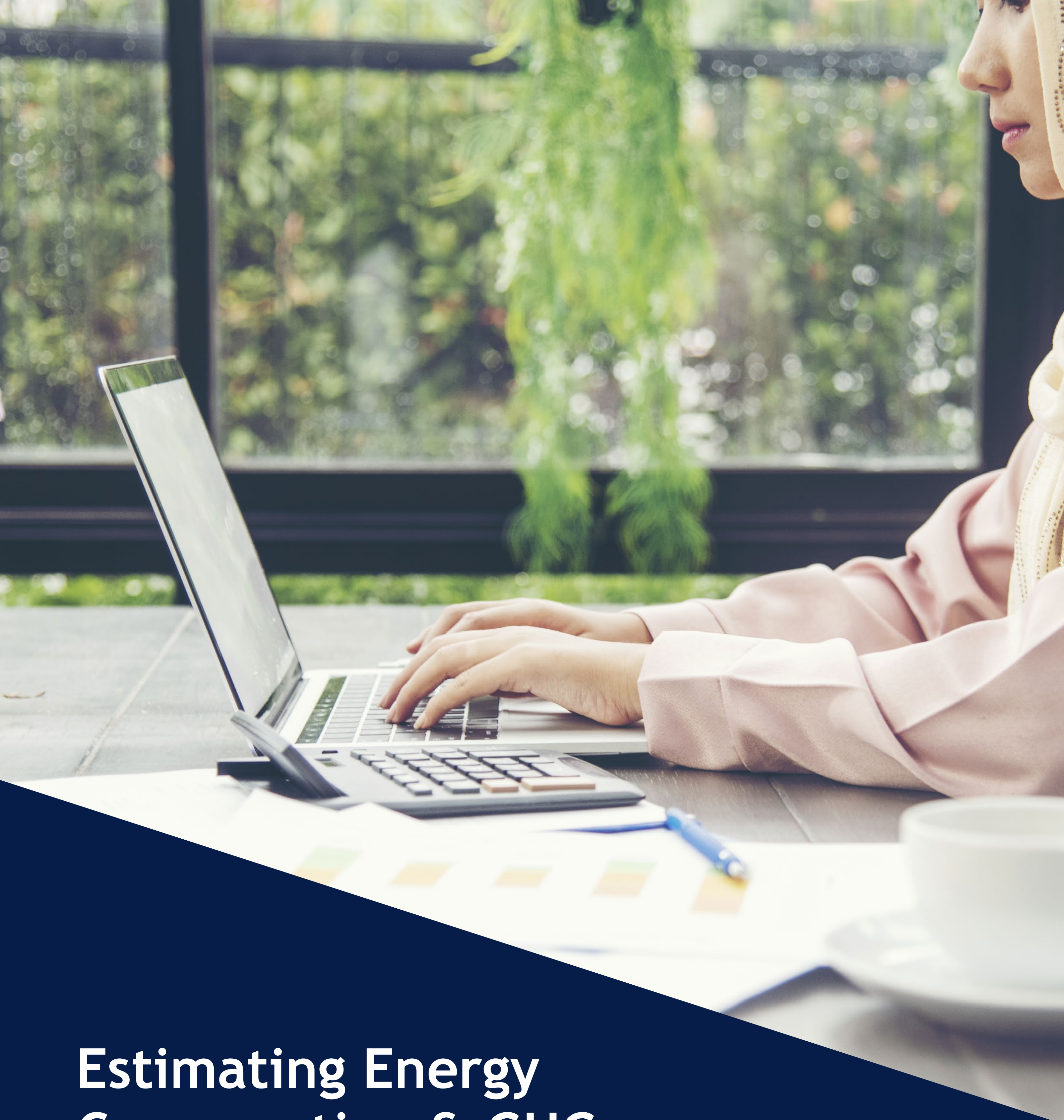

Estimating Energy Consumption & GHG Emissions for Remote Workers

White Paper | February 2021

Anthesis

Contents

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Introduction

Starting in March 2020, many office workers globally were required to work from their homes due to mandated (or voluntary) closures of businesses driven by the global COVID-19 pandemic. Since that time, some businesses have begun strategic planning to decrease their corporate real estate footprint and move to an operational model that centers on more of their staff assigned to work remotely (or at smaller drop-in meeting locations).

