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The use of artificial intelligence to improve the Sustainable Development Goals (SDG)

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Abstract

With the times changing and digitalization happening things like artificial intelligence have been on the rise. They have been used to affect many areas of the world navigation, chatbot or even digital assistants. The aim of this thesis is to find how artificial intelligence and be used to improve sustainability mainly focusing on sustainable development goals.

The study was a content analysis of research in order to find how artificial intelligence has been used now and how it will be in the future. A part of this research was to use ChatGPT a chatbot which is free access to all and fast growing to see how the AI would be able to collect information and compile them. The results show that AI has multiple uses assisting in sustainable development and will continuously be able to help increase the optimization and efficiency of sustainable development.

Keywords

artificial intelligence, sustainable development, machine learning, Sustainable Development Goals (SDG)

CONTENTS

1 INTRODUCTION

Artificial intelligence (AI) is a new and rapidly expanding industry. It has been estimated that by 2030 the global economy would have 15.7 trillion dollars added to it due to artificial intelligence (Chainey 2017; Rosen 2023, 1). This shows that AI has in order to improve the world in terms of the economy. Though it has future uses, AI is currently changing the world and raising issues of importance for governments, society, and the economy (West et al. 2018, 1). There have been talks in the European Parliament on having policies to create conditions for nurturing AI potential while considering possible risks (Szczepański 2019, 1) and they have been brought up in terms of governance where the Council of Europe has been promoting AI governance based on human right standards (Mijatović 2021, 1). In the past decade, the use of AI and the use of it in the workforce have more than doubled (Chui et al. 2022, 1). According to Michael Chui, a partner at McKinsey Global Institute, in the past 5 years, AI has had an exuberant growth, but now it is starting to plateau as other new technologies have emerged over the years during the early adoption period. The thought of AI plateauing has been addressed by others, VentureBeat and, HRReporter. (Dobson 2023; Grossman 2020; McKinsey & Company 2022, 1).

With all the developments in the field of AI, the question arises as to how this could be connected with the sustainable development goals. Some ways that this has been happening is by the use of their predictive capabilities and intelligent grid system to manage the demand and supply of renewable energy (Arumugham 2023, 1). International Business Machines (IBM) has been using AI in order to optimize the weather forecasting for better management of maximizing renewable energy production, which has resulted in a 30% improvement in the predictions (IBM n.d., 1). There has been AI use in the integration with satellite imagery in order to find changes in vegetation, forest cover, and the fallout of natural disasters (Tehrani 2023, 1).

With the sustainable development being such a large topic in this thesis, the focus will be on the sustainable development goals that have been set by the

United Nations (UN). In 2015, the United Nations adopted the 2030 Agenda for Sustainable Development, which has 17 sustainable development goals. The goals that were created recognize the different areas that will affect development in economics, social and environmental sustainability (United Nations (UN) 2023a, 2). The aim of this thesis is to show that artificial intelligence can be used to improve sustainable development. I will be looking at the two main sustainable development goals that have been set by the UN. The goals that I have decided to focus on are affordable and clean energy, which is point seven, and sustainable cities and communities, which is point eleven.

2 OBJECTIVES

The objective of this study is to use examples of AI use in the two SDGs that have been mentioned. The study will look at how AI can be used to improve the sustainable development goals? It will also address how AI can be used in the future development of the SDGs?

3 THEORETICAL BACKGROUND

3.1 Sustainable development

Sustainable development is meeting the needs of the present while protecting future generation's ability to meet their need. It involves efforts to build an inclusive and resilient future for the people and the planet. The key elements of economic growth, social inclusion, and environmental protection and they are essential for the wellbeing of all things (United Nations (UN) 2023b, 2). This can be seen in Figure 1, where each of these aspects overlaps with each other in a Venn diagram form. Eradicating poverty, promoting sustainable and equitable economic growth, reducing inequalities, improving living standards, fostering social development, and promoting sustainable natural resource management are all critical components of sustainable development. It is important to

remember that these aspects need to work together for there to be sustainable development (United Nations (UN) 2015, 3).

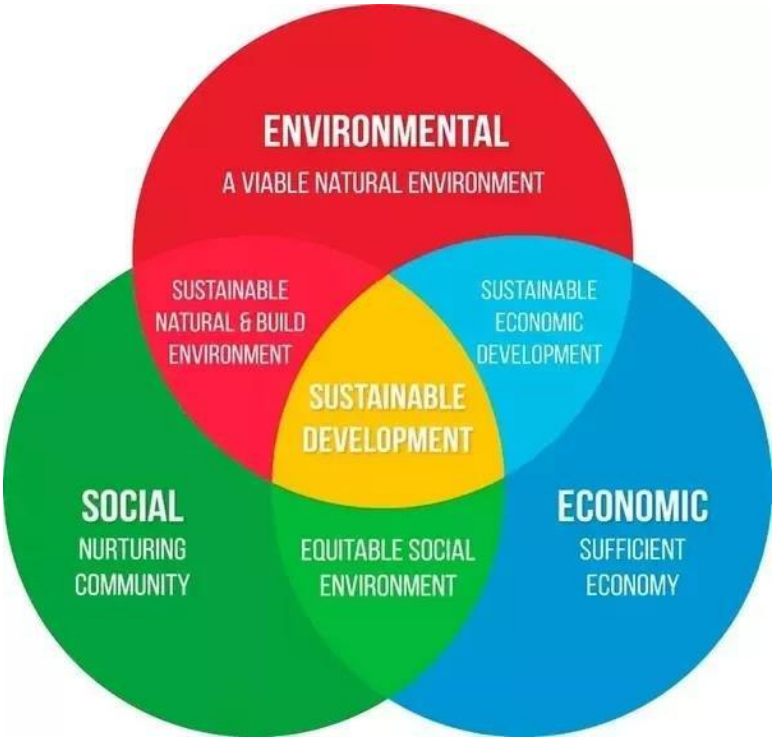

Figure 1. Venn diagram of three aspects of sustainability (United Nations (UN) 2015, 3)

In Figure 1 it can be seen that how each part interacts where in social and environmental we would get a sustainable naturally built environment which, can give us an adaptable, flexible, long lasting while looking at future climate risks, this mix focuses on sustainable development goals, 5, 7, 11, 12, 13 and 15 (wbcsd, n.d., 3). When environment and economics mix, we get sustainable economic development which is an economic growth that free of over-consumption of production and indebtedness while taking into consideration the future generations (Ellis 2023, 3). When social and economic mix we get equitable social environment which is the fair treatment and involvement of communities and people in the implementation, enforcement and development of policies and regulations (EPA 2022, 3).

