NET ZERO TRANSPORT GROWTH OPPORTUNITIES AND IMPACTS PROGRAMME

Report for an external audience

Report for: Department for Transport

Ref. TTDC0002

Ricardo ref. ED18256

Version 2 27/03/24

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Customer:
Department for Transport (DfT)

Customer reference:
TTDC0002

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Ricardo reference:
ED18256

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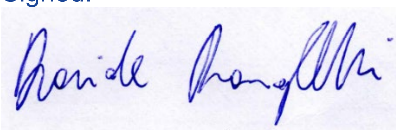

Date:
27/03/2024

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1. INTRODUCTION

The Department for Transport (DfT) commissioned Ricardo to develop **job growth potential calculators across nine key policy areas in its transport decarbonisation programme**, including cars and light duty vehicles (LDVs), heavy goods vehicles (HGVs), buses, motorcycles (L-category vehicles), maritime, aviation, low carbon fuels (LCF), rail and active travel. The calculators will equip DfT with a standardised methodology for estimating the expected employment and Gross-Value Added (GVA) opportunities that a transport decarbonisation policy or policy scenario will support based on input variables including deployment trajectories, estimated technology cost trajectories, tradeability, UK market share of the market, and labour productivity.

The calculators and the research underpinning them will:

- enable further understanding of the potential economic and employment benefits of transport decarbonisation;
- feed into Government-wide work monitoring and developing projected scenarios of workforce changes across the green economy;
- provide outputs on employment estimates for publication in Government strategies or as part of policy announcements; and
- support parallel work to ensure a pipeline of talent with the skills needed for delivering a net zero transport sector.

An earlier iteration of these calculators was commissioned from 2016 to 2018 by former BEIS (Department for Business, Energy, and Industrial Strategy) to provide analysis on future energy innovation needs. The Energy Innovation Needs Assessment (EINA) research consortium developed tailored calculators for twelve energy sub-themes, including road transport, the only transport-related calculator.

The road transport calculator has played a crucial role in supporting DfT to derive estimates for the number of jobs supported by its road transport decarbonisation policy. The DfT has commissioned Ricardo to extend and adapt the EINA methodology to other transport sectors to estimate the potential for green job creation across all modes of transport. This previous calculator has been used as a starting point for the development of Ricardo's calculators, and improvements have been built in around accuracy and user-friendliness.

The purpose of this report is to describe the methodology followed to develop the job calculators for the policy areas previously mentioned, as well as particularities and limitations of each calculator.

2. METHODOLOGY AND SCOPE

This section is split into five subsections, giving a holistic overview of how the calculators were conceptually developed and later implemented:

1. **Model logic:** explains the logic of how green job creation was estimated in the context of this project.
2. **Model structure:** illustrates how the logic is translated into an MS Excel structure.
3. **Model development process**: describes the process of co-developing each calculator with DfT.
4. **Model scope**: establishes the boundaries of what is considered in each model, detailing factors common to all calculators as well as specific technologies covered in each calculator.
5. **Model assumptions**: describing how assumptions were developed in general and in particular for the estimation of GVA multiplier and labour productivity multipliers.

There are particularities associated with the development of each individual calculator that are explored in the 'Deviations from methodology' section later in this report. However, the overarching thought and development process has been intentionally harmonised between each calculator in an effort to make all jobs estimates consistent with each other and comparable across policy areas.

2.1 MODEL LOGIC

The overall methodology used for each calculator largely follows the one established by Vivid Economics and partners (2019) in the Energy Innovation Needs Assessment (EINA) road transport calculator.[1] This was agreed at project inception as suitable for the purposes of estimating job creation.

Using existing demand and cost projections from DfT and adapting the existing model structure proposed by Vivid Economics is seen to represent an appropriate balance of resource use and accuracy. The overall approach was as follows:

1. Based on deployment and technology costs projections[2], estimate the **total size of the market for green technologies**, by summing domestic and foreign markets for each in-scope technology. Here and in future, the term "market" can be interpreted as synonymous with "turnover", "value of production", or "value of sales".
2. Estimate the **proportion of that market that can be assumed to be *tradable***, i.e. open to foreign competition, and ***non-tradable,*** i.e. domestic markets closed to foreign exporters (most typically, services such as maintenance as opposed to goods, that are more easily imported).
3. Estimate the **size of domestic and foreign markets which British companies[3] could realistically capture.**
4. **Convert the estimate of UK-captured market size into jobs estimates** by developing assumptions on levels of gross value added (GVA) for a given level of turnover and on labour productivity (i.e., GVA per worker).

A more detailed breakdown of this methodology is provided in Figure 2-1 below, with key terms defined in Table 2-1.

