Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Information Engineering

Master's Thesis

Information Technology and Green Deal

Iqra Ishtiaq

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

Bc. Iqra Ishtiaq

Informatics

Thesis title

Information Technology and Green Deal

Objectives of thesis

The main objective of this thesis is to determine the best approach to comprehend the green deal's implications for informatics.

The partial goals of this thesis are following:
- to explain the green deal issue in terms of informatics,
- to conduct an analysis of energy use in the classrooms, laboratories, or offices in a selected organization,
- to recommend necessary solutions in accordance with the green deal policy.

Methodology

The thesis will be based on a study of scientific and professional literature. In a literature review, there will be a summary of the currently available knowledge about the green deal issue in regard to informatics.

The next step is to conduct an analysis of energy consumption in the faculty of Economics and Management classrooms, laboratories, and offices to better understand these energy sources and their associated applications, equipment, efficiencies, charges, availability, and waste streams.

As a result, we can make required recommendations in line with the green deal policy.

The proposed extent of the thesis

60 – 80 pages

Keywords

Green Deal, informatics, Environmental, Social, and Governance (ESG) Criteria, Eenergy Consumption

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Recommended information sources

DAO, Viet; LANGELLA, Ian; CARBO, Jerry. From green to sustainability: Information Technology and an integrated sustainability framework. The Journal of Strategic Information Systems, 2011, 20.1: 63-79.

DASTBAZ, Mohammad; PATTINSON, Colin; AKHGAR, Babak. Green information technology: A sustainable approach. Morgan Kaufmann, 2015.

ECKERSON, Wayne W. Performance dashboards: measuring, monitoring, and managing your business. John Wiley & Sons, 2010.

LEE, Ki-Hoon; CIN, Beom Cheol; LEE, Eui Young. Environmental responsibility and firm performance: the application of an environmental, social and governance model. Business Strategy and the Environment, 2016, 25.1: 40-53.

SHARMA, Rohit, et al. The role of digital technologies to unleash a green recovery: pathways and pitfalls to achieve the European Green Deal. Journal of Enterprise Information Management, 2021.

Expected date of thesis defence

2022/23 SS – FEM

The Diploma Thesis Supervisor

doc. Ing. Jan Tyrychtr, Ph.D.

Supervising department

Department of Information Engineering

Electronic approval: 7. 3. 2023

Ing. Martin Pelikán, Ph.D.

Head of department

Electronic approval: 13. 3. 2023

doc. Ing. Tomáš Šubrt, Ph.D.

Dean

Prague on 29. 11. 2023

Declaration

I declare that I have worked on my master's thesis titled "Information Technology and Green Deal" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the master's thesis, I declare that the thesis does not break any copyrights.

In Prague on date of submission 29.11.2023 ____________________________

Acknowledgement

I would like to thank Dr. Ing. Jan Tyrychtr, Ph.D. for his advice and encouragement on my thesis. In addition, I want to express my gratitude to my family and friends for their guidance and encouragement as I worked on my thesis.

Title of Master's Thesis in English

Abstract

This thesis navigates the nexus of the European Green Deal and informatics, seeking optimal strategies for understanding their intersection. With a focus on clarifying the Green Deal's impact on information technology, the study spans a university context, analyzing energy consumption patterns for informed decision-making. The methodology integrates literature review and practical studies, emphasizing the link between the Green Deal and Information Technology. It culminates in the creation of a Power BI dashboard, serving as a proactive tool aligned with the Green Deal's objectives. The study contributes insights to sustainable informatics practices, offering sophisticated viewpoints and actionable suggestions in harmony with evolving environmental policies.

Keywords: European Green Deal, Informatics, Sustainability, Energy Consumption,, Power BI Dashboard, Data Analysis, Green IT, Renewable Energy, Sustainable Practices, Climate Neutrality, Information Technology, Data Integration, Decision Support, Sustainable Informatics Practices.

Title of Master's Thesis in Czech

Abstrakt

Tato práce se zabývá propojením Evropské zelené dohody a informatiky a hledá optimální strategie pro pochopení jejich průniku. Studie se zaměřuje na objasnění dopadu Zelené dohody na informační technologie a zahrnuje univerzitní kontext a analyzuje vzorce spotřeby energie pro informované rozhodování. Metodologie integruje přehled literatury a praktické studie, přičemž zdůrazňuje souvislost mezi Zelenou dohodou a informačními technologiemi. Jeho vrcholem je vytvoření řídicího panelu Power BI, který slouží jako proaktivní nástroj v souladu s cíli Green Deal. Studie přispívá poznatky k udržitelným postupům informatiky a nabízí sofistikované názory a praktické návrhy v souladu s vyvíjejícími se environmentálními politikami.

Klíčová slova: Evropská zelená dohoda, informatika, udržitelnost, spotřeba energie,, Power BI Dashboard, analýza dat, zelené IT, obnovitelná energie, udržitelné postupy, klimatická neutralita, informační technologie, integrace dat, podpora rozhodování, udržitelné postupy informatiky.

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1 Introduction

In the 21st century, the global imperative to address climate change and advance sustainable development has reached unprecedented heights. The European Green Deal has positioned Europe as a trailblazer in environmental leadership, propelling the continent toward climate neutrality by 2050 under the visionary guidance of European Commission President Ursula von der Leyen. This ambitious endeavor not only addresses the immediate challenges posed by climate change but also sets a precedent for international collaboration and sustainable development in the face of escalating global problems. *(Politico, 2020)*

Against the backdrop of these efforts, the vital intersection of Information Technology (IT) and environmental sustainability emerges as a focal point in this transformative journey. The incorporation of IT technologies, encompassing data analytics, AI, cloud computing, and IoT, isn't just a practical necessity but a fundamental component of the Green Deal's ambitious objectives. This literature-based study delves into the multifaceted role of information technology, showcasing how it drives environmentally friendly and intelligent solutions that align with the European Green Deal's goals.

Throughout this thesis, an exploration of various IT aspects unfolds, providing insights into its role in overseeing, enhancing, and directing the financial, social, and ecological frameworks outlined in the Green Deal. The thesis seeks to unravel the intricate interrelationships within this dynamic landscape, identify potential obstacles, and offer practical solutions. Amidst these discussions, a growing demand for basic resources like gas, water, and power, coupled with the swift pace of modernization and rising consumerism, becomes increasingly apparent. By 2050, this demand is projected to quadruple from 2010 levels, underscoring the urgency of altering energy consumption patterns to ensure sustainability.

Remarkably, the building industry stands as a significant contributor, emitting 25% of global greenhouse gas emissions and consuming nearly 30% of the world's energy. To effectively combat climate change, a strategic reduction in energy consumption is imperative. Here, technology breakthroughs play a crucial role in meeting the world's growing energy needs while reducing emissions, especially given the escalating global energy costs.

Offices and university buildings, as prominent energy consumers in commercial structures, demand a thorough examination of energy usage trends to achieve net-zero carbon emission targets and sustainability goals. Technological advancements have significantly increased the efficiency of energy-consuming devices, presenting opportunities to reduce building energy consumption. Tactics such as investing in LED lighting, replacing outdated air conditioners, and promoting energy efficiency initiatives exemplify effective measures. *(Moraliyage et al., 2022)*

2 Objectives and Methodology

2.1 Objectives

This thesis's main goal is to determine the best method for understanding the European Green Deal's effects on informatics." This main goal is accomplished by pursuing a number of related but separate sub-goals. First, the thesis aims to clarify the details of the Green Deal, specifically regarding its effects on informatics. In order to provide a nuanced understanding of its applications in this domain, a thorough exploration of the policies and their applicability in the context of informatics is undertaken.

As we move forward, the research is committed to obtaining a comprehensive understanding of energy consumption within the chosen university, paying close attention to various buildings and campuses. The extraction of useful insights into current patterns of energy utilisation is the main goal of this analytical phase. The goal of this thorough analysis is to identify inefficient or over consumptive areas so that decisions can be made with knowledge.

With inspiration from these deep realisations, the thesis aims to achieve various useful goals. The creation of a creative and user-friendly dashboard proposal is the most important of them. This entails using Google-Colab to enhance the dataset and Python for data processing to strategically integrate and refine key data columns. The final product of this process is a polished dataset that will act as the foundation for the Power BI dashboard that is being imagined.

In addition, the practical phase aims to accomplish a more efficient way for relevant data to be displayed on the suggested dashboard. Decision-makers at universities are expected to find the dashboard to be an effective tool as it streamlines complex data and improves visibility. The ultimate goal is to provide stakeholders with useful information about patterns of energy consumption, encouraging a proactive attitude towards sustainable practises in line with the goals and values stated in the Green Deal initiative.

2.2 Methodology

This thesis's methodology adopts a combination of methods, integrating a comprehensive assessment of the literature with a hands-on study of energy usage patterns in a university. The main goal is to establish links between the European Green Deal and Information Technology (IT), with an emphasis on learning about sustainable informatics practices. An initial focus of this technique is to analyze patterns of energy, gas, and water usage in the setting of universities. This entails using a dataset that was processed in Google-Colab and obtained from a published data set, laying the groundwork for a thorough comprehension and further

2.2.1 Literature review

After providing a brief overview, the literature review explores the primary goals and initiatives of the European Green Deal, providing the foundation for a thorough understanding. As we go into the realm of green IT and sustainability, the study addresses important subjects including data center energy efficiency, electronic waste management, sustainable computing techniques, renewable energy integration, and many more to understand the progress made in today's date to be zero net emissions by 2050.

2.2.2 Practical review

The practical aspect of this study accomplishes two related goals: it simplifies and gathers relevant information for efficient use in the Power BI dashboard, and it also makes a thorough comprehension of data patterns in the context of universities easier. Using a dataset that was processed using Python and acquired from a published data set, the study focuses mainly on the careful integration and cleansing of important data columns. The goal of this procedure is to produce a polished dataset that will serve as the basis for the Power BI dashboard's further development. The project's primary focus is on carefully compiling a unified dataset, which will act as the foundation for insightful analyses and visualizations.

One of the key components of the practical investigation is the creation of a model dashboard. While the Dashboard Analysis is underway, the initial review entails a fundamental evaluation of the dashboard, highlighting initial patterns and correlations among data. The tool's purpose is to visualize and analyze data connected to energy, opening the door for a more thorough examination in later phases.

2.2.3 Purposeful Suggestion

Beyond the current analysis's scope, the practical work aims to provide a framework for thoughtful decision-making. By encouraging mindfulness in sustainability practices and providing thoughtful guidance for upcoming initiatives, the Power BI dashboard transforms into a proactive tool. The limited analysis that was done offers a preliminary look at possible relationships and trends, laying the groundwork for more thorough investigations.

2.2.4 Aligning with Objective

This methodology attempts to add significant insights to the scholarly conversation on sustainable informatics practices, while also acknowledging the ongoing dashboard analysis. Through complying with existing environmental policy frameworks, specifically those delineated in the European Green Deal, the study aims to provide sophisticated viewpoints and practicable suggestions for more environmentally friendly practices concerning IT and sustainability.

3 Literature Review

3.1 Green Deal

The all-encompassing plan, the European Green Deal, demonstrates a dedication to tackling urgent environmental issues, encouraging economic expansion, and establishing social justice. Some key goals and initiatives it deals with are as mentioned below in Fig 1:

Figure 1: Key Goals of green deal. Source: (Budnakova, 2013.)

3.1.1 Key Goals and Initiatives of Green Deal

3.1.1.1 Carbon Neutrality by 2050: A Bold Commitment

Making the European Union (EU) carbon neutral by 2050 is the primary, ambitious objective of the European Green Deal. What does that mean now? The EU seeks to achieve carbon neutrality by maintaining the amount of greenhouse gases it releases into the atmosphere and the amount it absorbs from the atmosphere. It's comparable to attempting to have no environmental impact at all.

The route map for achieving carbon neutrality comprises a carefully, staged strategy. It requires a dramatic shift in several areas, all of which are essential to lowering emissions and improving sustainability. This covers a variety of industries and sectors, such as transportation, energy generation, and agriculture. The shift aims to completely restructure current procedures, strategically emphasizing the integration of renewable energy sources, improving energy efficiency, and rethinking industrial processes.

Making the switch to renewable energy sources is essential to becoming carbon neutral. To increase the proportion of renewable energy in the EU's overall energy mix, specific targets are outlined in the European Green Deal. Encouraging innovation and resilience in the energy sector, investments in wind, solar, and other clean energy technologies are given priority. *(European Green Deal - Consilium, 2023)*

The Green Deal also encourages sustainable mobility as a method of addressing the harmful effects of transport on the environment. The development of sustainable public transport systems, encouragement of alternative fuels, and the expansion of the infrastructure for electric vehicles are some of the measures being taken. The EU wants to significantly reduce emissions from the transport sector by giving sustainable mobility priority.