3.2 Sustainable Development Goals (SDG)

The Sustainable Development Goals (SDGs) were developed by the United Nations through an inclusive process involving various stakeholders to provide a comprehensive framework for addressing global challenges, promoting sustainable development, and ensuring inclusivity. Building upon the progress of the Millennium Development Goals (MDGs), the SDGs cover a broad range of issues and emphasize the need to balance economic, social, and environmental objectives. They are universal, inclusive, and part of the 2030 Agenda for Sustainable Development, serving as a roadmap for coordinated action towards a more sustainable and equitable future. The United Nations created their 17 goals for creating a more liveable world for all living beings. In Figure 2 you can see the goals that they have set (United Nations (UN) 2015, 4).

Figure 2. UN 17 Sustainable Development Goals (United Nations (UN) 2015, 4)

The United Nations created these goals in 2015 under the 2030 Agenda for Sustainable Development, and this agenda aims to improve the lives of people and protect the environment. The main goals have been divided into smaller sections that are the targets because some of the goals that are on the agenda

are very idealistic. As stated, this thesis will mainly look at the seventh and eleventh points of these goals. The targets for these goals are:

Affordable and clean energy (Goal 7) (United Nations (UN) 2023c, 5)

- Reliable, modern and affordable energy. The UN is keeping track of and evaluating the accessibility and cost of energy services, like clean cooking fuels and electricity. In order to monitor progress toward ensuring reliable, and affordable energy this includes tracking indicators relating to energy access, energy prices, and energy affordability (United Nations (UN) 2023c, 5).

- Double the energy efficiency - The UN is tracking and evaluating increases made toward doubling the rate of improvement in energy efficiency on a global scale. To encourage more efficient energy use across various sectors, buildings, transportation, and industry, this involves monitoring energy consumption trends, energy efficiency policies and measures, and technological advancements (United Nations (UN) 2023c, 5).

- Increase cooperation in order to have access to clean energy technology and research and promote investments in these areas - For the purpose of facilitating access to clean energy technologies, information exchange, and research collaboration, the UN promotes global partnerships. To quicken the achievement of SDG 7 targets, this means fostering technology transfer, capacity building, and monetary investments in clean energy technologies and research (United Nations (UN) 2023c, 5).

- Increase the use of renewable energy - The UN monitors and evaluates the use of renewable energy sources like solar and hydropower, as well as their proportion in the world's energy market. In order to encourage greater use of renewable energy and

lessen reliance on fossil fuels, this includes monitoring policies, regulations, and incentives for its adoption as well as evaluating investments, capacity building, and technology transfer (United Nations (UN) 2023c, 6).

- Increase infrastructure and technology to supply sustainable energy to developing countries - In order to support sustainable energy access, the UN tracks and assesses initiatives to improve energy infrastructure and technology in developing nations. This includes monitoring the development of energy infrastructure, increasing access to clean cooking options and electricity, encouraging the use of renewable energy sources, and enhancing technological capabilities in developing nations (United Nations (UN) 2023c, 6).

Sustainable cities and communities (Goal 11) (United Nations (UN) 2023c, 6)

- Reduce number of deaths and number of people that are affected and decrease the direct economic losses in relation to global GDP caused by disasters - Disasters, natural disasters or humanitarian crises, can prevent people from enjoying their rights and freedoms while resulting in fatalities, forced population displacement, and negative economic effects. Governments and communities can safeguard the right to life and security by putting in place disaster risk reduction measures, disaster preparedness plans, and early warning systems (United Nations (UN) 2023c, 6).

- Created access to safe, affordable housing and basic services to all - According to the UN, everyone has the right to a standard of living sufficient for their health and well-being, including housing. It places a strong emphasis on the requirement to guarantee the right to security in any event unemployment, sickness or disability. This

emphasizes how crucial it is to offer safe, affordable, and suitable housing options for everyone, including vulnerable and marginalized populations (United Nations (UN) 2023c, 6).

- Increase sustainable and inclusive urbanization and capacity for integrated and sustainable settlement planning - The UN calls for state cooperation to advance higher standards of living, full employment, and conditions of economic and social progress and development. This can be taken to mean supporting sustainable urbanization, which creates social inclusion, economic prosperity, and environmental sustainability. It highlights the necessity of integrating community input into decision-making processes through participatory urban planning methods (United Nations (UN) 2023c, 7).

- Create access to affordable, safe, sustainable and accessible transport systems - The UN has acknowledged the importance of the environment for both current and future generations. By lowering greenhouse gas emissions and air pollution, access to sustainable transportation systems, public transportation, electric or low-emission vehicles, and non-motorized transportation, can support environmental sustainability (United Nations (UN) 2023c, 7).

- Increase efforts to protect cultural and natural heritages - As these are frequently significant symbols of national and local identity, this can be taken to mean that the protection and preservation of cultural and natural heritage within cities and communities is supported. In order to achieve the shared objective of protecting cultural and natural heritages for future generations, it emphasizes the necessity of cooperation among states (United Nations (UN) 2023c, 7).

3.3 Artificial Intelligence

3.3.1 History

The first suggestions for AI come from very far in the past, around the years 750–650 BCE, and were first suggested by the ancient Greek poets. We have heard of Deadalus, who was a craftsman who created living statues, or even Pandora, who was described as an artificial being in Hesiod's Theogony (Shashkevich 2019, 8), but it was not just the Greeks who were thinking automatous beings. On the other side of the world, there were Buddhist tales of mechanical girls who appeared in Mahavastu and in ancient China, Artisan Yan She made a mechanical automata that could sing and dance. The writers of these poems taught of these ideas to show the power of human creativity to overcome obstacles while achieving amazing results, they were thinking on the complex interactions between creators and the risks and benefits of robotics, and the relation of humanity and technology. The tales look at concepts of impermanence, consciousness and technology while raising questions towards the role of technology in society and human life (Berguš 2020, 8).

