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The environmental impact of using Artificial Intelligence

Exploring the Environmental Impact of ChatGPT: A Literature Study and User Perception Analysis

OLIVIA HÅKANS

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Supervisor: Ylva Fernaeus
Examiner: Amir H. Payberah
School of Electrical Engineering and Computer Science
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Abstract

One of the most transformative technological advancements in recent years has been Artificial Intelligence (AI). The ability to help and assist with tasks in sectors from finance to healthcare has made AI in high demand. In particular, so-called generative AI has captured significant attention, which means AI systems capable of producing new content such as images, text, code or audio based on input prompts.

This study investigates the environmental impact of generative AI with a primary focus on ChatGPT. The research is a combination of a literature review of ChatGPT's water and energy consumption with a user study investigating user behaviour and perception of the environmental impact of utilising it.

The findings indicate that the training and operations of ChatGPT require considerable energy both for training the algorithms and for their operations in use. The estimated electricity consumption of ChatGPT is significant for the maintenance and processing of data. Moreover, water consumption, used primarily for cooling data centres, contributes to the environmental impact of ChatGPT and other AI services by increasing freshwater scarcity in regions already affected.

The user perception survey revealed that most participants were not actively thinking of the environmental impact that ChatGPT has while using the model. Many participants recognised the size and advancement of ChatGPT and the energy consumption for it would be similar but were unaware of the water consumption of the model. 25% of the participants indicated they would change their usage behaviour if they had more knowledge about the ecological footprint of ChatGPT and 47.2% thought they might change their behaviour.

This study sheds light on the water and energy consumption of AI to contribute to a more environmentally responsible approach to AI development and usage.

Keywords

Artificial Intelligence, Environmental Impact, Sustainability, Water Consumption, Energy Consumption

Sammanfattning

Artificiell intelligens har varit en av de mest transformerande teknologiska framstegen under de senaste åren. Dess förmåga att hjälpa och assistera med uppgifter inom olika sektorer, allt från finans till vård, har gjort AI mycket efterfrågat och använt. Särskilt den så kallade generativa AI har fått stor uppmärksamhet. Generativ AI innebär AI-system som kan skapa nytt innehåll såsom bilder, text, kod eller ljud baserat på inmatade promptar.

Denna studie undersöker miljöpåverkan av AI med primärt fokus på ChatGPT. Denna undersökning kombinerar en litteraturstudie om ChatGPT:s vatten- och energiförbrukning med en användarstudie som undersöker användarbeteenden och uppfattningar om miljöpåverkan när modellen används.

Resultaten visar att träning och drift av ChatGPT kräver en betydande mängd energi för att fungera effektivt. Den estimerade konsumtion av el som ChatGPT förbrukar är signifikant för den underhållning och behandling av data som görs. Vattenförbrukningen, som främst kommer från nedkylning av datacenter, bidrar till miljöpåverkan ChatGPT och andra AI verktyg har genom att öka sötvattenbrist i regioner som redan är påverkade.

Användarstudien visade att de flesta av deltagarna inte aktivt tänker på en potentiell miljöpåverkan som ChatGPT kan ha när de använder sig av modellen. Flera deltagare var medvetna om storleken av ChatGPT och hur avancerade verktyget är och att energikonsumtionen skulle kunna vara liknande men var omedvetna om vattenkonsumtionen. 25% av deltagarna tror på att de skulle förändra sin egen användning av ChatGPT om de var mer medvetna om dess miljöpåverkan och 47,2% tror att de kanske skulle förändra sitt beteende.

Denna studie belyser AI:s vatten- och energiförbrukning för att bidra till ett mer miljöansvarigt tillvägagångssätt vid utveckling och användning av AI.

Nyckelord

Artificiell intelligent, Miljöpåverkan, Hållbarhet, Vattenkonsumtion, Energikonsumtion

Acknowledgments

Thank you to everyone who participated in my study and my supervisor Ylva Fernaeus.

Stockholm, February 2025
Olivia Håkans

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List of acronyms and abbreviations

AI	Artificial Intelligence
GPT	Generative Pre-trained Transformer
GPU	Graphics Processing Unit
NFT	Non-fungible token
NLP	Natural Language Processing
RLHF	Reinforcement Learning from Human Feedback
SDG	Sustainable Development Goal
TWh	Terawatt hours
UN	United Nations

Chapter 1

Introduction

This chapter contains a short overview of the background, purpose, research goal, delimitations and thesis structure.

1.1 Background

The rapid development and advancement of Artificial Intelligence (AI) has revolutionised multiple sectors, its ability to aid in the analysis of medical records by extracting relevant information and summarising or in finance, automate financial reporting by analysing the market. AI is one of the most prominent and influential technology advancements in recent years [1].

Environmental change is a highly urgent problem that the whole world is facing. With rising water levels and temperature increases, many natural disasters can be linked to global warming [2]. How is AI contributing to this and how can we determine it?

