

Original Research

Meeting the Net Zero Emissions Challenge – Alphabet’s Carbon Management Actions and Opportunities

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Abstract

The first step in managing an entity’s carbon emissions involves measurement as ‘what gets measured gets managed’ and measurement lies at the heart of carbon management. The study of carbon management is important to all stakeholders as it enables calculation of emissions that can help determine opportunities for emissions reductions to address climate change which can improve energy efficiency and brand reputation. Alphabet is an interesting company to study given its main commercial activities relate to the development and use of information technology and provision of online services. It relies heavily on online advertising for its revenue but also develops new technologies to make its operations more efficient which also have commercial applications. Also, although not directly involved in manufacturing hardware, its hardware suppliers and products generate significant emissions through their manufacturing and lifecycles. Alphabet, formerly Google, claims to have net zero emissions through carbon management by improving efficiency, purchases of renewable energy and offsets since 2007. As of 2019, their operational emissions were 5.7M t CO₂e which they managed to reduce for the 3rd year in a row to zero. Alphabet will solely use carbon-free energy to power their operations by 2030 through investment in renewable energy. Furthermore, they plan to invest in renewable energy projects in regions where their suppliers



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operate. Carbon management and addressing climate change is a challenge to Alphabet but it also provides it with opportunities through commercialisation and expansion of their technologies. This paper contributes to the field by reviewing how Alphabet estimate and reduce their reportable emissions and, in the process, create commercial opportunities for their technologies. The paper also highlights how a limited range of emissions are reported by Alphabet.

Keywords

Alphabet; net-zero; performance; google; carbon; emissions

1. Introduction

The management of carbon and the push to net zero carbon emissions is important to all and driven by companies for business and ethical reasons. Carbon Management aims to enable action to manage companies carbon footprints [1] to address climate change and to achieve emissions cuts in line with the 1.5°C pathway [2].

Carbon management involves companies developing an understanding, or baseline, of their activities and how they generate Green House Gas (GHG) emissions and to minimise ongoing emissions in a financially and environmentally sustainable way [1]. Understanding how and where emissions are generated is important and can drive savings in a business with a view to reducing inefficient or wasteful activities in the company and its supply chain [1, 3, 4]. By employing carbon management and understanding sources of emissions it can help companies manage organisational risks in terms of potential policy and regulatory changes [1, 5, 6] such as carbon taxes.

Companies that exhibit leadership on climate change through carbon management, can maintain and improve their brand reputation with customers and employees whilst taking action to limit climate related risk or liability [1, 5, 7, 8]. Further a company's perceived environmental performance may, it has been found, be improved through the application of such voluntary management measures [8] and that pressure from out with companies may be an important driver in disclosing emissions [9] requiring the application of carbon management. An organisation's GHG emissions and carbon management are under scrutiny by shareholders and insurers [7] and it can also be important to financial investors that investees are in line with their sustainability policies. Standard Chartered, for example, through their sustainability policy, are gradually withdrawing financial services to clients who rely on earnings from thermal coal and by 2030 aim to only provide services to clients whose thermal coal incomes are less than 5% [10]. Their policy notes that '... now, more than ever, we need to act to reduce our impact on the environment and meet the goals of the Paris Agreement on Climate Change.' [10]. Companies with effective carbon management have been found to be more likely to disclose their emissions data [8] and to subsequently benefit in terms of environmental legitimacy and perception.

Alphabet is an interesting company to study as its main areas of business and income involve online activities and the use of Information Technology (IT) rather than traditional industries. Its sources of operational emissions are generated from the development and operation of online Information Technology services, although their hardware suppliers also generate significant

emissions [11]. Being a company with a significant financial turnover and what appears to be strong support for sustainability, it appears to have a proactive approach to addressing its impacts. Interestingly, Alphabet is not only important in what it can do to reduce its own footprint through developing new technologies, but important in what it can develop to help other companies, individuals, and institutions to reduce their emissions whilst creating new commercial opportunities. A prime example is data centres, which have been developed to help consumers/clients reduce costs and emissions by storing data in highly efficient storage centres [11].

