CROCEMS

COLLABORATIVE ROBOTICS FOR CIRCULAR ECONOMY IN MANUFACTURING SECTORS

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Report: SWOT Analysis about VET/ HE programms and national strategies regarding CE and CR

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1 Introduction

The CROCEMS-PR5A3 SWOT Analysis Report delves into the strategic frameworks, policies, and agendas of key European partners regarding the integration of Circular Economy (CE) principles and collaborative robotics within Vocational Education and Training (VET) and Higher Education (HE) systems. The partners involved in this comprehensive study include CETEM from Spain, ATMOTERM from Poland, TU Vienna from Austria, DEUSTO from Spain, and HKA from Germany.

This report emphasizes the significance of these topics, as the transition to a Circular Economy and the adoption of collaborative robotics are pivotal for sustainable development and technological advancement. The SWOT analyses for each partner country highlight their strengths, weaknesses, opportunities, and threats in these domains, providing valuable insights into how VET and HE programs can be optimized to support these innovative approaches.

Topics Covered

1. Strategies, Policies, and Agendas:
   - Each partner country's strategic approaches to Circular Economy and collaborative robotics.
   - National and regional policies that support these initiatives.
   - Agendas that outline future directions and goals for integrating CE and robotics into industry and education.
2. Vocational Education and Training (VET) and Higher Education (HE):
   - The role of VET and HE programs in equipping the workforce with skills relevant to CE and collaborative robotics.
   - Examples of innovative educational programs that combine technological expertise with sustainability principles.
   - The importance of updating curricula to reflect the rapid advancements in these fields.

Importance of the Overall Topic

The transition to a Circular Economy and the incorporation of collaborative robotics are critical for achieving long-term sustainability and economic resilience. Circular Economy principles aim to minimize waste and maximize resource efficiency, which is essential for addressing environmental challenges and promoting sustainable growth. Meanwhile, collaborative robotics enhances industrial productivity and safety, paving the way for smarter and more efficient manufacturing processes.

By analysing and aligning strategies, policies, and educational programs with these innovative concepts, the report aims to provide actionable insights that can drive progress in sustainability and technological innovation across Europe. This is crucial not only for meeting environmental goals but also for maintaining competitiveness in a rapidly evolving global market.

2 SWOT Analysis focus on strategies, policies and agendas

2.1 Spain

2.1.1 Introduction

Based on the information provided in the report of PR5-A1, here are **the five priority strategies related to Circular Economy and collaborative robotics** selected, along with justifications for their importance:

Implementation and Enforcement of Waste Management Regulations (Circular Economy)

Effective regulation, such as Law 7/2022 on waste and contaminated soils, is crucial for promoting sustainable waste management practices and advancing the Circular Economy. By enforcing laws and regulations, Spain can ensure proper waste disposal, recycling, and contaminated soil remediation, contributing to resource efficiency and environmental sustainability.

Promotion of Circular Economy Initiatives in Industrial Competitiveness Programs

Including Circular Economy objectives within industrial competitiveness and sustainability programs (e.g., Recovery, Transformation, and Resilience Plan) is essential. This integration encourages businesses to adopt circular practices, fostering innovation and competitiveness while reducing environmental impact through resource efficiency and waste reduction.

Support for Digital Transformation, Specifically in Collaborative Robotics (IC Strategy 4.0)

Embracing collaborative robotics under the National IC Strategy 4.0 and related initiatives like 'Activa Financing' promotes technological innovation and efficiency in manufacturing. Investing in robotics enhances productivity and safety in industrial settings, aligning with broader goals of digital transformation and industry 4.0.

Adoption of Safety Standards for Collaborative Robotics and Machinery (Robotics)

Compliance with safety standards (e.g., UNE-EN ISO 10218-1:2012, UNE-EN ISO 13849-1:2016) is critical to ensure worker safety and regulatory adherence in the implementation of collaborative robotic systems. These standards mitigate risks associated with machinery use, fostering a safe and productive working environment in Spain's evolving industrial landscape.

Integration of Circular Economy Principles in Municipal Waste Management Frameworks

Incorporating Circular Economy principles (as outlined in PEMAR 2016-2022) into municipal waste management frameworks enhances local strategies for waste reduction, reuse, and recycling. Aligning these efforts with national Circular Economy objectives strengthens Spain's overall sustainability agenda by promoting local-level circular practices and resource recovery.

2.1.2 SWOT analysis

STRENGTHS	OPPORTUNITIES
1. Spain's existing laws (e.g., Law 7/2022) provide a strong foundation for waste management regulations. 2. Effective waste management contributes to environmental sustainability and resource efficiency. 3. Aligns Circular Economy objectives with industrial competitiveness and sustainability. 4. Backed by government programs like the Recovery, Transformation, and Resilience Plan. 5. Promotes the adoption of cutting-edge technologies like collaborative robotics. 6. Helps businesses comply with safety regulations and standards. 7. Enhances sustainability at the municipal level, contributing to community well-being.	1. Encourages innovation in waste management technologies and practices. 2. Supports the growth of Circular Economy businesses and initiatives, as well as solutions. 3. Promotes new opportunities in Circular Economy-focused industries. 4. Stimulates growth in the robotics and automation industry. 5. Enhances workplace safety through advanced robotics technologies. 6. Compliance with safety standards enhances business reputation and credibility. 7. Promotes public awareness and engagement in sustainable waste management practices.
WEAKNESSES	**THREATS**
1. Ensuring widespread compliance and enforcement of regulations across diverse industries and regions may be challenging. 2. Adequate resources and funding are required for effective implementation. 3. Adoption of circular and digital practices by industries may require time and resources. 4. Requires investment in workforce training. 5. Encouraging behavior change among citizens and businesses may be challenging.	1. Limited awareness among businesses about the benefits and opportunities of Circular Economy initiatives. 2. Industries or stakeholders resistant to adopting new waste management practices. 3. Economic challenges may impact funding for waste management initiatives. 4. Concerns about job displacement due to increased automation. 5. Failure to comply with safety standards may result in legal consequences. 6. Resistance from stakeholders to adopt new waste management practices.

2.1.3 Explanation of the 4 sections and each bullet point

- **Strengths**

1. Spain's existing laws (e.g., Law 7/2022) provide a strong foundation for waste management regulations:

Having established laws specifically addressing waste management (such as Law 7/2022) creates a robust legal framework. This foundation sets clear guidelines and responsibilities for waste disposal, recycling, and contaminated soil remediation. It provides certainty to businesses and stakeholders regarding their obligations and promotes consistency and accountability in waste management practices across Spain.

2. Effective waste management contributes to environmental sustainability and resource efficiency:

Efficient waste management practices help minimize environmental impact by reducing pollution, conserving natural resources, and decreasing greenhouse gas emissions associated with waste disposal. By optimizing resource use through recycling and waste reduction, Spain can promote a

more sustainable and Circular Economy, where materials are reused and recycled to their fullest potential.

3. Aligns Circular Economy objectives with industrial competitiveness and sustainability:

Linking Circular Economy objectives with industrial competitiveness ensures that sustainable practices are not only environmentally friendly but also economically viable. By integrating Circular Economy principles into industrial strategies, Spain can foster innovation, improve resource efficiency, and enhance long-term competitiveness while minimizing environmental footprint and dependency on finite resources.

4. Backed by government programs like the Recovery, Transformation, and Resilience Plan:

Government support through programs like the Recovery, Transformation, and Resilience Plan provides financial and institutional backing to Circular Economy initiatives. Such programs signal commitment at the highest levels of governance, encouraging participation from businesses, investors, and stakeholders. Government backing also enhances coordination and collaboration across sectors towards achieving Circular Economy goals.

5. Promotes the adoption of cutting-edge technologies like collaborative robotics:

Encouraging the adoption of advanced technologies such as collaborative robotics drives industrial innovation and efficiency. These technologies enhance productivity, quality, and safety in manufacturing processes, leading to higher competitiveness and economic growth. By promoting technological adoption, Spain can position itself at the forefront of industrial transformation and innovation.

6. Helps businesses comply with safety regulations and standards:

Adhering to safety regulations and standards ensures a safe working environment for employees and protects businesses from legal liabilities. Compliance with these standards promotes workplace safety, reduces accidents, and improves overall operational efficiency. By facilitating compliance, Spain can create a safer and more conducive environment for businesses to thrive.

7. Enhances sustainability at the municipal level, contributing to community well-being:

Integrating Circular Economy principles into municipal waste management contributes to community well-being by reducing waste, minimizing environmental pollution, and promoting a healthier living environment. Sustainable waste practices also create economic opportunities, improve public health, and enhance overall quality of life in local communities.

- **Opportunities**

1. Encourages innovation in waste management technologies and practices:

Embracing Circular Economy principles fosters innovation in waste management technologies. This encourages the development of new methods for recycling, resource recovery, and waste reduction. Innovation in waste management can lead to more efficient processes, reduced environmental impact, and the creation of new business opportunities within the Circular Economy sector.

