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DOES TELEWORKING REDUCE GREENHOUSE GAS EMISSIONS? CONTEXT AND METHODOLOGICAL IMPLICATIONS

By Martín Bonzi, Aspen Global Change Institute

This year, teleworking became increasingly used worldwide due to the COVID-19 pandemic. Employers adopted this modality as a safety policy to protect employees and citizens from the virus (Belzunegui-Eraso et al., 2020). Teleworking is not new—it dates to the 1960s when information and communication technologies (ICTs), such as telephones and fax machines, first presented the technical capability to work from home. Then, teleworking was promoted as a social policy that afforded workers increased time with families due to decreased commutes. It wasn't until the mid-1990s, when internet and teleconferencing became widely adopted and climate change became increasingly prominent within popular discourse, that telecommuting started to be seen as an environmental or energy policy (Hook et al., 2020).

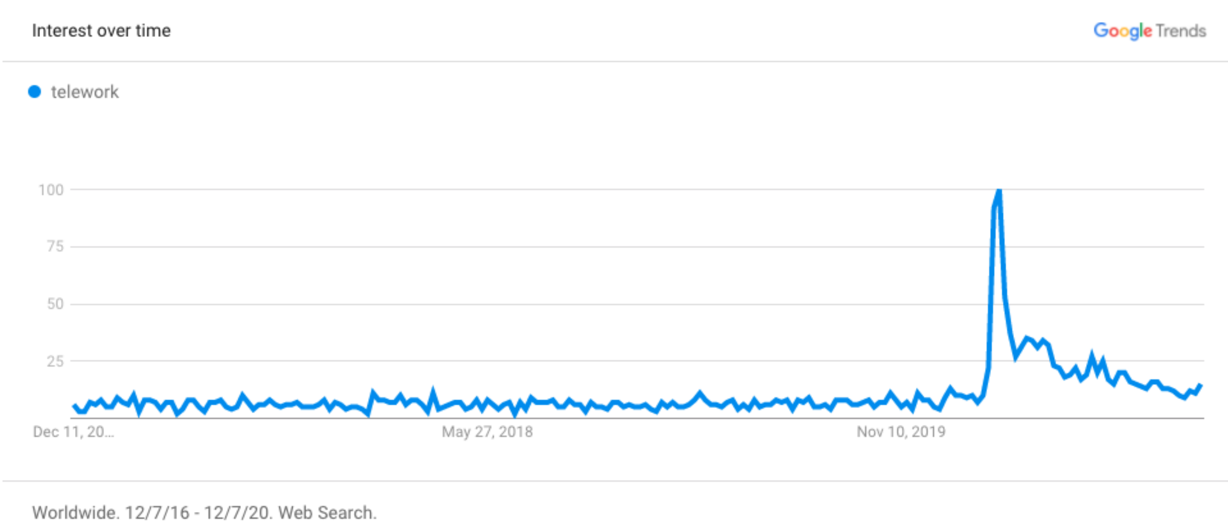

Figure 1. *Evolution of worldwide searches for the term "telework" on Google for the last 4 years. Interest over time represents search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. In this case, peak popularity is for March 2020, when governments mandated lockdowns in many countries around the world due to the first wave of the COVID-19 pandemic. Source: Author's own elaboration from Google Trends data.*

Much research has been conducted in recent years to determine if teleworking reduces greenhouse gas emissions and how effective teleworking is as an environmental or energy policy. One contribution by Hook and colleagues in *Environmental Research Letters* synthesizes the results of 39 empirical studies they identified through a comprehensive search of 9,461 published articles. The authors highlight the range of "direct" and "higher-order" effects of using ICTs for teleworking (Figure 2). These effects can be very difficult to measure, as they are usually unexpected and unintended.

