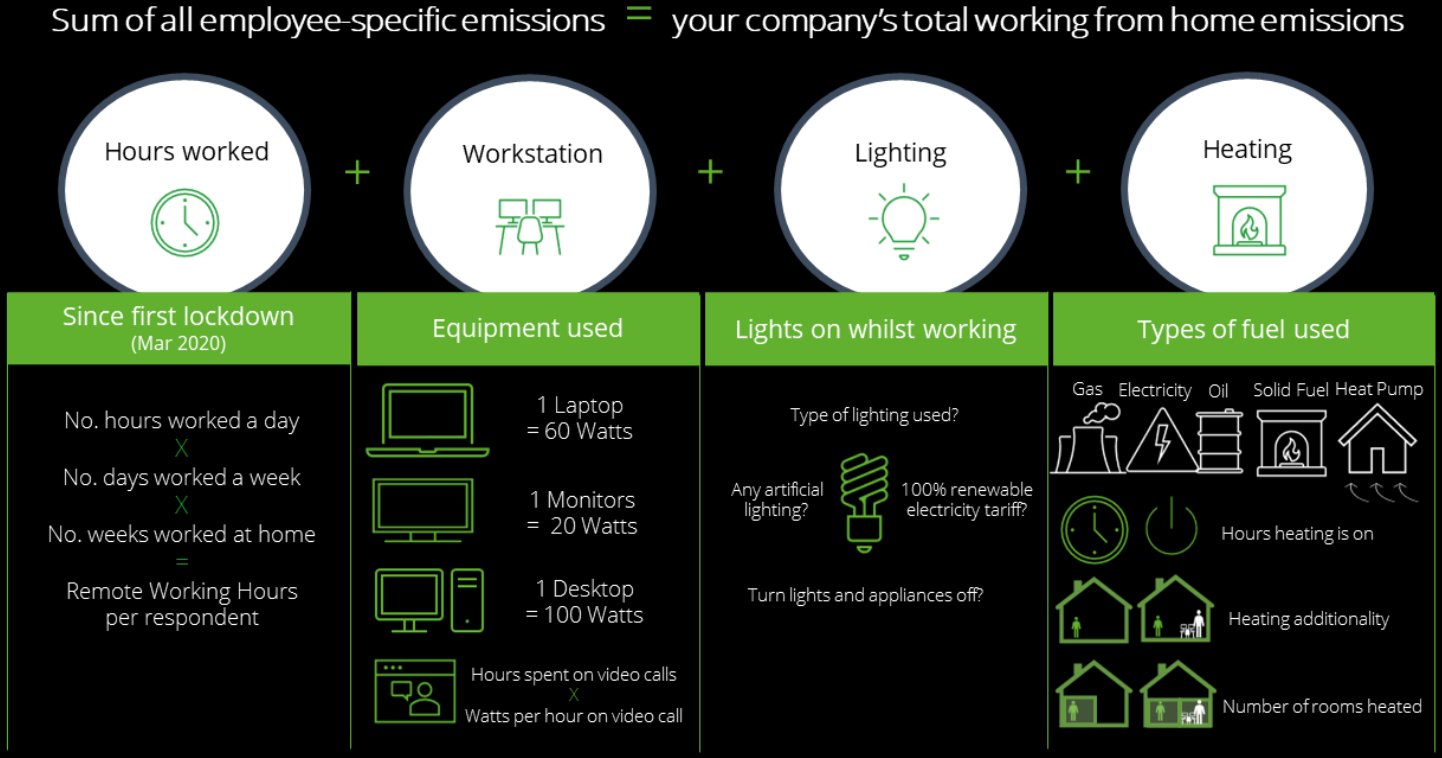
Green Element

Compare your FOOTPRINT

Certified B Corporation

New Methodology for Measuring Remote Working Carbon Emissions



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Reducing our digital footprint

Tom Greenwood of Wholegrain Digital advised that if a website or digital document has a black or darker background, it could reduce the energy used to read it online by 10%. Therefore, we are transitioning to dark backgrounds across our digital content.

Green Element and Compare Your Footprint

Green Element is an environmental management and sustainability consultancy offering a wide range of range of services and solutions to global organisations of all sizes and sectors.

Green Element's sustainability specialists created Compare Your Footprint to offer carbon footprint calculation and a benchmarking software that adheres to the GHG Protocol Corporate Accounting and Reporting Standard.

Our purpose is to empower organisations of all sizes to calculate the carbon footprint of their entire operation more easily and comprehensively in order to set science-based targets and accelerate the transition to a low carbon and sustainable world.

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List of Abbreviations

BEIS: Business, Energy, and Industrial Strategy
CO_2: Carbon Dioxide
CO_2e: Carbon Dioxide Equivalent
COP26: Conference of the Parties, 26th meeting
COVID-19: Coronavirus Disease 2019
EPA: Environmental Protection Agency
EPC: Energy Performance Certificate
gCO_2e: Grams of Carbon Dioxide Equivalent
GHG: Greenhouse Gas
Gt: Gigatonnes
IEA: International Energy Agency
kW: Kilowatt
kWh: Kilowatt hour
LED: Light-Emitting Diode
Mt: Megatonnes
ONS: Office for National Statistics
Ppm: Parts per million
SMEs: Small-to-Medium sized Enterprises
Solar PV: Solar Photovoltaic
tCO_2e: Tonnes of Carbon Dioxide Equivalent
WFH: Work from Home

Summary

- A new methodology has been launched to gather data from employees working from home focusing on hours worked, workstation, lighting, and heating. This is in the form of an employee survey and the results establish an organisations' home working carbon emissions as part of their overall carbon footprint. If home office emissions are seen as beyond an organisation's reporting boundary, it could result in companies under-reporting their impact as traditionally office-based emissions are shifted to home workers.

Extended summary

- New methodology obtains specific information about employees' working from home patterns and different energy fuel types used. This presents more accurate carbon emissions data to feed into an organisation's carbon strategy, where previously only averages were applied.

- Daily global emissions decreased by 17% in April 2020 compared with April 2019, and at peak global COVID-19 lockdown there was a 26% reduction.

- The largest portion of this decrease was due to a reduction in transport emissions, especially air and road, some of which was due to decreased commuting.

- Emissions from office energy consumption have reduced significantly during lockdowns and working from home.

- Global energy use increased by up to 40% as people worked from home during COVID-19.

- If everybody who was able to work from home worldwide did so for just one day a week, it would save around 1% of global oil consumption for road passenger transport per year (International Energy Agency – IEA, 2020).

- According to the International Energy Agency, global energy related CO2 emissions are projected to increase by 4.8%, equivalent to 180.6m USA homes' energy use for one year in 2021 (Environmental Protection Agency 2021). This is the biggest annual increase since 2008 when the world was recovering from the financial crisis.

Introduction

Globally, organisations large and small are measuring the carbon footprint of their operations. An increasing number are taking steps to calculate greenhouse gas (GHG) emissions beyond the boundary of their inventories to incorporate activities such as employee commuter travel[i].

The growing trend of working from home (WFH) over the last few years, accelerated by the implementation of lockdowns during COVID-19, has highlighted the need for companies to include home working emissions within their carbon footprint reporting.

The GHG Protocol Corporate Accounting and Reporting Standard[ii] ensures a faithful, true, and fair account of a company's greenhouse gas emissions. The framework is the most widely implemented global standard for measuring the carbon impacts of company operations.

However, carbon accounting and reporting standards currently include minimal guidance for organisations on how to calculate emissions from home offices[1]. This could result in organisations under-reporting their total GHG emissions and hinder the collective efforts to reduce the risk of the catastrophic consequences of global warming.

This paper shows the findings of a new home office emissions calculation methodology and how it was piloted. The measurement process has been designed for organisations of all sizes, as well as environmental professionals. The process has been piloted across five Small-to-Medium sized Enterprises (SMEs) to test different approaches and experiences.

Engaging organisations and employees in the carbon footprint process has helped to promote a better understanding of the implications of climate change and incentivise collective action to reduce the carbon emissions generated. This will help organisations capture working from home carbon emissions properly and enable them to prepare in time for an imminent regulatory change after COP26.

[1] There is reference to teleworking within Category 7 (employee commuting) of the GHG protocol stating that only additional emissions resulting from working from home should be included. This guidance formed the basis of our calculations.

This remote working carbon emissions paper aims to demystify carbon footprinting, as well as evidence an approach to measure emissions generated from home offices.

Who is the report for?

You may be responsible for the carbon emissions reporting in your organisation, you may lead an organisation, you may feel strongly that you can influence your organisation to report on their carbon emissions more transparently. Whether you are a small, medium, or large company, this methodology will enable you to gather data from the staff survey and use our calculator to estimate the carbon footprint of those home workers.

What is a carbon footprint?

A carbon footprint is a measure of the human impact of activities on global warming by calculating the GHG emissions of these activities, usually stated as CO2e, or carbon dioxide equivalent.

This is done to express all key Kyoto Protocol greenhouse gases (carbon dioxide, methane, and nitrous oxide) expressed as a common unit (e.g., tonnes or tonnes of carbon dioxide equivalent (tCO2e)), allowing easy comparison across organisations, products, industries, and countries.

The Kyoto Protocol, adopted in 1997, operationalises the United Nations Framework Convention on Climate Change by committing industrialised countries and economies to limit and reduce GHG emissions in accordance with agreed individual targets. The convention itself only asks those countries to adopt policies and measures on mitigation and to report periodically.

Organisation's carbon footprint

An organisation's carbon footprint measures the GHG emissions from all the activities across the organisation, including energy used in buildings, industrial processes, business travel, consumption of goods and services and waste disposal, etc. These inventories are sometimes referred to as corporate, company, or entity-level footprints.

Product's carbon footprint

A product's carbon footprint measures the GHG emissions over the entire life of a product (goods or services), from the extraction of raw materials and manufacturing through to its use and the final re-use, recycling, or disposal. This is known as Life Cycle Analysis.

How is a carbon footprint measured?

The GHG Protocol provides standards, guidance, tools, and training for businesses and governments to measure and manage climate-warming GHG emissions. The GHG Protocol divides the measurement of emissions into direct and indirect emissions and across three different scopes.

Direct GHG emissions are emissions from sources that are owned or controlled by the reporting entity.

Indirect GHG emissions are emissions that are a consequence of the activities of the reporting entity but occur at sources owned or controlled by another entity.