2. Supports the growth of Circular Economy businesses and initiatives, as well as solutions:

Investing in Circular Economy initiatives supports the growth of businesses focused on sustainable practices. This includes companies involved in recycling, remanufacturing, repair, and the

development of eco-friendly products. By nurturing Circular Economy businesses, Spain can create a thriving ecosystem that promotes sustainability and economic development.

3. Promotes new opportunities in Circular Economy-focused industries:

The emphasis on Circular Economy promotes the emergence of new industries and sectors aligned with sustainable practices. This opens up opportunities for entrepreneurs, startups, and established businesses to innovate and capitalize on Circular Economy principles. New jobs, products, and services can emerge, contributing to economic diversification and growth.

Stimulates growth in the robotics and automation industry:

Promoting the adoption of collaborative robotics stimulates growth in the robotics and automation sector. This creates demand for robotic technologies and solutions, driving investment, research, and development in this field. Growth in robotics enhances industrial productivity, efficiency, and competitiveness while spurring technological advancements.

4. Enhances workplace safety through advanced robotics technologies:

Adopting advanced robotics technologies improves workplace safety by automating hazardous tasks and reducing human exposure to risks. Collaborative robots are designed to work alongside humans safely, minimizing accidents and injuries. Enhanced safety not only protects workers but also boosts productivity and morale within industrial settings.

5. Compliance with safety standards enhances business reputation and credibility:

Meeting safety standards and regulations enhances a business's reputation for reliability and responsibility. Compliance demonstrates a commitment to employee welfare, customer satisfaction, and overall operational excellence. A strong reputation for safety can attract investors, partners, and customers, boosting business credibility in the market.

6. Promotes public awareness and engagement in sustainable waste management practices:

Public engagement and awareness campaigns raise consciousness about sustainable waste management practices. By educating and involving the public, Spain can promote behaviour change towards recycling, waste reduction, and resource conservation. Increased public support strengthens the effectiveness of Circular Economy initiatives and contributes to broader sustainability goals.

- **Weaknesses**

1. Ensuring widespread compliance and enforcement of regulations across diverse industries and regions may be challenging:

Achieving consistent compliance with waste management regulations across diverse industries and regions can be difficult due to varying levels of awareness, resources, and infrastructure. Lack of uniform enforcement can lead to inconsistencies in waste management practices and hinder progress towards Circular Economy goals.

2. Adequate resources and funding are required for effective implementation:

Implementing comprehensive waste management and Circular Economy initiatives requires substantial financial resources. Adequate funding is crucial for investing in infrastructure, technology, research, and public outreach. Limited resources can constrain the scale and effectiveness of Circular Economy programs.

3. Adoption of circular and digital practices by industries may require time and resources:

Shifting towards Circular Economy and digital practices demands significant investments in technology, training, and process reengineering. Industries may face challenges in upgrading infrastructure and retraining workforce to align with Circular Economy principles. The transition period may involve temporary disruptions and resource-intensive adjustments.

4. Requires investment in workforce training:

Adopting collaborative robotics and advanced technologies necessitates workforce training to operate, maintain, and manage these systems safely and effectively. Investing in training programs can be costly and time-consuming, particularly for small and medium-sized enterprises (SMEs) with limited resources. A skilled workforce is essential for maximizing the benefits of technological advancements.

5. Encouraging behaviour change among citizens and businesses may be challenging:

Promoting behaviour change towards sustainable waste management practices and Circular Economy principles requires overcoming ingrained habits and perceptions. Educating and motivating citizens and businesses to embrace recycling, waste reduction, and resource conservation can be a slow and challenging process. Resistance to change and lack of awareness may impede adoption of sustainable behaviours.

- **Threats**

1. Limited awareness among businesses about the benefits and opportunities of Circular Economy initiatives:

Lack of awareness among businesses about the advantages of Circular Economy practices can hinder adoption. Businesses may perceive circular practices as costly or complex without understanding the long-term benefits such as resource efficiency, cost savings, and improved market competitiveness. This lack of awareness may delay or limit investment in Circular Economy initiatives.

2. Industries or stakeholders resistant to adopting new waste management practices:

Resistance from industries or stakeholders to embrace new waste management practices can impede progress towards sustainable waste solutions. Established practices or reluctance to change may result in continued reliance on traditional, less sustainable methods of waste disposal and management. Overcoming resistance requires effective communication, education, and incentives.

3. Economic challenges may impact funding for waste management initiatives:

Economic downturns or budget constraints can limit funding available for waste management initiatives. Reduced financial resources may hinder investments in infrastructure, technology upgrades, and public awareness campaigns essential for advancing Circular Economy objectives. Securing stable funding amid economic uncertainties is crucial for sustaining progress in waste management.

4. Concerns about job displacement due to increased automation:

The adoption of advanced technologies like collaborative robotics may raise concerns about job displacement among workers. Automation and robotics can potentially replace certain manual tasks, leading to workforce restructuring and job transitions. Addressing these concerns requires proactive

workforce planning, reskilling, and policies to ensure a fair transition to new employment opportunities.

5. Failure to comply with safety standards may result in legal consequences:

Non-compliance with safety standards and regulations poses legal risks for businesses using collaborative robotics and machinery. Accidents or safety violations can lead to legal liabilities, fines, and reputational damage. Ensuring strict adherence to safety standards is essential for safeguarding workers' well-being and minimizing legal risks.

6. Resistance from stakeholders to adopt new waste management practices:

Stakeholder resistance, such as local communities, businesses, or policymakers, can hinder the implementation of innovative waste management practices. Concerns over cost, feasibility, or perceived disruptions may lead to opposition or delays in adopting new waste management strategies. Overcoming resistance requires effective stakeholder engagement and tailored communication strategies.

2.1.4 Conclusion

In conclusion, Spain possesses a strong foundation for waste management regulations and environmental sustainability, supported by existing laws and effective practices. By aligning Circular Economy objectives with industrial competitiveness and promoting the adoption of advanced technologies like collaborative robotics, Spain can drive innovation, efficiency, and sustainability across industries. Government programs and initiatives provide crucial backing to Circular Economy efforts, while public awareness campaigns and compliance with safety standards enhance community well-being and business credibility.

However, challenges such as ensuring widespread compliance with regulations, securing adequate resources for implementation, and overcoming resistance to change may hinder progress. Threats like limited awareness among businesses, economic constraints impacting funding, and concerns about job displacement require proactive strategies to address.

By capitalizing on opportunities to encourage innovation in waste management technologies, support Circular Economy businesses, promote new industries aligned with sustainable practices, and enhance workplace safety through advanced technologies, Spain can further its leadership in sustainable waste management practices and Circular Economy initiatives. Overcoming weaknesses and threats through strategic planning, stakeholder engagement, and investment in workforce training will be essential for Spain to realize its vision of a more sustainable and resilient future.

2.2 Germany

2.2.1 Introduction

Germany stands at the intersection of technological innovation and industrial transformation, driven by its strategic emphasis on the Circular Economy and collaborative robotics. As the country seeks to maintain its competitive edge in a rapidly evolving global market, it has placed significant focus on integrating Industry 4.0 principles and advancing digitalisation within its manufacturing sector. By integrating advanced digital technologies, Germany seeks to enhance performance, efficiency, and competitiveness.

Central to this transformation is the emphasis on standardization which ensures seamless interoperability and optimization across various industrial processes. A solid ecosystem of organizations and research institutions offers invaluable guidance, providing comprehensive recommendations and detailed transformation roadmaps.

However, the journey is not without challenges. Germany faces external threats from global competition, rapid technological advancements, and geopolitical uncertainties. Considering these developments, it is essential for the country to adopt strategies of continuous adaptation and robust investment in research and development.

At the regional level, the federal states of Germany have developed tailored strategies to support Industry 4.0, aligning with the broader national goals while addressing local strengths and needs. The Regional Innovation Strategies for Smart Specialization (RIS3) reflect this localized approach, prioritizing key sectors such as digitalization, energy, health, and mobility. These strategies emphasize sustainability and international cooperation, ensuring that Germany's industrial advancements are both forward-thinking and globally relevant.

Germany's active engagement in technological innovation and industrial transformation prompts a comprehensive examination of its strengths, weaknesses, opportunities, and threats, as the nation strategically navigates the convergence of the Circular Economy and collaborative robotics within its manufacturing landscape.

