BRIEFING NOTE:

UK 7th CARBON BUDGET & NON-ROAD MOBILE MACHINERY

This briefing note provides an overview of areas of the UK's 7th Carbon Budget that specifically relate to emissions from Non-Road Mobile Machinery (NRMM) used on construction sites. The 7th Carbon Budget is put together by the Climate Change Committee (CCC), which was established under the Climate Change Act 2008 and advises the UK and devolved governments on reducing emissions and adapting to the impacts of climate change. In their 'Balanced Pathway' the CCC outline what emission reductions and approaches they deem to be practical to decarbonise the sector.

It is impossible to predict the future, so we make no attempt to do so here. What we have included is a high-level description of the key considerations when using the technologies mentioned, and encourage appreciation of the case-specific challenges to their adoption today.

ELECTRIFICATION

QUOTES FROM THE 7th CARBON BUDGET:

"In the non-road mobile machinery subsector, about half of the abatement is due to the replacement of diesel equipment with electric alternatives."

"Electrification delivers most abatement (52% in 2050), via both battery electric and tethered equipment. Electric options are increasingly becoming available, even for very large equipment." (NRMM decarbonisation options feasibility study, DESNZ)

CPA & AMPS Comments: The source referenced by the CCC "does not consider practicalities beyond the commercial availability of the technologies themselves", but for plant-hirers and construction sites the practicalities are the most significant limiting factors. Electrification is possible in some use cases for some types of equipment, but these are currently limited. Electrification is also heavily dependent on available infrastructure. Sites often have no grid

connection at all, especially during groundworks when large mobile machines are in use and the power demand is at its highest.

There are two main types of electric equipment - battery, and tethered.

Tethered means that it needs to be plugged in at all times to operate, and is typically better suited to stationary applications due to safety issues with trailing high-power cables, especially when damaged, knotted, crossing a walkway/vehicle route etc. In mobile applications operators need to be careful not to wrap the machine up in it's own wire, run over their own cable, or rip the socket out of the wall. Sounds obvious, but it happens.

Mobile applications are usually better suited to battery equipment which only plugs in when charging, but this requires charging infrastructure and down-time. Duty cycles for battery equipment are shorter than for diesel. Advertised battery life is of limited use as the battery life depends on intensity of use. Working a machine hard or travelling long distances will usually deplete the battery quite quickly.

Fast charging is usually between 1-2 hours, which may allow you to use battery equipment more intensely, provided there is time to charge during the working day. This almost always requires an 'off-board' charger, like the charging columns we see for cars. In construction, these chargers often need to be temporary/mobile. A permanent charging column would need to be both compatible with machines and road vehicles, and suitably located for both the site during works, and the end user after works have completed. It isn't worth installing if it will be inaccessible/redundant once the building is complete, or would need to later be removed as it is in the way of the building works.

An 'on-board' charger is the charging capabilities that are built into the machine. The name is a little misleading, as you still need an external power supply and charger, but this is much smaller, requires less power, and is generally easier to install than an off-board/fast charger. However, Typical charge times are 6-12 hours, so this is mostly used for overnight charging. It can also mean a days delay if the site forget to put the machine on charge, or if charging fails during the night. Plugs and sockets vary, but are beginning to be standardised. Vehicle chargers and machine chargers cannot always be used interchangeably, and not all chargers are compatible with all machines/manufacturers. Various chargers may be required for mixed fleets.

Almost all types of electric machine require forward planning and a significant power supply, whether from a substantial grid connection (which could be enhanced with Battery Energy Storage Systems), or a diesel generator. Powering electric machinery from a diesel generator is a little counter-intuitive, but electric machines do not idle, so there is still potential for emission and carbon savings depending on the type of generator and how it is used, including hybrid power arrangements. Powering from grid is of course a far more desirable option, but often not possible.

Low-power items like lighting towers can be charged from solar if the site has a decent view of the sky, but a back up power supply may be required at certain times of year or for long usage hours. Always discuss your application with the supplier.

Fully electric machines generally cost much more to buy and are not worth as much when resold after use, compared to diesel. Less customers are able to use them, so utilisation is lower. The combination of these factors can make it very difficult to keep hire rates down, customers should expect to pay a significant premium for these machines. There are fuel savings to be had which can balance out the cost of the hire for some types of machine and uses, but this is often not the case.

