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Bachelor's Thesis

ARTIFICIAL INTELLIGENCE IN THE SERVICE OF THE COMMON GOOD AND COOPERATION. STUDY OF BUSINESS MODELS:

THE GREEN DILEMMA OF AI: ASSESSING THE ENVIRONMENTAL IMPACT AND SUSTAINABILITY STRATEGIES OF LEADING AI COMPANIES

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Abstract:

Artificial intelligence (AI) has rapidly grown the last five years and this growth is not going to stop soon. AI has the potential to transform businesses and address a range of problems, including sustainability. However, the environmental impact of these models has become a major concern due to a number of reasons, including high energy consumption, carbon emissions, and electronic waste. Several regulatory frameworks that either already exist, have been recently updated or newly introduced have been brought in by several different regulatory bodies to help mitigate the environmental impacts of the models. Despite this, there still remains a lack of standardised sustainability measures within AI-driven industries.

Most research focuses on AI's technical aspects, with little attention to its long-term sustainability impact and regulatory effectiveness. However, this study investigates the sustainability strategies of major AI-powered companies as well as evaluating the level of effectiveness of these regulations in guiding AI towards the common good.

Using a qualitative approach, a diversity of data were collected from case studies of major AI companies, including corporate reports, and sustainability metrics like energy consumption. This found that different companies' effort in relation to sustainability differ as many were transparent in their sustainability metrics and adopted the use of renewable energy or efficient hardware for example, while others lack transparency in their environmental impact. The results also highlighted the increasing energy demands, regulatory inconsistencies and the need for standardised sustainability and demonstrated the need for further research and studies to assess AI's full environmental footprint, develop standardised sustainability regulations and explore AI-driven solutions for sustainability.

Keywords: Artificial Intelligence (AI), Sustainability, Business Models, Environmental Impact, Regulatory Frameworks, Energy Consumption

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1 Introduction

Artificial intelligence can transform business practices and industries and the potential to address many major societal problems, including sustainability (Nishant, Kennedy, & Corbett, 2020). AI is transforming industries and society; however, its rapid development has also raised many concerns regarding its sustainability which must be addressed to ensure AI serves the common good and makes it a crucial topic for academic research.

AI can have both a positive and negative effect on the environment. It can be utilised in several different ways to improve efficiency and sustainability but poses many challenges in sustainability due to primarily its high energy consumption and carbon emissions, but also through water usage, e-waste and much more. Studies have shown that the process of training one large scale model produces the carbon emissions equivalent to five average cars over their lifetimes (Nishant, Kennedy, & Corbett, 2020) and that data centers are by far the fastest-growing carbon footprint across the whole ICT sector, with them generating up to 2% of global CO_2 emissions (Dayarathna, Wen, & Fan, 2015). As AI's influence grows, so too does the need for regulatory oversight to mitigate its environmental footprint. Regulatory frameworks introduced by governments and unions as well as international standards and agreements play a pivotal role in ensuring AI is aligned with sustainable and cooperative business practices. Many of these current regulations and frameworks have many flaws, such as the European Union's AI Act which prioritises ethical concerns over strong environmental requirements. This in turn weakens its alignment with other sustainability policies like the Green Deal and the Paris Agreement (Ugo, Jacopo Ciani, & Massimo, 2022).

As AI is a very recent phenomenon and due to its constant growth, there is still a lot we don't know about it. Existing research focuses on AI's technical innovations, with little information available regarding its environmental impact nor sustainability strategies. Majority of studies examine AI's immediate effects and not its long-term implications on sustainability (Rohde, et al., 2024) which is hugely important, demonstrating the need for an analysis and comparison of AI business models to determine the best sustainability practices.

This study aims to analyse both the sustainability potential and challenges of AI, exploring how major AI-powered companies balance innovation, efficiency, and environmental responsibility while also assessing the role and effectiveness of regulatory frameworks in guiding AI toward the common good. To achieve this, the research will examine whether AI ultimately helps or harms sustainability, what sustainability strategies AI companies are implementing, and how AI can be made more sustainable in the long term.

To address these questions, the study employs a qualitative approach, utilising case studies of major AI-driven companies to assess AI-driven business models' environmental impact and sustainability strategies. Data will be collected through various methods such as analysing corporate reports, regulatory framework as well through analysing certain quantitative data relating to companies for example energy consumption and carbon footprint. With the collection of this data, different analysis techniques will be applied, including a comparative analysis of business models, identification of trends in AI sustainability strategies and assessment of the gaps in regulatory frameworks to determine policy effectiveness. These techniques will support the answering of the research objectives.

The first chapter of this paper will present the results of the literature review, covering relevant information about the environmental challenges in AI-driven business models as well as different polices and regulatory framework for AI Sustainability. The following section will outline the methodology used in the case study of seven AI-powered companies. Finally, the results of the case study will be presented and discussed concerning AI’s sustainability before drawing a conclusion to the research question.

2. Theoretical Framework

2.1 AI's Key Components

To develop a better understand of AI-Driven business models and sustainability it is necessary to gain a deeper understanding of AI's key components. All of these are extremely important and relevant when it comes to sustainability discussions.

Data centers are one of AI's key components. The growth of data centers in recent times has been exponential which is demonstrated by the forecasted market growth of 11.5% CAGR from 2023 to 2030 and the market size is expecting to reach $711.5 billion by 2030 (Yahoo Finance, 2024). As a result the demand for AI applications has grown significantly also which is directly resulting in greater energy consumption and carbon footprints, therefore raising concerns regarding long-term sustainability (Choudhary, Kar, & Singh, 2022). They have become a necessity to companies with the likes of Amazon, Microsoft and Google leading the way with the most and biggest data centres in the world. The reason for this exponential growth can be narrowed down to two key main factors. Firstly, the growth of demand for data computing, processing and storage by the users of large-scale cloud computing and services for example Google and Facebook. These large technology companies are not the only companies, other sectors such as Telecommunications, banking and many others have spurred the increase of large data centers around the globe. These data centers can host up to millions of servers. The other primary cause of the recent growth of data centers can be put down to the need to support a wide range of different applications, some of which run for seconds whereas others can run every minute of every day on shared hardware platforms has created a need for the building of large-scale computing infrastructures (Dayarathna, Wen, & Fan, 2015).

Algorithms and machine learning are other key components of AI. AI algorithms have become more popular along with the growth of AI. An algorithm can be described as a well-defined computational procedure that takes some value, or set of values, as input and produces some value, or set of values, as output. They follow a series of computational steps that make the input an output. (Cormen, Leiserson, Rivest, & Stein, 2022). Through predictive analytics, AI has the potential to support sustainability efforts but due to its current reliance on pre-existing datasets it limits its current ability to adapt to unprecedented climate events (Nishant, Kennedy, & Corbett, 2020).

Hardware is the final major component of AI-driven models. Hardware can be best described as physical components of a computer system or any electronic device. Examples include

Central Processing Unit (CPU) or the Storage (Hard Drive or SSD). These physical parts specifically help store data or perform different tasks. New and improved AI-driven hardware strategies for example TinyML which combines processing data directly on the device with the enablement of smart technology is currently being explored in hope of making AI models more sustainable (Choudhary, Kar, & Singh, 2022).

2.2 Environmental Challenges in AI-Driven Business Models

There are numerous different environmental issues that AI's resource demands cause. Each of data centers, algorithms and machine learning and hardware all possess different environmental challenges.

A) Data Centers: Data centers are computer warehouses that store large amounts of data to reach the daily transaction processing needs of different businesses. These warehouses contain servers that collect, store and utilise data. The computation that is needed to be performed in data centers involves an energetic overhead in addition to the energy consumed for the computation itself such as the cooling process (Delort, Riou, & Srivastava, 2023). These data centers run every minute of every day all year round. Research shows that a typical data center may consume as much energy as 25,000 households and up to 200 times as much electricity as a standard office space (Dayarathna, Wen, & Fan, 2015). Other research shows that data centers are comfortably the fastest growing carbon footprint from across the whole ICT sector which generates up to 2% of global CO2 emissions and alone they contribute around 0.3% to overall global carbon emissions (Dayarathna, Wen, & Fan, 2015) this boils down to the exponential technological growth and advances for example with cloud computing and the constant increase of the use of internet services. The rise of these data centers in recent times is visibly clear and the amount of data centers as well as the power they consumer will continue to grow more as time goes on. Certain countries with cooler climates such as Ireland have been targeted by companies as ideal locations to build these data centers and with the constant increase for example in Ireland, they could account for 32% of Ireland's power consumption by 2026, almost double the 17% in 2022. On a global scale the potential rise of energy consumption would be the equivalent as adding the entire power consumption of a country like Sweden at the lower end, or Germany at the higher end of the scale (Intel Granulate, 2025).

The energy consumption of these data centers can be put down to six main factors which are cooling, lighting, power conversion, network hardware and server and storage.

The cooling systems implemented in these data centers consume 50% on average of the total power consumed (Dayarathna, Wen, & Fan, 2015).They are essential to have in data centers as they ensure that the optimal operating temperature of data centre equipment is maintained, which results in massive power consumption. There are many different types of cooling systems, for example traditional cooling methods like air conditioning which alone consumes a lot of energy. Many of these traditional cooling systems are inefficient and this results in extremely high operational costs and even more energy consumption. Water chillers, a different cooling system is said to be the most energy consuming as it supplies chilled water to the cooling coil in order to keep the indoor temperature low enough to remove the heat emitted by the servers and other equipment (Avgerinou, Bertoldi, & Castellazzi, 2017). More modern data centers designed and constructed in recent years use cooling systems like liquid cooling which entails using chilled liquid to transfer heat away from equipment in a more efficient way than air cooling.

The other major energy consumer in data centers are the servers and storage devices which on average consume roughly 26% of the total energy consumed by data centers. These devices are essential as they process and store large amounts of data. The specific amount of energy consumed depends on the workload and the performance required. This means that more tasks mean more energy and harder tasks also results in more energy consumption (Dayarathna, Wen, & Fan, 2015)

B) AI Model Training and Algorithms: Similarly to data centers, the growth in energy consumption in AI model training and algorithms such as data analysis and natural language processing to autonomous systems has also been huge. The increased use of these AI systems come with a series of social, environmental, and economic consequences including the rise of energy consumption and carbon missions resulting from different AI model development and application (Rohde, et al., 2024). These deep learning models are extremely resource sensitive, with some studies showing that training a single large-scale model produces the carbon emissions equivalent as five average cars over their lifetimes (Nishant, Kennedy, & Corbett, 2020). The training of deep neural models is another as they also take a high amount of computation time and resources due to the model itself needing to learn a comprehensive representation that enables it to better analyse the data. The energy needed and computation cost is even higher if the model is required to learn continuously (Ligozat, Lefevre, Bugeau, &

Combaz, 2022). In order to really gain a deeper understanding of how machine learning works, it is necessary to analyse and understand the machine learning pipeline end-to-end. The pipeline includes data collection, model exploration and experimentation, model training, model optimization and run-time inference (Chen, 2023). AI systems in general require a lot of energy consumption and computational resources to gather and process data as well as to train the models that are needed. Systems that focus on deep learning models require even more as they are more complex. The result of this large-scale data processing and complex training is a massive increase in AI technologies' environmental footprint (Chen, 2023). In addition, before being able to train the chosen final model much experimentation is needed, and many smaller models are needed to be trained to be to benchmark the different model components that will be used in the final version which results in an underestimation of the true impact of AI research (Delort, Riou, & Srivastava, 2023). The constant need of retraining and inference operations of these algorithms and machine learnings due to the continuous advancement in technology results in an increase in carbon footprint. On the other hand, as technology continues to advance the carbon footprint of machine learning training will plateau, then shrink (Rohde, et al., 2024). Research has shown that the carbon footprint of training one large machine learning model is equivalent to 242,231 miles driven by an average passenger vehicle (Chen, 2023). Other variables that contribute to algorithms and machine learning's energy consumption are how often the model needs to be retrained and the scale of each stage of the machine learning development cycle matter. This is determined by the life cycle of the machine learning software and system hardware.

A study done by Meta manged to demonstrate that the overall operational carbon footprint can be categorised into offline training, online training, and inference. Offline training includes experimentation and training models with historical data however online training includes the use of recommendation models where parameters are continuously updated based on recent data. The inference footprint represents the emissions generated from handling production traffic.

The study done by Meta on the carbon footprint of industry-scale machine learning training and deployment also demonstrated that depending on the exact AI systems used and the carbon intensity of the energy mixture that operational carbon footprint results can vary and that models with more parameters do not necessarily result in higher carbon emissions. Meta managed to show this by comparing one of their models in the study which was equipped with 1.5 trillion parameters to GPT-3 that has 750 billion parameters with Meta's model producing significantly less carbon emission. It proved that operationally efficient model architectures are much more efficient and sustainable (Chen, 2023). Research shows that the optimisation of algorithms can maintain performance while simultaneously significantly reducing computational costs and emissions (Nishant, Kennedy, & Corbett, 2020).

C) Hardware: The hardware needed to create and power AI for example Data Centres, GPUs, servers and microchips all require critical minerals like cobalt and lithium. The demand for AI hardware is at an all-time high, the recent growth of Nvidia who design graphics processing units, application programming interfaces for data science and high-performance computing demonstrates this high demand (Delort, Riou, & Srivastava, 2023). The extraction of these critical minerals that are an essential part of AI hardware result in a number of different environmental risks for example, deforestation, biodiversity loss, and significant CO2 emissions (Choudhary, Kar, & Singh, 2022). The process of producing simple technological items such as computers is also resulting in major hardware waste, for example, a 2 kg computer requires 800 kg of raw materials alone (UN Environment programme, 2024). The supply chain of these minerals is complex, volatile and opaque. These supply chains are also already at their maximum capacity (Deloitte, 2025). Research and studies done on this topic are scarce, however from what has been researched it is clear that mining practices these critical minerals are sourced through are both environmentally and socially harmful. Both surface mining and underground mining have caused substantial adverse impact on the environment as well as land (Worlanyo & Jiangfeng, 2021). AI infrastructure has short hardware cycles, which means companies must constantly update and replace their old systems, leaving electronic waste, which often contains hazardous substances, for example mercury and lead. As a result, these short hardware life cycles in AI-driven industries contribute to an accelerating e-waste crisis (Nishant, Kennedy, & Corbett, 2020).