2.2.2 SWOT analysis

STRENGTHS	OPPORTUNITIES
1. **National Industry 4.0 Initiative:** Germany's commitment to the National Industry 4.0 initiative reflects a strong governmental push towards digitalization in manufacturing and industry, positioning the country as a leader in technological innovation. 2. **Standardization Efforts:** The emphasis on standardization within Industry 4.0 facilitates the adoption of digital technologies, leading to the transformation of traditional factories into smart, optimized production environments. 3. **Supportive Ecosystem:** Germany benefits from a robust ecosystem of organizations, research centers, and industry players actively supporting the Industry 4.0 concept, fostering innovation and collaboration across sectors.	1. **Innovation Leadership:** Germany's focus on future technologies and key competencies, such as renewable energy, advanced materials, and digitalization, presents opportunities for innovation leadership and competitive advantage on a global scale. 2. **Cross-Sector Collaboration:** The convergence of technologies like AI, IoT, and robotics provides opportunities for cross-sector collaboration and the development of innovative solutions that address complex challenges in manufacturing and beyond. 3. **Sustainability Initiatives:** The emphasis on environmental economy, Circular Economy, and resource protection aligns with global sustainability trends, opening doors for Germany to lead in sustainable manufacturing practices and green technologies.
WEAKNESSES	**THREATS**
1. **Transition Challenges:** Despite strong support for Industry 4.0, there may be challenges in effectively transitioning traditional manufacturing processes to smart factories, including workforce retraining, infrastructure upgrades, and integration complexities. 2. **Resource Constraints:** Limited resources, including financial investment and skilled labor, may pose challenges in fully implementing Industry 4.0 initiatives and realizing their potential impact. 3. **Complexity in Integration**: Integrating various digital technologies, such as data analytics, artificial intelligence, and collaborative robots, into existing manufacturing processes may introduce complexity and require significant expertise and investment.	1. **Global Competition:** Intensifying competition from other countries investing in Industry 4.0 and advanced manufacturing technologies poses a threat to Germany's position as a leader in the field, highlighting the importance of continuous innovation and adaptation. 2. **Cybersecurity Risks:** Increased connectivity and digitization in manufacturing processes may expose systems to cybersecurity threats, potentially disrupting operations and compromising sensitive data. 3. **Regulatory Changes:** Changes in regulations or trade policies, both domestically and internationally, could impact the adoption and implementation of Industry 4.0 initiatives, creating uncertainty and compliance challenges for businesses.

2.2.3 Explanation of the 4 sections and each bullet point

- **Strengths**

1. National Industry 4.0 Initiative:

Germany's commitment to the National Industry 4.0 initiative reflects a strong governmental push towards digitalization in manufacturing and industry, positioning the country as a leader in technological innovation.

2. Standardization Efforts:

The emphasis on standardization within Industry 4.0 facilitates the adoption of digital technologies, leading to the transformation of traditional factories into smart, optimized production environments.

3. Supportive Ecosystem:

Germany benefits from a robust ecosystem of organizations, research centres, and industry players actively supporting the industry 4.0 concept, fostering innovation and collaboration across sectors.

Germany's strength lies in its comprehensive approach to digital transformation through initiatives like the National Industry 4.0, positioning the country as a frontrunner in technological innovation. This commitment is further bolstered by robust standardization efforts within Industry 4.0, facilitating the seamless integration of digital technologies into manufacturing processes. Additionally, Germany benefits from a supportive ecosystem comprising organizations, research centres, and industry players actively promoting the industry 4.0 concept, fostering innovation and collaboration across sectors. These strengths collectively contribute to Germany's leadership in driving the evolution of smart, optimized production environments, poised to capitalize on emerging opportunities in the global manufacturing landscape.

- **Opportunities**

1. Innovation Leadership:

Germany's focus on future technologies and key competencies, such as renewable energy, advanced materials, and digitalization, presents opportunities for innovation leadership and competitive advantage on a global scale.

2. Cross-Sector Collaboration:

The convergence of technologies like AI, IoT, and robotics provides opportunities for cross-sector collaboration and the development of innovative solutions that address complex challenges in manufacturing and beyond.

3. Sustainability Initiatives:

The emphasis on environmental economy, Circular Economy, and resource protection aligns with global sustainability trends, opening doors for Germany to lead in sustainable manufacturing practices and green technologies.

Germany has significant opportunities to further enhance its position as a leader in digitalization and Industry 4.0. With ongoing advancements in technology, there is potential for the adoption of new tools and frameworks to optimize manufacturing processes further. This includes leveraging emerging technologies like data analytics, artificial intelligence, and collaborative robotics to drive innovation and efficiency in production. Additionally, Germany can capitalize on international collaborations and partnerships to exchange knowledge and best practices, fostering continuous growth and competitiveness in the global market.

- **Weaknesses**

1. Transition Challenges:

Despite strong support for Industry 4.0, there may be challenges in effectively transitioning traditional manufacturing processes to smart factories, including workforce retraining, infrastructure upgrades, and integration complexities.

2. Resource Constraints:

Limited resources, including financial investment and skilled labor, may pose challenges in fully implementing Industry 4.0 initiatives and realizing their potential impact.

3. Complexity in Integration:

Integrating various digital technologies, such as data analytics, artificial intelligence, and collaborative robots, into existing manufacturing processes may introduce complexity and require significant expertise and investment.

Despite its strengths, Germany faces some challenges that could hinder its progress in digital transformation. One such weakness is the need for continuous investment in research and development to stay at the forefront of technological innovation. Additionally, there may be complexities associated with standardization efforts, requiring careful navigation to ensure alignment across diverse industries and stakeholders. Moreover, there might be potential gaps in digital infrastructure or skills, necessitating focused efforts to address any shortcomings and ensure widespread adoption of Industry 4.0 practices.

- **Threats**

1. Global Competition:

Intensifying competition from other countries investing in Industry 4.0 and advanced manufacturing technologies poses a threat to Germany's position as a leader in the field, highlighting the importance of continuous innovation and adaptation.

2. Cybersecurity Risks:

Increased connectivity and digitization in manufacturing processes may expose systems to cybersecurity threats, potentially disrupting operations and compromising sensitive data.

3. Regulatory Changes:

Changes in regulations or trade policies, both domestically and internationally, could impact the adoption and implementation of Industry 4.0 initiatives, creating uncertainty and compliance challenges for businesses.

Germany's digital transformation journey is not without its threats. One significant threat is the risk of cybersecurity breaches and data privacy concerns, particularly as digital technologies become more integrated into manufacturing processes. This underscores the importance of robust cybersecurity measures and regulatory frameworks to mitigate potential risks effectively. Furthermore, there may be external factors such as geopolitical tensions or economic uncertainties that could impact global supply chains and market dynamics, posing challenges to Germany's manufacturing sector. It's essential to proactively address these threats to safeguard against potential disruptions and ensure the continued resilience of Germany's digital economy.

2.2.4 Conclusion

In conclusion, the analysis of Germany's strategies, policies, and agendas related to Circular Economy and collaborative robotics reveals a multifaceted landscape poised for both innovation and challenges. Germany's strong emphasis on Industry 4.0 and digitalization underscores its commitment to remaining at the forefront of technological advancement in manufacturing and industry. The widespread support for these initiatives from various organizations and research centres highlights a cohesive effort to drive transformation and optimize production processes.

Strengths lie in Germany's robust infrastructure and expertise in advanced technologies, which provide a solid foundation for the integration of Industry 4.0 principles. Additionally, the strategic focus on key sectors such as energy, mobility, digitalization, and life sciences present significant opportunities for growth and competitiveness. Leveraging these strengths, Germany can further enhance its position as a leader in innovation and economic development.

However, weaknesses such as the need for greater standardization in programming practices and the potential challenges associated with cross-sectoral collaboration may hinder progress. It is imperative to address these weaknesses through targeted initiatives aimed at streamlining processes and fostering interdisciplinary cooperation. Despite the strengths and weaknesses, Germany faces threats such as global competition, rapid technological advancements, and geopolitical uncertainties. These threats underscore the importance of continuous adaptation and investment in research and development to maintain a competitive edge in the global market.

Nevertheless, the opportunities presented by emerging technologies, cross-sectoral collaboration, and strategic partnerships offer avenues for Germany to capitalize on its strengths and mitigate potential threats. By embracing innovation, fostering collaboration, and addressing weaknesses, Germany can navigate the complexities of the evolving landscape and emerge as a leader in the digital age of manufacturing and industry.

2.3 Austria

2.3.1 Introduction

Based on the information provided in the report of PR5-A1, here are **the five priority strategies related to Circular Economy and collaborative robotics** selected for Austria:

The Austrian Circular Economy Strategy

In a circular economy, the value of products, materials and resources within the economy is preserved for as long as possible and as little waste and environmental pollution as possible is generated. In resource-efficient and low-pollutant production, secondary raw materials or renewable raw materials are used as far as possible to keep resource consumption within planetary availability. A sustainable product policy ensures that the products manufactured are used, reused, repaired, refurbished and recycled for as long as possible. In this way, the life cycle of the products is extended and the consumption of primary raw materials is reduced overall. The Federal Ministry has therefore developed a national circular economy strategy with the involvement of numerous stakeholders. The vision of the strategy is to transform the Austrian economy and society into a climate-neutral, sustainable circular economy by 2050.

Shaping Austria's future with robotics and artificial intelligence

The whitepaper on robotics and artificial intelligence focuses on four fields of action that are seen as priorities for the development of a smart strategy for robotics and AI:

1. Technology, R&D and economy,
2. Working world and qualification,
3. Society and law,
4. Raising awareness, Communication and public relations.

In these four fields of action, the white paper addresses challenges and specifies - initial - recommendations for action, which are intended to provide impetus for the initiation of a corresponding strategy process.