The environmental impact that use of the internet and data centre services have in terms of carbon emissions is noteworthy. As of 2018, data centres generated 0.3% of global carbon emissions [12], a figure likely to increase as data centre demand is predicted to significantly increase by 2030 [13] and which is complicated as increased use of IT to date has been shown to result in increased energy demand despite efficiency improvements [14].

This paper aims to contribute to the field by highlighting Alphabet's emission sources, how they are measured and how they are achieving net-zero emissions whilst comparing them to other companies in the information technology and online service provision sectors. The study highlights the contribution of information technology to carbon emissions, ways in which Alphabet work to reduce emission and how emissions reduction technology is used by Alphabet but also offers opportunities for them as a business, opportunities other companies could employ. It also contributes by highlighting that only a limited number of Green House Gas emissions are included within their calculations. This case study will focus on Alphabet's measures to drive efficiency and its data centres.

Publicly available information from Alphabet and the other companies discussed in this paper has been sourced from their web sites and CDP Climate Change Responses or questionnaires, where available. Background and supplementary information has been obtained through searches using Google, Google Scholar, ScienceDirect and Scopus using the terms 'Carbon Management', 'GHG emissions', 'Emissions', 'Environmental Report', 'Energy usage', 'CDP', 'net zero benefits' and related terms.

2. Overview of Alphabet

Alphabet is the holding company for Google and several smaller businesses created in 2015 from Google Inc. [15] to improve its management [16]. A multi-national technology company, it provides internet services and technology to support a wide range of users as well as undertaking technological research [17]. At the end of 2019, Alphabet employed 118,899 employees and had a revenue of US \$161B [17] generating a US \$34B profit [18]. Some 99% of revenue came from Google activities including advertising, computer software such as Chrome and internet-based services such as Google Maps, Searches, YouTube, and Cloud data storage [11]. Alphabet has operations, research, and development sites across 170 cities and operates 21 data centres globally. It also manufactures, through its suppliers, a range of consumer devices and computer hardware [17].

Alphabet has assessed that failure to adequately address climate change risks and impacts may affect demand for their products because of a reduction in their reputation [17]. On a more practical level they have also identified the risk associated with increased energy demands, and hence costs, for their operations and data centres if global temperatures increase [17]. This would result in increased outside temperatures and greater need for cooling [17]. Additional regulation of GHG

emissions through Emission Trading Schemes has also been identified as a risk to their business due to increased costs, however they suggest this is mitigated as they currently voluntarily purchase carbon offsets [17].

Some documents referred to by Alphabet are produced by Google therefore for the purposes of this report the names are used interchangeably.

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3. Summary of Google's Aims and Claims

Google, as the main company held by Alphabet, claims that sustainability has been one of their central values since the creation of the company in 1998 [19]. To live up to this claim they became carbon neutral in 2007 and continue to maintain this status [19].

Going forward they aim to be the first major company to decarbonise their operational footprint by operating their worldwide data centres and campuses with 100% carbon-free energy by 2030 [17, 19]. To do this they will switch from purchasing electricity from Renewable Energy (RE) that matches their yearly consumption, to sourcing carbon free energy in all regions in which they operate to power their operations [19]. Google continues to invest in RE projects across their operations and in the regions where their suppliers operate and since 2010 has committed to invest approximately US \$2.7B in RE projects [19].

Google has also committed to develop new tools and technology investments beyond their own operations to develop a carbon free future [19].

Google is also committed to eliminating all historic carbon emissions since the company's formation in 2007 [19] to be the first major company to claim it has been carbon neutral for its complete trading period [19].

The authors consider that Google's pledges are driven in part by the need for increased efficiency and to develop useful and marketable services whilst providing sustainable solutions to the world [19]. Through solving climate and efficiency challenges, it is considered that they see commercial opportunities to support sustainable growth through carbon-free activities and services. The development, promotion and use of its Cloud based technology is an example [19].

