Towards a Greenhouse Gas Assessment of the Welsh Government Budget:

Illustrative Results for the 2021-22 Draft Budget

February 22nd 2021

Calvin Jones jonesc24@cf.ac.uk

Max Munday mundaymc@cf.ac.uk

Welsh Economy Research Unit
Yr Uned Ymchwil i Economi Cymru

Contents

1. Introduction and Background

In October 2020 the Welsh Economy Research Unit (WERU) was contracted by Welsh Government to assess the feasibility of developing a carbon assessment of Welsh Government budget expenditure. The agreed objectives were (broadly):

- To develop an experimental/illustrative estimate of greenhouse gases (GHGs) associated with activity connected to the Welsh Government Budget, following established Scottish Government concepts, coverage and techniques as far as practicable[1];
- To allow users to engage in 'what if' scenarios; whereby the illustrative GHG consequences of different spending choices could be assessed in real time by moving expenditure between different expenditure groups;
- To report on the key statistical, data and estimation issues that might currently impact the development of a realistic and robust estimate of the GHG impacts of Welsh Government spending.

In this final report we present our initial attempt to estimate the GHG emissions associated with planned revenue spending by the Major Expenditure Group (MEG) in the 2021-22 (draft) budget as supplied by Welsh Government in mid-February 2021; and separately of capital spending (in aggregate) – these together represent some £20.1bn of spending.

2. Methodology

Environmental and carbon accounting and impact analysis (typically) requires a detailed set of financial and environmental accounts for the territory in question. WERU has for many years collated and published Input-Output (IO) Tables for Wales, together with various extensions including Tourism and Environmental

[1] https://www.gov.scot/publications/carbon-assessment-budget-2020-21/

Satellite Accounts[2]. However, the last published Tables (with environmental extensions) were for base-year 2007[3].

The age of the core Welsh IO Tables together with a lack of data on the commodity and geographic nature of Welsh Government spending means our analysis is necessarily illustrative. The methodological task then was broadly as follows:

1. To estimate the emissions of carbon equivalent GHGs (in kilotonnes of CO2e) consequent on economic activity in Wales, disaggregated by the 88 sectors that comprise the IO Tables for Wales for as recent a time period as possible (and with 2018 estimates developed here).
2. To estimate the economic output of each of these sectors in the relevant year to arrive at a 'territorial carbon-intensity' of production for each sector.
3. To lever the (2007) IO Wales multipliers to assess the direct and indirect GHG emissions associated with Welsh Government spending for each sector and hence in aggregate. Note that we expect the estimates for Welsh sector multipliers to change less through time because these are determined by relatively settled (for most sectors) industry technical coefficients and import propensities.

The consequent estimate would then:

1. Effectively[4] describe GHG emissions arising in Wales (a 'territorial' measure), not those consequent on the production of imported goods (i.e. we do **not** develop a 'consumption' based measure here[5], but consumption based measures are important in the context of Wales' wider legal duties towards sustainable development),

[2] For uses. see for example Munday, M. C. R., Turner, K. and Jones, C. 2013. Accounting for the carbon associated with regional tourism consumption. *Tourism Management 36, pp. 35-44.* (10.1016/j.tourman.2012.11.005); Jensen, C. D.et al. 2013. Responsibility for regional waste generation: A single-region extended input-output analysis for Wales. *Regional Studies* 47(6), pp. 913-933. (10.1080/00343404.2011.599797)

[3] See Welsh Economy Research Unit, Input-Output Tables here

[4] We believe NAEI data and hence our developed emissions intensities are solely for devolved territories, e.g. would exclude the refining emissions associated with fuels refined in NW England then imported into Wales and burnt. Further clarification should be sought from the NAEI team https://naei.beis.gov.uk/.