For instance, reductions in commuting and office energy use reduces overall energy use and emissions. But the manufacturing, use, and disposal of ICT equipment for teleworking directly increases energy usage and emissions. Increases in emissions can also come from longer commutes on non-teleworking days (as telework can incentivize workers to take jobs that are farther away from their homes), more non-work travel (in response to feelings of isolation and sedentariness generated by teleworking), and additional travel by members of the teleworking household (due to increased availability of household vehicles). Energy consumption at home for cooling, heating, lighting, and other work-related uses can also increase emissions (without commensurate reductions in the energy used at the office). These are all higher-order effects that increase energy use and emissions.

(Pohl *et al* 2019) aggregate categories		(Horner *et al* 2016) aggregate categories	Impact mechanism (+ or − impact on energy consumption)	Teleworking example
Direct impacts	Technology perspective	Direct	Embodied energy (+)	Energy used to manufacture the ICTs and associated infrastructure needed to support teleworking
			Operational energy (+)	Energy used to operate the ICT equipment for teleworking, including cloud storage and video streaming
			Disposal energy (+)	Energy used to dispose of the ICT equipment for teleworking
Higher-order impacts	User perspective	Indirect: single-service	Efficiency/Optimisation (−)	(Does not apply in this example)
			Substitution (+ or −)	Energy saved by avoiding commuting to the office
			Direct rebound (+)	Energy consumed in longer commuting trips, owing to the availability of teleworking encouraging people to take jobs that are further away from home
		Indirect: complementary services	Indirect rebound (+ or −)	Energy used for heating (or cooling) the home during days in which the commuter is working from home
	System perspective	Indirect: economy-wide	Economy-wide rebound (+ or −)	Energy used and saved in multiple markets owing to economy-wide adjustments in prices and quantities (e.g. investments previously made in the car industry are now redirected towards ICTs).
		Indirect: society-wide	Transformational change (+ or −)	Energy used and saved because of far-reaching changes in the spatial structure of societies, including where people live and work.

Figure 2. *Classifying the mechanisms influencing the impacts of ICTs on energy consumption. In the case of teleworking, the substitution effect is normally considered to be the most significant. Source: Hook et al., 2020.*

Given this complexity, accurately estimating teleworking's net energy impacts requires studies with as broad a scope as possible. However, considerable methodological challenges exist in designing studies that capture the full range of teleworking impacts. As a result, the methodological quality of the 39 empirical studies reviewed by Hook varies (Figure 3).

Methodological quality of study	Study assessment of impact of teleworking impact on energy				
	Reduction	Neutral	Increase	Unclear	*Total*
Good	7	1	5	1	*14*
Average	8	2	-	1	*11*
Poor	11	-	-	3	*14*
Total	*26*	*3*	*5*	*5*	*39*

Figure 3. Methodological quality of studies mapped against the impacts of teleworking. Source: Hook et al., 2020.

While 26 of the 39 studies conclude teleworking contributes energy savings, more rigorous studies or those with a broader scope present more ambiguous findings. The authors conclude that given the uncertainties and complexities around the scopes and methodologies of these studies, we should cautiously draw conclusions about the scale and consistency of energy savings from teleworking.

Context is key, and many scenarios could result in negative or non-existent savings. Multiple factors affect energy savings, including carbon intensity of the energy used for transportation (conventional versus electric vehicles, personal versus public transport, etc.) as well as for cooling, heating, and powering buildings, or how people use time saved by not having to commute. Much of this data can only be gathered by qualitative methods, so modelers must collaborate with other social scientists to capture the energy saving potential of new practices.

Another recent review paper, published by O'Brien and colleagues in *Energy and Buildings,* arrives at a similar conclusion: This problem is complex once the scope is expanded to include home office energy use, the internet, long-term consumer choices, and other so-called rebound effects (Figure 4). The authors point to the COVID-19 pandemic along with the shift toward a knowledge-based economy and concerns around climate change as long-term drivers of increased teleworking. The researchers recommend increasing personal and public vehicle electrification and adapting building codes and technologies to accommodate varying levels of occupancy and use.

