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Determining commuting greenhouse gas emissions abatement achieved by information technology enabled remote working

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Abstract

Research indicates reduced commuting [1, 2] in 2020 has significantly lowered greenhouse gas emissions [3]. As transportation generates 14% of global GHG emissions [4, 5], reducing commuter emissions is key to a sustainable future and achieving international GHG abatement targets [6]. The United Nations (UN) indicates combining existing technology innovative and behavioural changes has the potential to transform societies and reduce GHG emissions [7]. Doing so will bridge the current projected emissions gap to slow global warming to 1.5°C by 2050 [8]. This research proposes that IT enabled remote working is capable of delivering innovation and behavioural changes to significantly contribute to this goal. To determine the percentage of GHG emissions abatement achieved by remote working, this research measures 815 employees across a 2-year time horizon, spanning both pre and COVID-19 periods. The results indicate remote working reduced commuting emissions by 43% in 2019 and 97% in 2020, generating a per capita abatement value of 1.9 tCO₂e. Examining the commuting data generated by the employees in twenty-four countries using twelve forms of transport, the research quantifies the impact of returning to a ‘new normal’ when commuting recommences. The results indicate that now the question of whether remote working is feasible for a wider audience has been proven by enforced business continuity in 2020, three key factors must be examined to ensure commuter emissions do not revert or exceed 2019 values. These include leveraging the benefits of work life balance delivered by remote working, awareness of the environmental impact of commuting and adoption of zero carbon transportation. In doing so, the statistics indicate that whilst employees will return to the office, future abatement of 60% is achievable in the ‘new normal’.

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1. Introduction

Accelerated by the Industrial Revolution, human activities known as anthropogenic interference have already caused 1.0°C of global warming. 1.5°C will be reached between 2030 and 2052 if emissions increases continue at the current rate [8]. However, scientists calculate that reaching and sustaining net zero global anthropogenic CO₂ emissions by mid-century, will halt global warming on a multi-decadal scale and temperature gains will begin to peak [8]. To achieve this goal, the world cannot rely solely on key strategies such as renewable energy, sustainable transport and building efficiency. Prevailing evidence indicates that rapidity of global adoption will not be sufficient to bridge the current 32GtCO₂e gap between success and failure [7]. Alternatively, all aspects of human pollutant activities must be examined and abatement alternatives researched and diffused [8].

The United Nations suggests that to succeed, the world must combine technological innovation with behavioural changes to reduce societal emissions [7]. In simple terms, both national and international political, administrative and scientific bodies suggest that humankind needs to examine technologies used in everyday life to enable humankind to become more sustainable. As sustainability is defined as the principle of ensuring that our actions today do not limit the range of economic, social, and environmental options open to future generations [9], then all activities must arguably be in scope and prioritised according to their impact. Future technologies able to bridge the emissions void, such as heat pumps and carbon capture storage do exist, although like renewables and electric vehicles they cannot be brought into immediate effect. This is due to issues such as product development, infrastructure limitations, early adopter reluctance and initial high cost [10, 11]. What can be brought into immediate effect, is information technology. Used innovatively to deliver behavioural change in the way we work; it is suggested that IT enabled remote working can deliver significant greenhouse gas emissions reduction. As an example, in the United Kingdom (UK) transport is the largest contributor to GHG emissions at 26% of the national total caused by 808bn annual passenger kilometres [12]. Of this vast cumulative distance, 18% is due to commuting and specifically, 68% of all business journeys are made in a car. Consequently, in the UK, 98.9bn car commuter kilometres are travelled each year [12].

Accounting for all car propulsion and fuel types, including ultra-low emissions vehicles (ULEV) [13,14], commuting by car in the UK created 17,418,125 tCO₂e GHG emissions in 2019 [12]. This level of pollution requires an estimated 22.7m acres of forest to sequester via photosynthesis [15]. Considering that the UK has only 7.9m acres of forest coverage currently [16, 17], this single source of emissions created by car commuting outstrips the country's natural ability to clean the local atmosphere by almost 200%. As such, research indicates that 'commuting to access IT' (CAIT) represents a significant abatement opportunity [6] and concomitant emissions could be reduced by the adoption of remote working enabled by IT. Realistically, not all workers are able to conduct their role remotely and therefore cannot reduce their commuter car miles. For example, 57% of the United States workforce are frontline workers and of those employees, only 49% utilise mobile devices [18]. However, as the recent coronavirus pandemic has highlighted, there remains a high number of employees within the public and commercial sectors globally that can work effectively from home, with over 55% of information workers enabled with mobile devices [18]. Simplifying the abatement possibilities, working remotely for two days per five-day week would reduce commuting emissions by 40%. Theoretically, moving to permanent home working removes the emissions entirely. For many, this transformation become a reality during the pandemic and certainly hastened business continuity planning accelerated remote working in some countries from as little as 4% to over 50% [19].