Artificial Intelligence Mission Austria 2030 (AIM AT 2030)

The Austrian AI strategy aims to promote the responsible use of AI based on European values, strengthen national sovereignty, and reduce dependence on global monopolies. It includes measures to mitigate AI risks and ensure transparency. The strategy emphasizes public awareness, social dialogue and civil society participation in AI regulation. It aims to raise AI research and innovation to a world-class level and position Austria as a leading AI location. It focuses on the modernization of public administration with AI, the transfer of AI applications to SMEs and the promotion of start-ups to boost economic growth and employment. It also aims to create a solid legal framework for the safe use of AI in line with EU legislation.

Masterplan for Raw Materials 2030

The Master Plan Raw Materials 2030 proposes solutions to respond to the challenges of this decade and to ensure Austria's secure supply of primary and secondary mineral raw materials from Austria and abroad. With a comprehensive package of measures, the Master Plan lays the foundation for Austria's resilient development.

The plan also supports expanding secondary raw material extraction, advancing research and innovation, and maintaining high standards. Additionally, it emphasizes social and ecological corporate responsibility, especially in mining countries.

2.3.2 SWOT analysis

STRENGTHS	OPPORTUNITIES
1. Strategy for implementing the Circular Economy in Austria 2. A lot of waste regulations that force companies to think about their waste 3. Making companies aware of the Circular Economy 4. Guarantee social and environmental responsible material sourcing in Austria 5. Safe use of AI	1. Be one of the leaders in the Circular Economy in Europe 2. Establish circular practices as standard 3. Increase innovation in Circular Economy 4. Independence from other markets 5. Be one of the leaders in AI in Europe
WEAKNESSES	**THREATS**
1. Circular Economy is voluntary 2. No penalties for linear economy 3. Benefits of CE are not always seen by companies	1. Waste regulations hinder the implementation of circular strategies 2. Concerns on job replacement through robotics 3. AI develops too fast to properly regulate it

2.3.3 Explanation of the 4 sections and each bullet point

- Strengths

1. Strategy for implementing the Circular Economy in Austria:

Establishing a comprehensive plan and framework to transition Austria's economy towards circular practices, including policies, incentives, and initiatives to promote resource efficiency and reduce waste.

2. A lot of waste regulations that force companies to think about their waste:

Stringent regulations and policies require companies in Austria to carefully consider their waste management practices, encouraging them to minimize waste generation, improve recycling, and adopt circular approaches.

3. Making companies aware of the Circular Economy:

Educating and informing businesses about the principles and benefits of the Circular Economy, fostering awareness and understanding to encourage adoption and implementation of circular practices.

4. Guarantee social and environmentally responsible material sourcing in Austria:

Ensuring that materials used in Austria's industries are sourced in a manner that prioritizes social welfare and environmental sustainability, including ethical labor practices and minimal environmental impact throughout the supply chain.

5. Safe use of AI:

Implementing measures and regulations to ensure the ethical and responsible development and deployment of artificial intelligence technologies in Austria, safeguarding against potential risks such as bias, privacy infringement, and job displacement.

- **Opportunities**

1. Be one of the leaders in the Circular Economy in Europe:

Striving to play a prominent role in advancing Circular Economy initiatives and practices within Europe, demonstrating leadership in sustainable resource management and waste reduction strategies.

2. Establish circular practices as standard:

Working towards making Circular Economy practices the norm across industries, encouraging widespread adoption and integration of sustainable principles into business operations and supply chains.

3. Increase innovation in Circular Economy:

Promoting and fostering a culture of innovation within the Circular Economy sector, driving the development of new technologies, processes, and business models that enhance resource efficiency and promote sustainability.

4. Independence from other markets:

Seeking to reduce reliance on external markets and resources by developing self-sustaining systems and strategies that promote economic independence and resilience.

5. Be one of the leaders in AI in Europe:

Aspiring to be at the forefront of artificial intelligence research, development, and application within Europe, contributing to advancements in AI technology and its ethical and responsible use.

- **Weaknesses**

1. Circular Economy Law missing:

The absence of specific legislation or regulations dedicated to the Circular Economy, potentially hindering the implementation of circular practices and the enforcement of related policies.

2. Circular Economy is voluntary:

Participation in Circular Economy initiatives and adoption of circular practices are not mandated by law or regulations, leaving it up to businesses and individuals to choose whether or not to engage in sustainable practices.

3. No penalties for linear economy:

Despite the push towards circularity, there are no consequences or penalties imposed on businesses or industries that continue to operate in a linear, wasteful manner, which may disincentivize the transition to circular practices.

4. Benefits of CE are not always seen by companies:

Some companies may not fully recognize or understand the potential benefits of transitioning to a Circular Economy model, such as cost savings, improved resource efficiency, and enhanced reputation, leading to reluctance or hesitation in adopting circular practices.

- **Threats**

1. Concerns on job replacement through robotics:

The rapid advancement of robotics and automation technologies raises concerns about potential job displacement, as tasks traditionally performed by humans may be replaced by machines, impacting employment opportunities and livelihoods.

2. AI develops too fast to properly regulate it:

The pace of development in artificial intelligence technology outstrips the ability of regulatory frameworks to keep up, raising challenges in ensuring that AI systems are developed and deployed in an ethical, safe, and responsible manner.

2.3.4 Conclusion

Based on the SWOT analysis provided, Austria demonstrates significant strengths and opportunities in advancing Circular Economy practices and Artificial Untelligence (AI) development. The country has a well-defined strategy for implementing the Circular Economy, strict waste regulations that prompt companies to consider waste management, and initiatives to ensure socially and environmentally responsible material sourcing. Additionally, Austria has measures in place to promote the safe use of AI, mitigating potential risks. Opportunities include establishing leadership in the Circular Economy within Europe, making circular practices standard across industries, fostering innovation in the Circular Economy sector, achieving independence from external markets, and leading in AI research. These opportunities pave the way for growth and leadership in sustainable practices and technological advancements.

However, there are weaknesses and threats that require attention. Weaknesses include the absence of specific legislation dedicated to the Circular Economy, voluntary participation in circular initiatives, lack of penalties for linear economy practices, and some companies not fully recognizing the benefits of transitioning to a circular model. These factors may impede progress towards a more sustainable and Circular Economy. Threats such as concerns about job displacement through robotics and the rapid pace of AI development outstripping regulatory frameworks underscore challenges that need careful consideration and proactive management.

In conclusion, by capitalizing on its strengths, seizing opportunities for leadership and innovation, addressing weaknesses through policy development and awareness campaigns, and mitigating threats through strategic planning and collaboration with stakeholders, Austria can continue to advance its position as a frontrunner in sustainable practices and technological advancements. Embracing a comprehensive approach that balances economic growth with environmental responsibility will be crucial for navigating these complex challenges successfully.

2.4 Poland

2.4.1 Introduction

The following national strategies were selected for SWOT analysis of agendas related to Circular Economy and Robotics in Poland:

- Smart Specialisation on Circular Economy (S7),
- Smart Specialisation on Automation and Robotisation (S11),
- Circular Economy Roadmap,
- National Waste Management Plan.

The selected strategies include appropriate policies and actions defining the approach to implementing the general principles of the Circular Economy and detailed recommendations on the application of CE in the production sector for the coming years.

2.4.2 SWOT analysis

STRENGTHS	OPPORTUNITIES
• **The National Waste Management Plan** together with CE Roadmap and waste regulations provides a good foundation for waste management in Poland including Circular Economy specific actions. • Many CE activities have already been implemented. There is engineering potential in building modern waste processing installations. • There is relatively high awareness among residents of what the circular economy is. • Investments in research infrastructure (CE and Robotics), which have strengthened the potential of research institutions. • High qualifications and extensive experience of a significant part of the scientific and research staff.	• Possibility to use support from EU funds. • Strong and growing industry demand resulting from the need to increase production efficiency and improve the quality of products. • Dynamic development of techniques for obtaining, processing and recovering raw materials. • Taking supportive actions regarding: – intensive promotion of eco-design, – development of tools for assessing environmental impact throughout the life cycle for the purposes of eco-design in selected industries
WEAKNESSES	**THREATS**
• Lack of knowledge transfer mechanisms to industry. • Lack of integration processes among entrepreneurs. • Lack of detailed financial analysis for non-municipal waste related Circular Economy actions. • No direct funds allocated to finance investments.	• Lack of qualified staff supporting and implementing Circular Economy and Robotics technologies and solutions in industrial enterprises. • Strong foreign competition in the field of technology. • Lack of sufficient processing capacity of installations intended for waste processing. • The use of materials in products that are difficult to recycle or materials that generate high recycling costs. • Imbalance in raw material markets and price competition of their suppliers.

2.4.3 Explanation of all 4 sections and each bullet point

- **Strengths**

  According to the National Waste Management Plan one of the main directions is to strengthen circularity by:

  - high-quality sorting and removal of contaminants from waste,

  - maintaining clean recycled waste streams.

  There is also an objective to implement coordinated actions for the development of markets for circular products.