2.3 Policy and Regulatory Framework for AI Sustainability

When implemented correctly AI has been shown to significantly reduces ecological footprints and carbon emissions as well as simultaneously promoting energy transitions (Qiang, Yuanfan, & Rongrong, 2024). However, the development, use and maintenance of AI has a major effect on many different important sustainability factors such as energy use, C02 emissions, water usage, e-waste and circular economy. Many of these large AI models have extremely high energy expenditure and carbon emissions training costs because of the computation and manufacturing of the specialised hardware accelerators that the models are trained on, resulting in significant environmental impact (Delort, Riou, & Srivastava, 2023). The effect is so large that it has driven governments and economic unions to either implement new or update existing regulations regarding sustainability. Europe's comprehensive regulatory framework and focus on sustainability across sectors set it apart and are leading the way in terms of their progress as well as their ambitious goals thanks to many different factors with one of the main ones being the regulations and standards the European Union have put in place.

These regulations and policies hold major importance in shaping AI-driven business models, especially those who take sustainability into account in their decisions. As these AI solutions continue to grow the models are growing in multiple different areas such as, data use, energy consumption and monetary cost (Delort, Riou, & Srivastava, 2023). These regulations and policies highlight the importance of compliance with environmental regulations, specifically in AI due to the energy it consumes, the emissions it releases and e-waste that is left as a result of using it. This holds countries and companies accountable for their use of AI and their sustainable practices as many of the regulations mandate transparency in their use of AI and the environmental consequences of using it.

As mentioned, the European Union are leading the way in sustainability and regulations and can be seen as a great example for other regions and institutions to follow. These regulations attempt to directly combat the different negative effects AI has on the environment. Although the European Union are leading the way, the AI Act recently introduced like many recent initiatives insist on a human-centric approach. However, to really maximise the effectiveness of environmental regulations they should be approached from an object-centred perspective rather than a human-centred one (Ugo, Jacopo Ciani, & Massimo, 2022). Another fault regarding the AI act is that its primary focus on ethical and safety risk doesn't do enough to control AI's environmental impact, with some of these regulations having possible legal loopholes or unintended effects which in turn, makes it harder to enforce sustainability measures (Michael & Frederik Zuiderveen, 2021).

A) Energy Use: The European Union introduced the Energy Efficiency Directive in 2012 and a revised directive in 2023 which raised their ambition on energy efficiency (Directive (EU) 2023/1791, 2023).Energy efficiency reduces overall energy consumption, this makes the directive key to the EU's sustainability targets which include a mandatory additional 11.7% reduction in energy consumption compared to previous projections of the EU reference scenario 2020 by 2030 for EU members combined.

The directive also enhances the present and future energy security and affordability which is vital not just to the EU, but globally. AI solutions have become key in energy planning and design, being used to support the integration of machine learning and decision-support systems which in turn improve efficiency, forecasting, and optimisation of energy consumption (Nishant, Kennedy, & Corbett, 2020). The directive also had legal standing for the first time which means all member countries in the EU must include energy efficiency in any relevant policy and major investment decisions taken in the energy and non-energy sectors.

The directive will help with many of the EU's sustainability commitments such as the Global Pledge which aims to increase the global rate of energy efficiency improvements from 2% to above 4% by 2030 (European Commision, 2025) this implies that by 2030, total EU energy consumption should not surpass 992.5 million tonnes of oil equivalent (Mtoe) for primary energy and 763 Mtoe for final energy. (Directive (EU) 2023/1791, 2023). The environmental impact of training these deep learning models for natural language processing is huge and requires significant regulatory attention (Rohde, et al., 2024).

The European Union are huge encouragement of trade openness goes hand in hand with their goal of reducing carbon emissions and energy consumption as increased trade openness improves AI's effectiveness in reducing carbon emissions and energy consumption (Qiang, Yuanfan, & Rongrong, 2024).

This regulation will have a significant impact on companies with AI driven businesses models as it introduces the obligation of monitoring and reporting of energy use and performance of data centres. Data centres must now keep a record of measurement points and devices for at least 10 years and certain KPIs must now also be reported to the EU database on data centres (COWI & European Commission, 2023). Companies above a certain threshold will be enforced to carry out an energy audit, specifically in areas where major energy savings are possible. Energy management systems have also been made mandatory for large energy consumers to make it possible for those energy consumers to monitor, analyse and hopefully encourage them to optimise their energy efficiency (Directive (EU) 2023/1791, 2023).

For these reasons companies must ensure to invest in renewable energy, optimise cooling, and manage data storage to comply with these rising energy efficiency targets and avoid being penalised. This again also highlights the need for AI in sustainability as it has the potential to support companies in the journey to become more sustainable as during this energy transition progresses AI is becoming better and better at helping cut carbon emissions and reducing its overall environmental impact (Qiang, Yuanfan, & Rongrong, 2024). The European Union's are huge encouragement of trade openness also goes hand in hand with their goal of reducing carbon emissions and energy consumption as increased trade openness improves AI's effectiveness in reducing carbon emissions and energy consumption (Qiang, Yuanfan, & Rongrong, 2024).

B) CO2 Emissions: The EU have also introduced a number of different carbon emissions regulations in order to tackle the large increase in carbon emissions, with AI being a huge reason for this. A study shows that the ICT sector, including AI is responsible for 1.8%–2.8% of worldwide GHG emissions. There is also a high chance that this is underestimated due to a lack of transparency in databases, as well as the recent rapid growth and expansion of AI, IoT, and blockchain (Delort, Riou, & Srivastava, 2023).

The EU Emissions Trading System (ETS) was brought in to help lower emissions from European power and industry plants by 47% in comparison to the levels in 2005 (European Commision, 2025). This regulation requires polluting bodies to pay for their greenhouse gas (GHG) emissions. As a result, companies will need to be more careful with their actions relating to emissions as they are charged for the emissions they release.

The Effort Sharing Regulation sets national targets and limits for the years 2021-2030 for each EU member state to reduce emissions. These national targets and limits again depend on a series of different variables ensuring that more powerful countries that release more emissions are given more ambitious targets. There is also clear rules for reporting and following up progress to evaluate annual progress. In the case of exceeding annual limits, the excess emissions are multiplied by a factor of 1.08, and the resulting value is then added to the emissions of the following year (European Commision, 2025). This will ensure that member states demand transparency from companies operating in the country and set limits on the emissions they release to comply with the regulations, meaning that companies will need to come up with ways to release less emissions without losing productivity.

The regulation that will have the biggest impact on companies is the EU Corporate Sustainability Reporting Directive (CSRD) which requires large, listed, SMEs and non-EU companies that generate over 150 million on the EU market to be transparent with their activities regarding sustainability. This includes a mandate on publishing how their activities impact people and the environment and reports based on the environmental risks associated with their activities (2022/2464, Directive (EU), 2022). The regulation requires companies to provide a business model review and KPIs on environmental matters such as the environmental impact of their operations, measures taken to address environmental risks as well as the effectiveness of those measures and finally their environmental policies and how they align with sustainability goals (Directive 2014/95/EU, 2014). (The success of many companies will be dependent on how well they can innovate operations, products, and services with their human capital meaning that businesses that invest in skilled employees and AI-driven innovation will be in a better position to comply with sustainability regulations (Di Vaio, Palladino, Hassan, & Escobar, 2020).

These regulations and frameworks have a massive impact on companies and governments decisions when it comes sustainability however, the exclusion of strong environmental requirements in regulations such as the AI act weakens the act's alignment with other policies like the EU Green Deal and international sustainability frameworks like the Paris Agreement (Ugo, Jacopo Ciani, & Massimo, 2022). When combined with the correct environmental regulations and policies, AI technology has the potential to reduce carbon emissions significantly (Qiang, Yuanfan, & Rongrong, 2024).

C) Water Usage, E-Waste and Circular Economy: The European Union introduced the Water Framework Directive to ensure that EU water bodies for example rivers and lakes are clean and healthy. Water used for the cooling of data centers and electricity production massively contribute to clean water scarcity. As a result, nearly 6 billion people will suffer from clean water scarcity by 2050 (Delort, Riou, & Srivastava, 2023). This directive has a big impact on companies as it requires them to submit reports on the measures they've taken as well as their current water quality and pollution levels, encouraging companies to implement pollution and water consumption reducing measures. This is something that AI could help with in the future (Directive 2012/19/EU, 2012).

Similar to the Water Framework Directive, the EU introduced a similar regulation for E-Waste called the Waste Electrical and Electronic Equipment (WEEE) Directive which aims to ensure responsible management of waste from electrical and electronic equipment and prevent waste while promoting recycling. The directive directly effects companies as quantity and categories of EEE placed on the market, as well as the amounts of WEEE collected, recycled, and recovered must be reported annually. Member states are responsible for enforcing compliance and have the right to impose fines on companies that don't comply. This directive will ensure companies take the appropriate steps in managing the lifecycle of electrical and electronic equipment (Directive 2012/19/EU, 2012). The specific circular economy business models that companies have are extremely important when it comes to for reducing e-waste, promoting sustainable supply chains, and ensuring compliance with environmental standards (Di Vaio, Palladino, Hassan, & Escobar, 2020).

D) AI: The EU recently introduced the EU AI Act to improve the conditions in which AI is developed and used. Many countries see AI as a top priority regarding innovation policies and governments are investing billions into AI while also taking into consideration its impact on the environment. A prime example is France, who in 2021 put a plan in place to invest €2 billion in AI until 2025.The EU are aware of the many benefits of AI, one of them being the potential to access cheaper and more sustainable energy. They would like to leverage this potential while regulating AI to ensure that the use of AI is completely safe and transparent, as well as fully traceable, non-discriminatory and environmentally friendly (European Parliament, 2025). They also want to ensure that these AI systems are kept overseen by people and not by automation to minimise the risk of harmful results. The legislation also aims to support start-ups and SMEs with the development and training of AI models. Currently, the regulation is specifically focused on ethical and safety concerns and to properly integrate environmental considerations sustainability needs to be made a core priority. The exclusion of strong environmental requirements in regulations such as the AI act weakens the act's alignment with other policies like the EU Green Deal and international sustainability frameworks like the Paris Agreement (Ugo, Jacopo Ciani, & Massimo, 2022). Sustainable AI can often be viewed in a negative way by companies and should be thought of more as a key strategy for redesigning sustainable business models and in the process shifting business models and decision-making strategies to be more environmentally friendly (Di Vaio, Palladino, Hassan, & Escobar, 2020) When combined with the correct environmental regulations and policies, AI technology has the potential to reduce carbon emissions significantly (Qiang, Yuanfan, & Rongrong, 2024).

E) International Environmental Agreements: There are many different international environmental agreements, the main one being the Paris Agreement which is prominent in the news as of late due to the departure of the US. The agreement is an internationally enforceable treaty on climate change (United Nations Climate Change, 2025).Its main goal is focused on climate and limiting global warming, however it has major implications on countries and companies operating within them. The agreement promotes emission reductions and sustainable development and encourages public and private development. It also promotes technology development and transfer to encourage companies to innovate in clean energy and sustainable technologies (United Nations Framework Convention on Climate Change, 2015). AI is an extremely powerful tool and as with most powerful tools they also have limitations. It is up to companies and policymakers to ensure that AI is implemented responsibly to achieve long-term sustainability (Nishant, Kennedy, & Corbett, 2020).

Although Trump has decided to withdraw the US from the Paris Agreement, Biden ensured to sign off on an ambitious order to bolster energy resources for AI data centers before leaving office. The goal of the order is to accelerate large-scale AI infrastructure development at government sites and agencies to offer federal sites for AI data centers and clean energy projects, assist with grid connections, and streamline permits. Biden himself said these efforts are designed to accelerate the clean energy transition in a responsible and respectful way to local communities. It is unclear whether Trump will keep this agreement in place but seeing Biden sign off on the order shows that in the right hands AI has a huge role to play in the environment in the future and the need for new ways to be more sustainable are at an all time high (ApNews, 2025).

As AI improves and more progress is made towards moving to renewable energy, AI is becoming more effective when it comes to helping to reduce carbon emissions (Qiang, Yuanfan, & Rongrong, 2024). To further increase this progress, it is necessary to deal with the current energy consumption and carbon emission problem AI is causing. There are many different strategies lawmakers can implement to improve on the current situation such as introducing new ways to assess AI’s impact on the environment, making companies share non-financial information and take responsibility for it and setting clear rules on how to include environmental considerations in EU laws (Ugo, Jacopo Ciani, & Massimo, 2022).

3. Methodology

After examining the theoretical framework of AI taking into consideration a variety of different aspects such as its different components, its effect on the environment as well as the different regulations and international agreements which demonstrate the need for sustainable AI development, the next step to be taken is an exploration on how AI-driven companies impact the environment. I will do this by analysing some of the most significant environmental factors affected by AI-driven companies, for example CO_2 emissions and total energy use. Subsequently I will complete a qualitative analysis of the business models of some of the primary companies that are heavy AI users to understand how they try to minimise the environmental harm caused by AI, as well as how they use AI to minimise environmental harm and how they plan to further develop these AI strategies in the future. I will carry out this qualitative analysis by using a multi-case study method to analyse how AI-driven companies approach environmental sustainability. To do this I will ensure to examine a number of different data sources, including sustainability reports, corporate disclosures, industry publications, and company web pages in order to complete a strong comparison on the various different business models and sustainability strategies. In addition to the multi-case study method, I will incorporate different elements of a discourse analysis to support me with my goal of identifying the different patterns in which companies frame their environmental impact. The combining of the multi-case study method with elements of a discourse analysis aims to provide both, a deep comparative analysis of sustainability strategies as well as different insights into the interpretations companies attribute to environmental responsibility (Benjamin & Helen, 2018).