Taking into account the possibility of some emissions that last, the European Green Deal covers carbon removal techniques. This comprises financial investments in natural solutions like afforestation and reforestation as well as technology that actively absorbs and stores carbon dioxide from the atmosphere, such as carbon capture and storage (CCS). By balancing any leftover emissions with removals, these creative methods seek to achieve net-zero carbon footprints.

fig 2 shows by 2030, the EU wants natural sinks to remove 310 million tonnes of CO2 equivalent from the atmosphere. To reach the new EU target, member states must maintain and increase their carbon sinks, which is their shared duty to remove carbon from the atmosphere. *(Delivering the European Green Deal, 2021)*

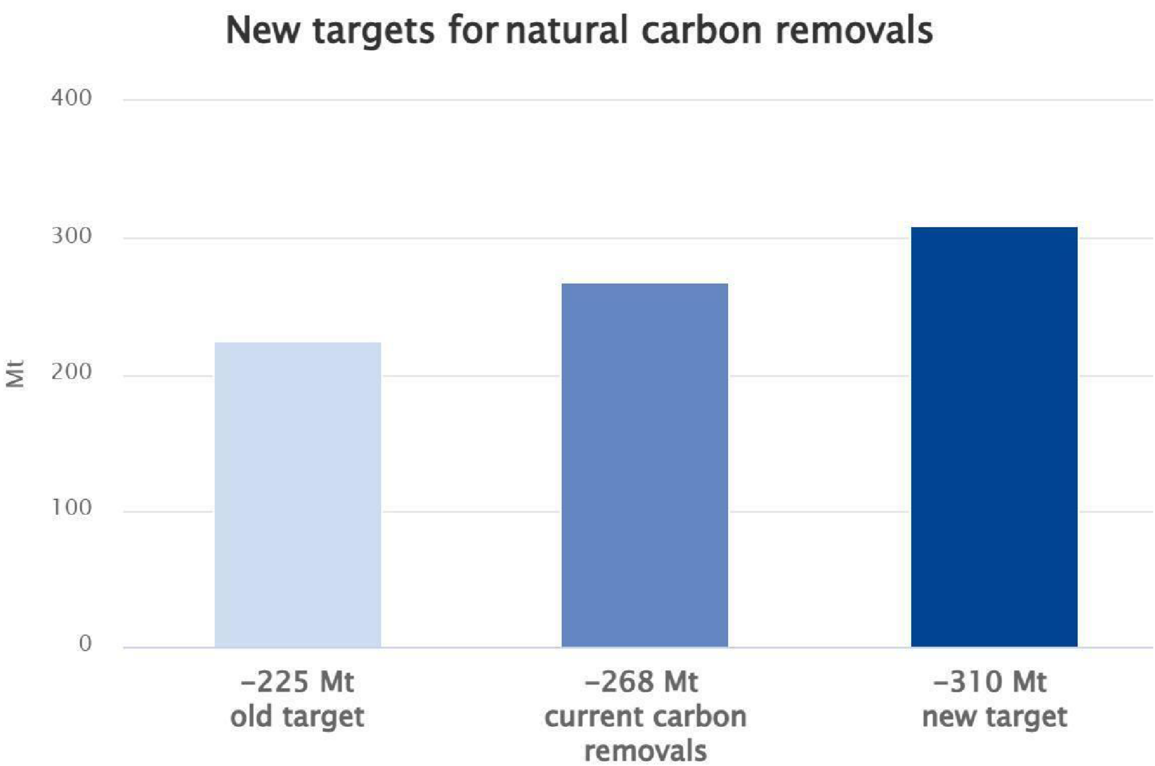


Figure 2: Target of natural carbon removal by 2030. Source: (Delivering the European Green Deal, 2021)

It is predicted that the requirement for batteries will rise by more than 10 times by 2030. The European Union passed a regulation that covers waste management and design, among other aspects of the battery life cycle, to promote a circular economy in the battery business. This research holds great significance, particularly considering the rapid growth of electric mobility. The new regulation, which was adopted in 2023, replaces the current batteries directive, which was issued in 2006. It aims to promote a circular economy and more equal competition in the internal battery market due to the safety, sustainability, and labelling requirements.

The EU is positioned as a global leader in environmental stewardship and climate action due to its goal of carbon neutrality. The European Union aggressively participates in foreign diplomacy, promoting ambitious climate goals and inspiring other countries to do the same. Through exercising leadership, the EU hopes to impact international efforts to tackle climate change and promote a shared commitment to a sustainable future. With a combined contribution of €23.04 billion in 2021, the EU, its Member States, and the European Investment Bank are the largest providers of public climate money to developing nations. Fig 3 shows the geographic distribution of EU climate finance. With Africa being highest at 31.68% Asia at 26.65%, America at 15.27%, Europe at 8.27% and the total of all other countries at 17.63%.

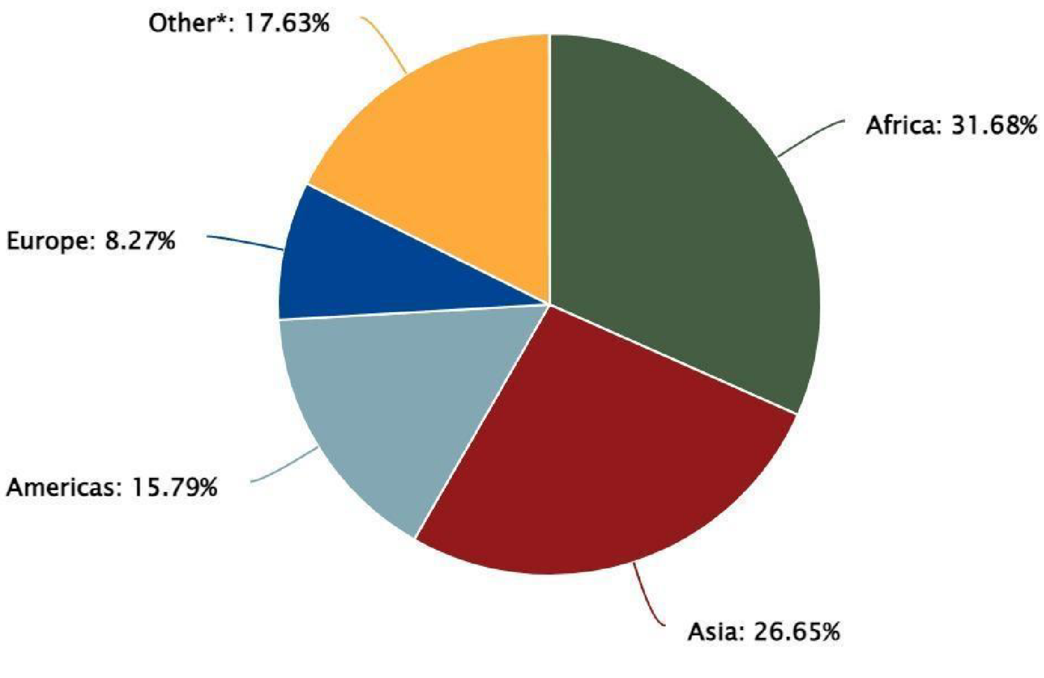


Figure 3: The Heographicall distribution of EU climate finance. Source: (Delivering the European Green Deal, 2021)

The goal of being carbon neutral is bold and revolutionary, but it is not without difficulties. There are technological, societal, and economic obstacles associated with the shift that must be carefully navigated. But these difficulties also present revolutionary opportunities: chances for creativity, the development of employment opportunities in the green sector, and the building of a strong and sustainable economic base. *(Delivering the European Green Deal, 2021)*

3.1.1.2 Biodiversity Preservation: Safeguarding Ecosystem

The European Green Deal focuses a great emphasis on biodiversity preservation in addition to combating climate change. The plan recognises ecosystems' interdependence and the vital role they play in maintaining life as we know it on Earth. Halting the loss of biodiversity is one of the main and most important goals of the European Green Deal. This entails a multifaceted strategy intended to actively repair ecosystems that have been harmed as well as stop more environmental deterioration. Protected areas are places set aside and maintained so that a variety of animals can live there unhindered by humans and allow nature to flourish.

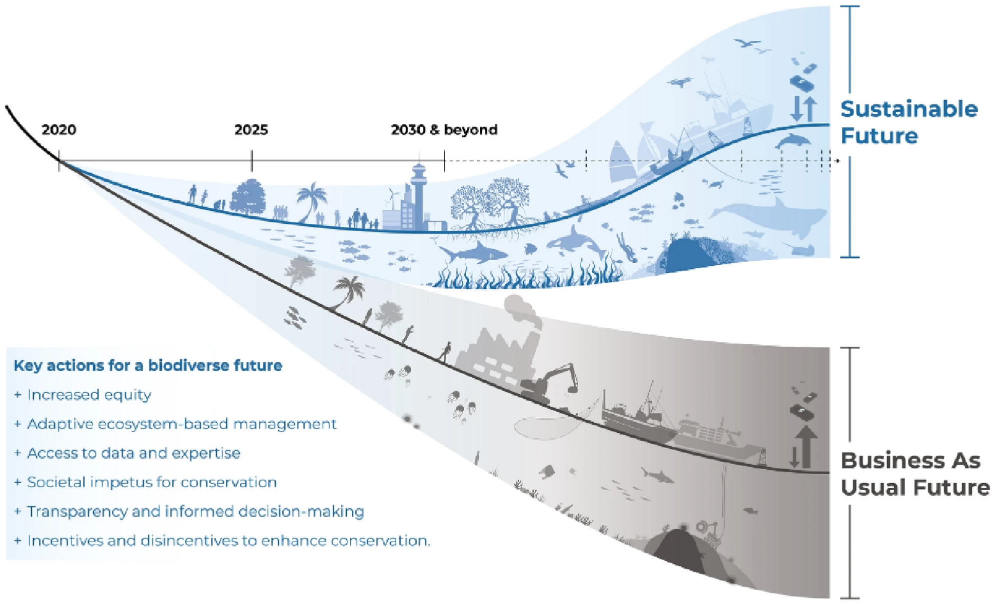


Figure 4: Shows what change possible by taking key actions for a biodiverse future Source: (Ward et al., 2022)

Fig 4 shows The changes in the trajectories of biodiversity that we anticipate under our more sustainable yet technically feasible scenario (blue line) and under the business-as-usual scenario (grey line). Time is represented by the x-axis, and marine biodiversity is represented by the y-axis. *(Ward et al., 2022)*

Farm to Fork' is a cornerstone of the Green Deal, intending to build a more ecologically friendly and sustainable food system. This entails encouraging organic farming, utilising fewer chemicals, and creating supply systems that are more transparent and sustainable. Guaranteeing that every step of the food production and distribution process adheres to environmental responsibility standards is the aim.

The GD places a strong emphasis on programs for habitat restoration and reforestation because it recognizes the vital role that natural ecosystems play in maintaining biodiversity. Planting trees, which not only function as carbon sinks but also offer habitat for a range of plant and animal species, is a crucial part of these attempts to counterbalance the loss of ecosystems. Reforestation and habitat restoration work together to support the general resilience and health of ecosystems.

GD also deals with the protection of endangered species. Protecting individual species—especially those in danger of becoming extinct—is essential to maintaining biodiversity. The preservation of endangered species is a top priority under the European Green Deal. To guarantee the survival and recovery of populations who are especially vulnerable, detailed strategies are created. This entails focused conservation initiatives, habitat preservation, and steps to address the unique dangers that these species face.

Acknowledging the possibility of social repercussions from the move to more sustainable practices, the Green Deal presents the idea of a "just transition for nature." This program ensures that the shift to practices that are favourable to biodiversity is equitable and inclusive. It involves actively involving local people, being aware of their needs, and offering assistance during the transition to guarantee that the advantages of biodiversity preservation are distributed fairly.

Maintaining biodiversity is an international effort that requires joint efforts. To solve frequently observed difficulties, the Green Deal aggressively encourages international collaboration. The European Union seeks to promote global projects, exchange information with other nations, and participate in global interactions to help the larger global effort to safeguard biodiversity and ecosystems.

At the heart of the Green Deal's success lies the active involvement of citizens. The program understands how critical it is to educate the public about biodiversity and cultivate a sense of responsibility. Participation in local ecological monitoring, outreach, and education are all components of citizen involvement. The Green Deal attempts to foster a sense of shared ownership to increase public commitment to biodiversity preservation. *(Corlett, 2020)*

3.1.1.3 Just Transition: Ensuring Social Equity

The European Green Deal's "just transition" idea emphasises how important it is to maintain equality and inclusion as societies move towards a more environmentally friendly and sustainable economy. This guiding concept aims to proactively address any potential socio-economic effects on workers and communities during this change. The Green Deal lays forth several essential elements to accomplish a fair transition.

A fundamental element of the just transition strategy is the dedication to reskilling and upskilling initiatives. Given that certain industries may change and grow, the Green Deal places a high priority on giving employees access to training opportunities. Giving them the tools they need to prosper in the new green economy, lowers their chance of unemployment and produces a workforce that is qualified for sustainable businesses.

