Written evidence submitted by Dolphin N2 (CGE0069)

1 Executive Summary

1.1 This submission responds to the issues identified in the Science and Technology Commons Select Committee Inquiry, Technologies for meeting Clean Growth emissions reduction targets, and specifically addresses measures for commercial subsectors of Transport including Heavy Goods Vehicles, Shipping and Rail.

1.2 Good progress has been made in achieving the first carbon budget with projections to overachieve on the second and third budgets, during which time there has been substantial growth in the UK economy.

1.3 However, overall carbon reduction has been achieved primarily by Power, Waste and Industry Sectors whilst other Sectors have remained relatively flat, and in particular Transport has recently grown and is now the largest emitting Sector at 28% of the UK inventory.

1.4 Projections show gaps in achieving the fourth and fifth budgets with the Committee on Climate Change identifying insufficient planning and policy in a number of areas, including Transport HGVs, with additional action needed.

1.5 The Clean Growth Strategy has identified the Shift to Low Carbon Transport as a priority, and in context of growing the UK economy commercial Transport will only deploy technologies that are operationally and financially viable, almost exclusively those that use liquid fuels, demanding increased efficiency of thermal propulsion systems and decarbonisation of fuel.

1.6 It is critical to note that the projected oil consumption for road freight and shipping increases substantially through to 2040, and therefore action now is essential to manage what will otherwise constitute a far larger challenge in 2050.

1.7 To ensure decarbonisation of the HGV fleet for the fourth and fifth carbon budgets, with a trajectory to achieve the 2050 commitment and net-zero, a combined approach is set out of improved engine efficiency and sustained fuel decarbonisation. For engine improvement alone, the following benefits apply.

1.7.1 Carbon reduction of at least 1.18 MtCO2e p.a. in 2032, with potential exceeding 5 MtCO2e. Further application in Transport includes Shipping and Rail.

1.7.2 Significant through life cost saving of £9,000 p.a. per truck enabling deployment at scale without subsidy and accompanying cost reductions to the UK economy.

1.7.3 Significant reduction in air pollutants with resulting air quality improvement and consequent health benefits of over 1,200 life-years and up to £660m economic damage saved p.a. by 2032.

1.7.4 Further application to other Sectors including Buildings (heating), Agriculture (farm vehicles), Industry (construction equipment), Power (flexible decentralised generation).

1.7.5 Deploys UK technology and manufacturing infrastructure with further benefit to the UK economy.

1.7.6 Substantial export market for HGV and decentralised power generation to further displace coal, with global carbon reduction potential exceeding several hundred MtCO2e p.a.

1.8 Recommendations are provided for planning and policy in support of achieving the fourth and fifth carbon budgets, and the path to net-zero.

1.8.1 The Government approach should be outcome based and technology neutral

allowing a full range of technologies to be addressed, thereby managing uncertainty and enabling risks and gaps in achieving budgets to be closed.

1.8.2 Plans and policy in the Transport Sector should fully address all subsectors including HGVs, Shipping and Rail.

1.8.3 Policy for assessment of carbon emissions should address full lifecycle to ensure best outcomes, and that emissions are not only moved between Sectors in a zero or negative-sum game.

1.8.4 Policy should be consistent over time to enable investment and deployment.

2 Introduction & Declaration of Interest

2.1 I am CEO of Dolphin N2, a spinout from a UK PLC, with twenty-eight years' industry experience in the development and delivery to market of innovative technology for transport, power generation and shipping sectors. I am signatory to the UN IMO taskforce established to accelerate the decarbonisation of international shipping[1].

2.2 Dolphin N2 is industrialising a new technology, CryoPower, targeted at substantial reduction of of carbon emissions and air pollutants for industrial engine applications in heavy transport, shipping, rail and power generation, and with capability to use a full range of decarbonised fuels including hydrogen. The early stage innovation of CryoPower has been funded by Ricardo PLC and Innovate UK. Dolphin N2 plans to manufacture in the UK.

2.3 I am submitting evidence for carbon reduction in areas of the Transport Sector that are otherwise challenging to address, primarily HGVs, shipping and rail, and for which further planning and potentially policy development are required to help ensure that the fourth and fifth carbon budgets are achieved.