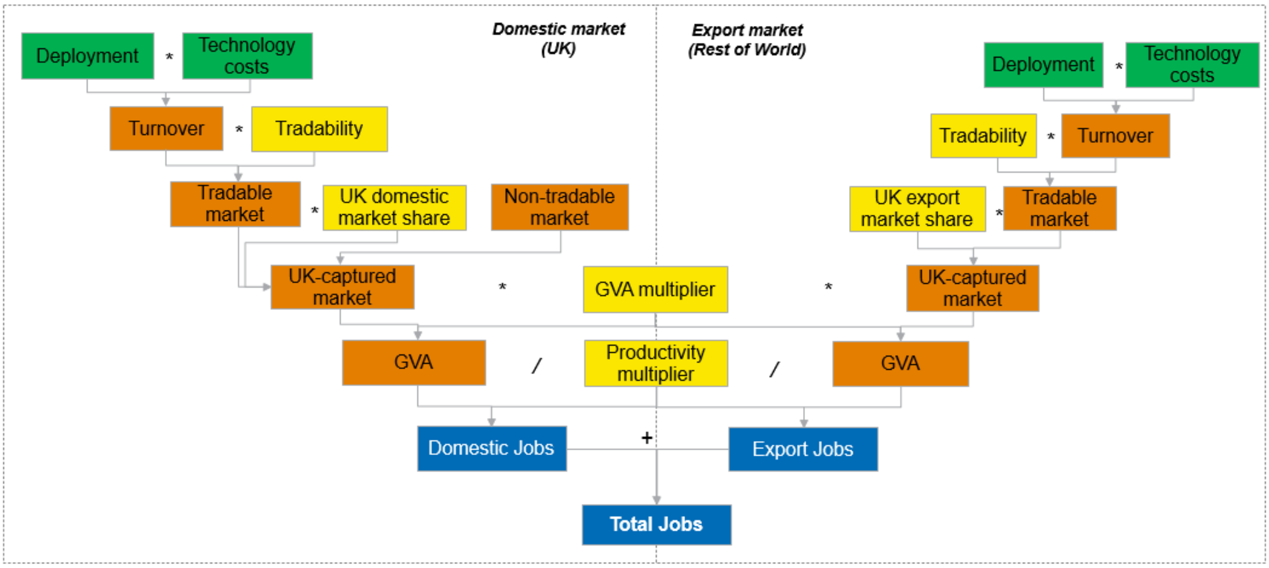
[1] See Appendix 2 of the sub-theme report on road transport, which outlines the methodology used by Vivid Economics and partners.

[2] In cases in which deployment and cost projections were not available, dummy estimates were used as placeholders.

[3] By 'British companies', we refer to companies based in the UK, irrespective of the ownership of such companies. For instance, the UK branch of a US-owned company would be a UK company in this project, as the activity of such company would generate jobs in the UK.

Figure 2-1: Model logic structure

Legend:



Legend:

Table 2-1: Definition of key terms used in the model logic structure

Term	Definition	Unit of measure
Domestic market	The market associated with the sale of the green technology, or associated services, in the UK.	Value (£)
Export market	The market associated with the sale of the green technology, or associated services, abroad (in the Rest of the World, RoW).	Value (£)
Deployment	The level of demand for (i.e. sales of) the green technology.	Various units, depending on the technology For example, the number of vehicles or quantity (i.e. energy content) of low carbon fuels
Technology costs	The unit market value of the good or service. This refers to the unit selling price (including any profit margin) rather than the cost of production.	Value per unit (£/unit)
Turnover	The total revenue generated from the sale of the good or service.	Value (£)
Tradability	A characteristic of each green technology (or associated services) that indicates whether it can be traded internationally. This captures the idea that some goods and services will necessarily need to be provided by domestic suppliers, especially those that require 'feet on the ground', such as maintenance services. In these cases, demand cannot be serviced by foreign suppliers.	Binary variable, where: 1 = denotes a tradeable activity 0 = denotes a non-tradeable activity

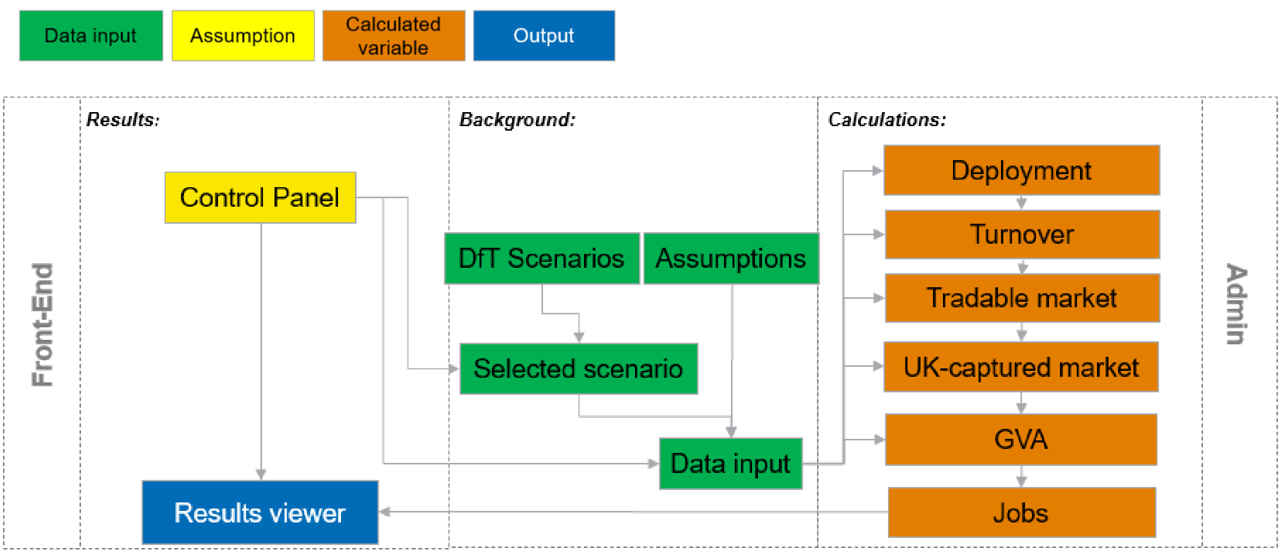
Term	Definition	Unit of measure
Tradable market	The market accessible to international companies (including but not limited to British companies)	Value (£)
UK market share (domestic and foreign)	The share of the tradable market that British companies could feasibly capture.	Percent (%)
Non-tradable market	The market closed to foreign exporters.	Value (£)
UK-captured market	The total revenue generated by British companies from the sale of the good or service, whether from domestic or export activity.	Value (£)
GVA multiplier	The share of turnover that is gross value added (GVA).	Percent (%)
GVA	Gross value added, i.e. turnover less the value of intermediate consumption. GVA includes wages and salaries, depreciation, and profit.	Value (£)
Productivity multiplier	A ratio of GVA generated per worker for the good or service in question - this has the capacity to change over time in the model, with the annual percentage change hereafter referred to as 'productivity gains'.	Value per worker (£/FTE)

