Data Management for Strategy Dashboards

proactive data asset management for the circular economy to support the achievement of its business objectives

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Declaration of honour

I declare on my word of honour that I have written this Bachelor Thesis on my own and that I have not used any sources or resources other than stated and that I have marked those passages and/or ideas that were either verbally or textually extracted from sources. This also applies to drawings, sketches, graphic representations as well as to sources from the internet. The Bachelor Thesis has not been submitted in this or similar form for assessment at any other domestic or foreign post-secondary educational institution and has not been published elsewhere. The present Bachelor Thesis complies with the version submitted electronically.

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Abstract

Circular economy has drawn more attention recently as a way to encourage sustainable development and reduce the negative effects of human activity on the environment. As policymakers and businesses in Austria work towards achieving circular economy objectives, effective decision-making tools are essential for monitoring progress and guiding strategic actions. This bachelor thesis presents the development of a strategy dashboard for Austria's circular economy, with a focus on data management and visualization techniques to support informed decision-making.

The research goals of this study are: to identify the key characteristics of a strategy dashboard tailored to Austria's circular economy, to determine relevant indicators and data sources for assessing circularity, to investigate the opportunities and challenges in developing and implementing data management strategies, and to provide suggestions for upgrading data sources.

To address these objectives, the thesis outlines the development process of the dashboard using Python, and Django, from design and implementation to testing and evaluation. The dashboard incorporates a range of indicators including recycling rates, energy consumption, and management of waste and their data sources, in order to offer an exhaustive overview of Austria's circular economy. A user-friendly visualization tool(interactive charts) is employed to make the data easy to understand and actionable.

The results of the thesis demonstrate how effectively the developed dashboard supports strategic decision-making for Austria's circular economy. The dashboard's data management and visualization techniques enable users to track and apprehend relevant metrics, identify trends, and make informed decisions. Additionally, the research highlights potential improvements and future work to further enhance the dashboard's capabilities and address any limitations.

In conclusion, this thesis contributes to the field of study by offering a practical tool for monitoring and managing Austria's circular economy. The developed strategy dashboard not only aids decision-makers but also serves as a valuable resource for researchers and practitioners seeking to advance sustainability efforts in the country.

Keywords: Circular economy, Django, Python, Strategic Dashboard, Data Management, Data-driven decision-making, Web application

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Introduction

In today's digital era, data management has become increasingly important in product creation, serving as a basis for creating value and generating revenues. Product development, a temporary activity carried out to produce a distinctive product, often faces constraints in terms of time and funding. Therefore, it is essential to have well-managed data management protocols to reduce potential errors, ensure productivity, and increase security [1].

Dashboards are widely used in product creation to present data and insights through visualization software. They can be applied in various fields, including construction, advisory reports, and software development. Proactive data asset management, involving the active management of data throughout its life cycle, is crucial for ensuring the accuracy, reliability, and accessibility of data in dashboards [2].

In this context, data management reduces potential errors through an agreed protocol that guides actions, builds trust, and supports decision-making [3]. Effective data management ensures productivity and security while enhancing customer service and fostering long-lasting customer relationships [4].

Circular economy, a sustainable economic model that prioritizes the reuse and recycling of materials to minimize waste and reduce environmental impact, is gaining significant recognition. Austria has set ambitious targets for transitioning towards a circular economy, aiming to maximize resource utilization through the equal participation of public and private sectors [5]. However, challenges such as a lack of technological capabilities and financial resources impede its progress.

Proactive data asset management can be extremely crucial in supporting Austria's circular economy. A strategy dashboard can help organize and present relevant data points and metrics to drive sustainability and minimize waste. Studies

for example, the Ellen MacArthur Foundation report [6], emphasize the need for businesses to develop a comprehensive understanding of data associated with the circular economy to drive innovation as well as open up new business prospects.

This thesis aims to explore the role of proactive data asset management in supporting Austria's circular economy to achieve its business objectives. We will examine the difficulties Austria is having in establishing a circular economy and discuss best practices for data management, including data quality, and data security. By effectively managing data assets, we can support Austria's evolution to a circular economy and maximize the effectiveness of its resources.

1.1 Problem Statement

In this study, the problem is the uniqueness of the topic i.e. the circular economy of Austria using dashboard strategies. There isn't much information available on this subject, which demonstrates that less attention has been paid to applying data management at the national level because other studies mostly concentrate on a particular project or sector [7]. In this context, lack of confidence in dashboard strategy is also a problem since there have been no successful case studies (at the time of research, there have been no studies found on a country level) that determine data management is quite effective in facilitating this project i.e. establishing a circular economy.

1.2 Research Objective

The following are the research objectives of the study:

- To identify the dashboard's characteristics that are required for proper tracking and understanding of Austria's circular economy. This entails defining the most important metrics and data sources for assessing circularity in Austria as well as the best layout and visualizations for displaying this information on the dashboard.

- To determine the relevant indicators and the sources of these indicators that can be utilized to gather precise and thorough data on Austria's circular economy. Reviewing existing research and studies on circular economy indicators

is required in order to determine which ones are most pertinent to the Austrian economy. The study will also look into potential new data sources that might be used to close any gaps in the available data.

- To investigate the opportunities and challenges involved in developing and implementing data management and dashboard strategies for the circular economy in Austria. This involves analyzing barriers to data collection and management and evaluating the likelihood of stakeholder collaboration and coordination to improve data availability and quality.

- To Provide appropriate suggestions for modernizing and upgrading the dashboard's data sources and administration techniques for those indicators in the dashboard.

1.3 Research Question

The main research questions to be probed in this study are as follows:

- What kind of tool support is needed for managers responsible for strategic decision-making in the context of Austria's circular economy?

  – How can this tool be designed to maximize its impact on decision-making processes?

1.4 The rationale of the Study

This study's contribution to dashboard strategies for the circular economy and the data management sectors is what gives it its significance. Despite the existence of literature on the topic, few studies have focused on how data management and dashboard techniques for the circular economy are applied nationwide [8].

The study's findings could close a knowledge vacuum in this field and offer insightful information about how to use dashboards and data management to further the goals of the circular economy. The study's conclusions can therefore help to clarify the Austrian circular economy and offer strategies for improving it.

Additionally, the insights obtained through this study can be applied by businesses and governments interested in implementing strategies for the circular economy as well as researchers looking into data management and dashboard

techniques [9]. This study aims to address key issues such as the qualities of dashboards that may assist in understanding the circular economy, the sources and indicators of information about the circular economy in Austria, along with the challenges of data management and dashboard strategies.

The study's importance ultimately resides in its potential to offer practical and relevant recommendations for updating the data for the dashboard's circular economy metrics, which will help Austria and other countries establish successful circular economy plans [10].

2

Technical and Theoretical Background

Understanding the state of knowledge, practices, and trends in these fields becomes more and more important as we delve deeper into the worlds of circular economy and data management. The concept of circular economy, its applications in Austria, and the crucial role data management and dashboard strategies play in supporting this economic model are all explored in this chapter. data sources and difficulties will also be looked at in locating and utilizing the data required to support a circular economy. In order to inform this study and, ultimately, better understand how to develop a more efficient and sustainable circular economy in Austria, existing literature will be reviewed in the final step.

This chapter investigates the relevant studies, methods, and developments in the circular economy and data management domains with the goal of providing a strong foundation for our research. As we proceed through this chapter, we will learn a lot about the circular economy's complexities, the significance of dashboard strategies, and the difficulties Austria has faced in implementing its circular economy ambitions. The subsequent chapters of this thesis, in which we delve deeper into the methodology, findings, and recommendations of our research, will be significantly influenced by this knowledge.

2.1 Circular Economy

2.1.1 Definition and Principles

Circular economy is a model in economics that encourages the reuse, repair, refurbishing, and recycling of materials and products throughout their lifespans in order to minimize waste and maximize the value of resources. [11]. The circular economy emphasizes reducing resource consumption, prolonging product life cycles, and limiting environmental consequences in contrast to the conventional linear paradigm of "Take-Make-Dispose" [12].

The three core principles of the circular economy have been recognized by the Ellen MacArthur Foundation: dispose of waste and pollution, reuse resources and products, and revive natural systems [13]. These principles emphasize the importance of designing products and processes to minimize waste generation, maximizing the utilization and value of resources, and restoring natural resources and ecosystems.

In a circular economy, materials are utilized, reused, and recycled again in a closed loop to reduce waste and pollution. It serves as an alternative to the conventional linear economy, which uses resources to be harvested, utilized, and ultimately wasted. A circular economy aims to boost the economy, generate jobs, and lessen its negative effects on the environment [14].

2.1.2 Circular Economy in Austria

Austria has taken the initiative to move toward a circular economy. The Austrian government has introduced various strategies and policies to assist with this transition, including the Circular Economy Strategy [16] and the Austrian Resource Efficiency Action Plan (REAP) [17]. The importance of circular economy concepts is primarily due to their potential to address environmental and climate policy issues while opening up new economic opportunities and promoting the efficient use of resources [18].

The more effective use of resources, prolonging product lifecycles, lowering manufacturing output, and eliminating waste are three key pillars of the green transformation toward a circular economy [9]. However, cycle-oriented innovation activities have so far only played a subordinate role in the Austrian innovation system, both in absolute terms and proportionately [19].

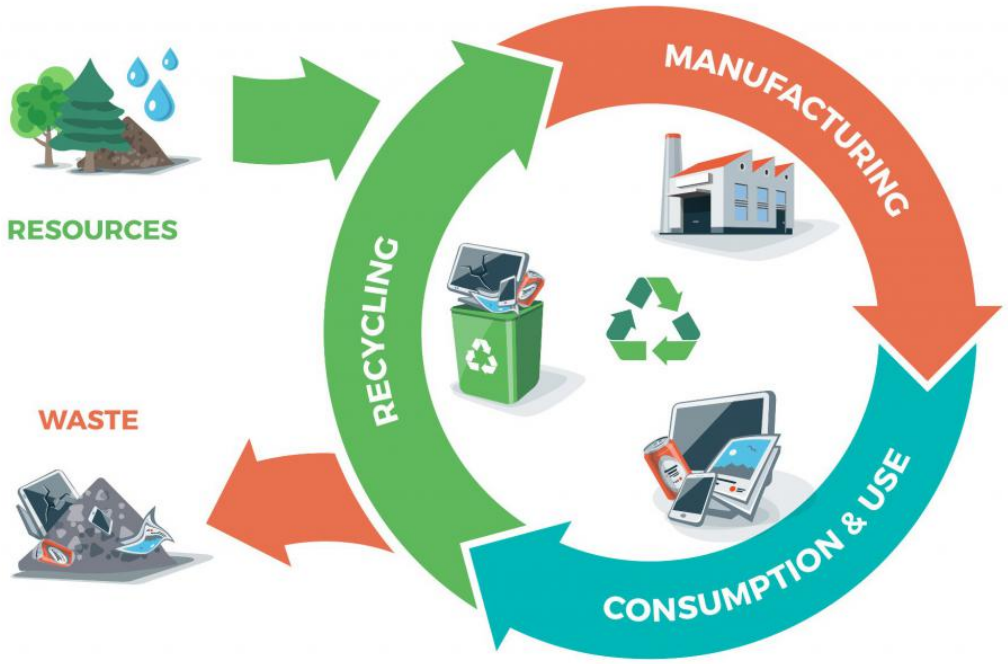


Figure 2.1: circular economy
[15]

In the European Union, the Green Deal relies on close integration with industrial policy when it comes to the circular economy. Austria's government program 2020-2024 announces the development of a strategic plan of measures for environmental technologies and the closed-loop and recycling economy (Austrian Federal Government 2020). Numerous projects are detailed, ranging from tax breaks for small repair services to the expansion of reusable systems, financial incentives, and removing regulatory obstacles for using secondary raw materials in the industry.

Austria has also developed an Austrian circular economy strategy that defines the guiding framework for the next few years [16]. This strategy identifies numerous points of contact and interfaces to existing programs and strategic documents. Furthermore, Austria has also established circular economy clusters and networks, such as the Circular Economy Platform Austria, which brings together businesses, research institutions, and public authorities to collaborate on circular economy projects and share best practices. These joint initiatives play a critical role in facilitating information sharing, stimulating innovation, and advancing the implementation of circular economy ideas across the nation [20].