The choice of researching both qualitative and quantitative data for this bachelor thesis ensures a comprehensive understanding and a more reliable and credible conclusion of how sustainability strategies of leading AI companies compare, and what best practices can be identified for minimising environmental harm. The use of quantitative research will give a clear picture of what is happening now, regarding the current effects of AI on the environment as well as the effectiveness of the current strategies. The use of qualitative research will help ensure an in-depth understanding of the effectiveness of these strategies and therefore help highlight those that are more effective.

In the following sections of this methodology an in-depth analysis of the selection process of the chosen companies will be completed, followed by an exploration of the data collection and compilation methodology. After laying out the foundations, the following chapter 'Analysis and Study of the Information' the criteria chosen to examine the companies will be brought in and validated.

3.1 Selection of the Companies Under Study

In a global survey done by McKinsey, they found that 65% of respondents reported that their company used GenAI in day-to-day operations. More than double 2023's figure (McKinsey, 2025). I've chosen to analyse 6 of the largest and well-known users of AI as these companies have access to the most up to date and possibly best AI as well as the financial resources to research, test and implement the best strategies for AI sustainability. These companies are: Amazon, Google, Meta, Microsoft, Nvidia and Open AI

I've also decided to include a new emerging company in the AI scene 'DeepSeek' who have generated significant attention in the past weeks as it became the most downloaded free app on Apple's iPhone store, surpassing OpenAI's ChatGPT (CBS News, 2025).

Analysing these 7 companies will allow me to gain a total understanding of today's current problem in sustainability in AI and what strategies are each of them using to negate the negative effect on sustainability as much as possible and having positive effects also.

Therefore, the criteria applied to choose companies relevant to the objectives of this work include their impact on environmental sustainability, their commitment to long term sustainability goals, their prominence in AI development and usage and their financial capacity to invest in sustainable AI initiatives. In the following sections, I will further elaborate and justify these criteria.

Impact on environmental sustainability: The companies chosen all have a significant impact on the environment due to their high energy consumption, data center operations, and resource-intensive computing power. Companies that have a large environmental impact whether their impact is positive or negative, play a crucial role in shaping sustainable practices. Due to having a much larger effect on the environment than most, it is key that they develop strategies to impact the environment in the most positive way possible as their efforts in reducing carbon footprints, energy consumption, and waste directly contribute to global sustainability goals. Most of these companies report their sustainability results of the year prior including what they did to achieve their goals which allows companies of smaller scale to learn from the companies who are constantly being scrutinised and made adhere to different regulations which forces them to adopt new sustainable strategies. This focus ensures a comprehensive evaluation of real-world sustainability efforts within the AI industry.

Commitment to Long-Term Sustainability Goals: Companies with long term sustainability goals tend to map out how they plan on achieving those goals. These companies are looking for real effective solutions that first will last in the future and secondly can be built and expanded on as AI advances. They are not just looking for a quick solution to comply with laws or regulations. Examples of long-term sustainability goals include achieving net-zero emissions or developing sustainable supply chains. These companies provide regular transparent updates on their progress and are constantly looking for ways to decrease their negative impact on the environment because of AI use.

Prominence in AI Development and Usage: The companies I've chosen are all heavy AI users and play a key role in AI's development. Companies at the forefront of AI development currently hold the power to shape industry trends, influence regulations, and drive technological advancements. Due to their access to the most up to date and best AI, they have a higher chance of developing more effective sustainability strategies using AI.

Financial Capacity to Invest in Sustainable AI Initiatives: The companies I've chosen all have the financial capacity to invest in sustainable AI initiatives. To research, test and develop sustainable AI strategies a lot financial capacity is needed. Investment in research, green infrastructure, and sustainable computing technologies are all things that are expensive and can only be afforded by companies with high revenues. These companies are also able to achieve their long-term projects easier due to their resources and are not relying on backing from government to achieve their goals.

3.2 Data Collection and Compilation of Information

This section outlines the data collection process used to examine how AI-driven business models impact sustainability. To do this I will focus on my data collection on companies that are leading in AI development and their different strategies to reduce environmental harm. The selected companies were chosen due to their high AI usage and due to them having the most developed AI.

Google, Amazon, Microsoft and Meta are huge, globally recognised tech companies. These companies all use AI extensively, but their main products are not AI itself, they use it to enhance existing offerings. Their large data centers around the world that power cloud services, AI, and internet infrastructure require an extreme amount of energy. These companies also produce a large amount of E-Waste because of different devices for example servers or cloud hardware which contributes negatively to the environment. These companies face heavy scrutiny for their environmental impact from governments, environmental organisations, investors, and the public. As a result, all 4 of these tech giants publish a yearly in-depth sustainability report which includes everything related to sustainability. The strategies implemented by these companies are the most advanced worldwide.

Nvidia are at the center of the AI and digitalisation transformation. They are a technology company primarily known for designing graphics processing units (GPUs). These GPUs are used for a range of different causes, including AI and data centers. Nvidia claim to engineer are the most cutting-edge chips, systems, and software for the AI factories of the future (Nvidia, 2025). They are also currently building new AI services that will allow other companies to create personal AI factories.

Open AI is an AI research and deployment company with according to their website a mission to guarantee that artificial general intelligence serves the best interests of all humanity (OpenAI, 2025). Open AI are a much newer company than the tech giants as they have only in recent years grew to reach new heights. Open AI is seen by many as the top player in the AI scene due to their work behind ChatGPT, DALL·E, and advancements in multimodal AI.

DeepSeek provides a similar offering as Open AI's ChatGPT. However, there is much less to be known about them as they have just recently entered the market. DeepSeek claim to rank at the top among open-source models and challenges the most advanced closed-source models globally (DeepSeek, 2025). Rumours that DeepSeek have managed to match the performance of Open AI's o1 model at a fraction of the cost has brought them a lot of publicity as well as the claims that their tech is more efficient than rivals due to them not having access to Nvidia chips which forced them to innovate their own (CNN Business, 2025) (DW, 2025).

By analysing these different companies, I hope to gain a comprehensive understanding of AI's environmental impact and sustainability strategies from many different perspectives as no two companies I analyse will have the exact same strategies.

Once the companies were selected all the collected information has been gathered from different data sources, the majority being from company websites and sustainability reports. However, different data sources such as news articles, industry reports, government databases, and third-party sustainability assessments were also reviewed in the process.

I ensured to analyse the most up to date information available to the public. The data gathered corresponds to the year 2024 when possible and 2023 if not. Given how rapid the rise of AI of has been as well as the constant changing and updating of the different relevant regulations, older date was considered irrelevant as so much has changed in the last two years in relation to AI. Table 1 below provides an overview of the selected companies, ensuring that the most important information regarding the companies and their AI use is included

Table 1. Selected Companies

Company & Category	Amazon	Google	Meta	Microsoft	Nvidia	OpenAI	DeepSeek
Primary Industries	E-commerce & Cloud Computing	Search & Cloud Computing	Social media	Cloud Computing & Software/Hardware	AI Hardware	AI Model Development & Machine Learning	Large Language Models & Open-Source AI Development
AI Role	Heavy User	Developer & User	Developer & User	Developer & User	Hardware	Developer	Developer
Geographical Presence	175+	70+	50+	120+	40+	7	1
Website	amazon.com	google.com	meta.com	microsoft.com	nvidia.com	openai.com	deepseek.com
Sources	Amazon 2023 Sustainability Report	Google 2024 Sustainability Report	Meta 2024 Sustainability Report	Microsoft 2024 Sustainability Report	Nvidia 2024 Sustainability Report	Several 3rd Party Sources	Several 3rd Party Sources
Revenue (2024)	$500B	$290B	$130B	$240B	$35B	$1B	N/A

Source: Compiled by the author

3.3 Analysis and Study of the Information

In order to ensure a comprehensive understanding and a more reliable and credible conclusion of how sustainability strategies of leading AI companies compare, as well as what best practices can be identified for minimising environmental harm, the decision was made to conduct both a qualitative and quantitative analysis of the examined companies following an abductive approach. This study draws on Gioia et al.'s (2012) systematic approach to qualitative research, which places a strong emphasis on the structuring and analysation of rigorous data to enhance conceptual development and ensure methodological credibility (Gioia, Corley, & Hamilton, 2013). Due to the approach being suited to both inductive and abductive research, the identification of emerging themes in organisational strategies becomes easier to identify and as a result, it facilitates the assessment of sustainability practices in AI-driven companies.

This allowed me to assess measure environmental impacts such as energy consumption and CO_2 emissions as well as examining business strategies and sustainability reports aimed at reducing AI's environmental footprint. To analyse the chosen companies' impact on environmental sustainability, commitment to sustainability goals, prominence in AI development and usage and financial capacity to invest in sustainable AI initiatives there was 11 standardised criteria were initially chosen based on a thorough review of existing literature. However, due to the constant rapid growth and change in AI and sustainability, other new and different elements were also considered throughout the analysis as different patterns and insights began to appear. As a result of combining both a deductive and inductive approach, a more comprehensive evaluation of the companies was completed. This resulted in the following final criteria:

- **Company Profile:** Basic details regarding the company such as its name, business model and AI usage to gain a basic understanding of each of the company's roles and goals regarding AI sustainability.

- **Mission and Sustainability Goals:** Information regarding the company's sustainability vision and any specific net-zero or carbon neutrality goals they may have to differentiate those with genuine commitment to those who are greenwashing.

- **Energy Consumption and Carbon Footprint:** Specific numerical reports on energy consumption and Co2 emissions to understand today's current sustainability problem and identify opportunities for sustainable AI.

- **Data Centers and Infrastructure:** Where company's data centers are based as well as information regarding their sustainability. Do they have any specific efficiency strategies for their data centers and any information regarding the cooling technologies used or energy optimisation. This gives a better understanding of how much energy is demanded by AI operations and how much of an effect using renewable energy or more optimal cooling systems could have.

- **Hardware and Critical Minerals Usage:** Does each company have any sourcing strategies for environmentally friendly supply chains as AI relies on resource-intensive hardware which leads to environmental issues relating to mining.

- **E-Waste and Hardware Lifecycle:** Does each company have any specific circular economy strategies or recycling programs for AI-related electronic components as hardware upgrades can result in toxic e-waste

- **Regulatory Compliance & Corporate Reporting:** Do the companies comply with key sustainability regulations. Are they transparent in sustainability reporting and corporate disclosures.

- **Key Partnerships & Sustainability Investments:** Do the companies invest in any sustainable AI research or collaborate with any renewable energy and carbon capture initiatives as these can indicate whether companies are committed to long-term sustainability.

- **Sustainable AI Development Practices:** Do the companies use AI to optimise environmental sustainability or have they developed any AI models to reduce emissions and improve efficiency as this can help companies be more sustainable without sacrificing performance.

- **Challenges and Barriers:** What are the different obstacles related to making AI more sustainable for example high costs or regulations. Are there any industry-wide limitations affecting AI sustainability. These barriers can help understand what is specifically needed for sustainable AI

- **Scalability of Sustainable AI Models:** Is it possible for other actors to replicate these sustainability strategies across industries and is it feasible to scale renewable AI applications globally as the companies examined have access to many resources which smaller actors would not have.

4. Results Obtained by the Study of the AI- Driven Business Models

The following section will focus on giving a descriptive presentation of the key findings from the analysis of AI-driven business models, ensuring to present them in their entirety while also highlighting specific features. The results are structured into eleven key sustainability themes and not analysed on a company-by-company basis in order to provide a clear structured comparison. More in-depth results specified by company can be found in appendix

Each section in this analysis will first include an introduction to the topic and the importance of the topic. It will then present key findings and trends as well as comparisons of the companies analysed. Finally, each section will highlight key takeaways, gaps, or industry wide challenges.

4.1 Company Profile: Business Model & AI Usage

AI plays a huge role in sustainability and its role is growing more by the day as its capabilities and use is increasing all the time. Generally speaking, AI's effect on the environment overall at this moment in time is negative. However, companies are trying to change that by finding ways to be more sustainable in their AI use. As a result of the research done, I discovered that some companies take that responsibility more serious than others as the implementation of sustainability efforts varies widely between companies.

In terms of business models, Amazon, Google and Microsoft operate in many different sectors compared to the others who operate a more focused business approach (Amazon, 2023) (Google, 2024) (Microsoft, 2024). All companies analysed are of course heavy AI users, therefore they are heavily investing in AI. However, their applications differ company by company. The tech giants tend to use AI for more business efficiency purposes whereas Nvidia, Open AI and Deepseek's use of AI takes more of a focus on AI research and computing advancements (Nvidia, 2024) (DeepSeek, 2025) (OpenAI, 2025). Amazon, Google, Meta, Microsoft and Nvidia all emphasise their use of AI for sustainability and their actions to lower its environmental impact, in comparison to Open AI and Deepseek in which any sort of sustainability initiatives was not available to be found online, which may demonstrate their mentality towards sustainability (Microsoft, 2024) (DeepSeek, 2025) (OpenAI, 2025) (Amazon, 2023) (Google, 2024) (Meta, 2024). This trend can be seen all the way through the results.

4.2 Mission & Sustainability Goals

One of the best, if not the best way to measure corporate commitment to sustainability goals is to analyse companies' sustainability goals as these goals show in time whether companies are engaging in greenwashing or are they serious about the goals they set and ensure to achieve them.

Below is a table demonstrating each of the companies' sustainability goals as well as their net-zero targets.