This project aims to examine the environmental impact of using AI with a focus on water and energy consumption. By analysing current research, this study will evaluate the environmental challenges of deploying AI.

1.2 Problem

With AI rapid development and advancement, many people are using and relying on it. How big is the water and energy consumption of using AI? And how sustainable is AI?

1.3 Purpose

This project aims to examine the water and energy consumption of ChatGPT and calculate the consumption for a person's usage. It is also to understand the previous knowledge of the people who use ChatGPT.

1.4 Goals

This project aims to bring more light to the environmental impact of AI. This has been divided into the following sub-goals:

1. Estimate the water and energy consumption of running ChatGPT.
2. Conduct a survey to estimate the usage of AI service ChatGPT and explore the users knowledge of the sustainability of AI.

1.5 Research Methodology

The research methods for this project will be a comprehensive literature study and a user survey. The literature study will be on previous research and studies on the water and energy consumption of AI and ChatGPT. The user study will be conducted with a group of people of different ages on their usage of ChatGPT and their perspective on the environmental impact that ChatGPT has.

1.6 Delimitations

This thesis project will be limited to examining the water and energy consumption of utilising AI. It does not cover the construction of the data centres, the mining of minerals needed for hardware, the production of hardware components, transportation of hardware or the energy consumption of users' devices while running AI. This project will focus on ChatGPT.

1.7 Structure Of The Thesis

Chapter 2 presents relevant background information about ChatGPT and environmental science. Chapter 3 presents the methodology and process used to solve the problem. Chapter 4 presents the literature and user studies results.

Chapter 5 discusses the results and chapter 6 concludes the work done, future work and reflections.

Chapter 2

Background

This chapter provides basic background information about ChatGPT. Additionally, this chapter describes sustainability goals, energy production and how AI uses water.

2.1 ChatGPT

This section describes the history of ChatGPT, its growth and how it is applied in society.

2.1.1 History Of ChatGPT

OpenAI introduced ChatGPT-3.5 in November of 2022 [3] and marked a significant milestone in conversational AI, since then AI has quickly become a tool that people utilise daily. To better understand the development of ChatGPT, it is important to explore Natural Language Processing (NLP) and the impact of the transformer architecture.

NLP got its breakthrough when the paper ”Attention Is All You Need” by Vaswani et al. in 2017 [4] introduced the transformer model. This paper presented the transformer architecture where by introducing self-attention mechanisms into NLP the need for sequential data processing could be eliminated. The model consists of an encoder-decoder structure: the encoder processes the input data to create representations while the decoder generates outputs based on those representations.

OpenAI developed the Generative Pre-trained Transformer (GPT) series building on the transformer model. GPT-1 introduced unsupervised pre-training on a large corpus of text followed by supervised fine-tuning for specific

tasks [5]. GPT-2 is built on this approach, exhibiting the power of scaling model size and training data. This resulted in more coherent and contextually relevant text [6]. The architecture was further scaled with GPT-3 by using 175 billion parameters to deliver performance for a wide range of tasks but without the requirement of task-specific fine-tuning [7].

The first version of ChatGPT is based on the GPT-3.5 model, which builds on the capabilities of GPT-3 with additional optimisations and fine-tuning for conversational use cases. ChatGPT stands out from earlier models by incorporating Reinforcement Learning from Human Feedback (RLHF) to align responses more closely to human intent and minimizing potential risks [8]. ChatGPT's ability to generate human-like and contextually correct responses to user prompts is the combination of pre-training, fine-tuning and RLHF.

2.1.2 User Statistics And Growth Of ChatGPT

Since its launch, ChatGPT has grown substantially. As of November 2024, ChatGPT has over 200 million active users. ChatGPT reached its first million users just five days after release and 100 million users just 2 months later. This can be compared to Instagram's 2 months or Spotify's 5 months to reach one million users. It is estimated that ChatGPT has over 1.5 million daily interactions [9].

2.1.3 ChatGPT In Society

ChatGPT is a versatile tool, it can answer questions, write text and solve problems in a few minutes. The fast responses can help students finish their assignments faster, people plan what to eat for dinner or help with work. ChatGPT has certain limitations in its capabilities. Initially, it did not have access to the internet, which sometimes led to outdated information or biased responses, as it was trained on human language data [10]. However, since September 2023, ChatGPT has gained internet access, enabling it to provide users with more current and accurate information [11].

2.2 Environmental Science And Sustainable Practices

This section provides the background of water and energy goals, energy production and how AI uses water.

2.2.1 Water And Energy Goals

The United Nations (UN) has established 17 Sustainable Development Goals (SDGs) that serve as a global blueprint for tackling critical challenges related to water, energy, and environmental sustainability. Goal 6 focuses on ensuring clean water and sanitation, emphasizing sustainable water management to safeguard this vital resource. Similarly, Goal 14 aims to protect oceans and marine ecosystems, recognizing their essential role in supporting life on Earth. Lastly, Goal 7 advocates for access to affordable, reliable, and sustainable energy. Collectively, these objectives work toward building a more sustainable and equitable future [12, 13, 14].