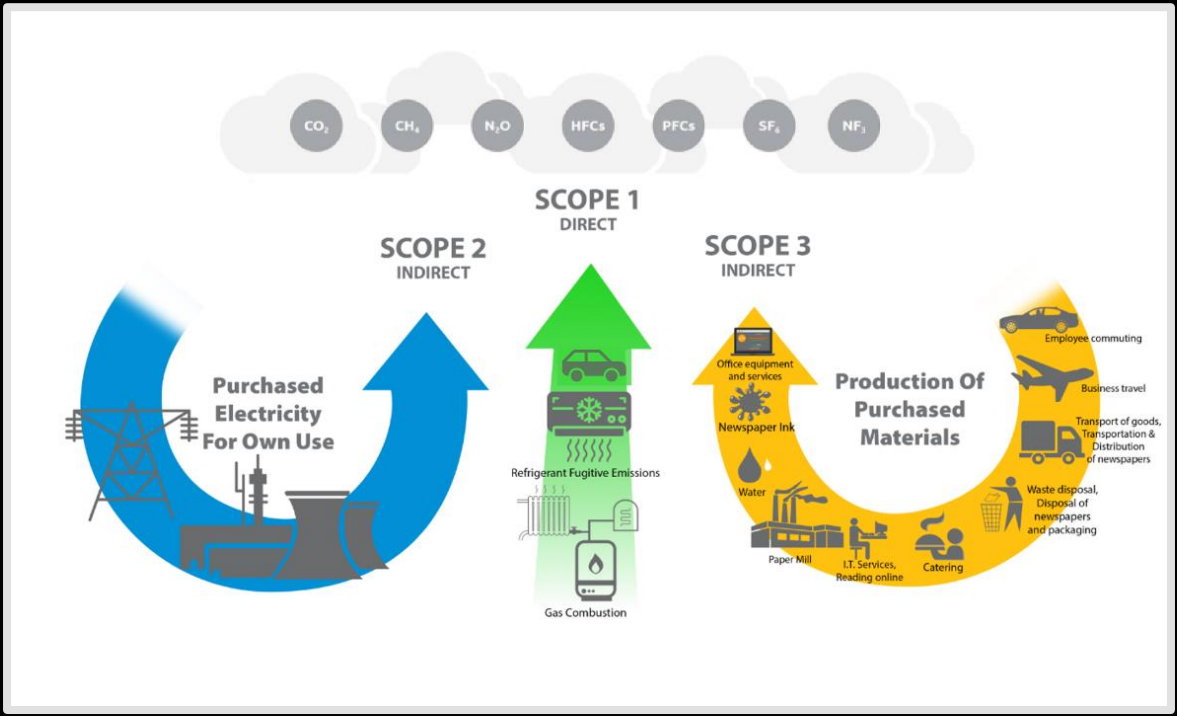
Scope 1 | All direct GHG emissions from the activities of an organisation or under their control. Including fuel combustion on site such as gas boilers, fleet vehicles, and air-conditioning leaks.

Scope 2 | Indirect GHG emissions from consumption of purchased electricity, heat, or steam.

Scope 3 | Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g., transmission & distribution losses) not covered in Scope 2, outsourced activities, waste disposal, etc.

Organisations reporting on their GHG emissions tend to measure and publicly report on their Scope 1 and 2 emissions, with many including Scope 3. Scope 3 emissions are generally the largest carbon footprint of a company's activities, so it is, therefore, vital to go beyond the regulatory requirements of Scopes 1 and 2 if you are to ensure thorough reporting.

Figure 1 | Overview of Scopes and Emissions Across a Value Chain



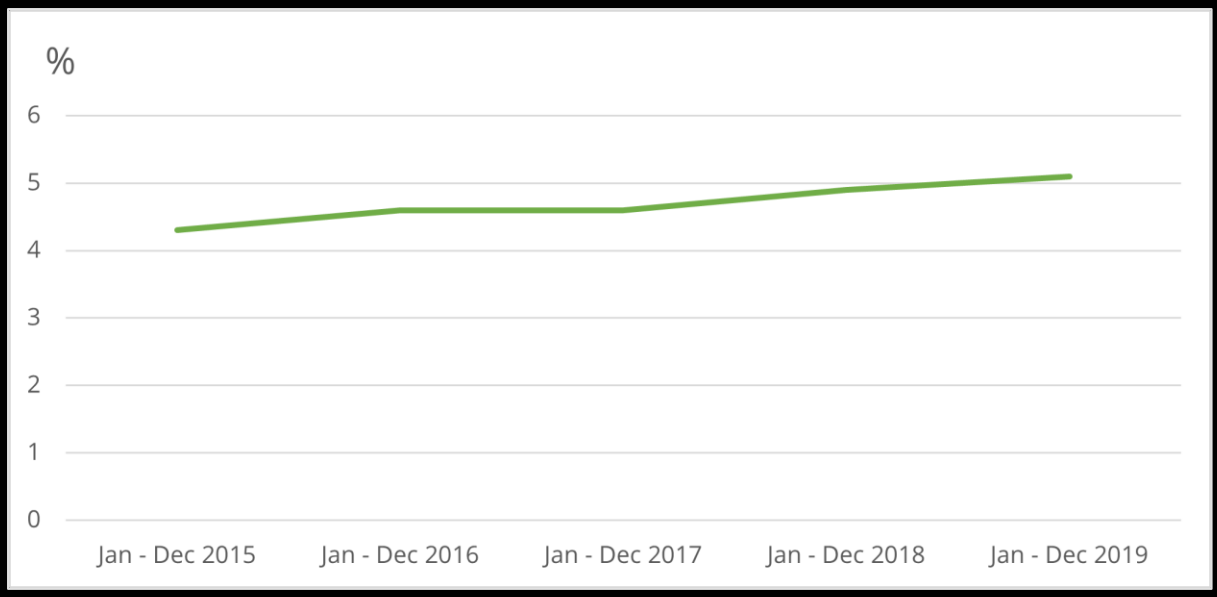
Source | Adapted from GHG Protocol Corporate Value Chain (Scope 3) Standard 2013

Before organisations and their employees begin to take steps to calculate the carbon footprint of their activities, they first need to understand what a carbon footprint is and how it can be measured.

The rise of working from home

Over the last five years from 2015 to 2019 the number and proportion of people who work mainly at home has increased[iii].

Figure 2 | Percentage of people in employment who mainly work in their own home, UK, between January to December 2015 and January to December 2019



Source | Office for National Statistics – Annual Population Survey | Adapted from data from the Office for National Statistics licensed under the Open Government Licence v.1.2019.

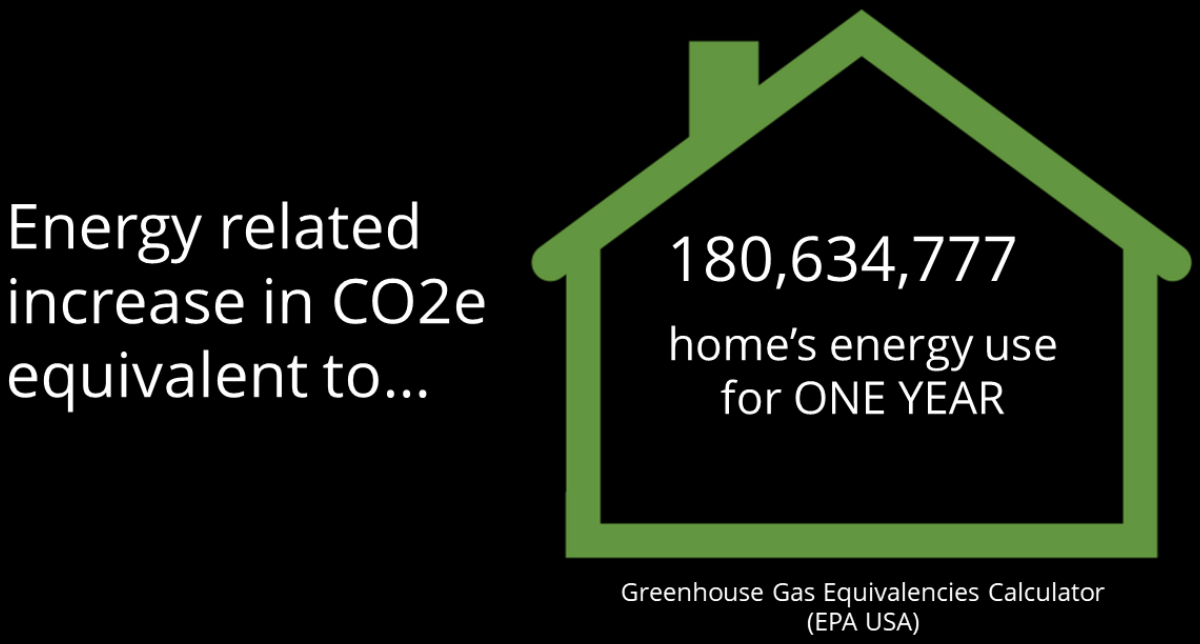
Of the 32.6 million in employment during January 2019 to December 2019, around 1.7 million people reported working mainly from home, with around 4 million working from home in the week prior to being interviewed for the Office for National Statistics (ONS) survey.

In April 2020, nearly half (46.6%) of people in employment did some of their work from home, with the vast majority (86.0%) of these homeworkers stating that this was because of the coronavirus (COVID-19) pandemic[iv].

It is already common for small business owners and freelancers to operate from home offices to save on the overheads of renting office space, and we are now seeing large global organisations like Apple offering a hybrid approach to working. CEO Tim Cook commented that "*when the pandemic is over, working from home will remain very critical*[v]."

According to a report from the International Energy Agency (IEA), energy related CO2e is projected to increase by 4.8%, or 1,500 megatonnes (Mt)[2][vi], in 2021 to reach 33 billion gigatonnes (Gt). This is the biggest annual increase since 2010, when the world was recovering from the financial crisis.[vii] [3][viii]

Figure 3 | Projected increase in energy related CO2e in 2021



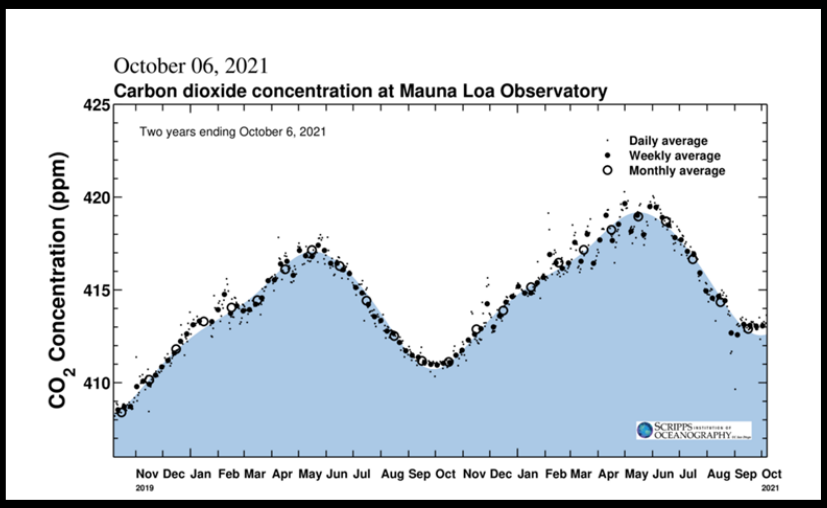
Source | Environmental Protection Agency 2021

[3] 1,500 Mt is the equivalent of 180,634,777 homes' energy use for one year (EPA Greenhouse gas equivalencies calculator).

What impact has COVID-19 had on carbon dioxide (CO2) concentrations?

The figures below from Scripps Institution of Oceanography show the CO2 concentrations in parts per million (ppm). This figure shows how many parts of CO2 there are in one million parts of air.