Table 2. Net-Zero Targets & Key AI Sustainability Goals

Company	Net-Zero Target	Key AI Sustainability Goals
Amazon	Net-zero by 2040	- 100% renewable energy by 2030 (achieved) - Water positive by 2030 - Carbon-neutral emissions by 2040
Google	Net-zero by 2035	- 24/7 carbon-free energy by 2030 - 50% Scope 1, 2 & 3 emissions reduction by 2030 - Circular economy focus
Meta	Net-zero by 2030 (value chain)	- Water positive by 2030 - 42% emissions reduction by 2031 - Supplier engagement for emissions targets
Microsoft	2030 (carbon negative)	- 100% renewable energy by 2025 - 50% Scope 3 emissions reduction by 2030 - Land protection by 2035
NVIDIA	100% renewable electricity for offices & data centers by FY25	- Zero Scope 2 emissions - Sustainability reporting aligned with global frameworks
Open AI	N/A	N/A
DeepSeek	N/A	N/A

Source: Compiled by the author

It is visible here that five out of eight of the analysed companies have set serious sustainability goals, some of which have already been achieved. Although specific goals vary from company to company, goals such as net-zero goals and renewable energy goals are the most common and possibly the most important. Other goals such as water positive goals which is an important factor can be seen in some of the reports. Scope 3 emissions focused goals are something that stood out to me as it is particularly promising seeing these large tech companies support smaller companies they work with. Google, Meta, and Microsoft are actively engaging suppliers to reduce emissions beyond direct operations, as Scope 3 emissions are by far the largest in terms of carbon emissions of the three (Google, 2024) (Meta, 2024) (Microsoft, 2024).

A lack of transparency from Open AI and Deepseek is a cause for concern as these two are some of the heaviest AI users worldwide and without their transparency it is difficult to understand the full picture when it comes to sustainable AI. This makes it clear that more industry-wide standards are needed.

4.3 Energy Consumption and Carbon Footprint

As discussed previously the training and use of AI models require large amounts of energy, resulting in high carbon emissions. However, AI is not the only cause of energy consumption as every action taken by companies has some sort of effect on their energy output and therefore their carbon footprint. To really understand the magnitude of their actions as well as to compare the output of the different companies analysed a table has been created for clear viewing.

Table 2. Net-Zero Targets & Key AI Sustainability Goals

Company	CO_2 Emissions (Metric Tons)	Energy Use (MWh)
Amazon	68.82M	N/A
Google	14.3M	25.3M
Meta	7.5M	15.3M
Microsoft	14.3M	25.3M
Nvidia	3.69M	612,000
OpenAI	N/A	N/A
DeepSeek	N/A	N/A

own illustration (2025)

As can be seen in the table, Amazon have the highest C02 emissions which although it has not been disclosed, likely means they have the highest energy use also (Amazon, 2023). While Meta and Nvidia have much lower emissions than the rest, Meta having a lower carbon output could quite possibly be because of their focus on energy-efficient data centers compared to the other tech giants, whereas Nvidia's lower energy consumption and carbon output is likely as a result of their focus on creating and designing chips in comparison to the technology giants who have large-scale AI infrastructure (Meta, 2024) (Nvidia, 2024). As mentioned in the previous section OpenAI and Deepseek failed to report on any sustainability measures. Despite this, DeepSeek's recent emergence has shown that there may be ways to reduce the emissions of AI with chip innovation and language model advances (Time, 2025). DeepSeek claimed to have the ability to cut down on how much electricity it consumes by using more efficient training methods. It has been speculated that by being more selective with which parts of the model are trained; you don't have to train the entire model at the same time and therefore saves energy. Also there has been claims that DeepSeek's model saves energy by using something called "key value caching and compression", which is a technique where the model stores and organises important information more efficiently. Instead of processing all the data from scratch each time, it retrieves and uses the summarised or compressed information, making the process faster and using less energy (The Verge, 2025).

4.4 Data Centers & Infrastructure

Data centers are the main reason for AI's high energy consumption and carbon footprint. These facilities are computer warehouses that store large amounts of data in order to reach the daily transaction processing needs of different businesses.

Due to their large energy consumption, discovering ways to make them more sustainable is key in the sustainability journeys of these companies. Use of renewable energy of course stands out as the obvious solution. Amazon, Microsoft, Meta and Nvidia are all working towards using as much renewable energy as possible (Amazon, 2023) (Nvidia, 2024) (Microsoft, 2024) (Meta, 2024). For example, Nvidia have set their focus on locating their data centers in areas with access to renewable energy sources and Amazon who have began their use of renewable diesel, such as hydrotreated vegetable oil for backup generators (Nvidia, 2024) (Amazon, 2023). Meta is leading the way in terms of energy and water efficiency as their operational data centres exhibited an average Power Usage Effectiveness (PUE) of 1.08 and a Water Usage Effectiveness (WUE) of 0.18 in 2023 (Meta, 2024).

Data center cooling systems consume around 50% on average of the total power consumed (Dayarathna, Wen, & Fan, 2015). Which means that companies need to discover and implement new cooling strategies and systems if they want to become more sustainable. The companies analysed have all adopted several different strategies such as Amazon's use of free-air and direct evaporative cooling systems to reduce energy consumption which is especially effect in hot temperatures (Amazon, 2023). Meta have adopted a similar strategy with their dry cooling technology which uses air instead of water for cooling (Meta, 2024). Other strategies include Microsoft's advanced liquid cooling or Nvidia's closed-loop liquid cooling systems where they recycle their engineered fluids that they use for cooling (Microsoft, 2024) (Nvidia, 2024). As a result of these strategies, huge strides are being made in the sustainability of these data centers, for example Microsoft's new data centres, which are designed to consume zero water for cooling, reducing reliance on freshwater resources. (Microsoft, 2024)

Despite these strides made, the energy used by data centres is still enormous and a major challenge for companies going forward will be balancing the constant increase demand of energy of these data centers with efficiency and environmental impact.

4.5 Hardware & Critical Minerals Usage

Amazon set their focus on avoiding specific conflict minerals as well as promoting chip energy efficiency and the use of recycled materials for devices. They aim for 100% of 3TG (tin, tungsten, tantalum, gold) smelters and refiners in its supply chain to meet recognized certification standards (Amazon, 2023). Meta on the other hand collaborate with initiatives such as the Responsible Minerals Initiative with the goal of ensuring ethical sourcing by assessing both the environmental and social risks of their supply chain (Meta, 2024). They also updated their Responsible Minerals Sourcing Policy in 2023 to align with OECD Due Diligence Guidance (Meta, 2024). Similarly, Nvidia's Responsible Minerals Policy also follows OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas (CAHRA) (Nvidia, 2024).

There is growing expectations on companies to adopt sustainable sourcing practices and overcome the ethical issues in sourcing minerals like cobalt. However, collaboration is key to solve this and partnerships such as Google's with SEMI and holding suppliers and partners to high standards will be key.

4.6 E-Waste & Hardware Lifecycle

E-Waste and AI-Driven hardware is a major environmental problem regarding AI. Data centers produce electronic waste, which often contains hazardous substances, like mercury and lead (UN Environment programme, 2024)._AI infrastructure also has short hardware cycles, which means companies must constantly update and replace their old systems. For example, the creation of new data centers and the upgrading of systems.

All companies except for OpenAI and DeepSeek offer trade-in or recycling programs, some of which seeing great results from this. For example, Microsoft who have achieved an 89.4% recycle and reuse rate for servers and components across all cloud hardware in FY23 (Microsoft, 2024). These companies have also introduced reuse and refurbishment programmes, which have been successful as can be seen with Google reselling 44M+ hardware components from data centers into the secondary market for reuse by other organisations since 2015 (Google, 2024).

Although companies are making great progress, AI hardware waste remains a challenge as short GPU/TPU lifespans is the main cause of rapid e-waste and therefore extending this lifespan as well as constant improvement in AI hardware recycling are needed going forward. To tackle this, Amazon have implemented a new strategy that extends server life from five to six years and prolongs S3 hard disk drive (HDD) use by up to two years through rack consolidation, reducing waste, water, and energy use (Amazon, 2023).

4.7 Regulatory Compliance & Corporate Reporting

The development, use and maintenance of AI has a major effect on many different important sustainability factors such as energy use, C02 emissions, water usage, e-waste and circular economy. The effect is so large that it has driven governments and economic unions to either implement new or update existing regulations regarding sustainability. These regulations and policies hold major importance in shaping AI-driven business models, especially those who take sustainability into account in their decisions. These regulations and policies highlight the importance of compliance with environmental regulations, specifically in AI due to the energy it consumes, the emissions it releases and e-waste that is left as a result. Google, Meta, Microsoft, Amazon and Nvidia all publish yearly sustainability reports, which is the first step to transparency in corporate reporting and regulatory compliance as these reports contain sustainability strategies, performance and certain qualitative data such as energy use and carbon emissions. Google also expects all suppliers to set public GHG reduction targets and report environmental data (Google, 2024). Other important topics which are becoming more mainstream are supply chain transparency and human right commitments. As a result, companies are offering more reporting services such as Amazon's whistleblower mechanism which is an anonymous web form in 19 languages for reporting human rights or environmental concerns (Amazon, 2023) which is a great initiative which other large corporations could follow .

Another key trend which can be seen is that companies are increasingly aligning with global reporting frameworks and third-party verification for example Meta obtains limited assurance for environmental metrics from Ernst & Young LLP (Meta, 2024). Amazon and Google also ensure independent verification on their reported metrics, with Amazon reporting their performance against SASB, SDGs, TCFD, and UNGPRF frameworks to maintain transparency (Amazon, 2023) (Google, 2024).

However, there is still some key challenges in regulatory compliance and corporate reporting such as again OpenAI and DeepSeek not having any sort of sustainability reporting or also companies who do not receive third party verification on their reports such as Nvidia. Finally, each company uses different reporting frameworks, this makes it very difficult to make accurate comparisons and analysis of those companies.

4.8 Key Partnerships & Sustainability Investments:

A key step towards companies becoming more sustainable is the partnerships and investments they make. Many leading companies, including Amazon, Google, Microsoft, Meta, and NVIDIA, are actively investing in AI-driven sustainability strategies, renewable energy projects, and carbon removal technologies (Amazon, 2023) (Google, 2024) (Microsoft, 2024) (Nvidia, 2024) (Meta, 2024). They are also always forming partnerships and funding research to learn more about AI and its environmental effects, which in turn will allow them to discover and integrate more effective sustainability strategies going forward. Amazon for example have invested in over 500 renewable energy projects like solar and wind farms (Amazon, 2023). Microsoft Meta and NVIDIA on the other hand have set their focuses more towards expanding clean energy procurement and supplier education (Nvidia, 2024) (Microsoft, 2024) (Meta, 2024). These companies have also invested in many different carbon capture and removal projects as well as multiple clean energy and circular economy partnerships.

Financial commitments and collaborations between companies, research institutions, and governments are key to achieving climate goals. Amazon and Google are currently at the forefront with Amazon investing $2B into the Climate Pledge Fund that supports hard-to-abate sectors (Amazon, 2023) and Google’s Carbon Removal Research Awards which has provided $3M for university research (Google, 2024) .These investments and partnerships demonstrate companies’ commitment to long term sustainability.

4.9 Sustainable AI Development Practices

AI has unbelievable potential to help companies on their sustainability journey. The technology itself is already allowing companies to improve their resource efficiency and reduce their carbon footprint. However, due to the constant advancement of AI there is more and more potential for it to contribute positively to sustainability goals.

Currently companies are using AI for a number of different purposes, with each company focusing their AI use on different objectives. Google and Nvidia are using AI in broad environmental initiatives such as to optimise the performance of solar and wind farms (Google, 2024) (Nvidia, 2024). Microsoft similarly are integrating AI with climate resilience, in an aim to use AI to help with several different sustainability challenges, such as with water leak detection and ecosystem monitoring (Microsoft, 2024). Meta focus of AI for sustainability slightly differs as Meta's main use for AI sustainability is related to improving the energy efficiency of its data centers by using AI to develop concrete mixtures with a lower carbon footprint (Meta, 2024). Amazon have developed two new chips, the Graviton4 chip which they have developed offers better performance and energy efficiency than previous models, while the other chip they have developed, the Inferentia2 chip delivers up to 50% more energy efficiency and 40% cost savings (Amazon, 2023).

DeepSeek's recent V3 emergence is an interesting matter, as claims that its structure improves energy efficiency, making it greener than dense LLMs could be important in the future if proven truthful (The Verge, 2025). This is because if applied correctly, it could be used for climate modelling, energy optimisation, and sustainable AI research. However, as it is only in early stages its full capabilities are still unknown.

What is clear is that AI is an extremely powerful tool that can be implemented to address different environmental challenges and improve overall sustainability, and this potential goes beyond its current use and can really help companies going forward with their sustainability goals.

4.10 Challenges & Barriers

Of course, every company would love to have the highest level of efficiency tied in with the lowest level of environmental damage. However, this is just not possible due to many different challenges and barriers. The main challenge that stands out is of course AI's increasing energy demands. AI models create a huge carbon footprint as a single AI model training can emit carbon dioxide equivalent to the lifetime of five cars and a request made through ChatGPT, an AI-based virtual assistant, consumes 10 times the amount of electricity as a Google Search (Electricity, I. E. A, 2024).

Another major challenge companies face is that they are being encouraged to be transparent about their environmental impact but without a standardised framework or clear rules it is very hard to compare different efforts. On that notes it is also difficult for these companies to keep up with the constant evolvement of sustainability regulations. This constant change can create uncertainty for businesses and result in a slowing down of innovation as well as creating more costs for companies to adapt to the new regulations, which takes away time and money which could be used to put towards new strategies or technologies to improve AI's sustainability.

One of the other primary challenges faced by companies is data scarcity. Companies are struggling to develop global solutions for several reasons. Firstly, the impact of the climate is different in every region which makes it difficult to find a solution that can be applied globally. The second reason is due to how spread out the global market is without a single system to track environmental data makes it difficult to collect, compare, and analyse sustainability information effectively.