[1] GLOBAL INDUSTRY ALLIANCE OVERVIEW, IMO: https://glomeep.imo.org/global-industry-alliance/global-industry-alliance-gia/

3 Response to Issues of Inquiry[2]

3.1 Strategy: Progress to Date and Gaps for Future Carbon Budgets – *good progress overall has been made to date however there are gaps in achieving the fourth and fifth carbon budgets and additional action is needed, particularly in Transport*

3.1.1 The UK has exceeded commitment for emissions reduction in the first carbon budget and is projected to exceed commitments for the second and third budgets. The reductions achieved have been primarily in Power, Waste and Industry Sectors, with overall progress now slowing and Transport increasing to become the largest emitting Sector now at 28% of the UK carbon inventory[3].

3.1.2 The fourth and fifth budgets require more challenging reductions of 62% from 1990 to 2030, and with current plans will not be achieved with a gap of up to 65MtCO2e at 2030. Based on current performance the Sector with highest risk is Transport.

3.1.3 Transport is divided into several subsectors for which there are technologies in production to address cars and vans (electrification, biofuels)[4], with focus now on speed of deployment. However, there are few if any measures identified to progress HGVs[5], Shipping, Rail and Aviation.

3.1.4 This submission is targeted at the difficult to resolve commercial Transport subsectors of HGVs, Rail and Shipping (domestic and international), with reference to other Sectors where there is cross-sector benefit.

3.2 Strategy: The Extent to Which Technologies can Help to Meet Carbon Budgets – *commercial Transport will only deploy technologies that are operationally and financially viable, almost exclusively those that use liquid fuels, demanding increased efficiency of thermal propulsion systems and decarbonisation of fuel*

3.2.1 Technologies have been identified, are in development and are deployed for several Sectors that will contribute to ongoing reduction in carbon emissions. However, as has been identified, gaps exist for the fourth and fifth carbon budgets which arise from:

3.2.1.1 Subsectors in which technology has not been identified to sufficiently abate emissions;

3.2.1.2 Barriers to the speed of technology deployment and therefore the actual benefit to be realised. These barriers typically include cost, operability or utility, ready availability of product, and policy and regulation.

3.2.2 For commercial Transport and other Sectors where vehicles 'work for their living' and business is capital intensive with narrow operating margins, the following factors must be considered for both the development and deployment of technology:

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[2] Technologies for meeting Clean Growth emissions reduction targets inquiry launched, Science and Technology Select Committee: https://www.parliament.uk/business/committees/committees-a-z/commons-select/science-and-technology-committee/news-parliament-2017/clean-growth-emisions-inquiry-luanch-17-19/

[3] Reducing UK emissions – 2018 Progress Report to Parliament, Committee on Climate Change: https://www.theccc.org.uk/publication/reducing-uk-emissions-2018-progress-report-to-parliament/

[4] The Road to Zero, OLEV: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/739460/road-to-zero.pdf

[5] Letter to Chris Grayling and Greg Clark – assessment of the Road to Zero Strategy, Lord Deben, CCC Chairman: https://www.theccc.org.uk/wp-content/uploads/2018/10/Lord-Deben-to-Chris-Grayling-Greg-Clark-on-Road-to-Zero.pdf

3.2.2.1 Capital Cost – additional cost for alternative technology must pay back through reduced operating cost within a limited period of time, typically up to 12 months for HGVs. Commercial vehicle equipment is expected to survive vehicle life of up to 1 million miles, or 10 years.

3.2.2.2 Operating Cost (fuel, service & maintenance) – in many commercial applications this will substantially outweigh capital cost and must be lower than existing vehicles by some margin to accept the risk of new technology adoption. Short term operating cost incentives are less likely to influence vehicle purchase decisions due to long vehicle life.

3.2.2.3 Utilisation (availability) – working vehicles must be available for productive operation for a maximum proportion of life, which is impacted by load capacity, refuelling and service time, and consideration of operating risk which includes off-board infrastructure such as distribution of fuelling stations.