With office buildings operating either with skeleton staff or inactive, commercial energy consumption has plummeted (in comparison to the pre-pandemic scenario) while residential energy use has increased.[1]

As businesses continue to determine the environmental impacts of this shift, estimating the energy use and associated greenhouse gas (GHG) emissions of working from home is a new activity with little or no precedent. Teleworking emissions are mentioned in the GHG Protocol's Category 7: Employee Commuting guidance document. However, most companies have not included these emissions to date. While other organizations have published case studies and comparisons, Anthesis has developed this guidance in response to our growing client requests—to provide further guidance on data collection and calculation approaches that may be broadly integrated into their corporate inventory processes.

Recommendations

Anthesis has developed this guidance through a thorough literature review, coupled with an analysis of sample residential energy consumption during the initial "first wave" of the COVID-19 pandemic (March-August 2020).

Anthesis has defined three methodological approaches to support businesses in collecting data and quantifying energy consumption and GHG emissions from their remote workers globally. Anthesis has also developed a suite of residential energy consumption intensities to support these approaches.

Anthesis has defined three methodological approaches to support businesses in collecting data and quantifying energy consumption and GHG emissions from their remote workers globally.

1 The International Energy Agency (IEA) collected data from more than 30 countries that showed a correlation between lockdown measures and significant reductions in commercial and industrial electricity demand. (IEA 2020 Global Energy Report, https://www.iea.org/reports/global-energy-review-2020)

Methodological Approaches

The needs of each business are different, and a single approach will likely not be feasible or appropriate for all businesses, just as companies are motivated to calculate their transportation commute emissions in different ways. To accommodate these varied needs, Anthesis recommends three different approaches that may be used by a business to estimate energy consumption and associated GHG emissions from its employees working at home (Table 1). These methods vary in ease of use, time and cost to implement, and data accuracy (Figure 1). This paper provides recommendations on how these methods may be best applied on a regular, ongoing basis.

The three approaches are:

1. **No Survey** – This approach uses the number of remote workers by country or geographic region and our recommended regional energy intensities (i.e., energy consumed per person per day) to estimate the amount of electricity and natural gas consumed. The energy consumption is then multiplied by appropriate emission factors to calculate the GHG footprint of remote workers. This option is the easiest of the three to implement as it requires minimal information from a company (likely obtained from the human resources department) and uses several assumptions for key factors that drive emissions. It also requires the fewest resources and least time to implement and, therefore, is the most cost-effective option. This option is also feasible to implement annually. To note: for companies that calculate and track commute emissions more granularly by country and/or business division, the No Survey approach is the simplest one but may take a nontrivial amount of time.
2. **Basic Survey** – This approach also uses the number of remote workers by country or geographic region and our recommended regional energy intensities. In addition, minimal data are collected via survey to adjust certain assumptions regarding energy use, such as the specific energy types used. While this approach relies on fewer assumptions and is slightly more accurate than the No Survey approach, it requires more time and resources to implement because of the need to develop, issue and manage the survey and to clean, assimilate and analyze the survey responses. While this approach could be repeated annually, it may be most cost-effective to conduct this basic survey every two to three years, especially if commute surveys are already conducted at that frequency.
3. **Enhanced Survey** – This approach also uses a survey but with questions designed to gather actual consumption data by energy type and to provide more in-depth insights into variables that may influence consumption. The energy data gathered can be classified by country, geographic region and energy type, and are then multiplied by appropriate emission factors to calculate the GHG footprint of remote workers. This approach uses the fewest assumptions and is the most accurate. However, it is also the most time- and resource-intensive of the three approaches because it requires significant time to clean, assimilate and analyze more extensive survey responses. As a result, it should be combined with existing commute surveys (or conducted at least every two to three years).