It is interesting to see how AI has been thought of for a very long time, so the question is: when did the dreams start to become reality? The first works started in the 1940s, but the birth of this technology was in 1956, when John McCarthy coined the term artificial intelligence. Since then, there has been a continuous breakthrough in the field. In 1964, the first chatbot was created. In 1997, DeepBlue beat a chess legend; and more recently, in 2016, the first robot citizen, Sophia, was created. One that has been in the news recently, GPT-4 which is OpenAI's new language model system and the predecessor of GPT -3.5. GPT stands for Generative Pre-trained Transformer that uses deep learning to generative human-like conversational text. The new model is more accurate and better able to understand the more complex requests the program has been released as of this year (Ayyagari 2022, 8).

3.3.2 Introduction to AI

Artificial intelligence is concerned with making a system able to replicate human problem-solving systems and intelligence. This is done by taking a large amount of data and processing it in order to learn from the past and improve for the future. As a result, basic AIs are able to complete complicated tasks. At the most basic level, AIs use different algorithms and iterative processing systems in order to find patterns in data. While advanced AIs are able to measure their own performance when they are used and improve the process itself, four main types of AI systems exist, defined by the amount of data that can be stored and the way the data is used (Tableu n.d., 9). Currently, out of the four types of AI the third and fourth types are just theoretical.

These types are (Kelley 2023, 9):

1. Reactive: Reactive systems are unable to store data, and as the name implies, they react to the data presented to them. These systems are unable to learn and always react the same to what is input. They are mainly used as spam filters for emails or as game-playing AIs.
2. Limited Memory: Limited memory AI's temporarily store data and then decide the next action on the inputted data. The difference between limited memory AIs and more advanced programs is that once programmed, the AI will not improve by itself. Examples of limited memory AIs are self-driving cars or robots that are self-working.
3. Theory of Mind: A theory of mind systems would be capable of understanding that the thoughts and feelings of humans can affect their decisions and mental state.
4. Self-awareness: The self-awareness system would be capable of being aware of itself and it place in the world; this AI would know its place around humans and have consciousness on a human level (Kelley 2023, 9).

3.3.3 Machine Learning (ML)

Machine learning (ML) is a subset of AI and computer science where the focus is on the use of algorithms and data to imitate the way that humans learn while gradually improving its accuracy. The term was coined by Arthur Samuel in his research on studies in machine learning using the game of checkers. The insights that are found through the use of algorithms or statistical methods, which are then used to make predictions or uncover details in data mining projects, have led to decisions being made in businesses or applications in order to ideally improve key growth metrics. Machine learning algorithms are typically made with frameworks PyTorch and TensorFlow. This technology has made advancements in self-driving cars and recommendation systems (IBM n.d., 9).

The four types of machine learning (Salian 2018, 10):

1. Supervised learning - this is when a labelled set of data is given to train an algorithm. A labelled set of data is data that has the answer attached, so when the model is given a new set of data, they will compare it with the training examples to give the correct answer.
2. Semi-supervised learning - this is when the model is given both an unlabelled and labelled data set. This model is used to find relevant features in more difficult data sets.
3. Unsupervised learning – where the model is given a data set without explicit instructions which it then tries to find structure in the data by extracting features and analysing the structure. The dataset is a collection of examples that has no answer. This is used when researchers are questions to the algorithm that they do not know the answer to.
4. Reinforced learning – this model work by having an AI find an optimal way to complete a certain task and when said task is complete, they receive a reward. This is done by learning from past feedback and exploring new options to create the best long -term strategy for the highest cumulative reward (Salian 2018, 10).

3.4 Artificial intelligence and Sustainable development

Sustainable development and artificial intelligence have been studied together quite a lot in the recent years, this is due to the recent increase in the use of artificial intelligence and the strides that have been made in the field. This can be observed in books that have been written like ‘AI and IoT for sustainable development in Emerging countries’ which collection of studies related to different ways that AI has been able to increase the ability of items in the IoT. It can be seen that in articles on artificial intelligence for sustainable development made by large organizations like the United Nations Educational, Scientific and Cultural Organization (UNESCO), in which they have address AI and certain aspects of sustainable development, they look at how AI has been and is being used (UNESCO 2019, 10). They address future AI strategies in terms of sustainable development and ways that it can be implemented in the workplace and nationally. Another large organization that has looked at the way that AI has improved the SDGs is the World Economic Forum (WEF), they had found numerous examples of this related to different SDGs. WEF has made a Global AI Action Alliance in ordered maximize the benefits of AI while minimizing the risk, it consists of more than 100 governments, international organizations, academics, leading companies and non-profits (Gast 2022, 11). To promote the use of AI and the SDGs the UN has created a Think Tank called AI for Sustainable development goals (AI4SDGs). The Think Tank is a collection of AI projects and proposal in which the SDGs are affect both negatively and positively, in which they promote the positive use of AI and investigate the negative impact that AI has on the SDGs. This Think Tank is open to the public so that they can be listed and rated in order to know how they effective they can be (United Nations (UN) 2023b, 11).

3.4.1 AI and SDG 7

While humans are able to find patterns and make predictions in data sets that are not incredibly large, as the amount of data grows, the difficulty of this rises. When this happens, the operators who are looking at this data can become overwhelmed by the terabytes of data they might need to pour through. This

problem can be solved with AI, which is designed to find patterns in large sets of data, and if iterative machine learning is added, the forecasts can become even more accurate as the AI refines its own predictions over time using the new information coming in. AI has been used to give better predictions even in other fields in a study on crop yield by Jeong et al. in 2016, the researchers used a machine learning method known as Random Forest which is a model that grows multiple decision tress which are merged in order to create more accurate predictions to predict crop yield in response to climate and biophysical variables. They used this method in comparison to multiple linear regression, which served as the benchmark. The study found that Random Forest outperformed multiple linear regression, with a root mean square error of 6 and 14% for Random Forest, while the multiple linear regression model had 14 and 49%. The results showed that Random Forest was effective due to its ease of use, utility in data analysis, and high accuracy and precision. Not only can AI models be used to improve on human methods, but just by changing the model being used, AI accuracy can be increased. In a study to predict corn yield using satellite and meteorological data under extreme weather conditions, The researchers tested 6 different AI models under the same conditions and found that there had been an approximate increase of 51-98% in accuracy for the DNN model in drought situations, and for heatwaves, there was a 30-77% increase in terms of root mean square error (Kim et al. 2020, 12).