The Green Deal has measures to assist these communities in recognizing that some areas may be more vulnerable to the economic changes brought about by the green transition. This support goes beyond financial assistance to include economic diversification strategies, guaranteeing that areas that primarily depend on carbon-intensive businesses can effectively make the shift to more sustainable practices. *(Crespy & Munta, 2023)*

3.1.1.4 Digital Transformation: Merging Green and Digital Agendas

The Green Deal embraces the necessity for a digital transformation that is in line with environmental sustainability goals in a world where technology is defining itself more and more. This entails utilizing digital technology to improve resource utilization, boost energy efficiency, and enable intelligent, sustainable urban design. By using technology like artificial intelligence and the Internet of Things to build more intelligent and sustainable systems, the EU hopes to leverage digitalization for environmental efficiency. The Ecological Deal promises a smooth integration of technology and ecological goals, from resource-sharing internet platforms to smart grids that optimise energy distribution. *(Crespy & Munta, 2023)*

3.2 Green IT and Sustainable Computing

In order to reduce energy consumption, minimise e-waste, and safeguard the environment, green IT and sustainable computing are essential strategies that support sustainable practices in the IT business. A detailed approach to the development, production, usage, and disposal of IT systems with an emphasis on sustainability is included in the notion of "green IT." The fundamentals of green information technology, such as sustainable computing techniques, electronic waste management, and efficient use of energy in data centres, are highlighted in recent literature. This paper examines the ways in which green IT and sustainable computing techniques may help make information technology more environmentally friendly. *(Carpenter, 2023)*

3.2.1 Energy Efficiency in Data Centers

An important source of energy consumption in the IT sector is data centres. Through the use of energy-efficient technology, energy-efficient data centre redesigns, and other green computing strategies, green IT seeks to lower data centre energy usage. Sustainable data centres run their operations using renewable energy sources like solar and wind power. To cut down on energy usage, they also employ energy-saving cooling techniques like geothermal cooling.

Geothermal cooling uses the constant temperature of the Earth's subsurface, as opposed to conventional cooling techniques that depend on energy-intensive technologies. A heat-exchange fluid is circulated via underground pipes, removing surplus heat from the data centre. After that, the fluid is carried to the surface, where the heat is released by Earth's inherent coldness. Geothermal cooling offers a more environmentally friendly option for sustaining ideal operational conditions in data centres by drawing on this steady and renewable heat sink instead of energy-intensive cooling equipment. (*What Is Green IT (Green Information Technology)?, n.d.)*

The benefits of geothermal systems are substantial. These systems make use of constant ground temperatures to reduce the amount of power needed, which results in reduced running costs and less carbon emissions—up to 50% less than with standard HVAC systems. Geothermal HVAC solutions, which embrace renewable energy, draw heat from the Earth's natural resources to reduce dependency on fossil fuels and increase the overall sustainability of data centre operations. Even though installation costs might be greater at first, there are considerable long-term benefits. Over time, lower energy consumption and maintenance requirements translate into significant cost savings and a positive return on investment (ROI). In addition to saving money, geothermal systems improve dependability by reducing mechanical breakdowns since their essential parts are buried beneath and protected from bad weather and debris. Furthermore, by running silently, minimising noise pollution, lowering distractions, and encouraging increased productivity among data centre staff, these systems also provide a favourable work environment.

According to research conducted by the U.S. Department of Energy, data centres account for between 1-2% of global power use. Because of this significant influence, finding energy-efficient solutions that take into account both the environment's effects and financial constraints becomes crucial. Industry trends highlight the significant sustainable cooling option that geothermal HVAC systems have become for data centres:

Based on forecasts, the market for geothermal HVAC systems is expected to reach $5 billion by 2027, growing at a compound annual growth rate (CAGR) of 11% throughout that time. We can witness the industry adopting this method by witnessing large IT companies such as Google have already implemented geothermal systems in several of their data centres, leading to notable decreases in their carbon footprint. The world is changing, a global example of this being Microsoft's data centre in Sweden is a prime example. It uses geothermal energy to produce net-zero carbon emissions and simultaneously heats the surrounding villages.

By 2025, the worldwide geothermal industry is expected to reach $10 billion due to the rapid expansion of geothermal HVAC systems in data centres. These technologies are essential to the design of sustainable data centres, effectively lowering energy consumption, carbon emissions, and operating costs, making a major contribution to the development of a sustainable and green data centre environment. *(Energy, 2023)*

3.2.2 Electronic Waste Management

In the IT business, managing electronic waste is a crucial part of sustainable practices. When an electronic product is tossed away after its functional lifespan has ended, electronic waste is produced. Electronic waste is produced in vast quantities as a result of the consumption-driven culture and the quick development of technology. Within the constantly changing IT business, sustainable practices are becoming increasingly important. One such practice is the management of electronic waste, or "e-waste."

Large corporations such as Garbage Management are leading the way in adopting environmentally friendly methods of disposing of electronic garbage. Governments from all across the world are taking action and pushing electronic firms to either set up internal e-waste treatment programs or contract these duties out to other groups. Government representatives meet yearly through the International E-Waste Management Network (IEMN), which provides a forum for sharing best practices and encouraging teamwork. Initiatives aimed at resolving the complexity of electronic trash include "Solving the E-waste Problem," a membership organisation housed within the United Nations University. All parties involved in the e-waste problem are encouraged to collaborate via StEP (Solving the E-Waste Problem), which emphasises a comprehensive, scientific, and effective approach.

With a staggering income of USD 56.56 billion as of 2021, the worldwide e-waste management industry is expected to soar to USD 189.8 billion by the year 2030. This increase is closely related to the increase in the use of electronic gadgets, which causes an exponential rise in the production of e-waste. Rapid advancements in technology, evolving media trends, falling costs, and intentional wearing out, all add to the growing worldwide surplus of electronic trash.

With the production and disposal of e-waste increasing, it is certain that appropriate regulations will be needed in the future, and infrastructure for managing e-waste will need to be developed. One of the main factors that will drive revenue growth in the e-waste management industry is an increase in refrigerator sets being disposed of from household appliances. The development of e-waste management initiatives becomes a key factor driving the segment's worldwide growth, especially in emerging nations. E-waste management is not only essential to the pursuit of sustainable IT practices, but it also serves as a lighthouse, pointing the way towards a time when environmental responsibility and technological advancement coexist harmoniously. *(Simon & Simon, 2022)*

3.2.3 Sustainable Computing Practices

In response to the urgent demand for ecologically friendly practices in the IT industry, sustainable computing comprises the design, development, usage, and disposal of computing systems in an environmentally sustainable manner. The use of energy-efficient gear and software, an emphasis on cutting down on electronic waste, and the adoption of sustainable practices in data centre operations are important components of sustainable computing. It aims to minimise energy consumption, curtail electronic waste, and foster environmentally responsible practices throughout the entire IT lifecycle.

Prominent instances of dedication to sustainable computing encompass NVIDIA's Sustainable Computing Resource Centre, which provides invaluable materials and insights; research on green computing practices and sustainable IT services published in the IEEE Xplore Digital Library; and resources selected by University of Oxford researcher David Mytton. It is projected that the market for sustainable computing will expand, demonstrating businesses' ongoing dedication to environmental responsibility and as the market grows it will also need to adjust and integrate new technologies and approaches to maintain consistency with environmental sustainability ideals. *(Carpenter, 2023)*

3.3 Renewable Energy in IT

As of right now, 25% of the world's energy comes from renewable sources, indicating the sector's rapid expansion. According to McKinsey projections, the share of renewable electricity in the worldwide generation market is expected to reach about 75% by 2050, up from 50% by 2035. The market for alternative energy sources has grown steadily in the US due to a number of factors, including the falling cost of solar and wind power generation, the growing use of smart grids, improvements in battery storage, and a strong demand for renewable resources from a variety of market segments. The number of companies installing solar power systems on a voluntary basis has significantly expanded; in the past year, they bought over 5 gigawatts of renewable energy, a record for the industry.

Essentially, tax incentives and state and local laws are helping to grow the US market for renewable energy. More than 200 towns have declared their intentions to switch to 100% renewable energy by 2035, while both California and Hawaii have set lofty targets to become 100% renewable by 2045. Renewable energy is becoming more and more popular among consumers; installations of solar panels surpassed two million in the previous year and are predicted to quadruple by 2023. With France and the Netherlands setting the pace, the demand for renewable energy in Europe surpassed 500 TWh in 2018. Other areas that have successfully adopted geothermal heating systems include Munich, Paris, and Thisted, Denmark. In terms of legislative backing and demand, the future of the renewable energy industry seems bright, but providers' capacity to satisfy high standards is still a major concern.

Adoption of renewable energy sources, such as hydropower, wind, and solar, not only solves traditional energy's environmental problems but also benefits the business in the long run. Some of the challenges that come with using renewable energy are the requirement for efficient energy storage, infrastructural development, and weather-related variations in energy supply. To contribute to a better digital future, major tech corporations like Google are actively striving towards obtaining 24x7 carbon-free electricity for their data centres globally. These results highlight the need for sustainable practices in the IT sector and highlight the possibility of renewable energy to power IT infrastructure. Organisations may significantly contribute to a digital future that is more environmentally friendly by embracing renewable energy technology. *(The Future of Renewable Energy: IT Solutions by Industry | InfoPulse, n.d.)*

3.4 Smart Cities and Sustainability

A smart city is a place in which companies and residents benefit from the use of digital technology to improve the efficiency of traditional networks and services. A smart city is more than just a place where digital technologies are used to reduce emissions and optimise resource consumption. It entails improved waste management and water supply systems, better urban transportation networks, and more effective building lighting and heating systems as summarised in Fig 5. It also entails attending to the requirements of an ageing population, safer public areas, and more involved and responsive local management.

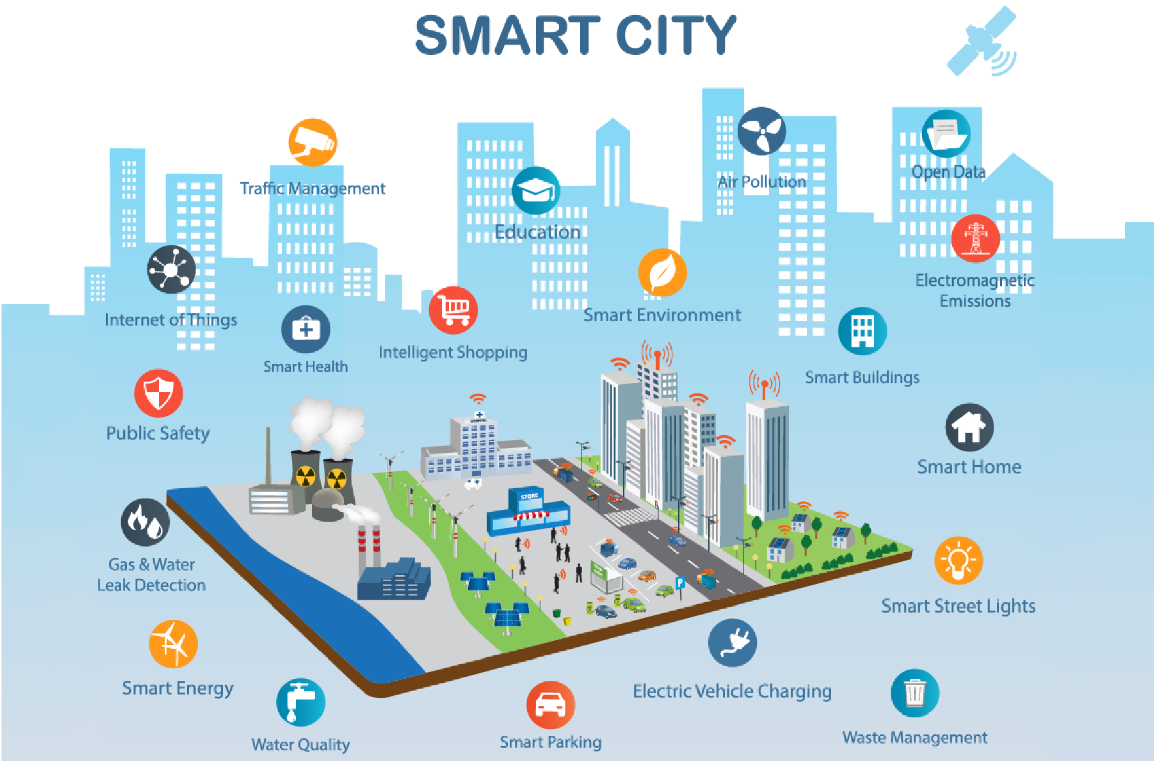


Figure 5: Descriptive Picture of Smart city. Source: (Sorri, 2021)

Key studies from various places show that information technology is essential to the development and improvement of smart cities for greater sustainability. Smart towns are gaining popularity as business hubs look to cut back on carbon emissions and encourage eco-friendly behaviour. The integration of Internet of Things (IoT) and Artificial Intelligence (AI) technologies is crucial for sorting through data and making informed decisions, which in turn promotes the growth of more sustainable communities. Green technology and the Internet of Things (IoT) are driving the transition to "smart cities," creating a digital environment that puts public safety, well-being, and sustainability first. Information technology is seen as the key facilitator for sustainable smart cities, which provide a substantial chance for extensive change.

A number of case studies demonstrate how IT may be used practically to maximise urban sustainability. For example, the city of Barcelona deployed a smart lighting system that uses IoT sensors to adjust lighting levels based on occupancy, the city of Miami-Dade partnered with Microsoft to implement a smart water management system, and the city of Amsterdam implemented a smart waste management system that uses IoT sensors to monitor waste levels and optimise collection routes, thereby reducing fuel consumption and greenhouse gas emissions. Furthermore, the city of Antwerp's participation in the EU's CITADEL initiative serves as an example of how technology may be used cooperatively in governance.

