitating investments and governments will likely be closely involved, especially given the possible impact on the number and types of jobs that the shift to alternative technologies will require.

46 **Estimation of required MDT/HDT production capacity – ILLUSTRATIVE**



Sources: IHS Markit (2020) Global commercial vehicle production to drop 22% (650,000 units) to 2.6 million units in 2020 in wake of COVID-19; Statista (2018) Global HDT registrations in 2017, by key manufacturer; IEA (2017) Future of Trucks; Deloitte analysis.
Note: 1) Average estimated plant capacity based on facility information of multiple OEMs. The largest truck assembly plant in the world is Mercedes-Benz's Wörth facility, with up to 100,000 trucks per year

20. Scaled energy production and distribution

To transition millions of trucks to alternative technologies, an unprecedented increase in renewable electricity generation will be needed to power BEVs and as feedstock for green hydrogen. In recent years, many countries have increased the renewable share of their energy mix, making technologies such as wind power economically viable. But much more investment is required. Interviewees noted that hydrogen production in particular needs to be scaled up to move it down the cost curve. "When hydrogen costs a fraction of what it does now, fuel cells will start making economic sense," said one fleet owner.

Once produced, green electricity and hydrogen need to be made available through a network of charging points and fuelling stations. Some interviewees noted that for BEVs, private charging points will likely dominate, with many required in warehouses and distribution centres to enable charging overnight and while trucks are parked for loading or unloading. Public infrastructure will also be used, although less widely given the space required to accommodate trucks parked for several hours.

Energy companies and governments will need to invest heavily in the transmission and distribution grids to handle the increased demand for electricity "We can manage the cost of charge points, but the grid can only support three chargers, and we can't upgrade it ourselves," noted one logistics company. Digital technologies and new market entrants can help smooth electricity demand across the network. One example is Greenlots, which allows shippers to optimise charging time and charging rate based on when trucks will be needed and the varying cost of electricity over time.

FCEVs will more likely rely on public infrastructure – particularly repurposed fuel stations – given the time needed to fuel a truck with hydrogen is comparable to diesel. The main focus for investment in the coming years should be on laying and repurposing distribution pipelines, to deliver hydrogen from production locations to demand locations.

21. Expansion of maintenance capabilities

To keep large alternative technology fleets on the road, the sector will require new maintenance capabilities to be made available at scale. Several interviewees noted they already struggle to find talent to maintain their modernised diesel fleets. "Maintenance requirements have completely changed over the past five years. Modern trucks are more connected, and our servicing team are now more technicians than mechanics," said one truck dealer.

This trend will continue as FCEVs and BEVs enter the market, and as automation and connectivity become even more integrated into modern trucks. This in turn will make maintenance difficult for fleet owners to perform themselves in the early years of the transition. To reduce this barrier, OEMs will need to scale and spread maintenance capabilities in tandem with production – possibly by expanding and opening their vocational education programmes to other stakeholders[63]. There may also be an opportunity for specialised third parties to enter the maintenance market in under-served areas.

However, new technologies will also present an opportunity to reduce the need for unplanned maintenance. OEMs should increase the use of sensors and analytics in their trucks to predict and prevent breakdowns. Operational pilots will be a good place to start testing these solutions and building the required datasets.

22. Future-fit logistics

Decarbonisation is only one of several trends that will transform the road freight sector in the coming decade. Interviewees noted that autonomous driving, connectivity and analytics will also have a profound impact on how supply chains are organised and how trucks are used. Shippers and fleet operators should take an integrated perspective on these trends when designing their decarbonisation, technology and operational strategies.

Developments in autonomous driving are particularly pertinent in decisions around decarbonisation pathways. On one hand, autonomous trucks could reduce the economic viability of BEVs, with one industry group representative noting: "With self-driving trucks, we eliminate the driver breaks and we can have 24/7 operations, which means we will no longer have the downtime to charge a battery." From that perspective, hydrogen might be a more natural low-emission option for autonomous trucks. On the other hand, BEV charging without human intervention is arguably easier than hydrogen fuelling, which may tilt the scale in the opposite direction.

Distribution centres and warehouses will also need to be reconfigured as new zero-emission and autonomous technologies are adopted. This will not only be required to enable the transition, but also to realise the full value of the new technologies, as summarised by a logistics company executive: "It feels like we are trying to figure out how to apply emerging technologies to today's supply chains. We will be much better off if we redesign the supply chains for emerging technologies."

The net impact of these trends is still unclear, but interviewees noted that together they present a unique opportunity to redesign the way the sector operates, increasing its quality and efficiency along the way.

The Roadmap: Accelerating Decarbonisation

MOTIVATION AND IMMEDIATE FOCUS

Interviewees recognise that the challenge of decarbonising road freight is too large for any one organisation or even one group alone. At the start, it will likely be a very a small group of like-minded companies that will lead the charge and work together to create the necessary momentum. These first-movers will likely reap the benefits of early access to differentiated insights, have the ability to share risks and investments, and influence outcomes in their favour. Engaging with their customers and other ecosystem players during the early phases of the transition will pay dividends for such relationships in the future. As these early initiatives expand, more companies will join to create the necessary scale and impact across the sector.

The sector will only be able to take advantage of the changing paradigm and make progress quickly through a collaborative effort between all stakeholders. The solutions that emerged from our research, interviews and workshops provide more clarity on where and how the ecosystem needs to collaborate to make progress, and the role everyone must play (see Exhibit 47).

Drivers will play a key role in improving the adoption of proven efficiency technologies as they move to new trucks for viable duty cycles. They will also need to be consulted by regulators throughout the transition, to make sure that alternative technologies are practical, safe and reliable.

Shippers will be instrumental in making decarbonisation economically feasible by stimulating consumer demand for lower-emission transport and providing incentives for logistics providers. Companies operating their own fleets are particularly well positioned to stimulate demand for alternative-technology trucks and bring them down the cost curve. In their dual role as shippers and fleet owners, these companies have greater control over the use of trucks than logistics companies. This allows them to capture the benefits of more efficient fleets in the form of direct savings and consumer goodwill.

For **fleet owners**, decarbonisation presents a unique opportunity to modernise what has historically been a conservative and low-margin industry. Fleet owners can reduce sector emissions while making their own operations more efficient in a number of ways: by adopting transition fuels – such as LNG, bioLNG, CNG or biodiesel – partnering with their customers to pilot alternative technologies, electrifying viable duty cycles, and embedding digital, connectivity and analytics into their operations.

Regulators can accelerate the sector's decarbonisation efforts by setting clear targets, and taking a system-wide view to enable all actors to play their part in decarbonisation. Key measures include targets on trucks, fuel supply requirements, and enabling infrastructure with a supportive R&D environment. By acting decisively and with all available instruments, regulators can contribute to creating cleaner cities, while protecting and transforming jobs in this critical sector.

The importance of **OEMs'** commitment to decarbonisation cannot be overstated. Big investments, targeted pilots and novel business models will be crucial the development of reliable new trucks, lowering their cost and producing them at scale. The OEMs that lead this process will be able to avert regulatory risks, achieve a strong competitive position and will develop new revenue streams by capturing a greater share of the growing market.

Energy companies can enable large-scale adoption of lower-emission trucks by scaling up production and distribution of renewable electricity and hydrogen, and setting up fuelling and charging stations. They can also leverage their cross-sector perspective to facilitate collaboration between industries and play a facilitation role across the value chain. Companies that move first will be able to shape the direction of the transition and use the infrastructure developed for road freight as a stepping stone for decarbonisation of other, harder-to-abate sectors.

Financiers will have a unique role in making the replacement of over 200 million trucks possible through funding products that are tailored to the needs of the fragmented value chain and reflecting the economic characteristics of alternative technologies.

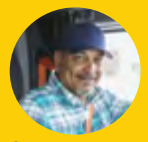
Exhibit 48 shows the key leading and supporting roles for the different solutions, providing the clarity needed for stakeholders in the ecosystem.

Exhibit 47

4. **RESEARCH HIGHLIGHT**

Through **collaboration** around a **catalogue of 22 solutions**, the sector will be able to **reduce emissions** now and **accelerate a shift** to low- and zero-emission trucks.

48 **Who will play what role in road freight decarbonisation?**



Sam
Truck Driver

I have volunteered to test drive the new hydrogen trucks that my company recently bought. They are more powerful, easier to drive and feel more reliable.
I have also been using all the new smart digital features that help me drive more efficiently.