Table 1: Comparison of Recommended Approaches

	No Survey	Basic Survey	Enhanced Survey
Data/Data Requests	High-level regional data; numerous assumptions	High-level regional data + limited data requested; refined assumptions	Detailed data requested; fewer and refined assumptions
Intensity Factors	Apply recommended energy intensity factors to estimate energy consumed	Apply recommended energy intensity factors **for specific energy types** to estimate energy consumed	Assimilate data to **calculate energy intensity factors**, filling gaps with estimates as required
Emission Factors	Apply appropriate emission factors by geography to calculate GHG emissions	Apply appropriate emission factors by geography and/**or type** to calculate GHG emissions	Apply appropriate emission factors by geography and/or **type** to calculate GHG emissions

To inform the development of the methodology, Anthesis performed a literature review to understand the research landscape of the emerging trend of remote working. Over the past five years, there has been an increasing number of blogs on this topic, but few have published quantitative data illustrating the increase in energy demand as a direct result of working remotely. Several organizations have recently published estimation methodologies and recommendations to address the gaps in remote working data. Through our literature review, we have identified two categories of data relevant to calculating remote working emissions: “Baseline Energy Intensity” and “Incremental Energy Intensity”.

For the purpose of this white paper, Anthesis has focused on energy consumption as the key driver of GHG emissions in residential homes. However, it is noteworthy that home water usage and waste/recycling volumes have also increased as a result of the shift towards working from home.

Baseline Energy Intensities

The baseline energy intensity refers to the energy consumption measured in a household before the pandemic period when some household members might have been home during the day while others were working outside of the home. The set of data sources we considered under this category were published by a range of organizations including national and international public agencies as well as private companies. Only data sources within the last 10 years have been included in this literature review. Table 2 summarizes the strengths and weaknesses of existing data sources based on our evaluation. This evaluation is intended to be qualitative and may be subject to refinements upon external feedback.

Table 2: Evaluation of Existing Data Sources[2] with Baseline Total Energy Intensities

Source	Strengths	Weaknesses
U.S. Energy Information Administration	• Well established source of residential building energy intensity data • Granular data by US region, building type and vintage	• US-specific survey data • Data published 2015
International Energy Agency	• Data published 2018 • Global coverage of country specific averages • Data reflects both residential electricity and natural gas consumption	• Total residential electricity and gas consumption data needs to be divided by a country's population to derive the baseline energy intensities
Carbon Trust	• Incremental change in home energy attributable to working from home • Reduction in office energy • Includes change in (transportation) commuting data	• Europe-specific • Assumptions and scenarios • Results presented in CO_2e

Incremental Energy Intensities

The **incremental** category of regional energy intensities refers to the incremental energy consumption measured in a household, in which some household members have transitioned to working from home, causing an increase in residential energy use. The set of data sources we considered under this category were published in 2020 to address the increased number of employees working from their homes. Based on our review, the incremental methodologies published by WSP (February 2020) and EcoAct (September 2020) use a bottom-up approach that characterizes energy consumption by end uses, such as office equipment, heating and cooling. IEA also published an article (June 2020) that presents high-level results on the increase of electricity and natural gas consumptions per person per day by country. Table 3 summarizes the strengths and weaknesses of these data sources based on our evaluation. This evaluation is intended to be qualitative and may be subject to refinements upon external feedback.

2
U.S. Energy Information Administration, 2015. Residential Energy Consumption Survey (EIA RECS). https://www.eia.gov/consumption/residential/data/2015/index.php?view=consumption#summary

Based on International Energy Agency (IEA) data from the IEA (2018) Data & Statistics. Electricity and Natural Gas Consumption by Sector, https://www.iea.org/data-and-statistics. as modified by Anthesis Group.