2.2.2 Energy Production

There are different ways to produce energy with different environmental impacts. They can be grouped into renewable and non-renewable energy sources. Renewable energy sources include wind, hydro and solar. Non-renewable sources include coal, oil and natural gas. Non-renewable sources have higher carbon emissions than renewable sources [15]. When using fossil fuels a residue is left. The residue is not reusable and needs to be disposed of, creating waste and pollution which increase the environmental decline [16].

OpenAI's servers are currently located in the US, not specified which state/states [17]. The two main US energy producers are natural gas and petroleum, which combined produce 74% of the US's energy. Both are non-renewable sources. Additionally, coal and nuclear power produced 18% and just 9% were from renewable sources [18].

2.2.3 How AI Uses Water

AI uses water in two ways, indirect and direct. Direct water usage includes the water used at the data centres and is mostly linked to cooling towers, which most data centres use. The cooling towers' design may differ from different data centres but have the same functional design. The functional

design includes two water loops, one closed loop between the chiller and the data centre server room. The second loop, an open one, is between the cooling tower and the chiller. The closed loop does not consume any water but circulates the water. The open loop is the loop that ”consumes” the water by evaporation. The water in the open loop can only be cycled a few times to avoid too high a concentration of minerals in the water before it needs to be discarded. Fresh water is added to the loop to compensate for the evaporated water or replace the discarded water. Water is also used when outside air cooling is used, to ensure correct humidity if the air outside is too dry or too warm outside. Indirect water usage refers to the water consumed to generate electricity that powers servers [19]. Assessing this indirect water consumption is more challenging, as it is tied to the electricity production required to operate data centres [20].

Chapter 3

Methods

The methods used in this degree project consist of literature study and user survey. The user study is a perception and behaviour study with environmental awareness of ChatGPT. The literature study will examine ChatGPT's water and energy usage.

3.1 Data Collection

3.1.1 Literature Study

The initial part of the data collection is a literature study. The most influential sources include 'Data centre water consumption' by David Mytton [21], 'Making AI Less "Thirsty": Uncovering and Addressing the Secret Water Footprint of AI Models' by Pengfei Li et al. [20], and 'Analysis of the Impact of Artificial Intelligence on electricity consumption' by Yuelong Jia [22]. Further significant references are 'The carbon footprint of machine learning training will plateau, then shrink' by David Patterson et al. [23] and 'Environment and sustainability development: A ChatGPT perspective' by Priyanka Bhaskar et al. [24]. These works provided critical insights into the environmental aspects of AI systems, including water and electricity consumption. The sources had to be validated by publication date before checking the published date. Sources older than 2020 were excluded.

3.1.2 User Study

This project was conducted by collecting data using a form. The form was created to gather information on people's usage of ChatGPT. The form

collected information on people's thought processes regarding ChatGPTs' environmental effects and to gain knowledge into people's ideas and if the environmental impact is something that they consider while using ChatGPT.

The form was created using Google Forms and started by asking the participants' ages and if they use ChatGPT. The age was asked to get a reference point and easily being able to compare and group together answers and making sure that they use ChatGPT is a requirement to be in the study. It then moves on to what they use ChatGPT for, school, work or personal. To better understand how much the user uses ChatGPT, it is asked how often and how long a session usually lasts. This created a base understanding of their latter answers and how familiar the user was with ChatGPT and the function as well as how much they utilise it, this is later used to estimate energy and water consumption for the average person use.

The latter part of the form focuses on people's previous understanding and thought process of the environmental impact of using ChatGPT. The first question in the part is if the user thinks about a potential environmental impact while using ChatGPT. The second question is if they guess ChatGPT has an environmental impact and what they think affects the environment when using ChatGPT. They were also given the choice to write something they thought about or wanted to add.

Most people filling out the form took it online by themselves, I was present for a couple of people but they filled it in themselves. The form was anonymous and no personal data from the participants were collected. The questions in the form can be found in Appendix A.

3.2 Assessing Reliability And Validity Of The Data Collected

The questions in the form were deliberately designed to minimise guidance or bias regarding what could potentially harm the environment, ensuring the highest validity of results possible. Specifically, the question regarding the users' beliefs about the environmental impact of using ChatGPT was open-ended and carefully structured to avoid leading the user towards a specific perspective and answer.

It is impossible to ensure fully reliable results and it is important to acknowledge the bias of the people answering the question.

3.3 Planned Data Analysis

The data collection results will be defined based on ChatGPT usage and an understanding of its environmental impact. The data will be stored in a Google Sheet and Google Forms, they were both used to structure the data and visualisation.

The data analysis consisted of analysing the average usage of ChatGPT which is the first part of the data.