4. Emissions Estimates

Alphabet's (Google's) Green House Gas emissions data is published in their annual environmental report and years 2015 to 2019 are shown in Figure 1 [11].

Google Green House Gas Emissions 2015 to 2019 inclusive					
	Fiscal year				
Emissions Inventory (tCO ₂ e)	2015	2016	2017	2018	2019
Scope 1	66,991	66,218	66,549	63,521	66,686
Scope 2 (market based)	1,384,427	1,518,643	509,334	684,236	794,267
Scope 2 (location based)	2,450,438	2,902,554	3,301,392	4,344,686	5,116,949
Scope 3 (total)	1,234,683	1,292,268	2,719,024	12,900,467	11,669,000
Scope 3 (business travel and commuting)	297,789	314,028	356,060	463,467	542,000
Scope 3 (other)	936,894	978,240	2,362,964	12,437,000	11,127,000
Total (Scope 1,2 (market based) and 3)	2,686,101	2,877,129	3,294,907	13,648,224	12,529,953
Operational emissions (tCO₂e)					
Scope 1,2 (market based), and 3 (business travel and commuting only)	1,749,207	1,898,889	931,943	1,211,224	1,402,953
Scope 1,2 (location based), and 3 (business travel and commuting only)	2,815,218	3,282,800	3,724,001	4,871,674	5,725,635
Emissions reduced and neutralised (tCO₂e)					
Emissions reduced by renewable energy PPAs	-1,066,011.00	-1,383,911.00	-2,792,058.00	-3,660,450.00	-4,322,682.00
Emissions neutralised by carbon offset projects	-2,686,101.00	-1,898,889.00	-931,943.00	-1,211,224.00	-1,402,953.00
Total emissions reduced and neutralised	-3,752,112.00	-3,282,800.00	-3,724,001.00	-4,871,674.00	-5,725,635.00
Net operational carbon emissions	0	0	0	0	0
Carbon Intensity					
Revenue US\$ M	74,989.00	90,272.00	110,855.00	136,819.00	161,857.00
Carbon Intensity per unit of revenue (tCO ₂ e/US\$M)	19.4	17.6	5.19	5.47	5.32
Energy Use (MWh)					
Energy Consumption	5,533,433	6,513,719	8,029,409	10,572,485	12,749,458
Total electricity consumption (US)	3,779,280	4,522,314	5,533,783	7,085,620	8,489,242
Total electricity consumption (rest of world)	1,442,196	1,686,877	2,075,306	3,018,675	3,747,956
Total electricity consumption	5,221,476	6,209,191	7,609,089	10,104,295	12,237,198
Energy Efficiency (PUE)					
Average annual fleetwide power usage effectiveness (PUE) across Google data centres	1.12	1.12	1.11	1.11	1.1

Figure 1 Environmental data from 2020 Environmental report [11] and revenue [20].

Google base their emissions and reductions figures on the operational control approach [17] which comprise Scope 1 direct (sources controlled by Google i.e., company vehicles/generators), Scope 2 indirect (purchased electricity) and limited Scope 3 indirect emission sources [11]. Scope 3 emissions are limited to business travel and commuting [11]. Scope 3 emissions from hardware manufacturing and transportation of goods by third parties and product lifecycle emissions out with operational control are excluded, technically being out-with Google’s direct management.

Google’s operational emissions and energy consumption between 2015 and 2019 increased from 2.82M t CO₂e to 5.73M t CO₂e and 5,533,433 MWh to 12,749,458 MWh respectively [17]. Figure 2 shows the increase in operational emissions with a corresponding increase in revenue during the same period [20].