Carbon Trust, 2014. Homeworking: helping businesses cut costs and reduce their carbon footprint. https://www.carbontrust.com/resources/homeworking-helping-businesses-cut-costs-and-reduce-their-carbon-footprint

Table 3: Evaluation of Existing Data Sources[3] with Incremental Energy Intensities

Source	Strengths	Weaknesses
Anthesis	• Collected and analyzed actual consumption data for 2019 and 2020 in three regions globally (i.e., North America, Europe and Asia-Pacific) • Survey questions included several variables that could influence energy consumption patterns (i.e., hours and days worked, primary energy sources, number of others at home, other high energy-using sources, size of home/ workspace, regional nuances, etc.)	• Data were limited to a six-month period during the Spring and Summer for most of the regions surveyed - thus, excluding comparison of Winter energy consumption. • Small data sample size
EcoAct	• Covers three remote working specific categories of energy use: (1) office equipment, (2) heating energy, (3) cooling energy • Provides two accounting and data collection approaches: (1) Base Case uses estimation methodology (2) Enhanced Case incorporates actual data collected through surveys	• US and UK-specific assumptions in the Base Case • Bottom-up approach driven by multiple sources of regional average data with varying degree of confidence (e.g. US Average Heating Gas Consumption, US Average Heating Electricity Consumption, US Average Domestic AC Use)
International Energy Agency	• Regional averages (US, China, EU) • Incremental change in home energy • Includes change in (transportation) commuting data	• Lack of data granularity • Assumption-laden with high-level results • Limits of regional coverage
WSP	• Covers three remote working specific categories of energy use: (1) office equipment, (2) heating energy, (3) cooling energy • While more granular than a high-level energy intensity, the calculations are relatively simple.	• UK-specific • Granular consumption data is based on assumptions of workspace floor area, which in turn is used extrapolate to per capita basis

3
EcoAct, 2020. Homeworking Emissions White Paper.
https://info.eco-act.com/en/homeworking-emissions-whitepaper-2020

International Energy Agency (IEA), 2020. Working from home can save energy and reduce emissions. But how much?
https://www.iea.org/commentaries/working-from-home-can-save-energy-and-reduce-emissions-but-how-much

WSP, 2020. Office vs Home Working: How We Can Save Our Carbon Footprint.
https://www.wsp.com/en-GB/insights/office-vs-home-working-how-we-can-save-our-carbon-footprint

Data Metrics and Assumptions

Our literature review uncovered several considerations important for methodology development. One concerns the broad variety of metrics used across the reviewed studies:

- kWh per person per day
- kWh per person per year
- kWh per household per year
- kg CO_2e per person per year
- kWh per square foot per year
- kWh per square foot per hour

Not surprisingly, the inconsistency in metrics makes it challenging to compare publicly available data on home energy consumption. To enable a transparent and consistent comparison, Anthesis extrapolated the available data to a common metric: **kWh per person per day**. Comparing with the same metric allows us to understand the range of values that have been published on home energy consumption and, consequently, to develop reasonable and justifiable assumptions in alignment with publicly recognized information.

In general, the baseline intensity data were published in the form of annual energy intensity that can be readily converted into the common metric by assuming 365 days in a year. However, for studies that have performed a bottom-up analysis on the environmental impact of remote working, the process of deriving an energy intensity value that is comparable among different studies can be more intricate. In the case of EcoAct and WSP, the authors have published a set of assumptions and calculations that can be used to estimate the carbon footprint of a remote worker per day. To derive an energy intensity value from the EcoAct study, we applied their published methodology and averaged the sub-regional values and other assumptions where deemed reasonable in order to develop a U.S. average of electricity and natural gas intensity values. Similarly, for the WSP study, we applied their published methodology and assumed a workspace of approximately 200 square feet (~20 square meters) in order to develop average U.K. electricity and natural gas intensities. The energy intensity values from the IEA study were taken directly from the published online article.

