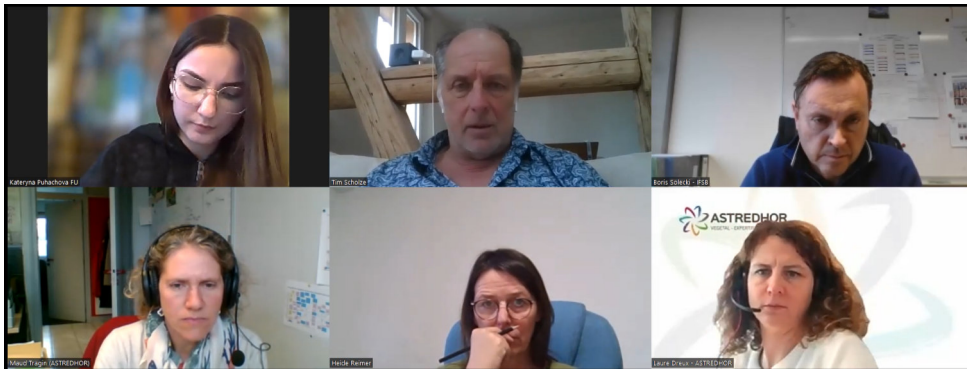
Biochar & Circular Carbon
Economy Competences

The B4C Project Interview Report



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Methodology

1. Interview Format

The interviews across the B4C project partners followed a structured approach to gather in-depth insights into the integration of Sustainable Development (SD) and Circular Economy (CE) principles, particularly around biochar, within vocational education training (VET) programs. Folkuniversitetet provided a guiding framework for the sessions, ensuring consistency and focus across discussions (see Annex 1).

1. **Introduction and Purpose** Each session began with a welcome and a brief introduction to the B4C project, clarifying its objectives to support sustainable practices and carbon-based circular economy within VET. Facilitators outlined the session's structure, which involved a video introduction, self-introductions from participants, and guided discussion based on a set of pre-defined questions. Consent for recording was also ensured as part of the initial setup.
2. **Introductory Video and Definitions** To provide participants with foundational knowledge, the sessions included a short video introducing biochar and the concept of a carbon-based circular economy. Following the video, participants reflected on these topics, defining biochar as a carbon-rich material produced from biomass and discussing how circular economy principles repurpose waste materials to reduce carbon emissions and support sustainability goals.
   Access link to the video: https://www.youtube.com/watch?v=BaOL_AU14LY
3. **Participant Introductions** Participants introduced themselves, describing their roles within their institutions and their relevance to the topics at hand. The groups comprised a diverse mix, including VET educators, curriculum developers, sustainability and construction experts, and agricultural professionals, providing a broad range of perspectives on integrating CE and SD principles into educational programs.
4. **Guided Discussion Topics** The main part of each interview was structured around specific thematic questions to ensure comprehensive coverage of key topics:
   - **Relevance of SD & CE in Education**: Participants discussed the importance of SD and CE in their institutions, sharing current initiatives and programs already in place.
   - **Opportunities for Carbon-Based Circular Economy Integration**: The discussion explored potential areas and courses where carbon-based circular economy topics could be introduced, with participants identifying practical applications for biochar.
   - **Barriers to Implementation**: Participants highlighted the main challenges in introducing these topics, including financial constraints, limited resources, and a lack of specialized knowledge or teaching materials.
   - **Potential of Biochar for Decarbonization**: Participants reflected on biochar's role in decarbonization, considering its applications across sectors such as agriculture and construction.
   - **Support from B4C**: Lastly, participants identified the types of support that would be most beneficial from the B4C project, including access to teaching materials, professional development, and partnerships with industry.
5. **Session Length and Modality** Each session lasted approximately two hours and was conducted in both online (Zoom) and offline formats, depending on the partner institution's preferences and participant availability. The blended approach allowed

flexibility and accommodated the geographical diversity of participants across European regions.

2. Participant Profiles

The B4C interviews engaged a diverse group of participants from various fields related to Vocational Education and Training (VET), sustainability, and industry, offering a well-rounded perspective on the integration of Sustainable Development (SD) and Carbon-Based Circular Economy (CCE) principles in educational settings. Below is an overview of the participant roles and expertise from each partner organization, highlighting their unique insights and contributions to the discussions.

VET Educators and Trainers

Folkuniversitetet (Sweden): Vocational training educators specialized in environmental management and sustainability were involved, focusing on implementing CCE principles within practical VET courses. These educators shared their experience in teaching sustainable farming practices and incorporating biochar topics into environmental science and agricultural education.
IFSB (Luxembourg): Trainers with extensive practical experience in sustainable construction and low-carbon materials, including bio-sourced materials, participated. Their expertise included the application of biochar as an additive to construction materials, emphasizing hands-on training and awareness-raising among VET students about sustainable construction practices.
DEULA-Nienburg (Germany): Vocational schoolteachers and agricultural engineers contributed perspectives on sustainable soil management and the integration of biochar in agricultural training. They discussed their ongoing efforts to instill circular economy principles in students through courses on soil fertility, sustainable crop production, and waste management in farming.

Curriculum Designers and Developers

Università Cattolica del Sacro Cuore (Italy): Curriculum developers with a focus on agroecology and climate-smart agriculture contributed insights into designing educational programs that integrate SD and CE concepts. They expressed interest in creating modules that combine biochar with broader environmental science topics to support climate resilience and soil health in agriculture.
University of Thessaly (Greece): Faculty specializing in agricultural sciences shared their experience incorporating biochar and circular economy topics into higher education curricula. They highlighted the importance of practical lab sessions and fieldwork for teaching biochar applications in sustainable agriculture and soil science.
Industry Experts and Environmental Consultants

Biotechnical Center Naklo (Slovenia): Educators and consultants specializing in sustainable development and circular economy themes provided insights into the practical use of biochar for soil enhancement and waste management. Their work at both secondary and tertiary education levels allowed for a comprehensive view of biochar's educational applications and potential for hands-on learning.
Neobuild and Cocert (Luxembourg): Innovation project managers and sustainable development engineers focused on construction sector innovations shared perspectives on CCE in the building industry. They provided valuable insights into integrating biochar as a sustainable material,

outlining its role in decarbonization through applications in low-carbon concrete and soil stabilization for urban greening projects.

Agricultural Specialists and Regenerative Farming Advocates

Food4Sustainability (Portugal): Specialists from regenerative agriculture backgrounds provided input on using biochar within sustainable food systems and soil health management. They advocated for collaboration with local farms and research centers to offer students hands-on experiences with biochar applications in soil enhancement and carbon sequestration.
Irish Bioenergy Association (Ireland): Agricultural experts focusing on bioenergy and sustainable farming practices contributed insights into biochar's dual role in waste-to-resource strategies and soil quality improvement, discussing how these principles can align with European climate targets and sustainable agriculture initiatives.

Project Managers and Sustainable Development Advocates

IFSB and Neobuild (Luxembourg): Project managers with a focus on corporate social responsibility (CSR) and youth engagement in sustainable construction were involved. They emphasized the role of education in promoting sustainable practices within the construction industry, advocating for early integration of biochar and CCE concepts to foster environmentally conscious professionals.

ASTREDHOR: In France, participants included technical advisors in ornamental horticulture, a VET school trainer in landscape management, a project developer in landscape design, an advisory engineer specializing in professional training, and a Ministry representative focused on agro-ecological transition in agricultural education. These participants provided perspectives on biochar's potential for soil and substrate management, emphasizing the need for practical examples and teaching materials that demonstrate biochar's real-world applications.

Each participant brought a unique perspective to the discussion, allowing for a multi-faceted analysis of biochar and circular economy integration in VET settings. Their collective expertise spanned curriculum development, hands-on training, and sector-specific applications, offering valuable insights into the educational needs, opportunities, and barriers associated with promoting sustainable practices in Europe's vocational education sector.

3. Data Collection and Analysis

The data collection for the B4C project interviews was designed to capture a rich, nuanced understanding of partner perspectives on Sustainable Development (SD) and the Carbon-Based Circular Economy (CCE) within vocational education and training (VET). Utilizing a structured interview framework provided by Folkuniversitetet, each focus group followed a guided protocol, ensuring consistent data collection across different sessions and locations.