4.11 Scalability of Sustainable AI Models:

The companies I have analysed in my study are some of the largest companies in the world with massive revenues and access to the most resources. Strategies and technologies developed by these companies need to be able to be replicated at some scale by smaller AI companies.

Many simpler strategies such as recycling and reuse programs and adopting renewable energy can be much easier replicated by smaller actors than some of the other more complex strategies. Many larger companies such as those analysed have began to work with their suppliers to decrease their Scope 3 emissions and promote sustainability. Google have partnered with stakeholders across several industries to create AI-driven sustainability solutions that can be scaled globally (Google, 2024). Others do this by setting challenges and goals for those they work with. For example, specific carbon reduction goals which require regular updates on current progress or providing training and support to other companies to help them calculate emissions, adopt clean energy, and improve resource efficiency. Many larger companies are also encouraging those they work with to adopt renewable energy by offering financial support for clean energy projects or supporting bulk purchasing agreements. The most effective strategy in which has been taken up by many of the large corporations is also the simplest. Companies need to be transparent and open to sharing their strategies. Amazon have made their sustainability best practices available to businesses through cloud-based AI services that optimize energy efficiency (Amazon, 2023) and Microsoft have made their AI-based sustainability tools, such as AI for Earth open-source models to help businesses and governments reduce environmental impact (Microsoft, 2024).

5 Discussion

The case study results have been introduced and will now be employed to address the question: 'How do the sustainability strategies of leading AI companies compare, and what best practices can be identified for minimising environmental harm'. Therefore, several different key questions will be analysed, discussed and answered: Does AI help or harm sustainability, what sustainability strategies are AI companies using and how can AI be made more sustainable long-term? These questions are important and need to be answered as AI has a dual impact and it is important that companies are ensuring to give themselves the best chance possible for the impact to be a more positive than negative one. There is also still a lack of transparency in AI's environmental footprint which makes it important that firstly this lack of transparency comes to an end and secondly it needs to be ensured that companies move past greenwashing and put real time and resources into developing genuine sustainability strategies that are both short and long term orientated. The conducted case study analysed several companies' current effect on the environment, their current strategies and their future goals. This combined with the previous research on the key components of AI as well as various policies and regulatory frameworks in relation to AI and sustainability will allow the research question to be answered.

5.1 AI's Environmental Impact – Balancing Benefits and Costs

The positive effects of AI are well documented and well known all around the world, AI has even now begun to be marketed as a sustainability solution by many. This has led to a wave of new AI sustainability start-ups as well as of course the large corporations incorporating AI into their sustainability strategies. For example, Google's use of AI to optimise cooling in data centers and Meta's use of AI to develop low-carbon concrete for its operations. On the other hand, this study has discovered that there are various environmental challenges associated with AI-driven business models for example, the energy it consumes and its reliance on resource-intensive hardware. This prompts the question, does AI's sustainability potential outweigh its environmental cost?

In order to understand if AI's sustainability potential outweighs its environmental cost, it is necessary to break down AI's negative and positive effects that have been identified in this research.

The case study confirms AI's high energy consumption, especially the training of AI models and energy consumed by the data centers. AI applications create a huge carbon footprint, which represents a direct form of rebound effects. According to Microsoft's sustainability report, the workload of AI accounts for a significant portion of the total 25.3 million MWh annual energy consumption in 2024. (Microsoft, 2024)In contrast, Nvidia's who focus on AI chip design rather than cloud services reported a much lower energy consumption of 612,000 MWh in 2024 suggests hardware efficiency plays a key role in AI's environmental impact. (Nvidia, 2024)

The energy consumption related to data centers is even worse. A typical data center may consume as much energy as 25,000 households and up to 200 times as much electricity as a standard office space (Dayarathna, Wen, & Fan, 2015). After analysing each of the companies' strategies, it became clear that dealing with this a priority for companies. Google's reported a total energy usage of 25,307,000 MWh in 2023 compared to Meta's reported 15,325,314 MWh shows the importance of data center operations optimisation, as Meta have achieved an industry-leading PUE (Power Usage Effectiveness) of 1.08 which shows when compared to others (Google, 2024) (Meta, 2024).

In addition to the energy consumed by the AI training applications and data centers, the study identified e-waste as another negative effect caused by AI. The process of producing simple technological items such as computers causes major hardware waste, for example, a 2 kg computer requires 800 kg of raw materials alone. Data centers produce electronic waste, which often contains hazardous substances, like mercury and lead (United Nations Climate Change, 2025). The study found that to combat this Amazon, Meta, and Microsoft have introduced initiatives such as server reuse and hardware recycling programs, with Microsoft achieving an 89.4% recycling and reuse rate for cloud hardware (Microsoft, 2024).

On the other hand, the analyses of the different companies showed that the rapid growth of AI has also brought to light its sustainability potential. Artificial intelligence (AI) based techniques can help reduce emissions in a variety of ways, like as facilitating the development of low-carbon technologies, improving sales forecasts, limiting system waste, satellite imagery, improving energy efficiency, predicting vehicle emissions from smartphone GPS traces, boosting single buildings, highlighting behavioural patterns, and planning and running low-carbon infrastructure. Many of the companies analysed as part of the case study have already begun to exploit AI for sustainability purposes and plan on continuing to do so to help them reach their sustainability goals. For example, Google are currently exploring how AI algorithms and aerial imagery can help implement reflective "cool roofs" to reduce urban heat. Google are also currently exploring a new strategy which combines data from MethaneSAT with its AI and infrastructure mapping capabilities to create a comprehensive view of methane emissions from oil and gas operations (Google, 2024). Some of the other most interesting projects by companies that were found during the research include Meta's utilisation of AI to develop concrete mixtures with a lower carbon footprint for use in its data centres (Meta, 2024)and Amazon's support for the SeloVerde tool in Brazil, using AI and satellite data to track deforestation risks in supply chains (Amazon, 2023).

Based on the case study findings, it's clear that AI has a lot of positive and negative effects on the environment and at the current moment it is safe to say that AI's sustainability benefits do not yet outweigh its environmental costs. However, AI is neither fully sustainable nor fully harmful and the impact it has on the environment whether that be positive, or negative is fully dependent on how it is used. This means that companies and policymakers must take responsibility to minimise its footprint by using AI responsibly and ensure to invest the necessary time and resources into new strategies to help them do this.

5.2 How AI-Driven Business Models Are Adapting to Sustainability Challenges

Companies are adopting many different sustainability-focused strategies which all contribute towards the common goal of becoming more sustainable. Amazon and Microsoft are heavily investing in renewable energy for AI operations with their ambitious goals of 100% carbon free energy in mind. They are doing this by investing in and partnering with a wide range of different projects and groups such as CarbonCapture Inc. which is for modular Direct Air Capture (DAC) systems and access to up to 100,000 carbon removal credits or collaborating with the Ellen MacArthur Foundation and WRAP to promote industry-wide circular economy solutions (Amazon, 2023) (Microsoft, 2024).

Nvidia has developed different strategies more suited to their business model, they are developing different AI chip design tools that enable chips to operate faster while consuming less energy (Nvidia, 2024). Amazon have also been working on producing more efficient chips with their Graviton4 chip offering better performance and energy efficiency than previous models, as well as their Inferentia2 chips which are delivering up to 50% more energy efficiency and 40% cost savings (Amazon, 2023).

Companies have also began using the AI technology they have invested so much in to help them with their sustainability goals. Already, AI-driven systems have been shown to optimize heating, ventilation, and air conditioning (HVAC) operations with a proven in HVAC energy reduction of 15.8% using a BrainBox AI technology. A study shows that energy consumption and carbon emissions could be reduced by approximately 8% to 19% in 2050 as a result of AI adoption. This combined with energy policy and low-carbon power generation has the potential of even more reducing energy consumption even more to 40% and carbon emissions to a possible 90% in comparison to business-as-usual scenarios in 2050 (Chao, Jing, Mark, & Nan, 2024). The companies analysed in the case study have introduced a wide range of different sustainable AI development practices. Due to them being more recent projects and strategies specific results of the implementation of these strategies are not available. Despite this, the trend of companies being successfully on their way to reaching their sustainability goals signals that the strategies along with other measures have been effective so far.

OpenAI and DeepSeek have not published any sort of sustainability reports or any sustainability metrics at all since their founding. With them being two of the primary AI developers and users, it is extremely concerning that they have not published these. Especially OpenAI who were one of the first and have consistently remained as a major pioneering company in AI. OpenAI operate on Microsoft's Azure infrastructure, which has been carbon-neutral since 2012 (Microsoft, 2025). This at least demonstrates that they have acknowledged the environmental implications of its operations and have taken steps to address them. Despite this there remains a lack of detailed public disclosure regarding the specific energy consumption and carbon emissions associated with OpenAI's AI models which makes it impossible to fully assess the environmental footprint of their AI operations. DeepSeek on the other hand have not once showed any specific interest at all in sustainability. However, as they are a more recent start up and have only recently become a global sensation this could change in the future. As of now the only information we have regarding sustainability from DeepSeek is their claim that the AI model they have developed is much more efficient than Meta's Llama 3.1 model with it using roughly one-tenth the amount of computing power than Meta's (The Verge, 2025). This is only speculation for now as it has yet to be proven and as for now it is the only sustainability information we must go off.

5.3 Future Outlook and Recommendations

A) Practical Recommendations for Companies: In order for AI to become truly sustainable in the future, several different steps need to taken by many different actors. Firstly, AI companies must develop energy-efficient computing strategies. These strategies have been discussed throughout the paper. However, the main strategies that would have the most positive impact are developing energy-efficient computing and infrastructure, transitioning to carbon-free and renewable energy and finally, focusing on circular economy and hardware lifecycle management.

In terms of developing energy-efficient computing we can again see many examples of from the companies analysed in the case study such as, Amazon and Nvidia's new energy efficient chips, Microsoft and Meta's AI-optimised data centers that reduce power usage effectiveness as well as using dry cooling technology, and Google and Nvidia's focus on the acceleration of workloads as a successful way to reduce the energy consumed per AI task.

Examples can also be found in the case study of the transition to carbon-free and renewable energy with many of the companies analysed attempting to shift not only their data centers, but their offices to 24/7 carbon-free energy sources like solar, wind, and hydropower as well. Major investments in renewable energy projects to power AI workloads is another strategy which has been implemented by Nvidia and Amazon which has serious potential in helping them with their transition to carbon-free and renewable energy.

Regarding focusing on circular economy and hardware lifecycle management, this is one of the simpler steps which is overlooked by many. However, companies who want to take their sustainability goals seriously should look to improve on this. For example, Microsoft circular centers refurbish and reuse 89.4% of cloud hardware components (Microsoft, 2024), Google has resold 44 million refurbished hardware components since 2015 as well as 29% of server components used for maintenance were from their refurbished inventory in 2023 (Google, 2024). Meta uses a strategy where they validate and deploy reused components which minimises the need for new servers and therefore, extends the lifespan of hardware. Amazon managed to cut roughly 65,000 metric tons of CO_2e in 2023 by shifting hardware transport to ocean freight (Meta, 2024).

These strategies demonstrate that simple strategies can go along way and not every strategy needs to be expensive nor advanced to be effective.

B) Policy and Regulatory Recommendations: Another step that needs to be taken for AI to become truly sustainable in the future is the implementation of standardised and clear sustainability regulations for AI. These regulations need to be implemented by governments and unions such as the European Union and will help ensure transparency from different actors and companies. Existing regulations such as European Union's Artificial Intelligence Act which imposes a series of requirements on high-risk AI systems, including obligations related to security, transparency, quality and environmental sustainability standards in an attempt to ensure that the development and deployment of the AI applications do not adversely impact ecological goals.

Outside of government and unions, international standards such as ISO/IEC 42001 have been introduced and developed to guide the management of responsible AI use. This standard is a great example of a framework that supports the integration of sustainability considerations into AI system development and deployment. This successfully supports the final goal of AI innovations which help in contributing positively to environmental objectives.

Although these regulations provide a strong foundation for sustainable AI, many more policy measures are needed to ensure AI's future sustainability. It is clear from analysing the quantitative data from the case studies that more strict energy efficiency benchmarks for the likes of AI training are needed. Also, with the lack of sustainability measures reported from the likes of OpenAI and DeepSeek that mandatory AI sustainability disclosures should be enforced. Government and unions can incentivise sustainable AI innovation through tax benefits, grants, and funding for AI projects that directly contribute to environmental goals, such as AI-powered carbon capture and energy optimisation solutions. We can see from the case study that without better and stricter regulations, the future environmental impact level of AI may be too much for current regulations which could lead to unsustainable energy consumption and environmental strain.

C) Recommendations for Future Research: Further research is needed to quantify AI's full environmental footprint across its entire lifecycle. From the case study while most companies report direct energy usage, there is a clear lack of specific information reported relating to carbon impact, including emissions from hardware production and supply chains, including their long-term impact. In future studies relating to AI, rebound effects of AI should be explored further as the higher usage of AI with a goal of making it more efficient, could cancel out the sustainability benefits. It is also clear from the analysis that the gap between AI development and environmental science needs to be bridged, to of course ensure that the AI solutions being developed are environmentally responsible in the long run.

D) AI's Role in Technological Innovation for Sustainability: There are many different emerging innovations that could improve AI sustainability. A prime example that has already been discussed in this paper is self-optimising AI models. DeepSeek's claim that the AI model they have developed is much more efficient than Meta's Llama 3.1 model with it using roughly one-tenth the amount of computing power than Meta's is an example of this, and it has great potential to reduce the environmental impact of AI operations.