Petra
Supply Chain VP
at a Shipper

Our sustainability targets are moving from the boardroom to daily operations.
We will attach more weight to emission criteria in our tenders and offer multi-year contracts to some trusted providers that invest in green trucks.
By implementing carbon labelling and other green marketing, we also try to nudge our customers towards lower-emission options.

Sahana
Owner of a
Logistics company

We are working with our customers to roll out BEVs in urban areas. On other routes, we are using biofuels and are preparing for hydrogen. We have also reduced a lot of empty kilometres through analytics. We are working with OEMs and energy companies to test FCEVs in some high-volume corridors. As soon as these trucks are ready, we plan to start deploying.

Lin
Director at a Road
Regulatory Authority

We work hand-in-hand with the sector to make sure regulation is practical and predictable. We will even bring forward some targets, especially in cities, because the technology is advancing rapidly, and we are putting in place incentives that will make alternative technologies more attractive for fleet owners.

Alyssa
EVP Commercial
Vehicles at an OEM

We continue improving the efficiency of diesel, while accelerating development and production of alternatives. Joint pilots and other partnership schemes with energy companies and fleet owners will help us bring reliable and affordable FCEVs and BEVs to the roads in the next few years. We will then kick-start demand with services that lower resale and maintenance risks.

Samuel
GM Fuel Stations at
an Energy provider

Our fuel portfolio is growing. As the first step, we are making LNG and biodiesel more widely available. In parallel, we are investing in the production of renewable electricity and hydrogen, starting with regions close to key freight corridors, where we can pilot them. We are engaging with the sector to align on charging and fuelling standards to make this transition as smooth as possible.

Jacques
Transport Sector
Lead at a Bank

In the next few years, all our loan portfolios will have sustainability targets. We are developing new products, designed to ease the burden of upfront investment and help manage the risk of resale value. Small fleet owners in particular will benefit.
We are also increasingly funding infrastructure projects in hydrogen and renewable electricity.

Zoe
Consumer

I do what I can to reduce my carbon footprint. I don't really need every package to be delivered the next day, and I will buy more products that I know are 'green'. If that means cleaner air and less noise in my neighbourhood, it will definitely be worth it.

49 Who will play what role in road freight decarbonisation?

	Solutions	Truck Driver	Shipper	Logistics company	Road Regulatory Authority	OEM	Energy provider	Bank	Consumer
Make impact now	1. Transition of viable duty cycles	Lead	Lead	Lead		Support	Support		
	2. Targeted deployment of transition technologies	Support	Lead	Lead			Lead		
	3. Operational and design efficiencies	Lead	Support	Lead		Lead	Support		
Create a snowball effect	4. Pilots in clusters and corridors	Support	Lead	Lead		Support	Lead	Support	
	5. Technology partnerships			Support		Lead	Support	Support	
	6. Joint truck-purchasing commitments		Support	Lead		Support		Support	Support
	7. Novel OEM revenue models & secondary-market certainty			Support		Lead		Support	Support
	8. Green transport procurement		Lead	Support					
	9. Green finance		Support	Support	Support	Support		Lead	Lead
Build conditions for success	10. Consumer awareness and choice		Lead	Support		Support			
	11. Regulatory pathways				Lead		Support	Support	
	12. Joint city campaigns		Support	Support	Lead		Support		
	13. Expanded policies for OEM				Lead	Support			
	14. Expanded policies for energy providers				Lead		Support		
	15. Expanded policies for fleet owners and shippers		Support	Support	Lead				
	16. Information democratisation	Support	Support	Lead	Support	Support	Support	Lead	
	17. Charging, fuelling and fuel standards	Support		Support	Lead	Support	Lead		
	18. Cross-sector R&D					Lead	Lead		
Scale	19. Scaled truck production					Lead		Support	
	20. Scaled energy production and distribution						Lead	Support	
	21. Expansion of maintenance capabilities					Lead			
	22. Future-fit logistics	Support	Support	Lead	Support	Lead	Support		

Lead role

Support role

TECHNOLOGY TIMELINES

Interviewees recognise the transition to new technologies will not happen at the same pace everywhere. Implementing the solutions outlined in this report will accelerate progress, but building production capacity and infrastructure will take time, and factors like cost of renewable electricity and truck lifespans will dictate the rate at which alternative technologies are adopted. Although views on the pace of the transition vary, a possible technology timeline emerged from the interviews and workshops (see Exhibit 50).

BEVs are expected to start entering the MDT and HDT fleet in the next three years. Specific duty cycle applications with lower range requirements and better access to charging networks, such as milk-runs in urban areas and drayage operations in ports, are likely to see the earliest adoption. The transition will start around cities with ultra-low-emission zones, or in clusters and corridors where early infrastructure has been established, such as overhead charging networks in Germany and Sweden. The technology will expand into longer-range applications as battery technology matures, possibly reaching around 30 to 40% of new truck sales in the mid-2030s. Notable examples of BEV adoption are already on the horizon, with DHL scaling up Class 8 BEV pilots in the Los Angeles area[64], and Volvo announcing the commercial introduction of its VNR Electric model in North America, with production beginning in 2021[65].

The first viable commercial applications of FCEVs are expected around 2025.

The transition will likely start in clusters and corridors that are close to large-scale renewable-electricity generation sites – for example, around the North Sea offshore wind parks, or in countries where hydrogen is central to the national energy strategy, such as China and Japan. The first duty cycles to transition in these clusters and corridors will probably include multi-day trips and 24/7 operations, where range limits and charging downtime preclude use of BEVs. FCEV adoption will gradually increase throughout the 2030s as green hydrogen production increases and cost declines. Most interviewees expect that by the early 2040s, FCEVs might account for over half of all MDTs and HDTs sold globally, and a much higher share in some markets – e.g. Europe and China.

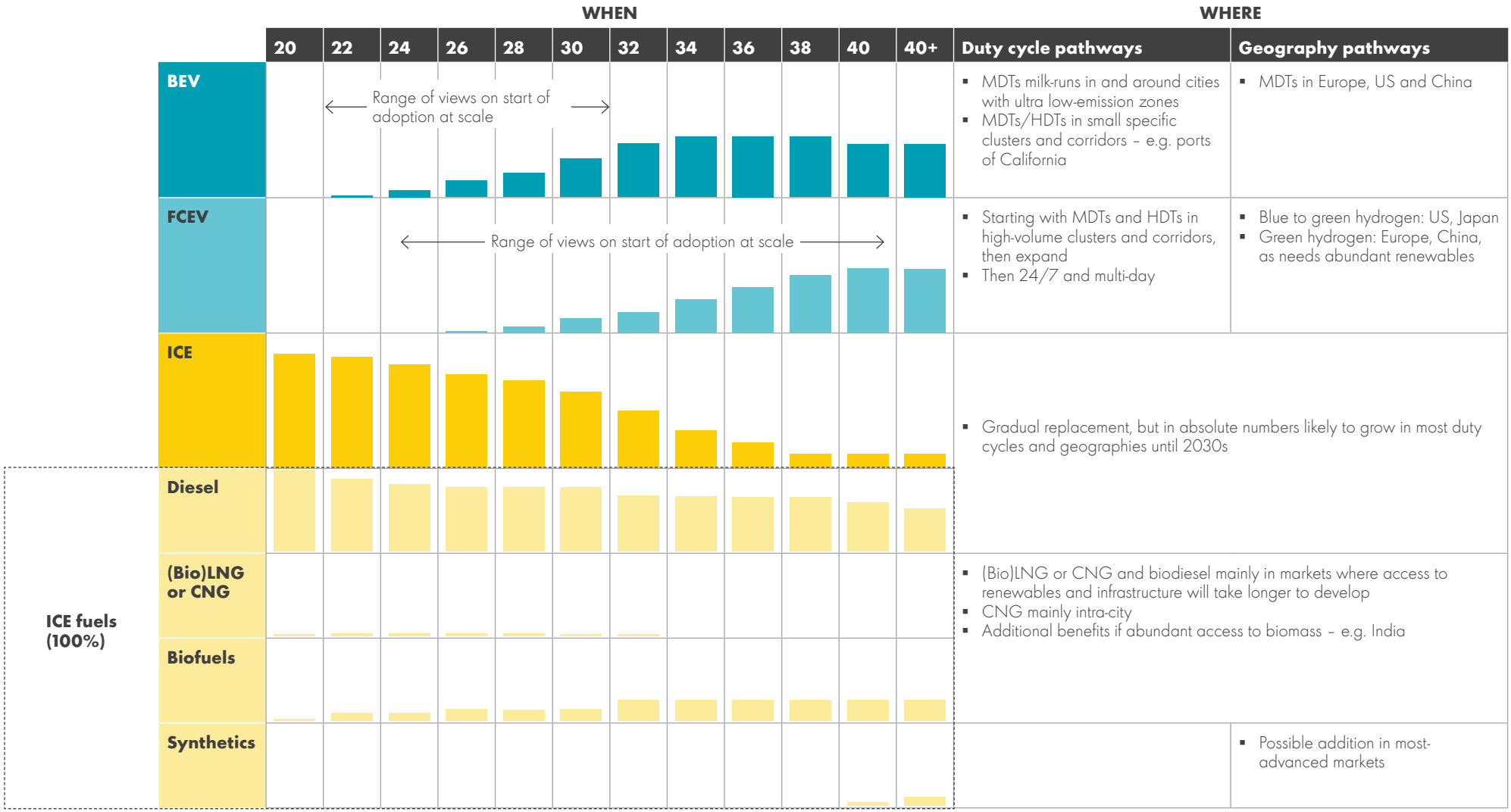
The internal combustion engine (ICE) will continue to play a role beyond 2040 – particularly in smaller, more remote markets, where the cost of developing BEV and FCEV infrastructure would be prohibitive. Biofuels will be the easiest to deploy to specific small-scale applications, and will be most viable in markets with sufficient supply of biomass – for example, in India. However, considering limitations in biofuel production, CNG and LNG will also be needed in those countries where a transition to zero-emission technologies is expected to take longer. Natural gas will also act as a transition fuel during the 2020s and early 2030s in some developed markets. Synthetic fuels may play a niche role if they are produced at scale for other sectors, but the pathway to affordable applications in road freight remains unclear.

