Net Zero Communities (NZCom)

D6. Community scale NZC 2050 carbon accounting method

Version	Written	Released	Notes/Changes
Final	X. Yan	01/02/2022	

Contents

1. Introduction

The Net Zero Communities project (NZCom) forms part of a larger project: Vulnerability and Energy Networks, Identification and Consumption Evaluation (VENICE). VENICE is funded by WPD under the NIA Call 2020 – 'Energy Transition - Leaving no one behind'.

NZCom is investigating the effects and opportunities created by the decarbonisation of the Wadebridge & Padstow Community Network Area, achieving a net zero condition in 2050. However, the work is undertaken such that many proposals will be suitable for scaling and relocation to other similar communities.

The overarching aim of NZCom is to propose methods and business models that use local solutions, for energy systems and generally, to prevent the more vulnerable energy users from being disadvantaged by the transition to net zero.

WP3 within NZCom will develop an appropriate community scale greenhouse gas (GHG) accounting method for the project to qualitatively assess and compare the GHG reduction impacts of interventions developed in WP4 (led by Planet A Solutions CIC) under different future scenarios developed in WP2. An Excel-based tool will then be developed based on this carbon accounting method to help communities explore pathways to reach net zero futures.

2. Review of published GHG accounting methodologies

Comprehensive, consistent and transparent GHG accounting is key to ensuring net zero is achieved. In this section, GHG accounting methodologies relevant to NZCom are reviewed.

2.1 Overview of GHG accounting

GHG accounting can be done at various levels, e.g., product/technology, individual/household, organisation, country, community/city/region etc, each with its unique purpose and set of challenges.

Broadly speaking, GHG accounting can be done from two different perspectives, i.e., the production-based (also known as territorial) accounting and the consumption-based accounting. Another way of categorising emissions is by scope, based on the scopes framework developed in 'The GHG Protocol Corporate Accounting and Reporting Standard' that provides requirements and guidance for companies and other organisations preparing a corporate level GHG emissions inventory [1]. Table 1 explains the three scopes of emissions.

Table 1. Categories of emissions by scope

Scope	Short description	Details
1	Direct GHG emissions	Direct GHG emissions occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment.
2	Electricity indirect GHG emissions	GHG emissions from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organisational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated.
3	Other indirect GHG emissions	Scope 3 emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company. Some examples of scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services.

The most common GHG accounts are territorial emissions at a national level, which are routinely produced by most countries. These cover all emissions incurred within a country's geographical boundary.

In recent years, there has been a lot of efforts in developing different approaches or standards to GHG accounting at a community/city level though this is currently still less established compared with national level or corporate level accounting. The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories – An Accounting and Reporting Standard for Cities (GPC) is a widely adopted GHG accounting method that offers cities and local governments a robust, transparent and globally-accepted framework to consistently identify, calculate and report on city GHG [2]. The accounting principles proposed in GPC to represent a fair and true account of emissions include:

- **Relevance**: The reported GHG emissions shall appropriately reflect emissions occurring as a result of activities and consumption patterns of the city. The principle of relevance applies when selecting data sources, and determining and prioritising data collection improvements, based on the decision-making needs of the city.
- **Completeness**: Cities shall account for all required emissions sources within the inventory boundary. Any exclusion of emission sources shall be justified and clearly explained.

- **Consistency**: Emissions calculations shall be consistent in approach, boundary, and methodology. Calculating emissions should follow the methodological approaches provided by the GPC. Any deviation from the preferred methodologies shall be disclosed and justified.
- **Transparency**: Activity data, emission sources, emission factors, and accounting methodologies require adequate documentation and disclosure to enable verification. The information should be sufficient to allow individuals outside of the inventory process to use the same source data and derive the same results. All exclusions shall be clearly identified, disclosed and justified.
- **Accuracy**: The calculation of GHG emissions shall not systematically overstate or understate actual GHG emissions. Accuracy should be sufficient enough to give decision makers and the public reasonable assurance of the integrity of the reported information.