3.2.2.4 Vehicle Life – working vehicle life may be at least 10 years, if not 30 or more for Rail and Shipping, therefore drop-in alternative fuels and vehicle retro-fit and are essential to make a significant impact to fleet carbon emissions. Accelerated rates of fleet replacement are limited by capital expenditure.

3.2.3 For commercial vehicle operation it is essential to consider the energy density of different technologies which determines the weight and volume of stored energy used to power the vehicle (energy carriers are fuel or batteries). Typical ranges are shown in Table 1:

Energy Carrier (with tank; at pressure)	By Weight Wh/kg	By Volume Wh/litre
Liquid Fuel (gasoline; diesel)	10,000 ~ 11,000	9,000 ~ 10,500
Gaseous Fuel (hydrogen; natural gas)	2,000 ~ 3,000	1,000 ~ 2,000
Li-Ion batteries (electrical energy)	200 ~ 300	500 ~ 600

3.2.4 Energy density has a substantial impact on the following aspects of commercial vehicle operation, and will determine if a vehicle is operationally and financially viable:

3.2.4.1 Vehicle range: a certain quantity of stored energy is required to power a vehicle over a certain distance. Energy carriers with lower energy densities deliver less range for the same mass or volume, and require more frequent refuelling, both of which limit vehicle utility.

3.2.4.2 Vehicle weight: maintaining range will increase vehicle mass for lower density energy carriers which will reduce load carrying capacity and can make vehicles inoperable.

3.2.4.3 Vehicle packaging: maintaining range will increase energy storage volume for lower density energy carriers and reduce load carrying capacity.

3.2.5 Full electrification of commercial vehicles is technically feasible although constrained by utility and operational viability, primarily through mass of batteries and charging time / infrastructure. To substantively decarbonise commercial vehicles, action is required on gaseous and liquid fuels.

3.2.6 Hydrogen has been demonstrated in a number of commercial vehicle applications however near-term deployment at scale will be constrained by cost and utility.

3.2.7 Natural gas, has been deployed widely in urban commercial vehicles and in a number of long haul commercial vehicles. However, due to a lack of refuelling infrastructure and some uncertainty in policy it is unlikely that natural gas will take significant market share in the near term. There does however remain an opportunity

for carbon reduction of up to ~20% compared to liquid fuels and the barriers to realising this should continue to be addressed in development.

3.2.8 Considering commercial vehicle requirements of range, weight, packaging and other measures of utility including refuelling time, together with the existing capital investment in fleets and infrastructure, it is evident that the use of liquid fuels will be sustained and globally is projected to be still increasing at 2040 for commercial vehicles[6]. Significant reduction of carbon emissions must deploy technologies that work efficiently with liquid fuels, and therefore include internal combustion engines. The final carbon emissions from vehicles are determined by both the carbon intensity of the fuel, and the efficiency with which it is converted into useful power.

3.2.8.1 Engine efficiency – further technology development of engines will yield higher efficiency[7] and therefore lower carbon emissions. This will be enabled through sustained funding of engine development and policy that is coherent both in terms of carbon emissions (well-to-wheel) and air quality, recognising that ongoing reduction is being addressed by industry and adopting an approach consistent with that of the UK Automotive Council roadmaps[8].

3.2.8.2 Carbon intensity – non-renewable fuels have higher carbon intensity. This may be reduced through to net-zero by blending or replacing with lower carbon liquid fuels (biofuels, eFuels)[9], and has been shown to be economically competitive[10]. Sustainable biofuel is already part of the Transport strategy, however further planning should include the extent of refinery and low-carbon liquid fuel measures, appropriate accounting of lifecycle carbon emissions rather than only at point of use, and implementation enabled by long term consistent policy.

3.2.9 Ultimately, commercial vehicle fleets will adopt the lowest through life cost, lower risk and highest utility technologies to remain commercially viable. Technology strategy and policy must address these factors to ensure deployment at scale and reduction in carbon emissions.

3.3 Strategy: Addressing Uncertainty – *contingency is required in planning and policy to achieve future carbon budgets, and must include commercial Transport subsectors with specific focus on deployment at scale*

3.3.1 The current plans to achieve the fourth and fifth carbon budgets leave a gap, and in addition the proposed technologies within the plans contain differing degrees of risk in delivering projected outcomes.