Whilst, this emergency and possibly short term measure will have delivered an environmental benefit by reducing commuting emissions, companies will return to an office based culture in the future when the pandemic is overcome [1,2,18,19]. The rationale being that the transformation is not permanent and both employees and employers will need to adjust to a balance between the old and new way of working. Research indicates a variety of return to workplace projections including a 20% increase in remote workers by 2024 [18], one quarter of businesses suggesting 10% of their workforce will remain permanently remote [1] and 41% of the workforce retaining an element of remote working moving forward [1]. Whilst it is not known what that new model will exactly look like, determining the impact within real life scenarios may help organisations and employees to find harmony in the work

life balance. As such, in order to examine the positive environmental impact of IT enabling remote working, this research paper uses survey techniques to measure the commuting activities of employees of an international cloud technology company for both business-as-usual travel in 2019 and a one-year period during the pandemic covering 2020 and early 2021.

The results track 815 employees working in four continents and using a variety of commuting modes. Key topics are discussed including miles travelled and abated, preferred transportation modes and their differing impact on pollution, attitudes towards climate change, remote working behaviours and ultimately the related reduction in GHG emissions created by remote working.

2. Methodology

The objective of the research is to measure the real life GHG emissions abated by remote working in a large company during two one-year periods before and during the pandemic. The rationale being that quantifying the values by sum, frequency, transport mode, geography and attitude will enable a discussion related to future impact when the current blanket travel ban is lifted.

Defined as an organisation employing more than two hundred and fifty people, a suitable candidate was identified within the technology vertical. Conducted online in accordance with ESOMAR principles [20], a survey was generated and supported by the Chief Executive Officer (CEO) and Chief Marketing Officer (CMO) that received responses from 815 employees.

The questions were designed to identify how many days per week remote working occurred, the distance travelled during a standard return commuting journey when not remote working, the frequency of this journey, what mode of transport was used, where the commuting occurred and what the individual's attitude is towards the importance of climate change. Ahead of answering the questions, a must read statement was included to ensure that the respondent understood that the research was to identify scope 3 [21] commuting emissions and not business mileage related to customer external meetings. Additionally, a selection box for miles or kilometres was included as the target employees were international. The five questions asked were:

- i. How many days each week do you normally work from home (before COVID 19 restrictions)?
- ii. How many miles/km would you usually commute to work and back on an average single day (return journey) before the current COVID 19 travel restrictions? Please enter the total miles/km for one return journey.
- iii. What is your predominant commuting mode of transport for commuting?
- iv. What geography, country or region do you work in?
- v. If 10 is the highest importance, how important to you is reducing your carbon footprint?

The questions were worded based upon the fact that when the survey was conducted, the software company had just announced a global lockdown of all office buildings. As such the approach was to determine the answers for normal behaviour and then compare the results to zero commuting and a future return to work. The company retained the complete commuting ban for 12 months (and more) thus enabling accuracy of comparison.

All emissions calculations are undertaken using specific mode of transport carbon intensity conversion factors related to the region in which the commuting was undertaken [14,22] in line with international GHG accounting protocol [21].

3. Results and discussion

The technology company operates globally and is organised into three geographic regions. Eight hundred and fifteen employees from twenty-four countries responded to the survey during April 2020; represented by 62% from

the Americas, 13.5% Asia Pacific and 24.5% from Europe, the Middle East and Africa (EMEA). Globally, 72% of employees included remote working as part of their routine, spending an average of 2 days per week away from the office before coronavirus travel restrictions were introduced. The remaining 227 employees worked permanently from company offices. Eighty-seven percent of employees (705 people) indicated that they commute, travelling an average of 71km per day. Whilst 13% (110 people) worked remotely at all times. Employee transportation modes included 74% by combustion propelled car, 8% train, 5% hybrid car, 4% electric car, 2% taxi, 2% motorbike, 2% bicycle, 2% walking, 1% bus and less than 1% on aircraft. Consequently, in 2019 employees commuted 6,845,821km to access IT generating 1,025,072 kgCO₂e GHG emissions and a per capita value of 1,258 kgCO₂e. The total emissions require an estimated 1,230 acres of forest to sequester the pollution, indicating that for each employee 1.51 acres is required annually to offset commuter emissions.