There is also guidance on using the above principles. Within the requirements of the GPC, a city will need to make important decisions in terms of setting the inventory boundary, choosing calculation methods, deciding whether to include additional scope 3 sources, etc. Tradeoffs between the five principles above may be required based on the objectives or needs of the city. For example, achieving a complete inventory may at times require using less accurate data. Over time, as both the accuracy and completeness of GHG data increase, the need for tradeoffs between these accounting principles will likely diminish.

An inventory boundary defines the gases, emission sources, geographic boundary and time period covered by a GHG inventory. These will be expanded below:

- **Geographic boundary**: Cities shall establish a geographic boundary that identifies the spatial dimension or physical perimeter of the inventory's boundary. Depending on the purpose of the inventory, the boundary can align with the administrative boundary of a local government, a ward or borough within a city, a combination of administrative divisions, a metropolitan area, or another geographically identifiable entity.
- **Time period:** The GPC is designed to account for city GHG emissions within a single reporting year. The inventory shall cover a continuous period of 12 months, ideally aligning to either a calendar year or a financial year, consistent with the time periods most commonly used by the city.
- **Greenhouse gases:** Cities shall account for emissions of the seven gases currently required for most national GHG inventory reporting under the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).
- **GHG emission sources:** GHG emissions from city activities shall be classified into six main sectors, including: Stationary energy; Transportation; Waste; Industrial processes and product use; Agriculture, forestry, and other land use; and Any other emissions occurring outside the geographic boundary as a result of city activities (collectively referred to as Other Scope 3). Emissions from these

sectors shall be sub-divided into subsectors and may be further sub-divided into sub-categories. Table 2 lists the six sectors and sub-sectors.

Table 2. Sectors and sub-sectors of city GHG emissions [2]

Sectors and sub-sectors
STATIONARY ENERGY
Residential buildings
Commercial and institutional buildings and facilities
Manufacturing industries and construction
Energy industries
Agriculture, forestry, and fishing activities
Non-specified sources
Fugitive emissions from mining, processing, storage, and transportation of coal
Fugitive emissions from oil and natural gas systems
TRANSPORTATION
On-road
Railways
Waterborne navigation
Aviation
Off-road
WASTE
Solid waste disposal
Biological treatment of waste
Incineration and open burning
Wastewater treatment and discharge
INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)
Industrial processes
Product use
AGRICULTURE, FORESTRY AND OTHER LAND USE (AFOLU)
Livestock
Land
Aggregate sources and non-CO_2 emission sources on land
OTHER SCOPE 3

- **Categorising emissions by scope:** GPC uses an adapted application of the scopes framework used in the GHG Protocol Corporate Standard mentioned earlier is used in the to distinguish between GHG emissions that occur inside and outside the city boundary. The GPC distinguishes between emissions that physically occur within the city (scope 1), from those that occur outside the city but are driven by activities taking place within the city's boundaries (scope 3), from those that occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross city boundaries (scope 2) (see Figure 1).