These results highlight how information technology may play a major role in the creation of smart cities and a more environmentally friendly future. Organisations may significantly contribute to the advancement of the sustainability agenda in the context of smart cities by implementing sustainable practices and making strategic use of information technology. Some examples include.*(Smart Cities, n.d.)*

- ➢ Smart Waste Management Systems: IoT sensors optimise waste collection routes, reducing fuel consumption and greenhouse gas emissions.
- ➢ Gunshot Detection Technology: Acoustic sensors detect gunshots, enhancing public safety.
- ➢ Smart Traffic Control Systems: IoT sensors monitor traffic flows and optimise streetlights, improving traffic flow and reducing congestion.
- ➢ Smart Air Quality Sensors: IoT sensors monitor air quality, providing real-time data for informed health decisions.
- ➢ Smart Lighting Systems: IoT sensors detect presence and adjust lighting levels, reducing energy consumption.
- ➢ Smart Water Management Systems: IoT sensors monitor water usage and detect leaks, improving water conservation.
- ➢ Smart Grid Platforms: IoT sensors monitor and optimise energy consumption, reducing energy waste and greenhouse gas emissions.

3.5 Internet of Things and Environmental Monitoring

IoT environmental monitoring collects data on a range of environmental parameters, including soil moisture, wildlife numbers, and the quality of the air and water. This approach is becoming more and more popular because it can quickly and effectively gather and analyse large amounts of data, giving businesses the capacity to make decisions that will lessen their environmental impact and help them achieve sustainability objectives. IoT has several uses in environmental monitoring, including commercial farming, water safety, monitoring extreme weather, protecting endangered species, and environmental protection.

In several areas of environmental monitoring, the integration of IoT devices and sensors has proven to be a game-changer, producing sophisticated applications in monitoring biodiversity, pollution management, forestry, and agriculture.

IoT sensors are versatile instruments used in agriculture that track several elements of the industry, including crop health, soil health, water quality, and current weather. Farmers can now optimise their irrigation techniques and make well-informed decisions about land management, fertilisation, and pest control thanks to this abundance of data. The combination of various Internet of Things-based solutions greatly improves agricultural practises' accuracy and productivity.

The real-time capabilities of IoT-based solutions are useful in the field of managing forests as well. They make it easier to monitor forest habitats continuously, which makes it possible to quickly identify fire occurrences and anticipate future soil deterioration. Additionally, the implementation of IoT guarantees efficient operations by offering predictions and control mechanisms concerning soil erosion, fire safety, and undesired depositions.

Internet of Things sensors have also become the front-line protectors of water and air quality when it comes to pollution management. By identifying air contaminants, these sensors help with thorough air quality monitoring that protects the environment and public health. In addition, IoT-powered water quality monitoring is essential for detecting pollutants, safeguarding water resources, and maintaining public health regulations.

The accuracy and coverage provided by IoT sensors are especially useful for monitoring biodiversity. These tools are excellent at keeping an eye on the numbers and habitats of animals, giving vital information for conservation initiatives. IoT sensors are essential to the preservation of ecosystems because they support biodiversity and help safeguard endangered species. The intricate system of IoT applications highlights how much these technologies can do to support environmental conservation and monitoring programs. *(Green New Deals: The Role of Business, n.d.)*

3.6 Big Data and Analytics for Sustainability

Big data analytics emerges as a transformative force in advancing sustainability efforts, offering profound insights and encouraging environmentally responsible behaviors. Uncovering intricate correlations and patterns, this technology proves indispensable across diverse realms of sustainable development. Notably, its application in critical domains like supply chain optimization, healthcare, and climate action facilitates smarter forecasts and informed decisions, enhancing our understanding of societal and environmental processes.

In the pursuit of sustainability goals, big data analytics plays a pivotal role by providing crucial insights into environmental impacts and identifying areas ripe for improvement. Addressing scalability challenges faced by green projects, it becomes a vital enabler for businesses committed to sustainability. Real-world case studies, exemplified by initiatives like "Green Inventory Management" and "Production Planning Optimization," underscore how supply chains can be optimised while minimising environmental impact through the strategic use of big data analytics.

Crucial to environmental management, big data analytics proves instrumental in monitoring diverse facets, including tracking fire incidents, assessing forest soil degradation, evaluating agricultural health, and identifying air pollution. Beyond environmental applications, it enhances healthcare systems by improving emergency department wait times, optimising Electronic Health Records (EHRs), and enabling real-time health tracking. Moreover, its role in monitoring water quality and detecting pollutants safeguards public health and water resources.

In summary, these outcomes underscore the immense potential of big data analytics in handling and analysing environmental data, marking significant strides toward a more sustainable and greener future. Businesses leveraging this technology stand poised to make substantial contributions to environmental stewardship, exemplifying the transformative impact of big data analytics on sustainable practices. (*Big Data for Sustainable Development*, n.d.)

3.7 BlockChain and Environmental Transparency

Due to its increased openness and traceability, blockchain technology has emerged as a revolutionary force, especially in supply chains involving ecologically sensitive items. It is clear from a number of case studies how blockchain technology is effectively used to confirm and document sustainable practises. First off, blockchain operates as a tool to offer a decentralised ledger, assisting in the detection and mitigation of environmental consequences and improving supply chain transparency. Businesses use blockchain's decentralised structure to provide customers with an open record of a product's lifecycle, from manufacture to sale. By integrating smart contracts, businesses may more easily automate certifications and compliance, which helps them prove that they are adhering to environmental and ethical standards.

Furthermore, blockchain technology is proving to be quite useful in the field of carbon credit monitoring since it provides precise data collection and measurement. A novel way to get an agreement on emission reduction that is in line with environmental objectives is to tokenize carbon credits on a blockchain. This application makes a substantial contribution to the transparent and trustworthy tracking and management of carbon credits.

Finally, taking into account the wider range of environmental effects, blockchain technology tackles sustainability issues in a number of fields. Its uses are constantly expanding and include supply chain transparency, financial inclusion, measuring carbon footprints, and even preventing human trafficking. Blockchain has a significant impact on Corporate Social Responsibility (CSR) programmes by improving traceability, accountability, and transparency in businesses' sustainability activities.

In summary, the case studies researched demonstrates how blockchain technology may be used to promote sustainable development by bringing traceability and transparency to the supply chains of items that are ecologically sensitive. Businesses that use blockchain technology not only support moral corporate conduct but also significantly contribute to the creation of a more sustainable and environmentally friendly future. (*Blockchain Technology and the Future of Sustainability*, n.d.)

3.8 CZU and the green deal

The Czech University of Life Sciences (CZU) is an advocate in sustainable practices and a strong proponent of the European Green Deal's principles. CZU's vision encompasses a wide range of goals, from promoting high-quality education for sustainable development to decreasing water pollution, boosting the use of renewable energy, minimising the environmental impact of urban areas, and strengthening resilience to climate change. These goals are anchored in the university's Sustainability Strategy 2030.

CZU's 2022 energy and carbon projects clearly demonstrate the university's commitment to sustainability. Notably, the institution used 10,400,000 kWh of electricity and 18,506,399 kWh (1,707,320 m3) of natural gas at its peak. CZU is aggressively increasing its share of renewable energy as part of its Strategy 2030 pledge; in 2022, on-campus solar power plants will produce about 39,000 kWh. An important step towards implementing more sustainable practices will be taken with the energy audit, which is now underway and set to provide insightful analysis and recommendations.

CZU's Sustainability Strategy 2030 includes waste management as a crucial element, in addition to energy and emissions. Acknowledging trash as a major issue that includes emissions and plastic pollution, the university wants to increase the percentage of segregated waste and apply circular economy concepts. Initiatives include optimising waste separation and composting, preventing waste with alternatives like drinking water stations and reusable cups, and composting all biodegradable trash.

Beyond waste, CZU has taken a number of steps to meet its emissions and energy goals. These include setting energy demand reduction targets based on energy management outcomes, switching to energy-efficient LED bulbs, utilising energy-efficient appliances, offsetting air travel emissions, adding low-emission cars to the university's fleet, and encouraging environmentally friendly modes of transportation. In an effort to further promote sustainable mobility, the university is also expanding its infrastructure to include electric vehicle and electric bike charging stations.

CZU is still being proactive in the areas of biodiversity and water management. Water conservation, rainfall optimisation, greywater utilisation research, and the installation of green facades and roofs are among the established objectives. In order to promote a flourishing biodiversity on campus, CZU is dedicated to implementing animal management techniques, protecting against bird attacks, and maintaining ecological greenery.

This all-encompassing plan demonstrates CZU's dedication to tackling the problems associated with waste, energy use, and water management while fostering ecological sustainability and biodiversity. The university's diverse strategy fits in perfectly with its main objective of creating an environmentally conscious and sustainable campus. As it moves forward, CZU not only satisfies but surpasses the requirements outlined in the European Green Deal, establishing itself as a leader in environmentally friendly higher education. *(Czech University of Life Sciences, 2020)*

3.9 Technologies used

3.9.1 Google-Colab

Google offers a cloud-based platform called Google Colab, sometimes known for collaboration for group Python coding. Because it can be accessed through a web browser, local instals are not necessary. It guarantees accessibility and facilitates real-time collaboration when integrated with Google Drive. Notably, Colab offers GPU and TPU access for free GPU stands for Graphics Processing Unit, and TPU stands for Tensor Processing Unit, speeding up computation for applications like machine learning. It is compatible with Jupyter notebooks and makes moving between local and cloud settings easy. With important libraries (NumPy, Pandas, TensorFlow, PyTorch) pre-installed, Colab makes starting a project easier. Its Google Docs-like real-time collaboration capability is helpful for group projects. The software supports Markdown and lets you add formatted text and documentation to notes. Jupyter, HTML, and PDF export options make it simple to share study findings and code. (*Colaboratory*, n.d.)

3.9.2 Power BI

Microsoft's Power BI is a feature-rich business analytics solution that makes business intelligence and interactive visualisations possible. Its flexible data integration allows for easy import and analysis across multiple sources. Notable for modelling and data transformation, Power BI enables users to combine, clean, and form data in preparation for organised analysis. The software is quite good at building dynamic, interactive dashboards that provide high-level analysis of important data and patterns. Questions in natural language improve accessibility for individuals who are not as knowledgeable about data structures.

Power BI streamlines data processing by integrating applications like Power Query and Power Pivot. There are on-premises and cloud-based deployment options available. The capacity to embed insights in other platforms and share reports and dashboards both inside and outside of organisations is made possible by collaboration features. Data confidentiality and integrity are guaranteed by security and governance solutions. Power BI is a popular option for businesses looking to make data-driven decisions because of its easy-to-use interface and seamless integration, which have gained it widespread adoption across several industries. (*Uncover Powerful Insights and Turn Them Into Impact*, n.d.)

4 Practical Part

As we move into this thesis's practical part, we suggest putting in place a thorough dashboard in order to meet our objectives for energy sustainability and acquire a thorough understanding of consumption trends. This dashboard will show trends in the use of energy, gas, and water over the course of several semesters in different university buildings. We are utilising a comprehensive published dataset from La Trobe University, an Australian university dedicated to achieving net zero carbon emissions by 2029, as a result of not being able to access the Czech University of Life Sciences (ČZU) consumption statistics. The concepts of sustainable energy management are transferable, in spite of the differences in ČZU's operational context. This enables us to model and suggest a customised solution that is appropriate for ČZU's specific requirements.

This practical part intends to assist ČZU by offering a data-driven approach, but it also aspires to bring useful insights and approaches that may be applied in a variety of institutional and educational settings. This program demonstrates how information technology can be used to drive sustainable practices, which is in line with the Green Deal's main idea and ČZU's dedication to operating an ecologically conscious and sustainable campus.

4.1 Purpose and Setup

This highly detailed available data set consists of detailed consumption of five campuses of La Trobe from 2018-2021, including the period of Covid-19 where the usage of electricity, gas or water had been significantly low in the university campus. The data also consists of smart electricity and water meters that read that data at a gap of 15 min, and Gas meter that reads at interval of an hour. This data also contains weather data from the weather stations near the campuses.

The published data sets contained the following files:

➢ Campus_meta.csv: This file includes details about every campus connected to the university.

- ➢ Nmi_meta.csv – This file contains information about NMIs, including peak demand and campus location.
- ➢ Building_meta.csv: This file includes metadata, such as campus location and floor space, about each building on campus.
- ➢ Calender.csv: This file contains the university calendar for the time frame of the data collection.
- ➢ Events.csv - Each building contains a list of events that have occurred, including energy-saving initiatives like updating HVAC systems and installing LED lighting. The dates associated with each building-level event are contained in this file.
- ➢ Nmi_consumption.csv: This file contains NMI consumption information.
- ➢ Building_consumption.csv: This file contains information on building consumption.
- ➢ Building_submeter_consumption.csv: This file contains consumption information for building sub-meters.
- ➢ Gas_consumption.csv: This file contains information on the gas usage of the campuses that are accessible.
- ➢ Water_consumption.csv: This file contains information on the amount of water used on the campuses that are accessible.
- ➢ Weather_data.csv: Weather information gathered from relevant

After exploring and understanding the data set we selected the following files to clean to create the dashboard. The goal while selecting the files to clean from was to select the main factors affecting the trends of energy consumption, Viewers can more easily comprehend and concentrate on the most important parts of the data when the dashboard is simplified and contains only essential information. A message that is too strong may be overwhelmed by too much information and become less clear.