2.2 MODEL STRUCTURE

The model logic presented in the previous section is translated into a MS Excel workbook by using a structure that allows it to be read like a book, from front to back (or in the diagram's case, from left to right). This is demonstrated in Figure 2-3 below.

Figure 2-2: Representative schematic of the green jobs calculators

Legend:



At the front end, the workbooks are introduced (**Title** tab), a map is provided of what each tab aims to achieve (**Map** tab), and guidance is given on how to use the workbook (**Guide** tab).

The core section of the workbook begins with the information feeding into the market sizing exercise, namely the **DfT Scenarios** and **Assumptions** tabs.

- Estimates from DfT teams on technology deployments is pasted into the **DfT Scenarios** spreadsheet. The template for data collection has been developed to be compatible with outputs from existing DfT models. This means that, as DfT collects new evidence and develops their own assumptions on the uptake of different technologies, these can be passed through to the jobs calculators with minimal effort.
- Estimates from DfT teams on the projected costs of these technologies are stored in the **Assumptions** tab, along with a number of other assumptions important to the market sizing process.

Independently, the user of the model can navigate to the **Control Panel** tab to (a) select the scenario they want to consider from the options provided in DfT Scenarios, and (b) adjust a number of toggles which influence job creation (e.g. turning on or off the calculation of replacement demand in certain technologies, or productivity increases). All calculators include a tab for scenario definition and selection, which was designed in such a flexible way that it allowed DfT to modify predefined scenario variables and define new scenarios in the future. The calculators also include a dedicated sensitivity analysis section in the Control Panel to allow for user-defined sensitivity scenario testing. This allowed us to comment on the robustness and accuracy of the analysis outputs.

The scenario selection pulls through the required deployment data into the **Selected scenario** tab. These data are then fed into the **Data input** tab, which acts as a central repository for all the data required for the model calculations. This draws in the deployment projections, cost projections, and other assumptions needed for the model.

The input data and assumptions then feed into a series of calculations tabs where all calculated variables in the model are derived (coloured orange in Figure 2-3 above), starting with the **Deployment** tab. Deployment scaling factors are multiplied by cost assumptions to generate **Turnover**, and so on until employment is estimated in the **Jobs** tab, following the model logic presented in Figure 2-1.

The back end of the model contains an informal QA log for reviewers of the model (**Queries** tab), some standard unit conversions (**Units** tab), and a **Lists** tab. This latter tab is important for the development and ongoing maintenance of the model. **The entire calculator is built around the Lists tab, with the purpose of efficiently adding new model technologies and enabling the rapid build of calculators for the other transport modes.** Here, the scope is defined, and technologies are grouped in a way so that assumptions can be made for groups of technologies rather than each individual technology. Other calculators can simply delete the maritime technology headings, add their own technology headings, and the calculator will be set up with formulae to estimate jobs once the corresponding input data and assumptions (deployment, costs, UK market share etc.) have been updated.

2.3 MODEL DEVELOPMENT PROCESS

A step-by-step approach to model development was taken for each calculator as follows:

- **Step 1: Model scoping.** A model scoping document was prepared to present the structure of each calculator (i.e. the list of key tabs and how they interacted) and agreed with DfT on the general modelling assumptions (e.g. base year, discount rate if GVA discounting was required, exchange rates, etc.). This document reflected any approved methodological changes specific to each calculator.
- **Step 2: Collection of input data**. In accordance with the terms of reference (TOR) for this contract, DfT was responsible for providing Ricardo with deployment and technology cost projections for the domestic market, and in some cases for the export market as well (including the maritime calculator). These were collected via a dedicated data collection template for each calculator following definition of the model scope. When gaps existed in the data received from DFT, Ricardo was requested to develop own research to fill these gaps.
- **Step 3: Building of the draft calculator.** An initial calculator was developed and then submitted to DfT for review, where this review focused on the implementation of the model’s scope, structure and functionality rather than the accuracy of any underlying assumptions.
- **Step 4: Definition of assumptions.** Work was undertaken to analyse the data and evidence gathered as part of a literature review, data collection, and internal expert consultation process. Each calculator includes a dedicated DataLog tab where all assumptions are documented and evidenced. The user

can click on hyperlinks in both the model body and in the DataLog tab to navigate quickly between the implementation and the justification of each assumption.