With the growing need for clean energy, technology solar photovoltaic (PV) systems and wind turbines has been increasing due to their scalable technologies, more so for solar, with the ability to be installed on residential roofs as well as large solar farms. The cost of these technologies has dropped in price between 2010 and 2020, with PV seeing an 85% decrease, onshore wind at 56%, and offshore wind at 48% (IRENA 2021, 12). With this being the case, the question is: how can this technology be improved with the help of AI technology? Having seen how iterative machine learning and AI can be used to improve forecasting abilities with increased accuracy over time, first by analysing the weather patterns, turbines can be positioned to optimize energy production based on real-time weather models in any location. An AI that can find high-accuracy

power generation predictions for solar power was found by Geethamahalakshimi et al. It can be used to autonomously adjust energy storage and production schedules for solar PV by predicting solar radiation, which would be good because on overcast days solar PV systems can have a decrease of 80% in performances. AI techniques can be used for the sizing of PV systems because, compared to more conventional methods, which would be used for places with the required weather data and information on the site itself, these techniques would not be able to be used in an area that does not have the required data, and the need for long-term meteorological data would be needed. To overcome this problem, techniques have been developed based on a study done on AI techniques for sizing and simulation of PV systems, and the techniques and number of applications in different areas of PV sizing can be seen in Table 1 (Mellit et al. 2008, 13). You will be able to see that with some of the AI techniques, they are able to handle multiple areas of PV sizing, which would increase the efficiency of the process.

AI technique	Area	Number of applications
Neural networks	Sizing of stand-alone PV-systems	5
	Identification of the optimal parameter of PV-system	
Neuro-fuzzy	Sizing of stand-alone PV system	1
Wavelet and neural network	Sizing of stand-alone PV-systems	1
Genetic algorithm	Sizing of hybrid system	6
	Stand-alone wind-generator system	
	Optimization of control strategies for stand-alone	
	Optimal allocation and sizing for profitability and voltage enhancement of PV systems	
Neural network, neuro-fuzzy and genetic algorithm	Sizing of stand-alone PV system in isolated area	2

Table 1. AI techniques and number of applications in different areas of PV sizing (Mellit et al. 2008, 14)

Secondly, AI can be used to extend the lifetime of these devices. This can be done thanks to advances in edge computing, edge AI, and the industrial internet of things (IIot) that have contributed to the deployment of lightweight product data management (PdM) solutions at the edge to increase the lifetime of industrial equipment. Edge computing is where computations are done on the edge of networks rather than on cloud servers; this has reduced network connectivity dependency, transmission bandwidth, response time, and required storage (Debaillie et al. 2023, 14). They are able to use AI, infrared imaging, and autonomous drones to scan PV plants for areas where panels have defects. AIs are being used in battery storage in order to charge and discharge batteries for more reliable energy deliveries, to optimize battery charging schedules, and to unlock new streams of revenue to increase profitability in the energy market. The closest example of optimization of batteries with AI is in the pockets of most people, the phone battery has a feature called adaptive battery, and what it does is use DeepMind AI from Google to learn your patterns and optimize the apps (Srivasta 2022, 14). Apple has introduced clean energy charging in IOS 16.1. This feature looks for an energy grid nearby and downloads the carbon emission forecast from the local load balancing authority with this information, IOS charges the phone selectively when wind or solar is available and stops charging when cleaner energy is not available. At the moment, this option is only available in the US, but once the software is updated and released to the rest of the world, there will be a larger use of clean energy (Zibreg 2023, 14).

Developed countries have started to use technologies and AI systems in order to improve the communication between smart grids, internet of things (Iot) devices, and meters, which has led to an increase in efficiency, an increase in the use of renewable energy sources, and an improvement in management. It is important to note that the energy sector faces challenges due to poor resource management, system inefficiency, rising consumption, and varying supply and

demand patterns. With this being a problem, if we adopt the age of digitalization and new technologies, it is possible for AI to decrease the cost and waste of energy (Makala et al. 2020, 15). AI is being used to optimize the operation, planning, and control of systems, and with the use of AI and ML techniques, there is the possibility of creating an AI-enabled smart energy grid. With the digitalization, we can see the electricity sector becoming more decentralized, and the digitalization has led to an increase in energy availability due to a direct connection to local distribution grids, which allows customers to produce electricity due to the aggregation that has occurred that allows customers to use, produce, and store electricity generated. Though this technology is very helpful in the energy sector, with new technology come new risks, and a large threat in using AI technology is cyberattacks through ransomware, malware, and more. This attack can be used to sabotage the energy systems, commit industrial espionage, or other threats. These threats have led the leading figures in the countries to create cybersecurity strategies, but they are not impenetrable (Kumar et al. 2022, 15).

Currently, the focus on AI in clean energy is on integrating renewable energy with power systems. There have been studies to address this by Hua et al., and scholars have suggested that a data-driven dynamic control strategy for bottom-up energy internet systems can improve the distribution of renewable energy. For high accuracy, large amounts of data sets can be given to deep learning models (Devaraj et al. 2021, 15). There have been researchers looking at AI and solar and wind energy; some of the research in this field is by Moazenzadeh et al., who looked at improving the general capability of AI solar radiation estimator models (Moazenzadeh et al. 2022, 15), or a study on optimizing an algorithm to predict wind speed reliably and effectively (Zhang et al. 2021, 15). The future trends in AI and clean energy are mainly focused on optimization and increasing the accuracy of prediction models.

3.4.2 AI and SGD 11

The aim of this goal is to encourage the development of cities that are more safe, inclusive, and sustainable by making urbanization more inclusive for

shareholders to reduce the negative effects of things like natural disasters so that sustainable development can be improved. While AI could be used to support the building of sustainable cities by creating solutions to enhance health, transportation, and energy for the people, it can be used to have citizens participate in actions to achieve sustainability. They could be used to collect data that could improve understanding of the progress made toward achieving the goal that has been set by the UN (Fritz et al. 2019, 16). This is good because, for a long time, there has not been attention to the citizen in the process of making a sustainable city (Martens 2019, 16). Citizen participation leads to a sense of trust, which helps with achieving the goal.