Data Collection Methodology

Interview Format and Tools: Data was collected through a combination of online and in-person interviews, with each session lasting approximately two hours. The interviews incorporated an introductory video to provide baseline knowledge on biochar and CCE principles, followed by

guided questions that encouraged participants to share insights on integrating these topics within their educational institutions.
Interview Guide: The guiding questions focused on thematic areas such as the importance of SD and CCE in current curricula, opportunities and challenges for incorporating biochar, and specific resource needs for successful integration. This structured approach facilitated the collection of focused, comparable responses across institutions, aiding in thematic analysis.
Participant Consent and Anonymity: Participants were informed of the study's purpose and provided consent prior to each interview. No recordings were made to respect participant anonymity, and facilitators documented responses through detailed notes, capturing both direct quotes and overarching themes discussed by the participants.

Data Analysis Approach

1.Thematic Analysis: The analysis followed a thematic approach, categorizing data into core themes identified during the interviews. These themes included understanding and perceptions of biochar, relevance and implementation of SD and CCE, potential for biochar in learning and acting for decarbonization, barriers to integration, and recommendations for B4C project support.
2. Coding and Categorization: Facilitators initially coded responses based on the main interview questions. Each category was further divided into sub-themes to capture specific insights and variations, such as sector-specific challenges (e.g., construction vs. agriculture) or unique curriculum needs for different educational levels.
3. Cross-Partner Comparisons: Data was then analyzed across partners to identify commonalities and differences in perspectives. This cross-partner analysis revealed shared challenges, such as limited teaching resources and budget constraints, as well as unique opportunities, including specific sectoral applications of biochar and CCE principles.
4. Synthesis of Key Insights: Key insights from each theme were synthesized to form a comprehensive understanding of partner needs, challenges, and potential solutions. These insights informed the final report structure, allowing for a cohesive presentation of findings and targeted recommendations for the B4C project's support initiatives.

Challenges in Data Collection and Analysis

Given the range of institutions involved—from agricultural schools to construction training centres—responses varied widely in terms of specific applications and challenges. To address this, analysis focused on identifying universal themes while noting sector-specific insights to maintain the richness of the data.
This systematic approach to data collection and analysis ensured that diverse perspectives were captured and synthesized, resulting in a thorough understanding of the current state, opportunities, and barriers for integrating biochar and CCE within European VET programs.

Thematic Summaries

The thematic areas in this report were defined based on recurring patterns and priority topics identified through our partner interviews. By analysing the responses provided by vocational education training (VET) institutions, curriculum developers, and industry experts, we sought to uncover the most critical factors affecting the integration of Sustainable Development (SD) and Carbon-Based Circular Economy (CCE) principles in education.

Each thematic area reflects an essential component of integrating biochar and CCE into VET, encompassing both universal concerns shared by multiple partners and sector-specific insights unique to certain fields, such as agriculture and construction. The thematic categories emerged from:

1. Common Definitions and Perceptions: Participants provided consistent definitions of biochar and CCE, establishing a foundation for understanding these concepts within educational settings. This helped us develop a unified approach to framing biochar's role and the value of circular economy principles.

2. Relevance to Current Educational Practice: Many partners highlighted the significance of SD and CCE in their curricula, discussing ongoing initiatives and setting benchmarks for potential future integration. This focus helped define a thematic area on the importance of these concepts within their educational missions.

3. Challenges and Opportunities for Integration: Responses revealed a balance of challenges, such as budget constraints and resource limitations, alongside specific opportunities for introducing biochar in practical, course-based applications. These were grouped into thematic areas focused on barriers to implementation and opportunities for curriculum integration.

4. Resource and Support Needs: Each partner expressed a need for targeted resources and support to effectively teach these topics. Identifying these needs allowed us to develop a theme around support requirements and potential assistance from the B4C project.

5. Sector-Specific Applications and Practical Learning: Certain sectors, such as construction and agriculture, presented unique applications for biochar, enriching the analysis with practical examples and hands-on learning activities. This input informed a theme on innovative learning formats and practical activities.

By structuring the thematic summaries around these key areas, we aim to provide a clear, actionable overview that reflects both the collective insights and individual perspectives of our project partners. Each theme is designed to capture the depth and diversity of the input received, allowing for a comprehensive understanding of how SD and CCE can be effectively integrated into VET programs across Europe.

1. Biochar and Carbon-Based Circular Economy: Definitions and Understanding

The initial focus of each interview centred on participants' definitions and understanding of biochar and the carbon-based circular economy (CCE). This exploration revealed both shared definitions and unique perspectives across countries and sectors, helping to clarify these foundational concepts in the context of vocational education.

Across the board, participants defined **biochar** as a carbon-rich material derived from organic waste through pyrolysis—a process that converts biomass into a stable, carbon-sequestering substance. Partners from various regions, including Sweden, Luxembourg, and Ireland, recognized biochar's dual environmental value: it enhances soil health by increasing nutrient and water retention while acting as a long-term carbon sink to mitigate climate change. This perspective was consistently highlighted by **agricultural and environmental education participants**, who emphasized biochar's regenerative potential in soil management and sustainable agriculture.

The participating partners defined biochar in terms that reflect both its scientific properties and practical applications in sustainable development. For instance, the French team provided a specific definition, describing biochar as a type of coal produced through pyrolysis that stabilizes carbon without releasing CO_2. They also highlighted the carbon-based circular economy as a "three-pronged approach" involving production, transformation, and recycling, specifically designed to support local, short-circuit economies utilizing organic and green waste. This perspective aligns with the common goals across partners to create sustainable practices in vocational training that emphasize environmental responsibility and resource efficiency.

The concept of a **carbon-based circular economy** was broadly understood as an economic model that repurposes organic waste into valuable resources, thereby reducing carbon emissions. Participants described it as an essential shift from a "take-make-waste" linear approach to a sustainable, regenerative model. This understanding was particularly strong among partners from **construction-focused institutions** in Luxembourg and Germany, who emphasized CCE's potential in sustainable building practices, waste reduction, and resource efficiency.

While definitions were largely consistent, the way partners viewed biochar's applications varied according to their institutional focus:

Agricultural and Environmental Education (Sweden, Germany (DEULA), Greece, Slovenia): Participants from agricultural institutions, like the University of Thessaly and Biotechnical Center Naklo, focused on biochar's potential in soil health and its role in improving crop yields and promoting sustainable agriculture. This group highlighted biochar's educational value as a practical, hands-on example of sustainable resource management, making it highly relevant for integration into agricultural VET programmes.
Construction and Sustainable Materials (Luxembourg, Germany): Participants from construction-focused institutions, such as IFSB and (partly blinc), saw biochar's value in building materials, particularly as an additive to reduce the carbon footprint of traditional materials like concrete. They emphasized the need to educate future builders on alternative, low-carbon materials and innovative waste-to-resource applications in construction, viewing biochar as a case study in sustainable building.

Circular Economy and Policy Advocacy (Ireland, Portugal): Participants from the Irish Bioenergy Association and Food4Sustainability in Portugal approached biochar within the broader framework of circular economy principles, noting its relevance in policy discussions on climate change and resource efficiency. They highlighted biochar's potential to support waste-to-resource policies in agriculture and energy, with a focus on integrating these topics into VET to align with European sustainability goals.

Many participants noted that, despite biochar's proven environmental benefits, it remains a relatively new concept in VET. However, its clear alignment with sustainable development and environmental management makes it an ideal topic for introducing students to the principles of the carbon-based circular economy. Several partners, such as Folkuniversitetet and the University of Thessaly, identified biochar as a gateway topic for teaching broader concepts like waste reduction, soil health, and climate change.

One recurring insight was the **versatility of biochar across sectors**. While traditionally associated with agriculture, biochar's potential applications in construction and waste management were highlighted, illustrating its value as a multi-disciplinary educational tool. Partners from Germany and Luxembourg proposed using biochar as a case study to promote collaborative learning, where students from different vocational backgrounds could work on biochar-related projects, enhancing their understanding of CCE from multiple perspectives.

Partners across several countries agreed that biochar's educational value could be better realized if its practical applications were more widely recognized. Participants from IFSB and Neobuild stressed the importance of engaging with industry partners who are pioneering biochar applications, suggesting that such partnerships could provide students with hands-on experiences and exposure to real-world CCE practices.

Despite biochar's appeal, some participants, particularly in Luxembourg and Slovenia, highlighted the challenges of standardizing biochar's application within VET due to varying perceptions of its benefits. These partners noted a lack of cohesive teaching resources and standards for biochar in vocational education, which could hinder its integration as a mainstream educational topic.