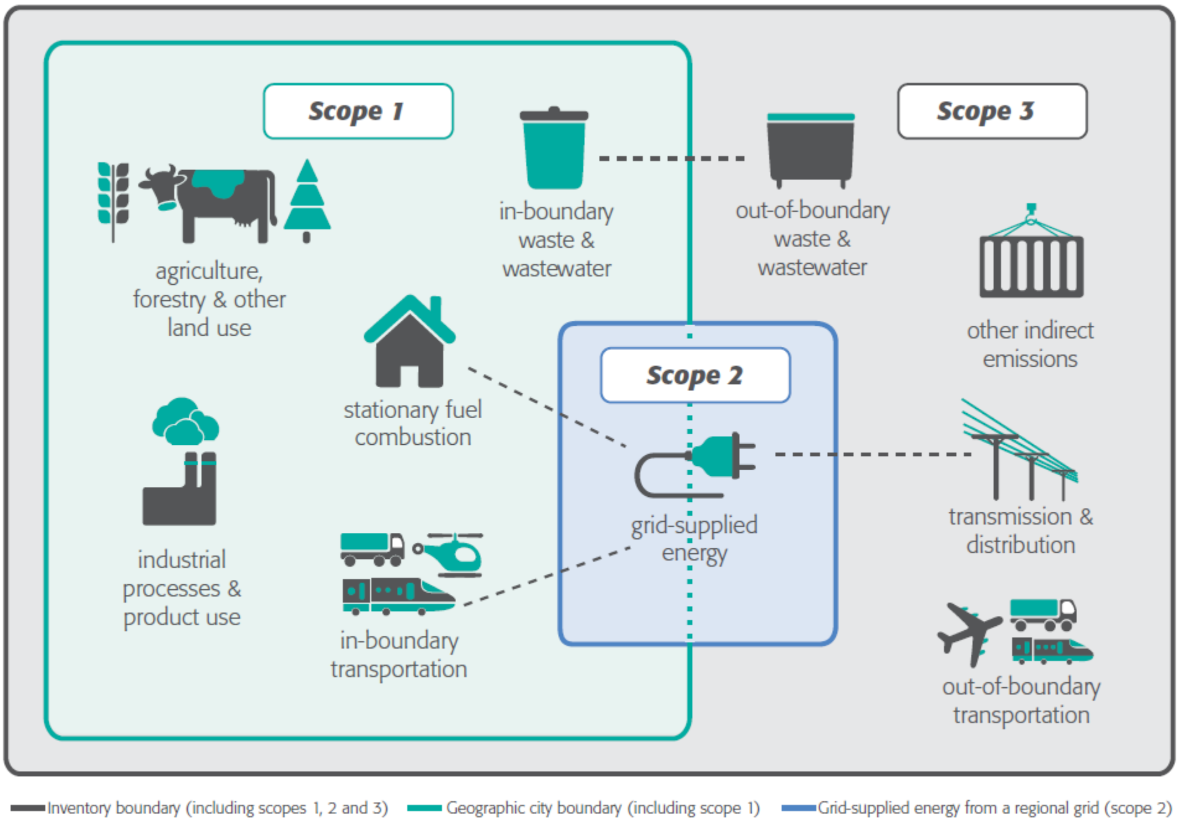


Figure 1. Sources and boundaries of city GHG emissions [2]

- **Other scope 3 emissions:** Cities may optionally report "Other Scope 3" sources associated with activity in a city such as GHG emissions embodied in fuels, water, food and construction materials. This consumption-based accounting is an alternative to the sector-based approach to measuring city emissions adopted by the GPC and it allocates GHG emissions to the final consumers of goods and services, rather than to the original producers of those GHG emissions. It therefore is complementary to the GPC and provides a different insight into a city's GHG emissions profile.
- **Boundaries for mitigation goals:** Cities are encouraged to align their mitigation goal boundary with the GPC inventory boundary. Mitigation goals can apply to a city's overall emissions or to a subset of the GHGs, scopes, or emission sources set out in the GPC.

There has been some academic research around community level carbon footprint assessment in the UK following accounting standards such as the GPC. For example, two community level carbon footprint tools were developed for England and published in 2021, which could potentially be useful for the project. These will be briefly reviewed below.

2.2 Existing community level carbon footprint tool - IMPACT

The IMPACT tool [3] was developed by the Centre for Sustainable Energy in collaboration with the University of Exeter's Centre for Energy & the Environment. It calculates carbon footprint at a parish level from both the production/territorial and the consumption perspective. The territorial perspective covers emissions that are directly produced from within the parish boundaries, following the same methodology as national emissions data is usually quantified. The consumption perspective covers all emissions, including upstream and downstream emissions, caused by residents of the parishes, regardless of where the emissions occur geographically. A wide range of data sources, data processing techniques and assumptions were used to calculate these emissions (see Tables 3 and 4). The online tool allows users to choose a parish in England and see its production- and consumption-based carbon footprints, both total and per household, from different activities/sources (see Figure 2).