Currently, many examples of AI improving our daily lives that we usually do not even recognize as AI. A few examples of this are the face detection technologies that are in security drones that help identify people so if crimes are committed, they can be found. Traffic management systems and vehicle parking systems that use AIs to gather data from cameras or road sensors in order to create real time traffic and parking maps (Cogito Tech LLC 2020, 16). Another way that AI has been used to improve our lives is in waste management, where by installing a few sensors in trash bins, they have been able to get information on when the trash bin is almost full, which has led to fewer unnecessary collections and a streamlining of collection routes. An AI that sorts out waste has been created; it is called Max-AI, Max-AI is able to identify recyclables and other items for recovery through the use of deep learning technology (MaxAI). There have been advancements in sewage treatment; Miao et al. conducted a study on a chemical plant in sustainable cities and proposed to apply machine learning to the sewage treatment. Their findings showed that the proposed system works efficiently in terms of methodology, and, according to the results, the system would be able to give early fault alerts with high performance, which would reduce the work load and difficulty significantly (Miao et al. 2021, 16).

The areas that I have just mentioned are quite large city-wide aspects of the use of AI to create a more sustainable city, but the technology is being used on small things., in Paris, the administration has implemented sensors on park benches that allow them to gather information air quality, atmospheric pressure, and frequency of traffic that will be analysed by AI for urban planning, Visitors to the park are able to give feedback to the benches on an app. There have been changes to improve the quality of workplaces by EncompassAV, which developed a system able to use AI with security cameras, HVAC, and lighting, The system is able to make decisions to adjust and adapt the environment depending on internal or external factors (Buttice 2022, 17).

The UN has launched an initiative that promotes technology-intensive and sustainable cities through knowledge transfer across the world (ITU 2020, 17), and by aiming to have more technological cities, the use of AI is endless, not only can they be used to help plan the city, but they can be used in development. AIs could be used to improve security through solving and predicting crimes. which is possibly a very effective idea but extremely controversial due to the nature of predictive policing (Shapiro 2017, 17).

A part of a sustainable community is smart cities, which are cities that are built and that rely heavily on energy efficient green communication and networking to connect important areas in the cities (Tomar et al. 2019, 17). The Blatchford project in Edmonton, Canada, is an example of a smart city, though we are unable to completely see how successful the project is due to it still being under construction. With the idea of smart cities, Smart health and transportation applications that have been made. Which have had a significant impact on health care in the case of smart health applications because, they have the ability to monitor, detect, and sense things that happen to the patient. Smart transportation has been found to reduce traffic issues, give arrival times to destinations, or even design parking areas (Shafie-Khah et al. 2016, 17). In a study conducted by Oussous et al., they aimed to integrate smart transportation with smart health.

They proposed an IoT platform for autonomous electric vehicles that would note the best route that would take the greatest number of people with the least number of stops and reduce costs. They proposed another IoT platform that was made to deal with the COVID-19 regulations that were set. The idea of their second platform was the same as the first, but people would be required to scan a QR code that shows they are COVID free. They were able to combine the two aspects, and for future work, they were planning to look at increasing security measures for a more optimal and secure platform (Oussous et al. 2022, 18).

Smart cities have started to use cloud computing with AI, which has brought us a step closer to the sustainable development goals that were set. In Newport, Wales, in the United Kingdom, they were able to address issues relating to flood control, air quality, and trash management in a few months rather than it taking a year or more with the original infrastructure. There is CityTouch, which is a control system for lights in public areas, CityTouch has more than 600 clients, including cities like Buenos Aires and Los Angeles. This technology is popular because it shows the energy traffic lights consume and which need to be updated, and with this information, the cities can employ resources and make better judgement calls if needed (Alam et al. 2022, 18).

Artificial intelligence is a large part of a sustainable future by optimizing aspects like environmental, economic, and social in cities. They have helped with the advancements in many technologies, which have given us the ability to understand large amounts of data by using the innovation ecosystems that mainly exist in cities. It has helped with the digitization of many cities (Villagra et al. 2020, 18), and by doing this, there has been the creation of a more sustainable and inclusive environment. An example of advancements that have been made are Earth Observation (EO) technologies that support various aspects of cities (Kuffer et al. 2021, 18). AI has given us the ability to address complex environmental interrelationships and social inequalities, which is why, it

is an important tool that will help with the problems of sustainable cities that may arise due to the problem of rapid urbanization.

Overall, there is so much potential for AI in creating sustainable communities, mainly through the optimization of aspects in preparation for urban areas, using IoT sensors and satellite imaging or other preferred methods. They are used for predictive mapping in order to find solutions for water security, air quality, natural disasters, and many other applications for supporting climate adaptation. The use of AI has not only given a more in depth understanding of climate indicators, but been able to increase trust in AI models due to their functional transparency rather than a black-box model (Sirmacek 2022, 19).

3.4.3 ChatGPT and SDGs

The United Nations' Sustainable Development Goals (SDGs) are a set of 17 global goals aimed at addressing the world's most pressing social, economic, and environmental challenges by 2030. Two of these goals, SDG 7 and SDG 11, focus on ensuring access to affordable, reliable, sustainable, and modern energy for all and making cities and human settlements inclusive, safe, resilient, and sustainable, respectively. Artificial intelligence (AI), as a transformative technology, has the potential to play a significant role in advancing these goals through its applications in energy optimization, regenerative energy management, urban planning and smart cities, disaster resilience and risk management, and transportation optimization.

Energy Optimization: Energy consumption patterns in various sectors, buildings, transportation, and industry, often exhibit inefficiencies that result in energy waste and increased greenhouse gas emissions. AI can analyse large datasets of energy consumption patterns, weather data, and other relevant factors to identify inefficiencies and suggest improvements. Machine learning algorithms can analyse data from smart meters, sensors, and other sources to optimize energy

use in buildings by identifying patterns of energy waste, predicting peak demand times, and recommending actions adjusting temperature settings, lighting controls, and scheduling energy-intensive processes during off-peak hours. Similarly, in transportation, AI can analyse data on traffic patterns, route planning, and vehicle efficiency to optimize logistics and transportation operations, leading to reduced fuel consumption and emissions (Raval 2021; Patel 2022; Cai 2021, 20).