- **Opportunities**

  Financial support in the circular economy area is expected to come from EU funds, in particular from the Cohesion Policy and the Common Agricultural Policy. The circular economy will also be included in various investment activities and activities focused on innovation, research and development.
  The implementation of circular economy will also be able to be financed from other sources of the public finance sector, such as environmental fees, and in the future also funds from deposit systems.

- **Weaknesses**

  No direct and specific financing framework has been assigned to the Circular Economy Roadmap due to the fact that the document identifies mainly legislative actions necessary to be undertaken.

- **Threats**

  Industrial staff working on site (engineers and technicians) are in many cases not familiar with modern technologies of the Circular Economy and Robotics. Their skills require constant updating. On the other hand, the mechanisms for transferring knowledge from the scientific and research community to industry do not work well enough.

2.4.4 Conclusion

In conclusion, the SWOT analysis of the National Waste Management Plan highlights significant opportunities for businesses to capitalize on the growing trend towards circularity. The plan's emphasis on high-quality waste sorting and clean recycled waste streams aligns with market demands for sustainable practices, presenting a competitive advantage for companies that prioritize environmental stewardship.

The availability of financial support from EU funds and other public finance sources offers businesses in the circular economy sector a pathway to secure investments for innovation, research, and development. However, the lack of a specific financing framework poses a challenge that requires strategic planning and advocacy to address.

Moreover, the identified weakness in knowledge and skills among industrial staff underscores the importance of continuous training and knowledge transfer initiatives within organizations. By investing in upskilling programs and fostering collaboration between industry and research

communities, businesses can enhance their workforce readiness and stay ahead of technological advancements in the Circular Economy and Robotics sectors. To mitigate threats related to skill gaps and knowledge transfer inefficiencies, businesses must prioritize talent development strategies and establish effective mechanisms for transferring expertise from academia to industry. By proactively addressing these challenges, companies can position themselves as leaders in sustainable practices and drive innovation in the circular economy landscape.

Overall, by leveraging strengths, seizing opportunities, addressing weaknesses, and mitigating threats, businesses can navigate the evolving landscape of the circular economy successfully. Strategic investments in workforce development, technology adoption, and collaborative partnerships will be key drivers of success in achieving sustainability goals while driving business growth and competitiveness.

3 SWOT analysis focus on HE/VET programmes

3.1 Spain

3.1.1 Introduction

Regarding the information provided in the report of PR5-A2, here are **the five HE/VET programmes related to Circular Economy and collaborative robotics** in Spain selected, along with justifications for their importance:

Master's Degree in Circular Economy and Sustainable Development

This master's degree specifically focuses on Circular Economy and Sustainable Development, providing advanced expertise in strategies and practices essential for transitioning towards a more resource-efficient and sustainable economy. Graduates from this program are equipped with the knowledge and skills needed to drive innovation and implement circular business models across various sectors.

Degree in Environmental Sciences - University of Granada

Environmental Sciences degrees offer a multidisciplinary approach to understanding environmental challenges, including those related to Circular Economy. Students gain a comprehensive understanding of environmental systems, waste management, and sustainable practices, preparing them for careers in Circular Economy initiatives, environmental consulting, and policy development.

Master's Degree in Management, Treatment, and Recovery of Organic Waste

This specialized master's degree focuses on organic waste management, a critical aspect of Circular Economy practices. Graduates are trained to develop innovative solutions for organic waste treatment, recycling, and resource recovery, contributing directly to sustainable waste management strategies and Circular Economy principles.

Master's Degree in Robotics and Intelligent Systems - University of Vic (Uvic) and Technology Centre of Catalonia (Eurecat)

This master's program provides in-depth training in robotics and intelligent systems, essential for professionals in collaborative robotics and Industry 4.0. Graduates gain expertise in robotic

technologies, automation, and control systems, positioning them for roles in advanced manufacturing, robotics engineering, and automation industries.

Degree in Robotics Engineering - University of Deusto

A degree in Robotics Engineering offers comprehensive education in robotics design, development, and application. Students acquire technical skills and knowledge necessary for implementing collaborative robotics solutions in industrial settings. This program prepares graduates to contribute to the development of safe and efficient robotic systems aligned with industry standards and practices.

3.1.2 SWOT analysis

STRENGTHS	OPPORTUNITIES
1. Provides specialized knowledge in Circular Economy and Sustainable Development. 2. Equips graduates with skills related to green topics (implementation of circular business models, waste treatment and resource recovery). 3. Addresses critical environmental challenges and promotes resource efficiency. 4. Provides a multidisciplinary approach to addressing environmental challenges. 5. Prepares graduates for diverse careers in environmental sectors. 6. Aligns with the demands of I4.0 and digital transformation.	1. Growing demand for professionals with expertise in Circular Economy or green topics in public and private sectors. 2. Opportunities to collaborate with industry partners on sustainability initiatives or even for research collaborations and projects. 3. Growing interest and investment. 4. Rising demand for skilled engineers in manufacturing and automation industries.
WEAKNESSES	**THREATS**
1. May require prerequisites in environmental or sustainability studies for effective comprehension. 2. Limited availability of similar specialized programs in certain regions. 3. Heavy reliance on theoretical coursework without sufficient practical experience. 4. Potential oversaturation of the job market for environmental science graduates. 5. Relatively narrow specialization. 6. Relatively high-cost association with specialized robotics equipment and software.	1. Competition from other sustainability-focused master's programs. 2. Economic downturns affecting funding for sustainable development projects. 3. Evolving regulations and policies impacting job prospects. 4. Budget constraints. 5. Rapid technological advancements requiring continuous skills updates.

3.1.3 Explanation of the 4 sections and each bullet points

- **Strengths**

1. Provides specialized knowledge in Circular Economy and Sustainable Development:

This strength highlights the program's focus on Circular Economy and Sustainable Development, offering in-depth understanding and expertise in these critical areas. Students gain specialized knowledge about circular business models, resource efficiency, sustainability principles, and strategies for achieving environmental and economic goals.

2. Equips graduates with skills related to green topics (implementation of circular business models, waste treatment and resource recovery):

The program equips graduates with practical skills relevant to green topics, including the implementation of circular business models. Graduates are trained in waste treatment, recycling, and resource recovery methods, preparing them to address environmental challenges and contribute to sustainable practices in various industries.

3. Addresses critical environmental challenges and promotes resource efficiency:

By focusing on critical environmental challenges, the program emphasizes the importance of sustainability and resource efficiency. Students learn how to identify, analyse, and address environmental issues such as waste management, pollution, and natural resource depletion, promoting responsible resource use and conservation.

4. Provides a multidisciplinary approach to addressing environmental challenges:

A multidisciplinary approach means integrating knowledge from various fields such as environmental science, engineering, economics, and policy. This approach allows students to understand environmental challenges from different perspectives and develop holistic solutions that consider social, economic, and environmental factors.

5. Prepares graduates for diverse careers in environmental sectors:

Graduates are equipped with versatile skills and knowledge that prepare them for diverse careers within environmental sectors. They can pursue roles in sustainability consulting, environmental management, renewable energy, conservation, policy development, and more. The program opens doors to a wide range of career opportunities aligned with environmental stewardship.

6. Aligns with the demands of Industry 4.0 (I4.0) and digital transformation:

Industry 4.0 (I4.0) and digital transformation are driving forces reshaping industries towards efficiency and automation. Programs that align with these demands ensure graduates are equipped with skills in digital technologies, data analytics, automation, and smart systems relevant to modern industrial practices. This alignment enhances graduates' competitiveness and adaptability in the evolving job market.

- **Opportunities**

1. Growing demand for professionals with expertise in Circular Economy or green topics in public and private sectors:

The increasing global focus on sustainability and Circular Economy creates a growing demand for professionals with expertise in these areas. Graduates of programs specializing in Circular Economy and green topics are well-positioned to capitalize on job opportunities in public and private sectors, including environmental agencies, consulting firms, renewable energy companies, sustainable product development, and corporate sustainability departments.

2. Opportunities to collaborate with industry partners on sustainability initiatives or research collaborations and projects:

Collaborations with industry partners provide valuable opportunities for students and graduates to apply their knowledge and skills in real-world settings. Partnering with businesses and organizations on sustainability initiatives or research projects enhances learning experiences, fosters innovation,

and strengthens professional networks. These collaborations can lead to internships, research funding, job placements, and potential entrepreneurship opportunities.

3. Growing interest and investment in sustainability:

The increasing interest and investment in sustainability create favourable conditions for graduates of Circular Economy and sustainability-focused programs. As governments, businesses, and communities prioritize sustainability goals, there is a growing need for professionals who can contribute to sustainable practices, environmental stewardship, and green innovations. This trend opens doors to diverse career pathways and opportunities for impactful work in sustainability-related fields.

4. Rising demand for skilled engineers in manufacturing and automation industries:

The rapid advancement of manufacturing technologies, automation, and Industry 4.0 fuels the demand for skilled engineers with expertise in robotics, automation, and intelligent systems. Graduates specializing in robotics engineering and related fields are well-positioned to pursue rewarding careers in manufacturing industries, robotics companies, research institutions, and technology-driven sectors. The rising demand for skilled engineers presents abundant career opportunities and possibilities for professional growth.

