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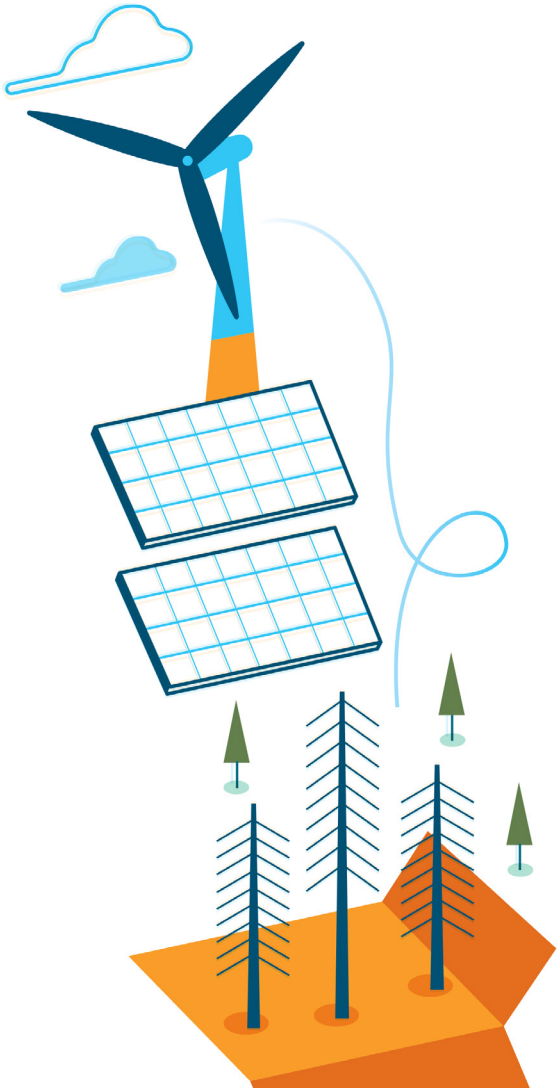
2022

Reaching Net-Zero Carbon by 2040:

Decarbonizing and Neutralizing the Use Phase of Connected Devices

Table of Contents



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Introduction

As part of our Climate Pledge commitment to reach net-zero carbon emissions by 2040, Amazon is working to measure, reduce, and neutralize the emissions across every part of our business. For Amazon Devices, we are integrating carbon reduction strategies across the life cycle of our devices, including materials and manufacturing, transportation, use, and end-of-life phases. This paper focuses on the use phase, which accounts for 10-15% of the overall carbon footprint of rechargeable battery-operated devices and 60-80% of the footprint of plugged-in devices. We believe this phase is an important area of focus, since consumer electronics will always require some amount of electricity to operate. As the world becomes more connected even beyond consumer electronics, we believe that connectivity in itself allows us to rethink how we approach use phase decarbonization for all connected devices.

In this paper, we lay out a four-part mitigation strategy for decarbonizing use phase emissions: 1) establish better measurement; 2) maximize energy efficiency efforts; 3) match the remaining electricity consumption with renewable electricity; and 4) neutralize the remaining emissions. First and foremost, in the world of connected devices, where devices can report on their own energy consumption, we must improve the way we measure the energy consumption of these devices beyond the current standard practices in the industry. With better measurement capabilities established, we must maximize any feasible energy efficiency opportunities that exist. Since use phase emissions are directly tied to energy production, we consider matching our energy consumption with new renewable energy production as the most effective and practical strategy for carbon mitigation of use phase emissions globally. Finally, we recognize that renewable energy technologies have embodied carbon emissions, and so we will invest in high quality carbon credits to remove or reduce the remaining carbon emissions through technological or nature-based climate solutions. Learn more about Amazon's approach to carbon neutralization.

At Amazon, we recognize that we cannot solve this challenge alone, and we are eager to invite other consumer electronics companies and connected device manufacturers to join the mission of driving to a net-zero carbon use phase.