In an attempt to quantify innovation activities in the circular economy sector, Reinstaller et al. (2022) [18] present several indicators, which, despite certain limitations, provide a positive overall picture for Austria. Weak outcomes in the sectors of trade balance and patents pertaining to the circular economy are what led to the overall outcome. This gap shows that there is still some catching up to do.

A similar picture emerges when analyzing patent applications in relevant fields of technology by Austrian inventors. Austria produces technologically and commercially relevant inventions in the areas of circular economy and supporting technologies, even if they are of little importance in the Austrian innovation system. This also seems to be reflected in the trade of goods, where a trade balance surplus can be observed in the area of goods and services relevant to the circular economy.

In summary, Austria has made substantial efforts in transitioning towards a circular economy. Despite this, there is always potential for improvement, especially when it comes to innovation, patent applications, and the overall integration of circular economy principles into the Austrian innovation system.

2.1.3 Measurement and Definition of the Circular Economy Indicators

A collection of precise indicators that reflect the essential features of circularity is necessary to track the growth of the circular economy. These indicators may be used by businesses and policymakers to gauge the success of circular economy strategies and pinpoint areas that require improvement [21]. The establishment of a set of indicators that may gauge multiple aspects of circularity is crucial for the successful implementation and tracking of the development of the circular economy. These indicators often fall into three groups: management of waste, the efficiency of resources, and the impact on the environment [22].

In the European context, Eurostat has developed a framework to observe the circular economy that includes a selection of indicators to track the development of circular economy policies by EU member states [23]. These indicators cover areas such as waste generation, recycling rates, use of secondary raw materials, and circular economy innovations.

Category	Indicator
Resource Efficiency	Material productivity
	Energy efficiency
	Water efficiency
Waste Management	Waste generation
	Recycling rate
	Landfill diversion rate
Environmental Impact	Greenhouse gas emissions
	Air pollution
	Biodiversity loss

Table 2.1: Examples of Indicators to measure the Circular Economy

In order to track Austria's progress in transitioning to a circular economy, both the Circular Economy Strategy and the Circular Economy Platform utilize specific national indicators in addition to these European ones [16] [20]. For the first time, efforts have been made in this context to evaluate innovative activity in the domain of the circular economy. However, there are two methodological limitations that must be considered when interpreting the results:

- The transformation of the economy based on circular economy principles requires extensive social, institutional, and societal innovations, as well as cross-company innovations and investments in infrastructure. These can lead to coordination failures and necessitate public intervention. At the level of individual companies, innovations in business models, logistics organization, and other areas are required. While new technological innovations are essential, they are not sufficient for a successful transformation process. considering this, restricting the available indicators to R&D, innovation, and trade in goods associated with circular economy developments and goods only provides a restricted view [18].

- Due to the absence of a common understanding of what defines "circular economy" among researchers and practitioners, it is difficult to draw exact statistical distinctions between innovation and trade in goods connected to circular economy technology. Existing classifications of environmental technologies and products often overlap with central, generally accepted principles of the circular economy. To achieve a more precise definition, more detailed analyses of individual technology classes or product categories would be required [18].

Considering these limitations, the evaluation of the indicators used for the circular economy presents a positive overall picture for Austria, even though the overall indicator for the circular economy is below the level of the innovation leaders. There is still an opportunity for improvement, as seen by the overall result's unsatisfactory outcomes in the circular economy's trade balance and patents sectors. This allows Austria to align its efforts with European policies while also addressing the unique challenges and opportunities within its national context.

Figure 2.2: Overview of Circular Economy Indicators

- Resource productivity: The economic output per unit of resource input is measured as resource productivity, which may be used to evaluate how effectively resources are utilized.

- Recycling rate: The recycling rate measures the percentage of waste that is recycled, which can indicate the level of resource efficiency in a circular economy.

- Renewable energy share: Renewable energy share measures the proportion of energy generated from renewable sources, which can indicate the level of decoupling of economic growth from fossil fuel use.

- Greenhouse gas emissions: Greenhouse gas emissions measures the number of greenhouse gases emitted, which can indicate the level of the environmental impact of an economy.
- Employment: Employment measures the number of jobs created by the circular economy, which can indicate the level of economic growth and social benefits.
- Circularity index: A circularity index is an assessment that shows the potential of a Product for circularity throughout its lifespan, as evaluated by a number of circularity metrics.
- Material consumption: Material consumption measures the use of materials in an economy, indicating the level of resource consumption.
- Water consumption: Water consumption measure shows the use of water in an economy, indicating the level of water consumption.

These indicators [14] can be used to track progress over time and to compare different countries, regions, and sectors in terms of circular economy performance.

2.2 Data Management and Dashboard Strategies

Effective data management and dashboard techniques are critical for advancing the circular economy by delivering actionable insights and allowing strategic decision-making [8]. These strategies enable stakeholders to track the impact of circular economy efforts and identify areas for improvement.

2.2.1 Role of Data Management in Circular Economy

Data management is indispensable in the circular economy because it ensures that reliable, precise, and timely data is accessible to assist informed decision-making. This involves collecting, processing, storing, and analyzing data related to various circular economy indicators and metrics. By efficiently managing data, organizations and policymakers can:

- Monitor progress: Data management helps track the performance of circular economy initiatives, allowing stakeholders to assess the effectiveness of their strategies and identify areas for improvement [21].

- Benchmark performance: Comparing data across different sectors, regions, or time periods can help stakeholders identify best practices, set targets, and evaluate their performance relative to other entities [24].

- Identify trends and patterns: Analyzing data can reveal trends and patterns that may inform future policies or strategies, such as emerging opportunities, challenges, or risks [14].

- Enhance transparency and accountability: Effective data management promotes transparency by making information on circular economy performance readily available to stakeholders, fostering accountability, and driving continuous improvement [10].

Dashboard strategies, in particular, can be a valuable tool for visualizing and communicating circular economy data in an easily accessible and understandable format [25]. Dashboards can be designed to display key indicators and metrics in real-time, allowing stakeholders to monitor progress, identify trends, and make informed decisions. Additionally, dashboards can facilitate collaboration among stakeholders by providing a shared platform for accessing and discussing data, promoting collective action towards circular economy goals [26].

Ultimately, data management and dashboard approaches are vital for expanding the circular economy by providing stakeholders with the insight and resources that they require to make strategic decisions and promote sustainable development. Organizations and policymakers may collaborate to build a more resource-efficient and sustainable future by using data efficiently.

2.2.2 Tool Support for Strategic Decision-Making: The Dashboard

Dashboards have become an essential tool for strategic decision-making in various domains, including the circular economy. They offer a user-friendly and visually appealing way to present complex data, helping stakeholders easily monitor, analyze, and understand critical information. Dashboards allow organizations to make well-informed decisions by presenting data in real-time and enabling users to identify trends and patterns in the data [27].

Stakeholders may evaluate progress towards circular economy goals and pinpoint areas where adjustments are required by using dashboards that highlight

important indicators and data relating to resource effectiveness management of waste, and the impact on the environment, among other things [25]. Furthermore, by providing a shared platform for accessing and discussing data, dashboards can facilitate collaboration among stakeholders and promote collective action towards circular economy objectives [10].

Several recent studies have explored the development and implementation of dashboards for supporting decision-making in the circular economy. For example, a study by a Local authority Amsterdam [28] presents the design of a dashboard to visualize circular economy indicators for Dutch provinces, highlighting the importance of user-centered design and stakeholder engagement in the development process. Similarly, a study on Sustainability (2021) [29] introduces a web-based dashboard for monitoring and evaluating circular economy initiatives in Italian regions, emphasizing the role of real-time data and user-friendly visualizations in enhancing decision-making capabilities.

These examples demonstrate the potential of dashboards as valuable tools for strategic decision-making in the circular economy, helping stakeholders make better-informed choices and contributing to the overall progress toward circularity.

Why Dashboard? The Austrian Council for Research and Technology Development (RFTE), is searching for a solution that can handle data sources and help managers make strategic decisions. In my study, I learned about the concept of creating a dashboard that would let users measure indicators for the circular economy, locate up-to-date data sources so they could create action plans, and make data-driven decisions.

2.2.3 Purpose and Characteristics of the Dashboard

Dashboards are powerful tools for visualizing and communicating complex information in a user-friendly format. According to Few, an effective dashboard should display data in a clear, concise, and visually appealing manner, enabling users to quickly understand and interpret the information presented [27]. The primary purpose of a dashboard is to support strategic decision-making by providing relevant, up-to-date information on key performance indicators and metrics.

Dashboards can potentially be extremely beneficial in the circular economy environment for tracking progress and flagging areas that need more attention or development. Dashboards have the potential to be cutting-edge visualization tool that promotes and tracks the circular economy in a variety of industrial sectors,

according to Bianchini and Rossi (2021) [25]. These dashboards can be designed to display key circular economy indicators, such as material productivity, recycling rates, and greenhouse gas emissions, helping stakeholders assess the effectiveness of their circular strategies and make data-driven decisions.

A well-designed dashboard for a circular economy should have the following characteristics:

- Relevance: The dashboard should display the most relevant indicators and metrics that reflect the core aspects of circularity, as identified by Antikainen et al. (2017) [10].

- Clarity: To make the information easy for people to understand, it should be delivered in a clear, succinct manner with relevant visuals [30].

- Timeliness: The dashboard should provide real-time or near-real-time data to ensure that decision-makers have access to the most current information available [25].

- Customizability: The dashboard should be customizable to meet the specific needs and requirements of different users, industries, and regions [10].

- Interactivity: Users should be able to interact with the dashboard, exploring the data in greater depth and uncovering insights through data exploration [30].

As a representation of a dashboard that presents important circular economy indicators for European countries and enables policymakers to follow the development and compare efficiency across the European Union, The monitoring framework for the circular economy by Eurostat is a strong contender [23]. By incorporating these characteristics, a dashboard can effectively support strategic decision-making and facilitate collaboration among stakeholders in the transition toward a more circular economy. There are also different types of dashboards that can be operational, tactical dashboards, and strategic dashboards [31]. The table effectively illustrates the differences between these dashboards in terms of their purpose, scope, users, primary activities, focus, data refresh, information, architecture, metrics, and appearance. For a better understanding a table has been given below:

Attribute	Operational	Tactical	Strategic
Purpose	Control operations	Optimize processes	Manage strategy
Scope	Short-term	Mid-term	Long-term
Users	staff+	Managers+	Executives+
Primary Activity	Real-time monitoring	Performance analysis	Strategic planning
Focus	Current	Past	Future
Data Refresh	Real-time	Daily/Weekly	Monthly/quarterly
Information	Detailed	Summary	Aggregate, historical
Architecture	Core systems	Data warehouse	Excel or Data warehouse
Metrics	Drivers	Drivers/Outcomes	Outcomes
Looks like a ...	Live feed, ticker board	Metrics Portal	Executive summary/Scorecard

Table 2.2: Comparison of Operational, Tactical, and Strategic Dashboards [31]

2.2.4 Strategy Dashboard for Circular Economy

A strategy dashboard for the circular economy is tailored to help stakeholders navigate the complexities of implementing and monitoring circular economy initiatives. By providing a comprehensive overview of the key performance indicators, the dashboard enables users to identify areas for improvement and assess the effectiveness of their strategies.

One of the key features of a circular economy strategy dashboard is its ability to provide insights and recommendations based on the performance data it displays. This involves analyzing the data and identifying patterns, trends, and potential areas for improvement [25]. Additionally, a strategy dashboard for the circular economy should offer bench-marking capabilities, allowing stakeholders to compare their performance against industry standards, regional or national targets, and best practices [23].