- **Step 5: Building of the final calculator.** The scope, structure and functionality of the draft calculator was revised based on DfT's feedback. Ricardo also worked to fill any remaining data gaps and define final modelling assumptions developed during step 4.
- **Step 6: Quality Assurance (QA).** Models were reviewed according to Ricardo's rigorous standard QA processes.[4] The extent of QA is determined by assigning a level from 1 to 4, where levels 3 and 4 are justified in case of 'business-critical' models (i.e. published models and/or models affecting financial or investment decisions). A bespoke level of QA was selected for all calculators whereby some criteria were evaluated at level 2, but Verification criteria were upgraded to the strictest level (covering formula correctness, usability testing, removal of external links, and the use of auto checks), as well as criteria related to assumptions, use of units, named ranges, and formula robustness & clarity. In addition, models were shared with a peer reviewer, Leonidas Paroussos (a macro-economic expert not directly involved in the research, analysis or calculator development).

2.4 MODEL SCOPE

2.4.1 Common scoping factors

Key scoping factors common to all calculators include:

- **Time period**: annual, 2023-2050.
- **Price base**: Real pound sterling (GBP) 2023. This is a tool designed to feed into UK policy appraisal. The calculators were built in 2023 using cost information gathered by the DfT in the same year, so choosing this year minimises the need for price deflation and hence any risk in conversion errors. Prices assessed in different currencies or years were converted and deflated into GBP 2023 figures.
- **The only requirement for a job to be green is that it must be associated with environmental protection or decarbonisation.** No judgement on the 'decency' of jobs is made. Typically, considerations on decency would include factors like the suitability of pay and the working conditions of jobs in each individual region. Various definitions of green jobs are available internationally and their scope is debated, with some including public health implications and some not (Office for National Statistics, 2021). The United Nations System of Environmental Economic Accounting sets out a definition of the 'Environmental Goods and Services Sector' (EGSS) - here, green jobs are associated with areas of the economy engaged in producing goods and services "for environmental protection purposes". By contrast, the International Labour Organisation (ILO) adopt a broader definition, extending it to include climate adaptation activities and placing emphasis on social factors, including that the jobs must be "decent" to be green.
- **These are estimates of <u>gross</u> employment and GVA produced in a transport sector from a policy or policy scenario, as opposed to <u>net</u> employment.** The gross employment and GVA estimates estimated in this model show the potential scale of future employment related to the emergence and development of green technology supply chains. These are designed to understand the future size and shape of industry in the UK, but are not designed to appraise the economic value of these industries. Net employment and GVA estimates would also take into account job losses in traditional supply chains (for example, net estimates could include the incremental change in employment – jobs gains net of jobs losses – as the automotive industry transitions from the manufacture and assembly of internal combustion engine vehicles to zero emission vehicles). Therefore, any jobs or GVA estimates reported in this calculator should be seen as jobs 'supported' and not as jobs 'created'. This was a request by the DfT as explicitly specified in the project specifications.

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[4] The calculators were tested and peer-reviewed internally through Ricardo's model Quality Assurance (QA), which has always been an integral part of our modelling work. To assess a workbook, a designated auditor is asked to score its performance against 30 individual criteria under five principles (Clarity and Structure; Data and Assumptions; Verification; Validation; and Documentation). For example, there are eight 'clarity and structure' criteria, dealing with the structure of the model and sheets, the labelling, formatting, comments, formula clarity and management of named ranges. To assist us with QA activities of our Excel models, Ricardo's Cross-Practice Modelling Group (CPMG) has developed a set of automated tools that we collectively refer to as our QA Workbench. The toolkit enables us to undertake in-depth systematic audits of Excel-based models and tools, including automatic checks of e.g., lists of the unique formulae, names, objects, comments, and references in the model; as well as cell dependences, precedents, links and errors.

- **Employment estimates account for direct employment only**. Indirect and induced employment is not assessed. Indirect employment refers to the number of additional jobs created in companies upstream in the supply chain (that provide inputs of production to company manufacturing/installing/maintaining the in-scope technologies) to meet their increased demand for inputs. Induced employment refers to the number of jobs created in other sectors (e.g. real estate, construction, tourism, retail, education, health care…) due to increased household expenditure by additional direct and indirect workers. It's important to note that a distinction between direct, indirect, and induced employment refers to the economic sectors where employment impacts materialise rather than to the nature or type of job function: direct employment refers to the number of jobs in companies belonging to the economic sector in which the initial change in economic activity occurs – this includes all jobs functions for those companies, also including e.g., admin, sales, marketing, HR, support staff (etc.), that are just as necessary to produce the technologies considered as (for example) assembly line workers.