Table 3. Sources of data used for the consumption footprint in IMPACT [4]

Sector	Data source
Domestic housing	Domestic Energy Performance Certificate data (2020)
	Experian Mosaic Public Sector
	Experian ConsumerView
	English Housing Survey (2018)
	National Household Model
	BEIS sub-national electricity consumption statistics, postcode and LSOA level data 2018
	BEIS sub-national mains gas consumption statistics, postcode and LSOA level data 2018
	Sub-national total final energy consumption data 2018
	UK local authority and regional carbon dioxide emissions national statistics
	Greenhouse gas reporting - conversion factors 2020
Non-domestic buildings	Non domestic Energy Performance Certificate data (2020)
	Display Energy Certificate data (2020)
Transport	National Travel Survey 2002-2019
	Experian Mosaic Public Sector
	Experian ConsumerView
	ONSPD data (urban/rural identification of locations)
	Road transport energy consumption at regional and local authority level
	Greenhouse gas reporting: conversion factors 2020

Table 4. Sources of data and data processing techniques for the territorial footprint in IMPACT [4]

Category	Primary Data Source	Processing and Apportionment to Smaller Geographies
Agricultural Activity	NAEI 1km and point source	Gridded data area apportioned, point data summed within area. Agricultural fuel subtracted.
Agricultural Fuel	Local Authority CO_2 reporting	Local authority data adjusted to account for non-CO_2 greenhouse gas emissions. Apportioned on basis of agricultural activity data.
Aviation	NAEI national data	Population apportioned
Domestic Electricity	Local Authority CO_2 reporting	Consumption based footprint used
Domestic Mains Gas	Local Authority CO_2 reporting	Consumption based footprint used
Domestic Other Fuels	Local Authority CO_2 reporting	Consumption based footprint used
F-Gases	NAEI national data	Apportioned on the basis of industrial and commercial electricity consumption since emissions are predominantly from refrigeration systems including air conditioning.
Industrial & Commercial Electricity	Local Authority CO_2 reporting	Local authority data adjusted to account for non-CO_2 greenhouse gas emissions. Apportioned on basis of NOMIS data on employment sites by size and sector at MSOA resolution.
Industrial & Commercial Mains Gas	Local Authority CO_2 reporting	Local authority data adjusted to account for non-CO_2 greenhouse gas emissions. Apportioned on basis of NOMIS data on employment sites by size and sector at MSOA resolution.
Industrial & Commercial Other Fuels	Local Authority CO_2 reporting	Local authority data adjusted to account for non-CO_2 greenhouse gas emissions. Apportioned on basis of NOMIS data on employment sites by size and sector at MSOA resolution.
Industrial & Commercial Large Users	Local Authority CO_2 reporting	Local authority data adjusted to account for non-CO_2 greenhouse gas emissions. Apportioned on basis of NAEI 1km data for industrial processes and industrial point source data.
LULUCF	Local Authority CO_2 reporting	Apportioned by land area. Non-CO_2 emissions not considered.
Power Generation	NAEI 1km and point source	Gridded data area apportioned, point data summed within area. **Note: this category overlaps with electricity emissions and is provided for information only.**
Railways (Diesel) *	Local Authority CO_2 reporting	Local authority data adjusted to account for non-CO_2 greenhouse gas emissions. Apportioned by route mileage of railway.
Road Transport	Local Authority CO_2 reporting	Local authority data adjusted to account for non-CO_2 greenhouse gas emissions. Apportioned on basis of NAEI 1km data for road transport.
Shipping	NAEI national data	Population apportioned
Transport Other +	Local Authority CO_2 reporting	Apportioned by land area. Non-CO_2 emissions not considered.