- **Weakness**

1. May require prerequisites in environmental or sustainability studies for effective comprehension:

Requiring prerequisites in environmental or sustainability studies may limit accessibility for students from diverse academic backgrounds. Students without prior knowledge or coursework in these areas may face challenges in comprehending advanced concepts, potentially creating barriers to enrolment and participation.

2. Limited availability of similar specialized programs in certain regions:

The limited availability of specialized programs in certain regions can restrict access to quality education for students living outside major urban areas or specific geographic regions. This limitation may hinder opportunities for individuals interested in pursuing studies in Circular Economy, sustainability, or engineering disciplines.

3. Heavy reliance on theoretical coursework without sufficient practical experience:

Programs emphasizing theoretical coursework over practical experience may overlook the importance of hands-on learning and skill development. Without sufficient practical exposure, graduates may encounter challenges transitioning into real-world environments or applying theoretical knowledge to practical scenarios, potentially impacting their employability and readiness for professional roles.

4. Potential oversaturation of the job market for environmental science graduates:

The job market for environmental science graduates may become oversaturated due to increasing numbers of graduates entering the field. This oversaturation can lead to heightened competition for available positions and potentially lower salary expectations, impacting the overall attractiveness of pursuing careers in environmental sectors.

5. Relatively narrow specialization:

Programs with relatively narrow specializations may limit graduates' career prospects by focusing on specific aspects of Circular Economy, sustainability, or engineering. A narrow specialization may restrict flexibility in job opportunities and professional development, particularly in rapidly evolving fields that require interdisciplinary knowledge and skills.

6. Relatively high-cost association with specialized robotics equipment and software:

Specialized programs in robotics engineering may involve high costs associated with acquiring and maintaining specialized equipment, software, and technology resources. This financial burden may pose challenges for students, particularly those from economically disadvantaged backgrounds, and limit accessibility to these programs.

- **Threats**

1. Competition from other sustainability-focused master's programs:

The presence of numerous sustainability-focused master's programs can lead to increased competition among institutions to attract students and faculty. This competition may result in challenges related to program differentiation, reputation, and enrollment numbers, potentially impacting the sustainability and growth of individual programs.

2. Economic downturns affecting funding for sustainable development projects:

Economic downturns and fluctuations in financial markets can lead to reduced funding for sustainable development projects and initiatives. Limited financial resources may hinder research activities, industry collaborations, and internship opportunities, affecting the overall quality and effectiveness of education in sustainability-related fields.

3. Evolving regulations and policies impacting job prospects:

Rapid changes in regulations and policies related to environmental sustainability and Circular Economy can influence job prospects for graduates. Shifting regulatory landscapes may create uncertainties in the job market, impacting the demand for specific skills and competencies required by employers. Graduates may face challenges in aligning their qualifications with evolving industry requirements.

4. Budget constraints:

Budget constraints at educational institutions can limit investments in infrastructure, faculty development, and student support services. Insufficient funding may compromise the quality of education, research opportunities, and access to state-of-the-art resources essential for programs in sustainability, Circular Economy, and engineering disciplines.

5. Rapid technological advancements requiring continuous skills updates:

The rapid pace of technological advancements, particularly in fields like robotics and automation, necessitates continuous skills updates for students and faculty. Programs focused on engineering and digital transformation must adapt to emerging technologies and industry trends to ensure graduates remain competitive and relevant in the job market. Failure to keep pace with technological advancements may render certain skills obsolete and impact program effectiveness.

3.1.4 Conclusion

In conclusion, the program specializing in Circular Economy and Sustainable Development equips graduates with specialized knowledge and practical skills to address environmental challenges and meet Industry 4.0 demands. Opportunities in sustainability sectors, industry collaborations, rising demand for skilled engineers, and growing interest in sustainability present favourable conditions for graduates.

However, challenges such as prerequisites in environmental studies, limited program availability, theoretical coursework emphasis, potential job market oversaturation, narrow specialization, and high costs need to be addressed. Threats like competition from other programs, economic downturns, evolving regulations, budget constraints, and rapid technological advancements require proactive measures for sustained success.

By enhancing accessibility, practical experience opportunities, and adapting to industry trends while securing funding and aligning with regulations, the program can prepare graduates for impactful careers in Circular Economy and Sustainable Development amidst a competitive landscape.

3.2 Germany

3.2.1 Introduction

The field of Circular Economy in Germany is gaining significant attention as the world increasingly turns to sustainable practices to combat environmental challenges. In Germany, a country renowned for its robust engineering education and commitment to environmental responsibility, academic programs in Circular Economy have increased significantly in recent years, reflecting the nation's dedication to developing innovative solutions for resource management.

These programmes, offered by numerous institutions across the country, are designed to cater to a wide range of interests and career goals within Circular Economy. They emphasize the importance of practical experience, flexibility in learning paths, and the integration of cutting-edge technologies. Consequently, they offer a comprehensive education that is both versatile and practical. By focusing on the efficient use of resources, waste reduction, and the integration of innovative technologies, these programs aim to create a future where economic growth is decoupled from resource consumption and environmental degradation.

A popular programme in the field of Circular Economy is the bachelor's degree in environmental and resource management. This programme offers an interdisciplinary approach to address contemporary environmental challenges by integrating knowledge from various fields. It covers fundamental technical subjects, natural sciences, sociology, and economics, followed by specialized courses on resource protection techniques, environmental planning concepts, and risk assessment.

An additional avenue for acquiring experience and knowledge in this field and for furthering one's interests is to pursue intermediate and higher vocational qualifications in recycling and waste management.

In this context, the following analysis examines the strengths, weaknesses, opportunities and threats of the Circular Economy programmes in Germany. It offers insights into their current state and prospects.

3.2.2 SWOT

STRENGTHS	OPPORTUNITIES
1. **Variety of programs:** There is a wide range of courses in the field of Circular Economy covering various aspects such as environmental engineering, recycling, and sustainable resource management. 2. **Strong network:** Programs in Circular Economy often have strong connections with industry partners, government agencies, and non-profit organizations. This network provides students with access to valuable resources, mentorship. 3. **Practical orientation:** Many programs offer hands-on experiences and projects to equip students with practical skills. Programs in Circular Economy often incorporate international perspectives and collaborations.	1. **Growing demand:** With the increasing focus on sustainability and Circular Economy in society, the demand for professionals with knowledge in this area is also rising. 2. **Innovation potential:** By integrating new technologies and approaches into the curriculum, the programs can be further developed to meet the current market requirements.
WEAKNESSES	**THREATS**
1. **Limited availability:** While there is a variety of programs, some regions in Germany may not offer all these courses, limiting accessibility for some students. 2. **Duration of courses:** Some programs have a longer duration of study up to 7 semesters, which may be too long for some students. 3. **Potential Job Market Oversaturation:** Concern about potential oversaturation of the job market because of the continuous growth in the fields of environmental science.	1. **Competition:** With many similar programs available, competition for students and professionals may increase. 2. **Rapid changes:** The constantly evolving landscape of the Circular Economy requires continuous adaptation of curricula and content to remain relevant.

3.2.3 Explanation

- Strengths

1. Variety of programs:

There is a wide range of courses in the field of Circular Economy covering various aspects such as environmental engineering, recycling, and sustainable resource management.

2. Strong network:

Programs in Circular Economy often have strong connections with industry partners, government agencies, and non-profit organizations. This network provides students with access to valuable resources, mentorship.

3. Practical orientation:

Many programs offer hands-on experiences and projects to equip students with practical skills. Programs in Circular Economy often incorporate international perspectives and collaborations.

Strengths of programs in Circular Economy include an interdisciplinary approach that provides students with a comprehensive understanding of sustainability issues from various perspectives, such as economics, environmental science, and social sciences. This holistic approach equips graduates with a well-rounded skill set that is valuable in addressing complex sustainability challenges. Additionally, these programs offer practical experience through internships, research projects, and collaborations with industry partners, allowing students to apply their knowledge in real-world settings and enhancing their employability. Moreover, the strong network of programs in Circular Economy with industry partners, government agencies, and non-profit organizations provides students with access to valuable resources, mentorship opportunities, and potential job placements upon graduation. Furthermore, these programs often incorporate international perspectives and collaborations, preparing students to work in diverse cultural contexts and contribute to sustainable development on a global scale. In addition to these strengths, programs in Circular Economy provide specialized knowledge in Sustainability Courses and Circular Economy, promote resource efficiency while addressing critical environmental challenges, prepare graduates for diverse careers in environmental sectors, and offer a wide range of courses available for children and young adults.

- **Opportunities**

1. Growing demand:

With the increasing focus on sustainability and Circular Economy in society, the demand for professionals with knowledge in this area is also rising.

2. Innovation potential:

By integrating new technologies and approaches into the curriculum, the programs can be further developed to meet the current market requirements.