Connected Devices and Increased Electrification

Connected Device: In this paper, we define a connected device as a device or physical object that is capable of connecting to the internet, directly or indirectly, and is either capable of reporting its direct energy consumption and/or data that allows for estimating its energy consumption with reasonable accuracy.

The number of connected devices has significantly grown in recent years. Based on the Total Energy Model (TEM) V2.0 (IEA EDNA, 2021), connected devices consumed 1.8% of total global electricity demand in 2018, a number that is projected to grow to 2.7% in 2030.[1] This projection underestimates the future scenario, as it excludes the large non-connected energy loads that will become a connected device or become controlled by a connected device (e.g., Smart Thermostats and HVAC systems, etc.) in the future. At the same time and as awareness for the climate crisis increases, a move to "electrify everything" is occurring, which includes vehicles, residential heating and cooling, water heating, cooktops, and more. This shift will result in large energy demands from HVAC, water heating, appliances, vehicles, and other products moving from fossil-based, non-smart end uses to electrified, connected end uses. This will require a significant increase in electricity generation. Based on a 2020 study by Princeton,[2] widespread electrification will cause electricity demand to more than double in the United States alone. While electricity demand will increase with electrification, the majority of this additional load will be network-connected, enabling better measurement, control, and mitigation of the environmental impacts of consuming that electricity.

However, to ensure this mitigation occurs, manufacturers and brands behind all connected devices must evolve their products to be net-zero during operation. A net-zero carbon future cannot simply be achieved through connectivity or electrification, rather it must be a coordinated effort across the entire life cycle, from designing and manufacturing a product that efficiently uses electricity, to ensuring there is enough renewable energy capacity on the grid to accommodate that product's demand. This extended responsibility encourages manufacturers and brands of connected devices that consume electricity to actively participate in accelerating the net-zero energy transition. We believe we have outlined a practical approach for all manufacturers and brands to do just that, and we welcome feedback and collaboration on this approach.

Better Measurement

Today, most companies leverage the Greenhouse Gas Protocol's (GHGP) Scope 3 Guidance to measure the emissions associated with the use of sold products. Under the GHGP, a company must account for:

> *The direct use-phase emissions of sold products over their expected lifetime (i.e., the scope 1 and scope 2 emissions of end users that occur from the use of: products that directly consume energy (fuels or electricity) during use.*[3]

A key issue with this approach is that it relies on estimated lifetime energy-consumption values based on the year in which a product is sold, rather than relying on measured energy-consumption values based on annual product usage. Additional issues with the current state are summarized below:

1. *Estimating future usage based on assumptions about a product's lifetime may result in major discrepancies with actual emissions.*
2. *With connected devices, energy consumption can change over time, as new features are launched with over-the-air updates.*
3. *There is no accountability for the use phase emissions of a device after the year in which it is sold or visibility into changes that can occur over a device's lifetime.*
4. *Without real energy consumption measurements, there is no way to credibly contract additional renewable energy projects and retire their environmental attributes against the actual energy usage.*

With connected devices, we can now improve upon the GHGP Scope 3 guidance to more accurately measure energy consumption during device operation. For most connected devices, hardware changes for precise energy measurement are not needed. If a device is aware of its current operating state, it can obtain the energy consumption for this state from an internal database that is measured and created in advance. A 2018 study by the Swiss Federal Office of Energy[4] determined that accuracy within 10% can be achieved through this software-only approach, which would be a step-change improvement over the GHGP Scope 3 guidance.

At Amazon Devices, we are constantly evolving our measurement approach. Our current approach is to take lab-scale or field-based power measurements, along with aggregated data on the amount of time devices spend in each power state, to produce annual energy consumption values by device. We then collect aggregated data on the overall active number of devices in the field to calculate total annual energy consumption. We are constantly working on better ways to improve our measurement capabilities in cost effective and scalable ways, and we will share these capabilities with others as we achieve our goals.