Recommended Regional Energy Intensities

For the No Survey Approach to be simple yet justifiable, Anthesis proposes the following estimation methodology that leverages existing industry data in combination with the latest research published on remote working. Under this approach, the participating company will only need to provide the number of full-time employees (FTEs) working from home by electricity grid region or, at minimum, by region.

Anthesis recommends using the energy intensities in Table 4 (baseline residential energy intensities) combined with the "incremental to baseline energy intensity" ratios in Table 5 that express the increase in energy consumption attributable to working from home. While regional level intensities may be used with the No Survey or Basic Survey approach, country-specific intensities may instead be used with if country-level data are collected. (Table 4 shows derived intensities for a few selected countries. See note 2 below Table 4 if intensities for additional countries are needed.)

Table 4: Recommended baseline residential energy intensities by country and region

Baseline Residential Energy Intensity by Country (kWh/person/day)				
Region	Country	Data Source	Electricity Consumption	Natural Gas Consumption
AMER	Canada	IEA (2018)	12.75	15.40
	United States	IEA (2018)	12.24	12.71
	Average		**12.50**	**14.05**
APAC	Australia	IEA (2018)	6.52	5.06
	China	IEA (2018)	1.90	1.02
	India	IEA (2018)	0.62	0.03
	Japan	IEA (2018)	5.62	2.40
	South Korea	IEA (2018)	3.62	6.61
	Singapore	IEA (2018)	3.44	0.35
	Average		**3.62**	**2.58**
EMEA	France	IEA (2018)	6.67	5.81
	Germany	IEA (2018)	4.23	9.48
	Italy	IEA (2018)	2.94	9.63
	Russia	IEA (2018)	3.13	16.49
	South Africa	IEA (2018)	2.34	0.00
	Spain	IEA (2018)	4.40	2.08
	United Kingdom	IEA (2018)	4.29	12.62
	Average		**4.00**	**8.02**

(1) The residential energy intensities in Table 4 are derived by dividing the energy consumption data from IEA[4] by the corresponding country's population data[5] from 2018. Energy intensity data shown here may be considered the baseline total energy consumption per person per day, spanning 365 days a year. The IEA energy statistical data set provides one of the most comprehensive and well-established set of electricity and natural gas consumption data for residential households. Therefore, we recommend using the IEA data source normalized by country population to obtain the baseline electricity and natural gas intensity per capita for the residential sector.

(2) To find comparable electricity and gas intensities for other countries, navigate to the Data & Statistics search browser of the IEA database. There are multiple dropdown menus provided to help users narrow down the search by specifying the Energy Topic, Indicator and Country/Region values. In the order of dropdown menus, select (1) "Energy consumption", (2) Electricity final consumption by sector with residential included as a sector and then (3) the desired country for data to be filtered. The search browser will then display a chart with historical data through 2018. (Last accessed in November 2020)

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[4] Based on International Energy Agency (IEA) data from the IEA (2018) Data & Statistics. Electricity and Natural Gas Consumption by Sector, https://www.iea.org/data-and-statistics. All rights reserved; as modified by Anthesis Group

[5] Worldometer Population by Country, 2018. Data & Statistics. Electricity and Natural Gas Consumption by Sector. https://www.worldometers.info/world-population/population-by-country/

Table 5:Recommended Ratios of Incremental to Baseline Energy Intensity from Literature Review

	Baseline Energy Intensity (kWh/person/day)		Ratio of Incremental to Baseline	
Region	Electricity	Natural Gas	Electricity	Natural Gas
AMER	12.50	14.05	62.57%	38.39%
APAC	3.62	2.58	26.24%	60.10%
EMEA	4.00	8.02	57.79%	70.68%

(1) The ratios are incremental to baseline energy intensity by region and energy type. The incremental energy intensities are an average of select countries covered by the various studies on remote work. The baseline energy intensities by region are the values from Table 4 and are an average of residential data reviewed for selected countries from the IEA data source.
(2) As a result of the shift towards remote work, the **ratio of incremental energy to baseline energy** is a metric that compares the increase in energy consumption relative to the baseline energy use per person per day in a home. The ratio values presented in the table above are rounded to the nearest two-decimal places.