A strategy dashboard can be helpful for several stakeholders in the circular economy, including policymakers, companies, and scholars. The dashboard, for instance, may be used by decision-makers to track the development of circular economy projects and policies, highlight areas that need more attention, and allocate resources appropriately [8]. Businesses can benefit from a circular economy dashboard by identifying opportunities for increased resource efficiency, waste reduction, and innovation, ultimately leading to cost savings and improved competitiveness [10]. Researchers, on the other hand, can use the dashboard to study the effectiveness of different circular economy strategies and identify areas for further research and innovation.

In order to maximize the value and utility of a circular economy strategy dashboard, it is crucial to ensure its integration with a wide range of relevant data sources, as discussed in Section 2.3. This will provide stakeholders with a comprehensive and up-to-date picture of circular economy performance, facilitating informed decision-making and more effective strategies. Furthermore, fostering collaboration among stakeholders and promoting a shared understanding of circular economy goals can be achieved through the use of interactive features, such as discussion forums and data-sharing tools, within the dashboard interface [32].

In summary, a strategy dashboard for the circular economy serves as a valuable tool for stakeholders to monitor progress, identify opportunities for improvement, and make informed decisions. By integrating with relevant data sources and fostering collaboration, the dashboard can contribute significantly to the successful implementation and advancement of circular economy initiatives.

2.3 Data Sources and Challenges

2.3.1 Where to Find Data on Circular Economy Indicators?

Data on circular economy indicators can be obtained from various sources, each providing distinct perspectives and types of information. To establish a precise and comprehensive narrative regarding the development of the circular economy, it is crucial to identify reliable and pertinent data sources [9]. In this section, we discuss the key data sources available for circular economy research. Some possible sources include:

1. National statistical agencies: National statistical agencies can be a valuable source of country-specific data on circular economy indicators. For example, Statistics Austria provides data on waste management, resource efficiency, and recycling rates in Austria [33].

2. International organizations: Several international organizations collect and publish data on circular economy indicators. Some of the prominent organizations include:

- Eurostat: Eurostat, the European Commission's statistical office [23], provides a wealth of data on circular economy indicators as part of its monitoring framework for the circular economy.
- World Bank: The World Bank provides a collection of data sources on matters pertaining to the circular economy, including Renewable energy consumption and CO2 emissions.
- OECD: The Organisation for Economic Co-operation and Development (OECD) provides data on material flows, waste generation, and recycling rates, among other circular economy indicators [34].

3. Industry associations: Industry associations often collect data on sector-specific circular economy indicators. The Ellen MacArthur Foundation [6], for instance, provides information and resources on the circular economy across numerous industries.

4. Research institutions and academia: Academic research institutions may also produce datasets and conduct studies related to the circular economy. For example, the Institute for European Environmental Policy (IEEP) [35] conducts research and publishes reports on circular economy policies and practices.

5. Non-governmental organizations (NGOs): NGOs engaged In circular economy often conduct research and compile data on various aspects of the circular economy. For example, the Global Footprint Network [36] provides data and research on resource consumption and ecological footprint.

6. Private companies: Some private companies may collect and publish data on circular economy indicators as part of their sustainability reporting.

When selecting data sources for circular economy research, it is important to consider the reliability, relevance, and timeliness of the data and It's important to keep in mind that data availability can vary depending on the country and sector, also data may not be directly comparable across different sources due to different methodologies and definitions used.

2.3.2 Identifying and Utilizing Data Sources: A Challenge

Despite there being several sources of data accessible to the study of the circular economy, it can be challenging to find and effectively utilize them. The following are some of the typical challenges researchers and practitioners encounter:

- Data quality and reliability: Data quality and reliability can fluctuate greatly between sources. It is essential to assess data sources closely to make sure that the data is reliable, current, and indicative of the circular economy variables being monitored [37].

- Data consistency and comparability: For circular economy indicators, various data sources may employ various methodologies, units of measurement, or definitions. This might make it challenging to combine data from several sources for analysis or to compare data from various sources and nations [38].

- Data availability and accessibility: For some indicators or geographical areas in particular, access to relevant and accurate data may be restricted. Data may not be publicly available at all or may just be restricted owing to proprietary or confidentiality considerations. Data from huge datasets or complicated databases may occasionally be accessible but challenging to access or extract [39].

- Data granularity and timeliness: Researchers' and practitioners' demands might not always be met by the degree of information and regularity of data updates. Instead of reporting data at the sector, business, or product level, which may be more relevant for analyses of the circular economy, data, for instance, may be presented at an aggregated national or regional level. Moreover, data may not be updated regularly enough to represent new developments or trends in the performance of the circular economy [40].

The development of standardized methodologies and reporting frameworks for circular economy indicators should be promoted in order to address these problems. Researchers and practitioners should also collaborate with data providers to improve data quality and availability. By doing this, they can improve the data's usability and quality for analysis, policy development, and decision-making in the circular economy.

3

Related Work

3.1 Literature Review

3.1.1 Current Practices and Challenges

In recent years, data management and dashboard strategies have become increasingly important for the effective implementation of the circular economy. Many studies have highlighted the crucial role of data management in supporting decision-making processes and promoting circular practices [25]. The circular economy has gained prominence due to its potential to address environmental and economic issues [6], and many nations are studying it as a means of increasing resource efficiency and reducing waste.

As more businesses and organizations adopt circular economy principles, various practices and challenges have emerged in implementing circular business models. Antikainen et al. (2017) [10] identified several barriers to circular economy business model innovation, including lack of market demand, regulatory issues, and difficulties in collaborating with external partners. These challenges highlight the need for effective strategies and partnerships to successfully implement circular economy practices.

While circular economy SMEs in Finland utilize data to support decision-making at both the strategic and operational levels, Järvenpää et al. (2021) [41] found that there is still scope for enhancements to their data utilization method. The adoption of predictive analysis methods could greatly enhance decision-making and help SMEs better prepare for operational changes, optimize their operations, and develop their competitive advantage. Rapid changes in business environments, competition, and legislation present both challenges and opportunities for circu-

lar economy SMEs. Developing dynamic capabilities related to data utilization is essential for exploring future challenges and opportunities.

With the use of a comprehensive collection of indicators, Eurostat [23] has developed a framework for monitoring the circular economy and tracking progress towards its objectives. However, data availability and comparability across countries and sectors remain significant challenges for policymakers and practitioners.

Two recent studies conducted in Austria offer novel insights into the situation of the circular economy. Kienberger et al. (2022) [19] found that the most significant circular economy potential lies in energy-intensive sub-sectors. Many technologies relevant to the circular economy have a high degree of maturity and are awaiting transfer to the commercial phase. Reinstaller et al. (2022) [18] provided evidence of technological developments in Austria that aid in the transition to a circular economy. Both studies emphasize the importance of comprehensive economic, social, and RTI policy approaches for successful transformation.

Overall, these studies highlight the importance of overcoming barriers to circular economy implementation, improving data-driven decision-making, and addressing data availability and comparability challenges to enable effective monitoring and management of circular economy practices.

In addition to these challenges, there are also opportunities for businesses and organizations to leverage data management strategies to support their circular economy practices. For example, businesses can use data analytics tools to identify opportunities for waste reduction or resource efficiency improvements [25]. They can also use data visualization tools to communicate their progress toward circular economy goals to stakeholders [23].

Furthermore, a collaboration between businesses, governments, academia, and civil society can help overcome some of the barriers to implementing circular economy practices. Public-private partnerships, for instance, may facilitate it easier to develop new technologies or infrastructure to assist in a transformation to a circular economy [10]. Collaborative research initiatives can also help identify best practices or develop new approaches to addressing challenges [18].

In conclusion, while there are many challenges to implementing circular economy practices, there are also many opportunities for businesses and organizations to leverage data management strategies and collaborative approaches to overcome these challenges and successfully transition toward a more sustainable future.

3.1.2 Trends and recent developments

In regards to the subject of circular economy, there have emerged a number of developments and trends recently, notably in data management, dashboard strategies, and digital technologies. Bianchini and Rossi (2021) [25] highlight the development of innovative visualization tools to monitor circular economy indicators across different industrial sectors. These tools help organizations track their progress toward circularity and identify areas for improvement.

Digital technologies are also playing an increasingly important role in advancing circular economy practices. The integration of technologies like the Internet of Things (IoT), artificial intelligence (AI), and blockchain is creating new opportunities for optimizing resource use, tracking products throughout their life cycle, and facilitating data sharing among stakeholders [37]. These technological advancements can provide more accurate monitoring and reporting of circular economy indicators and ultimately increase the effectiveness of circular economy operations.

Kienberger et al. (2022)'s [19] study highlights the importance of industry-related recycling loops and the role of waste management in securing raw materials supply for industries. In the context of Austria, the study suggests that further research and development efforts are necessary to exploit the potential of circular economy technologies, particularly in energy-intensive sub-sectors of the industry.

Reinstaller et al.'s study provides a case study on the establishment of circular value chains in the field of lithium-ion batteries in Austria [18]. The study demonstrates the importance of a "whole-of-government" approach, with the Council for Research and Technology Development playing a crucial coordinating role. This emphasizes the requirement for extensive and well-coordinated policies to promote an upsurge to a circular economy.

Furthermore, the adoption of digital technologies and data-driven decision-making is expected to grow in the coming years as businesses and policymakers continue to recognize the potential benefits of these approaches in advancing circular economy objectives. The widespread adoption of circular economy principles and the broader transition toward a more resource-conscious and sustainable economy are likely to be supported by the growing availability of data and the emergence of new digital tools and strategies.

In addition to these advancements and trends, there are also ongoing efforts to develop new approaches to data management for the circular economy. For example, researchers are exploring ways to improve data collection methods to

ensure that data is accurate, timely, and relevant [25]. There are also efforts to develop new data analysis techniques that can provide deeper insights into circular economy practices and support more effective decision-making [41].

Collaboration between corporations, nations, educational institutions, and civil society is also essential for accelerating circular economy principles. Public-private partnerships, for instance, may facilitate the simpler to develop innovative technologies or infrastructure to assist in switching to a circular economy [10]. Collaborative research initiatives can also help identify best practices or develop new approaches to addressing challenges [18].

In conclusion, while there are many challenges to implementing circular economy practices, there are also many opportunities for businesses and organizations to leverage advancements in data management strategies and collaborative approaches to overcome these challenges and successfully transition toward a more sustainable future.

3.2 Review of Circular Economy Data Management Strategies

Data management strategies are increasingly recognized as essential components for the deployment of the circular economy in a successful manner. These strategies can help businesses and organizations collect, analyze, and use data to support their circular economy practices.

One key area where data management strategies can support the circular economy is in monitoring progress toward circular economy goals. For example, the European Environment Agency (EEA) is exploring opportunities to collect and use data from new sources to better understand how the EU economy is changing. The EEA is developing new indicators for circular economy processes that are difficult to monitor with current data, using data sources such as digital fingerprints, openly accessible digital data from search engines or social media platforms, and novel data streams generated by the ongoing digitalization of many processes [42].

In conclusion, data management strategies are essential for advancing the circular economy's adoption. By leveraging advancements in digital technologies and developing new approaches to data management, businesses, and organizations can improve their ability to monitor progress towards circular economy goals, opti-

mize resource use, and collaborate with stakeholders to overcome challenges and successfully transition towards a more sustainable future.

3.3 Research Gaps and Opportunities

Based on the literature analysis and the difficulties mentioned earlier, research gaps and possibilities in the areas of circular economy and data management may be identified. The following are some of the main research opportunities and gaps:

1. **circular economy indicators Standardization:** Despite several indicators having been presented by organizations like Eurostat and the OECD, there is no set of indicators that are widely acknowledged for monitoring the performance of the circular economy. Future research can focus on developing standardized indicators that can be applied across industries and regions to allow for more accurate comparisons and evaluations.

2. **Integration of diverse data sources:** The current literature highlights the need for integrating data from various sources to provide a comprehensive view of the circular economy. Further research can explore methods and tools for effectively combining different data types, formats, and sources to facilitate better decision-making in the circular economy.

3. **Enhancing data quality and reliability:** The quality and reliability of circular economy data remain a challenge. Efforts should be directed toward improving data collection, validation, and verification processes to ensure that decision-makers and researchers have access to accurate and reliable data.