Although the timelines provide a helpful view of when and where changes are likely to start, interviewees recognise change will not happen by itself. A focus on tangible activities to build the conditions to enable these timelines will be critical in the coming years.

"We can say we will have hydrogen trucks by 2030 all we want, but unless we make changes it is not going to happen."

Logistics Company

50 **Applicability of alternative technologies in HDTs and MDTs (% new truck sales) – ILLUSTRATIVE**



LET'S GET MOVING

The road freight sector has begun to converge on a technology pathway and a range of solutions that can make the 2020s a decade of significant transformation (see Exhibit 51). Many stakeholders believe this can be done, but it requires the sector to act decisively, starting to work on the first solutions within the next two years. In this initial period, the goal is to make the maximum possible use of existing technologies to reduce emissions quickly, while dramatically expanding the reach and scope of alternative technology pilots. Simultaneously, shippers must translate board-level decarbonisation commitments into consumer propositions, while the regulators at all levels must push forward with well-targeted incentives and chart the policy pathway for the next decade.

Before the mid-2020s, the sector will need to step up its R&D efforts and start deploying FCEVs and BEVs in commercial operations. Incentives provided by shippers, financiers and OEMs will be critical in stimulating initial demand. At that stage, battery charging and hydrogen fuel cell infrastructure will also need to be standardised, to enable wider roll-out and cross-operability.

Low- and zero-emission trucks will get close to cost parity with diesel and will start entering the fleet at scale by the late 2020s as infrastructure providers and OEMs scale up production.

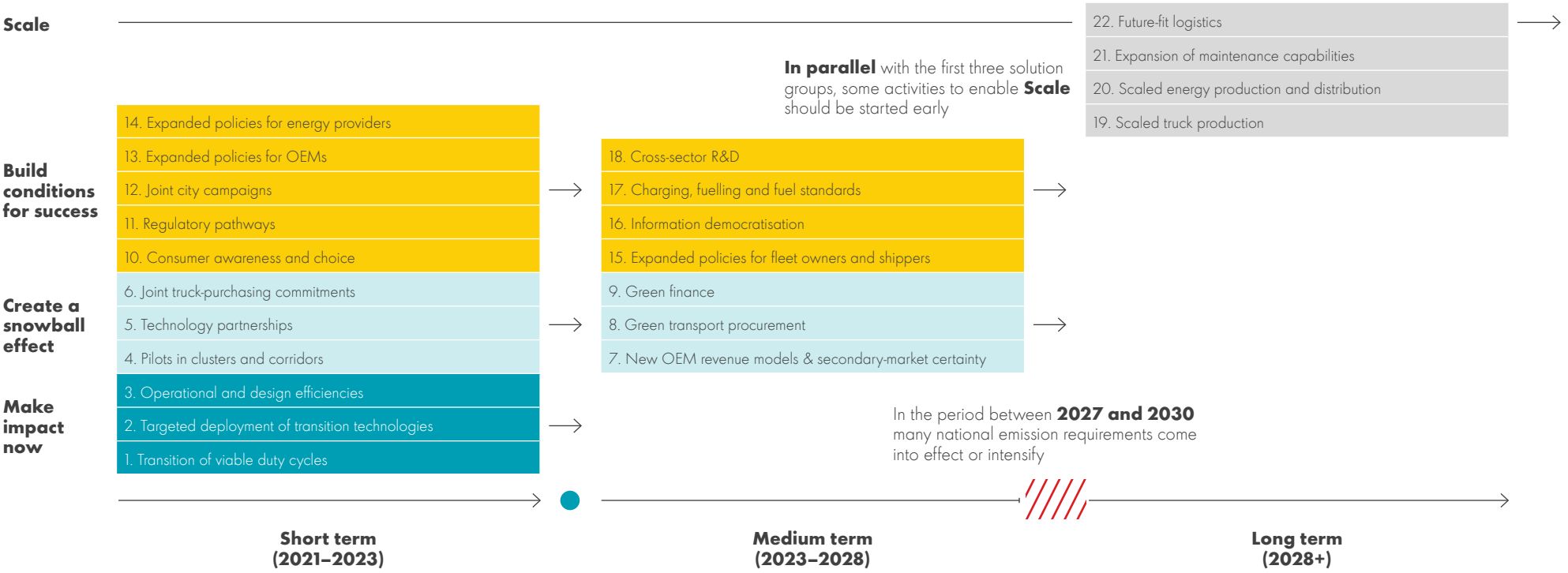
In total, this paper identifies 11 solutions as short-term priorities to decarbonise the sector; however, progress must be made across all 22 within this decade (see Exhibit 52).

Exhibit 51

5. **RESEARCH HIGHLIGHT**

The sector has defined a **decarbonisation roadmap**, which allows it to **start deploying** low- and zero-emission trucks **at scale by the late 2020s.**

62 **Solutions Roadmap**



Note: Timing of solution is related to period in which most activities are expected; however, most solutions require effort across short, medium and/or long term

Different rates of change across geographies underscore the global nature of the challenge. Europe and US together account for just 30% of global emissions, and the share will decline further as other markets grow. Europe has historically been seen as a champion of sustainability, however in many respects China already leads the road freight decarbonisation agenda, with one industry group executive noting that "China is heavily investing in alternative technologies for buses, and leading the hydrogen economy for heavy trucks." Other major countries, such as India and increasingly those in Africa and South America, will need to accelerate their efforts if the world is to achieve significant emissions reduction on a global scale.

Exhibit 53

6. **RESEARCH HIGHLIGHT**

Achieving significant emissions reduction requires a **concerted global effort**, with leading regions and companies **sharing knowledge and supporting others** to leapfrog ahead.

The solutions identified in this study are globally applicable, but each market has unique conditions and challenges that must be addressed as part of the transition, as outlined in the next chapter of this report. Fuel supply, technology maturity and access to infrastructure will determine which solutions are the most relevant to address first. For example, in some countries transition fuels, and even modernisation of diesel engines might play an important role for longer. In others, hydrogen development forms part of a national strategy and will be favoured early on.

In all cases, cross-border collaboration and multinational actors are key to accelerating learning, so that as solutions mature in one geography, they can be applied in others. That will allow them to leapfrog ahead to a decarbonised future (see Exhibit 53).

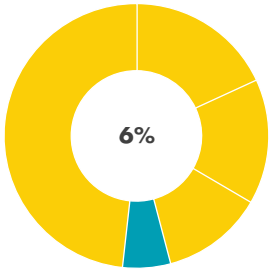
The path forward is clear, and it is time to **'get into gear'**.