[5] Due to data and modelling limitations we assume **all** Welsh Government spending occurs in Wales in the first instance. For more information of production versus consumption approaches in a Welsh context see Turner, K.et al. 2011. Incorporating jurisdiction issues into regional carbon accounts under production and consumption accounting principles. *Environment and Planning A* 43(3), pp. 722-741.

2. Be conceptually comparable to those emerging from Scottish Government carbon assessments,[6]
3. Include the direct and 'indirect' or 'multiplier' effects of this spending; for example, as Welsh Government funded health trusts bought electricity or fuel to heat/light their hospitals, and carbon was emitted either from onsite fuel burn or via the supplying power stations,
4. Exclude (what the Scottish Government term) 'second round' emissions, for example as patients drive their cars to funded hospitals for treatment,
5. Include the GHG emissions associated with capital spending allocated in that budget year (although projects and hence emissions may be multi-year),
6. Act **not as a 'real', reliable estimate of emissions consequent on public expenditure,** but rather be illustrative of the nature of the types of spend that drives emissions, and of the challenges associated with obtaining such an estimate.

As part of the research programme consultation was undertaken with Scottish Government staff to discuss their methodological approach. In consequence we have adopted an approach which accounts indirect emissions on a 'Type 1' basis. This then excludes induced household/wage effects. Relatedly, following Scottish procedure we model impacts wholly through the inter-industry matrix of the IO table. This means that there are no direct payments in our methodology from Welsh Government budgets to employees. This also means, for example, that in the Administration & Central Services MEG, Welsh Government pays £215m to 'Public Administration' which then disburses this spend across commodity groups according to the pre-estimated vector.

There are several reasons for this approach. First the estimate of how much of each MEG spend is wages is very difficult where Welsh Government do not hold data – for example, in the key sectors of Health & Social Care and Education. Second, we are seeking for comparability purposes to follow the methods employed in Scotland. This approach, however, has important ramifications in that the emissions we report are wholly *sector*-related, and all Government spending is routed through industry sectors . Thus, while direct household emissions (e.g. from private transport and

[6] but see later discussion.

heating) in Wales are excluded from the modelling, all Welsh Government budget spending *is* accounted for, albeit via higher spend and hence emissions from sectors.

It is difficult to make a firm conclusion on how far this 'simpler' approach, and excluding household emissions arising from supply chain wage effects (i.e. reporting through 'Type 1' multipliers) will under- or over-estimate emissions compared to assessing and separately modelling wage spending and/or using Type 2 multipliers. It is the opinion of Scottish Government (and of collaborating staff at the Fraser of Allander Institute at Strathclyde University) that this latter method risks double counting emissions. Unfortunately progressing this issue further would be extremely complex both conceptually and operationally. If carbon budgets become more established further consultation would be appropriate on this issue.

Readers should also be aware that due to data limitations we model all budget spending as if it occurs in Wales – i.e. no products and services are directly imported. Again, this approach is not ideal. We still seek to account for all Welsh Government budget spend in our GHG estimates, but these are based on Wales-specific industry production functions and industry output-GHG ratios.

3. Data

Emissions

The emissions data for this exercise were drawn from the National Atmospheric Emissions Inventory's (NAEI), Greenhouse Gas Emissions Inventories for Devolved Authorities (for 2018)[7]. The data are available by emissions source. While there is great detail in this data source (over 200 combustion, enteric, land use, and other emitter classes) this does not map well to the 88 industrial sectors reported in the IO Tables for Wales. For example, the NAEI reports 32 agriculture, forestry and fishing emission sources which are fitted within two IO categories, whereas the single NAEI 'Miscellaneous industrial/commercial combustion' category must be allocated across 24 Input-Output sectors[8]. This allocation is time consuming (and manual) but given

[7] https://naei.beis.gov.uk/reports/reports?section_id=4
[8] Using estimates from prior-published more detailed emissions data.

the emissions profile across sources – concentrated heavily into a small number of well-defined agricultural, industrial, construction and transport sectors – not actually important in shaping the final estimates.