Opportunities in the field of Circular Economy in Germany include a growing demand for professionals with expertise in Circular Economy or green topics in public and private sectors. This presents an opportunity for individuals who have completed programs related to Circular Economy to enter a job market that values their knowledge and skills. Additionally, there are opportunities to collaborate with industry partners on sustainability initiatives or even for research collaborations and projects, providing students with valuable hands-on experience and networking opportunities. The rising demand for skilled engineers in manufacturing and automation industries also creates opportunities for graduates with expertise in Circular Economy to contribute to sustainable practices within these sectors. Furthermore, the MINT field of study should remain attractive, offering a promising career path for individuals interested in pursuing a career in Circular Economy and related fields.

- **Weaknesses**

1. Limited availability:

While there is a variety of programs, some regions in Germany may not offer all these courses, limiting accessibility for some students.

2. Duration of courses:

Some programs have a longer duration of study up to 7 semesters, which may be too long for some students.

3. Potential Job Market Oversaturation:

Concern about potential oversaturation of the job market due to the continuous growth in the fields of environmental science.

Weaknesses of programs in Circular Economy in Germany include limited availability, as some regions may not offer all courses, limiting accessibility for some students. Additionally, the duration of study for some programs can be longer, with courses lasting up to 7 semesters, which may be too lengthy for some students. These limitations could potentially hinder the ability of students to access and complete programs in Circular Economy, impacting their educational opportunities and career prospects in the field.

- **Threats**

1. Competition:

With many similar programs available, competition for students and professionals may increase.

2. Rapid changes:

The constantly evolving landscape of Circular Economy requires continuous adaptation of curricula and content to remain relevant.

In the "Threats" section of a SWOT analysis for environmental science graduates, potential challenges and external factors that could hinder their success in the job market include oversaturation of the job market, competition from candidates with similar qualifications, limited job prospects, lower salaries, changing industry trends, as well as the impact of rapid technological advancements requiring continuous skills updates, competition from other sustainability-focused master's programs, and economic downturns affecting funding for sustainable development projects. It is crucial for graduates to address these threats by developing specialized skills, gaining practical experience, staying informed about industry developments, and adapting to changing circumstances to remain competitive in the field.

3.2.4 Conclusion

In conclusion, the programs in the field of Circular Economy in Germany exhibit a range of strengths, weaknesses, opportunities, and threats. The strengths lie in the diversity of programs available, offering a comprehensive selection covering various aspects of environmental engineering and resource management. Additionally, the flexibility in course duration allows students to tailor their education according to their needs. The practical orientation of many programs enhances the learning experience by providing hands-on opportunities and projects.

However, there are also weaknesses to consider, such as the limited availability of certain programs in some regions, which may hinder accessibility for interested students. Furthermore, the longer duration of some courses could pose a challenge for students seeking shorter-term education options.

Looking towards opportunities, there is a growing demand for professionals with expertise in sustainability and Circular Economy, presenting prospects for graduates of these programs.

Moreover, the potential for innovation through the integration of new technologies offers avenues for further development and relevance in the ever-evolving market.

Yet, there are threats to be mindful of, including increased competition among similar programs, which may require institutions to differentiate themselves to attract students and faculty. Additionally, the rapid changes in the Circular Economy landscape necessitate continuous adaptation of curricula to remain current and competitive.

Overall, while the programs in Circular Economy in Germany have their strengths and weaknesses, they also present promising opportunities for students and institutions alike. By addressing these challenges and capitalizing on the opportunities, these programs can continue to thrive and contribute to the advancement of sustainable practices and solutions in the country and beyond.

3.3 Austria

3.3.1 Introduction

Based on the information provided in the report of PR5-A1, here are **the priority VET/HE programs related to Circular Economy and collaborative robotics** in Austria selected:

Sustainable Production and Circular Economy - 6 semesters Bachelor's degree

In future, the design of products and their manufacturing processes will also have to take various sustainability criteria into account. The Bachelor's degree program in Sustainable Production and Circular Economy combines technological expertise with the requirements of the market and society.

Circular Engineering - 7 semesters Bachelor's degree

Circular Engineers have the knowledge and skills to design and conceptualize circular products and production systems. With this interdisciplinary education, graduates are highly competent decision-makers in industry, business and society.

Global Sustainability and Circular Business - 6 semesters Bachelor's degree

The Bachelor's degree program in Global Sustainability and Circular Business thoroughly prepares students for exciting careers in sustainability management and the circular economy. They not only gain fundamental specialist knowledge, but also deepen their understanding of the application of sustainable principles in business contexts.

Mechatronics - Robotics - 6 semesters Bachelor's degree

The Bachelor's degree course in Mechatronics - Robotics deals with automation technology in production, industrial robotics, mechatronics in plant engineering and mobile robotics. Students are actively involved in current projects with cooperation partners in industry. High-tech laboratories with extensive simulation software offer optimal framework conditions.

AI for Sustainable Technologies - 4 semesters Master's degree

Artificial intelligence and data science are technologies that are highly pervasive in almost all areas of life and work and have become indispensable. With the AI for Sustainable Technologies Master's degree program, students become responsible shapers of a future in which people are supported by AI in a sustainable way. During their studies, they focus on the two central concepts of 'artificial

intelligence' and 'sustainable technology development' and learn to combine their technical skills in data science and software engineering with the ability to design and discuss sustainable AI.

Mechanical engineering - robotics and smart engineering - 5 years College for Higher Vocational Education

The VET course "Robotics and Smart Engineering", focuses on classical mechanical engineering - with the three pillars of design, calculation and production in theory and workshop - as well as on the fields of digitization, automation, visualization and "additive manufacturing". Students learn for example how to use robots & build them yourself, bring constructions to life with VR & AR, use sensors & actuators for controlling machines and focus on computer aided design and simulation.

3.3.2 SWOT analysis

STRENGTHS	OPPORTUNITIES
1. Reduce the risk of supply disruption through circular products 2. broad interdisciplinary education 3. practical education on robotics in college 4. combination of the future trends of AI and sustainability in a course 5. high practical context for robotics 6. Not seeing the problem only locally but globally	1. More resilience 2. Reduce CO2 emissions 3. Reduce waste & resource demand 4. Decouple economic growth from resource demand
WEAKNESSES	**THREATS**
1. Theoretical concepts are not always feasible in a practical way 2. Practical examples missing for understanding circularity 3. Sustainability and robotics are not always combined 4. Sustainability is a niche 5. AI develops too fast to be fully covered in the curricula	1. Regulations can limit the feasibility of circular products 2. Development of technologies is too fast to prepare students properly 3. Sustainability not the main goal for companies 4. Leading AI and robotic firms are outside of Europe 5. Sustainability is a complex field that needs to take a lot of disciplines into account

3.3.3 Explanation of the 4 sections and each bullet point

- **Strengths**

1. Reduce the risk of supply disruption through circular products:

Implementing Circular Economy principles, such as recycling, reusing, and refurbishing materials and products, to minimize dependence on new raw materials and decrease vulnerability to supply chain disruptions.

2. Broad interdisciplinary education:

Offering a curriculum that integrates knowledge and skills from multiple disciplines, fostering a holistic understanding and problem-solving approach that prepares students for complex, real-world challenges.

3. Practical education on robotics in college:

Providing hands-on learning experiences in robotics, allowing students to apply theoretical knowledge in real-world scenarios and develop practical skills that are directly applicable to industry needs.

4. Combination of the future trends of AI and sustainability in a course:

Designing courses that merge the latest advancements in artificial intelligence with principles of sustainability, preparing students to innovate in ways that are both technologically advanced and environmentally responsible.

5. High practical context for robotics:

Ensuring that robotics education is deeply embedded in practical applications, where students can work on real-life projects and prototypes, enhancing their understanding and capabilities in real-world settings.

6. Not seeing the problem only locally but globally:

Encouraging a global perspective in problem-solving, where students learn to consider and address the broader, interconnected impacts of issues, promoting solutions that are globally sustainable and equitable.

- **Opportunities**

1. More resilience:

Enhancing the ability of systems, businesses, and communities to withstand and recover from disruptions, ensuring stability and continuity in the face of challenges.

2. Reduce CO2 emissions:

Implementing strategies and technologies to lower the amount of carbon dioxide released into the atmosphere, helping to mitigate climate change and its impacts.

3. Reduce waste & resource demand:

Minimizing the generation of waste and the consumption of natural resources through efficient use, recycling, and sustainable practices, promoting environmental conservation.

4. Decouple economic growth from resource demand:

Achieving economic development that is not directly linked to increased consumption of natural resources, enabling sustainable growth that minimizes environmental impact.

- **Weaknesses**

1. Theoretical concepts are not always feasible in a practical way:

Abstract ideas and theories may not always be easily implemented or applicable in real-world scenarios due to practical constraints and complexities.

2. Practical examples missing for understanding circularity:

The lack of concrete, real-life instances makes it difficult for individuals to grasp how Circular Economy principles can be effectively applied.

3. Sustainability and robotics are not always combined:

Often, advancements in robotics and sustainable practices are developed separately, missing opportunities for integrated solutions that address both technological and environmental goals.

4. Sustainability is a niche:

The concept of sustainability is often viewed as specialized or limited to certain sectors, rather than being mainstreamed across all areas of industry and society.