Diesel-hybrid equipment is emerging on the market and receiving significant R&D focus from many OEMs. It is a natural middle ground that is more flexible and deployable than fully-electric, being less dependent on infrastructure. There are both plug-in hybrid and battery-hybrid machines on the market, some of which still require an external power source, but usually a less substantial one than their fully-electric counterparts.

Hybrid equipment covers a broad spectrum, with machines that recover energy from mechanical movements and others that use electric for low-power activities, eliminating engine idling. Some models travel on diesel but work on electric, others can operate on either, with the same diesel engine but an optional plug-in point to tackle grid accessibility in different areas of a construction site. Hybrid machines can also include various combinations of the above features. Government should recognise the role of hybrid solutions in this dynamic sector, clarifying their support for those technologies.

HYDROGEN

QUOTES FROM THE 7th CARBON BUDGET:

"Switching to hydrogen has a meaningful role in […] non-road mobile machinery. […] There remains a role for hydrogen where electrification is either impractical or not cost effective."

"Our pathway selects hydrogen options (22% of abatement in 2050) mostly where we deemed electric equipment to be impractical, such as large electricity generators and intensively used machinery."

CPA & AMPS Comments: Hydrogen is a promising but novel technology for construction equipment. There are two main types of hydrogen machinery – Fuel Cell (H2FC), and Internal Combustion (H2ICE).

Hydrogen fuel cell is sensitive to dust and vibration, so it is better suited to applications like lighting towers and access platforms than mobile machines, earthworks and pumps. Fuel cell also doesn't fare well with sudden power demands and start up currents which are common in construction equipment. Solutions are emerging that use a combination of fuel cell and battery energy storage, with H2FC charging batteries which then deliver power to site more flexibly.

H2ICE is more conventional and is similar to a spark ignition gas engine, though more advanced. It does not suffer the same sensitivities as H2FC, but has poor energy storage density, requiring much larger fuel tanks and more frequent refuelling than

diesel (usually daily for medium sized machines). It is also challenging to transport in large volumes, so most hydrogen trials currently require frequent visits to refuel machinery, and are located near to hydrogen production/distribution networks ('clusters'). Investment in more hydrogen clusters could help to increase demand.

The cost is expected to come down as demand and supply increases, but green hydrogen is currently very expensive. Blue hydrogen is cheaper and more available but not as environmentally friendly as green. The CCC report does not mention the split between different types and colours of hydrogen in NRMM, but recognises that blue hydrogen will likely play a role as an interim/backup solution across the UK economy. Hydrogen can be challenging to source, and there are bespoke safety considerations to be made when using the fuel. For this reason hydrogen equipment is often supplied in partnership with specialists from the hydrogen industry, who can assist with the technical safety requirements, fuel supply and maintenance.

BIOFUELS

QUOTES FROM THE 7th CARBON BUDGET:

"Bioenergy in the form of liquid biofuels is important in our pathway as a transition fuel for non-road mobile machinery. This becomes steadily less important as hydrogen and electrification replace biofuels, starting in the 2030s."

"Transitional use of biofuels such as biodiesel and bioethanol can help reduce emissions in surface transport and in machinery in industry and agriculture."

CPA & AMPS Comments: The terms biofuel, biodiesel and HVO are often used interchangeably, but there are significant differences. HVO is a drop-in fuel that meets EN15940 specifications. It can require more oil filter changes in machines, but most manufacturers approve it's use in their engines. It does not normally invalidate warranties or require engine modifications.

Biodiesel (also known as FAME) meets a different specification; EN14214. Few manufacturers allow the use of biodiesel blends greater than B7 (standard white diesel) in their off-road engines, and those who do normally require enhanced fuel management. This is because of concerns that FAME-based fuels can cause damage to engines by blocking filters, 'gelling' in cold weather, and damaging fuel system components. Construction machinery and fuel storage can be modified to be more tolerant of FAME but this can cost several thousand pounds per machine and may jepodise manufacturer warranties. Enhanced daily checks may also be required, which can be challenging to adhere to in a dynamic construction environment. Even if plant-hirers issue a disclaimer absolving them of responsibility in fuel management, damages to machinery can still cause shelving of assets and arguments over who pays the repair costs.

However, some producers of these fuels are challenging the claims above, arguing that understanding in this area is often outdated, and that certain fuel additives can be used to improve temperature tolerance and shelf-life of the fuel. These discussions are ongoing, and we are keen to hear from anyone trialling these fuels what their experience has been. It is too soon to say for sure whether biodiesel has a place in the off-road market, we have to wait for confirmation and manufacturer instruction for the time being.