Input-Output Tables

More problematic are the issues associated with obtaining a full economic accounting for Wales in 2018. A separate (internally Cardiff Business School and ONS ESCoE[9] funded) project is seeking to develop updated Input-Output Tables for Wales, and when complete, this framework could be the 'home' to our emissions estimates. However, a combination of resource reallocation due to COVID, researcher availability, and a recruitment freeze, means this project is progressing slowly. Initial estimations of the 2018-base year framework have (as of Dec 2020) highlighted a number of structural and other issues that require some thought to ensure the Tables are robust and useful going forward.

This first estimate therefore uses a hybrid approach. It is effectively marrying 2018 Welsh production emissions by source with estimates of Welsh economic output in 2018 to assess emissions intensities. This then drives the GHG estimates both directly and in supply chains. Recall we are using the Input-Output framework that describes purchasing behaviours in 2007 to develop the indirect GHGs linked to public spending. We consider this a less-bad option than basing our estimates fully on a problematic 2018 IO Table, but it does raise some issues, not least for sectors – and indeed entire product classes – that have changed or emerged since 2007. However, the 2007 supply chain relationships which drive the (extremely important) indirect/multiplier GHG impacts are well developed and well understood in these Tables (albeit, they are old) and, importantly, the use of suitably amended 2018 GHG estimates means that key emissions trends – for example in Welsh energy generation which has moved from coal to gas and renewables – are accounted for. Our overall (non-household) GHG estimate tallies with the NAEI at around 31 Megatonnes. Note that the use of 2018 emissions intensities matched to 2018 output means that inflation is a minor issue[10].

[9] Economic Statistics Centre of Excellence - ESCoE : ESCoE

[10] Note we do not have to adjust our 2022 spend data as we are relying on 2018 ratios, not cardinal estimates.

Welsh Government Planned Budget Expenditure 2021-22

Our estimates are based on planned/draft Welsh Government budget expenditure by MEG for 2021-22 as at mid-Feb 2021 and supplied by Welsh Government. We have modelled the impact of each MEG category revenue spending separately, and then for all capital spending in aggregate – the data do not allow us to differentially model capital spending for each MEG group. This is important to note because elements of capital spending can support Welsh industry activity which is greenhouse gas intensive, such that in future some disaggregation will be needed here.

In order to estimate the GHG emissions associated with Welsh Government spending in Wales, we must estimate the 'pattern' of spend by individual commodity/industry. Ideally, this would be by the 88 sectors (currently) reported in the IO Tables, and in each case estimating the spend within Wales, as well as outside. We would also ideally require a full accounting of revenue versus capital spend across the piece to a similar disaggregation.

We are some way from this ideal. This is firstly, because Wales does not yet have a full set of official regional accounts (in IO format, and including detailed industry by industry/commodity transaction matrices). These would detail regional (or non-Wales) institutional spending by commodity and would be largely analogous to Welsh Government MEG spending. Secondly, estimating the spend vector of some MEG spending from scratch is difficult due to the institutional complexity of the sector. For example, Welsh Government disburses money to health trusts, local authorities and others who then use that money (often via further subcontract) to address the MEG priorities. We have not yet been able to establish if there is a central accounting of procurement by purpose, commodity, or company within Welsh Government, or whether such an estimate is possible in collaboration with the Welsh Local Government Association (WLGA), NHS colleagues and others.

In the absence of accurate and up to date estimates of MEG spending across the piece, we have several options based on extant resources including from UK Input Output (Analytical) Tables; Scottish data; existing Welsh Input Output spend patterns; information from various WERU projects undertaken since 2010; and more detailed information for some expenditure groups by sub-MEG budget head spending from the 2020-21 out-turn budget.