Energy Efficiency Is Key

Once better measurement is established, our next decarbonization priority is minimizing energy consumption. The Energy Star program established by the Environmental Protection Agency (EPA) in 1992 is the most recognizable program for identifying and promoting energy-efficient products. Since then, Energy Star and its partners have helped American families and businesses save 5 trillion kilowatt hours of electricity, avoid more than $450 billion in energy costs, and achieve 4 billion metric tons of carbon reduction.[5] However, even with decades of voluntary (and in some cases regulatory) efforts on energy conservation, many products still use more energy than is required for their application. For many connected devices, energy efficiency standards do not exist or have lagged behind the industry. Energy efficiency standards are derived by creating a representative simplification of a given product, with specific use cases and thresholds. However, these standards may or may not actually be representative of the real world, as the feature set and operation of these devices continue to grow in complexity. Therefore, there is an opportunity to leverage the connectivity to drive energy efficiency in more real-time and in a more data-driven way. Energy efficiency plays an essential role in a net-zero carbon future because it is how we can serve the world's increasing energy demands with less overall energy production. This reduction in overall energy demand alleviates the pressure on building additional renewable energy capacity.

For Amazon Devices, we have developed energy efficiency features like Low Power Mode to reduce the energy that wall-powered devices consume during periods of inactivity, except in certain instances. In 2020, we added Low Power Mode to the latest models of Echo and Fire TV devices, and we are rolling out free over-the-air updates to bring Low Power Mode to the most popular older models of devices already in customers' homes. Low Power Mode goes beyond industry and voluntary standards for the purpose of reducing energy wherever technically possible, based on the data available to us. We are always looking to make additional efficiency improvements and remain committed to reducing customer electricity consumption.

Renewable Energy Matching

Once actions are taken to maximize energy efficiency, our priority shifts to generating additional renewable energy capacity equivalent to the energy demand of all of our devices. These additional renewable energy projects should be contracted in an amount at least equivalent to the total energy demand and the renewable energy produced by these projects should be tracked using environmental attributes. The source of generation, technology, vintage (when they were generated), and quantity of environmental attributes should be matched and allocated to the overall energy demand of connected devices in the field.

For Amazon Devices, we announced an ambitious goal in 2020 to procure new renewable energy equal to the amount of energy consumed by all Amazon Devices, starting with our Echo devices. We are making investments in additional wind and solar farm capacity that, by 2025, will produce the clean energy equivalent to the use of all Echo, Fire TV, and Ring devices worldwide, and we are well on our way to building enough renewable energy capacity to match the energy demand of 100% of Amazon devices.

Getting To Net-Zero

After energy efficiency efforts have been maximized and the energy demand of the product portfolio has been matched with additional renewable energy capacity, high-quality carbon credits that remove or reduce emissions in accordance with global standards should be used to neutralize the small amount of remaining use phase emissions that stem from the

embodied carbon required for the new renewable energy projects and transmission and distribution losses. It requires resources and energy to build these projects. This embodied carbon is insignificant with respect to the savings from avoiding fossil fuels for electricity generation; however, it is still necessary to address these emissions to achieve a truly net-zero carbon future. While these embodied emissions should also be reduced as much as possible through low-carbon materials and manufacturing, a product manufacturer or brand will likely have limited control over this, so neutralizing these emissions becomes the short-term practical way to get to an entirely net-zero carbon use phase.

As part of our commitment to The Climate Pledge, Amazon is continuing to innovate and invest in decarbonizing our businesses, while also supporting immediate action through the Right Now Climate Fund to remove or reduce carbon emissions through nature-based climate solutions. Our approach focuses on three actions outside of our value chain that climate science tells us can deliver needed mitigation and that have a significant unmet need for investment: (1) reducing deforestation to near-zero, especially in tropical regions; (2) scaling up the removal of carbon from the atmosphere with nature-based solutions such as reforestation and agroforestry; and (3) scaling up carbon removal technologies, such as direct air carbon capture and storage. Learn more about Amazon's approach to carbon neutralization.

Carbon Footprinting

We have established a carbon footprinting methodology to account for the carbon footprint benefits that come with better measurement and the decarbonization strategies outlined above. The improvements are summarized in Table 1. While this method departs from the current GHGP, we believe this advancement makes use phase carbon reporting more accurate and actionable for connected devices.