Figure 4 | Carbon dioxide concentrations in parts per million between September 2018 to September 2021



September 2021 412.9
1.7
September 2020 411.2
2.7
September 2019 408.5
3.0
September 2018 405.5

Source | Scripps Institution of Oceanography 2021

These measurements show emissions in ppm increasing from an average of 405.5 in 2018 and 412.9 in 2021. However, between 2020 and 2021 the rate of increase slowed to 0.4% at an average of 1.7 ppm from 2.7 ppm between 2019 and 2020[ix4]. Despite carbon dioxide concentrations still increasing each year, the rate of increase is going in the right direction. It is important to note that CO2 stays in the environment between 300 and 1,000 years so any emissions will endure on the timescale of many human lives.

[4] Experts estimate that a level of 430 ppm has a 66% probability of keeping the world within a 2° C limit on warming (National Research Council). With aims now focusing on keeping warming well below 1.5 degrees, this figure is still far too high.

Why is it important to include home office emissions in a company's carbon footprint?

It is important to understand the interplay between reductions in commuting and office energy and the increases in home energy demand within a company's Scope 3 emissions inventory.

If everybody who was able to work from home worldwide did so for just one day a week, it would save around 1% of global oil consumption for road passenger transport each year[5x].

Considering the increase this would bring in energy use by households, the overall impact on global CO2 emissions would be an annual decline of 24 Mt – equivalent to the bulk of Greater London's annual CO2 emissions[x].

Emissions from office energy consumption have reduced significantly during lockdowns and home working. Despite these reductions, emissions have not been eliminated. Although, at a lower overall level compared with 2019, they have been partly relocated to employee homes beyond the company's direct control.

Global energy consumption increased by up to 40% as people worked from home during COVID19[xi].

The drop in emissions from commuting on average has more than balanced out the emissions from home working. But an organisation's overall emissions depend on the modes of transport and distances travelled in employee commutes and home office data such as the number of devices used and energy usage for heating.

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[5] There is some evidence to suggest that in pre covid19 times, individuals who worked from home travelled more kilo-meters in total for non-work trips on weekends. Furthermore, for those who work remotely usually, when they do travel, the distances are often far greater than regular commuters resulting in further questions. While nonwork related travel will not be included in the company footprint, it is still noteworthy. By increasing environmental awareness in the workplace, we hope that there will be overspill to the home and consideration about longer fossil fuel-based travel in leisure time may be reconsidered. (Cerqueira et al. 2020)

What does the GHG Protocol say regarding remote emissions reporting?

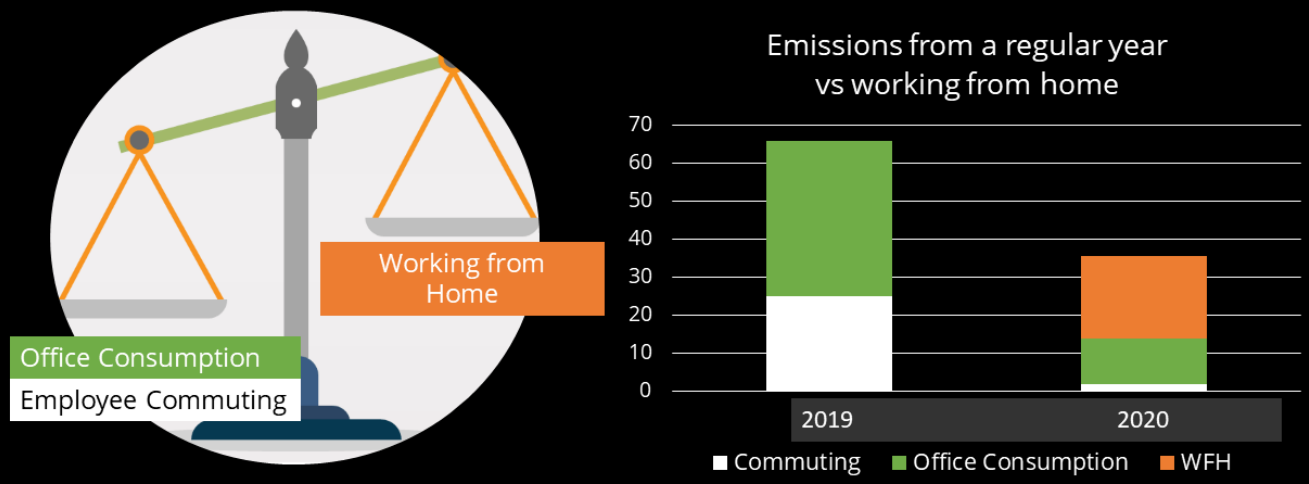
The GHG Protocol includes a Scope 3 emissions category for the measurement of "transportation of employees between their homes and their worksites during the reporting year (in vehicles not owned or operated by the reporting company)." But it is currently optional to report on emissions from employee teleworking.

Vanderbilt University Law School in the USA published a paper on accounting for working from home emissions as a pandemic legacy[xii]. They argue that the trend towards WFH in GHG reporting standards needs to change. If home office emissions are seen as beyond an organisation's reporting boundary, it could result in companies under-reporting their impact as emissions are shifted from office to the employee home.

Is home working or office working better for the environment?

It is a balance of a few key elements, as shown in the graphic below. On the one hand, there is commuting and office energy consumption during the business-as-usual working scenario, and then there is energy consumption during the WFH scenario.

Figure 5 | A regular year (2019), including office consumption and employee commuting emissions vs working from home emissions in 2020



Source | Author's Own.

In general, several aspects can cause the balance to sway one way or the other, including commute length, commute mode, and size of office, and company.

On the right of the graphic above is an example of this balance taken from data for a small business in the services industry based in London. Their office consumption, employee commuting, and WFH emissions were measured during 2020 and 2019 to offer a comparison.

The shift from office to home working has almost halved emissions between these two years. This reduction was mostly driven by a reduction in office consumption as most employees previously took public transport to work, with a relatively short commute distance. The increase in WFH emissions is minor compared with previous office consumption, providing evidence that working from home, for this specific company, is a better option, environmentally.

However, this should be measured on a case-by-case basis. If a company is larger, it could be more energy efficient to have one large office space as opposed to needing to use energy to light and heat multiple home offices.

Home energy consumption in the UK has, on average, declined since 2005 because of energy efficiency incentives via the UK Government, such as condensing boilers, insulation, and Solar PV (Photovoltaic) installation. The decline in emissions has been seen across all property types, household characteristics, geographies, and socio-demographic classifications. There may be scope for private businesses to increase this trend through investment in home office energy efficiency measures in line with wider company reduction strategies.

How can I calculate the energy consumption of my employees working from home?

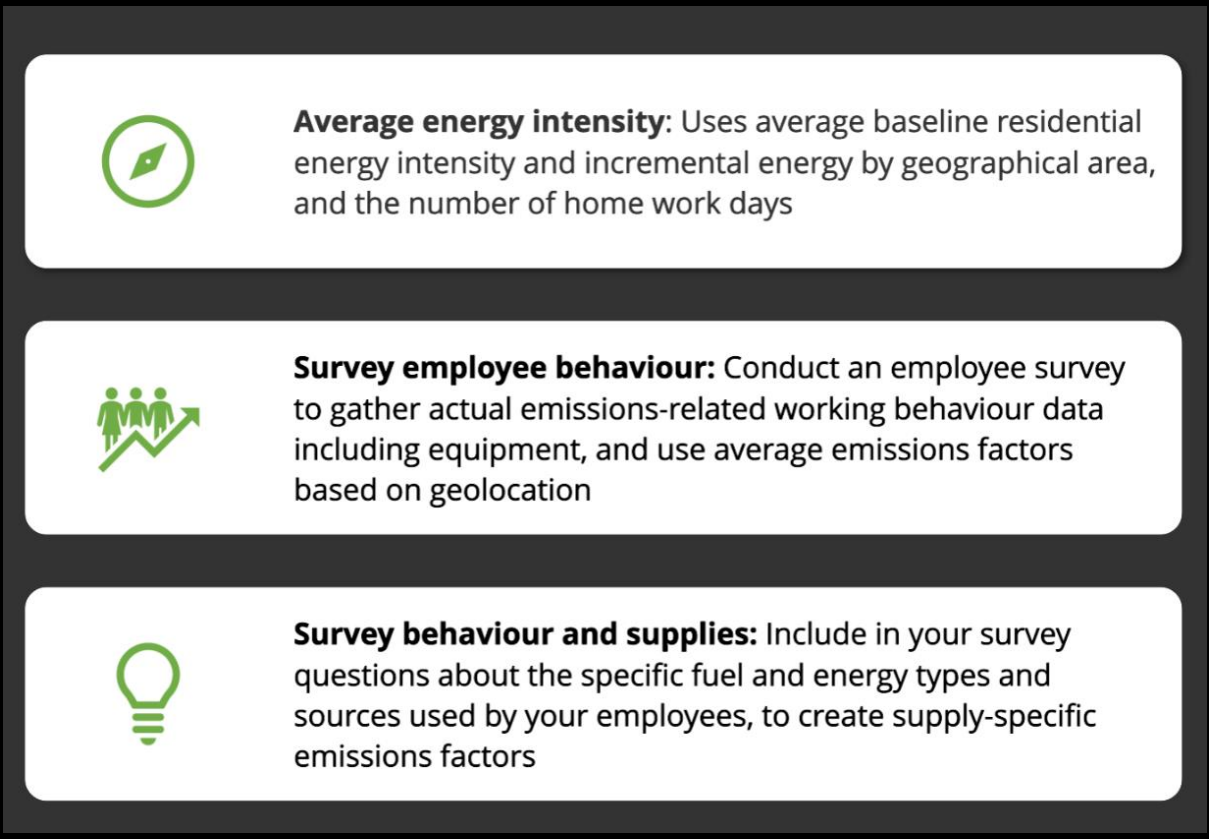
There are three main methods for calculating working from home emissions, with the choice of the method depending on the business motivation for including this category and feasibility of each, including the time and cost required to implement.

The first method uses the average energy intensity (e.g., energy consumed per person per day) by geographical region. This option is the easiest of the three, as it requires no survey, fewer resources, and minimal company information (total number of workers only).

The second method requires a basic survey to reduce the number of assumptions made in the first no-survey method, including specific energy types and equipment used. Whilst it does require more time and resources to implement and analyse the results, this is a very cost-effective approach to undertake every two to three years.

The final method is a full survey that asks a series of specific questions to understand employees' behaviours, household characteristics, energy providers, and other factors that may influence consumption. It is the most time and resource-intensive, however by far the most accurate means for capturing employee-specific consumption during working from home hours. This is the method that has been developed and detailed within this working from home emissions paper. Whilst organisations try and avoid sending out full surveys for employees to fill out, many are already having to conduct commuter surveys to capture employee travel data. At Compare Your Footprint and Green Element, we have been combining both surveys into one to streamline the data collection process and ensure that including working from home emissions accurately does not necessarily mean sending out additional surveys.

Figure 6 | Three main methods for calculating working from home emissions



Source | Author's Own.