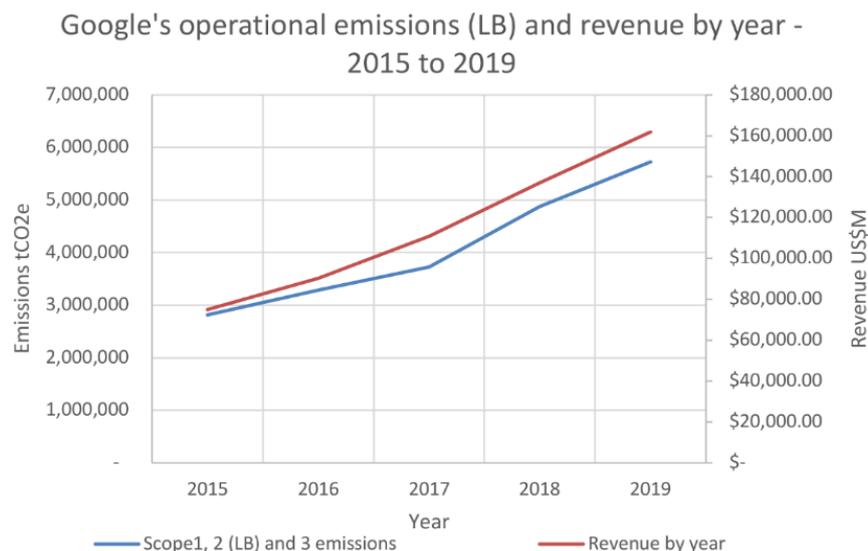


Figure 2 Operational emissions and revenue by year [11, 20].

Google’s Scope 1 emissions appear limited to CO₂, CH₄, and N₂O emissions [17] and remained around 66,000 t CO₂e between 2015 and 2019 [11]. Their Scope 2 market-based electricity generation emissions have reduced from 1.38M t CO₂e to 0.79M t CO₂e [11] whilst their Scope 2 location-based emissions increased from 2.45M t CO₂e to 5.12M t CO₂e. Carbon intensity decreased from 19.4 to 5.32 t CO₂e/US \$M over the same period [11] despite increased electricity use.

Google’s Scope 3 emissions increased between 2015 and 2019 from 1.23M t CO₂e to 11,67M t CO₂e in part due to changes in recording [11] but despite their increasing turnover, electricity use and emissions, they have maintained zero net operational emissions in the period [11]. In comparison to Google’s net zero emissions, their competitors, Amazon [21], have only pledged to be Net Zero by 2040 and emitted 51.17M t CO₂e in 2019 [22] whilst Facebook’s [21] operational emissions were net zero through comparable processes in 2020 [23].

5. Emissions Reductions

Google acknowledges that climate change means that they must transfer their energy supplies to carbon-free sources and are aiming for their operations to be carbon free by 2030 [11]. To do this they have employed several measures to reduce emissions through improved efficiency of their operations, developing new technology and systems, purchase of carbon free power from markets via power purchase agreements (PPAs), and where required the purchase of carbon offsets [11]. The notable strategies are discussed below.

A significant method that has allowed Google to claim it has reached net zero emissions is its purchase of renewable electricity (RE) through PPAs from the grids where they operate [11]. Although some of their operations use power from carbon emitting sources, they have purchased RE to cover all their data centre and office facilities’ electricity use from 2017 [24] (Figure 3) [11]. In 2019 they purchased 12.2m MWh of electricity which reduced their operational emissions by 4.32M t CO₂e to 1.40M t CO₂e [11]. A reduction from 5.72m t CO₂e (location-based) to 1.40M t CO₂e (market-based) [11] which is a considerable drop and shows how through carbon management and the purchasing of RE, their carbon footprint was substantially reduced.