4. **Enhancing data-driven decision-making:** According to the literature, there is still an area for improvement in how circular economy organizations, especially SMEs, apply data-driven decision-making procedures [41]. Further study can analyze the possible advantages of using predictive analytics in the circular economy environment as well as the obstacles to the implementation of data-driven decision-making and create solutions to overcome them.

3.4 Summary on Literature Review

An introduction to the circular economy concept, its indicators, and the role of data management and dashboard strategies in encouraging and monitoring its implementation have been presented in this chapter from the above-discussed literature review. The discussion emphasized the significance of data-driven decision-making in the context of the circular economy and the requirement for trustworthy and easily available data sources.

The literature review presented current practices, challenges, and recent advancements in the field, pointing out the research gaps and opportunities that can be addressed to further advance the understanding and application of circular economy principles. These opportunities include developing more comprehensive and standardized indicators, integrating advanced data analytics and machine learning techniques, enhancing data quality and reliability, creating robust and user-friendly dashboard tools, and fostering data accessibility for all stakeholders.

In order to promote the transition to a circular economy, more effective strategies, resources, and policies must be developed. This may be done by addressing these research gaps and making use of the possibilities that have been recognized.

4

Methodology

4.1 Research Design

This study's research design seeks to create a strategic dashboard prototype for the circular economy, its indicators, and data management. The methodology involves a combination of qualitative and quantitative approaches to ensure a robust analysis and interpretation of data. It will discuss the selection of the technologies used to implement the dashboard and provide an overview of the web application, focusing on UI(User Interface), and usage. The chapter will then discuss the backend of the application, detailing the process of retrieving data on different indicators from various sources such as Eurostat, the World Bank, and the OECD.

4.1.1 Approach: Qualitative vs. Quantitative

the qualitative methodology in this study encompassed thorough literature analysis, in order to fully understand the present state of advancement in the circular economy, metrics, and strategies for data management. This includes identifying challenges and opportunities in the field, as well as recent advancements and trends. This approach helps provide a solid theoretical foundation for the study.

The quantitative approach involves gathering and analyzing data related to circular economy indicators from various sources, such as Eurostat, World Bank, and OECD. The data is then used to design and implement a performance and data management dashboard that effectively communicates the circular economy's progress, trends, and challenges. The quantitative analysis helps validate the findings and provides a more objective perspective on the circular economy.

4.2 Performance and Data Management Dashboard

4.2.1 Data Collection and Data Quality

Data collection involves identifying relevant data sources for circular economy indicators, as well as obtaining and processing the data for analysis. Data on circular economy indicators is collected from several sources, including Eurostat, the World Bank, the OECD, and national statistics agencies. The data covers a variety of circular economy topics, including resource productivity, waste generation and management, employment, innovation, and competitiveness. The data also covers different levels of analysis, such as product, sector, country, and region. The data collection is mainly quantitative in nature but also involves some qualitative analysis of contextual information and explanations.

The data quality of this study Is based on the availability and reliability of data related to circular economy indicators. The data quality includes:

Data quality assessment: Relevance, accuracy, timeliness, coherence, completeness, and accessibility are used to evaluate the quality of data. This evaluation is based on any metadata that the data sources have supplied or other information that is readily accessible from the data sources. [43].

Data quality improvement: The quality of the data sources is improved by applying various methods and techniques, such as data cleaning, validation, integration, transformation, etc. The improvement is based on the needs and objectives of the study [43].

4.2.2 Dashboard Characteristics and Indicators

The dashboard characteristics as stated in the aforementioned section 2.2.3 and the study's indicators rely on the concepts and standards of the circular economy in addition to the accessibility and quality of the data. The dashboard aims to provide a comprehensive and coherent picture of the performance and advancement of the circular economy in Austria and other European nations, as well as to pinpoint the key difficulties and areas for development.

This dashboard's characteristics include:

- A user-friendly and interactive interface that allows users to explore, and compare the circular economy data and insights;

- A modular and flexible structure that enables users to select their choice of data source from the list and its different aspects of circular economy indicators [9] (e.g., waste management, production & consumption, secondary raw materials, and innovation) to load data on the dashboard.
- A clear and consistent methodology that explains the data sources, definitions, calculations, and limitations of the indicators;
- A regular and timely update that reflects the latest data and trends in the circular economy.

And as a result of the discussion in section 2.1.3, these dashboard indicators can be included:

No.	Organization	Data Categories
1.	Eurostat	**Production and consumption:** - Material footprint - Food waste - Waste generation per capita
		Waste Management: - Recycling rate of municipal waste - e-waste - biowaste
		Secondary raw material: - Trade in recyclable raw materials
		Competitiveness and innovation: - Patents related to recycling - secondary raw materials
2.	OECD	- Material consumption/Productivity - Renewable Energy - Municipal Waste - Food Waste
3.	World Bank	- CO2 emissions - Fossil fuel energy consumption - Renewable energy consumption - Annual freshwater withdrawals, industry

Table 4.1: List of Indicators categorized by Data sources [22]

4.3 Technology Selection

It's crucial to pick the correct technology for a strategy dashboard. It has an impact on the dashboard's functionality and usability. Although there are numerous possibilities available, we chose the finest ones for our project.

For our strategy dashboard in Austria, we needed technology that could handle data and make it look good. Additionally, we wanted it to be simple for users to utilize so We chose Python, Django, HTML, CSS, and JavaScript as a result. These are all popular choices because they're versatile and reliable.

We'll discuss in detail each of these technologies and the reasons we chose them in the sections that follow. This will help us understand how they all combine to create a useful tool for Austria's circular economy decision-makers by doing.

4.3.1 Python and its Libraries

Undoubtedly, **Python** has become one of the top programming languages in recent years. Python has continuously placed among the top coding languages. When compared to other alternatives like Java, C++, or PHP, choosing Python as the primary language offers several advantages. Remarkably, In terms of web development, Python has also achieved its peak, offering a number of features and innovations that are gaining popularity daily.

Python offers a number of powerful frameworks to use, like Django and Flask. The Reason to use Python for the strategy dashboard is due to its abilities in data processing, analysis, and visualization, as well as its potential to interact with a variety of web frameworks.

By using Python and its extensive library support, we can effectively gather, process, and visualize data from multiple sources to create a valuable and interactive strategy dashboard for Austria's circular economy.

In this project, we primarily use the following Python libraries:

1. **Requests:** Requests library enables to make HTTP requests to access data from various online sources, such as Eurostat, the World Bank, and the OECD. With This library, we can easily fetch data in different formats like JSON or XML, facilitating smooth integration into our application.

2. **Pandas:** Pandas is a powerful library for data manipulation and analysis. It provides data structures like DataFrame and Series, which allow us to clean,

aggregate, and transform data efficiently. With Pandas, we can handle large datasets, filter and sort data, and perform complex calculations required for our dashboard.

3. **Pycountry:** Pycountry provides ISO country, subdivision, and language codes along with their respective names, making it easier to standardize and compare country-specific data. Pycountry is particularly useful when aggregating data from different sources that use varying country naming conventions.

4. **Eurostat:** The Eurostat library is a Python wrapper for the Eurostat API, simplifying the process of accessing and retrieving data from Eurostat's vast database. This library allows us to fetch relevant data for Austria's circular economy with ease, ensuring that our dashboard stays up-to-date with the latest information.

5. **xml.etree.ElementTree and lxml:** Both of these libraries are used for parsing and processing XML data, which is one of the common data formats provided by organizations like the World Bank and the OECD. With The ElementTree XML API and lxml, we can extract relevant data from XML documents and convert it into a format compatible with our dashboard's visualizations.

6. **Plotly:** Plotly is an additional library we've incorporated for data visualization. It is a high-level, declarative charting library that simplifies the creation of visually appealing and interactive charts. We can quickly create line charts using Plotly to show the indicator data, improving the user experience and enabling a deeper comprehension of the data.

By leveraging Python and its powerful libraries, we can efficiently gather, process, and visualize data from multiple sources to create an insightful and interactive strategy dashboard for Austria's circular economy.

4.3.2 Django

Django is a high-level Python web framework that encourages rapid development and clean, pragmatic design. It follows the Model-View-Controller (MVC) architectural pattern, making it easier to separate the concerns of data handling, presentation, and user interaction. Django's popularity in web development can be attributed to its robust built-in features, ease of use, and extensive documentation.

For our strategy dashboard, we have opted for Django because it seamlessly integrates with Python and its libraries, allowing us to leverage the full potential of Python in our web application. Django offers several advantages, such as:

- Scalability: Django's modular architecture enables us to develop and maintain a scalable application that can handle increasing data volume and user traffic with ease.
- Security: Django provides built-in security features that help protect our application from common web security threats, such as cross-site scripting, cross-site request forgery, and SQL injection.
- Reusability: Django's "Don't Repeat Yourself" (DRY) principle promotes code reusability, making it easier to maintain and extend the application over time.
- Community support: Django has an active and supportive community, which ensures that the framework stays up-to-date and provides a wealth of resources, such as plugins, tutorials, and forums.

4.3.3 HTML, CSS, Bootstrap, and JavaScript

Fronted technologies such as HTML (HyperText Markup Language), CSS (Cascading Style Sheets), Bootstrap, and JavaScript are the foundation of any web application, responsible for its structure, presentation, interactivity, and responsiveness.

1. **HTML:** HTML is used to create the basic structure and layout of our dashboard. It defines elements like headings, paragraphs, tables, and forms, organizing the content in a semantic and meaningful way.
2. **CSS:** CSS is used to style the HTML elements, controlling their appearance, colors, fonts, and positioning. By employing CSS, we can ensure that our dashboard has a consistent look and feel across different devices and screen sizes.
3. **Bootstrap:** Bootstrap is a widely used CSS framework that streamlines the design process and ensures the responsiveness of our web application. It provides pre-built components, such as navigation bars, buttons, and forms, allowing us to create a professional-looking and consistent interface with

ease. Bootstrap also offers a responsive grid system that automatically adapts the layout of our dashboard to various screen sizes and devices, enhancing the user experience across different platforms.

4. **JavaScript:** JavaScript is a scripting language that enables interactivity and dynamic content within our dashboard. It allows simplifies the process of creating interactive elements, validates form entries, and handles user events.

By combining Django with HTML, CSS, Bootstrap, and JavaScript, we can develop a powerful, secure, and visually appealing strategy dashboard that offers an intuitive and interactive experience for users, enabling them to make informed decisions.

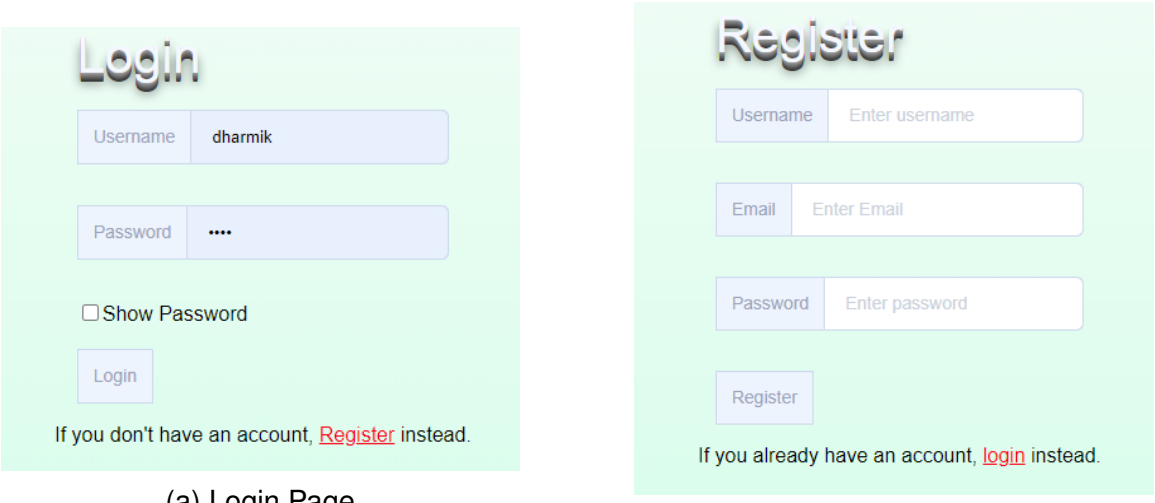
4.4 Dashboard Implementation

4.4.1 User Interface And Overview Of Dashboard

In this section, we will provide an overview of the web application, discussing its user interface (UI), and usage. The primary goal of our strategy dashboard is to offer a comprehensive and interactive tool that enables managers to make informed decisions in the context of Austria's circular economy. To achieve this, we have focused on designing a user-friendly, visually appealing, and responsive web application that combines the capabilities of applied Technologies as discussed in section 4.3.