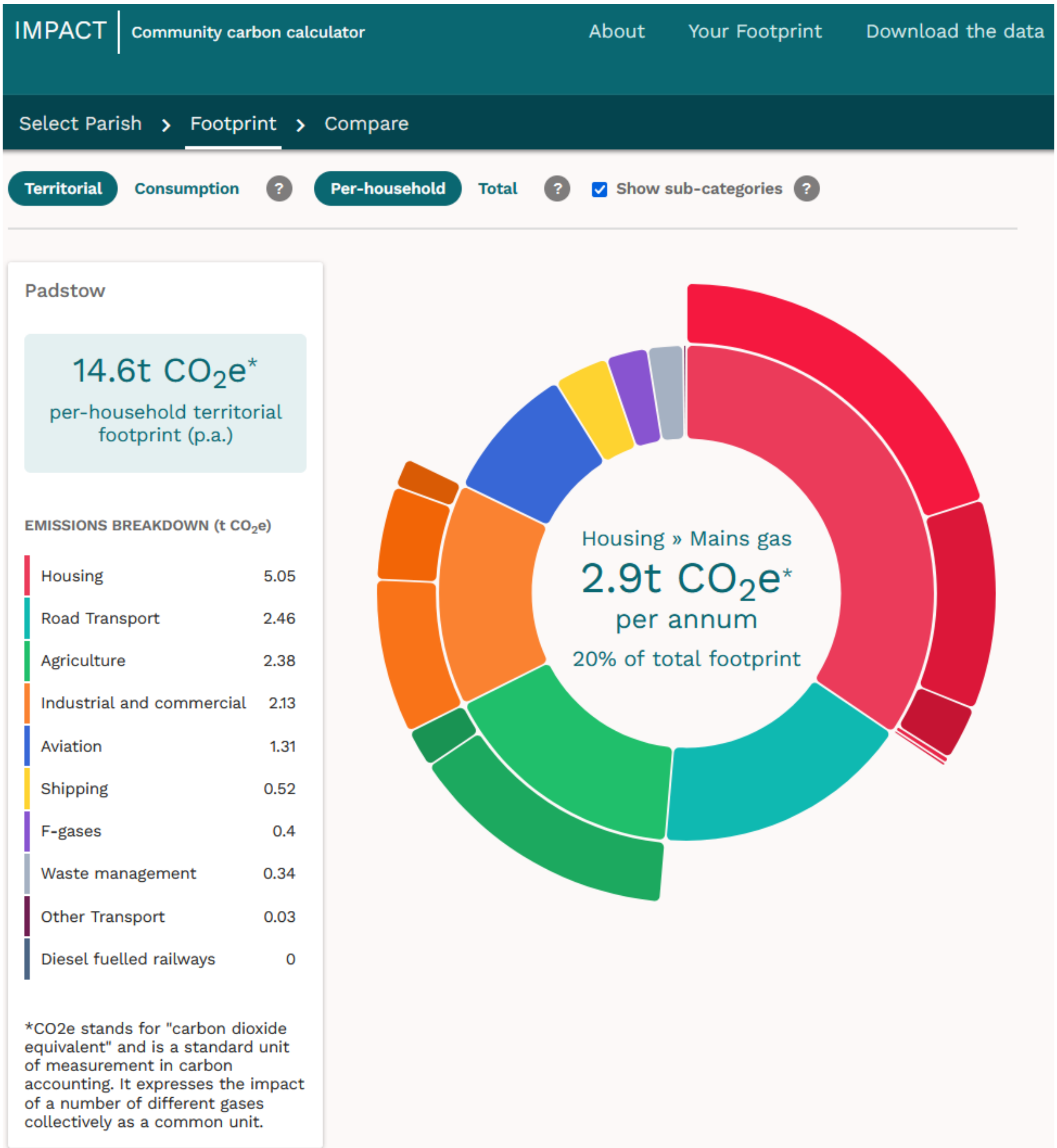


Figure 2. Screenshot of the IMPACT tool showing the per household territorial carbon footprint and its breakdown for the parish of Padstow in Cornwall

2.3 Existing community level carbon footprint tool - Place-Based Carbon Calculator (PBCC)

Place-Based Carbon Calculator (PBCC) [5] is a free tool developed by Centre for Research into Energy Demand Solutions (CREDS) that can estimate the average per-person consumption-based carbon footprint for every Lower Super Output Area (LSOA) in England. It uses detailed local data when available (e.g., for gas and electricity consumption) but relies on surveys and modelling to fill in the gaps for other types of consumption such as food. The total footprint for an LSOA is divided by the number of people living in the LSOA to get the average per person carbon footprint. Lots of different sources were used in compiling the carbon footprint of different activities. In general, scope 1 and scope 2 emissions are primarily calculated based on statistics and other datasets available at the LSOA level while scope 3 emissions are estimated based on the overall UK consumption-based carbon footprint scaled to account for England's population and then distributed to the LSOA's based on household income. The PBCC allows users to select an LSOA from a map (see Figure 3) or search for an LSOA by name and see its per person consumption-based carbon footprint from different sources (see Figure 4).