Regional differences

INDIA

Decarbonisation is a low priority for consumers, shippers and logistics companies relative to other geographies. "Hygiene factors", such as road safety, congestion, worker conditions and infrastructure quality remain the key focus areas for the sector. The government puts emphasis on reducing fuel consumption to limit dependency on oil imports and tries to improve air quality in cities, but infrastructure is lacking. LNG and CNG are expected to grow in the mid-term based on recent investments in LNG and infrastructure for passenger vehicles. Zero-emission solutions will take longer as the market matures and the hygiene factors are addressed.

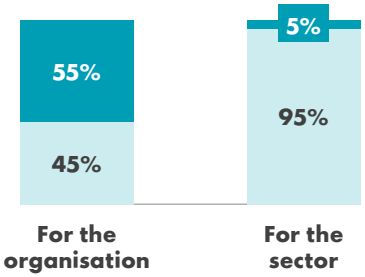
Country Highlights

		% global
Population	**1,366 M**	18%
GDP	**$ 2.9 T**	3%
Road freight volume	**2,436 TKM** (+10.1% p.a.)	11%
Road quality ranking	**55th** (score 4.3 out of 7.0)	
Road freight emissions		

Interviewees

- **24** Road freight stakeholders, including:
  - 9 CEOs and Senior Executives
  - 7 Logistics Leads and Experts
- **20** Organisations interviewed, including:
  - 1 of the largest OEMs in the region
  - 1 of the top 3 Logistics Companies

Importance of decarbonisation

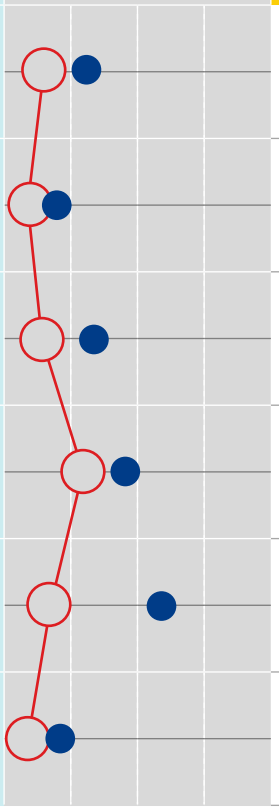


"Road quality and safety are the priorities for the industry. For example, there is no limit on driver hours."
– Fleet operator

"Very few stakeholders in the market are talking about decarbonisation right now, there are other priorities"
– Fleet operator

Sources: World bank (2020); OECD; Weforum Quality of roads (2018); IEA (2017) Future of Trucks; IEA (2020) CO_2 emissions from transport and heavy-duty vehicles in the Sustainable Development Scenario 2000-2030; OECD; Deloitte analysis

54 **India barriers**

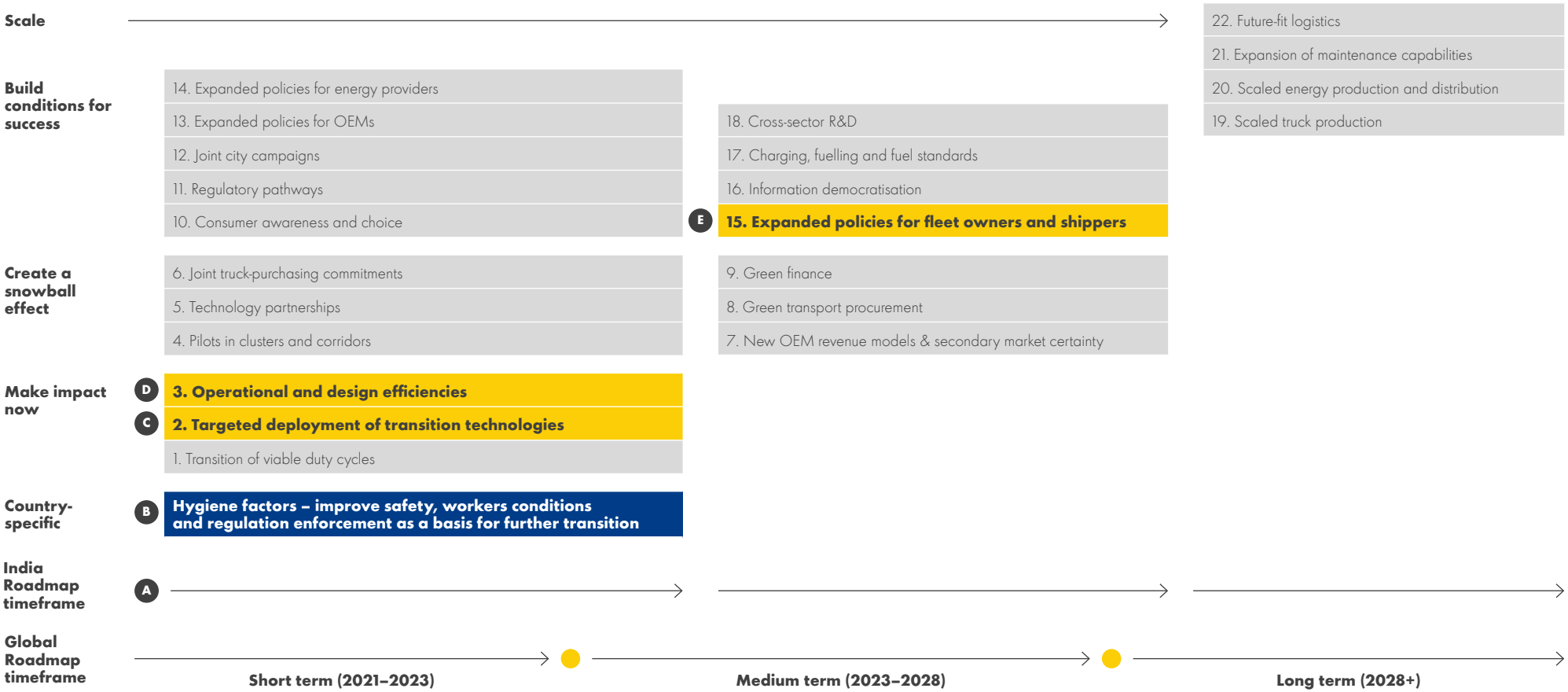
Readiness questions	Readiness factors	Criticality of barriers (Major – Minor)	Participants' views on barriers in India	Quotes
Why should the sector change?	1. Market and Customer Demand		Consumers and shippers are mainly focussed on cost efficiency and will implement fuel-saving initiatives where there is a clear cost saving opportunity. Multinationals and exporting companies with commitments are more likely to invest in decarbonisation than local companies	▪ "No shipper expects us to be environmentally friendly. They don't check or ask, so we compete on price." – Fleet operator ▪ "We reduce our environmental footprint for our European investors, who have sustainability high on their agenda" – Shipper
	2. Regulatory Incentives		The aim of the government is to reduce oil dependency and air pollution via improved vehicle efficiency regulations (e.g. increased payload and weight limits, scrappage, BS VI). However, enforcement is a challenge	▪ "The Indian government focuses on LNG and electrification due to air pollution in cities and dependency on crude oil imports" – Truck OEM ▪ "Pollution drives city regulation, and cities rule over the country." – Shipper ▪ "Many truck owners are not aware of existing regulation." – Fleet operator
Can the sector change?	3. Technology Alignment		Transition fuels and biodiesel are seen as cost-efficient solutions to reduce emissions today. CNG is supported by regulators who aim to increase the number stations to 10,000 by 2030 (1,400 today). However, a transition to zero-emission trucks is relatively far away as there is limited infrastructure or ability to cover higher costs	▪ "One half of the vehicles in Delhi drive on CNG and the other half on diesel." – Shipper ▪ "BEV truck adoption is quite far out, all new models introduced by OEMs are small vans which don't have enough loading capacity." – Shipper
	4. Clarity on Roles and Decision Making		Many small fleet owners have limited means to invest in new trucks, and feel limited pressure from consumers and regulators to make the transition, especially as TCO of alternative technologies is high	▪ "Small fleet owners try to stay afloat and make minimum profits to survive in this industry." – Fleet operator ▪ "India will never adopt environmental standards for the good of our hearts, it will be an economical decision always." – Fleet operator
How fast can the sector change?	5. Ease of Asset Replacement		OEMs are focusing primarily on EV and CNG cars, and there are limited plans to scale zero-emission trucks in the near future. Many owners extend the useful life of trucks or buy them on the second-hand market	▪ "The current priority of the government is to electrify two and three-wheelers, then cars, buses and lastly MDTs and HDTs." – Truck OEM ▪ "More than 80% of the fleet operators buy trucks on the secondary market." – Fleet operator
	6. Ease of Infrastructure Replacement		Investments in road quality and congestion are helping drive improvements, but both remain a concern. Fuelling Infrastructure is still limited, and significant grid improvements will be needed to scale zero-emission technologies. The government is emphasising rail networks to reduce the burden on roadways	▪ "Despite improvements the biggest bottlenecks are the infrastructure, not only for fuelling, but also the condition of the road itself." – Shipper ▪ "Improvements in rail infrastructure will trigger intermodal freight movements." – Industry Group