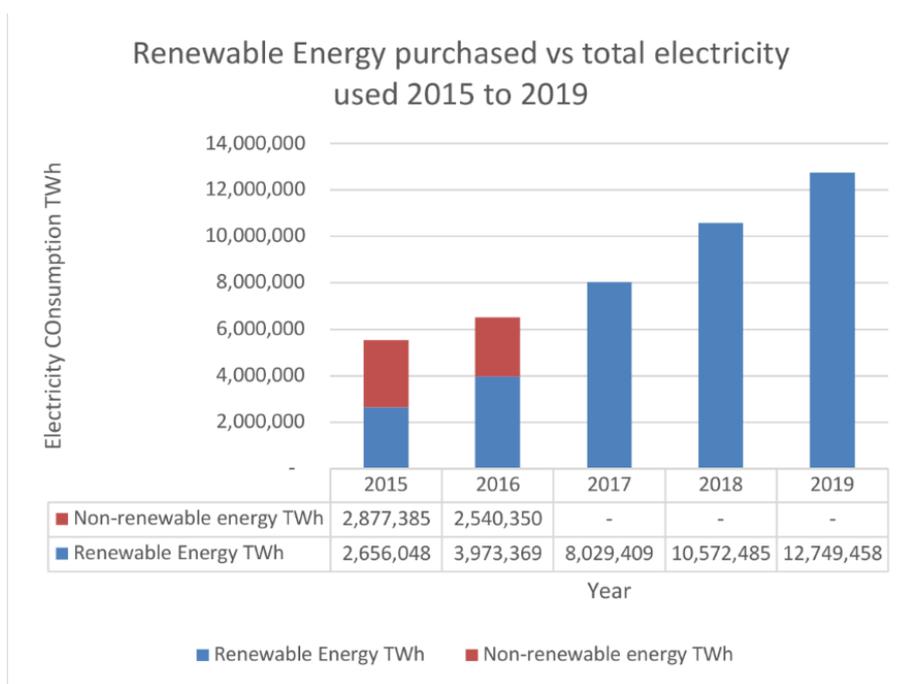


Figure 3 Renewable Energy purchased compared with total electricity used [11].

The remainder of the emissions for 2019, like previous years, were reduced through the application of carbon offsets to negate emissions from non-renewable sources. As can be seen in Figure 1, emission offsets vary but approximately 1.40M t CO₂e were offset in 2019 [11]. In the 13 years prior to 2020, Google has offset over 20M t CO₂e emissions through 40 projects [11]. Google states they only offset emissions through projects assessed as having additionality and permanence, i.e., projects that involve permanently reducing emissions that wouldn't have occurred without their investment [25]. Their offset portfolio funds the investment in the capture and burning for energy or destruction of methane from landfill sites, capture of agricultural methane and the protection, enhancement or replanting of forests [25]. One example is the Oneida-Herkimer Regional Landfill in New York state. Google committed to purchasing the offsets generated by a plan to capture and destroy methane released by the site which gave the operator financial certainty to build and operate the system [26]. From inception to 2018, the project has eliminated 0.5M t CO₂e and permitted further investment through the offset income to extend and convert the methane into electricity rather than burning it off [26]. No financial details are available.

Google has reduced emissions through improvements to the design and operation of their data centres which are considered the centre of Google's operations [11]. Globally, data centres accounted for 1% of electricity demand [27], a figure which hasn't changed in part due to increased efficiency of data centres [11] which is where Google has invested significant effort. As demand for computing and data centres has increased between 2010 and 2018 Google have increased their efficiency such that a 550% increase in computing demand only saw a 6% increase in energy consumption [11]. To increase efficiency Google looks at the lifecycle of their servers and design them to use as little energy as possible [11]. Cooling of their data centres is controlled through a programme they developed to allow machine learning to optimize temperatures by reviewing past weather records to adjust cooling in responses to weather changes [28]. A change in temperature will result in a change to the centre's heating or cooling and hence energy requirements. As a result

of Google's efficiency measures their Power Usage Effectiveness (PUE), a measure of data centre efficiency, reached an annual average low of 1.1 compared to the industry average of 1.67 in 2019 [11, 29] and has helped save over US \$1B [11]. Using their experience, they plan to develop and commercialize software to match carbon free energy with energy demand in other industries [11], sharing knowledge whilst capitalising on the drive to net zero.