Regenerative Energy Management: Renewable energy sources solar and wind are critical in transitioning to a sustainable energy future. However, the integration of renewable energy into the grid can be challenging due to the intermittent and variable nature of these energy sources. AI can play a crucial role in optimizing the generation, distribution, and consumption of renewable energy. By analysing weather data, energy demand patterns, and other relevant factors, AI can optimize the deployment of renewable energy infrastructure, solar panels and wind turbines, to maximize their energy generation potential. Machine learning algorithms can optimize the charging and discharging of energy storage systems, batteries, to store surplus energy during periods of high generation and release it during times of high demand. Furthermore, AI can enable predictive maintenance of renewable energy infrastructure by analysing sensor data and other relevant factors, helping to identify and address potential maintenance issues before they become critical, thereby improving the overall performance and reliability of renewable energy systems (Torres- Madroñero 2020; Xu 2019; Noorman 2023, 20). Urban Planning and Smart Cities: Cities are responsible for a significant share of global energy consumption and greenhouse gas emissions. Therefore, making cities sustainable is crucial for achieving SDG 11. AI can support urban planning and the development of smart cities, which are designed to optimize resource use, enhance security, and improve the quality of life for city dwellers. By analysing data on population density, traffic patterns, infrastructure use, and other relevant factors, AI can help optimize urban planning, land use, zoning, and transportation planning, to create sustainable and inclusive cities., machine learning algorithms can analyse data from sensors, Internet of Things (IoT) devices, and other sources to optimize traffic flow, reduce congestion, and

improve transportation efficiency. AI can help in designing energy-efficient buildings, optimizing waste management, and enhancing public safety through predictive analytics and data-driven decision-making (Sowmitha 2022; Ye 2023; Star 2022, 21).

Disaster Resilience and Risk Management: Cities are vulnerable to natural and human-induced disasters, floods, earthquakes, hurricanes, and terrorist attacks. AI can play a critical role in disaster resilience and risk management by analysing data on weather patterns, infrastructure vulnerabilities, and social dynamics to develop predictive models and support decision-making., AI can analyse satellite data, weather forecasts, and historical disaster data to predict the occurrence and severity of natural disasters, floods or hurricanes, and provide early warnings to help cities and communities prepare and respond effectively. AI can support real-time monitoring of infrastructure, bridges, dams, and buildings, to detect potential vulnerabilities and trigger alerts in case of potential risks. Furthermore, AI can analyse social media data, emergency calls, and other sources of information to assess the impact of disasters on vulnerable populations, identifying areas with high concentrations of elderly or disabled individuals who may need special assistance during emergencies. By using AI-powered risk assessment and predictive models, cities can make informed decisions to enhance their disaster resilience strategies and minimize the potential impacts of disasters on human lives and infrastructure (Elvas 2021; Harold 2020; Saravi 2019, 21).

Transportation Optimization: Transportation is a significant contributor to energy consumption and emissions in urban areas. AI can optimize transportation systems to reduce energy consumption, emissions, and congestion, thereby contributing to SDG 11. AI can analyse data on traffic patterns, public transportation usage, and commute patterns to optimize the design and operations of transportation networks. Machine learning algorithms can develop predictive models to estimate demand and optimize public transportation routes and schedules to improve efficiency and reduce energy consumption. AI can analyse data from connected vehicles, GPS and sensor data, to optimize traffic flow, reduce congestion, and minimize emissions. Additionally, AI can support the development of smart mobility solutions, ride-sharing and electric vehicle (EV)

charging infrastructure, by analysing data on user behaviour, travel patterns, and EV charging demand to optimize the deployment and utilization of these services, leading to more sustainable and efficient transportation systems (Hou 2022; Gui-E 2022; Du 2021, 22).

Artificial intelligence has the potential to revolutionize the achievement of SDG 7 and SDG 11 by enabling energy optimization, regenerative energy management, urban planning and smart cities, disaster resilience and risk management, and transportation optimization. Through its ability to analyse large datasets, develop predictive models, and support data-driven decision-making, AI can contribute to creating more sustainable, inclusive, and resilient cities while minimizing energy consumption, emissions, and risks. As we continue to harness the power of AI for sustainable development, it is crucial to ensure that AI technologies are deployed ethically, transparently, and inclusively, considering social, economic, and environmental implications to maximize their positive impact on achieving the United Nations' Sustainable Development Goals.

4 MATERIALS AND METHODS

When picking out which SDGs to analyze it was decided that SDG 7 and 11 would be used instead to the other SDGs because of the available research in SDG 7 and 11 but also because of how they are connected to the other SGDs. SDG 7 being about clean and affordable energy is related to many of the other SDGs such as SDG 11 and 13 which relates to climate action so by addressing this SDG there are some aspects of SDG 13 that will be looked at too, and SDG 11 can be related to SDG 1, 3, 4, 10 and 15, with it being able to address some aspects of different SDGs it made the most sense to analyze these SDGs (Wong 2021, 22).

This thesis aims to prove that artificial intelligence can be used to improve sustainable development, and to prove this, the thesis will look at case studies that show how this can be done and could be done. More specifically, we will use the content analysis approach to break down some literature reviews that have

been found in order to prove the research question. The content analysis approach is a tool that was designed to show certain themes, concepts, or words in some qualitative data. To prove the aim further, OpenAI's GPT-4 shall be used. GPT-4 (generative pre-trained transformer), which is a multimodal model that, while not yet at the level of humans in real-world scenarios, is able to show human-level abilities in different academic and professional benchmarks. OpenAI is an AI and research company that created ChatGPT and other AIs such as Whisper which is a speech recognition system and DALL-E 2 which is an AI art generator. GPT-4 is the latest language model for ChatGPT, which is an AI chatbot. By asking ChatGPT a series of questions on how AI can be used to improve sustainable development, it will be shown that this technology can be used to find ways to improve sustainable development.

The content analysis approach was chosen instead of the grounded theory approach due to the nature of the data that was collected. By using the content analysis approach instead of the grounded theory approach, the study will be able to breakdown the case studies rather than having to systematically collect and analyse the data, and the data can be taken from other studies. More specifically the inductive content relational analysis approach in the subsection of proximity analysis. The reason for choosing this method is because of the flexibility that is allowed with creating the code and which allows for a deeper understanding of the study according to the code that you create. It also helps to identify the patterns that are occurring in information that you chose. (Bingham 2023, 23) The steps that were taken in content analysis was firstly defining the code the has been chosen are AI and efficiency, AI and SDG and finally SDG and efficiency. After that in the findings portion the coded content will be laid out and finally the findings will be looked at in the discussion portion. Of course, by using the content analysis approach, there will be some level of subjective interpretation that will affect the reliability of the results and the conclusions that will be drawn.