3.3.2 To ensure the fourth and fifth budgets are achieved, specific measures are therefore needed in three areas to provide contingency and manage risk:

3.3.2.1 All subsectors should be addressed in technology planning, otherwise an

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[6] Changing lanes: A roadmap for transport and future energy markets, S&P Global Platts: https://secure.viewer.zmags.com/publication/3a128229#/3a128229/10

[7] US Supertruck Programme Brief, DOE: https://www.iea.org/media/workshops/2016/egrdtransportsystemsofthefuture/4SuperTruckBriefingOct2016IEAMtgRmG.pdf

[8] The Roadmap Report, Towards 2040: A Guide to Automotive Propulsion Technologies, UK Automotive Council: https://www.apcuk.co.uk/app/uploads/2018/06/roadmap-report-26-6-18.pdf

[9] The Low Carbon Pathways Project. A holistic framework to explore the role of liquid fuels in future EU low-emission mobility (2050), CONCAWE: https://www.concawe.eu/wp-content/uploads/2018/04/Working-plan_Low-Carbon-Pathways.pdf

[10] Impact Analysis of Mass EV Adoption and Low Carbon Intensity Fuels Scenarios – Summary Report, Ricardo report to CONCAWE: https://www.fuelseurope.eu/wp-content/uploads/Summary-Report-Mass-EV-and-Low-Carbon-Fuels-Scenarios-1.pdf

unachievable expectation will be placed upon too few Sectors.

3.3.2.2 A full range of technologies should be embraced in planning, development and deployment, to ensure that sufficient carbon abatement is achieved in recognition of uncertainty.

3.3.2.3 Technology options must include those that may be deployed rapidly and scaled as needed, to enable a tactical response in the event of reduced strategic outcomes.

3.3.3 The IPCC has set out strategy to further manage uncertainty in outcomes through scenarios for a 1.5 °C increase in global warming[11], identifying that a complete suite of measures (A+B+C) is required rather than selection of a few (A or B or C).

3.3.4 For commercial Transport, it is essential that planning encompasses subsectors for HGVs, Rail and Shipping with a complement of technology options and a focus on those that can be deployed at scale within the fourth carbon budget.

3.4 Support to the Development and Deployment of Technology – *the decarbonisation of commercial Transport is dependent on technology neutrality, supported by consistent long-term policy for both carbon emissions and air quality*

3.4.1 The development and deployment of technology must be guided through outcome-based policy specific to subsectors, and which is technology neutral.

3.4.1.1 National and local policy should not disadvantage specific technologies where these may achieve the intended outcomes.

3.4.1.2 Policy must be consistent over time to enable longer term investment decisions in technology development, and the longer-term capital investment decisions required for commercial equipment and infrastructure.

3.4.2 In specific instances, tactical support through investment or subsidy should be given to technologies either in development or deployment to overcome structural barriers to entry such as cost to scale, and refuelling infrastructure.

3.4.3 The primary path to decarbonise commercial Transport, through development and deployment of more efficient propulsion systems and the decarbonisation of liquid fuels, should be supported through the following actions.

3.4.3.1 Remain technology neutral – the focus on vehicle electrification has diverted attention, emphasis and resource from the development and deployment of thermal propulsion systems and fuels. To ensure best outcomes a balanced approach should be ensured, consistent with the UK Automotive Council roadmaps.

3.4.3.2 Policy for air quality – further development of engines is yielding further reduction of air pollutants to ultra-low and near zero levels, and this must be recognised in setting both local and national policy.

3.4.3.3 Policy for carbon emissions – the consideration of full lifecycle emissions for low carbon fuels and full lifecycle emissions for vehicles will ensure best outcomes, and that emissions are not moved between Sectors with a zero or negative sum game.

3.4.3.4 Long term and consistent policy to enable investment in development and capital equipment.

3.5 Examples of Specific Technologies – *for commercial Transport the improved efficiency of thermal propulsion systems and sustained decarbonisation of fuels are identified as the primary path for maximising carbon abatement*

3.5.1 Existing technologies that have been effectively supported so far include the

[11] SPECIAL REPORT: Global Warming of 1.5 ºC, IPCC: https://www.ipcc.ch/sr15/

following.