2.4.2 Technologies included in each calculator

The technologies and activities considered within the scope of each calculator are listed throughout Table 2.2 to Table 2.7. These were selected as follows:

- Maritime calculator: this calculator includes six technology categories and five activities which vary between the technology categories. These categories and activities were defined through a collaborative and iterative process together with DfT, and take into account: the on-board technologies currently considered in DfT's maritime emissions model, which estimates emissions arising from maritime activity based on assumptions and projections on the uptake of low-carbon fuels and technologies in shipping; other key on-board technologies; and relevant landside infrastructure that is not captured in the Low carbons fuels (LCFs) calculator (Table 2-2).
- Rail calculator: three technology categories and three activities, defined through collaborative and iterative process together with DfT and based on the limited data available to make projections (Table 22).
- Aviation calculator: four technology categories and two activities, defined through collaborative and iterative process together with DfT and using outputs from the FlyZero programme (Table 23).
- Road transport calculator: three technology categories and four activities (Table 2-4).
    - Low carbons fuels (LCFs) calculator: this standalone calculator was developed to avoid the risk of double-counting of fuel demand between modes - since LCFs are demanded by each transport mode - and to avoid ignoring the possibility of shared infrastructure and/or distribution of LCFs from site of production to point of use. It includes two technology categories and only one activity, chosen in discussion with the DfT LCF team. (Table 2-5). **Please note that while low-carbon forms of hydrogen are an important candidate for decarbonising various modes of transport, the jobs associated with its production and distribution to storage facilities are excluded from these calculators - parallel research is being run by DESNZ, where jobs from hydrogen production will be estimated separately.**
- Active transport calculator: two technology categories and three activities, set to account for the most prevalent active transport modes, excluding those that are fully self-propelled (e.g., electric scooters) (Table 2-6).

Table 2-2: Maritime calculator scope

Technology category	In-scope technologies	In-scope activities
On-board propulsion	- Battery Electric - Dual Fuel engines (with low carbon Ammonia, Hydrogen, Methanol) - Green newbuilds - Proton Exchange Membrane Fuel Cell (PEMFC) - Solid Oxide Fuel Cell (SOFC) - Spark ignition engines (low carbon Ammonia, Hydrogen, Methanol)	- Manufacturing & Installation

Technology category	In-scope technologies	In-scope activities
On-board storage	- Electric Low carbon: - Ammonia - Hydrogen - Methanol	- Manufacturing & Installation
On-board emissions capture/treatment	- *Exhaust gas cleaning systems (EGCS) - *Exhaust gas recirculation (EGR) - *On-board carbon capture and storage (CCS) - *Selective catalytic reduction (SCR)	- Manufacturing & Installation
On-board energy efficiency measure	- Air lubrication bubbles - *Block Coefficient Reduction - Boss cap fin - Contra Rotating Propeller - Energy saving lighting - Energy storage battery + power take-off (PTO) - Engine derating - *Fuel cells for aux system - Hotel systems - Organic Rankine Waste Heat Recovery - Pre-Swirl propeller ducts - Rudder bulb - *Shore power (Cold ironing) - Solar power - Steam Waste Heat Recovery - Turbo-compounding in Series - Twisted rudders - Vane wheel - Wind assistance (kites) - Wind assistance (rotors/sails/wings)	- Manufacturing & Installation
Shore LCF storage	Bunkering of low carbon: - Ammonia - Hydrogen - Methanol	- Manufacturing & Installation - Fuel distribution - Maintenance
Shore electricity	- Shore power connections - Grid upgrades for shore power	- Installation - Operation & Maintenance

*Notes: * Not yet modelled in the DfT maritime emissions model, and therefore employment estimates are not yet produced for these technologies, but included here as maritime analysts are intending to include these in future iterations of the model.*

Table 2-3: Rail calculator scope

Technology category	In-scope technologies	In-scope activities
Rolling stock	- BEV rolling stock - Hybrid BEV rolling stock	- Manufacturing - Maintenance
High value components	- Batteries	- Manufacturing
Infrastructure	- Track electrification - Grid upgrades	- Manufacturing - Installation - Maintenance

Table 2-4: Aviation calculator scope

Technology category	In-scope technologies	In-scope activities
Aircraft	- BE aircraft - FCE aircraft* - H2-fuelled aircraft – Regional - H2-fuelled aircraft – Narrow	- Manufacturing - Maintenance

Technology category	In-scope technologies	In-scope activities
	- H2-fuelled aircraft – Midsize	
e-VTOLs	- e-VTOL aircraft*	- Manufacturing - Maintenance
Drones	- Passenger-carrying drone**	- Manufacturing - Maintenance
High-value components	- Batteries for BE aircraft* - Batteries for e-VTOL aircraft* - Fuel cells for FCE aircraft* - Combustion engines for H2-fuelled aircraft*	- Manufacturing

Notes: The in-scope technologies include technologies for which no cost and deployment projections are available from FlyZero outputs. Ricardo prepared projections to produce employment generation estimates for technologies designated with one asterisk (*) but not for passenger-carrying drones designated with two asterisks (**). For the latter, the project team agreed with DfT to include the technology as in-scope despite unavailable projections, which may be added by DfT in future calculator iterations to produce employment generation estimates for this technology.