In 2020 Google neutralized their historic carbon footprint through offsets [11], however, limited information has been provided as to how this was achieved. Additional details or clarity may be useful for other organisations trying to achieve this goal.

To enhance their use of carbon free energy, Google has developed a 'carbon-intelligent computing platform' [11] (page 28) to adjust the timing of when less important tasks are undertaken. This allows them to undertake such tasks when carbon free energy is available, reducing their need to use carbon sourced energy. This is another example of their technology helping reduce carbon emissions that has commercial potential.

6. Performance Appraisal

Alphabet, as a commercial organisation with the ability to develop technology to aid efficiency, deals positively with their carbon management. They have been effective in terms of reaching net zero emissions since 2007 although this has relied on offsets, but these appear to be based on justifiable projects. They have driven a process of efficiency, applied RE PPAs, offsets and developed new technologies to help reduce their emissions whilst investing in RE projects across the world [11]. They have also pledged to switch to 100% carbon free power by 2030 to reduce Scope 2 emissions and to address obstacles that may prevent this in markets where RE supply is limited. This has led to investment in those regions which they propose to extend beyond their operational footprint to their suppliers [11], a positive action.

Alphabet has a comprehensive system for reporting their emissions and strategies for emissions reductions having started calculating their carbon footprint in 2006 [11]. They publish yearly Environmental Reports detailing emissions containing energy use and offset details, CDP Responses, policy statements, and additional information on their carbon offsets and performance on their website (<https://sustainability.google/commitments/>).

This way, Google has identified Scope 1, 2 and 3 sources of emissions in their operations and developed programs to reduce their carbon footprint and emissions. Where unable to reduce carbon-based energy sources, they have offset their emissions ensuring that the projects in which they invest are permanent and have additionality.

In terms of rigor and reliability, Alphabet disclose information to the non-profit charity CDP who report on companies' environmental performance and score them to measure progress on climate change action [30]. In 2020, Alphabet scored an 'A' related to climate change scoring [31] as did Microsoft however, Amazon failed to submit a response. Disclosure to such independent organisations is important as it allows Google to benchmark their progress for stakeholders, protect and improve their reputation, gain competitive advantage, manage regulatory change, highlight and address climate risks affecting their business and find new emission reduction and business opportunities [6]. It also shows their desire to be transparent. Having calculated their emissions and offsets data, Google employs a third-party auditor to provide assurance the data is correct [11], improving its credibility.

In Google's 2020 Environmental report they set the aim of becoming carbon-free by 2030 and to supply energy for their operations via 100% carbon free sources across their worldwide operations [11]. They are taking steps to work toward that through a variety of measures and recognise a need to move away from offsets to drive investment in RE projects and have invested large sums to do so. From 2010 to 2019 they committed to investing US \$2.7B in RE projects with a capacity of c.4.6 GW and are investing in RE in their supplier's energy markets to develop 8.7 GW of new energy hoping to spur over US \$5B of investment [11]. The idea being for their suppliers to have access to RE [11] which may help reduce Scope 3 emissions.

Google claims to be the world's largest annual corporate purchaser of renewable energy between 2010 and 2019. Through 52 agreements, for a cost of approximately US \$4B they have obtained a supply of 5.5 GW of new to the grid renewable energy capacity across four continents on which they operate [11].

Google has decreased their carbon intensity from 19.4 to 5.32 t CO₂e/US \$M between 2015 and 2019, achieved in part through the application of increasing RE PPAs [11]. Given Google have indicated that demand for further computing resources and data centres continues to increase [11], and global electricity demand by 2030 is forecast to be 3-13% compared to 1% in 2010 [13], it remains to be seen how Google will maintain net zero emissions particularly as they drive towards 100% carbon free energy. Maintaining carbon-free operations may constrain their data centre and online expansion and test Google's sustainability ethos. Furthermore, no targets appear to have been set to track their progress to 2030.