We have developed a prototype dashboard that offers a user-friendly experience with a clean and straightforward layout, focusing on providing easy access to relevant information on Austria's circular economy while maintaining a visually appealing interface.

Upon visiting the dashboard, users are presented with a login/register page as shown in Figure: 4.1. Once logged in, they are directed to the landing page (Figure: 4.2), which features a simple navigation bar containing the logo, a 'Dashboard' menu, and a logout button. The menu button launches a side menu bar with links to the circular economy page, log in, log out, and register buttons.



(a) Login Page

(b) Register Page

Figure 4.1: Dashboard: Login-Register Page

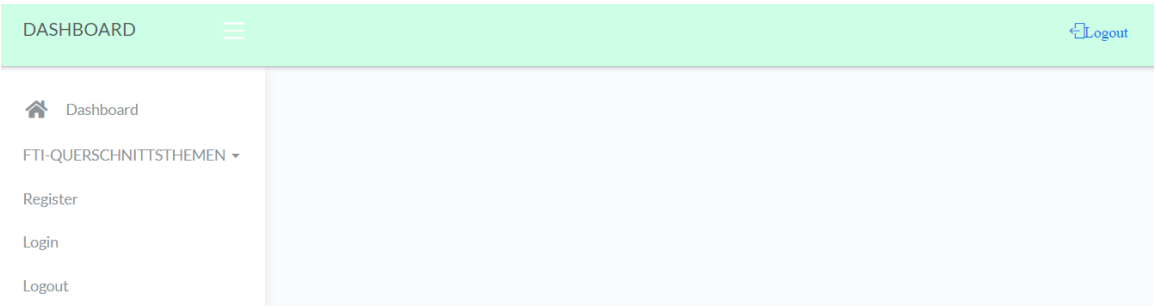


Figure 4.2: Dashboard: Landing Page

The circular economy dashboard page (Figure: 4.3) is designed to be simple, clean, and neat. At the very top, users can see the title "Circular Economy" and an 'ADD' button. When clicked, the button opens a modal form asking users to enter the name of an indicator group (Figure: 4.4), which will contain related indicators. Upon saving changes, a new table/container is created with a predefined structure for adding indicators and their data in a specific format.

Figure 4.3: Dashboard: Circular Economy Indicator Page

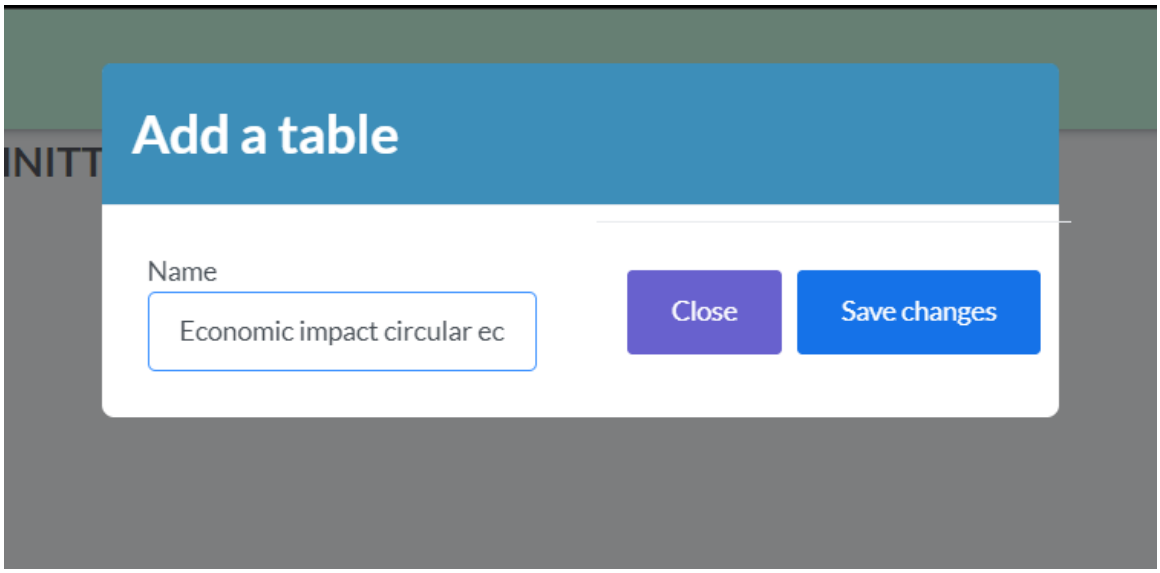


Figure 4.4: Dashboard: Creating Indicator group table

Each table or group features a header row displaying the group name, along with Edit, Delete, and Add buttons (Figure: 4.5). Below the header row, there are columns for ID, indicator name (Teilindikator), data source (Datenquelle), last up-

date date (Datum), status, Austria's value (Wert), the top-3 EU countries' average value (Top-3), and the EU average value (EU Durchschnitt).

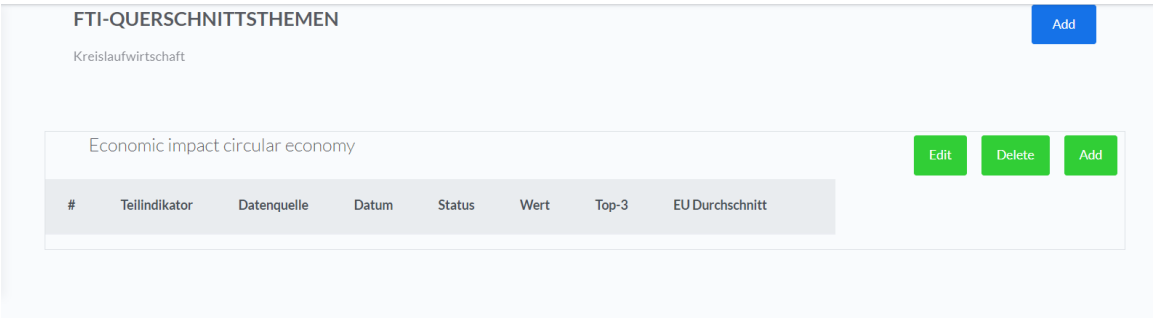


Figure 4.5: Dashboard: Overview of Indicator Table

Users can click the Add button within the table to add new indicators, open another modal form that prompts them to input the indicator name, select an appropriate data source from a dropdown menu (Eurostat, OECD, Worldbank), and enter the dataset code for the indicator(Figure: 4.6). When the user saves changes, the data is loaded into the table in the predefined format.

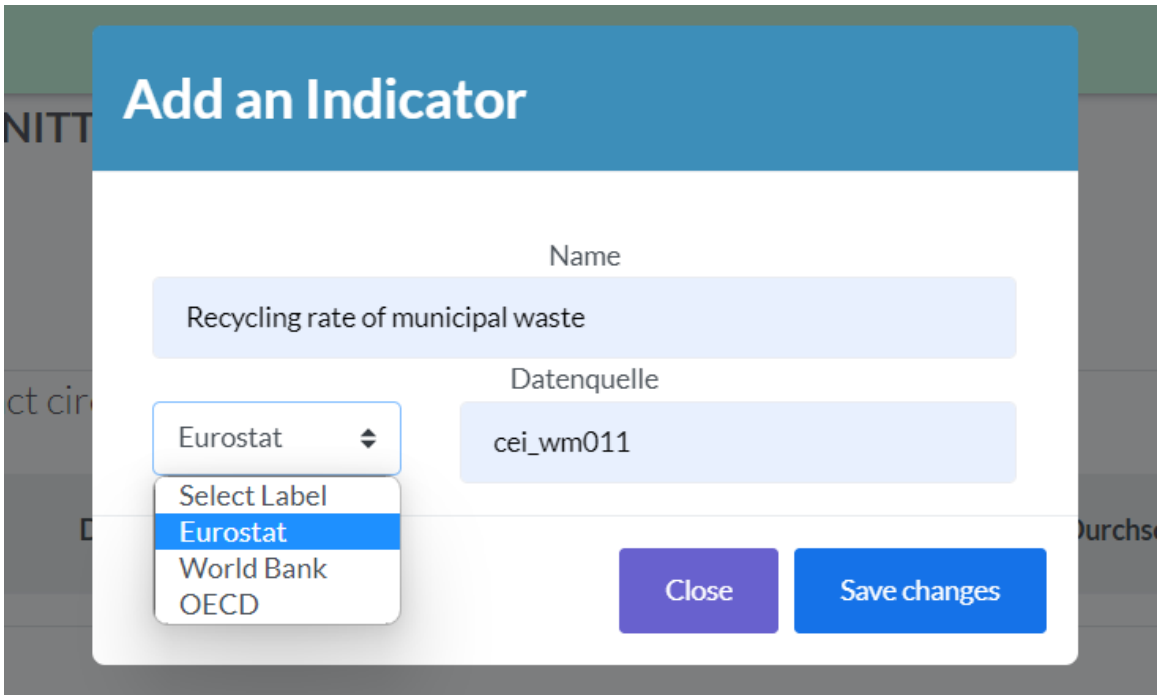


Figure 4.6: Dashboard: Adding the first Indicator to Table

Each row in the table also features five buttons: Check Update, View Data, Edit, Delete, and View Chart (Figure: 4.7).

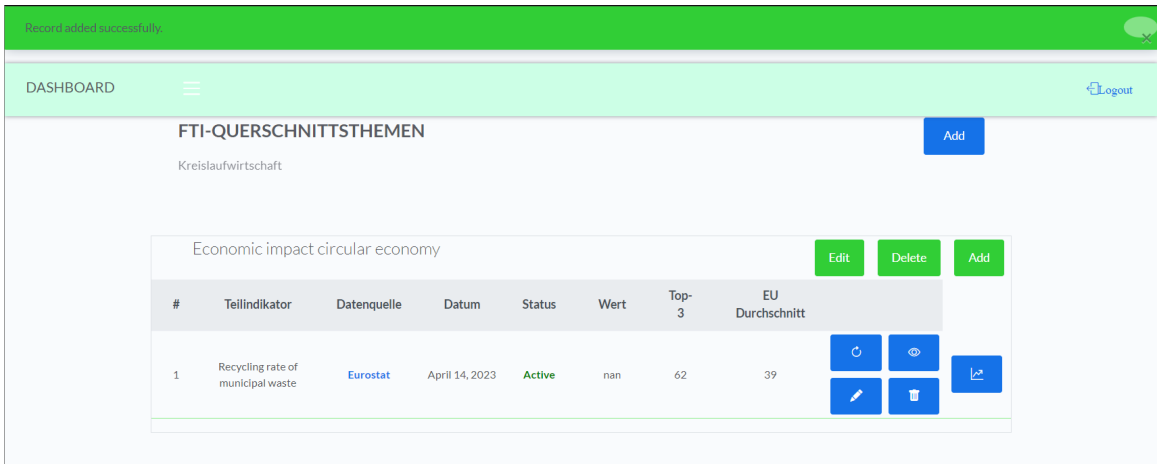


Figure 4.7: Dashboard: Overview of Table with Indicator

The Check Update button verifies if updates are available for the indicator, changing the status to 'Update' in red and the button to 'Update Now' in yellow if there is an update (Figure: 4.8).