Methodology Overview

Sum of all employee-specific emissions

=

a company's total working from home emissions

Green Element and Compare Your Footprint has created a rigorous methodology to capture emissions resulting from energy consumption during working from home hours.

This comes in the form of a survey containing around 18 questions that are sent to all employees under the given organisation. The survey has proven to be an effective tool, as it not only captures individual behaviours at home during work hours, which can be notoriously difficult to capture but also allows for the following:

Average energy intensities per employee within an organisation

In most cases, surveys sent out within an organisation do not receive a 100% response rate. The final estimate, therefore, does not capture all employees' consumption. We calculate company-specific energy intensities from those that do complete the survey. By applying a company-specific average to those that do not respond, all employees can be accounted for.

Average energy intensities per employee within a region/nation

Our survey has allowed us to create our own average energy intensity values in the case that a company does not wish to/cannot send out the survey, but still wishes to recognise the importance of including home working emissions and wish to plug the gap. So far, we have had over 300 responses from over 10 different organisations across the UK, Shanghai, Singapore, and the US. We have been able to calculate

country-specific average energy consumption values per employee during 2020 from the collated results of all completed surveys.

Over time, this collection of data will increase in sample size as well as geographical region. This means that companies who do not wish to send out a comprehensive survey are still able to plug the gap for home working in a more robust and accurate manner than existing average energy intensity values. This is because the averages we have formulated are based on actual bottom-up information on employees' behaviour whilst working from home. Existing energy intensity values are often top-down estimates based on the total regional / national increase in energy consumption in households that is apportioned per household and assumed to be due to increased home working.

These are likely to be overestimated due to four main, but not exhaustive, reasons:

1. **Hours Worked:** Calculating an average energy consumption per person using the general increase in energy consumption at the regional/national level will capture consumption during the entire day, rather than just hours worked. Our survey accounts for consumption attributable to working hours only.

2. **Influence of Lockdown:** The total increase in household energy consumption is not purely due to people working at home, but also other elements including people simply being at home more due to the closure of local amenities. Our bottom-up approach to calculating average energy intensities ensures that the final average energy intensity values obtained are only driven by home working.

3. **Heating:** Heating is a significant contributor to an employee's working from home energy consumption. However, without knowing people's exact behaviours regarding turning heating on additionally when working from home, previous estimates have assumed that employees have their heating on for the entirety of a 6-month heating season. As our bottom-up survey asks exactly how many additional hours per day, and months in the year heating has been on due to home working, our final average energy intensity value ensures an accurate depiction of heating.

The Survey

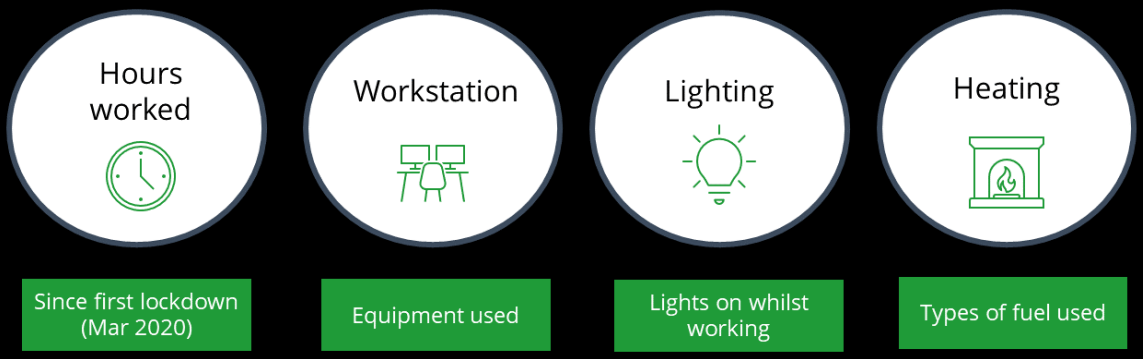
As with any methodology, it was essential to keep the survey up to date with the latest working from home research.

The learnings from the pilot company case studies helped to:

- Include questions in the survey that would add the most value
- Identify which questions could be tailored to add even more value
- Exclude questions that failed to add value

As a result, the survey has changed dramatically during its development. The current version provides a more accurate insight into people's behaviour and consumption at home. All questions detailed are tailored to the most recent reporting period; January to December 2020. By simply changing the wording of each question, we can capture any reporting period. The survey can be split into four main points of estimation: hours worked, workstation, lighting, and heating use.

Figure 7 | Remote working employee survey covers hours worked, workstation, lighting, and heating



Source | Author's own.

Most survey questions have the additional value of identifying energy efficiency opportunities and practices that could be implemented to help reduce emissions from home working.

Whilst the survey may seem lengthy, the questions are mostly based on simple multiple-choice answers. The following section will cover the value and methodology behind each question to help quantify an individuals' at home energy usage during working hours.

Hours worked from home

The first step to quantifying an individual's energy usage during home working hours is to know how many hours they have worked at home during the reporting period (2020). The following questions were asked in the survey:

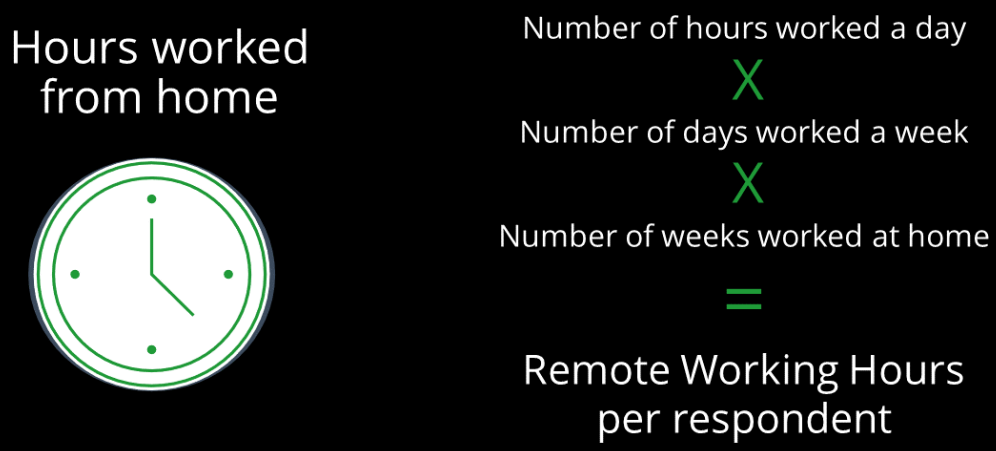
Q1. How many hours do you work on an average day at home?

Q2. On average, how many days per week did you work from home after the first lockdown (16th March 2020)?

Q3. How many weeks did you work from home in 2020? (Subtract any time taken for annual leave, sick leave, or furlough).

These questions allow for the simple calculation shown below. It is important to note that these questions assume employees only worked from home because of lockdown and that the organisation for which they work did not already practice working from home. If an organisation did in fact practice working from home before the COVID-19 pandemic, these questions can easily be tailored to allow for the inclusion of working from home before the March 2020 lockdown.

Figure 8 | Remote working hours per employee

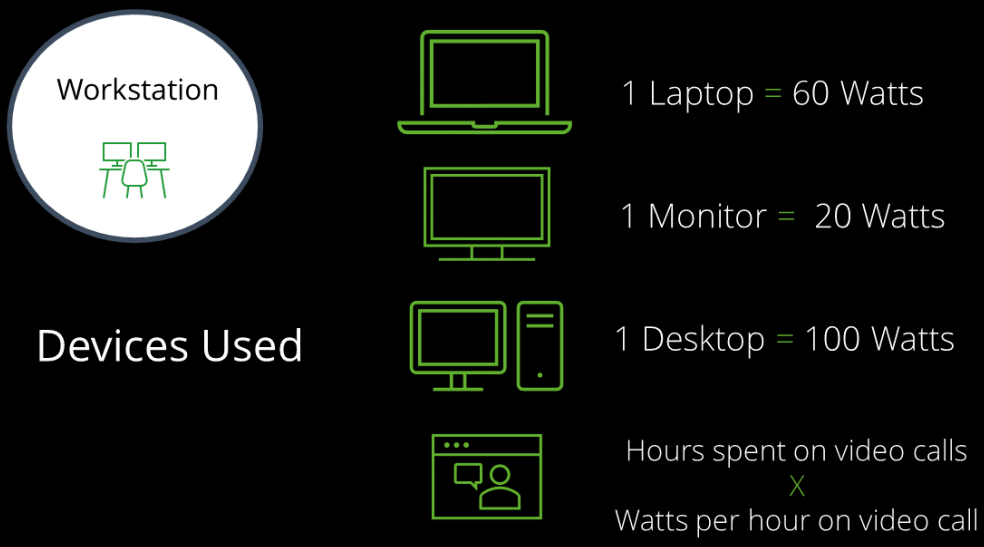


Source | Author's Own.

Workstation

The next set of survey questions helps to estimate the energy used by equipment at an employees' workstation. This includes laptops, desktops, and any additional monitors, all of which have a different power consumption, measured in Watts[6].

Figure 9 | Power consumption of employee's workstation



Source | Author's Own.

Q4. How many desktop computers do you use when working at home?

Q5. How many laptops do you use when working at home?

Q6. How many additional monitors do you use when working from home?

The above three questions (Q4, 5 & 6) are used to estimate the electricity usage of all electrical equipment used whilst working. To quantify this, the average power consumption (Watts) of running each equipment type was researched:

- 100 Watts per desktop computer
- 60 Watts per laptop
- 20 Watts per monitor

[6] Watts: A unit of power used to quantify the rate of energy transfer.

Multiplying the total Watts of all equipment used by the number of working hours at home provides an estimate of total kWh from using these devices:

Total Watts

x

Total number of hours working from home / 1,000

=

Total kWh from the use of electrical equipment

After careful consideration, other electrical items such as mobile phones or printers were not included. This was either because the power consumption of the item was very small or because it would be an extremely difficult item to accurately capture any energy consumption from (e.g., an employee is likely to use a printer when needed, rather than for a predictable length of time during a typical working day).

Q7. On a typical week, how many hours do you spend on video calls?

On top of the baseline energy consumption required to power monitors, laptops, and desktop computers, it is important to consider the additional energy requirements of videoconferencing.

Videoconferencing can have quite a significant impact on the environment which, up until the focus on remote working, has often been overlooked. However, as offices closed and flights grounded during COVID-19, there has been a significant shift in emissions from travel and office consumption associated with in-person meetings to people's individual electricity usage associated with virtual meetings. It is fundamental that this is captured to ensure any comparisons drawn between office working and home working are based on the full picture. A recent article by the Carbon Brief[xiii] which reviewed analyses from organisations such as the International Energy Agency (IEA) found that existing estimates exaggerate the actual climate impact of video streaming by up to 90x.

The article concludes that streaming a video for one hour consumes 0.077 kWh of electricity per hour. This translates to 22 gCO2e. Whilst the article was based on video streaming rather than conference calls, similar assumptions are generically used to estimate both. Moreover, the 22 gCO2e sites are within the data range of other recently revised figures, including Mike Berners-Lee's 'How Bad Are Bananas', which quotes a recently revised range of 2 gCO2e to 50 gCO2e depending on the device used. We, therefore, deemed the 0.077 kWh (or 22 gCO2e) estimate from video streaming as robust to use for video conferencing. [7], which quotes a recently revised range of 2 gCO2e to 50 gCO2e depending on the device used. We therefore deemed the 0.077 kWh (or 22 gCO2e) estimate from video streaming as robust to use for video conferencing.