Due to the mix of Google's and technology-based business' activities there are no directly comparable competitors. However, it does compete in some sectors with Amazon and Microsoft for Cloud data services and Facebook for advertising [21]. In comparison to Google, Amazon has pledged to be Net Zero by 2040 [22] and as of 2019 had a carbon footprint of 51.17M t CO₂e. In 2020 Facebook's operational emissions were net zero through processes comparable to Google [23]. Like Google, Microsoft has been carbon neutral since 2012 using offsets, has pledged to become carbon negative by 2030 and to remove all historical carbon emissions by 2050 [32]. Microsoft also want to power their operations from 100% RE rather than rely on offsets [32] but unlike Google they have yet to tackle their historic emissions.

Although it is difficult to directly compare without an in-depth study, it is evident that Google is generally comparable or ahead of their competitors in terms of having net-zero emissions and driving a change to carbon free energy through significant investment in RE. They are in a good position to make gains from RE and make the most of its availability given the new technologies they are employing and to commercialise the opportunities they create, a potential lesson for other companies. However, an in-depth study of the other companies' projects would be required to confirm this.

The business development and direction of Alphabet (Google) are clear signs of good carbon management based on the information available. Based on the information provided, CDP score and Alphabet's acknowledged openness it is considered that Alphabet's efforts in the technology sector are broadly accepted as positive. Through carbon management and calculating their footprint, they have determined what actions are required and developed new technology and tools as well as instituting investment in markets where they and their suppliers operate. Their drive to net zero emissions and onward to 100% carbon-free energy has and will continue to benefit their operation through reduced costs and development of new technologies with commercialisation potential.

In terms of improvements, further action, and its promotion, could be placed by Alphabet on the reduction of Scope 3 emissions within their supply chain beyond the use of re-cycled materials and investment in RE in their supplier's markets. Movement away from the use of offsets to achieve net zero emissions would be a great improvement and providing information on targets and progress to achieving this by 2030 would be transparent in line with their environmental performance disclosures to 3rd parties.

7. Conclusion

In this analysis of Google's carbon management performance, their 2020 Environmental Report and CDP Submission and associated documents have been reviewed. Research has been limited to a high-level study of Google's emissions data and reduction activities between 2015 and 2019 as detailed in the aforementioned report.

Based on the above, it is considered that Google has an effective carbon management system in place. They have already achieved net zero carbon emissions through efficiency measures, purchase of RE through PPAs and offsets. Through improved design and the application of technology and machine learning Google have improved efficiency and reduced carbon emission. Although Google can market such technologies, it is a clear learning for other companies whereby they could develop improvements to emulate Google's success yet tailored to their situations. Beyond net zero emissions through offsets, they have pledged to use 100% carbon free power by 2030 and are investing in RE infrastructure energy agreements to achieve that. Although Alphabet has no directly comparable competitors, it shares several activities with a range of companies including Amazon, Microsoft and Facebook. In comparison, it is considered that Google are as advanced, if not more so, in their drive to net zero emissions and are further advanced in their drive to carbon free operations.

This research helps in future and with policy makers as it has found that despite Alphabet having a well developed carbon management system there are still areas that require further assessment and addressing to test their net zero claims, namely GHG emissions beyond the CO₂, CH₄ and N₂O GHG emissions. Further, and based on this analysis of their performance and pledge to use 100% carbon free electricity by 2030, Google and other companies should provide information on their projected power demands compared against their proposed power capacity to be transparent about progress to this target.

Given the high emissions from their manufacturing supply chain it is recommended that more action should be taken by Alphabet to drive down those emissions. Further, a study of Alphabet's GHG emissions beyond CO₂, CH₄ and N₂O should be undertaken to fully understand their impact and to test their net zero claim.

Author Contributions

Chris Fraser: Writing (drafting), conceptualisation, analysis; Paul Dargusch: writing (editing), supervision; Genia Hill: writing (editing), administration.

Competing Interests

The authors have declared that no competing interests exist.

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