5. AI develops too fast to be fully covered in the curricula:

The rapid pace of advancement in artificial intelligence (AI) outstrips the ability of educational curricula to keep up.

- **Threats**

1. Regulations can limit the feasibility of circular products:

Regulatory frameworks may pose challenges or constraints that hinder the adoption or implementation of Circular Economy practices, potentially impeding progress towards sustainable product cycles.

2. Development of technologies is too fast to prepare students properly:

The rapid pace of technological advancements can outpace educational curricula, making it challenging to adequately train students to keep up with emerging technologies and their practical applications.

3. Sustainability not the main goal for companies:

Many companies prioritize profit-making over sustainability, resulting in practices and decisions that prioritize short-term gains over long-term environmental and social responsibility.

4. Leading AI and robotic firms are outside of Europe:

The primary innovators and industry leaders in artificial intelligence and robotics are often based in regions outside of Europe, potentially impacting Europe's competitiveness and influence in these fields.

5. Sustainability is a complex field that needs to take a lot of disciplines into account:

Sustainability issues are multifaceted and interconnected, requiring interdisciplinary approaches that consider factors from various fields such as economics, ecology, sociology, and policymaking to develop effective solutions.

3.3.4 Conclusion

Based on the SWOT analysis provided, it is evident that the VET and HE programs in Austria has several strengths and opportunities to leverage in the field of robotics education with a focus on sustainability and Circular Economy principles. The strengths include a practical approach to education, interdisciplinary curriculum, and a global perspective on problem-solving. These strengths position the VET and HE programs well to address current and future challenges in the field. Opportunities such as enhancing resilience, reducing CO2 emissions, and decoupling economic growth from resource demand present avenues for growth and innovation. By capitalizing on these opportunities, the VET and HE program in Austria can further differentiate itself and contribute positively to environmental sustainability efforts.

However, there are also weaknesses and threats that need to be addressed. Weaknesses such as theoretical concepts not always being feasible in practice and the lack of practical examples for understanding circularity could hinder effective implementation of initiatives. Additionally, threats like fast-paced technological developments outstripping educational curricula and companies prioritizing profit over sustainability pose challenges that need to be navigated carefully.

In conclusion, by building on its strengths, addressing weaknesses, seizing opportunities, and mitigating threats through strategic planning and collaboration, the institutions in Austria can continue to excel in providing high-quality robotics education that integrates sustainability principles effectively. Embracing innovation, fostering partnerships, and staying adaptable to changing landscapes will be key to long-term success in this dynamic field.

3.4 Poland

3.4.1 Introduction

For the SWOT analysis of HE/VET area the following programmes related to Circular Economy and Robotics were selected:

- VET Action Plan 2022-2025
- Specialized engineering studies (BSc) in the circular economy - University of Life Sciences in Lublin
- ‘Circular economy and climate protection’ master's studies - Wrocław University of Science and Technology
- 'Fundamentals of robot programming' course - University of Rzeszów
- 'Robot Collaboration' course - Wrocław University of Science and Technology

The selected programmes represent both general guidelines and specific examples of CE/Robotics implementation in the education system in Poland.

3.4.2 SWOT analysis

STRENGTHS	OPPORTUNITIES
• HE courses provide broader context. Students on the CE course can gain knowledge on a variety of environmental topics, including the legal framework. On the other hand, Robotics students study electronics and automation technology with a strong mathematical background. • The courses prepare graduates for diverse careers in environmental or automation/mechatronics sectors.	• New EU funds for education and capacity building (e.g. Erasmus+, regional funds) can be used for CE/robotics programmes update and extension. • New forms of education – e.g. online courses • International exchange at universities.
WEAKNESSES	**THREATS**
• Unbalanced geographic distribution of universities and centers offering specialized CE/robotics programmes. • Higher education courses sometimes focus on the theoretical side, without enough practical exercises. • Lack of integrated (CE+Robotics) courses.	• HE/VET programs do not meet the actual requirements of students and the market. • General recession and economic problems. • Technological changes too fast.

3.4.3 Explanation of the 4 sections and each bullet point

- **Strengths**

HE studies on Circular Economy are mainly conducted in Environmental Engineering faculties. These departments typically use a multidisciplinary approach, and teaching topics range from natural sciences to very specific subjects related to engineering and technology (e.g. fluid dynamics, heat transfer, statics).

- **Opportunities**

Online courses can be attractive to students from distant places. It is important to provide appropriate tools for such courses, including simulators and remotely accessible instrumentation.

- **Weaknesses**

For HE/VET institutions, the relatively high cost of robotics hardware and software may constitute a barrier to equipping laboratories with the latest technologies. This is why the offered courses sometimes focus on the theoretical side.

- **Threats**

There is always a risk of changing educational trends. Therefore, program developers must carefully monitor the market to ensure that the courses offered meet the actual requirements of students.

3.4.4 Conclusion

The SWOT analysis of Higher Education (HE) studies in Circular Economy and Robotics reveals valuable insights into the current landscape and future prospects of educational programs in these fields. The strengths identified in HE institutions specializing in Environmental Engineering underscore their multidisciplinary approach and diverse teaching topics, positioning them as key players in fostering innovation and sustainability through education.

Moreover, the opportunities presented by online courses offer a promising avenue for reaching students from distant locations and enhancing accessibility to specialized knowledge. By leveraging appropriate tools such as simulators and remote instrumentation, HE institutions can expand their reach and provide engaging learning experiences tailored to the needs of a diverse student population. However, the identified weakness related to the high cost of robotics hardware and software poses a challenge for equipping laboratories with cutting-edge technologies. This limitation may lead to a focus on theoretical aspects in course offerings, highlighting the importance of balancing theoretical knowledge with practical skills development to ensure comprehensive learning outcomes for students. Furthermore, the threat of changing educational trends underscores the need for continuous monitoring of market requirements to align program offerings with evolving student needs. Program developers must remain agile and responsive to emerging trends to ensure that HE courses remain relevant, competitive, and aligned with industry demands.

In conclusion, HE institutions in Circular Economy and Robotics face a dynamic landscape characterized by strengths to leverage, opportunities to explore, weaknesses to address, and threats to mitigate. By capitalizing on their strengths, embracing online learning opportunities, addressing cost barriers through innovative solutions, and staying attuned to market trends, HE programs can adapt proactively to meet the evolving needs of students and industries in these critical fields.

4 Conclusion of the SWOT analysis

The analysis of strategies, policies, educational programs, and industry landscapes across Spain, Germany, Austria, and Poland provides valuable insights into the state of Higher Education (HE) and VET studies in Circular Economy and Robotics. Each country displays unique strengths, weaknesses, opportunities, and threats shaping their approaches to fostering innovation, sustainability, and skill development in these critical fields.

Spain demonstrates a strong strategic commitment to Circular Economy and sustainability, supported by robust laws and government programs that lay a solid foundation for waste management regulations and circular economy goals. The country's focus on skill development aligns with global trends in environmental stewardship and industrial transformation. However, ensuring compliance with regulations and overcoming stakeholder resistance remain challenges that need targeted investments and adaptive strategies. In Germany, the diversity of HE and VET programs in Circular Economy offers a comprehensive range of courses covering various aspects of environmental engineering and resource management. While practical orientation enhances learning experiences, limited program availability in certain regions highlights the need for improved accessibility. Germany’s policies emphasize Industry 4.0 and digitalization as key drivers of technological advancement in manufacturing. The country’s expertise in advanced technologies

presents significant growth opportunities but requires greater standardization in programming practices to address weaknesses related to cross-sectoral collaboration. Austria's focus on teaching subjects like circular economy, robotics, and AI reflects a proactive approach to addressing global challenges such as supply chain risks and pollution.

The country's strengths include a well-defined strategy for implementing Circular Economy and initiatives to promote safe AI use. However, gaps in practical examples and sustainability awareness among profit-oriented companies underscore the need for enhanced education and regulation to promote eco-friendly practices. Opportunities for leadership in Europe and fostering innovation in the Circular Economy sector present avenues for growth, but voluntary participation in circular initiatives and lack of penalties for linear economy practices require attention to ensure progress towards sustainability goals. In Poland, the increasing popularity of circular economy solutions highlights the transformative potential for businesses seeking tangible benefits through sustainable practices. Despite supportive strategies, challenges like competence gaps, lack of qualified staff, and resource limitations require targeted investments in education and technology infrastructure. Implementing circular economy solutions necessitates significant investments with long-term returns, highlighting barriers associated with raw material markets and price competition.

Overall, these diverse perspectives underscore the importance of collaborative efforts to address common challenges while capitalizing on shared opportunities for growth and innovation in Circular Economy and Robotics education. By leveraging strengths, addressing weaknesses, seizing opportunities, and mitigating threats collectively, these countries can drive sustainable development, technological advancement, and global competitiveness in the evolving landscape of HE/VET studies. Embracing innovation and balancing economic growth with environmental responsibility will enable Spain, Germany, Austria, and Poland to navigate complex challenges successfully on a global scale.