Chapter 4

Results and Analysis

This chapter presents the results from the literature study and the user study. It is divided into two sections, energy consumption and water consumption.

4.1 Literature Study Results

The results presented in this section are from data collected from scientific articles and journals. In total 15 sources were used.

4.1.1 Energy Consumption

All global data centres' total electricity usage during 2022 is estimated at 460 Terawatt hours (TWh). With the growth of AI, energy consumption is projected to rise above 1000 TWh in 2026 if technological advancements and updated regulations are not put in place [25]. To put it into perspective, Sweden's total energy consumption was 503 TWh in 2023 [26].

ChatGPT's training and operations demand a substantial amount of energy. The training of GPT-3 in 2020 required 1,287 MWh of energy [27], which was 0.012% of Microsoft's total energy consumption in 2020 [23]. The energy consumption increased significantly when training GPT-4, it consumed approximately 7,200 MWh of electricity [28] which is close to 5.5 times more than for GPT-3. The energy consumption comparison between the two versions is shown in Figure 4.1.

The increase in the energy consumption between the two models is due to the expanded model size and complexity, GPT-4 was trained using over 25000 Graphics Processing Units (GPUs) compared to the 10,000 GPUs that GPT-3 was trained on [23]. Additionally, GPT-3 has 175 billion parameters, and

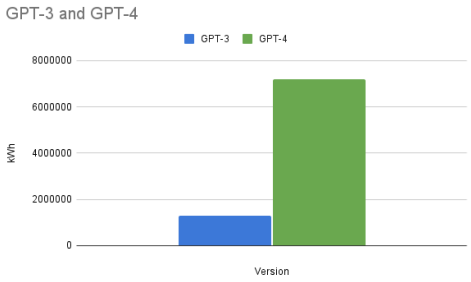

Figure 4.1: Energy consumption for training GPT-3 & GPT-4

GPT-4 has 1.7 trillion parameters, which is 9.7 more than GPT-3 [22]. For ChatGPT to generate a page of text, it is estimated it uses about 0.004 kWh which is 0.4 kWh per 100 pages [20]. Put into comparison, a Google search is estimated to consume 0.3 Wh of electricity and a request to ChatGPT is estimated to consume 2.9 Wh. While Google searches cannot generate text based on a prompt, if Google implemented AI into their searches, their energy consumption would increase ten times [29].

Comparing the energy usage for training, the training of GPT-3 could be compared to the energy an average Swedish household uses for 62.85 years. The training for GPT-4 consumed the same amount of energy an average Swedish household uses during 360 years [30]. All energy consumption is not equally environmentally damaging as the energy sources have different sustainability challenges, OpenAI's servers are located in the USA where fossil fuels dominate the energy mix [24] which is more damaging than more renewable sources.

4.1.2 Water Consumption

Microsoft saw an increase of 34% in their water consumption between 2021 and 2022. While training ChatGPT-3 it is estimated that Microsoft evaporated 700,000 litres of clean fresh water [20]. This can be compared to a Swedish household with 2 adults and 2 children's water consumption for 3.5 years [31]. It is estimated that ChatGPT consumes 500 ml of water for every 10-50 answers it produces [19]. This interval of the number of queries is based on the location of data centres, the season and the infrastructure of the servers [32]. Although the amount of water might not seem like much for one person's usage, ChatGPT has 1.5 million daily users [9], the amount of water becomes large exceptionally fast.

Water scarcity affects regions in the USA, India, and Southeast Asia. Excess water withdrawal can increase the problem of disrupted ecosystems, reduce water quality, and exacerbate water shortages [21]. Severe water scarcity already affects 4 billion people worldwide for at least one month every year [20].

Innovations to decrease the need for water in larger quantities are being explored and have included technologies such as liquid cooling, which requires less fresh water, and the usage of recycled or rainwater. Another explored solution is relocating data centres to regions with cooler climates to use naturally lower temperatures, such as Sweden or Finland [33].

4.2 Survey Results

The results presented in this section are the results of the user study. A total of 37 people participated in the study. Participants were of all ages but the majority were between 18 and 29. One answer will not be included because the person has not used ChatGPT. The first section regards the usage of ChatGPT and the second regards the perception of ChatGPT's environmental impact.

4.2.1 Usage Patterns Of ChatGPT

The study's results indicate patterns of frequency of usage, user areas and duration of sessions among the participants. Shown in Figure 4.2, the largest proportion of the participants, 33.3% reported using ChatGPT a few times a week. Closely followed by a few times a month which 25% of the participants reported their usage, 22.2% engage with ChatGPT daily, 16.7% estimate they use ChatGPT less than a few times a month and a small minority at 2.8% never use the platform.