2. Importance of Sustainable Development (SD) and Circular Economy (CE) in Educational Organizations

For B4C project partners from Sweden, Germany, Luxembourg, integrating Sustainable Development (SD) and Circular Economy (CE) principles into vocational education and training (VET) programs is essential for developing a future workforce prepared to address environmental challenges. While each country's approach varies based on sector focus and resources, SD and CE serve as foundational pillars that reinforce sustainability across educational disciplines. Insights from additional interview participants, including Ireland, Slovenia, Greece, Italy and Portugal, further broaden understanding of SD and CE applications in different contexts.

Partners from different countries highlighted the varying levels of interest and commitment to Sustainable Development (SD) and Circular Economy (CE) principles within their educational organizations. French participants noted that interest in sustainability is often driven by external mandates rather than intrinsic motivation among educators and institutions. They emphasized

recent reforms in France that mandate a focus on sustainability within agricultural education, which reflects broader efforts to institutionalize these values. However, they also pointed out the challenges in effectively conveying the importance of SD and CE topics to younger apprentices compared to adult learners, who may more readily understand the long-term impact of these practices.

Core Values and Institutional Missions

Partners from **Sweden** and **Luxembourg** incorporate SD and CE as essential elements in their educational missions. In Sweden, sustainability topics are integrated across various VET programs, including those in construction, environmental management, and agriculture, instilling values of social responsibility among students. In **Luxembourg**, VET programs emphasize low-carbon materials and sustainable construction practices, aligning students' skills with industry demands for sustainable practices.

In **Germany**, SD and CE principles are integral to agricultural education, applied in areas such as soil management, crop production, and waste management. This approach ensures that students experience SD and CE as cross-curricular themes that promote resource efficiency and environmental responsibility in agriculture. In **Ireland**, the emphasis on digital learning promotes SD and CE through blended learning tools, making these principles accessible to students across vocational fields and helping them understand and apply CE in digital contexts.
In **Slovenia**, sustainability practices are integrated into both secondary and tertiary education, focusing on sustainable soil management and biochar's role in agriculture. **Greece** and **Italy** incorporate SD and CE in agricultural sciences, with Greece emphasizing soil health and sustainable agriculture, while Italy focuses on agroecology and climate-smart farming techniques. **Portugal** incorporates regenerative agricultural practices within "Living Lab" initiatives, allowing students to gain hands-on experience with circular economy practices and sustainable resource management.

Relevance to Workforce Preparation

For partners from Luxembourg and Ireland, integrating SD and CE into VET is critical to preparing students for careers in fields where sustainability is increasingly prioritized. Luxembourg's sustainable construction training equips students with skills in low-carbon building techniques, waste reduction, and innovative material use, aligning with the demand for environmentally responsible professionals. Ireland's approach to digital learning emphasizes CE as a necessary competency in various sectors, helping students develop skills that will be vital in a circular economy.

Partners from Sweden and Germany noted that SD and CE concepts enhance students' understanding of environmental impact and social responsibility, fostering a mindset that values sustainability both professionally and personally. For German students, the principles of CE are directly applied in sustainable farming practices, connecting technical skills with ecological stewardship. Interview participants from Greece and Slovenia emphasized similar values, focusing on practical agricultural applications like soil regeneration and sustainable crop management.

Current Initiatives and Programs Supporting SD and CE

1. Hands-On Learning and Cross-Curricular Projects: Partners from Germany and Luxembourg emphasize experiential learning to make SD and CE principles tangible for students. In Germany, agricultural training includes practical work on sustainable soil management and crop production, while Luxembourg's low-carbon construction program teaches students about bio-sourced materials and sustainable building practices. In Ireland, digital resources support SD and CE integration across vocational disciplines, leveraging e-learning tools to bridge the gap between theory and practical application.

2. Program Innovations in Sustainability: In Sweden, partners lead several sustainability-focused initiatives, including a "Sustainability in VET" program that integrates SD and CE principles across various VET offerings. This program also offers short courses on circular economy for professionals, addressing competencies in waste reduction and resource efficiency.

3. Country-Specific Initiatives from Interview Participants: Additional countries bring unique perspectives and programs in SD and CE. In Portugal, regenerative agriculture initiatives like "Living Labs" allow students to collaborate with local farmers to test sustainable techniques. Italy focuses on agroecology programs that connect climate resilience with sustainable agricultural practices, while Slovenia emphasizes sustainable horticulture and biochar's applications in soil health. These initiatives align with EU sustainability targets, broadening the impact of SD and CE in VET.

Challenges in Emphasizing SD and CE within VET

Although SD and CE integration is highly valued, resource limitations pose challenges to implementing hands-on activities. Partners from Germany and Luxembourg reported that funding restrictions limit access to updated materials and practical tools needed for sustainable training.
Partners from Sweden and Ireland noted that rigid curriculum requirements hinder the integration of SD and CE in VET. In programs bound by strict regulatory standards, it can be challenging to introduce new, interdisciplinary content without substantial curriculum revisions.
Implementing SD and CE effectively requires faculty expertise, which partners noted is not always readily available. Partners from Luxembourg and Germany expressed a need for professional development programs to equip educators with the knowledge to teach these principles effectively, especially given the evolving nature of sustainable practices in fields like construction and agriculture. Additional interview participants from Greece and Italy echoed this need, highlighting the importance of professional training for educators in climate-smart agriculture and sustainable development.

Cross-Country Insights and Key Takeaways

Partners and interview participants across countries share a commitment to embedding SD and CE as central values in VET, seeing them as critical for developing responsible, skilled professionals and fostering a mindset of environmental and social responsibility among students. Each country brings a unique, sector-specific approach to SD and CE. Germany focuses on sustainable agriculture, Luxembourg emphasizes low-carbon construction, Sweden leads interdisciplinary sustainability programs, Ireland offers digital CE resources, and countries like Slovenia, Greece, and Portugal incorporate sustainability into agriculture, regenerative practices, and environmental science, collectively providing a multi-dimensional approach to sustainability education in VET.

Many of the initiatives described align with EU climate and sustainability targets, underscoring the relevance of SD and CE in VET programs. By supporting resource efficiency, carbon reduction, and eco-friendly practices, partners and participants contribute to achieving broader European sustainability goals.

3. Opportunities for Integrating Carbon-Based Circular Economy Topics in VET

The integration of Carbon-Based Circular Economy (CCE) topics, such as biochar and sustainable resource management, presents valuable opportunities for enhancing vocational education and training (VET) programs across Europe. B4C project partners from Sweden, Germany, Luxembourg, France alongside interview participants from countries including Ireland, Slovenia, Greece, Italy, and Portugal, highlighted several approaches to embedding CCE into VET, which align with industry needs and sustainability goals.

Embedding CCE in Sector-Specific Curriculum Modules

Partners from **Germany**, along with interview participants from **Greece, Ireland** and **Slovenia**, emphasized the potential of biochar as an educational tool in agricultural VET programs. Biochar's role in improving soil quality, promoting carbon sequestration, and enhancing crop yields makes it a highly relevant topic for agricultural training. Germany's DEULA programs, for instance, can incorporate biochar in practical soil management modules, where students gain hands-on experience in sustainable farming practices and resource-efficient crop production. In Greece and Slovenia, integrating biochar into agricultural VET aligns with local priorities for soil health and water conservation, giving students relevant skills in sustainable agriculture. In **Luxembourg**, where VET programs emphasize construction and building design, partners see significant potential for biochar as an additive in low-carbon construction materials. The use of biochar-enhanced concrete, for example, can be introduced in VET programs to teach students about sustainable building practices, waste reduction, and carbon footprint minimization. This aligns with Luxembourg's industry demand for professionals skilled in sustainable construction, providing students with practical, in-demand competencies. **Ireland** and **Sweden** highlighted opportunities to integrate CCE topics into digital learning resources that make complex environmental concepts more accessible. Ireland's digital learning initiatives allow CCE content to be incorporated across vocational fields, from agriculture to waste management, through e-learning modules and blended courses. Sweden's interdisciplinary VET programs provide opportunities to connect CCE topics with environmental science, business, and technology, fostering a holistic understanding of circular economy principles. **French** participants highlighted the potential for integrating CCE topics into vocational training, particularly in soil and substrate management courses, with the possibility of extending carbon-based circular economy subjects into ecology and biology curricula. They noted that access to practical tools and teaching resources, such as hands-on demonstration kits and tailored educational materials, would greatly facilitate this integration.