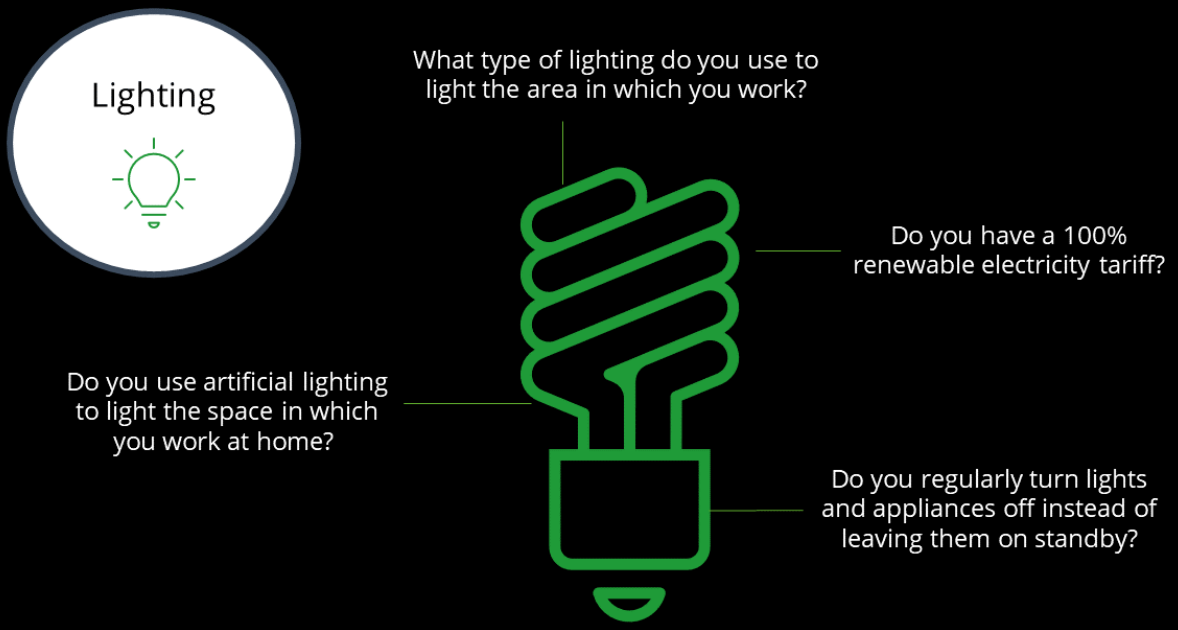
The average electricity consumption of devices has already been considered in Q4-6, and therefore a figure of 0.0214 kWh per hour of videoconferencing is applied instead of the 0.077 kWh total as per the Carbon Brief estimate.

[7] Mike Berners-Lee is the founder of Small World Consulting, an associate company of Lancaster University, which works with organisations from tech giants to supermarkets. Small World is a leader in the field of carbon metrics and their use.

Lighting

The third section of survey questions listed below help estimate energy usage from lighting.

Figure 10 | Survey questions related to employee's home office lighting



Source | Author's Own.

Q8. Do you have lights on whilst you work?

Q9. What type of lights do you use to light the area in which you work?

Q10. Do you regularly turn lights and devices off instead of leaving them on standby?

Q8-10 above helps to estimate the power consumption (in Watts) of any lighting required whilst working from home. They are all conditional on one another, and therefore based on the number of possible multiple-choice answers for each, there are over 15 different output power consumption values. Therefore, rather than just applying an average power consumption for lighting per person, we have been able to delve into the detail of individual behaviours and provide more accurate estimates according to these behaviours.

Here is a prime example of how such questions can help lead to energy efficiencies and emission savings at home; if someone answers 'No' to whether they turn lights and appliances off rather than leaving them on standby, it is likely to spark thought and/or discussion into why this might be the case. Before completing the survey, the respondent may not have been aware of the difference this could make on an individual's carbon footprint.

For Q8, the possible multiple-choice answers are Always, Sometimes and Never, and the impact of each answer on the final power consumption value from lighting is as follows:

- Always = 100% of the calculated Watts
- Sometimes = 50% of the calculated Watts
- Never = 0% of the calculated Watts

For Q9, the possible multiple-choice answers are Tungsten[8] (these are traditional/older incandescent bulbs), Halogen[9] (these are stereotypically used in spotlights), LEDs, and Don't Know. The type of light can make a significant difference to energy consumption, with LEDs using 80% less energy to produce the same amount of light as halogen bulbs according to the Energy Saving Trust. Moreover, with the UK Government's plans to end the sale of Halogen bulbs to tackle climate change, Q9 provides a great policy lever to incentivise employees to shift to LEDs.

[8] Tungsten: Refers to the most common and oldest kind of incandescent lightbulb. Tungsten lights feature a tungsten filament housed within an inert gas made up of made up of iodine and bromine. When a current is passed through the filament, the naturally high resistance of tungsten causes the filament to glow and output an orange light.

[9] Halogen: A type of light that is an enhanced version of incandescent. Just like with incandescent light bulbs, the electrical current enters the socket and travels up to the tungsten filament, heating up the filament to incandescence. Halogen light bulbs have tungsten filaments housed in a quartz capsule and filled with iodine and bromine gases. In September 2021, the UK Government banned as part of its plan to tackle climate change.

Figure 11 | Guide to Energy Efficient Lighting

Guide to Energy Efficient Lighting

Source: Energy Savings Trust

Traditional bulb	LED / CFL Bulb
15 watt	140 lumen
25 watt	250 lumen
40 watt	470 lumen
60 watt	800 lumen
75 watt	1,050 lumen
100 watt	1,520 lumen

Average Watts per lumen output for different light bulb types

+

recommended 7,000 lumens to light a home office

=

Watts required to light a home office

Source | Author's Own; adapted from the Energy Savings Trust 2021

The recommended lumens[10] (or brightness) to light a home office is 6,000 to 8,000. Each of the above lighting types have different energy efficiencies in terms of Watts required per lumen. We have used guidance from the Energy Savings Trust[xiv] on the average Watts per lumen output for different light bulb types, and the recommended 7,000 lumens to light a home office, to calculate the Watts required to light a home office.

Based on the average Watts per lumen for Tungsten, Halogen, and LED's being 0.074, 0.053, and 0.012, respectively, this equates to 516 Watts for Tungsten, 370 Watts for Halogen, and 86 Watts for LEDs being required to light a home office workspace per hour.

For Q10, the possible multiple-choice answers are Yes, No, and Don't Know. If the answer is Yes, then we assumed that all lights and devices used during working from home hours are turned off during a respondent's one-hour lunch break. This is subtracted from the total. If a respondent answers with No or Don't Know, then the combined answers to Q8 and Q9 are used alone; the person is assumed to have their devices on for all working hours.

[10] Lumens: A measure of the total quantity of visible light emitted by a source per unit of time.

Q11. Does your home have a 100% renewable electricity supply?

Q11 allows us to understand details surrounding supplier-specific fuel mixes. This is important considering the GHG Protocol strongly recommends dual reporting, whereby emissions associated with electricity are reported using both:

- Location-based reporting: whereby the average UK grid electricity fuel mix is used within the calculation.

- Market-based reporting: whereby the actual fuel mix/tariff supplied/used for consumption is used within the calculation. Asking Q11, therefore, allows for us to report emissions using the market-based method.

Previously, dual reporting has given companies an incentive to switch their office spaces to 100% renewable electricity tariffs to ensure Scope 2 emissions (associated with electricity) are 0 under market-based reporting. However, with the recent shift away from office consumption to domestic consumption, it is important to account for any renewable energy tariffs on the domestic level.

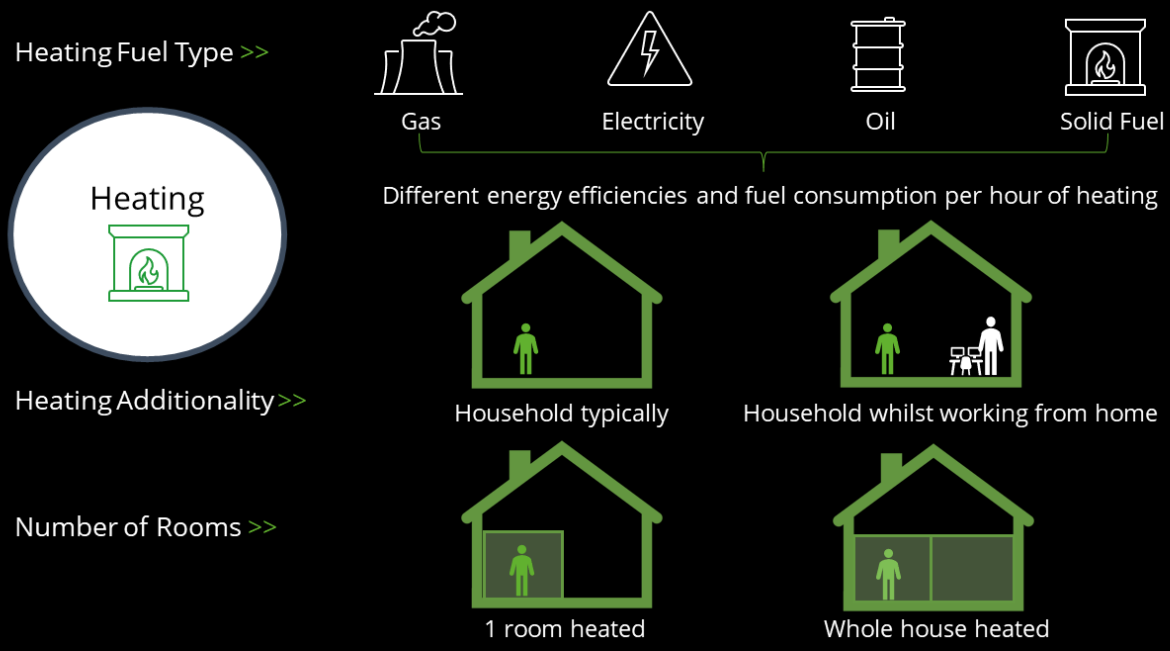
Q11 is a simple Yes, No, and Don't Know multiple-choice; an answer with No *and* Don't Know will assume that the respondent uses the average UK grid electricity fuel mix to calculate emissions, and the answer Yes will use the carbon factor for 100% renewable electricity supply under the market-based method, which is zero.

The importance of including this question has been apparent from all survey responses to date; 30% of all respondents stated that their home had a renewable electricity supply. This significant percentage highlights the need to ensure dual reporting is possible for emissions associated with home working.