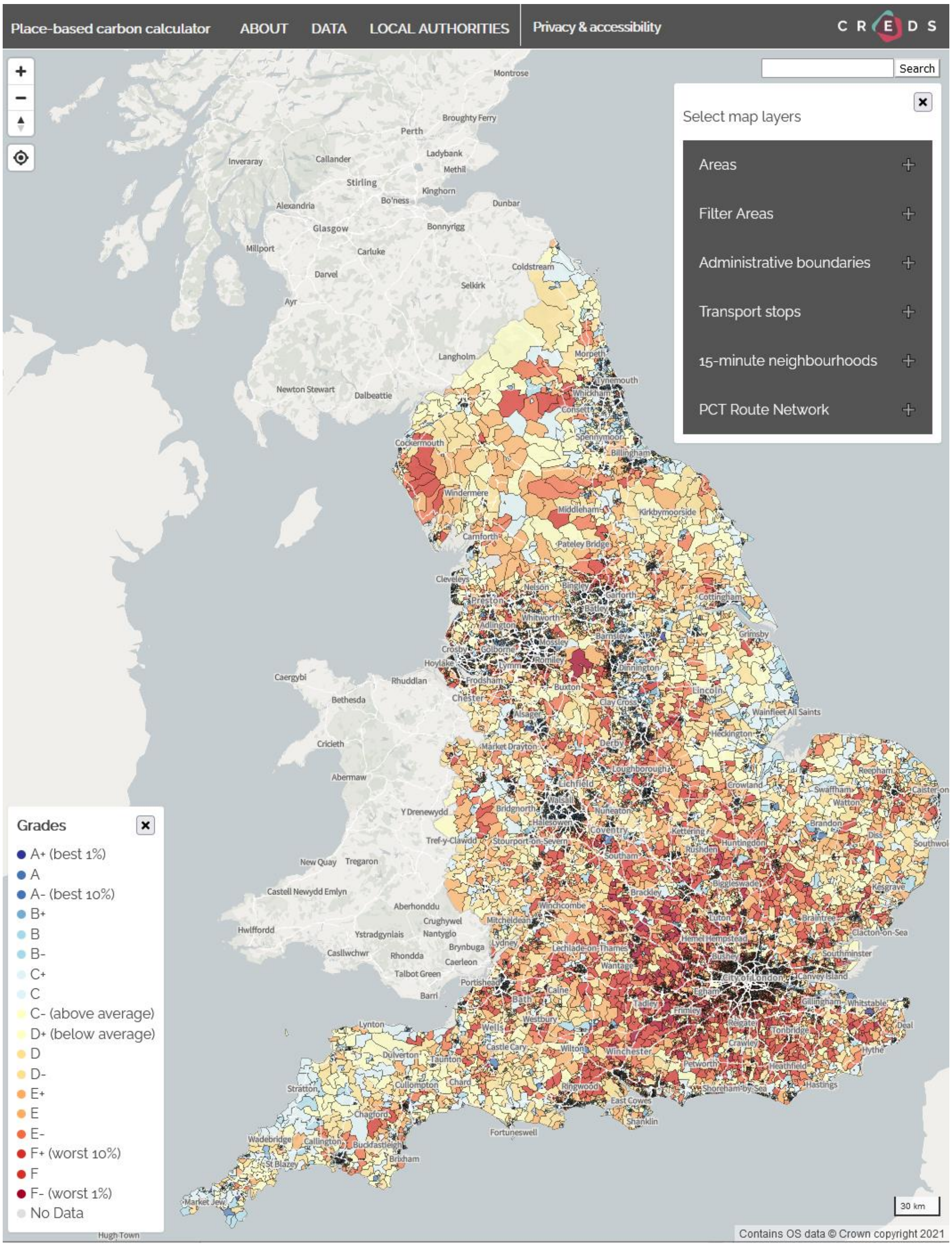
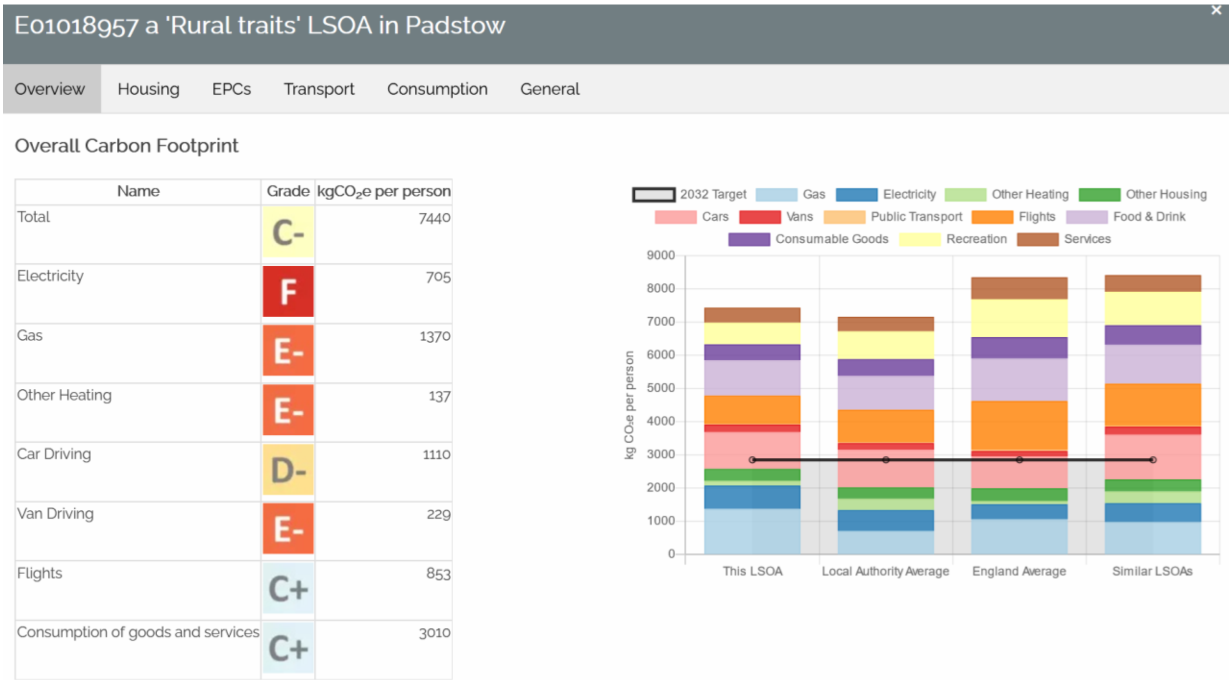