Hands-on learning and practical training represent another core opportunity. Across all partners, there is strong interest in introducing hands-on biochar production workshops to VET curricula. In Portugal, the "Living Labs" initiative provides students with practical experience in biochar production and applications, enabling them to learn circular economy principles through direct

engagement with local farms. Germany and Luxembourg also recognize biochar production as a feasible addition to VET programs, where students could observe pyrolysis, understand biochar's properties, and apply it in areas like soil management or construction materials. In this vein, community and industry partnerships can further enhance students' exposure to real-world applications of CCE. In Sweden, for instance, VET programs might collaborate with community projects to use biochar as a soil amendment, allowing students to participate in sustainable landscaping and urban agriculture projects. Meanwhile, industry partnerships in Luxembourg could introduce students to biochar-enhanced construction materials, demonstrating the material's potential in live construction contexts.

Field-based training opportunities are equally emphasized by participants from Italy and Slovenia, who recognize the importance of waste management visits. Students in VET programs could gain insights into the circular economy by observing waste conversion processes in biochar production, thereby deepening their understanding of sustainable waste management. Courses on Carbon Footprint Assessment provide students with skills in measuring and analyzing carbon emissions, fundamental knowledge for implementing CCE in agriculture and manufacturing sectors. Such hands-on and field-based experiences prepare students to apply CCE practices in real-world scenarios, equipping them with crucial skills in waste reduction and resource efficiency.

Moreover, cross-disciplinary and project-based learning provide further opportunities for integrating CCE into VET. Partners from Sweden and Ireland, for instance, are interested in interdisciplinary modules that span environmental science, chemistry, and agriculture, teaching students about biochar's chemical properties, production, and environmental impact. Italy's Università Cattolica del Sacro Cuore suggests courses on Climate Change Mitigation and Agroforestry as ideal for incorporating biochar, as these programs focus on the material's role in soil health and carbon sequestration. Furthermore, integrating CCE topics into business courses in Ireland and Italy helps students understand the economic aspects of biochar production, resource recycling, and sustainable business models. Resources like Circular Economy Fundamentals (Tiche Academy) introduce students to sustainable design and lifecycle thinking, preparing them for entrepreneurial opportunities within the circular economy.

Emerging opportunities in climate policy and the green job market add another layer of relevance to CCE in VET. Integrating CCE topics prepares students to support Europe's climate goals, such as those set out in the EU Green Deal. Partners from Germany and Luxembourg highlight the potential of biochar and other CCE topics to align VET programs with European sustainability initiatives, where students equipped with CCE knowledge and skills can contribute meaningfully to regional carbon reduction targets. Preparing students with competencies in CCE also helps to "future-proof" their skill sets. Italy and Portugal particularly emphasize that as industries increasingly adopt sustainable practices, demand will grow for professionals trained in CCE principles, including biochar applications and waste-to-resource processes. VET programs can play a critical role in equipping students for this dynamic workforce by embedding CCE in their curricula.

In summary, integrating carbon-based circular economy topics into VET provides cross-sectoral benefits, equipping students with essential environmental literacy and technical skills. By embedding CCE into VET programs, B4C partners aim to broaden vocational education's scope and prepare a workforce knowledgeable in sustainable practices, aligned with EU sustainability targets. Hands-on training, interdisciplinary projects, industry partnerships, and digital learning resources

collectively offer pathways to a well-rounded CCE education, preparing students for a sustainable, circular economy.

4. Required Resources and Support for Implementation

To effectively integrate Carbon-Based Circular Economy (CCE) principles, such as biochar, into vocational education and training (VET) programs, partners and interview participants identified a range of essential resources and support mechanisms. Drawing insights from core project partners in Sweden, Germany, Luxembourg, France as well as interview participants from Ireland, Slovenia, Greece, Italy, and Portugal, this section outlines the material, educational, and collaborative supports required to achieve a comprehensive integration of CCE topics.

The primary need identified was for **specialized educational materials** that clearly explain the science and applications of biochar and CCE practices. As biochar remains a relatively new topic in VET, participants noted that a detailed foundation is necessary to convey its value effectively. Suggested resources include educational books in both digital and traditional formats, explanatory videos, and technical data sheets that clarify biochar's potential in various fields, such as agriculture and construction. For example, courses in Sustainable Farming Practices, Soil Science, and Environmental Management—as highlighted by Folkuniversitetet in Sweden—would benefit from access to well-designed visual aids and practical guides, allowing students to engage directly with biochar's applications in carbon sequestration and soil enhancement.

Another crucial resource is **access to field-based learning tools and demonstration kits**. Hands-on materials, such as biochar production kits, would allow students to understand biochar's role through active experimentation. Portugal's Food4Sustainability and Germany's DEULA, both of which emphasize hands-on training, highlighted the potential of these kits for teaching students the entire biochar lifecycle—from organic waste collection to pyrolysis, and ultimately, application in agriculture or construction. Practical demonstration kits could include pyrolysis tools, soil testing materials, and comparative samples, giving students tangible insights into biochar production and its impact on soil quality and carbon retention. To supplement these kits, participants also recommended organizing visits to biochar production sites and sustainable farms where students could observe CCE practices in real-world settings, enhancing the practical relevance of their training.

Training resources and support for educators were also emphasized as essential. Many partners, including those from Luxembourg and Ireland, indicated that while educators value CCE, they often lack the background knowledge to teach these concepts effectively. Professional development programs that train educators in biochar production, carbon footprint assessment, and waste-to-resource management were suggested as ways to strengthen faculty competence in CCE. For instance, courses on Carbon Footprint Assessment provide essential knowledge for measuring and analyzing carbon emissions—a skill crucial for sectors such as agriculture and manufacturing. Faculty training in these areas would not only improve the quality of CCE education but also empower educators to create innovative, sector-specific learning modules that are responsive to industry demands.

In addition to educational and practical materials, **collaborative networks and industry partnerships** are necessary to contextualize CCE topics within local and regional labor markets. Partners and participants expressed that involving industry representatives and CCE experts could enhance students' understanding of biochar and CCE applications through direct industry insights. Sweden's VET programs, for example, have the potential to collaborate with community projects to use biochar in sustainable landscaping, while construction-focused programs in Luxembourg could benefit from partnerships with firms already applying biochar-enhanced materials. These partnerships would enable students to participate in real-world projects, such as soil remediation, sustainable agriculture, or low-carbon construction, reinforcing the value of CCE in diverse professional settings.

Furthermore, to support the sustainable implementation of CCE in VET, participants recommended the development of **technical data repositories and case studies**. Resources that document scientific results and demonstrate biochar's impact on soil health, carbon storage, and waste reduction would be invaluable for both educators and students. Case studies on successful CCE projects, such as Germany's Carbon2Chem initiative or Portugal's Living Labs, could be integrated into VET programs to showcase real-life applications of CCE and inspire students with tangible outcomes. Technical data sheets and case studies could also include guidelines on economic feasibility and business models for biochar production, supporting CCE integration in courses on Sustainable Resource Management and Circular Economy Fundamentals.

French participants specifically highlighted the need for **demonstration kits, video testimonials, concrete case studies, and visits to local sites** to help educators integrate biochar topics into their curricula. Additional requests included technical data on landscape management, economic information, and various teaching aids, such as scientific articles, fact sheets, and tutorials, to provide a comprehensive foundation for educators.

In summary, a well-rounded integration of CCE topics in VET requires a blend of specialized educational materials, practical demonstration kits, training for educators, and collaborative industry partnerships. These resources would not only enhance the effectiveness of CCE training but also prepare students to enter a workforce increasingly aligned with sustainable practices. By ensuring access to these supports, B4C partners can position VET programs as essential contributors to a sustainable, circular economy, equipping students with the skills to meet evolving industry demands and environmental challenges.

5. Barriers to Integrating Carbon-Based Circular Economy Topics

Despite the recognized value of integrating Carbon-Based Circular Economy (CCE) principles, such as biochar, into vocational education and training (VET), several barriers impede effective implementation. Feedback from B4C project partners in Sweden, Germany, Luxembourg, France as well as interview participants from countries like Ireland, Slovenia, Greece, Italy, and Portugal, underscores the practical, institutional, and cultural challenges that must be addressed to advance CCE integration in VET.

One primary barrier is the **lack of readily available educational materials and resources** specific to biochar and CCE. As biochar is a relatively new topic in vocational training, comprehensive resources, such as technical sheets, instructional videos, and case studies, are not widely

accessible to educators and students. Partners from Luxembourg and Germany noted that without clear guidelines, demonstration materials, or data sheets, it is difficult for instructors to fully explain biochar's economic and environmental benefits. Interview participants further highlighted the need for scientific documentation to substantiate biochar's applications, emphasizing that practical examples and visual aids are essential for engaging students with these complex topics.