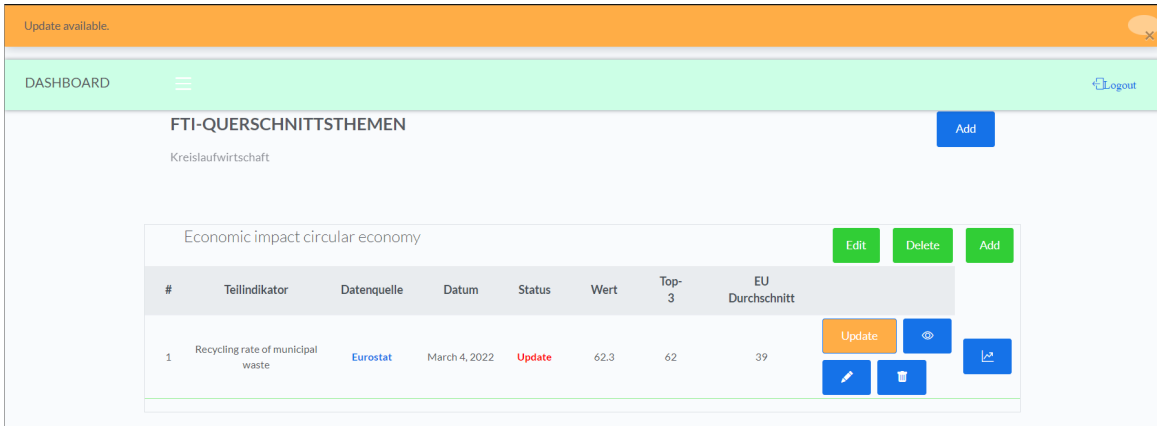


Figure 4.8: Dashboard: Update Available Notification

The View Data button (Figure: 4.9) displays the indicator data frame in a popup, the Edit button (Figure: 4.10) allows users to correct or modify indicator details, and the Delete button (Figure: 4.11) removes the indicator row after confirming the user's intention.

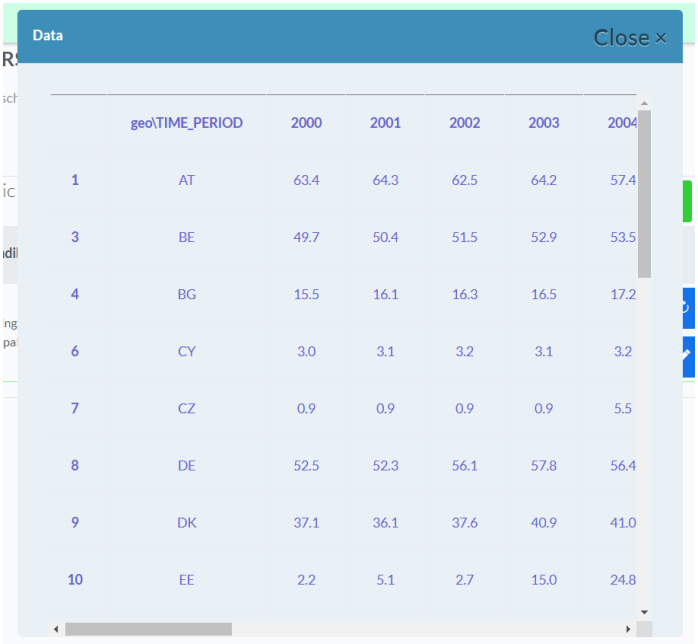


Figure 4.9: Dashboard: DataFrame Overview Popup

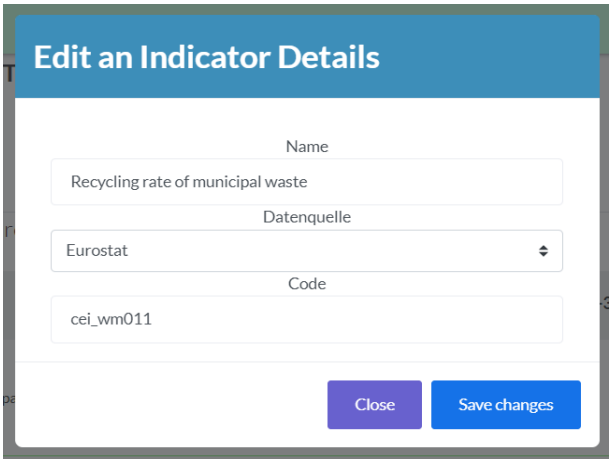


Figure 4.10: Dashboard: Modal Form to edit indicator Details

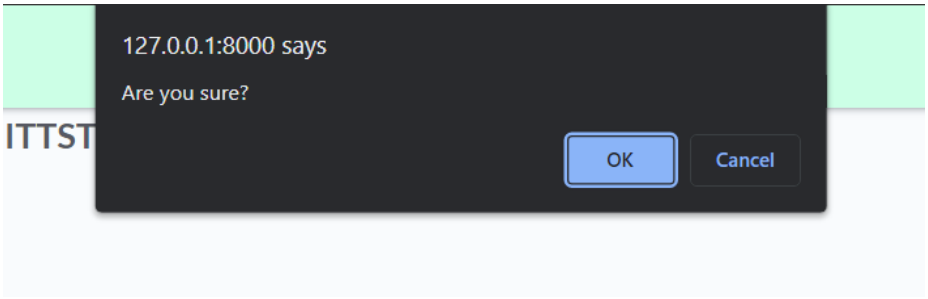


Figure 4.11: Dashboard: Alert on Deletion of Indicator or Table

The View Chart button displays a line chart (Figure: 4.12) using the Plotly library, visualizing the data with three lines representing Austria's value, the average of the top-3 EU countries, and the average of all EU countries.

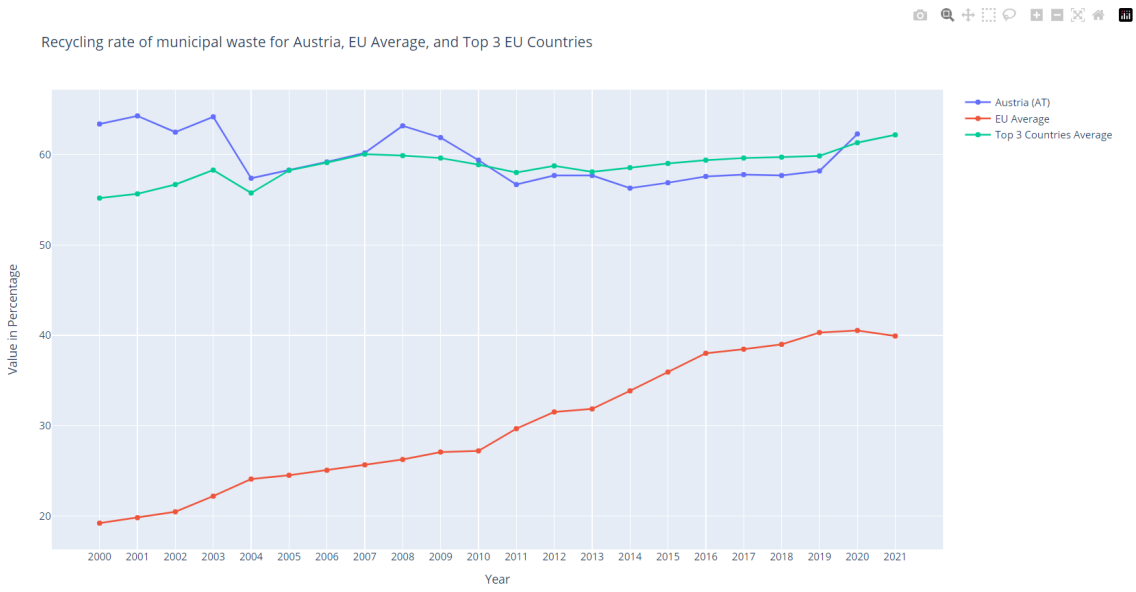


Figure 4.12: Dashboard: Visualization on Selected Indicator

The dashboard can accommodate multiple tables or containers, each holding groups of indicators and their data. Throughout the dashboard.

In summary, the User Interface and Overview of Dashboard section describes the prototype dashboard's design, layout, and functionalities. By leveraging a combination of Python, Django, HTML, CSS, JavaScript, and Bootstrap, we have developed an interactive and responsive tool that effectively supports managers in strategic decision-making within the context of Austria's circular economy.

4.5 Backend

4.5.1 Data Retrieval

The backbone of our strategy dashboard lies in its robust backend, which meticulously pulls data on various indicators from the sources such as Eurostat, the World Bank, and the OECD as discussed in section 4.2.2. Our system seamlessly integrates these data sources while ensuring data consistency and accuracy.

The data retrieval process is initiated when a user provides key information such as the indicator name, the data source from the drop-down menu, and the dataset code for the desired indicator. With this information, the backend takes action and sends a request to the appropriate data source using the most appropriate API, library, or method. For example, when accessing Eurostat data, we use the Eurostat library, while the requests library is used when interacting with the World Bank or the OECD through their respective APIs.

Once the data has been retrieved, it's time to pre-process it using the pandas library, which offers excellent flexibility in data manipulation and transformation. This step is vital for maintaining data consistency since each data source comes with unique structures, units, and time intervals. During the pre-processing of the raw data, it is converted into a uniform structure that corresponds to the predefined format of the dashboard.

A glimpse at the code used for retrieving data and converting it to a panda data frame from different sources is shown in Appendix A.1.

In this phase, we also pay close attention to the correctness of the data structure by carrying out various checks and validations, such as dropping unnecessary columns.

4.5.2 Data Processing and Storage

In this section, we'll delve into the details of data processing and storage, discussing how the data collected from various sources is filtered, transformed, and stored to ensure consistency and accuracy. Our primary goal is to convert the raw data into a uniform format, allowing for smooth integration and analysis.

Here's an overview of the data processing and storage steps:

1. Filter important values using functions like ATvalue, top3average, and EU average.
2. Define the database model using classes like Tabless and Rows.
3. Save the processed data to the database by creating instances of the Rows class and calling the save() method.

To achieve this, we use three key functions that help us filter important values from the processed data frames created in section 4.5.1. The ATvalue function returns the latest value for Austria based on the data source, while the top3average function calculates the average value of the top three EU countries for the latest year. Lastly, the EU average function returns the latest EU average value.

Our backend leverages a database model to store the processed data efficiently. The Tabless and Rows classes define the structure of the database tables, which include fields for storing indicator names, data sources, and various calculated values.

To save data to the database, we create an instance of the Rows class and assign the processed values to their respective fields. Then, we call the save() method to store the instance in the database.

By following this approach, we ensure that our data is securely stored and easily accessible for further analysis, visualization, and reporting. This robust backend supports the powerful functionality of our strategy dashboard, enabling users to gain valuable insights into circular economy indicators.

The code snippet for Data Processing and Storage is obtainable in Appendix section A.2.

4.5.3 Updating Data

Making sure the data is up-to-date is one of the dashboard's essential components. I've put in place a simple procedure to check for Updates and smoothly incorporate them into the system to manage this.

When a user requests an update, a function named `check_update()` is activated. The record ID, dataset code, and data source are required arguments for this function. It then pulls the relevant record from the database and verifies the dataset's most recent date.

The `updated_date()` function is useful in this situation. The latest update date is retrieved from a data source using the appropriate API request following the dataset code and data sources are supplied. We now compare this most recent date to the date in our database in `check_update()`. The availability of an update is indicated if they differ. The user is then informed after the status is changed to "update available".

The user only needs to click the "Update" button to update the data. Similar to what we described in section 4.5.1, this action causes a new API request to be made in order to obtain the indicator's updated data. The Update button then changes back to a Check Update icon button after the new data has been saved to the database. The status now shifts from Update Now to Active once more.

By ensuring that users always have access to the most recent data, this dashboard enables users with the exact and up-to-date data they need to make informed decisions.

The code snippet for updating Data is available in the Appendix section A.3.

4.5.4 Data Visualization

This section is discussing how to create beautiful, interactive visualizations to help users make sense of the data and make better-informed decisions.

We use the Plotly library to create our visualizations, specifically working with line charts in this example. The process begins after we've retrieved the data as we discussed in section 4.5.1, and we have a pandas DataFrame with an additional 'average' column for each country. With this in place, we're ready to create some stunning charts.