HVO is generally regarded as the more practical option, however it costs more than diesel, is not produced domestically, and there are ongoing concerns about sustainable sourcing of the fuel. It is designed to be made predominantly from waste products, but is vulnerable to international fuel fraud and there are suggested links to deforestation due to the land space taken up by plant feedstocks. Use of HVO should therefore be accompanied by significant due diligence regarding the supply chain.

EFFICIENCIES

QUOTES FROM THE 7th CARBON BUDGET:

"Energy efficiency plays at least a small role in all subsectors but is most significant in non-road mobile machinery"

"Energy efficiency also delivers important abatement in this subsector (25% in 2050), achieved through more efficient machines and operational improvements."

CPA & AMPS Comments: It is reassuring to see that efficiencies are now recognised as playing a significant role in reducing emissions from plant. Many fleet operators are now using telematics to measure, monitor and reduce fuel consumption not just from plant operations but also their delivery. This software does carry an administrative cost, but this is relatively low compared to the price and risks of a new machine. Telematics can also be used to monitor and reduce engine idling and allow for fuel saving competitions to incentivise fuel-efficient operation. Most modern machines can be programmed to switch off automatically after periods of engine idling. Modern machines often also include operator assistance features for accurate grading/levelling etc. These features help operators to get the job right first time, saving fuel burned in re-doing or perfecting their work.

Efficiencies are aways a focus for OEMs, and rumours are that EU Stage VI may focus more on improving efficiencies than the local Air Quality limits that have been the requirement to date.

ENFORCEMENT

QUOTES FROM THE 7th CARBON BUDGET:

"This subsector includes a wide range of machinery used in the mining, construction, ports, and waste sectors."

"Introduce regulations, supported by subsidies if necessary, to drive decarbonisation of non road mobile machinery. This could include regulatory measures with proven success in reducing road transport emissions."

CPA & AMPS Comments: We assume this is a reference to the Zero Emission Vehicle (ZEV) mandate, and Low-Emission Zones. Off-road machinery is a specialist sector where decarbonisation is highly case-specific. We feel that road transport schemes do not offer the best starting point for consideration of measures to decarbonise off-road machinery. A better framework for the drawing board would perhaps be existing work within the construction sector, such as NRMM London, Impact on Urban Health's Exemplar Sites scheme, Nine Elms AQ management, CESAR Emissions Compliance Verification scheme and Lambeth & Southwark's Construction Emissions Compliance Officers. Most of these schemes involve dedicated public sector staffing to engage, visit, and take individual site constraints into account.