Following the publication of our first Research Note on Carbon Budgeting in the Chief Economist's report (December 2020)[11] and after examining the difficulties and opportunities associated with different options, we have taken the following approach:

(1) estimating MEG spend profiles from the 'ground up' where suitable data exist from the 2020-21budget expenditure line (BEL) out-turn;

(2) relying upon new, sectors, hybridised from 2007 Input-Output vectors, where the sub-MEG spending data were considered insufficient to properly represent by-commodity spend; and

(3) Spreading capital spending in the same proportions reported in the Input-Output Gross Fixed Capital Formation final demand vector.

Figure 1 following summarises our approach for each MEG and capital spending – alternative estimation is of course possible, with differing implications for accuracy and resources. Full detail of this process, and the rationale for decision making is available from the authors.

Figure 1 The Commodity Spending Estimation Process

Major Expenditure Group	Estimation Process
Health and Social Services	IO sector *Health & social work*
Housing and Local Government	Weighted hybrid of IO sectors *Education; Health and social work; Public Admin; Other Professional Services; Banking and Finance; Legal services*.
Economy and Transport	New expenditure vector based on BELs
Education	IO Sector *Education*
International Relations and the Welsh Language	New expenditure vector based on BELs
Environment, Energy and Rural Affairs	New expenditure vector based on BELs

[11] See Welsh Budget 2020: Chief Economist's report | GOV.WALES

Central Services and Administration	IO Sector *Public Admin*
Capital Expenditure	IO Final Demand *Gross Fixed Capital Formation*

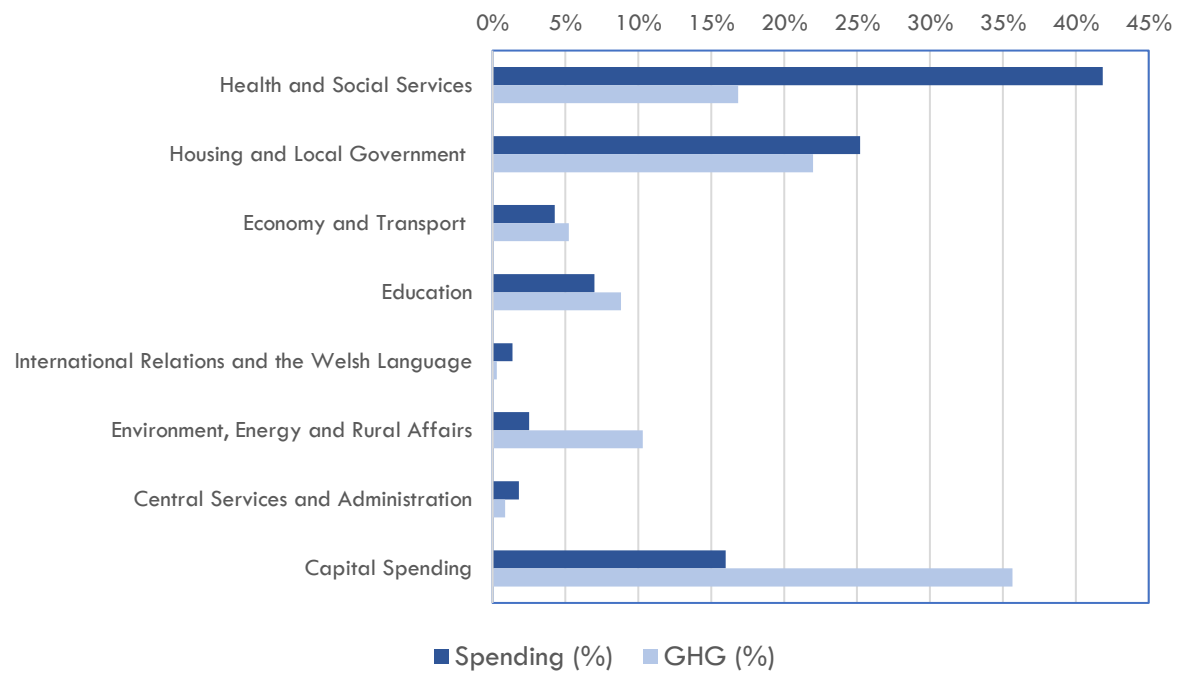
4. Results

Figure 2 presents our estimates of the Greenhouse Gas emissions associated with Welsh Government budget spending, in kilotonnes of CO2 equivalent. Our estimate of just over 7,000 kt (7Mt) would have comprised around 22% of the Welsh territorial sector[12] emissions in 2018 – although note that the appropriate denominator is open to question.