Data file	Data Field	Description	Unit
Campus_meta.csv	id	Unique identifier	
	name	Name of Campus	
	capacity	Student capacity	

Data file	Data Field	Description	Unit
nmi_consupmtion.csv	meter_id	Unique identifier	
	timestamp	Data record time	
	consumption	Energy consumption	kWh
	demand_kW	Energy demand in kW	kW
	demand_kVA	Energy demand in kVA	kVA
weather_data.csv	campus_id	Foreign key identifier to the campus id	
	timestamp	Recorded timestamp	
	apparent_temperature	Apparent Temperature	°C
	air_temperature	Air Temperature	°C
	dew_point_temperature	Dew Point Temperature	°C
	relative_humidity	Relative Humidity	
	wind_speed	Wind Speed	m/s
	wind_directio n	Wind Direction angle w.r.t. to North	°
gas_consumption.csv	capmus_id	Foreign key identifier to the campus id	
	timestamp	recorded timestamp	
	consumption	gas consumption	kJ
water_consumptio n.csv	campus_id	Foreign key identifier to the campus id	
	meter_id	Unique meter identifier	
	timestamp	Recorded timestamp	
	consumption	Water consumption	kL

Table 1: Data description (Own Work)

The initial step involved uploading the dataset to Google Drive

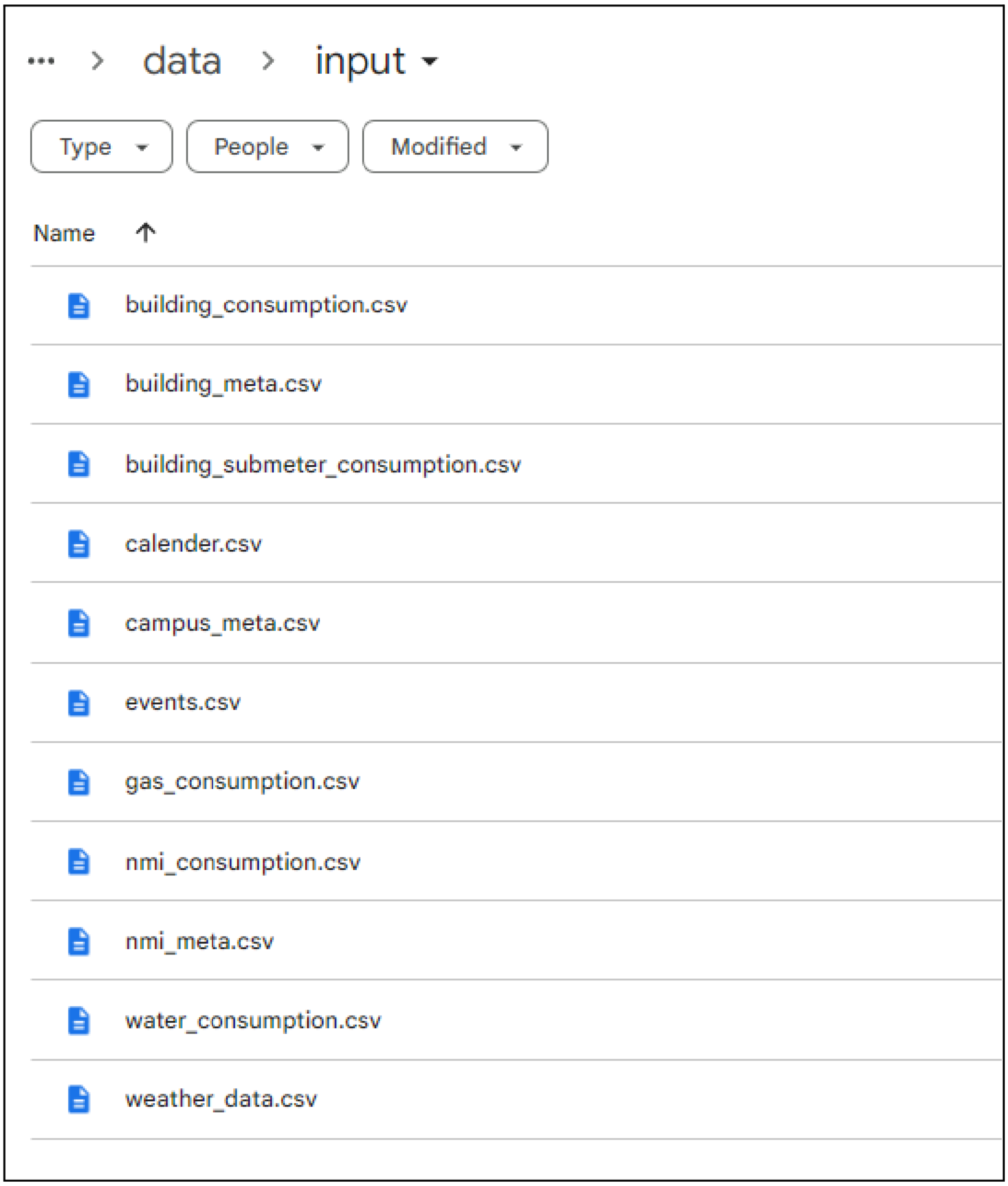


Figure 6: Data Files (Own Work)

The Python code presented in this section plays a crucial role in the preparatory stages of developing the energy consumption dashboard. Commencing with the essential step of importing requisite libraries, the code ensures the availability of necessary tools for the subsequent data processing tasks. To facilitate seamless access to data files residing in Google Colab, the code further includes the mounting of Google Drive. This strategic integration of external data sources sets the foundation for the comprehensive data preprocessing and cleaning procedures that follow. The objective is to create a refined dataset that is not only accurate and reliable but also well-structured for meaningful analysis within the Power BI dashboard. This initial phase underscores the importance of a meticulously crafted Python script in preparing the data for the ensuing stages of dashboard development.

```
import pandas as pd
import seaborn as sns
from google.colab import drive
drive.mount('/content/drive')
PATH_BASE = '/content/drive/My Drive/Thesis/data/'
PATH_INPUT = PATH_BASE + 'input/'
PATH_OUTPUT = PATH_BASE + 'output/'
SUMMER = [2, 3, 4, 5, 6]
WINTER = [9, 10, 11, 12, 1]
BREAK = [7, 8]
```

Code 1: Data processing in Python (Own work)

4.1.1 Data Reading

The Python code begins with a thorough reading of several data files, each of which is essential to building a solid basis for the dashboard showing energy consumption. The campus metadata files are among these, providing essential details regarding the physical and administrative configuration of the university. A key component of the investigation, the National Metre Identifier (NMI) consumption data, sheds light on the complex patterns of energy use. The dataset also includes weather data, which is crucial to comprehending environmental variability in energy consumption. The dashboard's analytical capabilities are further enhanced by the addition of data on gas and water use.

```
df_campus_meta = pd.read_csv(PATH_INPUT + 'campus_meta.csv')
df_nmi_consump = pd.read_csv(PATH_INPUT + 'nmi_consumption.csv')
df_weather = pd.read_csv(PATH_INPUT + 'weather_data.csv')
df_gas = pd.read_csv(PATH_INPUT + 'gas_consumption.csv')
df_water = pd.read_csv(PATH_INPUT + 'water_consumption.csv')
```

Code 2: Data processing in Python (Own work)

4.1.2 Data Processing

The following section of the Python code is dedicated to the crucial task of data cleaning and preprocessing, a foundational step aimed at ensuring the dataset's quality and integrity before undertaking any meaningful analysis. This stage is pivotal in enhancing the reliability of the insights derived from the dataset. Through a series of meticulous procedures, the code addresses various aspects of the data, including handling missing or inconsistent values, transforming timestamp formats, and extracting additional temporal features. The careful and systematic approach to data cleaning lays the groundwork for a more accurate and trustworthy representation of energy consumption patterns, setting the stage for the creation of a robust energy consumption dashboard. This commitment to data quality is essential for delivering meaningful, reliable, and actionable insights to stakeholders and decision-makers

```
df_weather['timestamp'] = pd.to_datetime(df_weather['timestamp'])
df_weather['date'] = df_weather['timestamp'].dt.date
df_weather = df_weather[df_weather['campus_id'] == 1]
df_temp = df_weather.groupby(['date']).min().reset_index()[['date',
'apparent_temperature']].merge(
    df_weather.groupby(['date']).max().reset_index()[['date',
'apparent_temperature']],
    left_on = 'date',
    right_on = 'date',
).rename(columns={
    'apparent_temperature_x': 'temp_low',
    'apparent_temperature_y': 'temp_high',
})
df_temp['date'] = df_temp['date'].astype("string")
```

Code 3: Data processing in Python (Own work)

```
df_nmi_consump['timestamp'] = pd.to_datetime(df_nmi_consump['timestamp'])
# Changing type of timestamp to dt
df_nmi_consump['year'] = df_nmi_consump['timestamp'].dt.year
# Extracting extra fields
df_nmi_consump['month'] = df_nmi_consump['timestamp'].dt.month
df_nmi_consump['time'] = df_nmi_consump['timestamp'].dt.hour

df_nmi_consump['date'] = df_nmi_consump['timestamp'].dt.date
```

```
df_nmi_consump =
df_nmi_consump.groupby(['meter_id','date']).mean().reset_index()
df_nmi_consump['semester'] = df_nmi_consump['month'].apply(lambda x:
'winter' if x in WINTER else ('summer' if x in SUMMER else 'break')) #
extracting semester
# df_nmi_consump = df_nmi_consump[df_nmi_consump['campus_id'] == 1]
df_nmi_consump['date'] = df_nmi_consump['date'].astype("string")
df_nmi_consump = df_nmi_consump.merge(
    df_temp,
    left_on='date',
    right_on='date',
    how='left'
)
```

Code 4: Data processing in Python (Own work)

4.1.3 Semester Classification and Carbon Footprint Calculation

As the Python code progresses, a significant step involves the classification of data into distinct semesters, providing a structured temporal framework for the subsequent analyses. This semester classification is a strategic element in understanding energy consumption patterns, allowing for a more nuanced exploration of trends and variations across different academic terms. Additionally, the code incorporates a sophisticated calculation process to determine the carbon footprint associated with energy consumption. This involves multiplying the energy consumption values by a predefined emission factor, resulting in an estimation of the carbon impact of the energy usage. The inclusion of carbon footprint calculations adds an environmental perspective to the dataset, aligning with sustainability goals and contributing to a comprehensive understanding of the ecological implications of energy consumption within the university setting. This dual functionality, encompassing both temporal classification and carbon impact assessment, enriches the dataset and positions it as a valuable resource for informed decision-making in the context of energy sustainability.

```
df_nmi_consump['campus_id'] =
df_nmi_consump['campus_id'].fillna(1)
df_nmi_consump =
df_nmi_consump[df_nmi_consump['year'].isin([2018,2019,2020,2021]
)]
df_nmi_consump['carbon_footprint'] =
df_nmi_consump['consumption'] * 0.68
```

```
df_nmi_consump['campus_id'] =
df_nmi_consump['campus_id'].astype('int')

df_gas['timestamp'] = pd.to_datetime(df_gas['timestamp'])
df_gas['timestamp'] = df_gas['timestamp'].dt.date
df_gas = df_gas.groupby(['timestamp']).mean()
df_gas =
df_gas.reset_index().rename(columns={'consumption':'gas_consumpt
ion', 'timestamp':'date'})
df_gas['campus_id']= df_gas['campus_id'].astype('int')

df_water['timestamp'] = pd.to_datetime(df_water['timestamp'])
df_water['timestamp'] = df_water['timestamp'].dt.date
df_water = df_water.groupby(['timestamp']).mean()
df_water = df_water.rename(columns={'meter_id':
'water_meter_id', 'consumption':'water_consumption'})
df_water = df_water.reset_index()

df_nmi_consump.to_csv(PATH_OUTPUT + 'nim.csv')
df_water.to_csv(PATH_OUTPUT + 'water.csv')
df_gas.to_csv(PATH_OUTPUT + 'gas.csv')
```

Code 5: Data processing in Python (Own work)

4.1.4 Data Quality and Completeness:

To obtain significant insights and support precise decision-making, it is critical to guarantee the quality and completeness of the dataset. A thorough process of data cleaning and preprocessing in Python using Google Colab is part of the actions taken to improve the quality and completeness of the data. A comprehensive cleaning process was applied to the dataset in order to find and fix any missing or incorrect data points. Depending on the type of data, either imputed or excluded values were missing. In Google Colab, the data was efficiently preprocessed using Python scripts, which included organising and structuring the data for easy analysis. Proper encoding of categorical variables made it easier to include them in the analysis. A series of quality checks were implemented to validate the accuracy and reliability of the dataset, encompassing cross-verifying data points against external sources and verifying the consistency of key metrics. The significance of quality assurance cannot be overstated, as accurate and reliable data forms the foundation for meaningful analysis and decision-making. By meticulously cleaning and preprocessing the data in Python using Google Colab, we guarantee that the dataset used in the dashboard is of high quality and completeness. This commitment to data integrity ensures that the insights derived from the dashboard are trustworthy and align with the objectives of the thesis.

4.2 Dashboard

The dashboard consists of an overall consumption trends section that gives a high-level overview of resource usage; a building-by-building breakdown to identify individual buildings with different rates of consumption; an analysis conducted semester-by-semester to show seasonal variations and patterns; comparison metrics to highlight changes over time; visualisations showing the results of energy efficiency projects that have been put into place; and, predictive frameworks and techniques that produce results that may be put into practise for improved management, net zero emissions, and energy efficiency. In order to thoroughly investigate these factors, a dynamic Power BI dashboard was developed shown in the Fig 7 below, An extensive analysis of the main dashboard and its visualisations and conclusions is provided in this section.