For the purpose of this study, only a select number of representative countries were analyzed to develop the regional average intensities. For example, in AMER, the baseline energy intensities are based on Canada and United States to be conservative as these countries generally consume more energy than other AMER countries in Central and South America. Table 6 lists the countries included in the regional averages provided in Table 4 and Table 5.

Table 6: Countries Included in the Baseline and Incremental Regional Average Intensity

Region	Baseline Energy Intensity	Incremental Energy Intensity
AMER	Canada, United States	United States
APAC	Australia, China, India, Japan, South Korea, Singapore	China
EMEA	France, Germany, Italy, Russia, South Africa, Spain, United Kingdom	United Kingdom

How to Use these Energy Intensities

The recommended baseline energy intensities and incremental-to-baseline ratios may be used with data from the No Survey and Basic Survey approaches as follows:

1. Multiply the country- or region-specific baseline energy consumption intensities for electricity and natural gas consumption (Table 4) by the regional ratio of incremental to baseline energy value of the corresponding region (Table 5)
2. To obtain the **incremental energy intensities per home remote worker per day**, distinct for electricity and natural gas.

   Note: The regional ratios of incremental to baseline energy values presented in the table above are rounded to the nearest two-decimal places.

3. Multiply the **incremental energy intensity** per home remote worker per day by the number of remote workers who are working from home in a particular year and by the number of days that they are assumed to work remotely.

   Tip: align the number of work days with assumptions made for traditional commute calculations; e.g., assume their work schedules are 5 days per week and 48 weeks per year.

4. Multiply the estimated energy values by appropriate emission factors, including site-specific emission factors for electricity. (It is up to the company on whether to use location-based or market-based emission factors. However, if the company may consider purchasing renewables to cover these employees' home electricity, market-based electricity emission factors should be used.)

*Sample Calculation (Using **No Survey** Approach)*

A company identifies that there are 2,000 remote workers across its North American operations, and it is assumed that they work 5 days/week and 48 weeks annually. The energy consumption for the 2,000 home workers would be calculated as follows:

1. Using the IEA baseline residential average intensities for North America (Table 4) and baseline to incremental ratios (Table 5):

- **Electricity intensities:** 12.50 kWh/person/day x 0.63 = 7.875 kWh/person/day for remote work
- **Natural Gas intensities:** 14.05 kWh/person/day x 0.38 = 5.339 kWh/person/day for remote work

2. With these intensities and number of remote workers:

- **Electricity consumption for the full year:**
  2,000 remote workers x (5 days/week x 48 weeks/year) x 7.875 kWh/person/day = 3,780,000 kWh
- **Natural gas consumption for the full year:**
  2,000 remote workers x (5 days/week x 48 weeks/year) x 5.339 kWh/person/day = 2,562,720 kWh

3. The resulting electricity would be multiplied by an average North American electricity emission factor to calculate the associated GHG emissions and similarly the natural gas consumed will be multiplied by an appropriate emissions factor (from US EPA or DEFRA).

Note

- If the company can provide the number of workers by country (or zip code), the IEA country-specific residential intensities and more location-specific (country, sub-regional, or utility-specific) electricity emission factors could be used.
- In the Basic Survey Approach, survey results could refine the intensities used. For example, if all APAC employees indicated that they do not use natural gas (or other heating energy), the company could choose to estimate electricity only (no natural gas) for APAC. If survey results indicated that all remote workers have at least one other person at home with them, the company could choose to halve the intensities.

Guidance on Selecting & Using Methodology

Methodology Selection

The key to selecting an approach is understanding the data required to support the user's objectives and the available resources for implementation. Table 7 compares the three approaches against a variety of potential objectives. A company/organization should consider what is feasible (i.e., can data only be provided by the business or can additional data be requested from employees through a survey) as well as the assumptions that will be used.