Additionally, **limited funding and budget constraints** present a significant barrier to implementing CCE in VET. Financial support is often necessary to procure specialized equipment for biochar production, conduct field trips, and develop interactive, hands-on learning modules. However, as many VET institutions operate on tight budgets, they struggle to allocate funds for new CCE-focused resources. This financial challenge is particularly evident in agricultural and construction-focused VET programs in Germany and Ireland, where practical training requires specific materials and tools. In countries like Portugal and Greece, where resources for field-based learning are limited, funding constraints hinder the integration of experiential activities that would otherwise enhance students' understanding of biochar and other CCE practices.

French participants identified several significant barriers to CCE integration, including knowledge gaps, economic constraints, and misconceptions about biochar's applications. Concerns were raised about the high cost of biochar production and the availability of educational materials, alongside the need for increased awareness and targeted training for educators and trainers to address these knowledge gaps.

Another major barrier is **curriculum rigidity and regulatory limitations** within VET systems. Many vocational programs are governed by strict curriculum frameworks, which restrict the flexibility needed to introduce new topics like biochar. Partners from Sweden and Ireland expressed concerns about the difficulty of fitting CCE content into already densely packed vocational courses. As these programs are often subject to national standards and regulatory requirements, adding interdisciplinary CCE content frequently requires extensive curriculum adjustments, which can be slow and resource-intensive. This rigidity affects not only what can be taught but also how it is delivered, limiting educators' ability to use innovative, cross-disciplinary approaches that would benefit CCE integration.

Lack of instructor expertise and training further complicates CCE integration in VET. Partners and interview participants noted that while instructors value sustainability principles, many lack the specialized knowledge to effectively teach CCE concepts. Without sufficient training in areas such as biochar production, carbon footprint assessment, and life cycle analysis, educators face challenges in conveying the technical aspects of CCE to students. This skills gap is particularly challenging for educators in construction and agricultural sectors, where CCE applications are highly specific and require detailed technical understanding. Training programs or professional development opportunities for educators are often limited, making it difficult for instructors to keep up with evolving sustainability practices.

Moreover, **limited awareness and understanding of biochar among students and communities** can hinder CCE integration in VET programs. Biochar remains a relatively obscure topic for many students, and partners from Slovenia and Italy noted that a general lack of familiarity with biochar's applications limits student engagement and interest. As such, students may not immediately perceive the relevance of CCE in their chosen vocational fields, reducing motivation to explore the topic in depth. Additionally, in regions where traditional agricultural or construction

practices are deeply ingrained, there can be resistance to adopting innovative methods like biochar and CCE practices. This cultural resistance can impact both students' willingness to learn about these topics and local industry's interest in supporting CCE-focused education.

Finally, **challenges in establishing industry partnerships** can further impede CCE integration. While industry collaboration is essential for giving students real-world exposure to CCE applications, establishing these partnerships often requires significant effort and mutual interest. Participants from Luxembourg and Sweden emphasized that, despite interest in sustainable practices, some companies remain hesitant to invest in biochar or circular economy initiatives due to perceived financial risks or uncertainties about return on investment. This hesitation can limit opportunities for students to engage with CCE principles in practical settings, restricting their ability to see these concepts applied in real-world contexts.

In conclusion, integrating Carbon-Based Circular Economy topics in VET is an ambitious yet challenging endeavor. Overcoming the barriers of limited resources, funding constraints, curriculum rigidity, instructor knowledge gaps, cultural resistance, and partnership difficulties will require targeted strategies, such as developing accessible materials, securing funding for practical resources, and offering professional development for educators. Addressing these challenges is crucial to fostering a new generation of vocational professionals who are equipped to contribute to sustainable, carbon-conscious industries.

6. Perceived Potential of Biochar for Decarbonization

Biochar's potential for decarbonization is widely recognized by B4C project partners and interview participants across countries. Biochar's unique properties make it a versatile tool in both carbon sequestration and sustainable resource management, providing opportunities for use across sectors. Insights from Sweden, Germany, Luxembourg, France along with perspectives from Ireland, Slovenia, Greece, Italy, and Portugal, emphasize biochar's applications and its impact on sustainable development and carbon reduction goals.

French participants acknowledged biochar's potential role in stabilizing carbon in soils and building materials but questioned its relative efficiency compared to other uses of plant waste. They emphasized local biomass management and bioregulation efforts as practical methods for reducing greenhouse gas emissions, particularly within landscape management practices.
Across countries, biochar is consistently valued for its **role in carbon sequestration**. Participants in agriculture-focused programs in Germany, Slovenia, and Greece highlighted biochar's capacity to trap and store carbon when integrated into soil. As biochar is produced through pyrolysis, a process that stabilizes carbon from biomass, it can effectively sequester carbon for long periods when added to soils. German VET programs specializing in agricultural training, for instance, see biochar as an ideal tool for educating students on sustainable soil management, emphasizing how biochar can increase soil carbon storage while improving soil health and productivity. Interview participants in Greece echoed this, noting that biochar can enhance soil quality, reduce erosion, and ultimately lead to healthier crops with higher yields. This dual benefit, which combines carbon sequestration with agricultural productivity, reinforces biochar's appeal in agricultural VET programs across countries.
In **construction and urban greening**, biochar also shows considerable promise as a low-carbon material, particularly in Luxembourg. VET programs focused on sustainable construction and

materials science see biochar as an opportunity to reduce the carbon footprint of building materials when used as an additive in concrete and other composites. Biochar's potential as a lightweight, durable material that traps carbon aligns well with Luxembourg's focus on sustainable building practices. Incorporating biochar into construction offers students hands-on experience with low-carbon technologies, preparing them for roles in green construction—a sector with rising demand for sustainable practices. Ireland's interest in using biochar in construction was similarly highlighted, though more focused on landscaping and urban greening, where biochar can enhance soil stability and water retention in green spaces, contributing to urban sustainability and resilience.

In both **agricultural and industrial contexts**, biochar's waste-to-resource capabilities resonate with Portugal and Italy, where circular economy initiatives are gaining momentum. For Portuguese VET programs in regenerative agriculture, biochar is seen as an efficient way to convert organic waste into a value-added product. Portugal's Food4Sustainability initiative emphasizes biochar's role in improving soil health while contributing to carbon sequestration, making it ideal for Living Labs where students explore sustainable resource management. Similarly, Italy views biochar as a key component in agroforestry and soil restoration. Italian interview participants suggested that biochar's potential to reduce waste, improve soil quality, and contribute to carbon neutrality could be particularly impactful in rural areas where agricultural practices are central to local economies. Incorporating biochar into Italy's agroforestry programs aligns with national goals for climate-smart agriculture and reinforces biochar's potential in decarbonization.

However, biochar's effectiveness in decarbonization is not without challenges. Interview participants from Slovenia and Germany acknowledged that **more empirical evidence and technical data** are needed to support biochar's large-scale applications in decarbonization. Although biochar's carbon-storing properties are promising, uncertainties around its long-term impacts on soil ecosystems and the scalability of biochar production remain areas of concern. Slovenia, for example, emphasized the need for additional research on biochar's environmental effects to guide its integration in VET. These insights underscore the necessity for technical documentation, case studies, and demonstration projects to validate biochar's benefits and address any environmental concerns.

From a **policy and climate strategy perspective**, biochar aligns closely with the European Union's Green Deal and carbon neutrality goals, which has generated strong interest among partners in countries like Germany and Luxembourg. Incorporating biochar into VET aligns with national and regional carbon reduction targets, allowing students to learn about biochar's role in achieving climate goals. Partners in Germany highlighted the opportunity for VET programs to play an active role in Europe's decarbonization efforts by training a workforce that is skilled in sustainable practices. By integrating biochar into VET, students become aware of the significance of their future roles in green industries and the impact of sustainable practices on global climate goals.

In summary, biochar's perceived potential for decarbonization is substantial across countries, with applications in agriculture, construction, and waste management. Its ability to sequester carbon, improve soil health, and act as a low-carbon material positions biochar as an invaluable tool in VET, aligning educational outcomes with sustainability and carbon neutrality goals. To fully realize biochar's potential, however, supportive resources such as scientific data, case studies, and industry partnerships are essential. Addressing these needs can help VET programs prepare a skilled workforce capable of advancing Europe's decarbonization objectives through sustainable, carbon-conscious practices.