The development of more efficient AI chips for example from Google and Nvidia is also one of the main emerging innovations that could improve AI sustainability. These chips improve the performance of AI and speed up chip design so much that the time needed to create chip layouts can be reduced from weeks to hours, contributing to more energy-efficient AI hardware (New Atlas, 2024).

AI has also been used to assist with carbon removal technologies. Amazon for example, are currently testing the effectiveness of AI-designed material in its data centres. This AI-designed material acts like a sponge at the atomic level to capture CO_2, potentially providing a cheaper alternative to carbon offsets (Reuters, 2024).

AI has massive sustainability potential, but this potential can only be realised if policymakers, businesses, and researchers all take real action. However, if these actors focus on everything discussed above it would be a real positive step forward and would give the best chance for AI sustainability can be improved in the future.

6. Conclusions

This study examined the environmental impact of AI-driven business models, highlighting both their sustainability potential and challenges. The study found that AI can contribute to sustainability in several ways. Through various strategies companies can also effectively reduce its environmental harm. For example, adopting renewable energy, developing efficient cooling systems and optimising AI models. However, the high energy consumption, carbon emissions and e-waste to name a few are significant challenges related to AI's sustainability. A lack of serious regulation and standardisation in sustainability reporting is also a major barrier to achieving AI sustainability.

The research was guided by several different objectives building towards answering the final research question which were answered throughout the study. These were conceptualising AI-driven business models, evaluating AI's environmental impact, analysing regulatory frameworks and identifying best practices. Each of these building towards answering the final research question.

The case study provided insights into the environmental impact of major AI companies like Google, Meta, and Microsoft which provided a better understanding of AI-driven business models. Gaps in enforcement and transparency in regulations such as the EU AI act were highlighted during the assessment of the effectiveness of various regulations and policies. It became clear through the study that AI-driven businesses are doing a great job exploring new renewable energy solutions but at the same time are significantly contributing to energy consumption, and through this analysis it was also possible to determine the best sustainability practices.

Many key findings were determined throughout the study. The energy consumption and carbon emissions directly resulting from AI applications, mainly from data centers is the biggest sustainability problem regarding AI. Most companies analysed in the case study are aware of this and are implementing strategies to combat the problem. Meta and Microsoft's use of advanced cooling systems and renewable energy integration are key examples. Another key finding is the trend in sustainability strategies, many are heavily investing different strategies to reach a common goal of reducing energy and carbon emissions with the goal of being carbon neutral. Finally, the challenges regarding regulatory and policy frameworks were another key finding as while existing regulations promote AI sustainability, enforcement is inconsistent, and no global standard exists. This has a major effect on the use of AI and its sustainability.

Despite the study successfully answering the different research objectives and the final research question, there were some limitations regarding the study. As this study solely focused on seven AI-driven companies which included two that limited full analysis due to transparency issues the study may not fully represent the broader AI industry. Hopefully soon more smaller companies and start-ups begin to report on their sustainability strategies and metrics to enable future studies to explore AI sustainability strategies in smaller firms and emerging markets. On top of the inclusion of smaller companies, long-term studies tracking the evolution of AI regulations and environmental impact are needed to fully assess and compare past and present strategies and metrics.

Due to the rapid growth and expansion of AI, ensuring its sustainability is crucial for long-term environmental responsibility. For this to happen, businesses, policymakers and researchers must ensure to work together to develop better more sustainable AI, better sustainability strategies and better regulation frameworks. With strategic investment, more transparency, more sustainability strategies and policy support, AI has the potential to become a key driver of global sustainability and move away from being an environmental challenge.

Declaration of Use of Generative Artificial Intelligence Tools in the Bachelor's Thesis

Hereby, I, Morgan Griffin, student of Business Administration and Management with International Mention (E4) at Universidad Pontificia Comillas when presenting my Bachelor's Thesis entitled "The Green Dilemma Of AI: Assessing The Environmental Impact And Sustainability Strategies Of Leading AI Companies ", declare that I have used the Generative Artificial Intelligence tool ChatGPT or other similar IAG code tools only in the context of the activities described below:

1. **Research idea brainstorming:** Used to devise and outline potential areas of research.
2. **References**: Used in conjunction with other tools, like ScienceDirect/ Google Scholar, to identify preliminary references that I then cross-check and validate.
3. **Template Builder:** To design specific formats for sections of the work.
4. **Literary and language style corrector:** To improve the linguistic and stylistic quality of the text.
5. **Synthesiser and disseminator of complicated books:** To summarise and understand complex literature.
6. **Reviewer:** To receive suggestions on how to improve and refine work with different levels of demand.

I affirm that all the information and content presented in this work are the product of my research and individual effort, except where otherwise indicated and the corresponding credits have been given (I have included the appropriate references in the TFG, and I have made explicit why ChatGPT or other similar tools have been used). I am aware of the academic and ethical implications of submitting a non-original work and accept the consequences of any violation of this statement.

Date: 18/03/2025

Signature: MORGAN GRIFFIN

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Appendix

Appendix 1: Results Obtained from the Case Study

	Company Profile	Mission & Sustainability Goals	Energy Consumption & Carbon Footprint
Amazon	**Business Model:** A global company operating in e-commerce, cloud computing (AWS), consumer goods, entertainment, and logistics. It offers products and services from both Amazon-branded and third-party sellers. **AI Usage:** Uses AI to optimise packaging, monitor energy use, and combat deforestation.	**Sustainability Commitments:** Co-founded and committed to The Climate Pledge, aiming for net-zero carbon emissions by 2040, a decade ahead of the Paris Agreement. **Renewable Energy:** Reached its goal of matching 100% of global operations' electricity with renewable energy in 2023, seven years ahead of schedule. **Water Positivity:** AWS aims to be water positive by 2030, with 41% progress as of 2022. **Carbon Neutralisation:** Plans to offset any unavoidable emissions by 2040 through investments in climate mitigation beyond its value chain. **Emissions Reduction:** Focuses on minimising emissions, waste, and water use, increasing carbon-free energy adoption, and improving packaging and materials.	**CO_2 Emissions:** 68.82 million metric tons in 2023. **Energy Consumption:** Did not publicly disclose exact energy use for 2023.
Google	**Business Model:** Develops digital services that enhance everyday life, including Search, YouTube, Android, Google Cloud, and Google Workspace. **AI Usage:** Leverages AI for environmental sustainability, data optimisation, and emissions reduction while improving efficiency across its platforms.	**Sustainability Strategy:** Reducing its environmental impact while using its products to drive positive action. **Net-Zero Goal:** Aims for net-zero emissions across operations and its value chain by 2035. **Carbon-Free Energy:** Plans to run entirely on 24/7 carbon-free energy across all operational grids by 2030. **Emissions Reduction:** Targets a 50% reduction in Scope 1, 2 (market-based), and 3 absolute emissions by 2030 (from a 2019 baseline). In 2023, total emissions were 14.3 million metric tons of CO_2e. **Circular Economy:** Seeks to maximise the reuse of finite resources across operations, products, and supply chains.	**CO_2 Emissions:** 14.3 million metric tons in 2023. **Energy Consumption:** 25,307,000 MWh.
Meta	**Business Model:** Primarily generates revenue from advertising on Facebook, Instagram, and Messenger, while also focusing on metaverse development. **AI Usage:** Invests in AI to enhance social experiences, improve content moderation, and create immersive technologies.	**Sustainability Vision:** Reduces emissions, energy, and water usage in data centres while ensuring supply chain human rights and safety. **Net-Zero Target:** Achieved net-zero emissions in global operations since 2020 and aims for net-zero across its value chain by 2030. Plans to be water positive by 2030. **Emissions Reduction:** Committed to cutting Scope 1 and 2 emissions by 42% by 2031 (from a 2021 baseline). **Supplier Engagement:** Aims for two-thirds of suppliers to set science-based emissions reduction targets by 2026.	**CO_2 Emissions:** 7,496,231 metric tons. **Energy Consumption:** 15,325,314 MWh.
Microsoft	**Business Model:** Provides cloud computing, software, and devices with a strong emphasis on sustainability and enterprise solutions. **AI Usage:** Utilises AI to drive sustainability efforts, support climate resilience, and enhance wildlife protection through improved threat detection.	**Sustainability Goals:** Plans to be carbon negative, water positive, and zero waste by 2030, while protecting more land than it uses. **Carbon Negative:** Aims to remove all carbon it has emitted since its founding by 2050. **Renewable Energy:** Targets 100% renewable energy use by 2025. **Scope 3 Emissions:** Plans to cut Scope 3 emissions by over 50% from a 2020 baseline by 2030. **Land Protection:** Committed to protecting more land than it uses by 2025; exceeded its FY23 target by over 40%.	**CO_2 Emissions:** 14,314,800 metric tons. **Energy Consumption:** 25,307,000 MWh.
Nvidia	A leading computing company specialising in accelerated computing, offering solutions for AI, data centres, and gaming. **AI Usage:** Develops AI-powered hardware and software for applications in robotics, finance, healthcare, and energy-efficient computing.	**Sustainability Reporting:** Adheres to global frameworks, including GRI, SASB, TCFD, and UN SDGs. **Climate Targets:** Aims for 100% renewable electricity for offices and data centres under its operational control by FY25, leading to zero Scope 2 market-based emissions.	**CO_2 Emissions:** 3,692,423 metric tons. **Energy Consumption:** 612,008 MWh.
OpenAI	**Business Model:** An AI research company focused on ensuring artificial general intelligence (AGI) benefits humanity. Initially a non-profit, it now operates as a capped-profit entity backed by Microsoft. It develops AI tools like ChatGPT for natural language understanding and generation.	**Renewable Energy:** Has not disclosed details on the proportion of renewable energy used. **Carbon Offsetting:** No dedicated carbon offset programmes have been announced for ChatGPT, though partners may engage in offsetting.	**Energy Use:** Training and operational energy consumption is very high. Each ChatGPT query is estimated to use ~5× the electricity of a standard web search. **CO_2 Emissions:** Estimated at ~8.4 tons annually, but detailed breakdowns are undisclosed
DeepSeek	**Business Model:** A Chinese AI company funded by hedge fund High-Flyer, focusing on developing open-source large language models (LLMs). Despite a smaller budget than competitors, its research-driven approach has produced models that rival leading AI technologies.	N/A	**Energy Efficiency:** Uses a Mixture of Experts (MoE) model, reducing energy consumption per query by ~30-50% compared to dense models like GPT-4o. **Training Energy Use:** Likely requires multiple GWh of electricity due to high-performance GPUs/TPUs.