Transportation related GHG emissions differ globally due to a variety of factors including land mass, city distribution, commerce and infrastructure that influence distances travelled plus the mode of transport and its regional efficiency. As an example, the primary source of global GHG emissions is human activity including electricity, heat production and other energy (35%), agriculture, forestry and other land uses (24%), industry (21%), transportation (14%), and buildings (6%) [4]. In the United Kingdom (UK) GHG contributions differ due to the influencing factors. As such, transport, rather than energy, is consequently the largest contributor at 26% caused by 808bn annual passenger miles [5] dominated by a continued reliance on combustion engine propelled vehicle.

In the Americas, the number of remote working days matched the global value. Eighty-five percent of employees (426 people) indicated that they commute, travelling an average of 80km per day representing a 13% increase on global averages. Whilst 15% (78 people) worked remotely at all times, 27% indicated that they worked permanently from a company office. Employee transportation modes included 87% by combustion propelled car, 6% hybrid car, 4% electric car, 1% aircraft, 1% walking and 1% train. Consequently, in 2019 employees in the Americas commuted 4,509,411km, representing 66% of global kilometres travelled. This generated 744,558 kgCO₂e GHG emissions, representing 73% of global emissions, creating a per capita value of 1,477 kgCO₂e. The total emissions require an estimated 893 acres of forest to sequester the pollution, indicating that for each employee 1.77 acres is required annually to offset commuter emissions. The Americas per capita pollution proved to be the highest of all three regions, exceeding Asia Pacific by 119% and EMEA by 43%. This was arguably surprising as Asia Pacific employees commuted on average for one extra day per week with twice the number of staff working from an office permanently. The cause was due to three key factors of distance, mode of transport and localised transport inefficiency. Firstly, in the Americas the average commuting distance was 64% higher than in Asia Pacific. Secondly, nine out of ten commuters opted for combustion propelled cars compared to Asia Pacific's five out of ten. Thirdly, the excessive reliance on car transportation was exacerbated by cars in the Americas being 40% less fuel efficient than European and Asian vehicles, thus increasing the carbon intensity per kilometre.

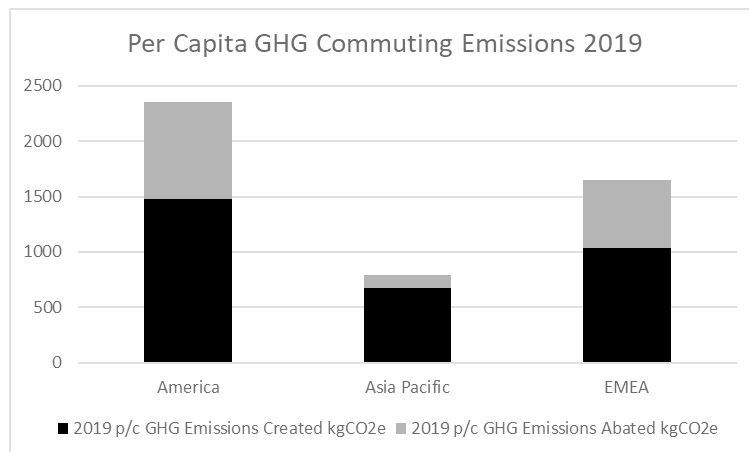


Figure 1 Global Per Capita Commuting Emissions 2019

In Asia Pacific, the number of remote working days was half the global value at one day per week. Ninety percent of employees (99 people) indicated that they commute, travelling an average of only 29km per day representing a 59% reduction on global averages. Whilst 10% (11 people) worked remotely at all times, 54% worked permanently from a company office. Employee transportation modes included 54% by combustion propelled car, 13% by train, 12% by taxi, 7% motorbike, 6% electric car, 5% bus, 1% bicycle and 1% walking. Consequently, even with an additional day of commuting per week, in