Table 7: User objectives supported by each approach

Methodology	Develop estimate of energy use & GHG emissions	Develop solid baseline of energy use & GHG emissions	Provide ability to quantify annually	Consider multiple variables	Uderstand factors influencing energy use	Input to strategic decisions	Couple with employee commute survey	Cost effective to implement
No Survey	✓		✓					✓
Basic Survey	✓		✓				✓	✓
Enhanced Survey		✓	✓	✓	✓	✓	✓	

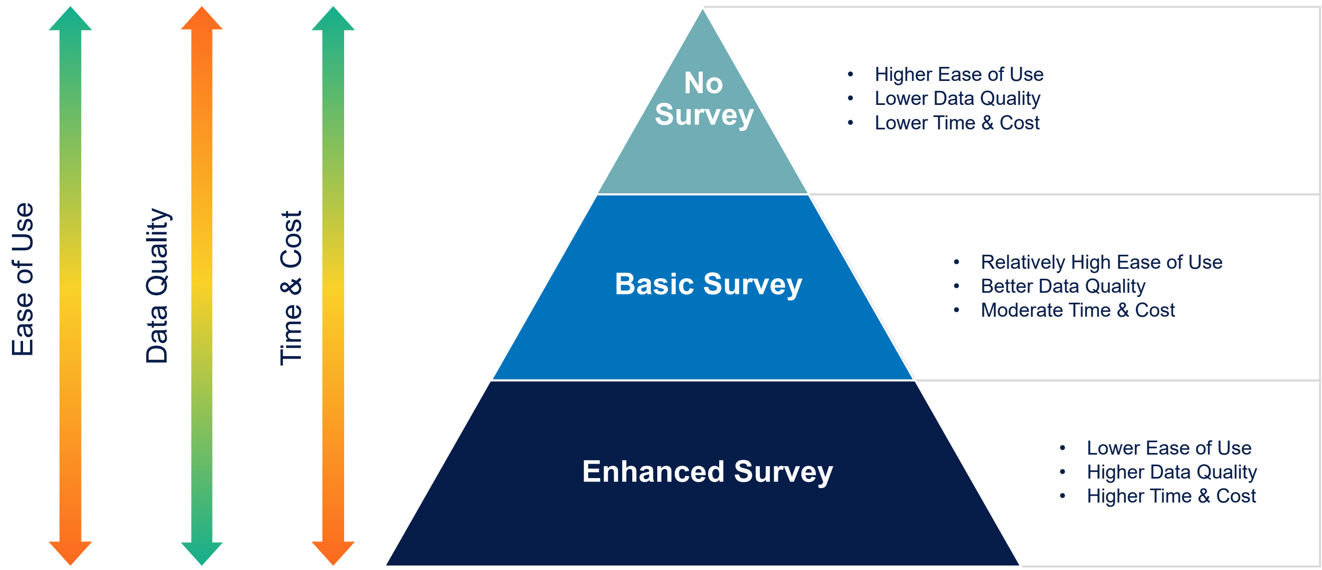
Many variables may influence energy consumption, such as whether additional people occupy the worker's residence during working hours, the length of workday, season, geographical region, use of other energy-using equipment, central vs. zone-specific temperature control, etc. While the No Survey and Basic Survey approaches consider a limited number of variables, the Enhanced Survey approach provides an opportunity to consider multiple variables. Table 8 summarizes and provides some insights on the recommended data requests and assumptions for each of the approaches.