	Data Centers and Infrastructure	Hardware and Critical Minerals Usage	E-Waste and Hardware Lifecycle	Regulatory Compliance & Corporate Reporting
Amazon	**Energy Efficiency:** Uses free-air and direct evaporative cooling systems to reduce energy consumption, even during peak summer temperatures. **Renewable Diesel:** In 2023, began switching backup generators in the U.S. and Europe to renewable diesel (HVO) made from waste and plant oils. **Water Conservation:** Utilises real-time data for leak detection, water treatment pilots, and monitoring water use with sensors. **Water Recycling:** On-site treatment systems allow increased water reuse in cooling systems. **Chip Innovation:** Graviton4 and Inferentia2 chips deliver higher performance and energy efficiency, with the latter providing 50% more efficiency and 40% cost savings.	**Sustainable Sourcing:** Amazon prioritises avoiding conflict minerals in its supply chain, ensuring that minerals are sourced responsibly to protect local communities and ecosystems. **Mineral Certification:** Amazon aims to have 100% of the 3TG (tin, tungsten, tantalum, gold) smelters and refiners in its supply chain meet recognised certification standards. **Cobalt Due Diligence:** Uses industry-standard reporting to identify and mitigate risks in the cobalt supply chain. **Supplier Engagement:** Collaborates with suppliers through initiatives like the Responsible Minerals Initiative (RMI) to promote transparency and responsible sourcing. **Recycled Materials:** Incorporates recycled content in device designs to reduce carbon emissions associated with hardware production. **Energy-Efficient Chips:** Develops efficient chips like the Inferentia2, which contribute to reduced energy consumption and cost savings. **Ocean Freight Expansion:** In 2023, shifted hardware transport to ocean freight, cutting around 65,000 metric tons of CO_2 emissions.	**Efficient Design:** Amazon designs its server racks to be reusable and lower-carbon, minimizing excess materials and increasing the use of recycled content. Since July 2023, plastic parts used in hardware must contain at least 30% recycled or bio-based plastic. The use of steel from electric arc furnaces has increased recycled content in steel from 10% to 90%. **Extended Lifespan:** AWS extends the life of servers from five to six years and prolongs hard disk drive (HDD) use by up to two years through rack consolidation, reducing waste, water, and energy consumption. **Resource Recovery:** Decommissioned hardware undergoes secure data removal, followed by refurbishment or reuse across global facilities. In 2023, 14.6 million components were either recycled or resold. **Trade-In Program:** Available in the U.S., UK, and Germany, customers can trade in devices for gift cards or discounts, with eligible devices refurbished and resold as certified refurbished or used products. **Recycling Program:** Devices not eligible for trade-in are sent to licensed recycling facilities with provided shipping labels.	**Framework Disclosures:** Amazon reports its performance against multiple sustainability frameworks, including SASB, SDGs, TCFD, and UNGPRF. **Policy Advocacy:** Amazon actively supports policies that promote carbon-free energy, zero-emission fuels, vehicle deployment, grid modernization, and investments in clean technologies. **Supply Chain Transparency:** Amazon provides transparency into its supply chain by publishing a supplier list and an interactive map for Amazon-branded products. **GHG Reporting:** Amazon regularly measures and reports its greenhouse gas emissions. **Third-Party Validation:** Amazon uses the Zero Carbon Certification (ZCC) program to verify its progress on building decarbonization. **Carbon & Energy Assurance:** Amazon offers public assurance statements for its carbon emissions and renewable energy data. **Restricted Substances:** Amazon enforces a list of restricted substances, ensuring that harmful chemicals are excluded from various products. **Reporting Mechanism:** Amazon offers an anonymous web form in 19 languages for reporting human rights or environmental concerns. **Human Rights Commitment:** Amazon upholds global principles respecting human rights and dignity in its business operations.
Google	**Data Centre Efficiency:** Google is known for its energy-efficient data centres, achieving an average Power Usage Effectiveness (PUE) of 1.1. Its data centres use advanced cooling techniques like evaporative cooling and artificial intelligence for real-time optimisation. **Renewable Energy:** Google's data centres are powered by 100% renewable energy, and the company continues to aim for 24/7 carbon-free energy across all locations by 2030. **Water Conservation:** Google uses AI to improve water usage and efficiency, including advanced cooling systems that reduce water consumption. It also uses reclaimed water for cooling in several locations. **Energy-Efficient Infrastructure:** Google designs its data centres to be as energy-efficient as possible by optimising hardware and cooling systems to reduce energy and water consumption. **Circular Economy:** Google aims for data centre waste to be fully recycled, and many of its facilities are LEED-certified, showcasing a commitment to sustainability in building design.	**Supplier Expectations:** Google expects all suppliers to set public GHG reduction targets and engage in transparent reporting of their environmental data. It collaborates with some suppliers to directly collect data, encouraging others to respond to CDP's Climate Change survey. **Decarbonisation Roadmaps:** Google worked with its largest hardware manufacturing suppliers in 2023 to obtain decarbonisation roadmaps. **Renewable Energy Addendum:** Imposed a Renewable Energy Addendum, requesting hardware suppliers to achieve 100% renewable energy use by 2029. **Industry Collaboration:** Google is a founding member of Imec's Sustainable Semiconductor Technologies and Systems programme and part of SEMI's Semiconductor Climate Consortium. **Recycled Materials in Devices:** Google uses recycled materials in its consumer devices, helping lower the product manufacturing carbon footprint. **Supplier Audits:** Regular supplier audits are conducted to monitor adherence to environmental regulations, particularly regarding local waterways around Google's data centres.	**Circularity Principles:** Google's circularity principles aim to eliminate waste and pollution from the start, keep products and materials in use, and promote safer chemistry and healthier materials. **Data Centre Waste Diversion:** Google diverted 78% of operational waste from disposal in 2023 across its global fleet of owned and operated data centres. **Zero Waste to Landfill Goal:** In 2023, 29% (8 out of 28) of Google's data centres achieved the Zero Waste to Landfill goal. **Hardware Component Reuse:** Google extends server life by refurbishing, reusing, or reselling components, and ensures device longevity through software updates and repair options. **Hardware Resale:** Since 2015, Google has resold over 44 million hardware components from its data centres, contributing to the circular economy. **Refurbished Inventory:** As of the end of 2023, 29% of components used for server deployment, maintenance, and upgrades were refurbished inventory. **Device Recycling:** Google offers free recycling for eligible devices from any brand in every country where it ships consumer hardware devices. **Sustainable Packaging:** Google's goal is to eliminate	**Environmental Reporting:** Google's 2024 Environmental Report provides an overview of its sustainability strategy, progress, and achievements from the 2023 fiscal year, highlighting notable accomplishments from 2024. **Supply Chain Collaboration:** Google works with stakeholders across its supply chain to uphold high environmental and labor standards. **Board Oversight:** Alphabet's Board of Directors, through the Audit and Compliance Committee, oversees risk exposures, including sustainability risks, and reviews the company's management of those risks. **Sustainability Management Team:** Google has an internal management team focused on sustainability, led by the SVP of Learning and Sustainability, providing centralized oversight on climate-related issues. **Third-Party Assurance:** Google obtains limited third-party assurance for certain environmental metrics, including select greenhouse gas emissions, energy, and water metrics. **GHG Emissions Reporting:** Google calculates its GHG emissions according to the Greenhouse Gas Protocol standards developed by WRI and WBCSD.

Meta	**Energy and Water Efficiency:** Operational data centres achieved an average PUE of 1.08 and a WUE of 0.18 in 2023. **AI-Optimised Data Centres:** New centres optimised for AI with liquid-cooled hardware and a high-performance network, requiring a smaller footprint for similar compute capacity. **Dry Cooling Technology:** New AI-optimised data centres will feature dry-cooling technology to minimise water usage. **LEED Certification:** 100% of operational data centres are LEED Gold certified. **Fuel Consumption:** Piloting the use of hydrotreated vegetable oil (HVO) to reduce emissions from backup diesel generators.	**Responsible Sourcing:** Meta expects its supply chain partners to meet high human rights and environmental standards. **Responsible Minerals Sourcing:** In 2023, Meta updated its Responsible Minerals Sourcing Policy to align with the OECD Due Diligence Guidance, mitigating adverse impacts from mineral sourcing. **Supply Chain Engagement:** Meta collaborates with external partners like the Responsible Business Alliance and the Responsible Minerals Initiative to ensure responsible sourcing. **Human Rights and Forced Labour:** Meta outlines its policies to prevent forced labour and human trafficking within its supply chain. **Risk Assessment:** Meta uses a risk-based methodology to assess social and environmental risks in its supply chain and works closely with suppliers to build their capabilities for improvement. .	**Circularity in Hardware Development:** Meta employs circularity principles to limit the use of new materials and reduce waste. **Electronics Reuse and Recycling Standard:** Meta's standard ensures safe, healthy environments for manufacturing, use, and recycling of hardware. **Post-Consumer Recycled (PCR) Materials:** Meta prioritises using post-consumer recycled plastics and recycled metal in hardware to lower the carbon footprint and improve the circular supply chain. **Hardware Life Extension:** Meta is investing in systems to extend the life of its hardware, reusing components across its data centres. It has rigorously tested reused components since 2021.	**Sustainability Reporting:** Meta's 2024 Sustainability Report follows Global Reporting Initiative (GRI) standards, SASB, Internet and Media Services Industry Standards, the United Nations Global Compact, and TCFD. **Third-Party Assurance:** Meta obtains limited assurance from Ernst & Young LLP for select environmental metrics. **Stakeholder Engagement:** The disclosures in Meta's report are based on priority topics identified through conversations with stakeholders. **Corporate Governance:** Meta is committed to sound corporate governance practices and promotes effective, efficient, and climate-informed decision-making.
Microsoft	**New Data Centres:** Designed to support AI workloads with zero water usage for cooling, reducing reliance on freshwater resources. **Data Centre Efficiency:** Designed for near-PUE of 1.0; achieved 1.12 PUE in the reporting year. **Operational Efficiency:** Reduces peak power consumption, maximises server density, and harnesses unused power within data centres. **Water Management:** Expanding the use of reclaimed and recycled water, and harvesting rainwater in regions like Texas, California, Singapore, and Europe. **Leak Detection:** Partnered with FIDO Tech to reduce water loss through leak detection projects in London, Mexico, and Arizona.	**Circular Cloud Hardware:** Microsoft is scaling Circular Centres to reuse and recycle cloud hardware, prioritising sustainable hardware practices. **Ecodesign Principles:** Microsoft implements ecodesign principles for hardware engineers and suppliers, ensuring designs prioritise recycled content and material recyclability. **Supplier Selection:** Microsoft integrates social and environmental factors into its supplier selection process, helping suppliers meet sustainability expectations. **Renewable Energy in Manufacturing:** In FY23, 59 suppliers transitioned to renewable energy for manufacturing facilities, avoiding 105,000 metric tons of CO_2 emissions. **Device Design for Circularity:** Microsoft designs devices for a smaller manufacturing footprint, increasing the use of recycled and repurposed materials and reducing carbon intensity. **Carbon Emissions Budget:** Microsoft uses a carbon emissions budget for logistics, enabling precise emissions target setting and greater transparency across its supply chain.	**Circular Centres:** Microsoft scales Circular Centres to reuse and recycle cloud hardware wherever possible, reducing waste and supporting sustainability efforts. **Reuse and Recycling Rates:** In FY23, Microsoft achieved a reuse and recycle rate of 89.4% for servers and components across all cloud hardware. **Intelligent Disposition and Routing System (IDARS):** Microsoft's IDARS system helps establish a zero-waste plan for cloud hardware, identifying the most sustainable disposal paths for hardware parts at any lifecycle stage. **Sustainable Rack Packaging:** Microsoft's Sustainable Rack Packaging system, made predominantly from recycled materials, is free of single-use plastics and designed for repairability, further reducing waste. **Device Trade-In Program:** Microsoft's trade-in program extends device life by refurbishing where feasible, or by following environmentally sound practices for end-of-life devices. **Recycling Program Expansion:** Microsoft is expanding its recycling program to include more products, aiming for better resource recovery and waste reduction. **Cloud Packaging Goals:** By 2025, Microsoft plans for all cloud packaging to have at least 50% recycled content, eliminate single-use plastics, and be 100% reusable, recyclable, or compostable..	**Environmental Sustainability Reporting:** Microsoft publishes an annual Environmental Sustainability Report to share its strategy, progress, and challenges in reaching net-zero emissions. **Environmental Data Disclosure:** Microsoft publishes its environmental data separately in its Environmental Data Fact Sheet. **GHG Emissions Reporting:** Microsoft presents its GHG emissions following the GHG Protocol and uses the Global Reporting Initiative (GRI) Standards for select environmental metrics. **CDP Reporting:** Microsoft has reported to CDP Climate Change since 2004 and to CDP Water Security since 2011. **TCFD Alignment:** Microsoft's climate-related disclosures align with the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD). **Board Oversight:** The Environmental, Social, and Public Policy Committee of Microsoft's Board of Directors oversees and provides guidance on the company's environmental sustainability strategy.

Nvidia	**Energy-Efficient Operations:** LEED Gold certified buildings in Santa Clara, CA, and Hyderabad, India, designed for energy and water efficiency. **Water Conservation:** Conducts annual water risk assessments for all facilities and partners to identify water conservation needs. **Cooling Technologies:** Implementing closed-loop liquid cooling systems to improve water efficiency and eliminate water loss from evaporation.	**Responsible Sourcing:** NVIDIA is committed to sourcing minerals responsibly, ensuring that the 3TG minerals used in its products are conflict-free and sourced from socially responsible sources. **OECD Due Diligence Guidance:** NVIDIA follows the OECD Due Diligence Guidance for Responsible Supply Chains to ensure that its minerals are sourced responsibly and do not contribute to conflict or human rights abuses. **RBA Code of Conduct:** All NVIDIA manufacturing suppliers must comply with the Responsible Business Alliance (RBA) Code of Conduct and associated policies. **Material Disclosure:** NVIDIA maintains Full Material Disclosures for its chip designs and select system products, ensuring compliance with restricted substances regulations. **Supplier Engagement:** Engages suppliers to adopt science-based targets and work towards reducing their environmental footprints. **Recycling and E-Waste:** NVIDIA has not disclosed specific details on hardware recycling programs for AI model infrastructure, though it has measures in place to ensure compliance with responsible sourcing and environmental standards.	**Internal Reuse:** NVIDIA supports internal reuse of equipment that is not at the end of its useful life, such as for testing, R&D, and production purposes. **E-Waste Recycling:** NVIDIA uses a global specialist e-waste recycling vendor to ensure proper tracking of the chain of custody, decommissioning, data erasure, and recycling of unusable hardware. **End-of-Life Management:** NVIDIA-branded products are subject to electronic waste disposal regulations globally, and the company provides consumers with information about how to recycle its branded products through labeling and on its website. **Customer Monetization:** NVIDIA helps customers monetise the residual value of older DGX servers through a remarketing partner. Systems not resold are typically dismantled for component recycling.	**Sustainability Reporting Frameworks:** NVIDIA uses frameworks such as GRI, SASB, TCFD, and UN SDG to guide its sustainability reporting, assessing the company's social and environmental impacts based on stakeholder expectations, market trends, and risks. **Transparency:** NVIDIA is committed to transparency and reports metrics that are material to the company and its sector. It uses frameworks such as TCFD, SASB, and GRI to provide clear and accurate reporting on environmental and social impacts. **Fiscal Calendar Reporting:** NVIDIA's sustainability reports are based on its fiscal calendar, reflecting the company's impacts, risks, and opportunities.
OpenAI	**Data Centre Energy Use:** No specifics disclosed on energy consumption for ChatGPT or AI-related workloads. However, it's acknowledged that data centres hosting AI models like ChatGPT require substantial energy and advanced cooling systems.		The rapid turnover of specialized hardware contributes to e-waste. Lifecycle details for the hardware used in training/operating AI models are not comprehensively reported.	N/A
DeepSeek	**AI Infrastructure:** Likely uses cloud providers such as Google Cloud, AWS, or Microsoft Azure, which offer carbon-neutral data centre options. **Energy Efficiency:** Utilising MoE architecture, DeepSeek-V3 reduces energy consumption per query compared to dense models, but lacks publicly available efficiency metrics like PUE.	**AI Hardware:** No specific details on hardware sourcing or lifecycle management for DeepSeek's infrastructure are publicly available, though it likely relies on cloud providers like AWS, Google Cloud, or Microsoft, all of which have sustainable sourcing initiatives in place. **MoE Efficiency:** DeepSeek-V3 uses a Mixture of Experts (MoE) architecture, reducing the number of active parameters, which likely extends the hardware's lifespan and reduces wear and tear compared to dense models. However, lifecycle management and hardware recycling or refurbishment details remain undisclosed.	**AI Hardware Lifespan and Recycling:** Details on DeepSeek's hardware recycling or refurbishment program are currently unavailable. The company likely relies on cloud infrastructure providers with robust e-waste management practices, but specifics on lifecycle management remain unclear. **Hardware Obsolescence and MoE Models:** AI training and inference, particularly with power-hungry GPUs and TPUs, lead to shorter hardware lifespans (3-5 years). However, the use of Mixture of Experts (MoE) models helps extend hardware lifespan by reducing the number of active parameters, thereby reducing wear and tear compared to denser models. .	N/A