○ India road freight average

● Global road freight average

Source: IEA (2020) India Energy Policy Review; Energyworld.com (2020) India to have 10,000 CNG stations in next 10 years, on track to adapt cleaner fuels

55 India roadmap

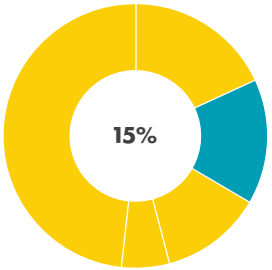


Adapt		Start		Emphasise	
A	India will take additional time to decarbonise relative to leading markets due to the low priority of decarbonisation and limited maturity of the sector	B	The primary focus will be on improving factors like road safety, worker conditions, infrastructure and regulation enforcement. This will help build a solid base to accelerate future decarbonisation efforts	C	Availability of natural gas and biodiesel provide early opportunities to reduce emissions as transition fuels. HDTs in particular will be slow to transition to other alternatives
				D	Operational improvements can be achieved by increasing and standardising truck dimensions and optimising routing. Additionally, overly crowded road network and development of rail infrastructure both provide opportunity for mode shifts
				E	There is a clear need for standards, targets and incentives on emissions and emission reporting to build awareness and visibility while laying the foundation for future policy measures

CHINA

Consumer and shipper demand for decarbonised transport in China remains limited as more visible sustainability initiatives are pursued, for example recyclable packaging. However, with continued focus on clean-air policies in cities and recent Government commitments to national emission reduction, decarbonisation is expected to accelerate. The transition will be helped by strong enforcement mechanisms. Battery charging and hydrogen fuelling infrastructure will both need significant investments.

Country Highlights

		% global
Population	**1,398 M**	18%
GDP	**$ 14.3**	16%
Road freight volume	**6,677 TKM** (+2% p.a.)	31 %
Road quality ranking	**42nd** (score 4.6 out of 7.0)	
Road freight emissions		

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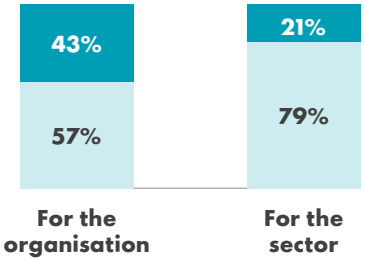
- **14** Organisations interviewed, including:
  - 3 of the top 5 Logistics Companies
  - 1 of the largest OEMs in the region

Importance of decarbonisation

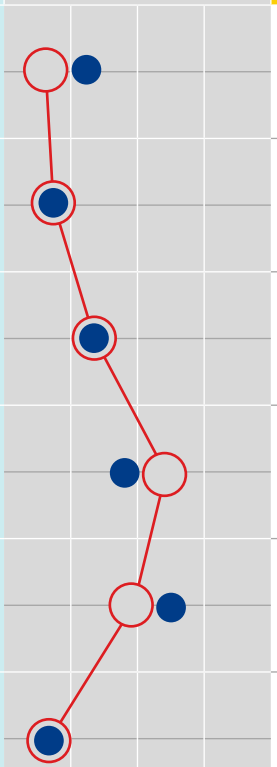


"We learn from the leading international counterparts and strive towards playing an exemplary role in the domestic industry."
– Courier

"Private logistics companies are more cost-conscious than state-owned enterprises, who have decarbonisation higher on the agenda."
– Courier

Sources: World bank (2020); OECD; Weforum Quality of roads (2018); IEA (2017) Future of Trucks, IEA (2020) CO_2 emissions from transport and heavy-duty vehicles in the Sustainable Development Scenario 2000-2030; OECD; Deloitte analysis

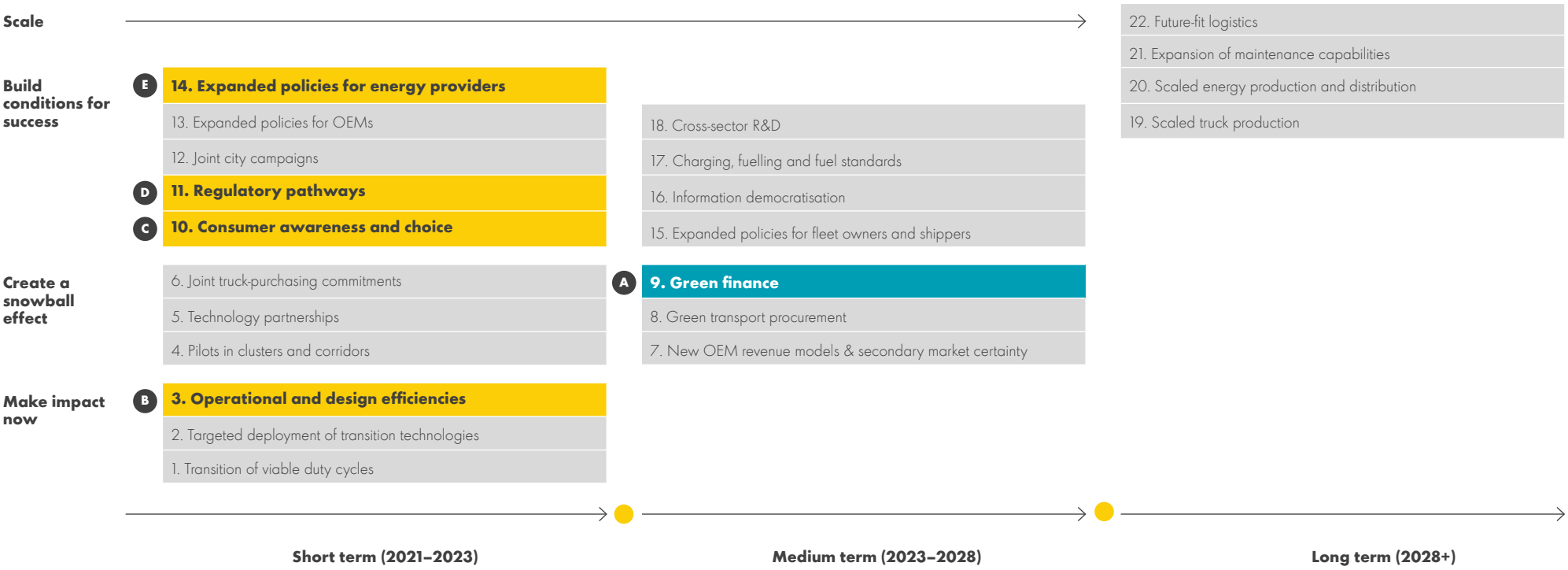
56 **China barriers**

Readiness questions	Readiness factors	Criticality of barriers (Major – Minor)	Participants' views on barriers in China	Quotes
Why should the sector change?	1. Market and Customer Demand		Still little consumer and shipper focus on transport - sustainable packaging has received more attention. Multinationals and export companies are starting to require emission reporting, but this is still early stage	▪ "End consumers care about green packaging because it is visible to them, road decarbonisation is less important." – Courier ▪ "Major brands from Europe and the US are starting to request carbon emission data, but we don't report these yet." – Courier
	2. Regulatory Incentives		A lot of emphasis on municipal clean-air policies, and strong record of regulation enforcement Current 5-year action plans end in the next 1-2 years, and new ambitious targets are not yet translated into clear policies or a roadmap	▪ "Emission regulation is tightened through the government's 'blue sky' policy and additional energy policies for top tier cities." – Truck OEM ▪ "Developing countries look toward developed countries for trends and emission standards to prevent reinventing the wheel." – Industry Group
Can the sector change?	3. Technology Alignment		Government supports pilots with alternative technologies where maturity and cost are the major hurdles for realisation. Most city buses have already been transitioned, and the number of LNG/CNG trucks is gradually increasing	▪ "When the government stops subsidies for alternative fuels, only the most advanced companies and technologies will survive." – Infrastructure Provider ▪ "LNG and CNG are the 2nd most commonly used fuel type for many companies after diesel." – Industry Group
	4. Clarity on Roles and Decision Making		Although the truck owner segment is extremely fragmented, the strong role of government is seen as a focusing force that can accelerate the transition, especially if hydrogen becomes part of the national strategy	▪ "Due to the fierce competition between logistics companies, sustainable business development needs to be cost efficient." – Fleet operator ▪ "After transitioning to an energy-saving fleet, our market share increased, especially in cities with strict emission requirements." – Fleet operator
How fast can the sector change?	5. Ease of Asset Replacement		Local OEMs indicate decarbonisation is important, but are reluctant to make commitments or announce roadmaps until regulatory expectations become clear	▪ "Government policy and regulations are a major influence for OEM product roadmaps." – Truck OEM
	6. Ease of Infrastructure Replacement		China is the world's largest producer of wind and solar energy and hydrogen, and has installed more than 1.2 million electric car charging stations. However, there are no known plans to extend the charging network towards trucks, grids will need upgrades and there is limited hydrogen refuelling infrastructure	▪ "China is 2-3 years ahead of any other country regarding charging infrastructure, but the limiting factor is the grid." – Infrastructure Provider ▪ "The government should undertake infrastructure investments, which require much higher capital than fleet replacements." – Courier