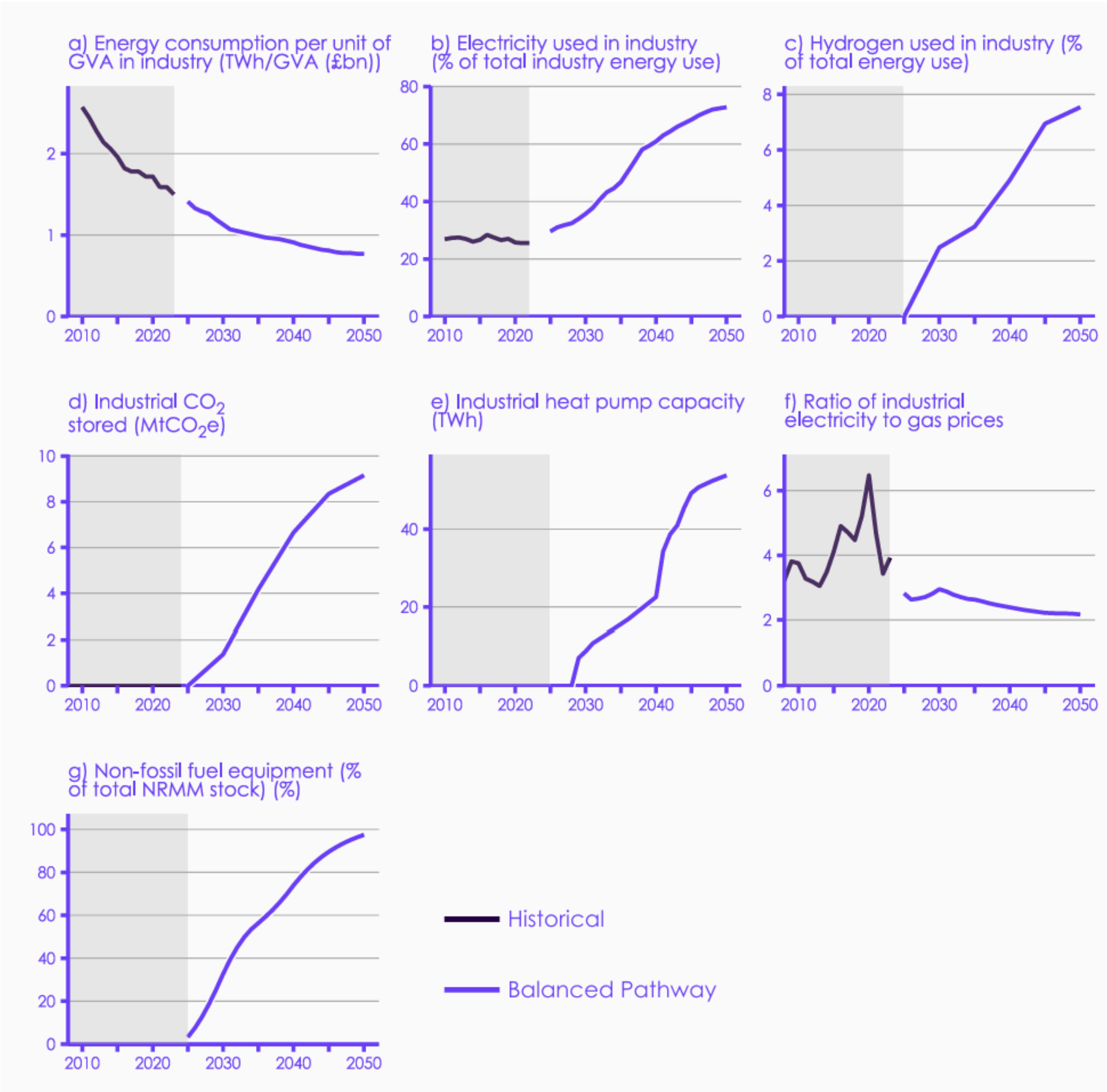
Regulation does not resolve practical challenges, and dramatic increases in cost can slow construction activity. Blanket requirements and rigid schemes may force specific technologies into unsuitable applications, damaging productivity and growth. If government is set on regulating this industry, there must be a tailored and pragmatic approach, with reasonable expectations.

Table 7.3.1
Key values in the Balanced Pathway for Industry

		2025	2030	2035	2040	2050
Emissions	Emissions in year ($MtCO_2e$)	44.6	31.4	21.1	11.2	3.6
	Change in emissions since 1990	-69%	-78%	-85%	-92%	-97%
	Change in emissions since 2023	-14%	-39%	-59%	-78%	-93%
	Share of total UK emissions	11%	11%	11%	10%	
Key drivers - quantity variables	Index of industrial GVA (2023 = 100)*	101	103	108	115	128
	Total industrial energy use (TWh)	280	231	211	205	196
	Percentage of industrial energy use supplied by electricity	30%	36%	47%	61%	73%
	Industrial heat pump electricity demand (TWh)	0	9	16	23	54
	Percentage of industrial energy use supplied by hydrogen	0%	2%	3%	5%	8%
	Million tonnes of CO_2 captured and stored	0	1.4	4.2	6.7	9.2
	Percentage of non-road mobile machinery not powered by fossil fuels	3%	33%	56%	74%	97%
Key drivers - price variables	Industrial heat pump - cost per capacity of thermal output (£/kW)	680				

Source: CCC analysis.
Notes: We have blanked out the share of total UK emissions in 2050 because total UK emissions have reached Net Zero at this point. All costs are in £2023 real. *GVA = gross value added. The index of industrial GVA is based on UK Government figures in its Energy and Emissions Projections. The index does not take account of the effect of the resource efficiency measures in our pathway, which would reduce overall demand for materials.