Figure 2 - The Greenhouse Gas Emissions Consequent on Planned Budget Spending

	Spending (£m)	***Spending (%)***	***GHG (kT CO2e)***	***GHG (%)***
Health and Social Services	8,830	41.9%	1,183	16.8%
Housing and Local Government	5,320	25.2%	1,544	22.0%
Economy and Transport	900	4.3%	368	5.2%
Education	1,476	7.0%	618	8.8%
International Relations and the Welsh Language	290	1.4%	21	0.3%
Environment, Energy and Rural Affairs	529	2.5%	724	10.3%
Central Services and Administration	381	1.8%	60	0.9%
Capital Spending	3,372	16.0%	2,504	35.7%
Total	21,099	100.0%	7,021	100.0%

[12] Agricultural/primary, industrial, transport business and public sector but excluding household-consequent.



Note: Some numbers are rounded here, meaning column sums may not add exactly to totals.

Figure 2 reveals that the largest portion of emissions is related to capital spending, 36%, despite this only accounting for 16% of planned spending. At the other extreme the significant proportion of expenditure on health (42% of the total) results in a much lower GHG burden.

As the figure illustrates, there are considerable differences in the GHG consequences of spending across different portfolios. Figure 3 provides estimates of the GHG emissions intensity of spend, and relative industrial sources.

Figure 3 - Origin of Greenhouse Gas Emissions by Sector and Major Expenditure Group

Origin Sector	Health & Social Services	Housing & Local Gov.	Econ. & Trans.	Edu c-ation	Int'l & Welsh Lang	Environ, Energy & Rural	Central Serv & Admin	Capital Spend	All Spend
Agriculture & other primary	11%	6%	1%	18%	4%	83%	2%	3%	15%
Manufacturing	24%	33%	10%	28%	20%	3%	17%	14%	20%

Energy, Gas & Water	20%	14%	4%	18%	12%	1%	7%	4%	10%
Construction	6%	29%	65%	8%	45%	5%	14%	75%	39%
Private Services	1%	1%	0%	1%	2%	0%	1%	0%	1%
Transport	25%	10%	18%	24%	14%	5%	6%	3%	11%
Public Sector & other services	13%	7%	1%	2%	3%	1%	53%	0%	5%
Emissions Intensity (kt/£1m)	0.13	0.29	0.41	0.42	0.07	1.37	0.16	0.74	0.33
Total (kT CO2e)	**1,183**	**1,544**	**368**	**618**	**21**	**724**	**60**	**2,504**	**7,021**

Emissions intensities vary significantly across MEGs. In general there are intuitively clear reasons for this. Relatively high intensities for *Capital Spending* and *Economic Development and Transport* are driven by a high proportion of emissions-heavy construction spending (in the latter case related to road maintenance). Meanwhile the higher emissions-intensity of *Education* originates across a variety of supplying sectors, including paper and publishing, computing, road transport services and general retail purchases.

The most emissions-intense MEG is *Environment, Energy & Rural Affairs*, some four times more emissions-intense than the average. This is almost wholly due to agricultural support activities (giving rise to a basket of GHGs, including enteric methane which we report here in carbon-equivalence). Note that here that unlike in Scottish results, we *do* account for the carbon sequestration/reduction associated with Welsh Government supported forestry activities[13].