Heating

The last of the four types of consumption that we capture within our survey is heating. The previous three (hours worked, workstation, and lighting) can all be applied at the global level as electricity consumption in kWh from lighting and appliances is not influenced by the respondent's location. Only at the very end of the process when converting electricity kWh into emissions using specific carbon factors does location come into play; a carbon factor for the UK electricity grid will be used for a respondent-based in the UK, and a carbon factor for the Singapore electricity grid will be used for a respondent-based in Singapore for location-based reporting.

Figure 12 | Heating fuel type, additionality, and number of rooms heated captured in survey



Source | Author's Own.

However, heating is more complex, as calculating the energy consumption per heating fuel type per respondent requires national level consumption data to feed into the methodology. The following section, therefore, highlights the methodology developed to calculate heating energy consumption within the UK from all potential fuel types.

Q12. What type of fuel does your home use for heating?

A Business, Energy, and Industrial Strategy (BEIS) UK survey in March 2021[xv] asked over 4,000 respondents 'What is the main way you heat your property during winter?'. The results found that 87% heated their homes with gas, 7% with electricity (4% portable heaters, 2% storage, and 1% not storage) with the remaining 4% using oil. Therefore, we ensured to include a 'Gas', 'Electricity' and 'Oil' as multiple-choice options for Q12. After feedback from initial survey versions, we also deemed it important to include options for 'Solid Wood – Fuel', 'Solid Wood – Coal', and 'Heat Pumps' for the few million UK households who use such means for heating.

Gas

To calculate the gas consumption (in kWh) required for heating during home working hours, we first sourced the average gas consumption across UK households from Ofgem's 2020 Typical Domestic Consumption Values; 12,000 kWh[xvi]. In the UK, 77%[xvii] of domestic gas is used for heating purposes. From BEIS' Energy Follow-Up Survey[xviii], which is representative of the UK's entire population, the average length of time that households have their heating on across a year is 8.7 hours a day for 5.6 months. This is equivalent to 1,501.62 hours in 2020.

Therefore, the average hourly gas consumption (kWh) for domestic heating in the UK is:

12,000 kWh X 77% / 1,501.62 hours = **6.15 kW per hour**

Electricity

A Statista survey[xix] on how people heat their homes revealed three different electrical heating systems: portable heaters, storage heaters, and non-storage heaters.

Resources available on the energy consumption of **portable heaters** suggest they, on average, consume 1,800 Watts to run. It is assumed that the average person uses 1.1 electric portable heaters when working from home to heat the room they are working in, as the recommended wattage to heat an average-sized room, with just an electric heater and no other heating sources, is **2.0 kW per hour**. Non-storage heaters are assumed to have the same wattage. This is because the primary benefit of storage heaters over non-storage are cost savings, rather than increased energy efficiency; storage heaters take advantage of cheaper off-peak electricity to heat a home by storing thermal energy during the night, rather than using more expensive electricity during peak hours.

Calculating the energy consumption of **storage heaters** is a little more difficult, as such systems can consume electricity, even when turned off, to recharge during off-peak electricity times. Therefore, a similar methodology to that used to calculate gas consumption was adopted. Ofgem's 2020 Typical Domestic Consumption Value for electricity usage in the average UK household is 3,550 kWh. As most households use gas for heating, it is assumed that no electricity is used for heating purposes, as the impact of this on average is likely to be negligible. The BEIS Energy Follow-Up Survey provides the electricity consumption of a sample of households in the UK that use electricity as the main source of heating. The survey reports that the average (median) consumption for households using storage heaters only is 6,700 kWh. Therefore, we assume that 6,700 kWh – 3,550 kWh = 3,150 kWh used by the average household for storage heating. The average length of time that the same sample of households are using electricity as their primary source of heating is 7.4 hours a day and for 5.5 months, which is equivalent to 1,254.3 hours in 2020. Therefore, the average hourly electricity consumption for heating using storage heaters in the UK is:

3,150 kWh / 1,254.3 hours = 2.51 kW per hour

A very similar methodology to gas was adopted to calculate the electricity consumption of households who use electricity as their main heating fuel.

First, the average electricity consumption (kWh) for heating purposes in households using electricity as their main heating in the UK was obtained from the Department of Energy & Climate Change (now BEIS). This was reported to be 4,860 kWh[xx]. Second, the same BEIS Energy Follow-Up Survey as used for the gas methodology was accessed to obtain information on the average heating season length for households using electricity as their primary source of heating; 7.4 hours a day, for 5.5 months. This is equivalent to 1,254.3 hours in 2020. Therefore, the average hourly electricity consumption for the average UK household using electricity as their main heating source is:

4,860kWh / 1,254.3 hours **= 3.87 kW per hour.**

The type of electric heating system used could be another question to be asked, however, the difference in the kWh per system was deemed too small to justify an additional question that would increase survey length and potentially decrease survey response rate. Moreover, households that use electricity as their main heating fuel are also more likely to heat in a non-regular manner that is difficult to capture. Adding in different electricity heating systems is therefore unlikely to add accuracy to the estimate.

However, it is important to also disclose that households using electricity as their main heating fuel are also more likely to heat in a non-regular manner that is difficult to capture.

Oil and Solid Fuels

Whilst gas and electricity are the main methods used for heating homes within the UK, there are over 4 million homes in Great Britain without access to the national grid and therefore rely on either solid or liquid fuels as their primary source of heating. On 21st February 2020, the UK government's action to phase out the sale of household coal and wet wood over England was confirmed[xxi]. However, as millions of homes still relied on using such fuels to heat their homes over lockdown and working from home, we must include all potential fuels within working hours to accurately capture emissions for 2020.

As the addition of these multiple-choice options has been recent, the methodology behind their estimation is still under finalisation. As a result, the final methodology will be released shortly after the publication of this paper. Should anyone in the meantime wish to access the preliminary methodology, do contact us at hello@compareyourfootprint.com

Heat Pumps

Heat pumps are the final and most recent addition to the multiple-choice options under Q12. Whilst the above solid fuels for heating are being phased out, households will be increasingly incentivised and encouraged to install heat pumps to meet emission targets. With the government aim of 600,000 heat pump installations per year by 2028, this is likely to significantly increase. Including heat pumps within any working from home estimate into the future is therefore fundamental.

Heat pumps are the most energy-efficient method of heating your home; whilst requiring electricity to run, they work to extract renewable heat from the environment which means that the heat output is greater than the electricity input. On average, heat pumps are much more efficient than traditional boilers, using on average 4,000 kWh of electricity annually to heat the average UK home. Assuming the same heating season length as a standard electrical heating system, this equates to:

4,000 kWh / 1,254.3 hours = 3.19 kW per hour

Existing work on replacing electric heating with more efficient electric heating systems like heat pumps found a potential saving of 12% in total electricity use[xxi]. Our results from electric heating systems (3.87 kW per hour) and heat pumps (3.19 kW per hour) find this potential saving to be 17.6%. Therefore, our calculations appear to be realistic and in line with previous work and case studies.

Heat pumps are the future for domestic heating, meaning there is therefore scope for companies to help incentivise employees to install heat pumps. This will not only reduce an organisation's emissions, but help the UK drive down emissions from domestic heating as a whole and ensure we can keep on track to reach our climate target to help limit global warming to below 1.5C.

Q13. In the colder months, do you heat your home additionally because of working from home?

Q14. If YES to Q13, how many additional hours per day in 2020 did you have your heating on as a result of working from home?

Q15. If YES to Q13, how many months in 2020 did you have your heating on additionally as a result of working from home?

Q16. If YES to Q13, do you additionally heat just the room you work in, more than one room, or the entire house?

Q13-16 are the final three questions required to calculate the energy consumption of heating due to working from home in 2020. They also help us incorporate the idea of additionality, whereby an individual new to working from home may not necessarily cause an increase in consumption due to heating. This is because one or more household members may normally be at home during the day with the heating on, and therefore heating during working from home hours should not be attributed to the individual. Rather than assuming an average incremental increase in heating, Q13-15 allows for a more tailored estimate based on the actual household situation for everyone answering the survey.

If an individual answers No to Question 13, no emissions from heating can be attributed to the given individual working from home. Emissions from heating will be zero. If an individual answers Yes, then our calculation will multiply the kW requirements of a specific heating system ascertained from the previous question by the number of additional hours heating has been switched on:

Energy consumption from heating (kWh)
=
kW of specific heating system
X
Q14 (number of hours heating is on
X
Q2 (number of days worked per week)
X
4 (number of weeks in a month)
X
Q15 (number of months that the heating is on)

The final component to consider is Q16; the number of rooms heated because of working from home. An individual may only work in one room, however, may heat more than just that room because of working from home.

The multiple-choice options are: Just one room, More than one room, and The whole house. The final kWh estimates per heating system type have been calculated for heating an average 3 bedroomed house (3 bedrooms and 1 living room). Therefore, if the respondent's answer is The whole house, the calculation returns these estimates. If the respondent's answer is More than one room, then half of the estimated kWh per heating system is taken (as it is assumed two rooms are heated, rather than four). If the respondent's answer is Just one room, then a quarter of the estimated kWh per heating system is taken (as it assumes one room is heated, rather than four).

Q17. How would you rate your productivity at home in comparison to working in the office?

This final question is not used to estimate at-home energy usage, however, is fundamental to allow for employers to understand exactly how easily and productively their employees have been able to work from home. The question acts as an incredibly powerful tool to formulate future policy/strategy on whether a given employer should be encouraging employees back to work or implement a more hybrid-style working permanently. For example, if the results from the survey indicate that emissions due to working from home are much lower than emissions from office working, and if the majority of most employees answer that they work much more productively, then there is scope to simultaneously drive a reduction in the company carbon footprint, an increase in productivity, output, and even an increase in employee satisfaction.

Company case studies

This next section provides a transparent breakdown of all previous survey versions which we were able to analyse through some pilot research.

The five Small-to-Medium Sized Enterprises (SMEs) listed below work within the service sector. Under our pilot research, they all agreed to act as case studies for the new working from home process and methodology.

Since this pilot research was conducted, the home working emissions methodology was launched to a wider customer base to include larger organisations across a range of sectors.

Bray Leino Events

Type of business I Events Agency
Number of employees I 74
Survey approach I Version 1

Don't Cry Wolf

Type of business I Brand Agency
Number of employees I 10
Survey approach I Version 1

Forster Communications

Type of business I PR Agency
Number of employees I 15
Survey approach I Version 3

LEAP

Type of business: I Design Agency
Number of employees I 8
Survey approach I Version 3

Montanaro Asset Management

Type of business I Independent Investment Boutique
Number of employees I 33
Survey approach I Version 2

Home Emissions Survey results

Results from the pilot research allowed for us to develop our initial working from home survey into the comprehensive and rigorous version we currently offer.

The responses from case studies provided insight into whether each question added value to the estimates or not, and which questions needed tailoring to ensure they were both valuable and simple to answer. As a result, each case study filled in slightly different versions of the survey, with the reasoning behind the removal or addition of questions included below. If a question was added, it was deemed because the increased insight and accuracy to the estimate that the question offered was worth the additional time required to complete the survey.

Survey Version #1

Case Study's: Don't Cry Wolf and Bray Leino Events

The first version of the survey asked basic questions on the respondent's equipment, renewable energy supply, whether lights and equipment are regularly turned off, and whether heating was used additionally due to home working. Results from this initial version provided invaluable insights to improve both the estimates for electricity and heating consumption.