○ China road freight average

● Global road freight average

57 China roadmap



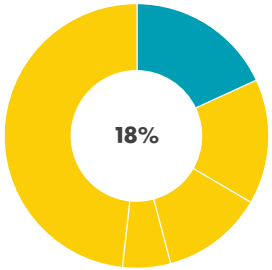
Adapt		Emphasise	
A	Green finance is needed early in the process to overcome cost barriers for the many small, cost conscious fleet owners who have limited access to capital	B	The sector believes significant operational improvement is achievable through route optimisation by using network transport instead of point-to-point transportation, transitioning goods away from road to other transport modes (e.g. road to rail and waterway) and increasing digitisation
		C	Consumer demand for green packaging should be refocussed to create awareness around green transportation by increasing the transparency and visibility of trucking through carbon labelling, green truck and product branding and marketing
		D	A clear and detailed regulatory roadmap is needed to articulate the government's ambitious targets, as well as short-term measures and actions
		E	Very significant investments are needed in a comprehensive and standardised infrastructure network for both electricity and hydrogen – especially along highways and in emission zones – to enable zero-emission trucks

UNITED STATES

Large companies (e.g. Fortune 500) are increasingly making commitments to decarbonise road freight, particularly their own truck fleets. Small fleet owners, who often serve large companies, are more sceptical and reluctant to transition as price and speed of delivery are still prioritised over green criteria. Regulation is often set at a state or city level, and is being led by new measures set in California. A coordinated approach to regulation, infrastructure and pilots would decrease uncertainty for fleet owners.

Hydrogen will likely play a significant role because of the large distances required in the country.

Country Highlights

		% global
Population	**328 M**	4%
GDP	**$ 21.4 T**	24%
Road freight volume	**2,954 TKM** (+1% p.a.)	14%
Road quality ranking	**10th** (score 5.7 out of 7.0)	
Road freight emissions		

Interviewees

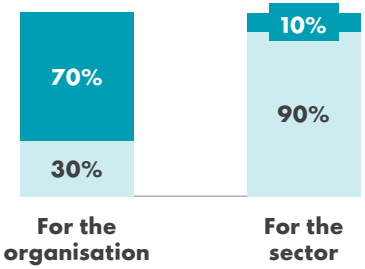
22 Road freight stakeholders, including:

- 9 CEOs and Senior Executives
- 5 Logistics Leads and Experts

21 Organisations interviewed, including:

- 1 of the largest OEMs in the region
- 1 of the top 3 Logistics Companies

Importance of decarbonisation

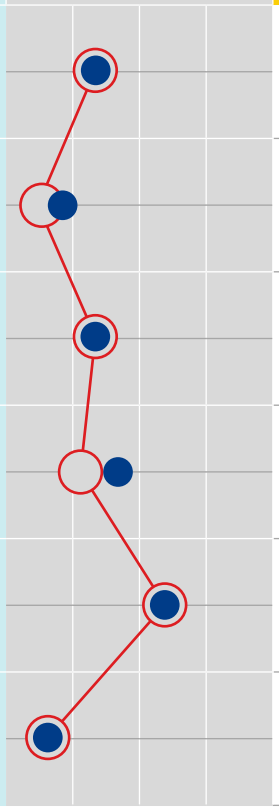


"We are willing to pay for green shipping as we see ourselves as leaders in sustainability and we believe it also pushes competitors." – Shipper

"There is a discrepancy between what is being said and what is actually being done." – Industry Group

Sources: World bank (2020); OECD; Weforum Quality of roads (2018); IEA (2017) Future of Trucks, IEA (2020) CO_2 emissions from transport and heavy-duty vehicles in the Sustainable Development Scenario 2000-2030; OECD; Deloitte analysis

58 **US barriers**

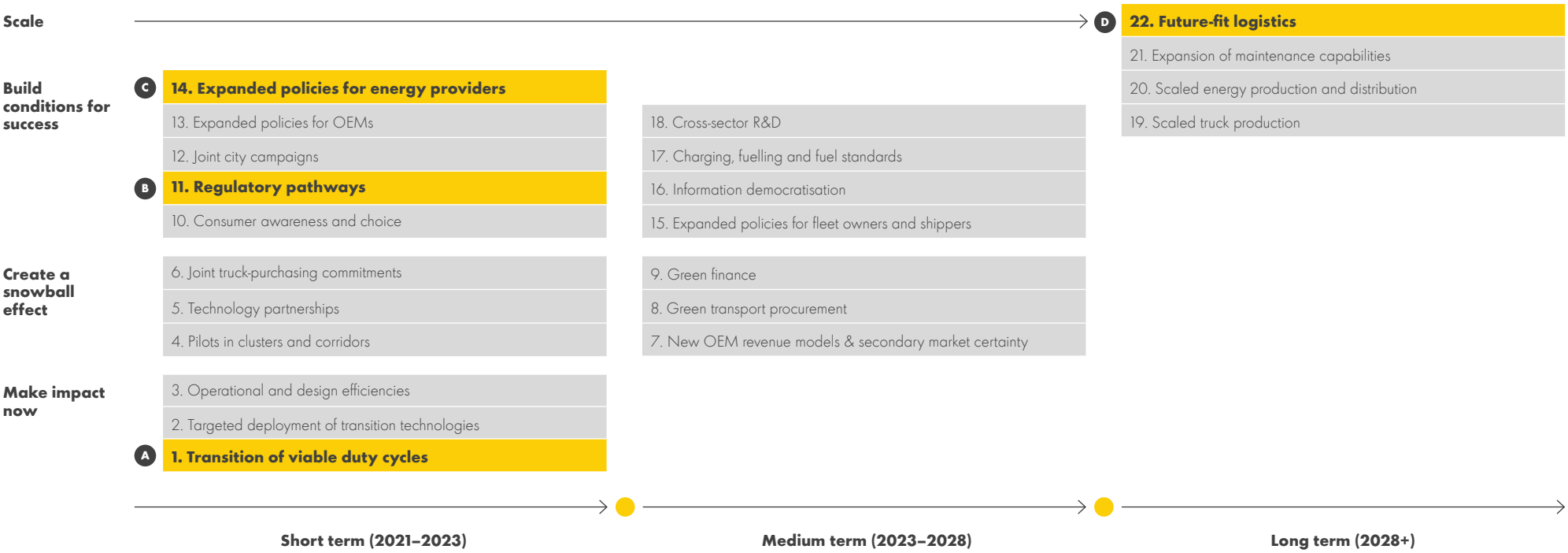
Readiness questions	Readiness factors	Criticality of barriers (Major – Minor)	Participants' views on barriers in the US	Quotes
Why should the sector change?	1. Market and Customer Demand		Large, consumer-facing companies in eCommerce, large-area retail and FMCG increasingly commit to decarbonisation goals. Those with their own fleet are front-runners. However, consumer demand remains limited	▪ The pressure to decarbonise comes from all angles: the customer, the business DNA, carbon taxes and future workforce." – Shipper ▪ "Corporate social responsibility goals drive shippers' decisions to invest in low-emission logistics companies." – Industry Group
	2. Regulatory Incentives		Fuel efficiency rules push companies to seek alternative technologies, although regulation remains fragmented. At a state level, California[1] is leading the charge around decarbonisation, but other states (e.g. Mass., NY) are following suit. New administration is expected to double-down decarbonisation efforts	▪ "California adopted the most aggressive regulation to date. This sends strong signals to the marketplace." – Industry Group ▪ "State-based regulations complicate operations massively. We would rather see federal legislation that smooths it out for everyone." – Shipper
Can the sector change?	3. Technology Alignment		Large shippers are starting to scale BEVs for short-range duty cycles with their own private charging points. Long-distance operators are testing CNG while they wait for FCEV to mature. Given long-distances, hydrogen will likely play a significant role	▪ "The heavier long-haul trucks will likely adopt hydrogen since BEVs compromise payload, and are limited by today's grid." – Truck OEM ▪ "A tremendous amount of fuel efficiency can be garnered through platooning, capacity sharing and drag resistance." – Fleet Operator
	4. Clarity on Roles & Decision Making		Road freight in the US is primarily focused on achieving the lowest cost per mile, which limits appetite for investments in more expensive technology. A 'machismo' culture exists which can drive irrational truck-purchasing decisions (i.e. over-powered or over-sized trucks)	▪ "Logistics companies are hesitant to invest if there is no immediate ROI because the sector competes on cost." – Industry Group ▪ "We don't know which truck to buy and when as the future is uncertain, but the truck needs to last at least 6 years." – Fleet Operator
How fast can the sector change?	5. Ease of Asset Replacement		International OEMs, e.g. from Japan, have announced zero-emission trucks. US-based new BEV and FCEV OEM entrants are applying pressure, but struggle to deliver on launch dates and promised performance. Truck operators struggle to finance alternative trucks	▪ "Even if we wanted to, there are no trucks that we could buy from the OEMs." – Shipper and Private Fleet Operator
	6. Ease of Infrastructure Replacement		Large shippers install private charging infrastructure at their depots, which increases strain on the electricity grid. In most states it is not yet clear who will provide public charging/refuelling infrastructure, and incentives for renewable energy production are limited	▪ "Due to lack of charging opportunities we will install chargers at our own stores, which will transform stores into distribution centres with charging stations." – Shipper