The first thing we do is find the top 3 countries by average value from the last column 'average' and calculate their average value of these top 3 countries for each year. We also grab Austria's value for each year and the EU's average value.

With these key pieces of data in hand, we create a Plotly Figure and add traces for Austria, the EU average, and the top 3 countries' averages. This creates a line chart with markers for each data point, making it easy for users to see trends and patterns.

We then add labels, a legend, and a title to the chart, giving it a polished look. Finally, the chart is displayed using the `fig.show()` command.

As mentioned earlier, this chart is rendered on an HTML page using the `dashpage()` function. Users can load the chart by clicking on the 'show chart' icon button, as

described in section 4.4.1 User Interface And Overview Of Dashboard. This action opens a new tab with the line chart visualization of the correlated indicators.

The appendix section A.4 contains the code snippet for Data Visualization.

Thanks to the Plotly library, Visualization is interactive. Users can choose which lines to display on the chart and that allows them to easily compare results and make better decisions.

5

Results and Discussion

The outcomes of our work to create a strategy dashboard for Austria's circular economy are presented in this chapter, with an emphasis on data management, visualization, and the general efficiency of the tool in assisting decision-making processes. The findings are divided into a number of areas that highlight the dashboard's effectiveness, ability to carry out the study's goals, and contribution to enhancing strategic decision-making.

5.1 System Performance and Effectiveness

The strategy dashboard was designed with a user-friendly interface, allowing users to easily navigate and interact with various indicators, data sources, and visualizations. The dashboard was tested with different indicators and data sources, showing its flexibility and adaptability to different contexts within Austria's circular economy.

5.2 Identification of Key Performance Indicators and their Sources

Our research has led to the identification of several key performance indicators relevant to Austria's circular economy, along with their corresponding data sources. We deliver a comprehensive assessment of the circular economy and all of its aspects by integrating these indicators into the strategy dashboard. The selection of relevant indicators and data sources is essential for ensuring the accuracy and effectiveness of the dashboard in supporting decision-making.

5.3 Fulfillment of Research Objectives and Research Questions

Throughout the development of the strategy dashboard, we have addressed the research objectives and questions by identifying the dashboard's characteristics, determining relevant indicators and data sources, investigating opportunities and challenges in data management, and providing suggestions for modernizing and upgrading the dashboard's data sources and administration techniques. The resulting dashboard serves as a practical tool for monitoring and managing Austria's circular economy and supports informed decision-making.

5.4 Enhanced Decision-Making through Visualization and Impact Analysis

The strategy dashboard effectively utilizes interactive visualization techniques to present complex data in an accessible and user-friendly manner. By incorporating various indicators with line charts representing Austria's values, the average of the top-3 EU countries, and the average of all EU countries, the dashboard provides a comprehensive view of Austria's circular economy performance. This approach enables decision-makers to compare and evaluate data efficiently and identify trends, opportunities, and areas that require attention, ultimately supporting more accurate and informed decision-making processes.

The impact of the strategy dashboard on decision-making processes is evident in the way it facilitates a better understanding of Austria's circular economy and its various components. By allowing users to rapidly evaluate the status of the circular economy, detect trends, and explore new possibilities, the dashboard fosters sustainable development and bolsters the effectiveness of strategic decisions.

Moreover, the inclusion of additional charts for various indicators not only enriches the visual representation of the data but also provides deeper insights into specific aspects of Austria's circular economy. This further empowers decision-makers to make well-informed choices, ultimately contributing to a more sustainable future for Austria.

Here are a few illustrations of data visualization on a few of the indicators.

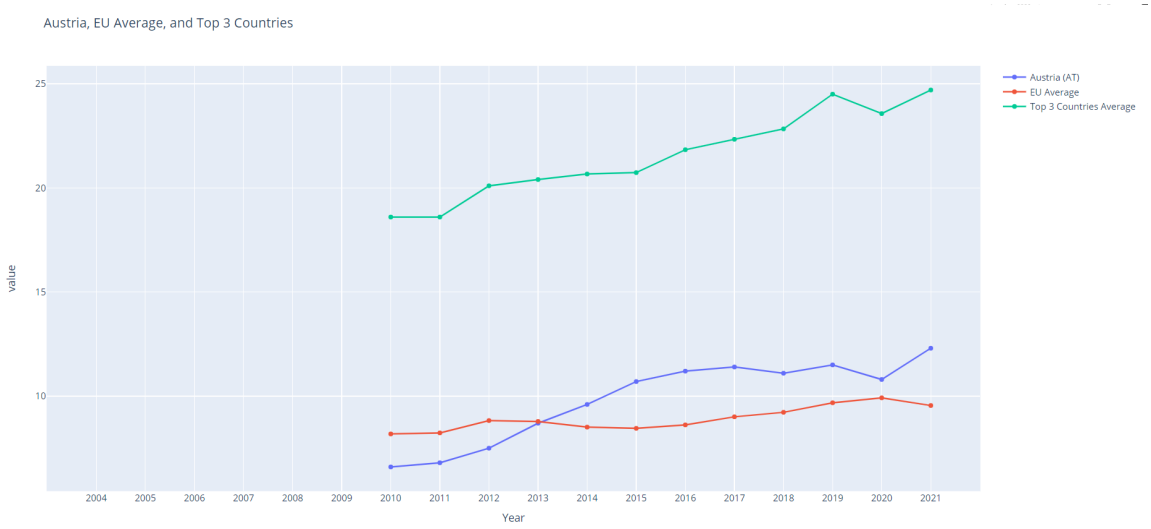


Figure 5.1: Charts: Circular material use rate

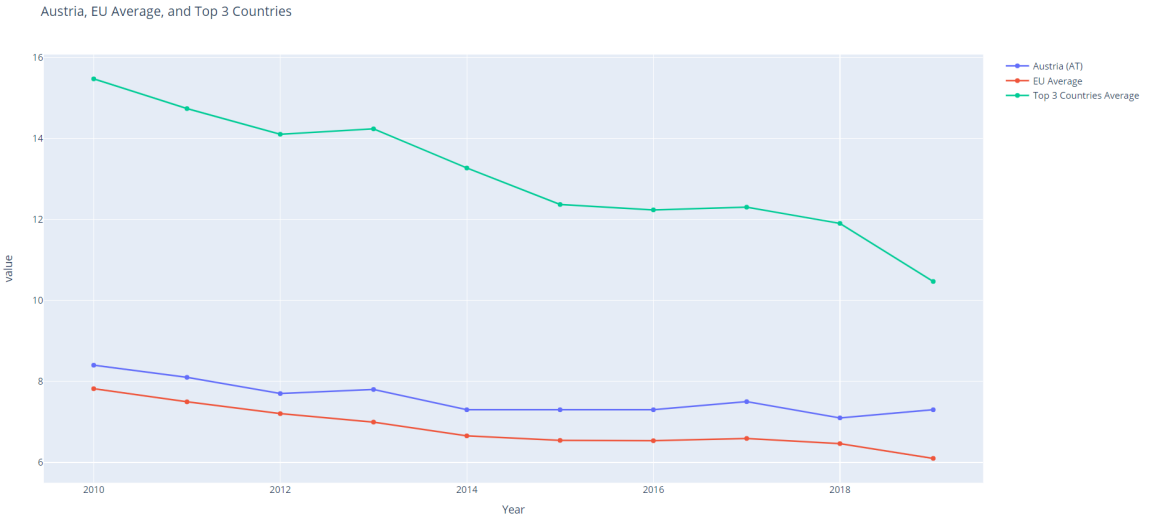


Figure 5.2: Charts: CO2 emissions (metric tons per capita)

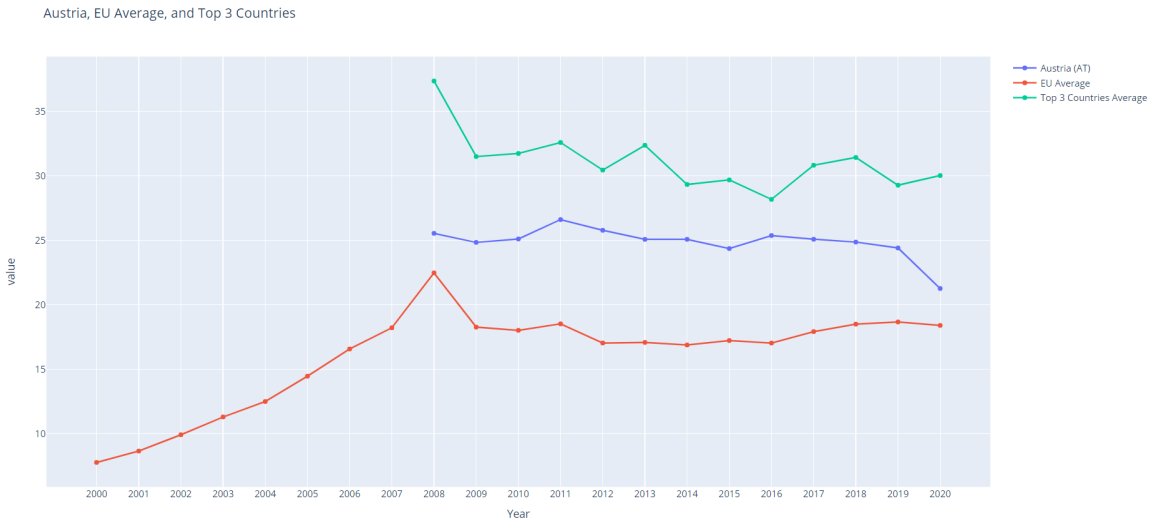


Figure 5.3: Charts: Material Footprint

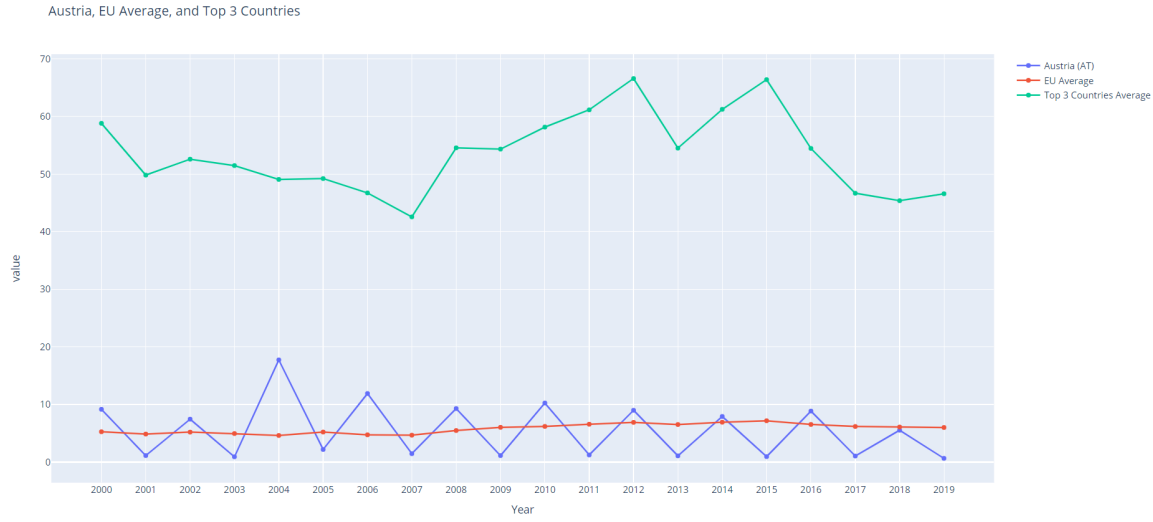


Figure 5.4: Charts: Patents related to recycling and secondary raw materials

In conclusion, the results of this study demonstrate that Austria's circular economy strategy dashboard is highly effective in supporting data-driven decision-making processes. It offers valuable insights into the development of the circular economy and promotes sustainable development by making complex information easily accessible, understandable, and actionable.