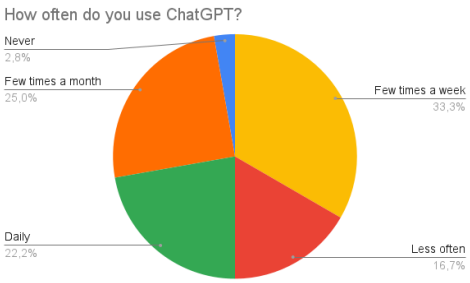

Figure 4.2: How often do you use ChatGPT?

Participants use ChatGPT for various purposes, 21 individuals reported using ChatGPT during their free time. 21 participants use ChatGPT for their school work and 13 participants employ it for tasks at work. The findings indicate the range of ChatGPT and the tasks it can help with, catering to all possible needs.

The time the participants spent with ChatGPT per session varied. As shown in Figure 4.3, the majority of the participants, 37.1%, reported spending under 5 minutes per session, reflecting a brief interaction and a few questions asked. Further, 34.3% of the participants reported spending between 5-15 minutes for each session, indicating more questions asked and larger interaction with the tool. 22.9% of the participants use ChatGPT for 15-30 minutes per session and only 5.7% reported usage for over 30 minutes per session.

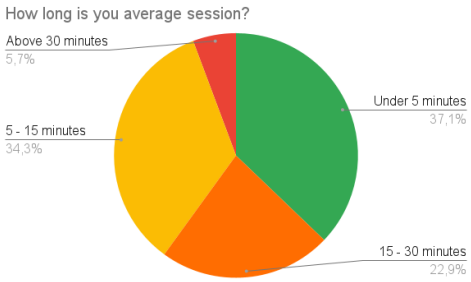

Figure 4.3: How long is your average session with ChatGPT?

The results highlight the difference in usage among ChatGPT users. These results provide valuable insight into the behaviour and context of ChatGPT users.

4.2.2 Perception Of ChatGPT's Environmental Impact

The majority of participants, 80.5%, do not consider a potential environmental impact while using ChatGPT. Only 19.4% think of a potential environmental impact while using ChatGPT as shown in Figure 4.4. This directly indicates the lack of awareness or concern of any potential environmental impact of their tool usage.

Regardless, as shown in Figure 4.5, 77.8% of the participants believe that ChatGPT has an environmental impact. A small minority, 2.8%, indicated that they do not believe that ChatGPT has any environmental impact and 19.4%

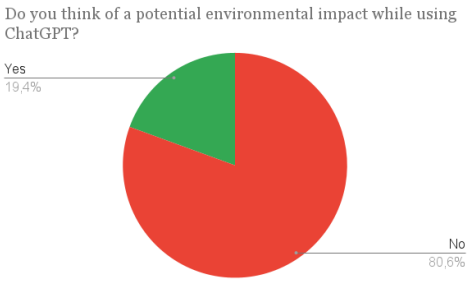

Figure 4.4: Do you think of a potential environmental impact while using ChatGPT?

reported uncertainty of the topic, reflecting a degree of limited understanding about ChatGPT and everything behind it.

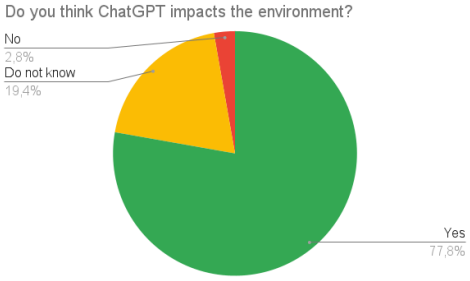

Figure 4.5: Do you think ChatGPT impacts the environment?

When participants were asked, ”What do you think impacts the environment when using ChatGPT or other AI tools?” the responses were of great range, indicating and reflecting varying levels of understanding and awareness of the environmental impact of AI technologies.

A dominant theme in the responses was understanding the high energy demand to train and operate ChatGPT or other AI services. Multiple participants mentioned the electricity usage of centres, maintaining servers, and training models. Statements similar to ”It takes a lot of electricity to keep servers running”, ”All data processing that AI requires consumes a lot of energy” and ”Primarily high energy consumption for training and using AI models” were most common among the participants.

Several responses highlighted the environmental impact of building and maintaining data centres that can handle the large-scale servers needed to

process and store the data. An example is the response ”It takes a lot of materials to build new servers as the demand grows”.

Participants were aware of the size of ChatGPT and the sheer volume of user interactions and data traffic. Participants noted that the extensive network traffic generated by large user bases requires more electricity, one participant stated ”Many people use it, and the traffic sent across the network consumes electricity”.

A few participants acknowledged ChatGPT’s water consumption for cooling data centres. One comment ”Data centres require significant electricity and even water for cooling” highlights the often overlooked aspect of the environmental impact of large data centres.

Despite the insights, many participants expressed a lack of knowledge of the subject with comments like ”No idea” and ”Don’t know how but I can imagine that it does”. This reflects the gap in understanding how a ”website” has an environmental impact.