○ US road freight average

● Global road freight average

Note: 1) ICCT (2020) California's Advanced Clean Trucks regulation: Sales requirements for zero-emission heavy-duty trucks

59 **US roadmap**

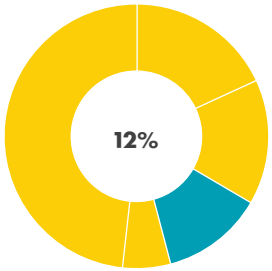


Emphasise	
A	The size and population distribution of the US imply that the transition will happen at a different pace across duty cycles. Nevertheless, some duty cycles can transition early, especially with private charging networks in depots. Additionally, adapting the supply chain to accommodate existing technology maturity levels may help fleet owners accelerate their transition
B	In urbanised areas, city and state mandates for decarbonisation offer opportunities to build conditions for success. The frontrunner position of some states like California has the potential to extend and align city campaigns between regions, in which ecosystem players can partner and form coalitions to generate scale
C	The government will need to implement incentives for companies to transition and provide a coordinated and strategic approach to infrastructure
D	Autonomous technologies are likely to play a role in the transition and must co-exist with zero-emission technologies. It is critical to develop an understanding of how emerging technologies will impact each other both positively (more flexibility, less downtime) and negatively (increased complexity, safety while fuelling) to create a future fit-logistics network

EUROPE

Consumer demand for sustainable supply chains and municipal emission regulations are increasing relative to other geographies. Many fleet owners are making commitments to reduce fleet emissions, and some transitional fuels are being adopted, however zero-emission HDTs and MDTs remain at pilot stage as costs have not yet reached parity, and supporting infrastructure is limited. Coordination between pilots, green truck finance and transportation procurement criteria, and scaling up zero-emission truck production can help accelerate progress in the region.

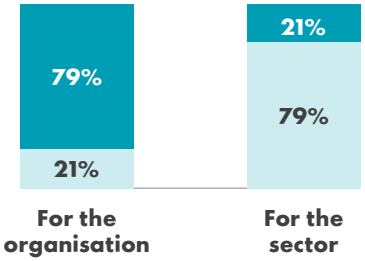
Region highlights

		% global
Population	**448 M**	6%
GDP	**$ 15.6 T**	18%
Road freight volume	**2,278 TKM** (+3% p.a.)	11%
Road quality ranking	Highest country: **2nd** Most countries in **top 50**	
Road freight emissions		

Interviewees

- **71** Road freight stakeholders, including:
  - 24 Logistics Leads and Experts
  - 22 Sustainability Leads and Experts
- **52** Organisations interviewed, including:
  - 2 of the largest OEMs in the region
  - 3 Consumer Goods Multinationals

Importance of decarbonisation

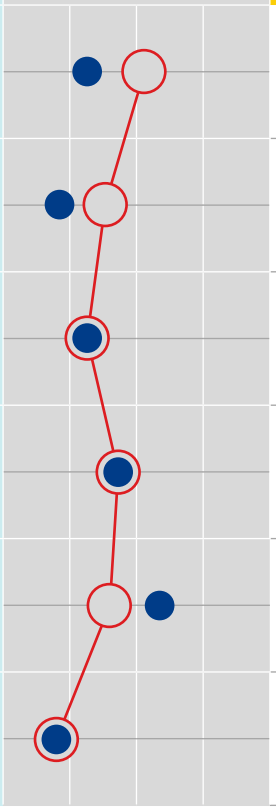


"Sustainability has really come to the forefront recently, and it is our number 1 priority."
– Shipper

"There is a general interest combined with little knowledge around decarbonisation."
– Fleet operator

Sources: World bank (2020); OECD; Weforum Quality of roads (2018); IEA (2017) Future of Trucks, IEA (2020) CO_2 emissions from transport and heavy-duty vehicles in the Sustainable Development Scenario 2000-2030; OECD; Deloitte analysis