Table 1: *Summary of Improvements in New Methodology*

Key Areas of Improvement	Old Methodology	New Methodology
Incentivizes Renewable Energy Matching	No	Yes
Annual Energy Consumption	No	Yes
Establishes Accountability to Products Already Sold	No	Yes

Methodology

In this method, we calculate the emissions associated with the use phase using the below equation.

$$ef_{Use,wRE,t,j} = \sum_{k=1}^{K} E_{t,j,k} * \left[\left(1 - \sigma_{t,j,k}\right) * \varphi_{grid,j} + \left(\sigma_{t,j,k}\right) * \left(\varphi_{T\&D,j} + \varphi_{RE_{Type},j}\right)\right] \qquad (1)$$

In this equation, average energy consumption (E_t) is calculated for some month (t), for some country (j), and for each product (K) using lab-based or field-based power measurements and aggregated data corresponding to how much time each device spends in each power state. To account for renewable energy matching, we take the renewable energy matching percentage ($\sigma_{t,j,k}$) for each country, month, and device, and apply the grid emissions ($\varphi_{grid,j}$) for unmatched consumption, while applying an average transmission and distribution ($\varphi_{T\&D,j}$) and average upstream embodied emissions factor for each renewable energy type ($\varphi_{RE_{Type},j}$) for the matched consumption.

The total Scope 3 contribution from the use phase is then calculated by summing use phase emissions across all countries and months based on the following equation:

$$Scope\ 3_{Product\ Use} = \sum_{t=1}^{T}\sum_{j=1}^{J} ef_{Use,wRE\ t,j}$$

This methodology is flexible enough to be applied at more specific location and time granularities that corresponds to a particular product's field data and renewable energy procurement practices. For Amazon Devices, we are currently applying this methodology at the monthly and country levels for time and location granularities.

Conclusion

With the climate crisis demanding all hands on deck, we believe the use phase of connected devices is an area that needs more attention. We need more manufacturers and brands to actively participate in reducing the impact of their product's operation through the application of the four-part mitigation strategy outlined in this whitepaper:

1. *Establish better measurement of the use phase for connected devices.*
2. *Maximize energy efficiency efforts across all connected devices, going beyond regulatory and voluntary standards.*
3. *Match the use phase consumption of your connected devices with new renewable energy projects.*
4. *After maximizing real business change in Parts 1-3, invest in carbon removal or reduction projects to neutralize the remaining embodied emissions associated with renewable energy technologies.*

We know that our mitigation strategy and accounting approach can always be improved. We invite other companies, product brands, and manufacturers to collaborate as we take action to drive the use phase of connected devices to net-zero carbon. We also know that not all companies can commit to all aspects of this approach, but we believe all companies should be measuring their product portfolio's overall energy consumption and setting targets for reduction. Collectively, we can raise awareness for the use phase impact of connected devices, while also converging on practical mitigation solutions to accelerate all products and the world to a net-zero carbon future.

[1] IEA 4E EDNA (2021), Total Energy Model V2.0 for Connected Devices. https://www.iea-4e.org/wp-content/uploads/publications/2021/02/EDNA-TEM2.0-Report-V1.0-Final.pdf
[2] E. Larson, C. Greig, J. Jenkins, E. Mayfield, A. Pascale, C. Zhang, J. Drossman, R. Williams, S. Pacala, R. Socolow, EJ Baik, R. Birdsey, R. Duke, R. Jones, B. Haley, E. Leslie, K. Paustian, and A. Swan, Net-Zero America: Potential Pathways, Infrastructure, and Impacts, interim report, Princeton University, Princeton, NJ, December 15, 2020. https://netzeroamerica.princeton.edu/the-report
[3] https://ghgprotocol.org/sites/default/files/standards/Scope3
[4] Swiss Federal Office of Energy SFOE (2018). Potential of Energy Aware Devices. https://www.iea-4e.org/wp-content/uploads/publications/2018/07/09c_-_potential_of_energy_aware_devices.pdf
[5] https://www.energystar.gov/about/origins_mission/impacts