These results indicate that even if users understand that ChatGPT might be very energy-intensive there is still a limited understanding of the full environmental impact of AI. When asked whether their behaviour would change with greater knowledge and understanding of ChatGPT’s environmental impact, as shown Figure 4.6, 47.2% of the participants thought they would maybe change. 27.8% responded that they do not think their behaviour would change and 25% responded that they think they would change their behaviour if they knew more.

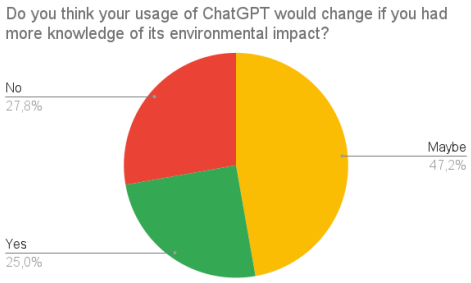

Figure 4.6: Do you think your usage of ChatGPT would change if you had more knowledge of its environmental impact?

The findings from this study highlight a gap in awareness of the environmental impact of ChatGPT and where the effect is coming from. To improve understanding, more transparency from the provider, ex OpenAI, and more education regarding online AI tools could potentially foster more

environmentally conscious usage patterns and more pressure on the creators for more environmental practices.

4.3 Per Capita Energy And Water Usage Estimate

To calculate the energy and water consumption for a person's usage during a week, the following assumptions are based on the findings from the user study on average usage patterns and the literature review on ChatGPT's water and energy consumption:

- 4 sessions a week
- 10-minute session
- 500 ml of water each 10-50 prompts
- 0.4 kWh per 100 pages

For these calculations, additional assumptions are made. During a 10-minute session, approximately 15 prompts are generated, for each prompt about 0.75 pages of text are produced. This results in 11.25 pages per session or 45 pages per week. Based on these figures, a single user consumes approximately 0.18 kWh of energy and about 1 litre of water per week.

Chapter 5

Discussion

Although the energy and water consumption for the training and operation of ChatGPT is smaller than other industries like agriculture and manufacturing, it remains a significant demand on limited global resources [24]. While addressing these environmental challenges, implementing new strategies and solutions could help minimise ChatGPT's environmental footprint without compromising its quality and functionality.

The approaches could be divided into indirect and direct user experience. The indirect meaning is something that the users will not notice while interacting with ChatGPT and the direct with something the users will notice while interacting with ChatGPT.

An indirect approach could be to relocate data centres to regions with colder climates. This approach could reduce energy and water consumption as more outside air could be used. The colder climates are mostly found in Scandinavia and the need for energy-intensive cooling systems would reduce. This approach also includes integrating data centres into areas with higher availability of renewable energy. The relocation of data centres is not something that comes without an environmental cost as well. Another approach could be to build more renewable energy sources in proximity to existing data centres.

In addition to relocating data centres, advancements in cooling technologies offer promising solutions. One emerging effective cooling method compared to the traditional cooling systems is liquid cooling which significantly reduces the need for freshwater [19]. Seawater and wastewater are also being explored as sustainable alternatives for areas facing water scarcity [21, 19].

A direct approach to the problem is to make the users more aware of their

impact on the environment by using ChatGPT because the current awareness of users is low. Educating the users through visible information could foster more environmentally conscious use of ChatGPT. For example, ChatGPT could display an estimated summary of each user resource consumption above the input box that could state ”Since December 1, 2024, you have used X Wh and Y ml of water which is equivalent to running a Swedish average household for Z days” where the country of household is changed based on the user’s location. The user could then watch the number grow for each prompt and might be more mindful of their interactions with ChatGPT. However, this might not work on all users as some do not care.

Another direct approach is introducing financial incentives or incentives for interactions to reduce unnecessary interactions. For instance, introducing a pay-per-prompt where the user has to pay for each interaction or introducing a system similar to the gas fee of Non-fungible tokens (NFTs) [34] could discourage users from using ChatGPT for information that can be easily found with a Google search. While this might appeal to some users, others will disregard it.

In reducing the environmental impact of AI technologies such as ChatGPT, multiple approaches are required as there is not just one solution. The combination of technological innovations, strategic infrastructure planning and increased user awareness is needed to ensure the benefits of AI are realised without compromising the planet’s resources in the process.

Chapter 6

Conclusions And Future work

This chapter concludes the work done, the limitations of the project, future work and reflections on the project.

6.1 Conclusions

This study explored the environmental impact of ChatGPT with a focus on water and energy consumption. A user survey will be added to estimate the user's knowledge and awareness of the environmental impact of ChatGPT.

The project achieved its goal of estimating ChatGPT's water and energy consumption and examining the user perception of its environmental impact. The results highlighted the gaps in user awareness with the majority of users not being actively aware of the environmental impact while interacting with the tool. However, 25% of the participants indicated that they would change their usage if better informed and 47.2% would maybe change their behaviour, demonstrating a potential avenue for promoting sustainable practices through transparency and education.