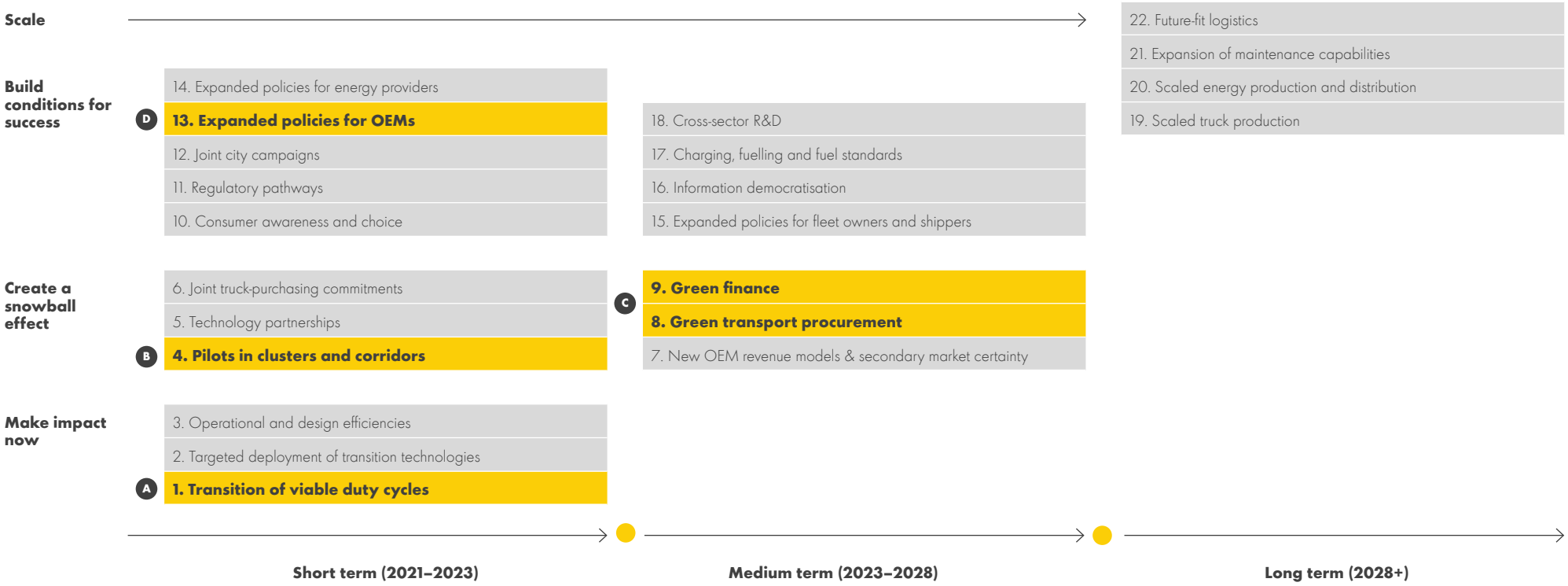
60 **Europe barriers**

Readiness questions	Readiness factors	Criticality of barriers (Major – Minor)	Participants' views on barriers in Europe	Quotes
Why should the sector change?	1. Market and Customer Demand		Shippers are responding to increased consumer demand for sustainable products by incorporating green transportation criteria. An increasing but still limited number of shippers are willing to pay more for green transport	▪ "We started to implement clear sustainability criteria in our transport supplier selection." – Shipper ▪ "All large companies realise they need to do something on sustainability, but this is in the boardrooms, not on the buyers' desks." – Fleet Operator
	2. Regulatory Incentives		The EU recently set ambitious targets to reduce road freight emissions, and many cities are adopting zero- or low-emission zones. However, city regulations are still fragmented with different approaches and timelines. A standardised implementation approach is lacking	▪ "Very ambitious targets are set without a clear roadmap, which makes it difficult for the operational parties to act." – Fleet Operator ▪ "If regulations are created to solve one problem or for one city, we will create a lot of fragmentation and complexity." – Shipper
Can the sector change?	3. Technology Alignment		Uncertainty about large-scale production and technical maturity of BEVs and FCEVs moves operators to delay their investments. Transition fuels are not seen as a long-term solution, have the risk of lock-in and are perceived to have limited availability	▪ "Bridge fuels have the potential to create lock-in." – Industry Group ▪ "OEMs want to benefit as long as possible from their existing technology." – Fleet Operator
	4. Clarity on Roles and Decision Making		Operators are piloting the first green trucks (especially in and around cities) to test viability. Availability of green financing options and shipper willingness to pay are key enablers for Owners to transition, as TCO is not competitive across all segments yet	▪ "We can adapt our duty cycles as needed to accommodate whatever trucks OEMs can offer us today." – Fleet Operator ▪ "Smaller companies lack the capabilities and financial means to invest in untested technologies." – Industry Group
How fast can the sector change?	5. Ease of Asset Replacement		OEMs have announced zero-emission trucks but large scale production has not started. Historically, European OEMs have invested in ICE trucks and they must balance generating returns from these investments while developing capabilities for alternative fuels	▪ "When we called the OEM to order a zero-emission truck, it was not available for sale." – Fleet Operator ▪ "Nobody knows what the residual value of an alternative technology truck is, which makes it hard to for financiers to take the risk." – Truck OEM
	6. Ease of Infrastructure Replacement		The energy infrastructure in Europe is typically considered as some of the best in the world. However, major investments in charging points and grid capacity will be needed for zero-emission trucks. Hydrogen production is still at an early stage in most countries	▪ "We need to collaborate with energy providers to set-up the required infrastructure along frequently used routes." – Shipper ▪ "If we moved our fleet to BEVs and started charging it in our main depot the city would have a power outage immediately." – Fleet Operator

○ Europe road freight average

● Global road freight average

61 **Europe roadmap**



Emphasise	
A	Population density and mature road freight networks throughout Europe limit the maximum distances a long-haul truck has to travel between depots, and makes an early transition of some duty cycles more viable
B	Most ecosystem players emphasise the need for collaboration around existing and future pilots. These connections will be key to share knowledge and build scale within key clusters and corridors
C	Truck owners will need new green finance options and transport procurement criteria to resolve the initial TCO disadvantage for alternative trucks, and technology risk as technologies rapidly improve
D	Policy measures for OEMs to scale up production will be needed to overcome labour union concerns and project jobs, while creating stronger incentives to accelerate production of zero-emission trucks

ACKNOWLEDGEMENTS

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We appreciate your time, energy and enthusiasm – particularly during the period of disruption caused by the COVID-19 global pandemic.

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The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate legal entities. In this Decarbonising Road Freight: Getting into Gear report, "Shell", "Shell Group" and "Royal Dutch Shell" are sometimes used for convenience where references are made to Royal Dutch Shell plc and its subsidiaries in general. Likewise, the words "we", "us" and "our" are also used to refer to Royal Dutch Shell plc and its subsidiaries in general or to those who work for them. These terms are also used where no useful purpose is served by identifying the particular entity or entities. "Subsidiaries", "Shell subsidiaries" and "Shell companies" as used in this Decarbonising Road Freight: Getting into Gear report refer to entities over which Royal Dutch Shell plc either directly or indirectly has control. Entities and unincorporated arrangements over which Shell has joint control are generally referred to as "joint ventures" and "joint operations", respectively. Entities over which Shell has significant influence but neither control nor joint control are referred to as "associates". The term "Shell interest" is used for convenience to indicate the direct and/or indirect ownership interest held by Shell in an entity or unincorporated joint arrangement, after exclusion of all third-party interest.

This Decarbonising Road Freight: Getting into Gear report contains data and analysis from Shell's Sky scenario. Unlike Shell's previously published Mountains and Oceans exploratory scenarios, the Sky scenario is based on the assumption that society reaches the Paris Agreement's goal of holding the rise in global average temperatures this century to well below two degrees Celsius (2°C) above pre-industrial levels. Unlike Shell's Mountains and Oceans scenarios, which unfolded in an openended way based upon plausible assumptions and quantifications, the Sky scenario was specifically designed to reach the Paris Agreement's goal in a technically possible manner. These scenarios are a part of an ongoing process used in Shell for over 40 years to challenge executives' perspectives on the future business environment. They are designed to stretch management to consider even events that may only be remotely possible. Scenarios, therefore, are not intended to be predictions of likely future events or outcomes.

Additionally, it is important to note that as of January 21, 2021, Shell's operating plans and budgets do not reflect Shell's Net-Zero Emissions ambition. Shell's aim is that, in the future, its operating plans and budgets will change to reflect this movement towards its new Net-Zero Emissions ambition. However, these plans and budgets need to be in step with the movement towards a Net-Zero Emissions economy within society and among Shell's customers.

This Decarbonising Road Freight: Getting into Gear report contains forward-looking statements (within the meaning of the U.S. Private Securities Litigation Reform Act of 1995) concerning the financial condition, results of operations and businesses of Royal Dutch Shell. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward looking statements are statements of future expectations that are based on management's current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Royal Dutch Shell to market risks and statements expressing management's expectations, beliefs, estimates, forecasts, projections and assumptions. These forward-looking statements are identified by their use of terms and phrases such as "aim", "ambition", "anticipate", "believe", "could", "estimate", "expect", "goals", "intend", "may", "objectives", "outlook", "plan", "probably", "project", "risks", "schedule", "seek", "should", "target", "will" and similar terms and phrases. There are a number of factors that could affect the future operations of Royal Dutch Shell and could cause those results to differ materially from those expressed in the forward-looking statements included in this Decarbonising Road Freight: Getting into Gear report, including (without limitation): (a) price fluctuations in crude oil and natural gas; (b) changes in demand for Shell's products; (c) currency fluctuations; (d) drilling and production results; (e) reserves estimates; (f) loss of market share and industry competition; (g) environmental and physical risks; (h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (i) the risk of doing business in developing countries and countries subject to international sanctions; (j) legislative, fiscal and regulatory developments including regulatory measures addressing climate change; (k) economic and financial market conditions in various countries and regions; (l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; (m) risks associated with the impact of pandemics, such as the COVID-19 (coronavirus) outbreak; and (n) changes in trading conditions. No assurance is provided that future dividend payments will match or exceed previous dividend payments. All forward-looking statements contained in this Decarbonising Road Freight: Getting into Gear report are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward-looking statements. Additional risk factors that may affect future results are contained in Royal Dutch Shell's Form 20-F for the year ended December 31, 2019 (available at www.shell.com/investor and www.sec.gov). These risk factors also expressly qualify all forward-looking statements contained in Decarbonising Road Freight: Getting into Gear report and should be considered by the reader. Each forward-looking statement speaks only as of the date of this Decarbonising Road Freight: Getting into Gear report, January 21, 2021. Neither Royal Dutch Shell plc nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this Decarbonising Road Freight: Getting into Gear report.

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