7. Innovative Learning Formats and Practical Activities Suggested

The findings from B4C project partners and interview participants reveal a strong consensus on the need for innovative, hands-on learning formats and practical activities to integrate Carbon-Based Circular Economy (CCE) topics, particularly biochar, into vocational education and training (VET). These suggestions serve as a foundational layer for a cohesive learning program that interlinks theoretical concepts with real-world applications. By aligning with educational goals for circular economy (CE) and sustainability, this approach helps students gain both technical skills and a robust understanding of CCE principles, creating a clear pathway from this report to an applied curriculum.

Blended Learning and Interdisciplinary Approaches

To engage students fully, a blended learning model combining online theoretical courses, in-person workshops, and fieldwork has been recommended across countries. For example, Germany and Ireland emphasized the importance of embedding CCE principles within interdisciplinary studies that link environmental science, chemistry, and business with practical applications. A course on **Circular Economy Fundamentals** could introduce the basics of CE, covering resource conservation, waste minimization, and the economic implications of sustainable systems. Here, virtual simulations and interactive discussions on waste-to-resource strategies can illustrate these principles, followed by in-person sessions where students explore waste conversion to biochar and the environmental benefits of carbon sequestration.

Practical Learning Fields for Biochar Production and Application

Practical learning experiences, especially those that emphasize biochar production and application, have been identified as crucial for bridging the gap between theoretical knowledge and real-world skills. A core component, as suggested by partners and outlined in the curriculum draft, is the inclusion of **Biochar Production Workshops** where students learn pyrolysis techniques, observe carbon sequestration processes, and understand biochar's effects on soil health and agricultural productivity. Participants from countries like Belgium and Ireland highlighted biochar's dual role in carbon sequestration and soil health, suggesting that students could engage in hands-on projects converting organic waste into biochar as part of a circular carbon economy. This approach would allow students to understand the transformative nature of waste-to-resource practices directly.

Field-Based and Community-Engaged Projects

Field-based activities and community partnerships were consistently recommended to create authentic learning environments where students apply CCE concepts in tangible ways. Suggested activities include **partnering with local farms or agricultural businesses** to implement biochar in real soil applications, as proposed by participants in Greece and Portugal. For instance, Food4Sustainability's Living Lab in Portugal already engages students in regenerative agriculture practices, using biochar to enhance soil health and reduce emissions. By partnering with these local initiatives, students could participate in soil enhancement projects, study biochar's long-term effects on soil and water retention, and witness its role in carbon sequestration.

Additionally, construction-focused programs in Luxembourg could benefit from **collaborative projects with sustainable construction firms** to explore biochar as an additive in concrete or other building materials. This would enable VET students in fields like urban landscaping and construction to engage in projects where biochar not only supports sustainable building practices but also aligns with circular economy principles. Such partnerships allow students to engage with professionals, observe biochar applications in real-world settings, and explore its relevance to sustainable industry practices.

Integrated Project-Based Assessments

Project-based learning was highlighted as essential for deepening students' understanding of CCE. Participants suggested designing projects that span multiple weeks, giving students the opportunity to apply biochar-related knowledge in practical contexts. In a **Biochar Applications and Development Project** module, students could choose a topic such as biochar application in agriculture or waste management and conduct a complete project cycle from planning through execution. Such projects could be done in collaboration with local businesses, environmental organizations, or municipal bodies, providing students with both experiential learning and exposure to real-world sustainability challenges. For instance, a German program developer suggested structured project assessments where students calculate biochar's carbon sequestration potential in agricultural settings, analyze results, and propose future improvements.

Virtual Learning Tools and Digital Resources

To accommodate a broader reach and flexibility in learning, digital tools can complement on-site experiences with interactive online resources. Ireland and Sweden emphasized the use of virtual learning tools for subjects like **Carbon Cycle and Carbon Footprint Analysis**. Through virtual simulations and online assessments, students could learn to calculate and interpret carbon footprints, an essential skill in evaluating CCE's impact across various industries. These tools can also support self-paced learning, allowing students to explore complex concepts like life cycle analysis and carbon footprint assessment through interactive exercises and simulations.

Resources for Enhanced Understanding and Skill Development

The cross-country analysis highlights a need for dedicated resources to support hands-on learning and reinforce student comprehension. Essential resources, such as **educational books, technical sheets, and explanatory videos**, would provide background information on biochar's properties and applications. Additionally, **lab spaces and demonstration materials** were suggested to facilitate in-depth exploration of biochar's physico-chemical properties. Slovenian and Italian participants emphasized the importance of such resources to substantiate biochar's applications in decarbonization and circular economy processes, recommending that technical data sheets and scientific results be readily available to students. French participants proposed using biochar demonstration kits, video-based case studies, and incorporating biochar topics into specific courses like 'Urban Landscape Ecology' to promote applied learning. These practical formats were viewed as essential for making CCE topics accessible and engaging for students.

Continuous Evaluation and Feedback Mechanisms

To ensure that students master key CCE concepts, a continuous evaluation approach is recommended. This includes formative assessments such as quizzes, lab reports, and short essays

that track student progress. Each stage of learning, from theoretical foundations in CCE to practical applications in biochar production, would be assessed through project presentations, reflective discussions, and skill-based evaluations. Regular feedback sessions allow instructors to address students' difficulties in real-time and provide additional support for complex concepts.

Key Insights

This structured approach to innovative learning formats and practical activities emphasizes blended learning, hands-on workshops, interdisciplinary modules, and project-based assessments to equip students with both the knowledge and skills needed to navigate a carbon-based circular economy effectively. The recommendations gathered in this report highlight the importance of practical applications of CCE, preparing students for sustainability-oriented careers and advancing their competencies in green technologies and resource management. This interconnected approach aims to foster a generation of VET graduates ready to implement biochar and CCE practices, driving sustainable change across various industries.

Additional Comments or Insights

Beyond the structured findings on Carbon-Based Circular Economy (CCE) and biochar integration, partners and interview participants shared broader insights that reflect both opportunities and areas for further exploration in vocational education and training (VET). These insights underscore the evolving role of CCE within VET and point to potential enhancements in program design, industry engagement, and policy support.

Growing Interest in Digital Tools and Remote Learning Enhancements

Many partners emphasized that digital tools could significantly enhance CCE learning, especially for students in remote or resource-limited regions. Ireland and Sweden, in particular, highlighted the success of virtual simulations and interactive online modules in expanding access to concepts like carbon footprint analysis and life cycle assessment. These tools not only support flexible learning but also align with the growing digitalization in green industries. Participants suggested exploring more advanced digital tools, such as virtual reality simulations for biochar production, to provide immersive experiences even in the absence of physical lab environments.

Emphasis on Collaboration with Industry and Research Institutions

Participants noted that industry and academic collaborations could be pivotal for reinforcing the real-world relevance of biochar and CCE topics in VET. Slovenia and Germany emphasized that partnerships with companies and research institutions specializing in sustainable technologies would not only provide students with practical insights but also bridge the gap between VET and labor market demands. Engaging industry experts as guest lecturers, mentors, or internship providers was also recommended as a way to give students firsthand exposure to current CCE practices. Furthermore, creating joint projects with research centers was viewed as a means of

generating innovative approaches to sustainable challenges, such as upcycling waste or optimizing carbon sequestration through biochar.

Value of Multilingual and Culturally Adapted Resources

In multi-national VET programs, especially those with cross-border collaborations, the need for culturally adapted and multilingual resources was frequently highlighted. Italy and Portugal, for instance, noted that accessible resources in multiple languages could foster inclusive learning environments, particularly for students from diverse backgrounds. This approach would also support cross-border knowledge sharing on biochar's applications and enable collaborative projects among VET institutions across Europe.

Integrating CCE with Broader Sustainability and Climate Change Curriculum

Several partners expressed that CCE topics, including biochar, should not be limited to standalone modules but integrated within broader sustainability and climate change curricula. Germany and Greece suggested that biochar could be framed as part of a holistic approach to environmental responsibility, encompassing biodiversity, water conservation, and energy efficiency. By embedding CCE within a larger sustainability framework, students can appreciate the interconnectedness of these issues and see biochar as one of many tools available to address global environmental challenges. This integration also reflects European climate policies, reinforcing the alignment of VET with regional and national sustainability goals.