Table 7.3.3
Key indicators for the industry sector



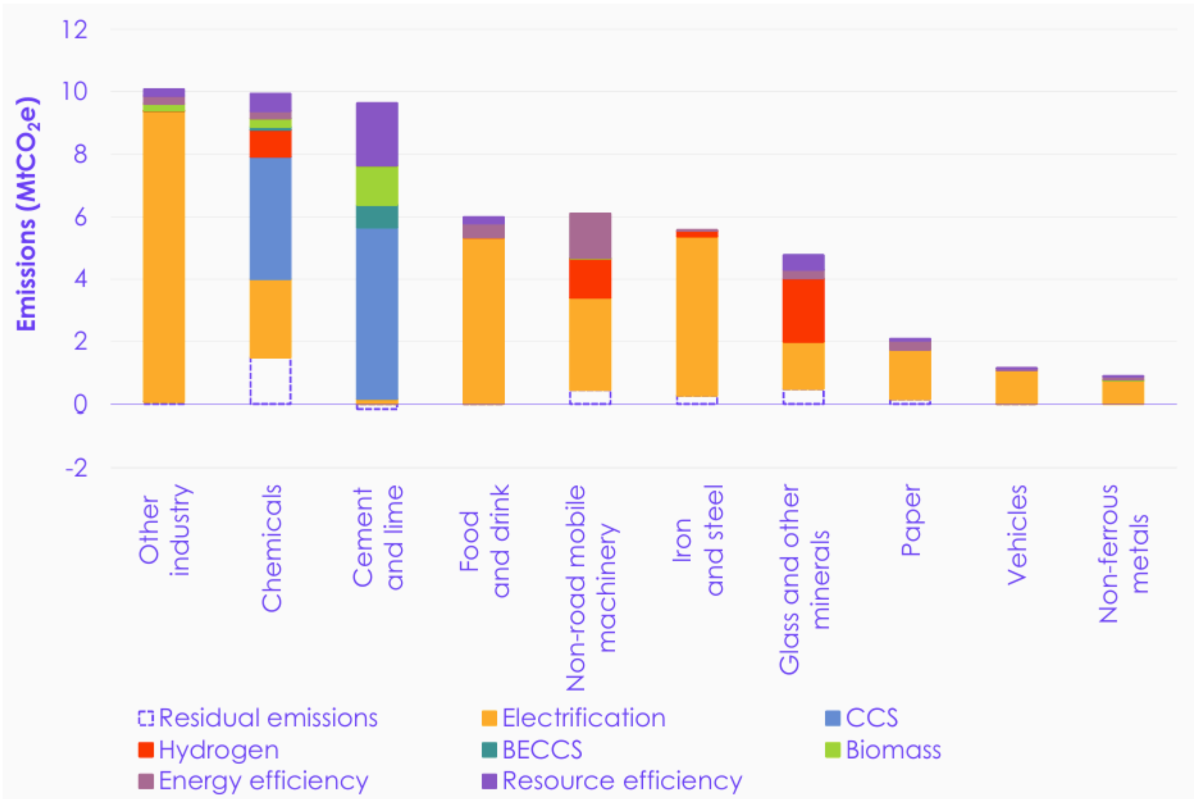
Description: The key indicators for industry in the Balanced Pathway show substantial growth in the use of electricity, including industrial heat pumps. This leads to a more efficient system, requiring less energy per unit GVA. The use of low-carbon hydrogen and CCS both increase from zero today.

Source: Historical data from DESNZ and ONS; CCC analysis.

Notes: (a) GVA data calculated from UK Government figures on industry GVA in its Energy and Emissions Projections. (c) Hydrogen refers only to low-carbon hydrogen used as a fuel. (e) Heat pump capacity relates to electricity input: heat output will be higher. (f) The future price ratio is based on estimates of retail energy prices for manufacturers minus the climate change levy, which is also removed in historical data. The Balanced Pathway series also deducts the policy costs on electricity from which some energy-intensive manufacturers are currently exempt. In the analysis for the industry pathway, we use long-run variable costs which have a ratio similar to this series. (g) NRMM = non-road mobile machinery. The share of non-fossil fuel stock includes traditional equipment that switches to biofuels.

Figure 7.3.4

Abatement and residual emissions from industrial subsectors in 2050



Description: CCS contributes the largest share of abatement in chemicals and cement and lime subsectors. Hydrogen has the largest role in glass and other minerals. Electrification contributes the largest share of abatement in all other subsectors.
Source: CCC analysis.
Notes: (1) Abatement relates to baseline emissions in 2050. Baseline emissions for any subsector could be higher or lower than current levels. (2) We typically include BECCS in the removals sector but have included it here to show how BECCS contributes to abatement in industry. The inclusion of BECCS results in negative emissions in cement and lime and slightly lower residual emissions in chemicals.

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