Heating: the original survey included a question on the Energy Performance Certificate (EPC) rating of your home to try and create a more accurate estimate on gas usage for heating purposes. The premise was that houses with a higher EPC rating would use less gas to heat their homes due to better energy efficiencies. However, 7 out of the 11 respondents from Don't Cry Wolf answered that they did not know their rating. Therefore, the question was removed, as it did not offer additional value.

Electricity: the original survey version did not ask any specific questions on the type of lighting used. Lighting was included as the average wattage required to light a home office space. Feedback highlighted that households use different lighting types, with many employees consciously deciding to use much more energy-efficient lighting. It also assumed that both lighting and equipment were left on for all home working hours, giving no scope to understand whether respondents regularly turn these off. We, therefore, edited the question on lighting to account for different lighting types and added a new question (Q10 of the current survey) on whether respondents regularly turn lighting and equipment off. This had two major benefits:

- A more accurate estimate of emissions from lighting.
- Scope to identify and implement energy-saving activities, including encouraging staff to consciously turn lighting/equipment off when not in use, and to make the switch from traditional/halogen lighting to LEDs.

Survey Version #2

Case Study: Montanaro Asset Management

The benefits of the changes made to the first survey version were made clear once we had received results from the second version. For example, with the inclusion of different lighting types, 15 out of the 26 Montanaro responses stated that LED lights are used. With the original survey, the average electricity would have been 310.8 kWh per person. Considering the energy efficiency of different lighting types rather than an average, this reduced to 263.9 kWh due to the considerable number of respondents using the most energy-efficient lighting type.

Results from the second survey provided further insight to improve the estimation for heating.

Heating: it was previously assumed that if employees answered 'Yes' to having the heating on more due to home working, then it was left on for all working hours during the heating season in colder months. It was identified that this will overestimate energy consumption due to heating, as respondents may only have the heating on for a few hours a day, particularly those making a conscious effort to stunt the inevitable rise in energy bills due to home working. New questions (Q14-15 of the current survey) were added to capture the exact number of hours heating was on.

Survey Version #3

Case Studies: LEAP and Forster Communications

The benefits of the changes to the heating estimate in the second survey were made clear once we had received results from the third version. For example, considering the actual number of hours each respondent has their heating on additionally for saw the gas kWh estimate decreased by 12% from 1,818.7 kWh to 1,594.3 kWh. Rather than using BEIS values on the average length of the heating season in the UK (8.7 hours a day for 5.6 months), we found the average length of time people working from home additionally have their heating on is for 3.9 hours a day for 3.4 months.

Results from the third and last survey version of the pilot provided additional insight to improve the estimates for electricity and gas.

Heating: as 80% of households in the UK use gas as their primary heating source, we had originally assumed all respondents used gas. However, feedback asked us to consider different heating systems such as electricity, oil, and solid fuels for those not connected to mains. Including heat pumps has been a more recent request. We, therefore, added a question (Q12 of the current version) asking for the respondent's specific heating system used.

Electricity: it was previously assumed that, unless a respondent regularly turned their lights off, which we assume to be over the one-hour lunch period, then their lights were on for all hours of the working day. However, one respondent pointed out that they do not use artificial lighting at all, but rather rely on natural lighting.

Some also only have lighting on for the morning or the evening. Based on this, we added a question (Q8) asking whether respondents always, sometimes, or never turn on artificial lights whilst working.

Final results

Results from all three pilot survey versions have led us to the 17-question survey version that is currently being used, the only additional question since being Q16 on the number of rooms additionally heated. Based on the collation of all responses to date, our final working from home figures for 2020 are:

For the average household using gas as their primary source of heating:

231.3 kWh electricity (with 24% of respondent's having a 100% renewable energy tariff)

1,048.7 kWh gas (for heating purposes)

This is based on the average heating behaviours of individuals in this heating sample; 69% additionally heat their homes with gas due to working from home, from which 47% additionally heat their whole house, 41% additionally heat more than one room, and only 12% additionally heat just one room.

Of the households who do heat their home, total gas consumption due to heating is on average 1,514.1 kWh. This ranges from 522.2 kWh for those who additionally heat only one room, 735.6 kWh for those who additionally heat more than one room, and 1,975.4 kWh for those who additionally heat their entire homes.

For the average household using electricity as their primary source of heating:

562.7 kWh electricity (with 24% of respondent's having a 100% renewable energy tariff)

250.4 kWh is due to equipment/lighting and 312.3 kWh is due to heating

This is based on the average heating behaviours of individuals in this heating sample; 46% additionally heat their homes with electricity due to working from home, from which 24% additionally heat their whole house, 18% additionally heat more than one room, and 59% additionally heat just one room.

Of the households who do heat their home, total electricity consumption due to heating is 674.6 kWh. This ranges from 291.4 kWh for those who additionally heat

only one room, 593.4 kWh for those who additionally heat more than one room, and 958.6 kWh for those who additionally heat their entire homes.

As mentioned, these are constantly being updated as our sample size of the final survey version increases. Please do reach out if you would like access to our most up-to-date values which include heating options for electricity, oil, solid fuel (wood and coal), and heat pumps.

Interview results

Online interviews were conducted with key representatives from each of the case study organisations. The objective was to understand:

- The respondents' motivations for measuring home working emissions.
- Their experience of the process.
- Plans for future measurement and reduction.

The questions and answers from the interviews held are featured below.

Q1. What is your role in the organisation?

The aim was to create a methodology whereby anyone within an organisation could easily implement and communicate its process and importance. The survey was designed to be understood by staff with little or no understanding of environmental management.

The key representative roles within our pilot organisations were:

Director Finance | Manager Founder & CEO | Head of Operations | Office Manager

Challenges and Opportunities

Q2a. What is your biggest challenge regarding homeworking emissions?

"If we're in an office, we're able to have a closer eye on what we're using."	"We know everything about what's going on in the office, and you don't know what's going on at home."
"We're all-electric in the office, whereas I know a lot of people have probably got gas central heating. So, of course, that's not 100% renewables. There's obviously a bit of a challenge there and getting the right calculation if you want to be perfectly accurate. "	"It's quite difficult to calculate what everybody is using at home, in addition to their normal working day. If everybody had a smart metre, we could do some comparisons."
"Being able to get people to, for example, consistently decide that they need to use a renewable energy provider at home to get their energy supply. Without it impacting their bank balance."	"People who live in landlord accommodation don't necessarily have the choice."
"How to begin calculating it, I had no idea."	"Meeting commitments we've made in our climate-positive plan. Measuring them at all was a challenge and not having the opportunity to use the structure finally offered by you [Green Element / Compare Your Footprint]."

Q2b. What do you see as the biggest opportunity?

“It's nice to have all the correct information rather than guesstimating.”	“No one's getting the bus, no one's getting the train, no one's driving in. So that's a positive as well. Even as we come out of the other side of lockdown, we won't all be in the office every day. We're all very used, like everybody else across the world, to virtual meetings.”
“Opportunities around reducing the number of emissions that we have for travel and commuting.”	“We could potentially help to not just influence the way that staff work, but also the way that our teams live as well. By giving them some tips, tricks, advice and helping them to adjust at home from a work perspective, I think that will probably bleed into their day-to- day lives as well.”
“Encouraging people to change. It's small steps. If enough people make a small change, it adds up to a big change. We already encourage people to sign up for renewable energy.”	

Motivation

Q3. What was the number one reason for your organisation wanting to measure your home working emissions?

“We wanted to know the full impact. It’s quite easy to say it’s not happening in the office, put your blinkers on and say, we’ve hardly used any electricity or water, hardly anyone has moved. But that’s not true. I think it’s appropriate to consider home working.”	“Prior to the pandemic, people would work from home every now and again. We probably wouldn't try and capture that because it was just a day here and a day there. But certainly, moving forward with a 50/50 or 60/40 split of working from home, it’s important to have that information as well.”

“I think the whole narrative over the last year has been about climate change and our impact on the environment. This made it more important that we do this.”	“We needed to have a very clear understanding of our carbon footprint as an organisation. If we just measured what we were doing in the office, we'd have had a very warped, inaccurate view of our footprint. So, it's important that as our working practices change, so do our measurement policies and the approach that we take to understanding our footprint.”
“We're heading to net zero, and we need to inspire other people to take that journey with us...by getting people to think about their admissions at homes. It’s an easy step for people to take.”	

Experience and accessibility

Q4. How did you / your fellow employees find completing the survey?

“It was quick and easy.”	“I emailed the team and asked exactly what they had said, and those that came back to me (probably about 50%) said it was absolutely fine. I guess if it was a total pain, I would have heard to be fair. Or if it's difficult, nobody would have done it.”
“Very simple questions, very straightforward to answer. But sometimes with simplicity, people feel there should be more to it and those kinds of people get a bit stumped.”	“Some of them found it quite eye-opening and important. Some had questions around whether the information they provided is accurate because we're obviously asking them retrospectively, rather than getting them to track and measure and log things in real-time and then provide a report.”

Q5. What was your experience of leading this project for your organisation?

“It would have been good to know who replied. So, people could put their name on it, so we know who to encourage to submit it.”	“I would have been interested to see what people had said and how they live. Only because if I didn't think it was right, I could question and say, is that right or is that wrong? There are some people that probably live at home with a parent, that would probably be in the house anyway. And so, therefore, the heating zone, it would be on anyway.”
“If you must find out all this new terminology to understand [the process], it puts you off finalising. It just delays the whole process. Whereas I think we did it quite quickly really.”	“Quite smooth from the point of view that you'd send me the questions and they just did it remotely without my kind of input.”
“The process seemed to go pretty smoothly. No one complained that the survey was long and clunky because it wasn't. It was well set up and it went pretty smoothly.”	“Giving a lot of it over to your team made it a tremendously easy process. Because other organisations have found it so hard or are afraid that it would be so hard. My message back to them would be that it doesn't have to be.”
“It was quick and easy. It was a good process all round.”	

Q6a. Do you think anyone in your organisation could have managed this project?

“No, because I think we needed to be set in the right direction. And it's not so much how you collect the data, it's the questions that are being asked. And if we don't know what the right questions are, then whatever data we collect will be relatively pointless.”	“I'd like to say no. I think from our point of view, your team does a lot of the heavy lifting, and it's more about kind of getting readings right from our side and kind of the information inputted correctly because then your kind of your help kind of makes our calculation easier.”
“Yes!”	

Q6 b. Is it accessible to all levels of understanding?

“There's quite a bit of technical stuff within it. I'd say probably not. But you know, with a bit of reading around, I guess it could be.”	“Yes, absolutely. Like with all these things though, if you don't provide either some sort of clarity or context around why you're doing something and what the importance of it is, then it might get lost in the ether. So, when we were communicating this to our teams and getting them to take the effort and time to fill the documentation out, we made sure they knew why they were doing it, and what the greater good was.”
“I think so. There certainly there wasn’t anything particularly challenging about it.”	“Yes.”

Future expectations

Q7. Will your organisation encourage staff to continue working from home?