Table 2-5: Road calculator scope

Technology category	In-scope technologies	In-scope activities
Vehicles	- Battery electric vehicles (BEVs) - Plug-in hybrid electric vehicles (PHEVs) - Fuel cell vehicles	- Manufacturing and assembly - Maintenance
High-value components	- Batteries - Fuel cells	- Manufacturing and assembly - Maintenance
Infrastructure	- Charging infrastructure - Grid upgrades	- Manufacturing and assembly - Maintenance - Installation - Grid upgrades

Table 2-6: LCF calculator scope

Technology category	**In-scope technologies**	**In-scope activities**
Biofuels and recycled carbon fuels	- Ammonia - Ethanol and other gasoline/petrol replacements - Fatty Acid Methyl Ester (FAME), Hydrotreated Vegetable Oil (HVO) and other diesel replacements - Heavy Fuel Oil (HFO) replacements - Hydroprocessed fatty acids (HEFA) - Kerosene replacements - Methane - Methanol - Naphtha replacements	- All jobs in fuel supply chain until point of sale (production, distribution to buyer, etc.)
Synthetic, non-biological low carbon fuels	- Ammonia - Diesel replacements - Gasoline replacements - Kerosene replacements - Methane - Methanol - Naphtha replacements	

Note 1 - Biofuels refer to fuels produced from biomass and recycled carbon fuels to fuels produced from unrecyclable fossil waste. 'Synthetic, non-biological' refers to fuels produced from captured, non-biogenic, CO2. Hydrogen produced via any method is intentionally omitted from the above table due to parallel research being run by DESNZ, where jobs from hydrogen production will be estimated separately.

Note 2 - There is only one in-scope activity for each fuel, which is an aggregated activity to capture all associated jobs with the fuel. This level of aggregation was chosen because, at the time of writing, only the total cost of fuels was available as a metric to quantify the size of the market for all in-scope fuels. Therefore, to create jobs estimates that are consistent across all fuels and transport modes, it was necessary to perform the job estimation exercise at a high level of aggregation.

Table 2-7: Active transport calculator scope

Technology category	In-scope technologies	In-scope activities
Vehicles	- Bicycles - E-bikes	- Manufacturing - Maintenance
Infrastructure	- Cycling and pedestrian paths - Cycling and pedestrian bridges - Cycling and pedestrian tunnels	- Construction

2.5 MODEL ASSUMPTIONS

2.5.1 General

DfT provided Ricardo with data projections for the domestic market and export markets where possible. For cases where this was not possible, Ricardo undertook a comprehensive literature review to complement DfT's data on technology deployment and cost projections, tradability, market shares, productivity and employment related to in-scope technologies for each calculator. Experts across the different transport policy areas within Ricardo were also consulted to point out relevant literature and to provide insight on assumptions.

The primary areas where expert judgement was applied are shown below and elaborated in following sections:

- UK market shares – transport mode experts were consulted to supplement information gained from trade statistics.
- GVA multiplier and labour productivity multipliers – economists were consulted to weight the values gathered from various statistical sources.
- Productivity gains – dedicated modelling experts at E3M, a Ricardo subsidiary, were consulted to substitute historical trends in productivity where data sources were incomplete or patchy, making the extraction of trends less suitable.

These assumptions were developed for different scenarios, considering varying market penetration rates and levels of ambition. Due to the extent and level of detail, these assumptions are not included in this report. The assumptions derived from research and expert judgement can be updated as Government projections become available.

2.5.2 UK market shares

Assessment on current and projected UK market shares was determined based on available trade statistics in existing industries from ITPD-E (explained in more detail below). Nevertheless, due to the lack of granularity in the trade data, Ricardo sought complementary sources to assess the UK's share of its domestic and export markets, such as in-depth literature review and application of expert judgement. Experts across the different transport policy areas within Ricardo were consulted by being provided with a standardised data collection template. Justifications for the selected market shares chosen are reflected in the DataLog tab of each calculator, but often included consideration of related datasets, policy trends, and knowledge of leading companies operating within the respective transport mode-specific activities.

The Gravity Portal: ITPD-E of the United States International Trade Commission was used as a main source. This source is preferred to other available international trade databases (e.g. UN Comtrade) in that it reports data on both bilateral trade flows and "domestic trade", this latter estimated as the difference between the (gross) values of total production and total exports. "Domestic trade" estimates are a useful source of evidence for the UK market share of its own domestic market.

2.5.3 GVA multiplier and labour productivity multiplier

This section describes the method adopted to derive the GVA/turnover ratios (GVA multiplier) and GVA/worker ratios (labour productivity multipliers) for each technology type / activity pair.

A number of differences in the approach have been taken in some calculators. Deviations from this general approach are described in the 'Deviations from Methodology' section.