Figure 3. Screenshot of the PBCC tool in map view



Name	Grade	$kgCO_2e$ per person
Total	C-	7440
Electricity	F	705
Gas	E-	1370
Other Heating	E-	137
Car Driving	D-	1110
Van Driving	E-	229
Flights	C+	853
Consumption of goods and services	C+	3010

Figure 4. Screenshot of the PBCC tool showing the per person consumption-based carbon footprint and its breakdown for one of the LSOA in Padstow in Cornwall

2.4 Limitations with existing tools

There are some important limitations with these existing tools in the context of NZCom. As the key aims of these tools are to provide a full coverage of all local areas in England, their use of often fragmented and/or highly aggregated data means that there are significant data gaps at the local level and many parameters were extrapolated down to local areas based on national or local authority level statistics. This is a particularly significant issue for a rural community area such as Wadebridge & Padstow as the aggregated statistics at higher levels might not reflect the situation in these areas. In addition, the use of aggregated data in these tools does not allow a detailed understanding of the underlying drivers of emissions and therefore limit their ability to quantitatively assess technological or behavioural changes in future emissions pathways. For example, although the use of the electricity and gas consumption data available at the LSOA level can provide relatively accurate estimates of emissions from these sources, it's not possible to know what activities (e.g., water heating, space heating, cooking etc) drive the consumption and what technologies or behavioural solutions might be effective and feasible to implement in order to reduce emissions substantially. These limitations suggest that there is a need to develop a GHG accounting method for NZCom in the context of its aims and objectives.