Figure 7: Power BI Dashboard Overview (Own Work)

4.3 User Interface (UI) Design:

The User Interface (UI) design of the dashboard adheres to principles that prioritise clarity, user-friendliness, and efficient data interpretation. The layout is thoughtfully structured to provide an intuitive navigation experience, ensuring that users can easily interact with and comprehend the information presented. A prominent feature is the filter panel positioned on the left side of the dashboard, offering a centralised location for users to customise their view. This filter panel incorporates various options, such as filters for year, month, consumption type (electricity, gas, water, or combined), campus, meter ID, and semester, allowing users to refine their data according to specific parameters. The purpose of this filter panel is to enhance user control and enable focused analysis based on individual preferences.

Key metrics and charts are strategically placed for easy interpretation, contributing to an overall user-friendly experience. For instance, the top row showcases essential Key Performance Indicators (KPIs) for average consumption, maximum demand, and total carbon footprint, offering a quick snapshot of critical information. The subsequent rows contain visualisations such as area charts, clustered bar charts, line charts, donut charts, scatter charts, and predictive line charts, presenting data in diverse formats for comprehensive understanding. The placement and organisation of these visual elements facilitate a smooth flow of information, ensuring that users can quickly grasp trends, correlations, and insights without unnecessary complexity. In summary, the dashboard's UI design prioritises accessibility and user engagement, promoting an effective and enjoyable interaction with the presented data.

4.4 Interactivity

The dashboard boasts interactive features that empower users to customise their viewing experience and extract targeted insights based on specific criteria. The filter panel, positioned on the left side, serves as the central hub for these interactive functionalities. Users can manipulate various filters to refine the displayed data according to their preferences.

1. **Year and Month Filters:**
   a. Purpose: Users can select specific years and months to narrow down the temporal scope of the data.
   b. Functionality: Allows users to focus on energy consumption patterns within particular timeframes.
2. **Consumption Type Filter:**

a. Purpose: Permits users to choose between electricity, gas, water, or a combination of these consumption types.
b. Functionality: Enables a detailed examination of each energy type individually or collectively.

3. **Campus ID Filter:**
   a. Purpose: Facilitates the exploration of energy consumption patterns within specific campuses.
   b. Functionality: Users can select a particular campus to analyse energy usage within that specific geographical location.
4. **Meter ID Filter:**
   a. Purpose: Enables users to drill down to data from a specific meter.
   b. Functionality: Useful for a more granular analysis of consumption patterns associated with a particular meter.
5. **Semester Filter:**
   a. Purpose: Allows users to filter data based on academic terms, distinguishing between summer, winter, and break semesters.
   b. Functionality: Users can explore how energy consumption patterns vary across different academic periods.

These interactive filters collectively empower users to tailor their exploration, making the dashboard a versatile tool for extracting insights across various dimensions. Whether focusing on a specific timeframe, consumption type, location, or academic term, users can dynamically adjust the dashboard's display to suit their analytical needs. This level of interactivity enhances the overall user experience and ensures that the dashboard caters to a diverse set of analytical requirements. Additionally the Power BI dashboard ensures a dynamic and interactive user experience through various features. Hover-over details enable users to glean specific values instantly by placing the cursor over data points. Click-to-drill functionality allows for a deeper exploration of data by clicking on chart elements. Cross-filtering is seamlessly integrated, enabling the automatic adjustment of related data in other charts with a single click. The selection pane offers users the ability to tailor their displayed visuals, ensuring a personalised and focused view. Bookmarking functionality facilitates the creation of bookmarks for saving specific views, streamlining navigation. Drillthrough pages provide a structured approach to accessing more detailed information. Altogether, Power BI's interactive features, when combined with a well-designed dashboard and user-friendly filters, empower users to engage with data visually and explore insights comprehensively.

4.5 Performance of the Dashboard

The performance of the Power BI dashboard is a critical aspect that ensures a seamless user experience. It boasts exceptional responsiveness, even when handling large datasets, allowing users to interact with the visualisations smoothly. The load times are consistently reasonable, contributing to the overall efficiency of the dashboard. This focus on performance is paramount to provide users with a responsive and efficient platform for data exploration, aligning with the objective of delivering meaningful insights without compromising user experience.

4.6 Dashboard overview

4.6.1 Filter Panel

Fig 8 shown below, Presents the filter panel inserted in the Dashboard.

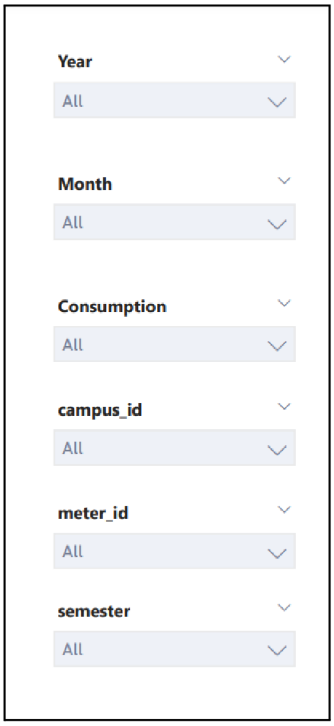


Figure 8: Filter Panel of Dashboard (Own Work)

4.6.2 Consumption Trends Over Time

The 'Consumption Trends Over Time' chart, as presented in Fig. 9 shows a area chart, providing a detailed understanding of patterns in the use of electricity. Through the analysis of monthly patterns, we are able to identify significant swings that may be related to seasonal variations or other external factors that impact consumption. An overview of the temporal dynamics of the dataset is given in this section.

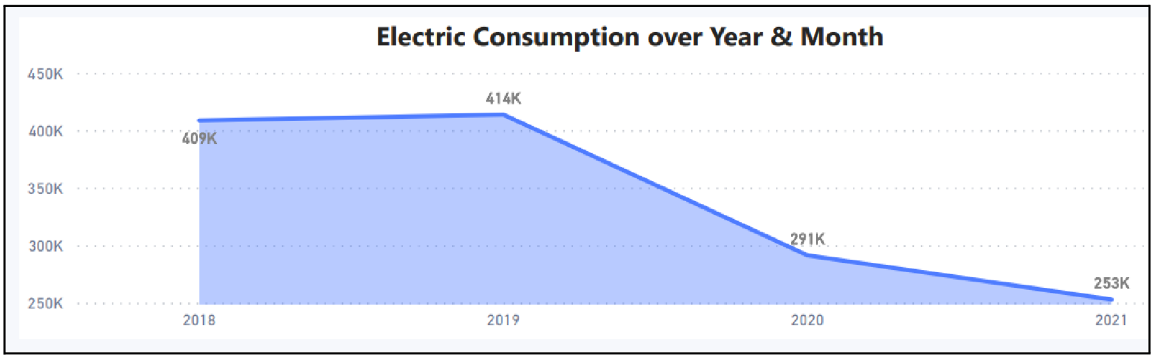


Figure 9: Consumption Trends Over Time area chart in dashboard (Own Work)

4.6.3 Seasonal Patterns

By classifying consumption into semesters, the 'Seasonal Patterns' visualisation done using donut chart in Fig. 10, digs deeper into the temporal intricacies of the dataset. This division reveals unique trends in the winter, summer, and break seasons. During periods of peak use, these insights can direct focused sustainability measures that help optimise resources.

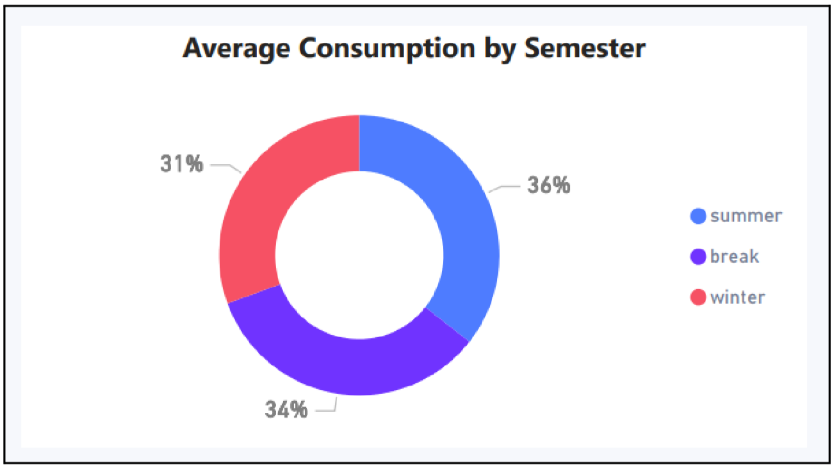


Figure 10: Seasonal Patterns presented using donut chart in Dashboard (Own Work)

4.6.4 Carbon Footprint Analysis

One important aspect of our investigation is the measurement of environmental effects using the 'Carbon Footprint investigation' graphic. This component shown in Fig 11, highlights a positive trend that is suggestive of effective sustainability activities by showcasing the overall carbon footprint over time. The ongoing decrease in carbon footprint demonstrates the efficacy of green measures put into practise and is in line with environmental goals.

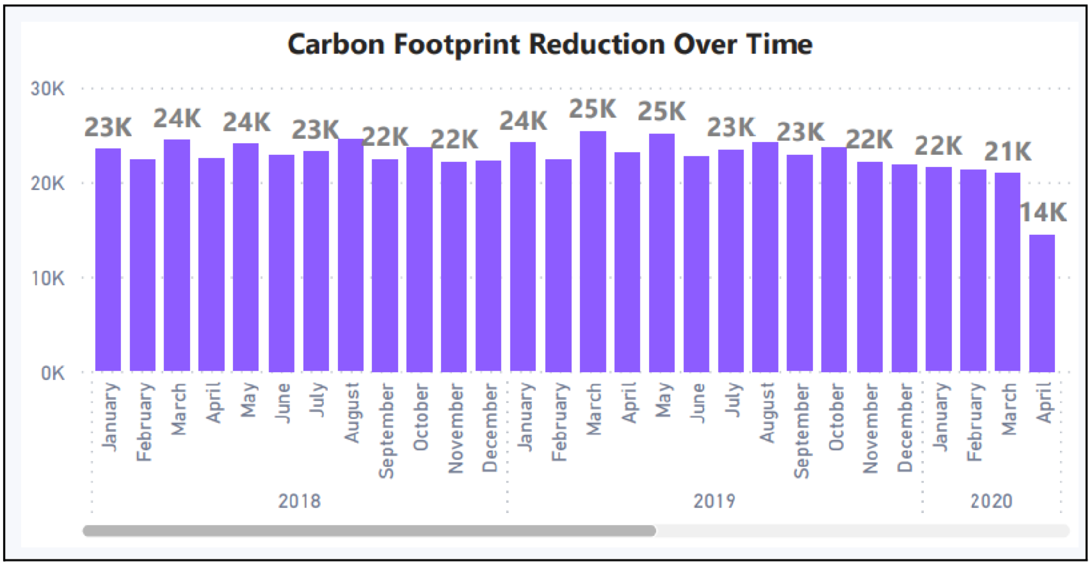


Figure 11: Carbon Footprint Analysis presented using Clustered Cloumn Chart in Dashboard (Own Work)

4.7 Comparative Analysis charts

4.7.1 Gas and Water Consumption

We included statistics on gas and water consumption in the analysis to further our understanding as shown in Fig 12. A comparison is given by the 'Gas and Water Consumption' using a clustered bar chart in the dashboard. By examining any relationships or differences in the use of gas, electricity, and water, this cross-resource investigation provides important information for integrated resource management.

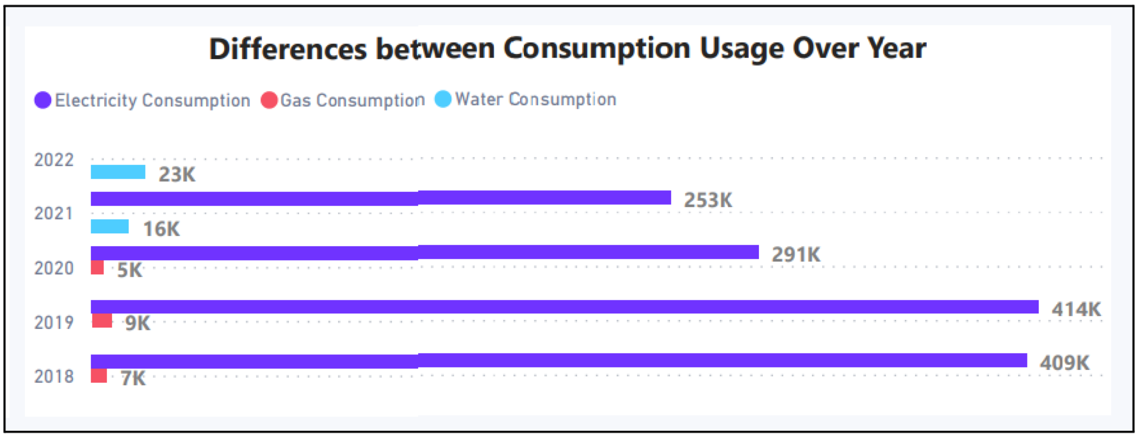


Figure 12: Gas and Water Consumption presented by Clustered Bar Chart (Own Work)

4.7.2 Campus Comparison

The 'Campus Comparison' segment, as illustrated in Fig 13, allows for a detailed analysis of energy data between various campuses. By comparing demand, consumption, and other important metrics, interested parties can learn a great deal about how to best manage energy on a particular campus. Making well-informed decisions on resource allocation and sustainability activities is made easier by this section.