Need for Policy Advocacy to Support CCE in VET

Participants from Luxembourg and Sweden pointed to the need for greater policy support in promoting CCE topics in VET. They noted that formal recognition of biochar and CCE within national VET standards would provide additional resources and structural support for implementing these topics widely. Furthermore, policy advocacy for funding dedicated to sustainability in VET—particularly for hands-on equipment, field projects, and instructor training—would alleviate many of the barriers identified, ensuring CCE concepts receive adequate attention within VET.

Long-Term Impact and Community Engagement

Finally, several participants highlighted the potential long-term benefits of CCE training on both students and their communities. By educating students in sustainable practices like biochar production, VET programs can indirectly promote environmental awareness and sustainable behaviors within local communities. For instance, Germany and Portugal pointed out that students trained in CCE often share their knowledge with local farmers, small businesses, or family members, contributing to grassroots sustainability movements. This ripple effect of CCE education underscores the role of VET as a catalyst for positive environmental change beyond individual career paths. One French participant highlighted a general awareness of biochar's importance for sustainability. They suggested that raising awareness among technical advisors could serve as a positive step toward promoting biochar practices within professional sectors, contributing to broader acceptance and implementation of these methods.

These additional insights emphasize the importance of innovative teaching methods, collaboration, inclusive resources, policy support, and community engagement in making CCE a well-rounded and impactful element within VET. By addressing these areas, VET programs can extend the benefits of biochar and CCE training to equip students for sustainable careers and empower them to make meaningful contributions within their communities and industries.

Overall Summary of Findings

The integration of Carbon-Based Circular Economy (CCE) topics, especially biochar, into vocational education and training (VET) presents a multi-faceted opportunity to equip students with essential skills and knowledge in sustainability. Across countries, B4C project partners and interview participants consistently highlighted biochar's potential to promote environmental responsibility and its practical applications in agriculture, construction, and waste management. This report provides a foundational understanding of the opportunities, challenges, and recommended resources for embedding CCE within VET curricula, offering a comprehensive pathway for aligning educational practices with Europe's sustainability and carbon neutrality goals.

1. Key Findings

- **Significance of Biochar for Decarbonization and Sustainability** Biochar is widely regarded as an effective tool for decarbonization due to its ability to sequester carbon when applied to soil. This dual benefit of improving soil health and storing carbon makes biochar a valuable resource for sustainable agricultural and construction practices. VET programs that incorporate biochar can provide students with hands-on experience in carbon-based sustainability practices, aligning their skills with industry needs and environmental targets.
- **Need for Specialized Educational Resources** Integrating biochar and CCE topics effectively in VET requires a robust set of educational resources. Partners and participants across countries identified a need for accessible materials, such as technical data sheets, case studies, instructional videos, and scientific research, that illustrate biochar's applications and impacts. Such resources are essential for supporting both instructors and students in mastering complex CCE concepts.
- **Importance of Practical, Field-Based Learning** Hands-on, experiential learning emerged as a cornerstone for effective CCE integration. Biochar production workshops, community projects, and fieldwork with local industries provide students with real-world exposure to biochar's benefits in carbon sequestration, soil health, and sustainable building. Practical activities allow students to internalize theoretical concepts and see firsthand how sustainable practices can be applied across sectors.
- **Barriers to Implementation** Despite the recognized benefits of biochar and CCE, several barriers hinder effective integration in VET. Limited funding, resource constraints, curriculum rigidity, and lack of instructor expertise all present significant challenges. In addition, awareness gaps among students and limited industry partnerships restrict the impact of biochar education. Addressing these challenges requires dedicated funding,

policy support, and collaborative networks that bring industry expertise into the classroom.

- **Collaborative Networks and Community Engagement** Partnerships with industry, research institutions, and community organizations are vital to support CCE learning in VET. Such collaborations offer students access to current CCE practices, enhance the practical relevance of their education, and connect them with potential employers. Moreover, engaging students in community-focused projects extends CCE's benefits beyond individual learning, fostering environmental awareness and sustainable practices at the community level.
- **Recommendations for Policy and Structural Support** The findings highlight the need for policy advocacy to support formal CCE integration in VET. Establishing CCE and biochar as recognized elements within national VET frameworks would enhance resource allocation, curriculum flexibility, and instructor training. Policy-level support, particularly for sustainability funding in VET, would help overcome current implementation barriers, facilitating a smoother integration of biochar and CCE topics.

Key Takeaways

- **Biochar as a Practical and Versatile Learning Tool**: Biochar's applications in agriculture, construction, and waste management make it a versatile tool for teaching students about circular economy principles. Its dual benefits in carbon sequestration and soil improvement align well with sustainability goals, offering students practical knowledge that directly addresses real-world challenges.
- **Blended and Interdisciplinary Learning Approaches**: A blend of online resources, hands-on workshops, and interdisciplinary project-based assessments is essential for a comprehensive CCE education. Combining virtual learning tools with practical activities enables students to grasp complex CCE concepts effectively, preparing them for future roles in green industries.
- **Hands-On Experience as a Cornerstone of CCE Integration**: Practical learning, through biochar production and application, is invaluable for CCE education. Field-based and community-oriented projects provide students with direct exposure to sustainable practices, reinforcing the importance of carbon-conscious and circular approaches in vocational fields.
- **Resource Accessibility and Instructor Training Are Key**: For successful CCE integration, VET institutions need access to specialized resources and training for instructors. Ensuring that teachers have the necessary background in biochar and CCE empowers them to deliver high-quality, relevant education that aligns with industry standards and climate goals.
- **Strategic Partnerships to Enhance Learning and Industry Alignment**: Collaboration with industry partners, research institutions, and community organizations strengthens CCE programs and connects students with sustainable career paths. These partnerships bring valuable industry insights into the classroom and provide students with pathways to apply their skills in meaningful ways.

2. Shared Challenges and Proposed Solutions

The integration of Carbon-Based Circular Economy (CCE) principles, particularly biochar, into vocational education and training (VET) programs is a promising initiative with strong support

across multiple countries. However, the findings highlight several shared challenges that could impede the successful incorporation of CCE topics into VET curricula. By addressing these challenges with targeted solutions, VET programs can foster effective CCE education and prepare students for a sustainability-focused workforce.

Challenge: Limited Educational Resources and Practical Materials

A significant barrier to CCE integration is the lack of specialized educational resources, such as instructional guides, technical data sheets, and case studies tailored to biochar and CCE concepts. Partners across countries noted that, without accessible and comprehensive materials, both instructors and students struggle to fully grasp biochar's practical applications and environmental benefits.

Proposed Solution: To address this, the development and distribution of a dedicated CCE resource package, including multimedia content like videos, infographics, and scientific documentation, is recommended. Providing VET programs with a centralized repository of digital and physical resources will ensure that all students, regardless of geographic location, have access to foundational and advanced biochar knowledge. Furthermore, collaboration with industry and research organizations could support the creation of case studies and demonstration projects that showcase real-world applications of biochar.

Challenge: Funding Constraints for Hands-On Learning Experiences

Hands-on learning is vital for effective CCE education, yet financial constraints limit VET institutions' ability to organize field trips, purchase specialized equipment, or set up biochar production workshops. These experiences are critical for students to understand the practical side of CCE and gain skills directly applicable to green industries.

Proposed Solution: Securing targeted funding for sustainability initiatives in VET is essential. Pursuing grants from environmental and educational organizations, as well as exploring public-private partnerships with green companies, could provide necessary financial support. Industry sponsors, for example, might be willing to supply equipment or sponsor field trips in exchange for visibility within the VET program. Developing low-cost or shared resource models, where schools can access biochar production kits and field-based learning tools through community centers or regional hubs, could also help alleviate funding challenges.

Challenge: Curriculum Rigidity and Regulatory Limitations

Many VET programs face strict regulatory requirements that limit the flexibility to add new content or adjust curricula. This rigidity makes it challenging to incorporate interdisciplinary CCE topics, which may require adjustments in course structure or the inclusion of new assessment types like project-based learning.

Proposed Solution: Policy advocacy for flexible, modular curricula that allow for the integration of emerging topics such as CCE and biochar is essential. Stakeholders in education, including VET institutions and industry representatives, could advocate for the inclusion of sustainability modules within national VET standards. Another approach is to develop optional, supplementary modules focused on CCE that can be integrated without displacing core vocational skills. These modules could be designed to fit within existing regulatory frameworks, allowing schools to adopt them as supplementary certifications or elective courses.