2019 employees in Asia Pacific commuted 548,722km, representing only 8% of global kilometres travelled. Whilst the region's workforce is 14% of the global total employees, the resulting 73,981 kgCO₂e was proportionate to 7% of global emissions. This is a per capita value of 673 kgCO₂e. The total emissions require an estimated 89 acres of forest to sequester the pollution, indicating that for each employee 0.81 of an acre is required annually to offset commuter emissions. The per capita pollution proved less than half the value of that reported in the Americas despite the western counterparts working from home on average twice as much per week as noted. The achievement is directly attributed to the shorter average journeys combined with more sustainable modes of transport. As an example, Asia Pacific employees utilise public transport for 18% of journeys whereas the Americas achieved only 1%. As a result, not only did the carbon intensity of fuel reduce per commuting km, the adoption reduced the reliance upon car travel by 37%.

In EMEA, the number of remote working days matched the global value of two per week. Ninety, percent of employees (180 people) indicated that they commute, travelling an average of 72km per day, again reflecting the global value. Whilst 10% (21 people) worked remotely at all times, only 16% worked permanently from a company office. Employee transportation modes included 55% by combustion propelled car, 20% by train, 6% bicycle, 5% walking, 3% hybrid car, 3% electric car, 3% bus and 2% motorbike. Consequently, in 2019 employees in EMEA commuted 1,787,688km, representing only 26% of global kilometres travelled. This generated 207,277kgCO₂e GHG emissions, representing 20% of global emissions and creating a per capita value of 1,031 kgCO₂e. The total emissions require an estimated 249 acres of forest to sequester the pollution, indicating that for each employee 1.24 acres is required annually to offset commuter emissions. The per capita pollution for EMEA is 30% lower than the Americas and 53% higher than Asia Pacific. With twice the number of remote working days are undertaken in EMEA compared to Asia Pacific, the increase is due to the average commuting distances being 2.5 times higher. However, the ability to remain a third lower than the Americas is achieved by the high adoption of public transport (25%) and zero environmental impact modes such as cycling and walking at 11% compared to the Americas at 1% and 1% respectively and more fuel efficient cars.

3.1. GHG commuting abatements enabled by IT

To ensure that all employees are able to work remotely should they wish to, the technology company deployed a Citrix digital workspace solution [23]. Employing zero trust security and threat analytics capabilities, the virtual desktop infrastructure enables desktop and applications to be securely accessed on any device from any location. As such, in 2019, the approach enabled 72% of global employees to work remotely. 217 (27%) opted for one day at home, 161 (18%) for two days, 59 (7%) for three days, 41 (5%) for four days, 110 (13%) for five days, whilst 227 (28%) of employees chose to work from the office full time. The 110 staff already working from home permanently indicated that had office working been mandatory, then their return commute journeys would have averaged 49km daily. The transportation choices would have included 74% (81) fossil fuel propelled car, 7% (8) walking, 7% (8) specified only as other, almost 4% (4) bicycle, 3% (3) electric car, 3% (3) train, 2% (2) taxi and just below 1% (1) hybrid car. Reflecting the global reliance on car travel, the main difference in those working from home to the commuter group is the 10% indication that their commute would involve zero impact modes such as walking and cycling. In this instance, those capable of utilising a bicycle to commute would travel on average 10km whereas those walking lived within one to two kilometres of the office.

Consequently, for those working at home permanently in 2019, the 31% reduced average journey distance and sustainable transport choices mean that the commuting emissions values avoided were 209,336 kgCO₂e. This creates an elevated group per capita abatement value of 1,903 kgCO₂e, up 131% when compared to the commuter group. The total emissions avoidance frees an estimated 273 acres of forest from sequestering commuting pollution. This indicates that for each employee choosing to work from home permanently, 2.48 acres is not required to sequester emissions. The remaining commuter group consisting of 705 people, as discussed, averaged 2 days per week working remotely. As such, triangulating individual remote working statistics with transportation carbon factors and distance travelled, the commuters avoided 579,995 kgCO₂e transport GHG emissions in 2019. This creates a commuter group per capita abatement value of 823 kgCO₂e. The total emissions avoidance free an estimated 757

acres of forest from having to sequestering commuting pollution. This indicates that for each employee choosing to work from home on average two days per week, 1.07 acres is no longer required to offset emissions. Combined, in 2019, the IT remote working solution deployed by the technology company enabled the 815 employees to avoid the generation of 789,331 kgCO₂e scope 3 commuting GHG emissions. This creates a per capita abatement value of 969 kgCO₂e. The total emissions avoidance free an estimated 1,031 acres of forest from having to sequestering the commuting pollution. This indicates that for each employee choosing to include remote working as part of their working behaviour, 1.27 acres of mature forest is no longer required to offset emissions.