2.5.3.1 GVA multipliers

The method used follows two main steps, which are both performed in an Annexes to the calculators:

- Step 1. Data collection from different data sources
- Step 2. Calculation of a weighted average of the identified sources

Step 1: Data collection from different data sources

Four different data sources have been consulted:

- UK company financial statements, 2021 and 2022[5,6];
- ONS input-output table, Product by Product, 2019;
- Eurostat Structural Business Statistics dataset, which reports data for Member States of the European Union up to 2021 and for the UK up to 2018 (following the UK's exit from the European Union).

Data is taken from each source for the most recent year available at the time of writing.

Table 2-8 below shows more details about the data sources considered above, the method used to choose and extract relevant data, and the relative benefits and drawbacks of each data source compared to each other.

Table 2-8: Data sources considered to derive GVA multipliers

Source	Method	Benefits	Drawbacks
1. Financial statements of the most representative companies in each of the in-scope technology categories. **Geography:** UK **Year:** average of 2021 and 2022	Relevant companies are identified based on expert judgement from Ricardo's sector experts From companies' UK financial statements, turnover, GVA, and employment (only referring to these companies' activities in the UK) can be calculated. Based on this data, the GVA/turnover ratio can be derived.	Analysis at the company level provides higher granularity in comparison to trade statistics that refer to more aggregated economic sectors	Many of the companies identified produce goods and services other than those listed in the technology group. It is not possible to isolate the level of turnover / GVA / employment connected to the production of the technology category in question. Many of the companies identified are not required to file their financial statements onto the UK Gov Company House (Find and update company information - GOV.UK (company-information.service.gov.uk)) because they are beneficiaries of an exemption as e.g., micro entities of dormant companies. In many cases, financial statements are available for larger companies (for which the first bullet point above applies) while are not available for smaller, more representative companies, which are often exempted from submitting full accounts (second bullet point above).

[5] This data source was consulted in addition to national statistics (i.e. ONS and Eurostat data) as national statistics do not report data with the level of granularity required for some transport policy areas and in-scope technologies.

[6] Contrary to ONS and Eurostat data where we only use data from one year, for analysis of company financial statements, we take data from two different years to improve robustness. ONS and Eurostat data are aggregated/averages of many companies, whereas our analysis of financial statements is only based on a small sample. Taking the average of two years limits the risk of bias.

Source	Method	Benefits	Drawbacks
			The number of companies identified and/or financial statements analysed may not be considered fully representative of the technology group in question.
2. Office for National Statistics (ONS), UK input-output analytical tables, product by product **Geography:** UK **Year:** 2019	Expert judgement has been applied to identify the most relevant economic sector (Product) for each of the in-scope technology type / activity pairs	For each Product, data on both GVA and turnover is available, so the GVA/turnover can be derived	Includes a total of 105 Products (all sectors of the economy). These economic aggregations are in most cases too wide in order to be fully representative of our in-scope technology categories. Last year available is 2019.
3. Eurostat, Structural business statistics – historical data, **Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E)** **Geography:** UK **Year:** 2018	Expert judgement has been applied to identify the most relevant economic sector (Class) for each of the in-scope technology type / activity pairs	Most relevant economic sector aggregation: This dataset includes a total of 616 Classes (all sectors of the economy) identified by four-digit numerical codes. This disaggregation is more detailed than any source available on the UK ONS web portal. Eurostat Classes are more representative of our in-scope technology categories. Data for the UK is included in historical data up to 2018.	Most outdated data source (2018).
4. Eurostat, Structural business statistics, **Enterprises by detailed NACE Rev.2 activity and special aggregates** **Geography:** EU27 **Year:** 2021	As above	Most relevant economic sector aggregation (see above) Data for the UK is no longer reported Most recent data	Less relevant geography (EU27)

Source: Ricardo analysis

Step 2: Calculation of a weighted average of the identified sources

To estimate the GVA/turnover assumptions to be assumed in the calculators, weighted averages of the four identified values was calculated for each technology type / activity pair. The choice of the weights has been conducted based on expert judgement.

Albeit the most outdated source, Eurostat's Structural business statistics (historical data) referring to the UK, 2018 (last year available) has often been included in weighted averages given the higher level of detail available in terms of sectoral disaggregation and relevant geography.

DfT users can modify the choice of weights.

2.5.3.2 Labour productivity multipliers

For the GVA/jobs ratios (labour productivity multipliers), a similar methodology as for the GVA multipliers was adopted. The only differences being:

- Instead of the ONS UK input-output analytical table (product by product), another ONS dataset was used: ONS, Annual GVA per job by division-level industry aggregations. This source includes 78 divisions, so it shares the same limitation as the UK input-output table (low disaggregation by economic sector compared to alternative sources such as Eurostat).

- All nominal values in GBP or EUR have been converted into real 2023 GBP.

2.5.4 Productivity gains

Productivity gains are defined as annual percentage increases in the productivity multiplier due to e.g. technological advancement.

The calculators contain a toggle in the Control Panel tab where these can be switched on or off. The reason for this is that some drivers of productivity growth may lead to reduced labour requirements (e.g., automation and labour productivity increases), whereas others may not (e.g., reduced battery costs stemming from greater input availability or more efficient battery chemistries). Within the context of this methodology, there is a somewhat counterintuitive effect that the more productivity increases, the fewer jobs are created. This is because jobs are worked out based on a fixed amount of production, so if workers are more productive you need fewer of them. Given the ambiguity around the impact of productivity growth on job creation, the default setting is 'off' to minimise labour productivity gains in the long run and give an upper bound on job estimates, but the option is present to include these effects by turning the toggle to 'on'. The latter would be a more conservative estimate, effectively assuming that all productivity growth reduces labour requirements.