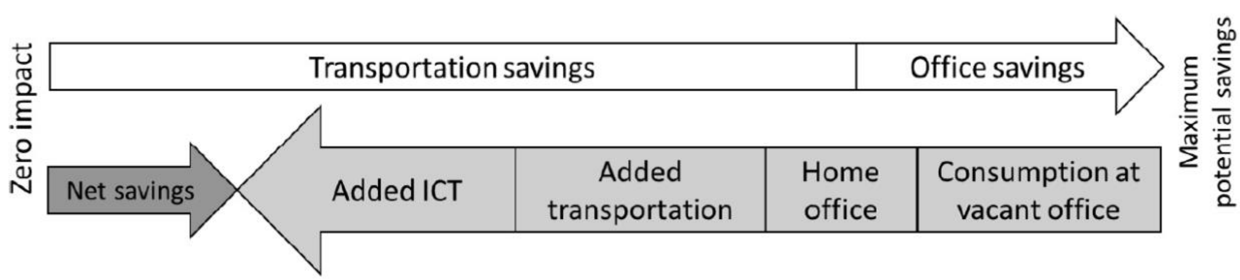

Figure 4. *Conceptual illustration of primary potential for net energy savings from telecommuting and rebound effects. It is noteworthy that a net impact can be negative if the rebound effects are larger than the savings. Source: O'Brien et al., 2020.*

Finally, a recent paper by Pomponi et al. in *Environmental Science and Technology Letters* uses a novel global multiregional macro-economic model, complemented by Google Community Mobility Reports (CMRs) and national transport data, to estimate emissions reductions caused by pandemic-imposed mobility restrictions and, specifically, impacts from teleworking. Google

CMRs indicated that visits and lengths of stay in workplaces decreased globally by 24.4 percent on average. Under an assumption that office building energy consumption decreased at least 50 percent, the authors found positive net energy savings for the substitution of working from office to home, as well as from reduced commuting. Besides greenhouse gas reductions, researchers also found significant reductions in other pollutants such as sulfur dioxide, nitrogen oxides, and particulate matter 2.5. The researchers identified teleworking and a drop in work-related travel to be the most feasible and long-lasting practice to reduce work-related emissions.

These papers show teleworking has the potential to significantly reduce greenhouse gas emissions, but the level depends entirely on context. If decreased office energy use and commuting are offset by increased home energy use and personal travel, emissions reductions can be minimal or, in some cases, emissions may even increase.

Featured Research

Belzunegui-Eraso, A., Erro-Garcés, A. (2020). Teleworking in the context of the Covid-19 crisis. MDPI Sustainability, 12(9), 3662. https://doi.org/10.3390/su12093662

Bojovic, D., Benavides, J., Soret, A. (2020). What we can learn from birdsong: Mainstreaming teleworking in a post-pandemic world. Earth System Governance, 5, 100074. https://www.sciencedirect.com/science/article/pii/S2589811620300331

Hook, A., Court, V., Sovacool, B. K., Sorrell, S. (2020). A systematic review of the energy and climate impacts of teleworking. Environmental Research Letters, 15, 093003. https://iopscience.iop.org/article/10.1088/1748-9326/ab8a84/meta

O'Brien, W., Yazdani Aliabadi, F. (2020). Does telecommuting save energy? A critical review of quantitative studies and their research methods. Energy and Buildings, 225, 110298. https://doi.org/10.1016/j.enbuild.2020.110298

Pomponi, F., Li, M., Sun, Y., Malik, A., Lenzen, M., Fountas, G., D'Amico, B., Akizu-Gardoki, O., Anguita, M.L. (2020). A novel method for estimating emissions reductions caused by the restriction of mobility: The case of COVID-19 pandemic. Environmental Science and Technology Letters, 1021, 00764. https://doi.org/10.1021/acs.estlett.0c00764