	Key Partnerships & Sustainability Investments	Sustainable AI Development Practices	Challenges and Barriers	Scalability of Sustainable AI Models
Amazon	**AI for Sustainability:** Amazon utilizes AI to optimize energy use, combat deforestation, and reduce packaging waste. **The Climate Pledge Fund:** Amazon has a $2 billion fund focused on supporting technologies that can help achieve net-zero carbon emissions, particularly in hard-to-abate sectors. **Carbon Capture:** Amazon has invested in CarbonCapture Inc. for modular Direct Air Capture (DAC) systems and secured up to 100,000 carbon removal credits. **Renewable Energy:** Amazon has invested in 513 renewable energy projects worldwide, including 243 utility-scale wind/solar projects and 270 rooftop solar installations. **Sustainable Aviation Fuel:** Amazon co-founded the Sustainable Aviation Buyers Alliance (SABA) and launched the SAF certificates (SAFc) Registry at COP28. **Transportation Collaborations:** Amazon collaborates with industry groups to promote electric vehicle (EV) adoption, develop charging infrastructure, and support low-carbon fuels. **Sustainability Exchange:** Amazon provides free resources, such as playbooks and case studies, to help its suppliers meet sustainability goals. **Circular Economy Partnerships:** Amazon partners with the Ellen MacArthur Foundation and WRAP to promote circular economy solutions across industries. **Clean Energy Procurement Academy:** Amazon co-founded the Clean Energy Procurement Academy (CEPA) to train suppliers in clean energy adoption. .	**Packaging Optimization** AI models are used to minimize packaging waste by analyzing product attributes and customer feedback to reduce empty space in multi-item orders. **Energy Efficiency** AI monitors and optimizes energy consumption across various processes. **Deforestation Combat** Amazon supports the SeloVerde tool in Brazil, leveraging AI and satellite data to track deforestation risks in supply chains. **Water Leak Detection** Internet of Things (IoT) technology is used to analyze real-time water usage, saving 700,000 cubic meters of water at 53 UK sites over two years. **Recycling Automation** Investment in Glacier, a company using AI-powered robots to sort recyclables and collect recycling data. **Transportation Efficiency** AI is used to optimize delivery routes, improving logistics efficiency and reducing emissions.	N/A	. **Decarbonisation Initiatives** – Improve efficiency in logistics, packaging, and facilities. **Carbon-Free Energy Transition** – Shift to renewable energy sources for operations. **Supplier Engagement** – Encourage suppliers to set and share emissions reduction goals. **Circular Economy Practices** – Implement recycling, reselling, and reusing programmes. **Data-Driven Improvements** – Use data to enhance energy efficiency and cut emissions. **Employee Engagement** – Launch sustainability initiatives and training to foster a green culture. **AI in Supply Chains** – Optimize packaging, reduce waste, and streamline logistics with AI. **Industry Collaboration** – Partner with businesses to tackle sustainability challenges. **Policy Advocacy** – Support policies that promote renewable energy and zero-emission solutions. **Water Leak Detection** – Use IoT and cloud monitoring to prevent water leaks and improve efficiency.
Google	**AI for Sustainability:** Google is using AI to drive environmental change, including using AI algorithms and aerial imagery for projects like reflective "cool roofs" to reduce energy use. **Methane Emission Tracking:** Google combines data from MethaneSAT with its AI and infrastructure mapping to track and reduce methane emissions from the oil and gas sector. **AI for Climate Action:** Google supports AI-driven initiatives like machine learning models to monitor wetlands and detect methane emissions, with funding from Google.org. **Semiconductor Sustainability:** Google is a founding member of Imec's Sustainable Semiconductor Technologies and Systems program, focusing on decarbonizing the semiconductor industry using transparent data and early-stage trials. **Carbon Removal Research:** Google introduced Carbon Removal Research Awards, providing over $3 million to academic institutions for research into carbon removal technologies. **Global Partnerships for Climate Action:** Google.org is supporting global initiatives by providing free, open-sourced tools and datasets for climate action, leveraging technology to help mitigate global emissions. .	**Cool Roof Implementation** Google explores how AI algorithms and aerial imagery can help implement "cool roofs" to reduce urban heat. **Methane Emission Monitoring** Google combines data from MethaneSAT with its AI and infrastructure mapping capabilities to track methane emissions from oil and gas operations. **Seagrass Carbon Measurement** Google uses AI to measure the carbon sequestration potential of seagrass ecosystems to aid in conservation. **Natural Language Interface** Google is utilizing large language models to create a natural language interface that makes sustainability information more accessible to the public. **Wind Power Forecasting** Google employs machine learning solutions to optimize wind power forecasting, enhancing the reliability of renewable energy sources.	**Data Scarcity** The complex and localized nature of climate impacts, combined with a fragmented global market, makes it difficult to develop scalable sustainability features. **Evolving Regulations** Adapting to evolving regulations requires system-level changes and can be challenging due to varying standards across regions. **Coordination and Communication** Collaboration across stakeholders is essential, but misalignment in priorities and resources can slow the implementation of solutions.	**Replicability of Sustainability Strategies** Through direct supplier engagement, Google collects primary manufacturing data to more accurately model its carbon footprint. **Feasibility of Scaling Renewable AI Applications Globally** Google is a founding sponsor of Catalyze, a decarbonisation program that accelerates access to renewable energy in the semiconductor value chain by combining energy purchasing power and enabling supplier participation in renewable energy projects. **Commitment to Renewable Energy Purchases** Google has signed contracts to purchase 4 gigawatts of clean energy capacity in regions like Texas, Belgium, and Australia. **AI for Energy Efficiency** Google is using AI algorithms and aerial imagery to implement reflective "cool roofs" to save energy and reduce temperatures. **Environmental Monitoring and Methane Leak Detection** Since 2012, Google has partnered with the Environmental Defense Fund (EDF) to map air quality and detect methane leaks in U.S. cities using Street View cars.
Meta	**AI in Data Centres:** Meta designs data centres with AI to increase efficiency and reduce carbon footprint. **Sustainable Concrete Mixtures:** Meta used AI to develop concrete mixtures with a 40% lower carbon footprint for data centre construction. **Sustainable Aviation Fuel:** Meta committed to purchasing nearly 50 million gallons of SAF certificates in 2023, abating around 500,000 tons of CO2e. **Hydrotreated Vegetable Oil (HVO) Testing:** Meta is transitioning its Clonee, Ireland data centre's backup generator fleet to use HVO in 2024 to assess the feasibility of this solution across its full data centre fleet. **Zero Emission Shipping:** Meta joined the Zero Emission Maritime Buyers Alliance (ZEMBA) to enable access to zero-emission shipping solutions. **Carbon Capture:** Meta signed contracts with CarbonCapture and Heirloom for DAC carbon removal credits in 2023 and with Charm Industrial for storing carbon through pyrolyzed waste biomass.	**AI-Driven Data Centre Design** Meta integrates AI into the design of its data centres to improve energy efficiency and sustainability. **Low-Carbon Concrete** Meta uses AI to develop concrete mixtures with a reduced carbon footprint for use in building data centres. **System Efficiency** Meta applies observability tools to identify and eliminate inefficiencies in its systems, improving overall sustainability performance. **Recycling Automation** Meta integrates AI into its recycling processes, including the use of robotic systems for waste sorting and recycling data collection.	N/A	**Replicability of Sustainability Strategies** Meta shares its environmental learnings and practices across the tech industry and beyond. **Open Sourcing** Meta responsibly advances AI by sharing its data, models, and learnings with the AI and broader community. **Feasibility of Scaling Renewable AI Applications Globally** Meta's majority carbon footprint consists of Scope 3 emissions. To address this, they created the Net Zero Supplier Engagement Program, which sets expectations with key suppliers for committing to emissions reduction targets and provides support to meet those goals. **Capacity-Building for Suppliers** Meta offers capacity-building training to its suppliers on calculating emissions, setting

Microsoft	**AI for Sustainability:** Microsoft's AI for Good and research teams are driving sustainability by focusing on solutions for climate resilience, sustainable material discovery, and enhancing carbon capture. **AI for Water Leak Detection:** Microsoft partners with FIDO Tech to use AI for reducing water loss through acoustic leak analysis. **AI for Materials Optimization:** Microsoft works with Makersite's AI to automate analysis of electronic product bill of material (BOM) data for sustainability. **Carbon Capture and Storage:** Microsoft collaborates with Schlumberger and Northern Lights to optimize global carbon capture and storage workflows. **AI for Transparency in the Paris Agreement:** Microsoft partners with UNFCCC to develop AI-based systems that support transparency in climate action under the Paris Agreement. **Hack for Sustainability:** In 2023, Microsoft organized a global hackathon to develop AI solutions for environmental challenges, engaging over 700 participants. **AI for Biodiversity:** Microsoft is working with the Humboldt Institute and Sinchi Institute in Colombia to use AI to monitor biodiversity in the Amazon rainforest.	**Climate Resilience** Microsoft's AI for Good teams are accelerating climate resilience strategies by developing innovative solutions. **Water Leak Detection** Through a partnership with FIDO Tech, Microsoft uses AI-enabled acoustic analysis to reduce water loss from leaks. **Material Analysis** Microsoft uses AI to analyze electronic product bills of materials (BOM) and material compositions to assess the environmental impact of production. **Utility Invoice Processing** Microsoft developed a cognitive visual learning (CVL) tool to automate the extraction of data from utility invoices, streamlining the process. **Ecosystem Monitoring** Microsoft uses AI to monitor the impact of regenerative design solutions around its data centres, helping improve local biodiversity. **Sustainability Solutions** Microsoft integrates AI into its sustainability products to help customers perform advanced analytics and gain actionable data insights. **Cloud Empowerment** Microsoft uses AI-powered cloud computing and machine learning to support sustainability initiatives.	**High Energy Consumption** Training AI foundation models requires substantial computing power, and the demand will grow as models become more complex and are trained on larger datasets. **Policy Advocacy** Encouraging transparency regarding AI's environmental impact and promoting voluntary commitments from AI providers to mitigate this impact, including sourcing carbon-free energy for operations and supply chains.	**Replicability of Sustainability Strategies** Microsoft is sharing its learnings to support global construction efforts, aiming to inspire greater sustainability in construction and transparency in reporting from other organizations. **Regenerative Data Centre Design** Microsoft has completed concept designs for five additional data centre campuses across four regions, establishing a globally applicable and locally configurable regenerative framework. **Feasibility of Scaling Renewable AI Applications Globally** Microsoft is focused on accelerating the availability of new climate technologies, strengthening its climate policy agenda, and developing a more reliable and interoperable carbon accounting system. **Green Workforce Development** Microsoft advocates for skilling programmes to expand the green workforce and works to enable a just energy transition. **AI-Based Solutions for Sustainability** Microsoft is investing in AI-based solutions in areas where progress on global sustainability goals is bottlenecked. **Microsoft Sustainability Manager ESG Solution** Microsoft piloted a new feature in Microsoft Sustainability Manager, called the ESG value chain solution, to collect emissions data from top in-scope suppliers.
Nvidia	**AI for Energy Efficiency:** NVIDIA applies AI to save energy and optimize renewable energy sources. **Battery Innovation:** NVIDIA's AI has helped accelerate the discovery of new battery materials, leading to promising alternatives that reduce lithium usage by up to 70%. **Energy Grid Optimization:** NVIDIA's AI is used to enhance renewable energy integration into the power grid, including collaboration with Portland General Electric for more efficient energy distribution. **AI for Climate Data:** NVIDIA's Earth-2 initiative uses AI and high-performance computing to process vast amounts of climate data for better decision-making. **Supercomputing and Efficiency:** NVIDIA powers seven of the top ten supercomputers on the Green500 list, emphasizing energy efficiency in high-performance computing. **Semiconductor Sustainability:** NVIDIA is a member of the Semiconductor Climate Consortium (SCC), working to reduce carbon emissions across the global semiconductor supply chain. **Renewable Energy Optimization:** NVIDIA helps optimize solar and wind farms to improve efficiency and drive the energy transition forward.	**Energy Savings** NVIDIA applies AI to assist companies in saving energy by optimizing energy usage across various applications. **Optimizing Renewable Energy** NVIDIA uses AI to enhance the performance of solar and wind farms, improving the efficiency of renewable energy sources. **Efficient Chip Design** NVIDIA develops AI chip design tools that allow chips to operate faster while consuming less energy, contributing to energy savings. **Improved Weather Prediction** NVIDIA's Earth-2 platform uses AI to predict weather patterns more efficiently than traditional physics models, contributing to energy efficiency and better climate modelling.	N/A	**Energy Efficiency** NVIDIA's focus on energy-efficient GPUs and DPUs demonstrates how technology can enhance performance while reducing energy consumption. This approach can be replicated in other industries by adopting similar energy-efficient hardware and optimizing computing processes. **AI for Sustainability** AI can be utilized to discover sustainable materials and optimize energy use. Other organizations can replicate this by investing in AI research and development to find innovative solutions for environmental challenges. **Renewable Energy** NVIDIA's commitment to sourcing renewable energy is a key strategy. Other companies can follow suit by transitioning to renewable energy sources, supporting the development of clean energy infrastructure, and purchasing renewable energy credits. **AI Applications Globally** **Technological Advancements** The development of more energy-efficient platforms, such as NVIDIA's Blackwell platform, makes scaling AI applications more feasible by lowering energy consumption. Continuous innovation in AI and computing drives environmental responsibility. **Digital Twins and Optimisation** NVIDIA Omniverse enables companies to optimize digital twins of physical infrastructures, reducing costs, material consumption, and energy usage. This can be applied across industries to identify areas for improvement and implement sustainable practices. **Energy-Efficient Infrastructure** Emphasizing energy-efficient data centres and renewable energy sources is crucial for scaling AI