Whilst during 2019 IT enabled remote working delivered substantial GHG commuting abatements, 2020 inadvertently surpassed all expected improvements to the sustainability metrics. In early February, travel restrictions were set in place for employees in China, and by mid-March a global remote working policy was announced that lasted to the end of the year and beyond. Consequently, due to the initial regional commuting restrictions and all employees working from home for nine months, commuting emissions in 2020 declined by almost 75% to 256,052 kgCO₂e. This created a new per capita value of 314 kgCO₂e compared to the previous year value of 1,258 kgCO₂e. The total emissions require an estimated 334 acres of forest to sequester the pollution and represent a reduction of 896 acres compared to 2019. For the travel restricted year, the data indicates that for each employee 0.41 acres is required annually to offset commuter emissions; a value of 1.1 acres less per employee than in 2019. The reduced commuting GHG emissions consequently increased the abatement values by 97% compared to the previous year. As such, the IT remote working solution enabled the 815 employees to avoid the generation of 1,558,351 kgCO₂e scope 3 commuting GHG emissions. This 769,020 kgCO₂e improvement creates a per capita abatement for 2020 of 1,912 kgCO₂e compared to 969 kgCO₂e in 2019. The restricted commuting total emissions avoidance frees an estimated 2,035 acres of forest from having to sequestering the commuting pollution and represents an increase in twelve months of 1,004 acres. This indicates that for each commuting employee forced by the pandemic to work remotely and for each of those who already choose to include remote working as part of their working behaviour, 2.5 acres of mature forest is no longer required to offset emissions. This value represents an additional 1.2 acres relieved during 2020. Considering that the total forest land mass no longer required is equal to 8.2 km² and more than four times the size of Monaco, this is arguably a positive environmental outcome for the eight hundred and fifteen employees who each played a part in releasing almost 2.5 acres each by reduced commuting in 2020.

3.2. *New normal' IT enabled remote working behaviours*

With the lifting of travel restriction and office access in 2021, it is reasonable to state that there will initially be a desire to re-enter the office and engage in person with colleagues. As noted previously, research projections agree that there will certainly be an increase in remote working [1,2,18,19]. However, the success of IT enabling GHG commuting emissions abatement via remote working in the longer term will rely on three factors. Firstly, working behavioural changes driven by experiencing remote working. Secondly, people's attitude towards reducing their carbon footprint. Thirdly, by instigating long term behaviour changes related to transportation modes. In the first instance, it is too early to accurately determine whether employees will wish to hold onto the work life balance afforded by remote working or revert to the same working behaviours displayed in 2019. However, prevailing research indicates that three quarters of employees would welcome the ability to remain a remote worker. The sentiment was in fact so strong that the employees would accept a 14% pay decrease to do so [24]. Arguably, it is unlikely that all 815 employees would remain permanent remote workers for the long term. Whilst the 2020 figures already highlight the abatement for such a scenario, encouraging those who are not already achieving the average remote working days indicated in 2019 would make a significant difference. Theoretically, if the company mandated a working behaviour that required a minimum of two days remote working in all regions for all employees, commuting emissions would reduce by 20% to 827,474 kgCO₂e and abatements would increase proportionately by 25% of the new total to 986,930 kgCO₂e.

In the second instance, the 815 employees collectively noted a '7.5' score when asked, 'If 10 is the highest importance, how important to you is reducing your carbon footprint?'. Whilst no accurate gauge of intention, the fact that the results are in the upper quadrant indicate an axiology of positivism towards actions that may reduce

pollution. Asia Pacific's positive attitude towards environmental impact exceed the Americas by 19% at 8.7. Comparatively, the Americas per capita GHG emissions value is 93% higher than Asia Pacific. As previously discussed the 74% reliance on car travelled compared to Asia Pacific (54%) combined with extended commuter distances is key to this disparity. Considering that Asia Pacific appears to have already exercised the adoption of more sustainable transport driven by its opinion of carbon footprint reduction then it is fair to state that increasing awareness and therefore improved attitude in the Americas (and EMEA) may prove an important factor. To support this view, prevailing research suggests that of all the resistance factors preventing the adoption of sustainable practices, a lack of awareness and subsequent impact perception can increase barriers by between 20-30% [25].