The reason that ChatGPT will be used is because by using this tool, which is an AI and the focus of this study, it will be possible to further prove the aim of this

study. The questions that have been crafted revolve around how artificial intelligence can be used to improve sustainable development. To be more specific I have chosen to use the relational content analysis so that the concepts that are found to be used frequently throughout the text can be used to find a relationship between the concepts that have been recognized in the different literature reviews across the different SDGs that have been chosen. The key concepts that I have chosen for AI, efficiency and SDG because they are the main ideas of this thesis and they will help to further prove the aim of this thesis.

ChatGPT is an AI language model based on the GPT- 3.5 architecture which is a variant of the GPT series that was develop by OpenAI. The algorithm uses a deep learning approach while being built on the Transformer architecture. The Transformer architecture is a neural network model that was design for sequential data processing in reference of tasks that involve natural language. It contains multiple layers of self-attention mechanisms and feed-forward neural networks. The layers allow the model to capture long-range dependencies and generate coherent responses. GPT- 3.5 has been trained by large amounts of text data that are from books, articles, internet and websites. The unsupervised training process helped the model learn grammar, reasoning abilities and facts. The model when trained has the ability to generate responses that are human-like based on the input received. The architecture of GPT -3.5 has a stack of Transformer encoder layers, with each layer comprising self-attention mechanisms and feed-forward neural networks. The layers process the pitted sequence and generates and output token based on the patterns and representations. By using the power of deep learning which is a method that Ai uses to learn to process data in a way that is inspired by the human brain and the Transformer architecture GPT -3.5 has shown that it is able to understand advance language and it is able to generate answers across a wide range of topics and conversational contexts (Windsor 2023, 24).

The largest flaw with this method is that ChatGPT is unable to provide actual references due to its inability to have direct access to external sources or the internet, so the references that ChatGPT gives are created based on patterns

and information from its training data. Though this is an issue, the information given comes from a range of sources websites, books, and other publicity available as text data, though because ChatGPT does not have direct access to external sources or the internet, the information that it is capable of accessing will be from September 2021 and before then (Marr 2023, 25). To overcome this issue, the references that ChatGPT gives will be cross-referenced with more accurate and reputable sources. Another weakness of employing this method is that if the questions that are crafted are too general or specific, the output would be affected.

5 FINDINGS

This chapter will be split into four subchapters, the first three will be a content relational analysis with the chosen code of AI and efficiency, AI and SDG and lastly SGD and efficiency of each individual section from the theoretical background sub section 3.4.1 – 3.4.3 and the last part will tie all results together.

5.1 SDG 7

In this section the concepts will be looked at together:

1. **AI and Efficiency:**
    - The text emphasizes that AI has the potential to enhance efficiency by uncovering patterns in extensive datasets and making accurate predictions, particularly in fields like crop yield and energy production.
    - AI has the capability to optimize energy production by analysing real-time weather models and adjusting schedules for solar PV systems and wind turbines.
    - Deep learning models and other AI techniques can enhance the accuracy of prediction models for solar radiation and wind speed, thereby increasing efficiency.

- AI is applied in the sizing and simulation of PV systems, leading to improved process efficiency.
- The adoption of AI, along with edge computing and IoT, plays a role in extending the lifespan of industrial equipment and optimizing battery storage, ultimately boosting overall system efficiency.
- Incorporating AI into the clean energy sector can result in increased energy availability and decreased energy waste, leading to greater efficiency overall.
- Future trends in AI and clean energy primarily focus on optimization and improving the accuracy of prediction models, further enhancing efficiency.

2. **AI and SDG:**
    - Integrating AI into the clean energy sector aligns with the objectives of the Sustainable Development Goals (SDGs) by contributing to increased efficiency, the utilization of renewable energy sources, and improved energy management.
    - The implementation of AI-enabled smart energy grids and digitalization enables decentralized energy production and usage, supporting the goals outlined in the SDGs.
    - However, it is important to address cybersecurity threats associated with AI implementation to ensure the reliability and security of energy systems, which is essential for achieving the targets set by the SDGs.

3. **Efficiency and SDG:**
    - Enhancing efficiency within the energy sector plays a crucial role in advancing SDG objectives, affordable and clean energy (SDG 7) and sustainable cities and communities (SDG 11).

- Measures optimizing energy production, reducing waste, and promoting the use of renewable energy sources contribute to the achievement of these SDGs.
- The efficient utilization of AI in areas power generation prediction, solar PV sizing, and battery storage optimization supports sustainable energy practices.

5.2 SDG 11

1. **AI and SDG:**
    - AI is recognized as a valuable tool for promoting the development of sustainable cities through advancements in health, transportation, and energy systems.
    - The text emphasizes how AI can gather data to enhance our understanding of progress towards attaining the United Nations' sustainable development goals.
    - Various applications of AI are mentioned, including technologies for face detection, traffic management systems, waste management, sewage treatment, and urban planning.
    - The text acknowledges the debates surrounding the utilization of AI for predictive policing.

2. **AI and Efficiency:**
    - The text highlights the significance of using AI to enhance efficiency across different domains security, waste management, traffic management, workplace environments, and resource allocation.
    - Examples are provided, optimizing collection routes based on data from trash bins, utilizing AI for waste sorting, and implementing adaptive environment adjustments in workplaces through AI.

3. **Efficiency and SDG:**
    - The text emphasizes the critical role of establishing safe, inclusive, and sustainable cities in achieving the SDGs.
    - AI is presented as a tool to support these goals by fostering inclusivity in urbanization and mitigating adverse effects like natural disasters.
    - Specific examples are given to illustrate how AI contributes to sustainability in areas health, transportation, energy, waste management, and urban planning.
    - The text mentions smart cities, smart applications, and the integration of IoT and AI as integral components of sustainable communities, aimed at improving health and transportation services.
    - Cloud computing with AI is suggested as a potential solution for addressing environmental concerns, flood control, air quality, and waste management.

5.3 ChatGPT's Work

Just like the ChatGPT section in the literature review portion of this thesis. The content relational analysis will do by ChatGPT with the same key concepts that are being used for the other sections.