A significant insight is a need for a greater public understanding of ChatGPT and other AI services environmental costs. Many of the participants were aware of potentially high energy demands but limited awareness of water usage and the indirect environmental effects.

6.2 Limitations

The limitations of this project are the limited research and knowledge of the impact that AI and ChatGPT have. The transparency from OpenAI and other companies developing AI is low and most research is estimated values.

This project only covered the water and energy consumption, it did not explore the CO2 emissions or the emissions and material used to build the data centres and other infrastructure needed. The results do not take into account the environmental impact of the user's hardware while using ChatGPT.

The user survey is limited by the small number of participants relative to the overall user base of ChatGPT, and the question provides little to no insight into users' understanding of how ChatGPT operates

6.3 Future Work

Due to the breadth of the problem and the limited knowledge, not every aspect of the environmental impact of AI was explored. Future work could dive more into the CO2 emissions of ChatGPT as all their data centres are located in the US and have limited renewable energy. Additionally, a larger user survey with more comprehensive questions would provide deeper insights into users' understanding of the topic. Future work could include a life cycle analysis of the hardware used to build, create and maintain data centres.

6.4 Reflections

ChatGPT and AI provides an immense value economically as it is driving innovation and productivity forward. However the environmental cost of ChatGPT, including water consumption for cooling and the reliance on non renewable energy, raises ethical concerns. Balancing all the factors requires a commitment from both developers and user to sustainable practices.

The thesis contributes to the UN SDGs numbers 6, 7 and 12 by raising awareness about the water and energy consumption of ChatGPT and the sustainability of usage.

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Appendix A

Questions Used In Form

- Hur gammal är du?
  - Under 18
  - 18-29
  - 30-39
  - 40-49
  - 50-59
  - 60+
- Har du använt ChatGPT?
  - Ja
  - Nej
- Hur ofta skulle du säga att du använder dig av ChatGPT?
  - Dagligen
  - Några gånger i veckan
  - Några gånger i månaden
  - Mer sällan
  - Aldrig
- Om du använder ChatGPT, vad använder du det till?
  - Skola
  - Jobb

  - Fritid
- Hur länge brukar du använda dig av ChatGPT under en session?
  - Under 5 minuter
  - 5-15 minuter
  - 15-30 minuter
  - Över 30 minuter
- Tänker du på en potentiell miljöpåverkan när du använder dig av ChatGPT?
  - Ja
  - Nej
- Tror du att ChatGPT påverkar miljön?
  - Ja
  - Nej
  - Vet inte
- Vad tror du påverkar miljön när man använder ChatGPT eller andra AI verktyg?
- Tror du att ditt användande av ChatGPT skulle förändras om du visste mer om dess miljöpåverkan?
  - Ja
  - Nej
  - Kanske
- Övrigt?

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”First name”: ”Olivia”,
”Local User Id”: ”u1l0085x”,
”E-mail”: ”ohakans@kth.se”,
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One of the most transformative technological advancements in recent years has been \gls{AI}. The
ability to help and assist with tasks in sectors from finance to healthcare has made \gls{AI} in high
demand. In particular, so-called generative AI has captured significant attention, which means
\gls{AI} systems capable of producing new content such as images, text, code or audio based on input
prompts.

This study investigates the environmental impact of generative \gls{AI} with a primary focus on
ChatGPT. The research is a combination of a literature review of ChatGPT's water and energy
consumption with a user study investigating user behaviour and perception of the environmental impact
of utilising it.

The findings indicate that the training and operations of ChatGPT require considerable energy both
for training the algorithms and for their operations in use. The estimated electricity consumption of
ChatGPT is significant for the maintenance and processing of data. Moreover, water consumption, used
primarily for cooling data centres, contributes to the environmental impact of ChatGPT and other
\gls{AI} services by increasing freshwater scarcity in regions already affected.