Table 8: Summary of data requests and assumptions for each methodological approach

Methodology	Recommended Data Requests	Assumptions
No Survey	• Full Time Employees (FTEs) per region • General business hours (e.g. 5 days/ week and 48 weeks/year)	• Energy types consumed, by region • Percentage split in energy type, by region • No renewable energy used, Renewable Energy Credits (RECs) purchased, nor emissions offset
Basic Survey	• Region / Country of work • Energy types consumed (i.e., electricity, natural gas, other) • Average days/year worked at home • Number of others sharing home during work hours	• 8 hours/day worked from home • No renewable energy used; RECs purchased nor emissions offset
Enhanced Survey	• All similar data requests for Basic Survey • Hours/year worked from home • Total electricity consumed • Total natural gas / other fuel consumed • Control-level for heating/cooling (i.e., centrally or zone-specific) • Other high-energy using devices/ appliances in home • Renewable energy purchases (incl. RECs) and carbon offsets purchases	

As illustrated in Figure 1, the use of a survey could yield comparatively better data quality but would require additional time and cost to implement. Companies that want a baseline of their remote workers' energy consumption with their employees' actual energy consumption might opt to use an Enhanced Survey initially. The choice between the Basic versus Enhanced Survey will likely be driven by available resources and interest in the additional effort to develop, deploy and analyze the outcomes of a survey. Companies with existing programs that already conduct commute surveys may be the best suited for the Enhanced Survey. The Basic Survey provides somewhat of a balance between the Enhanced and No Survey options. Businesses with limited resources and time might best be served by basic data collection and assumptions and not use a survey.

Figure 1. Considerations for each methodological approach



Ultimately, the most appropriate approach for a company is dictated by available resources, feasibility for the business, and company objectives.

Survey Frequency

Just as with 'traditional' commute surveys, businesses that choose a survey approach do not necessarily need to deploy a remote work survey annually. They could use the initial survey to determine baseline energy intensities for their remote workers and then use those intensities and the number of remote workers in subsequent inventory years to estimate energy use and emissions. Table 9 summarizes the recommended frequency for each approach.

Table 9: Recommended frequency of surveys for each methodological approach

Methodology	Recommended Frequency of Survey	Comment
No Survey	N/A (i.e. No Survey)	
Basic Survey	2-3 years	Use initial survey results to refine energy intensities that are used in survey and subsequent non-survey years (until next survey is deployed)
Enhanced Survey	2-3 years	Use initial survey results to create energy intensities that are used in survey and subsequent non-survey years (until next survey is deployed)

Conclusions

This methodology attempts to provide guidance on a topic which historically has been sparse. We acknowledge that our recommended approaches and emission intensities are limited by existing published data and applied assumptions. We fully expect that the methodologies and intensities within this document will continue to evolve as more comprehensive and better-quality data on remote working become available. We would welcome opportunities to collaborate with businesses, thought leaders and other agencies to create more robust and consistent guidance. In the interim, we welcome user validation and feedback on improvements, which would be valuable input into future updates of this guidance.

We also recognize the development of other methodologies. As a Natural Capital Partners assessment partner, our results following the No Survey approach in this paper align with their other assessment partners' results for an initial test case.

We anticipate the following refinements:

- Baseline energy intensities: increase the number of countries included in the regional averages and continue to compare widely accepted public data sets
- Incremental energy intensities: use future studies, data and methodologies to amend or replace our current approach for determining these intensities

Despite current limitations, this guidance may be used by businesses to evaluate, provide insight and support decision-making on:

- The impacts and benefits of strategically reducing their operational real estate footprint to increase remote working among its employee base regionally or globally;
- The shift of operational energy consumption and GHG emissions (i.e., Scope 1 and 2) to the value chain (i.e., Scope 3 in employees' homes);
- The shift of transportation commute emissions to remote work commute emissions;
- The financial implications of remote working and addressing climate impacts - for example, the cost difference between reducing operational costs and mitigating GHG emissions for its employee working remotely (e.g. through the purchase of Renewable Energy Credits (RECs) and offsets).

Overall, it is our hope that this guidance will enable businesses to make the necessary changes as they navigate the current turbulence in the abrupt shift to remote work—to become more resilient and sustainable going forward—while remaining transparent in their activities.

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