Relating to the third point, if increased levels of sustainable travel could be adopted through awareness programs related to the carbon intensity of differing transport modes, then further impact could be added to the values created by unifying the minimum number of remote working days. Naturally, switching fossil fuel cars for more sustainable transport modes such as electric cars and public transport that produce x37 and x4.6 less GHG emissions per km [14], will significantly reduce commuter emissions. Whilst the former will come to fruition slowly and organically as legislation ceases the production of petrol and diesel cars from 2030 onwards, validity of any suggested adoption level ahead of the market within the commuter group would be speculation. The rationale being that in order to create an accurate projection additional data such as affordability and available charging infrastructure not gleaned by this research would be required. Additionally, the available data does not geographically confirm if public transport links and schedules are available to all employees as post and zip code location data was not collected. As such, where an assessment can be made in order to highlight the benefits of sustainable transport is in relation to an adoption of zero impact transportation. The data indicates that the average commuting bicycle return journey is 7km and the average walking journey 3.2km. As such it is feasible, unless physically unable, for employees to conduct any commute of up to 7km daily by a form of zero carbon transport. Globally, there are 98 employees with a round trip journey of less than 7km who are not currently walking or cycling. Statistically, 92% (90) travel by fossil fuel propelled cars. Encouraging this group, representing 12% of employees, to switch to cycling or walking in conjunction with the new extended remote working mandates would further reduce commuting emissions by 5,247 kgCO₂e per year. Consequently, with what could be seen as a relatively uncomplicated transport program, the company could reduce total commuting to access IT emissions a further 0.6% to an annual figure of 822,227 kgCO₂e. This new normal would create a per capita value 1,008 kgCO₂e and delivering a reduction of 20% when compared to 2019. The total emissions require an estimated 1,074 acres of forest to sequester the pollution, indicating that for each employee 1.32 acres would be required annually to offset commuter emissions

4. Summary and conclusion

As noted, the UN suggests that to succeed in bridging the 32GtCO₂e GHG emissions gap, the world must combine technological innovation with behavioural changes to reduce societal emissions [7]. Whilst future technologies such as common place carbon capture and wholesale adoption of renewable energy will become a reality; this research both identifies and quantifies the immediate availability of IT to enable remote working and deliver innovation that drives working behaviours and lowers GHG emissions. As indicated by the emissions reduction figure for 2020, it is substantiated that IT enabled remote working can deliver commuter GHG abatement by, in this extreme scenario, 86%. In reality the current determination is that for this technology company the 'business as usual' abatement value is 43%. Considering that the original hypothesis suggested an average of two days theoretically delivering a 40% reduction, then the results indicate that this is true when examining a company working five days per week for one year. The focus moving into 2021 as commuting restrictions lift must be upon recognising that IT enabled remote working does support sustainable practices and GHG abatement. As such, the 'new normal' should include both an increase on pre COVID-19 home working instances coupled with an adoption of more sustainable transport modes where feasible. These modes should include the natural transition to electric vehicles plus increases in public transport utilisation and zero carbon activities such as cycling. Doing so, as demonstrated by a mandated average number of remote working days per week and an incremental shift to sustainable transport example, can increase the ability IT to abate GHG emissions by a further 20% to 60% in a 'normal' year. In isolation, applying the findings and recommendation for future remote working to the 17.4m

tCO₂e commuting emissions experienced annually in the UK [12] would arguably deliver an incremental 20% reduction. As such, a further 3.5m tCO₂e could be avoided annually in the UK if remote working behaviours accelerated by the pandemic are examined and built into the culture of our working lives. Extrapolate this globally and the cumulative abatement would begin to bridge the 32GtCO₂e as we head towards 2050. In conclusion, the prospect of increasing the average 40% reduction to 60% annually using IT to enable remote working is a technological innovation that is worthy of continued global adoption in the years beyond the coronavirus pandemic. With small and arguably beneficial increments great change can be delivered by technological innovation that is not something from the future, but available immediately and already proving its worth.

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