# Methodology and Data Sources

## Measuring and Forecasting Carbon Emissions

### Categories of emissions

The emissions data available on the *Can Do Cities* site are available in production-based and consumption-based forms. These, in turn, relate to a standard system of accounting developed as part of the *Greenhouse Gas Protocol*[1] for cities. This protocol uses three GHG emissions categories:

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| Scope 1: | *Direct* emissions from sources located within the geographic boundaries of an area |
| Scope 2: | Emissions associated with the direct use of electricity or heat within the area |
| Scope 3: | Indirect emissions occurring outside the area due to activities within the area |

'Production-based' emissions are most commonly reported and measured, and are, almost exclusively, the basis for regional and national emissions targets. They are equal to Scope 1 and 2 emissions combined.

'Consumption-based' emissions are more difficult to estimate and less commonly measured. But in developed, post-industrial, and generally more affluent areas these are critical[2]. They are equal to scope 1, 2 and 3 emissions combined *minus* any scope 1 and 2 emissions involved in producing goods/services that are exported from the area.

### Measuring and Forecasting

The methodologies we use are reported in detail elsewhere[3] and build upon a body of work from the University of Leeds and many others[4].

Production-based emissions for the 'baseline' scenarios – often referred to as 'business as usual' – are estimated from a mix of local and national trends. We utilise local authority energy and emissions data for 2014/15, national UK-level emissions forecasts out to 2035, and local authority population projections [5]. The method then takes the current sources of emissions in each local area, assumes the per-person rates of change of these emissions matches the rates that are expected at the national level over the period 2015-2035, and thus estimates the total emissions from the area using the local population forecast. There are inherent uncertainties when making such forecasts in an inherently uncertain world, and further discussion of these can be found in our other work[6].

Consumption-based emissions estimates typically employ a technique called environmentally extended, multi-regional input-output (EE-MRIO) analysis. This uses monetary data capturing international trade to reallocate production-based emissions to the goods and services that are finally consumed. These are particularly difficult to

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[1] Developed by the *World Resources Institute*, *C40 Cities Climate Leadership Group* and *Local Governments for Sustainability (ICLEI)*; see www.ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

[2] Peters et al. (2011) *Growth in emission transfers via international trade from 1990 to 2008*, Proceedings of the National Academy of Sciences

[3] Millward-Hopkins et al. (2017), *Uncovering blind spots in urban carbon management: the role of consumption-based carbon accounting in Bristol, UK,* Regional Environmental Change

[4] Summaries and reports can be found at www.climatesmartcities.org and www.emissions.leeds.ac.uk

[5] From the UK's *Department for Business, Energy & Industrial Strategy* and the *Office for National Statistics*

[6] www.cccep.ac.uk/publication/the-economics-of-low-carbon-cities-a-mini-stern-review-for-the-city-of-bristol

apply at scales below the national-level, so we again use a combination of local and national data, including local household expenditure data and national carbon intensity data for goods produced within, and imported into, the UK. Our forecast assumes that the observed change over the past 12 years in (1) UK spending and (2) carbon intensities of production within the UK and within other global regions, continue at the same rate until 2035. Other more complex methods have produced very similar results[7].

## Reducing Carbon Emissions: Options, Costs and Benefits

### *Uncovering Available Options to Reduce Emissions*

The methodology we apply to assess how an area's emissions may be reduced is based upon an evolution of the *Mini-Stern* methodology developed at Leeds[8], which considers the most effective and efficient ways of decarbonising a city. It should be noted from the start, however, that this method focuses on production-based emissions and primarily on technology-driven mitigation options; only a small subset of options addressing potential behavioural changes are considered. Consequently, the (substantial) emissions reductions that may be made by eating less meat or buying second hand clothes and electronics are not included.

To assess how the production-based emissions of a city or other area may be reduced, we examine the available options ('measures') for energy efficiency improvements and small-scale renewables. We consider four sectors: domestic, commercial, industrial and transport. The mitigation options range from improved insulation in buildings, through more efficient control systems for industrial applications, to increasing the number of hybrid vehicles in the fleet. For each sector, we first identify a range of applicable measures and then we assess their investment costs, energy savings and deployment potentials in the area[9]. This allows for a new emissions trajectory to be estimated that includes the extra emissions reductions that an area may achieve beyond what is expected in the baseline case described above.

### *The 'Cost-Effective' Scenario*

The mini-Stern assessment uncovers many different options for reducing a city's emissions. But not all of these are economically attractive in a direct sense. By direct here, we refer to the 'net present value' (NPV), which is the overall value of an investment when the monetary costs and future savings are taken into account. NPVs of investments are calculated by discounting future savings using a 'discount rate', which accounts for the fact that an investment made today would generate returns if invested elsewhere. This opens a Pandora's Box of ethical issues, as the typically high discount rates applied in the commercial world may deem the future benefits (economic or otherwise) are negligible. In contexts of climate change this is a highly problematic as a long-term view is clearly essential. For example, the benefits of solid wall insulation, which has high upfront costs but a lifetime of 40 years over which savings may be made, can be undervalued.

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[7] See Scott K and Barrett J (2015) *An integration of net imported emissions into climate change targets*, Environmental Science & Policy, http://eprints.whiterose.ac.uk/87099/

[8] See www.climatesmartcities.org

[9] For the domestic sector, we use data from *The National Household Model* developed by the Centre for Sustainable Energy for Bristol (see www.cse.org.uk/projects/view/1233); for the commercial sector we use the report of the *Investment Property Forum,* namely, *Costing Energy Efficiency Improvements in Existing Commercial Buildings* (www.ipf.org.uk/resourcelibrary.html); for the industrial sector we use European-level assessments from the *International Energy Agency* (www.worldenergyoutlook.org/investment), and for the transport sector …

In our 'cost-effective scenario' we focus upon only those measures that are cost-effective in this direct sense – i.e. that have a positive NPV – however we use a relatively low real discount rate of 3%. This could be considered quite conservative, as the potential benefits of climate action are of course far broader than these direct economic impacts and include, for example, air quality improvements from expanded public transport systems and reductions in fuel poverty from more efficient buildings.

*Assessing to Total Benefits*

Once a list of cost-effective options for each sector has been compiled along with their energy savings, investment costs, and potential for deployment within the area of interest, then important outputs can be estimated relatively simply by combining these with forecasts for energy prices and the carbon intensity of UK electricity[10]. These outputs include the total investment requirements, carbon savings, and cost savings across the area. These are the headline results that are output on the *Can Do Cities* site.

We also add to this an estimate of job creation, by considering the 'job intensity' of different low-carbon sectors, drawing on the literature review of the *UK Energy Research Centre*[11]. The estimates we offer consider these job intensities – that estimate the number of years of employment created per million pounds of investment – in combination with our estimated investment requirements for the cost-effective scenario. We also remove the jobs that would have been created had this money been invested in fossil fuel based energy generation from our estimates, and consider that not all of the jobs created will be in the local area and not even necessarily in the UK[12]. Such job creation estimates are notoriously difficult to estimate so our estimates should be interpreted with caution.

[10] We utilise standard national projections from the UK *Department for Business, Energy & Industrial Strategy*, found at: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2016

[11] See *Low carbon jobs: The evidence for net job creation from policy support for energy efficiency and renewable energy* at www.ukerc.ac.uk

[12] We assume 50% of jobs created in the domestic, commercial and industrial sectors are in the local area, but only 10% of transport related jobs as much of this investment is in electric vehicles that will be manufactured elsewhere