Note that we estimate the GHG consequences of planned spending (2021-22) at around 18% of Wales territorial emissions, including those of households (2018) and with that expenditure equal to around 13% of estimated Wales' economic output (again in 2018). Whilst these comparisons are conceptually and empirically difficult,

[13] Which our model estimates at around 32 kT of CO2e

the Government's role in infrastructure maintenance and capital expenditure may well explain this additional 'carbon intensity' compared to the territorial average.

5. Observations on the Results

Quality, Scope and Reliability

As we noted in our first Research Note, despite the aged nature of the underlying economic account (for base year 2007), and the paucity of data relating to Welsh Government spending patterns, the model delivers results that are in general intuitive and – importantly – fairly transparent. We can investigate particular areas of carbon impact and trace these back via the inter-industry matrix to individual sectors and/or spending patterns. Whilst we do not claim these results are highly accurate, we believe they are indicative of the GHG impacts of budget spending, remembering some key caveats and assumptions.

The first, most trivial point to note is related to our limited modelling capability which does not (currently) distinguish direct and supply-chain carbon, although this would be a relatively easy fix.

Secondly, the scope of our analysis is limited geographically. This is both a data problem – Welsh Government does not know where its money is spent – and an accounting/modelling issue – we cannot assess the GHG emissions of commodities produced outside Wales and imported (by suppliers) to service Welsh Government demands as we do not have 'rest of the world' (or rest of UK) environmentally-extended Input Output Tables. The second of these issues is soluble, for example in collaboration with Scottish Government and Strathclyde University colleagues who do have these accounts, albeit in a different structural form.

Thirdly, the underlying 2007 framework is increasingly archaic – frustratingly so when carbon (territorial emissions) data are good. This is an issue that is of concern to WERU and Cardiff University but requires fairly significant thought and investment. Without such investment, there are limits on how far WERU can develop the analysis further.

Fourthly, we note that there are a number of policy areas where the approach adopted here will not be overly useful, even if data and modelling were improved

significantly. Input-Output and associated analyses rely upon average (and past) behaviours in aggregated sectors: modelling the impact of discrete regulatory or policy change (for example, requiring certifications, or particular geographic origins in procurement) would be challenging.

Comparisons with Scottish Results

We have largely followed the approach of Scottish Government colleagues in methodological choices here. Given this, some comparison (broadly at least) of our results with those from their 2020-21 budget carbon assessment in terms of carbon intensity of spend overall is possible. Figure 4 reports Scottish findings by their major expenditure group.

Figure 4 - Greenhouse Gas Intensity of Scottish Government Budget 2020-21

	Spend (£m)	*GHG (kT CO2e)*	*GHG Intensity (kT/£1m)*
Health and Sport	14,970	1,925	0.13
Communities and Local Government	11,323	2,131	0.19
Finance, Economy & Fair Work	6,241	841	0.13
Education and Skills	4,126	575	0.14
Justice	2,774	408	0.15
Transport, Infrastructure and Connectivity	3,325	1,081	0.33
Environment, Climate Change and Land Reform	435	90	0.21
Rural Economy	745	1,274	1.71
Culture, Tourism & External Affairs	349	48	0.14
Social Security & Older People	3,788	1,070	0.28
Government Business	16	2	0.13
Crown Office & Procurator Fiscal	129	20	0.16
Scottish Parliament & Audit Scotland	103	15	0.15
Total	**48,324**	**9,480**	**0.20**

As Figure 4 shows, Scottish spend is estimated, overall at a lower level of carbon intensity than for Wales (0.2 kt/£1m compared to 0.33 for Wales). Differences in spending group are harder to assess because of the very different MEG classification but note that the Scottish ‘Rural Economy’ MEG is by far the most carbon intense, mirroring the Welsh results.

We cannot be definitive on why Scottish results are lower overall than those for Wales, but one avenue of interest is around the estimation or treatment of construction CO2e, and whether this is fully accounted, either within revenue or capital spending. We note that the carbon intensity of Scottish Government capital spending is assessed at 0.20 kT/£1m – basically the same as the revenue average – whilst we estimate 0.74 kT/£1m in Wales. Separately, but relatedly our estimate is that 39% of *all* budget GHG emissions arise in the construction sector in Wales: for Scotland this figure is only 2%. It is highly likely therefore that Welsh-Scottish differences result in the different treatment of (functionally similar) government spending, rather than 'real' differences.