The user perception survey revealed that most participants were not actively thinking of the
environmental impact that ChatGPT has while using the model. Many participants recognised the size
and advancement of ChatGPT and the energy consumption for it would be similar but were unaware of the
water consumption of the model. 25\% of the participants indicated they would change their usage
behaviour if they had more knowledge about the ecological footprint of ChatGPT and 47.2\% thought
they might change their behaviour.
```

This study sheds light on the water and energy consumption of \gls{AI} to contribute to a more environmentally responsible approach to \gls{AI} development and usage.

%Write an abstract that is about 250 and 350 words (1/2 A4-page) with the following components:

% key parts of the abstract
%\begin{itemize}
% \item What is the topic area? (optional) Introduces the subject area for the project.
%\item Short problem statement
%\item Why was this problem worth a Bachelor's/'Masters thesis project? (\ie, why is the problem both significant and of a suitable degree of difficulty for a Bachelor's/'Masters thesis project? Why has no one else solved it yet?)
% \item How did you solve the problem? What was your method/insight?
%\item Results/Conclusions/Consequences/Impact: What are your key results/\linebreak[4]conclusions? What will others do based on your results? What can be done now that you have finished - that could not be done before your thesis project was completed?
%\end{itemize}

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"Keywords[eng]": €€€€
Artificial Intelligence, Environmental Impact, Sustainability, Water Consumption, Energy Consumption €€€€,
"Abstract[swe]": €€€€

Artificiell intelligens har varit en av de mest transformerande teknologiska framstegen under de senaste åren. Dess förmåga att hjälpa och assistera med uppgifter inom olika sektorer, allt från finans till vård, har gjort AI mycket efterfrågat och använt. Särskilt den så kallade generativa AI har fått stor uppmärksamhet. Generativ AI innebär AI-system som kan skapa nytt innehåll såsom bilder, text, kod eller ljud baserat på inmatade promptar.

Denna studie undersöker miljöpåverkan av AI med primärt fokus på ChatGPT. Denna undersökning kombinerar en litteraturstudie om ChatGPT:s vatten- och energiförbrukning med en användarstudie som undersöker användarbeteenden och uppfattningar om miljöpåverkan när modellen används.

Resultaten visar att träning och drift av ChatGPT kräver en betydande mängd energi för att fungera effektivt. Den estimerade konsumtion av el som ChatGPT förbrukar är signifikant för den underhållning och behandling av data som görs. Vattenförbrukningen, som främst kommer från nedkylning av datacenter, bidrar till miljöpåverkan ChatGPT och andra AI verktyg har genom att öka sötvattenbrist i regioner som redan är påverkade.

Användarstudien visade att de flesta av deltagarna inte aktivt tänker på en potentiell miljöpåverkan som ChatGPT kan ha när de använder sig av modellen. Flera deltagare var medvetna om storleken av ChatGPT och hur avancerade verktyget är och att energikonsumtionen skulle kunna vara liknande men var omedvetna om vattenkonsumtionen. 25\% *av deltagarna tror på att de skulle förändra sin egen användning av ChatGPT om de var mer medvetna om dess miljöpåverkan och 47,2\% tror att de kanske skulle förändra sitt beteende.*

Denna studie belyser AI:s vatten- och energiförbrukning för att bidra till ett mer miljöansvarigt tillvägagångssätt vid utveckling och användning av AI.

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"Keywords[swe]": €€€€
Artificiell intelligent, Miljöpåverkan, Hållbarhet, Vattenkonsumtion, Energikonsumtion €€€€,
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acronyms.tex

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%%% Local Variables:
%%% mode: latex
%%% TeX-master: t
%%% End:
% The following command is used with glossaries-extra
\setabbreviationstyle[acronym]{long-short}
% The form of the entries in this file is \newacronym{label}{acronym}{phrase}
%                                      or \newacronym[options]{label}{acronym}{phrase}
% see "User Manual for glossaries.sty" for the  details about the options, one example is shown below
% note the specification of the long form plural in the line below
\newacronym[longplural={Debugging Information Entities}]{DIE}{DIE}{Debugging Information Entity}
%
% The following example also uses options
\newacronym[shortplural={OSes}, firstplural={operating systems (OSes)}]{OS}{OS}{operating system}

% note the use of a non-breaking dash in long text for the following acronym
\newacronym{IQL}{IQL}{Independent -QLearning}

% example of putting in a trademark on first expansion
\newacronym[first={NVIDIA OpenSHMEM Library (NVSHMEM\texttrademark)}]{NVSHMEM}{NVSHMEM}{NVIDIA OpenSHMEM Library}

\newacronym{KTH}{KTH}{KTH Royal Institute of Technology}

\newacronym{LAN}{LAN}{Local Area Network}
\newacronym{VM}{VM}{virtual machine}
% note the use of a non-breaking dash in the following acronym
\newacronym{WiFi}{-WiFi}{Wireless Fidelity}

\newacronym{WLAN}{WLAN}{Wireless Local Area Network}

\newacronym{UN}{UN}{United Nations}

\newacronym{NLP}{NLP}{Natural Language Processing}

\newacronym{SDG}{SDG}{Sustainable Development Goal}

\newacronym{AI}{AI}{Artificial Intelligence}
\newacronym{TWh}{TWh}{Terawatt hours}

\newacronym{LLM}{LLM}{Large Language Model}

\newacronym{GPT}{GPT}{Generative Pre-trained Transformer}


\newacronym{ICL}{ICL}{In-context learning}
\newacronym{IFT}{IFT}{Instruction Fine-Tuning}

\newacronym{RL}{RL}{Reinforcement Learning}

\newacronym{GPU}{GPU}{Graphics Processing Unit}

\newacronym{RNN}{RNN}{Recurrent Neural Networks}

\newacronym{LSTM}{LSTM}{Long Short-Term Memory}

\newacronym{RLHF}{RLHF}{Reinforcement Learning from Human Feedback}

\newacronym{NFT}{NFT}{Non-fungible token}
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