"There's no plan to come back to the office full time at all, for anybody. Prior to that, we always had a bit of flexibility with the hours. There's nobody at all in the office on a Friday for example."	"Our intention is that people will come back to work three days a week. I feel that people like working from home some of the time. But we feel it's important that the team work together."
"We have a semi-flexible policy in place, which has two days a week in the office, which will be compulsory, and then three days working from home."	"It's very unlikely that we're going to go back to a full office, possibly ever again. I think too many people enjoyed working from home. I think it will be lucky to have a half-full office."

Q8. Do you anticipate including home office carbon emissions in your carbon reporting year-on-year? If so, what would be the benefit to your organisation?

"Now we've started it, we'll continue to do so. Just so we are capturing everything we can capture...Everybody's kind of on board with sustainability."	"I think it's not possible to be completely accurate. But if the rule of thumb would be somebody is working from the office three days a week, then we would."
"You need to have all bases covered. If you're not measuring home emissions, you are just kind of fooling yourself. I mean, especially this year when there's been very little kind of time spent in the office."	"Absolutely! [The benefits would be] accuracy, realism, and a sense of understanding what our carbon footprint is, rather than what we think it might be."

Reduction strategy

Q9. Do you aim to engage with the home office in your emissions reduction strategy? If so, how? If not, what would change your mind?

"If we have the figures, we can do some comparisons. I will probably need to see a breakdown of how many people said this, how many people said that to be able to make a plan for reduction, where possible."	"I suppose the only thing is...is it worthwhile for us? Because we're so small and the nature of our business, etc. But if there is a need for input from lots of small businesses, then we should be happy to participate."
"We've put in place policies around things such as: printing at home, stationery, what sort of equipment to buy. When we're providing technology to our teams to work remotely, we put in place a policy that will procure that technology second-hand. So, it's refurbished rather than brand new. All of which helps to reduce our emissions. And then we provide guides to our team as to how to sustainably operate from home."	"We're doing a project with Patagonia talking about community energy. So, we're looking at changing from renewable to community energy to help that process along. I know that it's not necessarily as cost-effective for individuals as a kind of normal energy. Our hope for the future is that this becomes more widespread, so it's cheaper to buy. But that would be our hope that we can include that in our in the strategy and those who are in landlord accommodation to change their suppliers."

Q10. What additional guidance on how to help employees reduce the carbon footprint of their home office is needed? For example, introduce an energy switch provider to help employees benefit from switching to a 100% renewable option.

"We were talking about the renewables. We encourage people to use eco products and we have a transport policy. Don't go driving out to every meeting if you can do it remotely. Although if you are out on a limb and the infrastructure is not great for transport, it can be a problem. It's all the general things of just being very mindful of all of what we do."	"Swapping to renewable energy is kind of the main one. Encouraging people to make sure they're turning out the lights. And, you know, kind of going back to the kind of all the old campaign stuff from like, the last 10 years, like when you don't need the heating on, turn the heating off. Encouraging people to kind of be more thoughtful on their kind of consumption at home."
"Everything comes down to cost and accessibility. It's less guidance and more a case of finding a sustainable and an economical way of solving that energy conundrum."	"Pointing people to renewable energy suppliers. I guess that would be good. But. I think we'd be hesitant to tread too much into their headlights."

Q11. Could the process have been improved in any way?

"Having it within Compare your footprint would be helpful, but actually thinking about it, that probably makes it more complicated for us, because then we have to kind of collect the data. And it's probably easier for us if you [Green Element or Compare Your Footprint] are doing that."	"I would be interested in seeing the results, even if it's not listing names people, and I don't think anybody would care if they were named anyway. But it will be interesting, because, for somebody that I know, for example, that does this or doesn't do that. It would be perhaps nice to use that information as a baseline for next year."

Discussion

Over a year has passed since the pandemic resulted in a significant shift to remote working, but there is still no clear consensus on the best method for calculating working from home emissions and the resultant environmental impact of remote working. Through an environmental lens, it is still subject to debate as to whether a move to remote working has in fact had a positive impact on the environment, or whether the energy consumption required to heat and power individuals' homes have a much larger footprint than initially thought. Due to this, the impact of home working must be looked at case by case, company by company, and individual by individual.

Companies should strive to understand the specific energy consumption behaviours of their employees as accurately as possible, particularly if remote or hybrid working will become the new norm.

Asking individuals for their exact electricity and gas consumption from either meter readings or bills is the most accurate way of capturing the total energy consumed whilst working from home. However, apportioning total consumption to one person during working from home hours only presents a challenge, particularly in large households containing many individuals with varying consumption behaviours and work schedules. This method also provides little in the way of understanding what specific behaviours are driving consumption in the first place, and therefore minimal scope for a company to try and understand how they can help their employees become more energy efficient whilst working from home.

Therefore, working from home emissions will always be an estimate requiring several assumptions, and so we recommend choosing the most apt methodology for each specific company's structure, goals, and objectives.

Many organisations view asking individuals directly for their domestic energy bills as intrusive. Our solution is to send out an anonymous survey to understand how people may be consuming energy at home, and the different types of fuel used. This approach to capturing home working emissions offers a balance between accuracy, time efficiency, anonymity, scope for understanding behaviours to help target and promote energy efficiency, and thus ultimately reducing emissions. Since companies who report on their carbon footprint often send out a survey to capture employee commuting patterns, integrating the two surveys ensures that employees are still only required to fill in one survey.

We acknowledge that the survey does not cover the increased consumption from a variety of other sources, such as the increase in energy from home-cooked meals, water consumption from cooking, washing hands, and using the toilet, as well as using equipment such as printers or mobile phones. We deemed that the increased value of adding further questions to help quantify such elements does not justify the increase in survey length. This is because the above actions are not necessarily the most predictable behaviours, and therefore asking how many times on average a respondent uses a printer, boils the kettle, or flushes the toilet is likely to be a rough estimate by the respondent. Such estimates could be made without the need to directly ask the question. We, therefore, have strived to ask respondents questions that help capture emissions from the three largest and more predictable sources of energy consumption: lighting, workstation equipment, and heating.

Emissions from all equipment used (lights, monitors, laptops, and desktop computers) are estimated by taking the average energy consumption of each specific equipment type.

This is the same method used as existing bottom-up methodologies that consider the average power consumption of an individual's workstation and lighting and then multiply this by the number of hours worked from home. However, our methodology goes a step further by asking questions on individuals' specific energy-saving behaviours including lighting type, how often lighting is used, and whether individuals switch their equipment off when not in use rather than leaving them on standby. This not only creates a more accurate estimate of emissions from all equipment used but offers further scope to highlight the most energy-efficient practices that could be encouraged. Highlighting and encouraging such behaviours will not only benefit at the organisational level through a reduction in a company's carbon footprint, but help individuals reduce their own carbon footprint and energy bills.

However, using our average estimate has identified that emissions from all equipment used only account for ~12% of the total working from home emissions. The remaining ~88% is due to heating, which will be discussed in more detail within the next section.

Emissions from Heating

Of all sources of home working emissions estimated within our methodology, emissions from heating are the largest, but most difficult to estimate.

Due to this, heating provides the most significant opportunity for reduction; we found that decreasing the number of additional hours/months heating is on for, the number of rooms heated, and changing the heating fuel type all lead to a significant decrease in working from home emissions. Moreover, with the new UK government plans[xxii] to reduce carbon from domestic heating through incentivising the installation of greener systems such as heat pumps, heating has significant relevance to environmental policy, both now and in the future.

Most existing methodologies assume that all households within the UK use gas to heat their homes, given that 87% of properties in the UK heat their homes with gas[xxiii]. However, feedback from the original survey led us to tailor the survey to include all types of potential fuels used for heating within the UK, including heat pumps. This allows us to make more accurate estimates of consumption by each fuel type and additional scope to highlight the most efficient heating systems. The aim is to encourage people to think more about the environmental impact of their heating and make changes where possible. The inclusion of greener heating systems that are not currently prevalent in many households, such as heat pumps, but are projected to rapidly increase soon, ensures the methodology is already set up to track such changes.

Current methodologies also assume that individuals have the heating on throughout the entirety of the 6-month heating season. For households using gas for heating, our previous survey version made this assumption, resulting in an estimated 1,818.7 kWh of gas consumed for heating purposed per person in 2020. However, by directly asking whether individuals heat their home additionally due to working from home, and if so the exact number of additional hours, this estimate decreased significantly to 1,277.4 kWh (30% decrease from original estimate). By also directly asking how many additional rooms each person has their heating on in lead to a further decrease in the original estimated consumption to 1,048.7 kWh (42% decrease from original estimate).

Finally, our results revealed some interesting findings and insights into individual's heating behaviours. It appears that whether a household has a 100% renewable electricity tariff is not influenced by heating fuel type; ~24% of all households were found to have 100% renewable electricity tariffs regardless of the heating fuel type.

This gives scope to highlight that those individuals who do use electricity to heat their homes have a massive opportunity to significantly reduce their personal carbon footprint, and contribution to their organisation's carbon footprint, by switching to 100% renewables. However, households using varied heating fuel types show differences in heating behaviours depending on whether households heat their home additionally in the first place, and if so, exactly how many additional rooms are heated.

Results from our survey found that individuals in households with electric heating systems are much less likely to additionally heat their home due to home working than those with gas heating systems; only 46% of respondents additionally heated their home with electricity compared to 69% for gas. This could be because electricity is much more expensive per kWh than gas, and therefore individuals are making a conscious effort to ensure their energy bills do not creep up due to working from home hours. Lastly, results from our survey found that individuals in households with electric heating systems are much less likely to additionally heat their entire homes than those with gas heating systems; only 24% of respondents heating their homes with electricity heat the whole house, compared to 47% for gas. Not only are electricity heating systems more energy efficient and therefore associated with less carbon emissions per hour of heating, but it further appears that individuals in households powered by electricity tend to use less energy for heating in general.

The Energy Helpline projected average winter energy bills to rise by 17.8% in households where individuals work from home five days a week[xxiv]. This highlights that the average household is significantly likely to feel the effects of working from home on their energy bills and more likely to make conscious efforts to minimise additional heating where possible. The results of our survey emphasise this point and furthers our case on the importance of understanding people's specific heating behaviours to estimate emissions from heating as accurately as possible.

Future Work

The survey questions and methodology have continually been updated to reflect current information and feedback from the previous survey version. Future work is planned to ensure that the survey provides the most accurate and up-to-date reflection of remote working emissions.

One such update has been the expansion of the survey in terms of its geographical reach. The current methodology described in this paper is tailored towards estimating the working from home emissions of UK-based workers during 2020. As a result, we have included emissions from devices, lighting, heating, and have excluded emissions from air conditioning.

However, we have recently expanded the survey to include estimates for the US, Shanghai, and Singapore. For such countries, we have been able to tailor the calculation for heating to ensure it reflects the specific heating requirements per heating system per country. As many households in such countries also use air conditioners, we have been able to incorporate estimates for the energy requirements of air conditioning.

We aim to fully develop our methodology and continually expand its geographical reach based on ongoing research and client requests.

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