Key Metrics for Different Campuses

campus_id	carbon_footprint	demand_kVA	demand_kW	Electricity Consumption	Gas Consumption	Water Consumption
1	786,658.75	4,880,898.64	4,778,875.23	1,156,851.10	20,787.47	39,759.19
2	31,040.84	212,103.82	185,070.58	45,648.30		
3	99,227.01	624,067.08	589,390.65	145,922.07		

Figure 13: Campus Comparison using data visualization Table in Dashboard (Own Work)

4.8 Key Insight and Observations from the Dashboard

4.8.1 Hourly Consumption Distribution

Patterns in consumption throughout the day are revealed by the 'Hourly Consumption Distribution, shown in line chart presented in fig 14, Determining the hours of highest energy consumption is essential for maximising infrastructure and energy resources during times of increased demand. The foundation for both infrastructure optimization and strategic energy planning is laid out in this section.

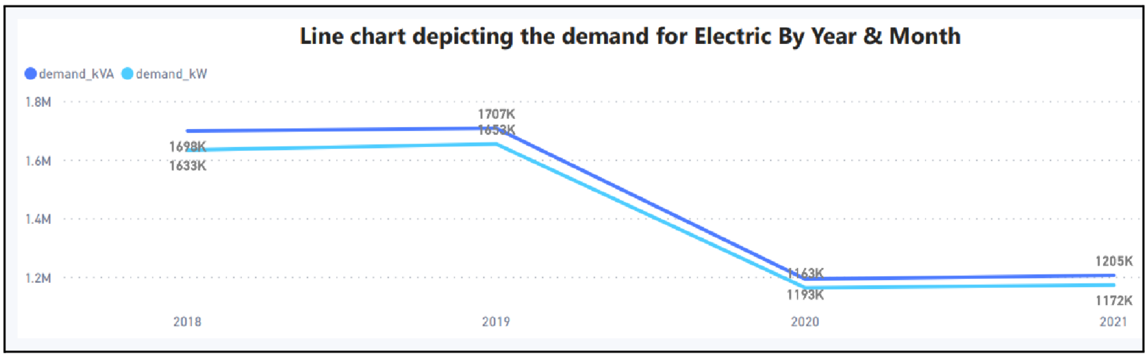


Figure 14: Hourly Consumption Distribution presented using Line Chart in Dashboard (Own Work)

4.8.2 Forecasting

An optional forecasting model was used for a potential future viewpoint using line chart. This forecasting tool provides information on possible future patterns in energy usage. This forecasting component is optional, although it is a useful tool for long-term sustainability plans and proactive resource planning.

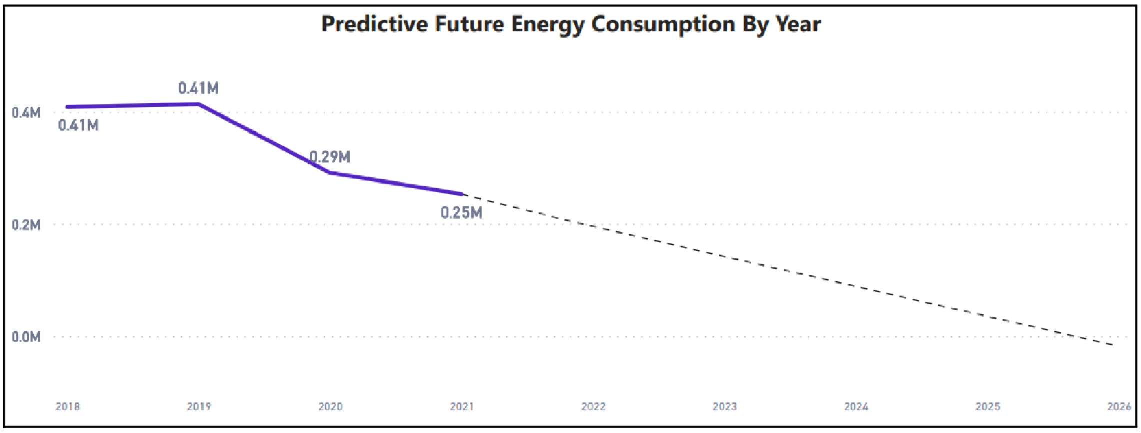


Figure 15: Forecasting presented using line chart in the dashboard (Own Work)

4.8.3 Key Performance Indicators (KPIs)

Figure 16:Key Performance Indicator presented in the Dashboard (Own Work)

The dashboard incorporates key performance indicators (KPIs) on the top row as shown is the Fig 16, offering a quick and insightful snapshot of the overall energy performance within the university. These KPIs include average consumption, maximum demand, and total carbon footprint.

The average consumption KPI provides a consolidated figure (66.23) that reflects the mean energy usage across different dimensions. This metric serves as a baseline for assessing deviations or improvements in consumption patterns.

Maximum demand, represented by 3,665.89, signifies the peak energy demand experienced by the university. This KPI is crucial for capacity planning and understanding the infrastructure's ability to handle peak loads.

The total carbon footprint KPI, quantified at 929,200.23, encapsulates the environmental impact of the university's energy consumption. Aligning with sustainability goals, this metric serves as a quantifiable indicator of the institution's ecological footprint, enabling stakeholders to track progress and make informed decisions toward reducing environmental impact.

These KPIs collectively provide a concise yet comprehensive overview, allowing stakeholders to quickly assess the university's energy performance against sustainability objectives. The strategic placement of these indicators on the top row ensures their visibility and prominence, reinforcing their significance in guiding decision-makers toward sustainable practices.

4.9 Insightful Analysis

The dashboard conducts a comprehensive analysis of energy consumption patterns, unearthing nuanced trends and intriguing anomalies. A notable observation emerges from the line chart depicting the demand for electricity over time, revealing a substantial drop from 2019 to 2020, both in kVA and kW measurements. This intriguing shift prompts further investigation, as the data hints at potential efficiency improvements or shifts in consumption behaviour during this period. The average demand decrease from 2019 to 2020 is statistically significant, with kVA dropping from 1707K to 1163K, and kW dropping from 1652K to 1193K.

Additionally, the clustered bar chart, offering a comparative analysis of consumption usage across different years, highlights variations in electricity, gas, and water consumption. Notably, the absence of water consumption data for 2022 raises questions about data collection practices or potential changes in campus facilities. The percentage reduction in carbon footprint, as indicated by the clustered column chart, illustrates a substantial decrease from 23K in January 2019 to 14K in January 2021.

Enriching the analysis, the scatter chart correlating weather conditions with different consumption types showcases a positive slope, suggesting a connection between temperature and energy usage. Simultaneously, the line chart depicting trends in consumption, demand, and carbon footprint unveils intriguing dynamics. Despite fluctuating demand, consumption consistently hovers around the 1 million mark, while the carbon footprint remains below 0.1 million. This suggests an efficient use of energy resources.
These statistics and visualisations not only provide a detailed portrayal of energy consumption but also establish a foundation for informed decision-making. The insights garnered from the dashboard foster a proactive approach towards sustainable practices, aligning with the European Green Deal initiative.

4.10 Comparative Analysis

The comparative analysis segment within the dashboard offers a nuanced exploration of energy consumption, comparing various dimensions such as buildings, departments, and academic terms. The clustered bar chart, a focal point of this analysis, provides a detailed breakdown of electricity, gas, and water consumption disparities over the years.

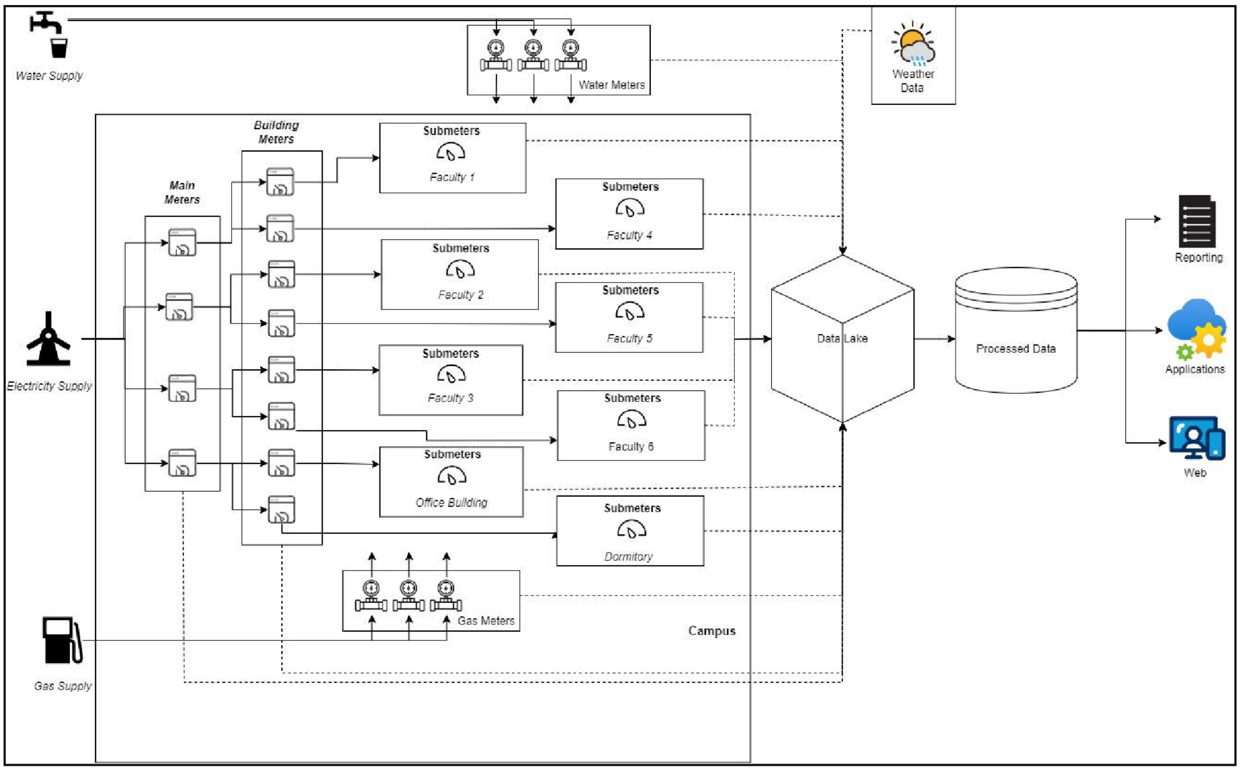
Examining the chart's data reveals compelling statistics. For example, in 2019, a notable rise in electricity consumption is observed, potentially indicating increased energy usage in that period. Conversely, a decrease in gas consumption during the same year raises questions about the efficiency of gas-dependent systems or alterations in usage patterns.

Further comparisons between academic terms expose trends deserving of attention. The absence of water consumption data for 2022, for instance, raises curiosity and suggests the need for investigation into data collection practices or potential changes in university facilities.

This in-depth comparative analysis goes beyond presenting raw data; it serves as a diagnostic tool, unravelling trends, anomalies, and statistical variations. By elucidating these patterns, the Power BI dashboard empowers stakeholders to make informed decisions, identify areas for improvement, and advance sustainability objectives effectively.

4.11 Network Structure for Comprehensive Monitoring

In the process of accomplishing the sustainability goals outlined in the Sustainability Strategy 2030. Supporting CZU in achieving and surpassing its environmental goals is the recommended network architecture for comprehensive surveillance, which has been thoughtfully designed to suit its specific requirements. The suggested network system shown below in Fig 17, gathers weather data and skilfully combines gas, water, and electricity consumption monitoring and control across the whole university campus



.*Figure 17: Network Diagram for collecting data effectively (Own Work)*

Description of the network diagram:

- Gas and Water Flow: The university receives its gas and water supplies through specially designed metres that allow for precise measurement.
- The flow of electricity: Provided via primary metres to monitor the overall consumption of the university. Distributed further to building metres for monitoring in specific areas. Submeters provide detail at particular locations in every building.
- Data Lake: Centralised location where raw consumption data is kept combined with meteorological information to offer context.
- Data Processing: Processing is done on raw data to clean it up and make it normal. After processing, data is routed to web interfaces, applications, and reporting

5 Result and Discussion

This study's practical section explores the critical function of an energy consumption dashboard as a strategic instrument for achieving ČZU's zero-emission objectives. Numerous insights were obtained from the information using the Power BI dashboard, which provided visually accessible visualisations that offered a thorough understanding of demand patterns, energy consumption trends, and the resulting environmental impact. Stakeholders in energy management benefit greatly from this resource, which gives them the knowledge and skills to make wise decisions and promotes a flexible, sustainable strategy.

Furthermore, the suggested network architecture offers a thorough rundown of the system intended to monitor water, power, and gas consumption. The network topology that has been implemented allows ČZU to have more control over how much energy it uses. The incorporation of weather information enhances decision-making abilities by offering significant perspectives on seasonal fluctuations. Additionally, reporting, application development, and web interfaces all depend on the data processing stage.