Our Estimation and Results in the Wider Context

During this project we have, in parallel held conversations with officials across Welsh Government, representatives of the Future Generations Office, and NGOs who are interested in the process, results and potential future direction. At the same time, we have communicated with Scottish colleagues about the uses and usefulness of their longstanding (since 2012) carbon analysis.

In all cases, stakeholders were interested in the ability of bespoke environmental IO to provide guidance on audit on both budget and wider decarbonisation. Additionally the question of 'fit' with Wellbeing Indicators, the Future Generations and Environment Act were raised, specifically in the last case with respect to the requirement for consumption based GHG emissions to be reported.

It is our view that current statistical resources and modelling frameworks are some way from being robustly fit for such purposes. Further, that whilst such approaches might be suitable for such uses, their development would require a well-resourced, multi-stakeholder and genuinely co-created approach over an extended period.

The IO approach can provide useful whole-economy estimates and comparisons, and be extended (in tandem with colleagues across Welsh Government and the UK) to properly include consumption GHG estimates that include those arising from non-Welsh production, the process of decarbonisation of budget spending requires a complementary 'Life Cycle Analysis' approach within areas of competency. Here the specificity of carbon (and other environmental) impacts of spend and activity can be

properly detailed, and proper remediation undertaken. The Natural Resources Wales Carbon Positive project is exploring techniques in this regard[14]. We come to this conclusion in part as it is our reading and interactions suggest that the Scottish IO based analyses undertaken since 2012 are very lightly used, and with limited (demonstrable) impact on policy.

6. Conclusions

This first, indicative analysis has demonstrated the significant limitations that exist in terms of current data availability and modelling structures in terms of how we represent the GHG impacts of Welsh Government spending, but also that interesting and actionable results can emerge from such analysis.

We would highlight here there are some key issues in addressing data constraints. Note that because we are talking here of improvements to economic data, addressing these limitations would bring various policy and analytical benefits which would follow across devolved areas beyond carbon.

(1) The relative paucity of economic data, where current ONS Regional Accounts are not in the 'shape' required (insufficient sector disaggregation) and do not have the coverage needed (only really GVA reported; no data on intra-regional purchases etc. (although we note some progression here in terms of the Wales Trade Survey). Contrast this with Scotland, with a mainstreamed programme of IO compilation within Scottish Government.

(2) The lack of any bespoke data on how Welsh Government budgets are distributed over different Welsh and imported commodity/industry groups by MEG or any other thematic grouping – these data would be required for any reliable 'what if' analysis that involved moving money between headings and assessing the carbon consequences.

[14] https://cdn.naturalresources.wales/media/687222/cym-evidence-report-303-carbon-positive-project-technical-report-calculating-nrws-net-carbon-status.pdf

Additionally, our (admittedly informal and limited) conversations undertaken with stakeholders over the last six months have highlighted that the creation of a wider forum with a focus on how statistical resources could enable and audit progress towards Wales' legally mandated climate and environmental objectives would be both useful and warmly welcomed.

Finally here the focus is necessarily on greenhouse gas emissions. At the very least the estimates presented in this report provide context for the impacts of spending, but with more difficulties in actually influencing the level of greenhouse gases connected to different spending activities. However, the estimates allow Welsh Government to consider how spending that improves welfare in many respects might actually reduce the welfare of the population in terms of environmental externalities. It is accepted that there are a complex set of externalities arising from public spending in Wales but carbon is a key issue. This analysis then represents a more thorough consideration of the welfare trade-offs in spending and with carbon budgeting a welcome development in our better understanding of the full socio-economic costs of growth.