5.5 Limitations and Areas for Improvement

While our system has shown promising results, there are some limitations and areas for improvement. These may include:

1. Data coverage and availability: The system relies on the data provided by external sources, which may not always be complete or up-to-date.
2. Error handling and edge cases: Our system may not handle all possible errors or edge cases, leading to potential inaccuracies or inconsistencies in the presented data.
3. Scalability and performance: As the number of users or the volume of data increases, the system's performance may be affected, requiring optimizations and adjustments to maintain a smooth user experience.

5.6 Future Enhancements

Based on the identified limitations and areas for improvement, we can propose potential future enhancements to the system. These may include:

1. Expanding the range of data sources and indicators to provide a more comprehensive view of the recycling landscape.
2. Implementing more robust error handling and edge case management to ensure accuracy and consistency in the data.
3. Optimizing the system's performance and scalability to handle increased user traffic and data volumes.
4. Enhancing data security and privacy measures to protect user information and comply with data protection regulations.
5. Introducing additional data visualization options, such as maps or bar charts, to offer users more ways to explore and analyze the data.

6

Conclusion

As a result, a strategic dashboard for the circular economy is a helpful tool that can assist organizations and governments in tracking, communicating, and monitoring their progress toward circular economy goals. This bachelor's thesis has successfully developed a prototype dashboard for the circular economy in Austria, focusing on data management and visualization methods to support informed decision-making. The study's findings have demonstrated the effectiveness of the dashboard in tracking and comprehending relevant metrics, identifying trends, and guiding strategic actions.

Throughout this thesis, we have addressed the research objectives by identifying the key characteristics of a strategy dashboard tailored to Austria's circular economy, determining relevant indicators and data sources, investigating the opportunities and challenges in developing and implementing data management strategies, and providing suggestions for modernizing and upgrading data sources and administration techniques.

The dashboard incorporates a range of indicators and data sources that offer a comprehensive view of Austria's circular economy. Through the use of user-friendly visualization tools, such as interactive charts and graphs, the data is easily understandable and actionable for decision-makers. Furthermore, the research highlights potential improvements and future work to further enhance the dashboard's capabilities and address any limitations.

This study contributes to the field by offering a practical tool for monitoring and managing Austria's circular economy, serving not only decision-makers but also researchers and practitioners seeking to advance sustainability efforts in the country. The developed strategy dashboard represents a significant step towards enabling

better data-driven decision-making and fostering a more sustainable future for Austria.

As we move forward, it is essential to continue refining the dashboard and incorporating new data sources and indicators as they become available. Further research and collaboration with stakeholders will help ensure that the dashboard remains relevant, up-to-date, and aligned with the evolving needs of the circular economy in Austria. By embracing a data-driven approach and leveraging the power of effective visualization tools, we can accelerate progress toward a more sustainable and circular future.

A

Backend Code Snippets in Python

A.1 Data retrieval & converting Data to Dataframe

```
import eurostat
import requests

#Retrive Data from Eurostat using eurostat Library
data = eurostat.get_data_df(datasetcode)

#Retriving Data from Worldbank using Request
api_url = f"https://api.worldbank.org/v2/countries/all/indicators/{
    datasetcode}?format=json&per_page=20000"
response = requests.get(api_url)
data = response.json()[1]

#Retriving Data from OECD using Request
api_url = f"https://stats.oecd.org/restsdmx/sdmx.ashx/GetData/{
    datasetcode}/{countries}.RECYCLING/all?startTime=2015&endTime
    =2021"
response = requests.get(api_url)
data = response.content.decode("utf-8-sig")
```

Listing A.1: Data Retrieval

```
import pandas as pd
from lxml import etree
import pycountry

#Eurostat
# Filter the DataFrame to only include European countries
df = pd.DataFrame(data[data['geo\TIME_PERIOD'].isin(
    european_countries)])
# Rename the column
df = df.rename(columns={'geo\\TIME_PERIOD': 'countries'})
# Drop the unwanted columns
df = df.drop(columns=df.columns[:df.columns.get_loc('countries')])
#adding additional average column with mean value of each row for
    further calculation
df['average'] = df.iloc[:, 1:-1].mean(axis=1)
print(df)

#WORLDBANK
# Convert the response data to a pandas DataFrame and process it
df = pd.json_normalize(data)
df = df[['country.value', 'date', 'value']]
df.columns = ['Country', 'Year', 'Value']
df.dropna(inplace=True)
df = df[df['Country'].isin(european_countries)]
df['Year'] = pd.to_datetime(df['Year']).dt.year.astype(int)
df = df.sort_values(['Country', 'Year'], ascending=[True, False])
df['Value'] = df['Value'].round(1)
df = df.pivot(index='Country', columns='Year', values='Value').
    reset_index()
df = df.loc[:, ['Country', *df.columns[-11:]]]
df['average'] = df.iloc[:, 1:-1].mean(axis=1)
print(df)

#OECD
root = etree.fromstring(data)
# Extract the necessary data from the ElementTree object
new_data = []
for series in root.findall(".//generic:Series", namespaces=nsmap):
    country_code = series.find(".//generic:Value[@concept='COU']",
    namespaces=nsmap).get("value")
    country_name = pycountry.countries.get(alpha_3=country_code).
    name
```

```
38      year = [obs.find("generic:Time", namespaces=nsmap).text for obs
        in series.findall(".//generic:Obs", namespaces=nsmap)]
39      value = [obs.find("generic:ObsValue", namespaces=nsmap).get("
        value") for obs in series.findall(".//generic:Obs", namespaces=
        nsmap)]
40      new_data.append({"country": country_name, "year": year, "value":
        value})
41
42  # Convert the extracted data to a pandas DataFrame
43  df = pd.DataFrame()
44  for d in new_data:
45      country = d['country']
46      # create a temporary data frame with the values for this
        dictionary
47      temp_df = pd.DataFrame({'country': [country], **{d['year'][i]: [
        float(d['value'][i])] for i in range(len(d['year']))}})
48      # append the temporary data frame to the main data frame
49      df = pd.concat([df, temp_df])
50
51  # Calculate the average for each country
52  df['average'] = df.iloc[:, 1:-1].mean(axis=1)
53  print(df)
```

Listing A.2: converting data to Dataframe using Panda

A.2 Data Processing and Storage

```
def ATvalue(df,str):
    if(str=='Eurostat'):
        austria_latest_value = df.loc[df['countries'] == 'AT'].iloc
    [:, -2].values[0]
    elif(str=='WorldBank'):
        austria_latest_value = df.loc[df['Country'] == 'Austria'].
    iloc[:, -2].values[0]
    else:
        austria_latest_value = df.loc[df['country'] == 'Austria'].
    iloc[:, -2].values[0]

    return austria_latest_value
```

Listing A.3: Austria's latest Value

```
#to get the average of the top3 countries
def top3average(df):
    # Get the top 3 countries by average recycling rate
    top_3 = df.nlargest(3, 'average')
    top_3_average = top_3.iloc[:, 1:-1].mean()
    # Calculate the average recycling rate for the top 3 countries
    for each year
    top_3_latest_average = top_3_average.iloc[-1]
    return top_3_latest_average
```

Listing A.4: Average of top3 EU countries in latest Year

```
#Get the EU average value for the latest year
def eu_average(df):
    eu_average = df.iloc[:, 1:-1].mean()
    # Get the EU average value for the latest year
    eu_latest_average = eu_average.iloc[-1]
    return eu_latest_average
```

Listing A.5: Average of EU countries in latest Year

```
class Tabless(models.Model):
    id = models.AutoField(primary_key=True)
    name = models.CharField(max_length=500, default="name", unique=True)

    def __str__(self):
        return self.name


class Rows(models.Model):
    id = models.IntegerField(primary_key=True, auto_created=True)
    Tables = models.ForeignKey(Tabless, on_delete=models.CASCADE)
    Teilindikator = models.CharField(max_length=500, blank=True, null=True)
    Datenquelle = models.CharField(max_length=500, blank=True, null=True)
    Code= models.CharField(max_length=500, blank=True, null=True)
    Datum = models.DateField(blank=True, null=True)
    Status = models.CharField(max_length=500, default="Active")
    Wert = models.CharField(null=True, blank=True,max_length=500)
    Top3 = models.IntegerField(null=True, blank=True)
    EUDurchschnitt = models.IntegerField(null=True, blank=True)

    def __str__(self):
        return self.Teilindikator
```

Listing A.6: Database Model

A.3 Updating Data

```
def check_update(request):
    if request.method == "POST":
        id = request.POST.get('recordid')
        datasetcode = request.POST.get('Code')
        res = Rows.objects.get(id=id)
        source = request.POST.get('Datenquelle')
        dataset_date = updated_date(datasetcode, source)
        # if the date in database and updated data date is different
        if str(dataset_date) != str(res.Datum) and res.Datenquelle
    == source:
            res.Status = "Update available"
            res.save()
            messages.warning(request, "Update available.")
    return redirect(dashpage)
```

Listing A.7: Function to check for update

```
def updated_date(datasetcode, source):
    if source == 'Eurostat':
        url = f"https://ec.europa.eu/eurostat/api/dissemination/sdmx
    /2.1/dataflow/ESTAT/{datasetcode}"
        resp = requests.get(url)
        root = ET.fromstring(resp.content)
        for annotation in root.findall(".//{http://www.sdmx.org/
    resources/sdmxml/schemas/v2_1/common}Annotation"):
            if annotation.find("{http://www.sdmx.org/resources/
    sdmxml/schemas/v2_1/common}AnnotationType").text == "UPDATE_DATA"
    :
                dataset_date = annotation.find("{http://www.sdmx.org
    /resources/sdmxml/schemas/v2_1/common}AnnotationTitle").text.
    split("T")[0]
                return dataset_date
    elif source == 'WorldBank':
        api_url = f"https://api.worldbank.org/v2/countries/all/
    indicators/{datasetcode}?format=json&per_page=20000"
        response = requests.get(api_url)
        metadata = response.json()[0]
        dataset_date = metadata['lastupdated']
        return dataset_date
    else:
```

```
17        countries = "AUT+BEL+CZE+DNK+EST+FIN+FRA+DEU+GRC+HUN+IRL+ITA
    +LVA+LTU+LUX+NLD+NOR+POL+PRT+SVK+SVN+ESP+SWE+CHE+TUR+GBR"
18        url = f"https://stats.oecd.org/restsdmx/sdmx.ashx/GetData/{
    datasetcode}/{countries}.RECYCLING/all?startTime=2015&endTime
    =2021"
19        response = requests.get(url)
20        nsmap = {'generic': 'http://www.SDMX.org/resources/SDMXML/
    schemas/v2_0/generic', 'common': 'http://www.SDMX.org/resources/
    SDMXML/schemas/v2_0/common', 'xsi': 'http://www.w3.org/2001/
    XMLSchema-instance', 'message': 'http://www.SDMX.org/resources/
    SDMXML/schemas/v2_0/message'}
21        data = response.content.decode("utf-8-sig")
22        root = etree.fromstring(data)
23        dataset_date = root.find(".//message:Prepared", namespaces=
    nsmap).text.split("T")[0]
24        return dataset_date
```

Listing A.8: Function to get latest dataset date

A.4 Data Visualization

```
import plotly.graph_objs as go
# Get the top 3 countries by average recycling rate
top_3 = df.nlargest(3, 'average')
top_3_average = top_3.iloc[:, 1:-1].mean()
# Get Austria's recycling rate for each year
austria = df.loc[df['countries'] == 'AT'].iloc[:, 1:-1].transpose()
eu_average = df.iloc[:, 1:-1].mean()
fig = go.Figure(data=[
    go.Scatter(x=austria.index, y=austria.values.flatten(), mode='
    lines+markers', name='Austria (AT)'),
    go.Scatter(x=eu_average.index, y=eu_average.values, mode='lines+
    markers', name='EU Average'),
    go.Scatter(x=top_3_average.index, y=top_3_average.values, mode='
    lines+markers', name='Top 3 Countries Average')])
fig.update_layout(
    title='Recycling rate of municipal waste for Austria, EU Average
    , and Top 3 Countries',
    xaxis_title='Year',
    yaxis_title='Value in %')
fig.show()
```

Listing A.9: Data Visualization for indicator 'Recycling rate of municipal waste' from Eurostat

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