An important part of my research was utilising Python to clean the data before building the Power BI display. The precision and dependability of the conclusions drawn were made possible by the data cleaning process, which involved finding and fixing mistakes or inconsistencies in the information. The flexible frameworks and tools available in Python allowed for effective data cleansing, which enhanced the overall reliability of the results. The dashboard's visualisations were improved by the cleaned dataset, which also gave users more trust in the validity of the findings reached. This thorough data cleaning procedure is the first step in the process, demonstrating how crucial high-quality data is to the effective setup and use of the energy usage dashboard.

Essentially, a thorough framework is established by combining a potent visualisation tool like Power BI with an organised network architecture and efficient data cleansing using Python. In the final phase of the dashboard development, the significance of comprehensive documentation cannot be overstated. Documentation serves as the cornerstone for transparency and reproducibility, ensuring that the processes and insights derived are accessible and understandable. A thorough documentation package accompanies the dashboard, covering key aspects such as data sources, processing steps, and assumptions made during the analysis. This documentation not only enhances transparency but also facilitates reproducibility, allowing stakeholders to revisit the methodology, understand the intricacies of data processing, and validate the findings. The content of the documentation provides clarity on the origins of the data, the sequence of processing steps applied, and the assumptions that underpin the analysis. This commitment to detailed documentation aligns with best practices in ensuring the integrity and reliability of the insights derived from the dashboard.

In addition to providing ČZU with the resources required for strategic energy management, this framework guarantees the validity and applicability of the conclusions drawn. The study contributes to the overall sustainability goals of the university by highlighting the synergy between data processing, strategic decision-making, and technical implementation.

6 Conclusion:

In conclusion, the integration of Green Deal principles with Information Technology (IT) presents a crucial framework for environmentally conscious growth and sustainable development. The literature review has covered a wide range of topics related to the intersection of IT and environmental sustainability. These topics include Green IT, renewable energy integration, smart cities, IoT applications for environmental monitoring, the use of big data and analytics, blockchain transparency, and the laws that impact sustainable practices. Every component supports the main objective of reducing environmental effects and promoting a resilient, environmentally friendly future.

This thesis's practical section focuses on using IT solutions to help the Czech University of Life Sciences (ČZU) achieve its sustainability objectives. The creation of an energy consumption dashboard through design and implementation, made possible by the recommended network architecture and the use of Power BI and Python for data cleansing, serve as examples of how the theoretical frameworks studied have practical applications. This all-encompassing strategy not only helps ČZU manage its energy consumption, but it also fits in well with its adherence to the Green Deal and other sustainability goals.

The proposed network architecture gives ČZU a tool that goes beyond simple supervision by offering a strong foundation for tracking gas, electricity, and water usage. By incorporating weather data, it makes informed decision-making easier and enables the university to respond quickly to seasonal variances. Moreover, the focus on utilising Python for data cleansing prior to creating a dashboard highlights the fundamental significance of data quality in guaranteeing the precision and dependability of the conclusions drawn.

This thesis emphasises the revolutionary potential of information technology in promoting sustainability across several industries in the context of Green IT and the Green Deal. The literature explores the theoretical setting, and ČZU's practical application validates the relevance and effectiveness of these theories in an actual context. Organisations and institutions like ČZU may actively contribute to the global aim of developing a greener and more sustainable future, while also minimising their environmental imprint, by embracing IT solutions. Technology and sustainability are emerging as powerful forces that work together to shape a future that is both technologically advanced and environmentally sensitive.

7 References

- ➢ European Green Deal Policy Guide. (2021b, November 15). KPMG. https://kpmg.com/xx/en/home/insights/2021/11/european-green-deal-policy-guide.html
- ➢ Delivering the European Green Deal. (2021, July 14). European Commission. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en
- ➢ European Green Deal - Consilium. (2023, October 22). European Council. https://www.consilium.europa.eu/en/policies/green-deal/
- ➢ The EU Green Deal explained. (n.d.). Global Law Firm | Norton Rose Fulbright. https://www.nortonrosefulbright.com/en/knowledge/publications/c50c4cd9/the-eu-green-deal-explained
- ➢ The European Green Deal: How the 27 EU countries are preparing for 2050. (2023, April 17). https://www.enel.com/company/stories/articles/2023/04/european-green-deal
- ➢ The economics of climate change. (n.d.). Google Books. https://books.google.cz/books?hl=en&lr=&id=U-VmIrGGZgAC&oi=fnd&pg=PA3&dq=%22The+Economics+of+Climate+Change:+The+Stern+Review%22+by+Sir+Nicholas+Stern&ots=9fv10wkukb&sig=OCHTU3eg1NZeMgu7a62oBJSj_vk&redir_esc=y#v=onepage&q&f=false
- ➢ The European Green Deal - European Climate Foundation. (n.d.). European Climate Foundation. https://europeanclimate.org/the-european-green-deal/
- ➢ The EU Green Deal explained. (n.d.-b). Global Law Firm | Norton Rose Fulbright. https://www.nortonrosefulbright.com/en/knowledge/publications/c50c4cd9/the-eu-green-deal-explained
- ➢ Carbon neutrality by 2050 is still achievable despite energy crisis, according to new UN report | UNECE. (2022, September 19). https://unece.org/climate-change/press/carbon-neutrality-2050-still-achievable-despite-energy-crisis-according-new-un
- ➢ Politico. (2020, December 26). What is the Green Deal? POLITICO. https://www.politico.eu/article/what-is-the-green-deal/
- ➢ Carbon neutrality by 2050: the world's most urgent mission | United Nations Secretary-General. (2020, December 11).

https://www.un.org/sg/en/content/sg/articles/2020-12-11/carbon-neutrality-2050-the-world%E2%80%99s-most-urgent-mission

- Simon, F., & Simon, F. (2022, April 6). EU Commission lays out plan to become climate neutral by 2030. www.euractiv.com. https://www.euractiv.com/section/energy/news/eu-commission-lays-out-plan-to-become-climate-neutral-by-2030/
- Wikipedia contributors. (2023b, November 19). European Green Deal. Wikipedia. https://en.wikipedia.org/wiki/European_Green_Deal
- Wikipedia contributors. (2023b, November 19). European Green Deal. Wikipedia. https://en.wikipedia.org/wiki/European_Green_Deal
- Energy, E. C. (2023, November 2). Geothermal HVAC Systems A Sustainable Solution for Data Centers. Energy5. https://energy5.com/geothermal-hvac-systems-a-sustainable-solution-for-data-centers#anchor-0
- 12 of world's largest investors make bold commitment to net zero emissions. (n.d.). https://www.unepfi.org/industries/investment/at-climate-action-summit-today-12-of-worlds-largest-investors-make-unprecedented-commitment-to-net-zero-emissions/|
- Ward, D., Melbourne‑Thomas, J., Pecl, G., Evans, K., Green, M., McCormack, P. C., Novaglio, C., Trebilco, R., Bax, N., Brasier, M., Cavan, E. L., Edgar, G., Hunt, H. L., Jansen, J., Jones, R., Lea, M., Makomere, R., Mull, C., Semmens, J. M., . . . Layton, C. (2022). Safeguarding marine life: conservation of biodiversity and ecosystems. Reviews in Fish Biology and Fisheries, 32(1), 65–100. https://doi.org/10.1007/s11160-022-09700-3
- The Green Deal: Origins and Evolution - Groupe d'études géopolitiques. (n.d.). Groupe D'études Géopolitiques. https://geopolitique.eu/en/articles/the-green-deal-origins-and-evolution/
- Wildlife Conservation Society. (2022, June 2). At least 44% of Earth's land requires conservation to safeguard biodiversity and ecosystem services. Phys.org. https://phys.org/news/2022-06-earth-requires-safeguard-biodiversity-ecosystem.html
- How can you protect biodiversity? | Royal Society. (n.d.). https://royalsociety.org/topics-policy/projects/biodiversity/how-can-you-protect-biodiversity/

➢ Safeguarding people and biodiversity. (n.d.). UNEP - UN Environment Programme. https://www.unep.org/explore-topics/forests/what-we-do/safeguarding-people-and-biodiversity

➢ Safeguards & multiple benefits | UNREDD Programme. (n.d.). UNREDD Programme. https://www.un-redd.org/work-areas/safeguards-multiple-benefits

➢ Corlett, R. T. (2020). Safeguarding our future by protecting biodiversity. Plant Diversity, 42(4), 221–228. https://doi.org/10.1016/j.pld.2020.04.002

➢ Crespy, A., & Munta, M. (2023). Lost in transition? Social justice and the politics of the EU green transition. Transfer: European Review of Labour and Research, 29(2), 235–251. https://doi.org/10.1177/10242589231173072

➢ Olivia. (2019, March 4). A green new deal must be rooted in a just transition for workers and communities most impacted by climate change - Climate Justice Alliance. Climate Justice Alliance. https://climatejusticealliance.org/green-new-deal-must-rooted-just-transition-workers-communities-impacted-climate-change/

➢ Admin. (n.d.). Social Goals for the European Green Deal – How can we ensure a Just Transition? https://sdgwatcheurope.org/social-goals-for-the-european-green-deal-how-can-we-ensure-a-just-transition/

➢ David. (2023). Exploring the Potential of Geothermal HVAC Systems as Sustainable Alternatives for Energy-Efficient Heating and Cooling: A Comprehensive. OMICS International. https://doi.org/10.4172/2576-1463.1000337

➢ The Future of renewable Energy: IT Solutions by industry | InfoPulse. (2022). Infopulse. https://www.infopulse.com/blog/the-future-of-renewable-energy-it-solutions-by-industry

➢ Safeguarding biodiversity. (n.d.). SLB. https://www.slb.com/sustainability/nature/safeguarding-biodiversity

➢ Usher, A. (2023, September 12). IoT-Based Environmental Monitoring: How IoT technology can help businesses go green. Caburn Telecom. https://caburntelecom.com/iot-environmental-monitoring/

➢ Smart cities. (n.d.). European Commission. https://commission.europa.eu/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en

➢ Smol, M. (2022). Is the green deal a global strategy? Revision of the green deal definitions, strategies and importance in post-COVID recovery plans in various regions of the world. Energy Policy, 169, 113152. https://doi.org/10.1016/j.enpol.2022.113152

➢ Green New Deals: The role of business. (n.d.). ERM. https://www.sustainability.com/thinking/green-new-deals-the-role-of-business/

➢ Carpenter, D. (2023, September 5). What is green information technology (Green IT) & why should businesses follow it? CACI. https://www.caci.co.uk/insights/opinions/what-is-green-information-technology-green-it-why-should-businesses-follow-it/

➢ D'Souza, D. (2022, May 28). Understanding the Green New Deal & What's in the Climate Proposal. Investopedia. https://www.investopedia.com/the-green-new-deal-explained-4588463

➢ UNICON: an open dataset of electricity, gas and water consumption in a large Multi-Campus university setting. (2022, July 28). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/9869498

➢ *What is green IT (green information technology)?* (n.d.). Techtarget. Retrieved September 29, 2023, from https://www.techtarget.com/searchcio/definition/green-IT-green-information-technology

➢ Atherton, L. (n.d.). *Meet the Future: Big Data and Sustainability Solutions*. https://seas.umich.edu/.https://seas.umich.edu/stewards/spring-2023/meet-future-big-data-and-sustainability-solutions

➢ Big Data for Sustainabl eDevelopment.(n.d.).https://www.un.org/en/global-issues/big-data-for-sustainable-development

➢ *Blockchain Technology and the Future of Sustainability*. (n.d.). https://www.computerscience.org/resources/blockchain-and-sustainability/

➢ *Embracing sustainable innovation: understanding the environmental impacts of blockchain technology*. (n.d.). https://www.pwc.com/us/en/services/digital-assets/blockchain-environmental-impact.html

Colaboratory. (n.d.). https://research.google.com/colaboratory/faq.html

Uncover powerful insights and turn them into impact. (n.d.). https://www.microsoft.com/en-us/power-platform/products/power-bi

- CSR Report 2019. (n.d.). *https://csr.czu.cz/cs/r-13686-strategie-a-zprava-o-udrzitelnosti*. https://www.dcceew.gov.au/sites/default/files/documents/national-greenhouse-accounts-factors-2022.pdf
- Budnakova, T. (2013). *Horizon 2020 Work Programme for research & Innovation 2018-2020* [Slide show].
- CSR Report 2019. (2019). https://csr.czu.cz/cs/r-13686-strategie-a-zprava-o-udrzitelnosti. https://www.dcceew.gov.au/sites/default/files/documents/national-greenhouse-accounts-factors-2022.pdf
- Czech University of Life Sciences. (2020). Sustainability Strategy 2030. https://csr.czu.cz/cs/r-13686-strategie-a-zprava-o-udrzitelnosti.
- Moraliyage, H., Mills, N., Rathnayake, P., De Silva, D., & Jennings, A. (2022). UNICON: An Open Dataset of Electricity, Gas and Water Consumption in a Large Multi-Campus University Setting. UNICON Energy Consumption Dataset. https://doi.org/10.1109/hsi55341.2022.9869498
- Budnakova, T. (2013). Horizon 2020 Work Programme for research & Innovation 2018-2020 [Slide show].
- Sorri, A. (2021, September 28). What is a smart city? *SECURE INSIGHTS*. Retrieved October 10, 2023, from https://www.axis.com/blog/secure-insights/what-smart-city/?utm_source=Enews&utm_medium=Partner

8 List of pictures, tables, graphs and abbreviations

8.1 List of pictures

8.2 List of tables

8.3 List of Code