For the **road calculator**, estimates on productivity gains have been informed by ONS databases. For the **rail and active travel calculators,** productivity gain assumptions are based on an analysis of historical Eurostat data on labour productivity (GVA per employee) for relevant sectors and the derivation of trend lines. The choice of Eurostat databases (rather than ONS) is due to the fact that Eurostat's “Structural business statistics” databases report data at a higher granularity than the ONS databases.

For the **maritime, aviation, and LCF calculators**, fragmentation and data gaps in ONS and/or Eurostat databases prevented the derivation of robust trend lines to apply this methodology. Therefore, productivity gain assumptions are based on expert judgment of colleagues at E3M, a Ricardo subsidiary specialising in macroeconomic modelling, derived from their work with E3M’s GEM-E3 computable general equilibrium model. The model covers a number of countries (including the UK) and world regions; as well as a number of economic sectors (including Transport equipment excluding EVs; Warehousing and support activities, Construction, Power supply, Biodiesel, and Equipment for CCS power technology).

3. DEVIATIONS FROM THE METHODOLOGY

This section delineates the specific cases in which the methodology applied diverges from the methodology explained above due to particular circumstances of each calculator.

3.1.1 Geographies considered

For the **maritime calculator**, the definition of the domestic and export markets was based on shipping activity at UK ports as defined in DfT's maritime emissions model, as follows:

- Domestic market defined as goods or services relating to vessels entering or leaving UK ports, which includes:
    - Vessels always operating in the UK and not undertaking any international journeys;
    - Vessels sometimes calling at UK ports and sometimes calling at non-UK ports.
- Export market defined as relating to vessels that do not ever pass through UK ports.

The **aviation calculator**, rather than distinguishing between domestic and export markets, assesses job creation opportunities for a single worldwide market to better accommodate the global nature of aviation, which challenges a clear split between domestic and export segments.

For the **LCF calculator**, the estimation of the export market departs from the core methodology and assumed to exist only when projections for domestic production exceed domestic demand. It is assumed that any domestic production exceeding domestic demand in a current or future period will be exported and consumed abroad. This assumption was taken because the size of the export market is not known - DfT do not have projections of LCF demand in non-UK regions, and it was not within the scope of this project to derive these. UK demand for LCFs has historically been greater than domestic production, in part generated through UK targets for suppliers requiring minimum renewable shares of fuels used in transport (Department for Transport, 2021).

3.1.2 Tradability

For the **aviation calculator**, all activities are considered tradable, including those that would be considered non-tradable in other calculators (e.g., maintenance). This decision stems from the calculator's focus on the global market (rather than on a domestic and export markets). In a standard (i.e. two-market) calculator, non-maintenance activities would be assigned a 0 for tradeability. Consequently, UK-based companies would capture 100% of domestic demand for maintenance activities and 0% of foreign demand. However, in the context of a single-market calculator, maintenance activities are assigned a value of 1 (i.e., tradable) to allow us to estimate the share of global demand for maintenance activities that is captured by UK-based companies. This adjustment ensures that a portion of global maintenance activities are accessible to UK-based entities.

3.1.3 UK market shares

For the **road calculator**, besides the United States International Trade Commission's International Trade and Production Database for Estimation (ITPD-E), various databases were employed to estimate UK market shares. The underlying data sources for these methodologies including UK vehicle production, trade flows in certain sectors of interests, and vehicle registration statistics, including:

- The Society of Motor Manufacturers and Traders (SMMT);
- International Organization of Motor Vehicle Manufacturers (OICA)'s global production database;
- The Motorcycle Industry Association (MCIA);
- Information Handling Services (IHS) Markit's production forecast database.

These databases were compared and utilised, and the outputs of this analysis (the selected central assumptions) were presented to sector experts for validation.

4. ANALYTICAL ASSURANCE

The assessment of green job creation in the long term associated with new technologies is uncertain. Rather than attempting to forecast what will happen, this study attempts to provide a realistic and consistent analysis on the green jobs that could be supported by the UK based on currently available data. Whether these jobs are indeed realised depends on domestic and international developments, political decisions, macro-economic conditions, and numerous other complex variables.

Aside from external drivers, many of the core assumptions in the model (technology deployment, costs, UK market shares, productivity multipliers, etc.) are themselves subject to a significant degree of uncertainty given the nascency of some of these green technologies. Sensitivity testing has been performed to understand the impact of changes in core assumptions on model results, namely for UK market shares, productivity multipliers, and the variation of productivity over time. In addition, we recommend that various deployment scenarios are considered to provide a range of outputs depending on the extent of technology uptake. However, for assumptions on technology costs (which are a key driver of the future turnover, and thus jobs associated with a technology) only one set of central assumptions are used given interaction effects with technology uptake, meaning that these are a significant driver of uncertainty.

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