3. GHG Accounting Method for NZCom

The objective of WP3 is to work closely with WP4 to develop a hybrid carbon accounting method for communities that is suitable for quantitatively assessing likely technologies, systems, approaches and community-led business models to achieve net zero carbon by 2050 that deliver impact and benefits to Network Operators. This section presents the GHG accounting method developed for NZCom, based on the objective and resources of the project, characteristics of and available data for the case study area, and limitations of existing approaches/tools, while ensuring the accounting principle set out in the GPC are followed.

3.1 GHG inventory boundary

- **Geographic boundary**: The Wadebridge & Padstow Community Network Area is used in NZCom as the case study area. The method developed will be applicable to other regions.
- **Time period:** GHG emissions within a calendar year will be calculated for future years up to 2050.
- **Greenhouse gases:** emissions of CO_2, CH_4 and N_2O will be covered as these are the most relevant for energy technologies.
- **GHG emission sources:** Stationary energy for residential buildings and industrial & commercial use as well as public and private road transport will be covered.
- **Categorising emissions by scope:** Scope 1 and scope 2. Scope 3 emissions are excluded as in the context of energy, scope 1 and 2 emissions are the dominant sources of emissions for fossil fuels. Scope 3 emissions for established renewable electricity generation technologies such as wind and solar are much lower than the scope 1 and 2 emissions from fossil fuels on a per unit electricity generated basis and are not very well established for some emerging renewable and low carbon technologies. In addition, local communities are unlikely to be able to influence the scope 3 emissions of most of these energy technologies.
- **Boundaries for mitigation goals:** The boundary for the net zero target is limited to the above-mentioned inventory boundary.

3.2 Calculating GHG emissions

As Planet A Solutions CIC will produce the consumption of various types of building and transport energy by the Wadebridge & Padstow Community Network Area as an output from the modelling within WP4, GHG emissions from the area can then be calculated based on the appropriate GHG emission factors for different types of energy carriers such as electricity and transport fuels. GHG factors for direct combustion emissions (scope 1) for most solid, gaseous and liquid fuels as well as for UK grid electricity (scope 2) are available from the "UK Government GHG Conversion Factors for Company Reporting" document [6]. However, some emerging renewable fuels such as hydrogen are not covered in this document. Given that green hydrogen

(hydrogen produced from electrolysis of water using renewable electricity) is the only type of hydrogen included in the technological solutions assessed by Planet A Solutions CIC, the emission factor for hydrogen is zero. All the emission factors used will be detailed in the Excel-based community scale NZC 2050 carbon accounting tool.

As the GHG emission intensity of UK grid electricity is expected to change significantly over time, the calculation of emissions from the consumption of grid electricity in future years will be based on a future emission intensity trajectory estimated by Planet A Solutions CIC using historical trends and carbon targets set in UK legislation (detailed in WP4 deliverables). It should be noted that this trajectory can and should be revised periodically to reflect actual changes in emission intensity of the UK grid electricity.

4. Outcome

4.1 Advantage of the method developed

The GHG accounting method developed for NZCom has a reasonable representation of the baseline for the target area in terms of buildings and transport based on available data and the ability to project GHG emissions in annual steps in future years. It allows for the assessment of the effects of different interventions such as adoption of lower carbon energy technologies and changes in energy consumption behaviours as the emission calculation is based on disaggregated energy consumption produced by models developed by Planet A Solutions CIC. The method should be relatively easy to implement in other areas in the UK given the similar level of data availability and therefore forms a replicable approach to guiding communities towards Net Zero Carbon.

4.2 Limitations of the method developed

The main limitation of the method developed is the focus on stationary energy for residential buildings and industrial & commercial use as well as road transport in terms of emission sources and scope 1 and 2 emissions in terms of the coverage of emissions of different scopes. However, this limitation, resulted mainly from data availability and project resources, does not affect the core aim of the NZCom project, i.e., to develop a replicable approach to identifying local solutions that can prevent the more vulnerable energy users from being disadvantaged by the transition to net zero.

References

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[4] Centre for Sustainable Energy, University of Exeter. Impact Tool Method Paper. 2021.

[5] Place-based carbon calculator. Place-Based Carbon Calculator n.d. https://www.carbon.place (accessed January 28, 2022).

[6] Department for Business, Energy & Industrial Strategy. UK Government GHG Conversion Factors for Company Reporting. 2021.