3.5.1.1 In Power, the deployment of off-shore wind capacity at substantial scale.

3.5.1.2 In Transport, the deployment of biofuels in gasoline (E5, E10) and diesel (B7), and development of technology and infrastructure to electrify the passenger car and van subsectors.

3.5.2 Technologies that show particular promise for commercial Transport are those that can be most readily deployed, offer minimum or no impact to operation, and offer a total cost of ownership benefit. As identified above, the primary solutions are decarbonised liquid and potentially gaseous fuels, and higher efficiency propulsion systems. These technologies should be used in conjunction to give the best opportunity for commercial Transport decarbonisation as part of meeting the UK Government's carbon emissions targets.

3.5.3 The further decarbonisation of fuels through increased use of sustainable biofuel, reducing carbon footprint of refineries, carbon capture and use in fuel manufacture, and power to gas or liquid are well documented and can deliver carbon reduction across current vehicle fleets. The support required is summarised in 3.2.8.2.

3.5.4 There are multiple technologies in development and deployment that increase the efficiency of engines and thereby reduce fuel use and carbon emissions. One such technology, CryoPower, has been in development for several years and has now been demonstrated at proof of concept or Technology Readiness Level 3 (TRL3[12]), with deployment commencing during the fourth budget period and displaying the following potential. The support required is summarised in 3.2.8.1.

3.5.4.1 An efficiency improvement and fuel consumption reduction of ~30%, equating to a carbon saving of 19.8 t CO2e p.a. per truck[13], and 1.12 MtCO2e p.a. in UK by 2032[14] with potential exceeding 5 MtCO2e.

3.5.4.2 An operating cost saving of ~20%, enabling capital payback within 12 months and significant through life cost saving, ensuring market adoption without subsidy and UK economic benefit.

3.5.4.3 A substantial reduction in air pollutants from HGVs to near zero levels, delivering UK health benefits of over 1,200 life years and up to £660m economic damage saved p.a. by 2032[14].

3.5.4.4 Application to other subsectors of commercial Transport including Shipping and Rail, and to other Sectors including Buildings (heating), Power (flexible decentralised generation), and also Industry and Agriculture (off-highway construction and agricultural vehicles).

3.5.4.5 Scheduled to develop and industrialise for manufacture in the UK, delivering sales and service revenue in excess of £100m by 2030 whilst growing the UK supply chain and providing significant incremental employment opportunity.

3.5.4.6 Very high export opportunity for global HGV and decentralised power generation markets, with global carbon reduction potential exceeding several hundred MtCO2e p.a.

4 Recommendations

4.1 The Government should adopt an outcome based and technology neutral approach in policy, thereby ensuring that a full range of technologies can be pursued in planning,

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[12] Automotive Technology and Manufacturing Readiness Levels, SMMT: https://www.smmt.co.uk/wp-content/uploads/sites/2/Automotive-Technology-and-Manufacturing-Readiness-Levels.pdf

[13] Results of the Dolphin N2 Emissions saving model, report due for publication

[14] Life Cycle Assessment of Dolphin N2, report due for publication

development and deployment to manage uncertainty. The approach must recognise that deployment at scale in commercial vehicle fleets is contingent on operational and financial constraints.

4.2 Policy for carbon emissions should account for Transport “well-to-wheel” rather than only at point of use “tank-to-wheel”, to ensure an effective interpretation of “zero emission” and ensure emissions are not moved between Sectors in a zero-sum game. Ultimately, full lifecycle emissions should be addressed.

4.3 Policy should be long term and consistent both over time and between local and national administrations, to enable long term investment in development of technology and deployment in capital assets and infrastructure.

4.4 Plans and policy should incorporate the UK Automotive Council roadmaps for Thermal Propulsion Systems and ensure that effort is balanced between technologies to realise the maximum opportunity for decarbonisation of the Transport Sector.

4.5 The strategy to deploy the extensive decarbonisation of liquid and gaseous fuel should be developed with industry, identifying plans to address technical, commercial and policy risks.

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