1. AI and Efficiency: AI has the potential to improve efficiency in various areas related to sustainable development. The text mentions several examples:

- Energy Optimization: AI can analyze large datasets of energy consumption patterns and other factors to identify inefficiencies and suggest improvements in sectors like buildings and transportation.
- Regenerative Energy Management: AI can optimize the generation, distribution, and consumption of renewable energy by analyzing weather data, energy demand patterns, and other relevant factors.

- Urban Planning and Smart Cities: AI can optimize resource use, enhance security, and improve the quality of life in cities by analyzing data on population density, traffic patterns, and infrastructure use.
- Disaster Resilience and Risk Management: AI can analyze data to develop predictive models for natural disasters, monitor infrastructure vulnerabilities, and support decision-making to enhance disaster resilience.

2. AI and SDG: The Sustainable Development Goals (SDGs) aim to address global challenges, and AI can contribute to achieving these goals. The text highlights several ways AI can support SDGs:

- SDG 7: AI can optimize energy use, improve energy efficiency, and support the transition to renewable energy sources.
- SDG 11: AI can contribute to sustainable urban planning, smart cities, and disaster resilience, improving the sustainability and inclusivity of cities.

3. Efficiency and SDG: Efficiency plays a crucial role in achieving SDGs as it helps reduce waste, resource consumption, and emissions. By leveraging AI for efficiency improvements, progress can be made towards various SDGs, including SDG 7 (affordable and clean energy) and SDG 11 (sustainable cities and communities).

Overall, the text emphasizes the potential of AI in enhancing efficiency, advancing SDGs, and addressing sustainability challenges in areas energy, urban planning, disaster management, and transportation.

5.4 Overall

In this section the different parts will be summarized together.

1. **AI and Efficiency:**
    - By analysing extensive datasets and making accurate predictions, AI has the potential to boost efficiency significantly.

- Real-time weather models can be analysed by AI to optimize energy production and adjust schedules for renewable energy systems.
- The use of AI techniques improves the accuracy of prediction models for solar radiation and wind speed, leading to increased efficiency.
- AI is employed in sizing and simulating PV systems, resulting in improved process efficiency.
- The adoption of AI, along with edge computing and IoT, extends the lifespan of industrial equipment and optimizes battery storage, thereby enhancing overall system efficiency.
- Integration of AI into the clean energy sector increases energy availability and reduces energy waste, ultimately improving efficiency.
- Future trends in AI and clean energy revolve around optimization and enhancing prediction models for further efficiency gains.

2. **AI and SDG:**
    - The integration of AI into the clean energy sector is aligned with the objectives of the SDGs.
    - AI contributes to increased efficiency, utilization of renewable energy sources, and improved energy management, which supports the SDGs
    - Implementing AI-enabled smart energy grids and digitalization enables decentralized energy production, aligning with the SDGs.
    - Addressing cybersecurity threats associated with the implementation of AI is crucial for achieving SDG targets.

3. **Efficiency and SDG:**

- Enhancing efficiency in the energy sector plays a vital role in advancing SDG objectives, affordable and clean energy (SDG 7) and sustainable cities and communities (SDG 11).
- Measures like optimizing energy production, reducing waste, and promoting renewable energy sources contribute significantly to achieving the SDGs.
- The efficient utilization of AI in power generation prediction, solar PV sizing, and battery storage optimization supports sustainable energy practices.

6 DISCUSSION

In this study, the point was to show that AI can be used to improve sustainable development. This was done by finding studies and relatable information on how AI is being used in sustainable development currently and in the future in relation to SDGs 7 and 11. From the findings, it is clear that AI can be used to improve SDG 7 by increasing the ability to predict weather in order to improve efficiency in energy systems. They are able to help increase the life span of these technologies that are used in clean energy, and they help increase efficiency with smart grids. Most of the future thoughts towards the use of AI in SDG 7 are about optimization. In consideration of SDG 11, AIs are able to help create smart cities that rely on energy-efficient green communication, but they are being used in smaller-scale places as benches to analyse air quality and foot traffic to help in urban planning. Even with SDG 11, a lot of future projects are moving to optimization and predictive mapping. In the section written by ChatGPT, it can be seen that the chatbot, even though the information that it has is limited to before 2021, was given in line with findings that were found in Chapter 6 without the use of the chatbot, and with cross-referencing, the points that are given by the chatbot help further prove that AI can be used to improve sustainable development while focusing on SDGs 7 and 11. With this information, it can be seen that AI has endless possibilities in the sustainable development aspect of work. This can be seen in the findings that have been mentioned, and while this

thesis only looked at two aspects of the SDG set by the UN, the number of benefits that can be seen in just these two is quite large, so in further studies, the question could be how AI could be used to improve the other SDG goals. The results of this thesis support other works that show how AI can be used to improve sustainability.

7 CONCLUSION

The SDGs 7 and 11 were examined in relation to AI, efficiency, and their effects. The work shows how AI has the potential to improve efficiency across a range of fields. Real-time weather analysis, precise solar and wind energy prediction models, and enhanced modelling and simulation of renewable energy systems have all been shown to help AI optimize energy production. Additionally, the combination of AI, edge computing, and the Internet of Things (IoT) improved battery storage, increased the lifespan of industrial equipment, and improved system efficiency. The study also demonstrated how AI contributes to increased productivity, the use of renewable energy sources, and enhanced energy management, all of which are goals of the SDGs. Digitalization and the adoption of AI-enabled smart energy grids encouraged decentralized energy production, supporting SDGs 7 and 11 objectives. The research, however, emphasized the significance of addressing cybersecurity threats related to AI implementation to guarantee the dependability and security of energy systems, which is essential for meeting SDG targets. SDGs 7 and 11 in particular benefited greatly from energy sector efficiency, which also helped other SDGs. These SDGs were found to require a number of strategies, including waste reduction, renewable energy promotion, and energy production optimization. It was believed that the effective application of AI in fields like power generation prediction, solar PV sizing, and battery storage optimization was essential for promoting sustainable energy practices and achieving the SDGs. The work showed that AI has the potential to improve efficiency, support SDGs, and address sustainability issues, particularly in the areas of energy, urban planning, disaster management, and transportation. In order to create a more sustainable future, the research emphasized the

importance of responsible and inclusive AI implementation as well as the transformative role that AI can play in promoting sustainable development.

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