Challenge: Lack of Instructor Training and Expertise

A consistent theme across countries is the need for instructor training in biochar and CCE-related topics. Many educators lack the specialized knowledge required to teach biochar production,

carbon footprint analysis, or waste-to-resource processes, which affects the depth and quality of CCE education.

Proposed Solution: Establishing professional development programs focused on CCE for VET instructors would be a strategic investment. These programs could include workshops, online courses, and certification opportunities that cover biochar, carbon sequestration, and sustainability principles. Collaboration with industry experts who can provide real-world insights and training could enrich these programs, enhancing instructors' ability to teach CCE topics confidently. Additionally, peer-to-peer learning networks could connect instructors who are more experienced in CCE with those just beginning, fostering a community of shared knowledge and ongoing support.

Challenge: Limited Awareness and Engagement Among Students

Biochar and CCE are relatively new concepts, and in many regions, students lack familiarity with these topics. Without a strong awareness of biochar's benefits or relevance to their future careers, students may struggle to engage with CCE learning or see its importance in vocational training.

Proposed Solution: Introducing awareness-building activities, such as introductory seminars, guest lectures from industry professionals, and community projects that showcase biochar's impact, can foster student interest and understanding. Creating student-led initiatives, like "Green Ambassadors" programs, where students advocate for sustainable practices within their schools and communities, could also build a culture of environmental engagement. Additionally, framing biochar and CCE in terms of career opportunities and industry relevance, particularly in sectors like agriculture, construction, and waste management, can help students recognize the practical value of these topics in today's job market.

Challenge: Establishing Industry Partnerships for Practical Exposure

Effective CCE education relies on strong industry partnerships to give students real-world exposure to biochar applications and circular economy practices. However, many VET institutions face difficulties in establishing these partnerships due to limited connections with green industry sectors or companies' hesitance to invest in educational collaborations.

Proposed Solution: Building structured partnerships with local and regional companies involved in biochar, waste management, or green construction could provide valuable practical experiences for students. Industry representatives could be invited to serve as guest lecturers, offer internships, or sponsor practical projects within VET programs. Developing a consortium of CCE-focused VET institutions, supported by industry representatives, could formalize these partnerships, making it easier to create consistent engagement across multiple VET schools. Additionally, engaging industry representatives in curriculum development can help ensure that CCE programs align with evolving workforce needs and industry standards.

Addressing these shared challenges with targeted solutions will enable VET programs to integrate biochar and CCE principles more effectively, equipping students with the skills needed to participate in a carbon-conscious workforce. By investing in resources, building partnerships, and fostering flexible curricula, VET institutions can overcome these barriers and contribute to a skilled generation of sustainability-focused professionals capable of advancing Europe's decarbonization and circular economy goals.

Recommendations for Future B4C Support

To build a robust framework for biochar and Carbon-Based Circular Economy (CCE) education in VET, B4C's future support should focus on enhancing practical, interdisciplinary, and community-centered learning experiences. These recommendations are designed to strengthen key areas identified in the draft curriculum, providing a foundation that equips students with actionable skills in sustainability and carbon management.

Given the emphasis on practical applications in the draft curriculum, B4C should prioritize expanding access to hands-on resources, including biochar production kits and mobile lab spaces. By incorporating these resources, students can directly engage with biochar production methods like pyrolysis, soil enhancement techniques, and carbon measurement tools. Additionally, sponsoring field trips to local farms or construction sites where biochar is used would reinforce the real-world relevance of CCE topics. Offering field-based experiences in partnership with community organizations or green industries would further deepen students' practical understanding and insight.

Instructors, who play a crucial role in delivering the curriculum effectively, particularly for interdisciplinary topics like biochar's role in carbon management and circular economy applications, would benefit from specialized training. B4C could support this need by developing instructor training programs with both theoretical and practical components focused on biochar properties, carbon footprint analysis, and sustainable resource management. Certification programs in CCE education would enhance instructors' ability to teach these complex topics with confidence, bridging knowledge gaps identified in VET settings. Through continuous training and peer-learning workshops, instructors could also refine their skills and stay updated on industry trends, which would directly support curriculum goals.

To enhance flexibility and accessibility in CCE education, B4C could develop a digital resource hub that includes interactive tools like carbon cycle simulations, biochar lifecycle videos, and self-paced modules on sustainable development goals (SDGs) and carbon footprint analysis. This resource hub would support the curriculum's blended learning approach, allowing students to engage with foundational topics like Circular Economy Fundamentals and Carbon Cycle and Carbon Footprint Analysis regardless of their location or schedule. By integrating multimedia resources that cater to various learning preferences, B4C can ensure students gain a thorough understanding of CCE topics.

French partners recommended incorporating online courses and MOOC content, developing outreach materials, and organizing exchanges or webinars with European partners to showcase practical biochar applications. Additionally, they suggested a closing seminar for trainers, educators, and agricultural leaders to share findings, foster collaboration, and encourage a cohesive approach to biochar integration in VET.

Project-based learning is central to the curriculum, where students are encouraged to apply biochar knowledge in real-life contexts. B4C could further support this approach by providing project management resources and guidance on project planning, execution, and evaluation. For instance, B4C could offer templates and toolkits for designing and assessing projects in biochar applications, encouraging students to think critically about biochar's potential in agriculture, waste management, or environmental restoration. Additionally, by fostering partnerships with local businesses and farms, B4C can connect students with project opportunities that align with industry needs, reinforcing the curriculum's commitment to industry relevance.

Cross-institutional partnerships and industry collaborations are also essential for providing real-world context to CCE education. B4C can actively facilitate partnerships between VET institutions, industry representatives, and environmental organizations. These partnerships could include guest lectures, internships, and on-site visits, giving students exposure to current practices in biochar and circular economy implementation. Collaborations with research institutions could also introduce students to cutting-edge advancements in carbon sequestration and waste-to-resource practices, enriching the practical aspects of their education and better preparing them to meet industry demands.

Furthermore, community-based projects, such as urban greening or soil health initiatives, can provide powerful learning experiences for students. B4C could encourage VET institutions to integrate community engagement into the curriculum, allowing students to apply biochar in local contexts, such as community gardens, agricultural fields, or landscaping projects. By sponsoring these initiatives, B4C would enable students to see the impact of their learning in tangible ways, fostering a sense of environmental responsibility. This approach aligns well with curriculum objectives to connect theory with community-centered applications, promoting both environmental awareness and social responsibility.

To ensure that CCE education remains responsive to evolving industry needs, B4C could establish a continuous feedback and adaptation framework. Regular assessments through student and instructor surveys, performance analytics, and industry feedback would provide valuable insights into curriculum effectiveness. Such a framework would enable data-driven adjustments to learning resources, project requirements, and practical activities, allowing B4C to support timely curriculum updates. This approach would also promote an iterative improvement process, keeping biochar and CCE content relevant and impactful for future students.

In addition to these recommendations, B4C can support career awareness in biochar, sustainable agriculture, construction, and waste management. By developing career-oriented resources such as industry insights, job market forecasts, and skills mapping, students would better understand the diverse career paths linked to biochar and CCE topics. These resources could include testimonials from professionals, case studies of sustainable projects, and explorations of roles in green technology sectors, helping students see the practical impact of their learning on future employment opportunities.

By focusing on these recommendations, B4C can support a curriculum that not only educates VET students in the principles of biochar and the carbon-based circular economy but also prepares them for careers that prioritize sustainability and environmental responsibility. With well-rounded support across instructional resources, industry partnerships, and student-centered projects, B4C's involvement can bridge existing gaps in CCE education, fostering a generation of VET graduates ready to lead in green industries and contribute meaningfully to Europe's sustainability goals.

Annexes

Annex 1- Interview Guide

Introduction

1. Welcome participants
2. Explain the purpose of the interview
3. Outline the structure of the session
4. Ensure consent for recording the session

Intro Video

Show a short introductory video explaining biochar and the carbon-based circular economy.

Link: https://www.youtube.com/watch?v=BaOL_AU14LY

Ask participants to reflect:

- Based on the video, how would you define biochar?
- How would you define a carbon-based circular economy?

Warm-up

Can each participant briefly introduce themselves?

Main Questions

1. **Relevance of SD & CE in Educational Organisation:**

How important is Sustainable Development and Circular Economy in your current curriculum?

Follow-up: Can you provide examples of any initiatives or programs related to these topics that are already in place?

2. **Potential Opportunities for Integrating Carbon-Based Circular Economy:**

What opportunities do you see for integrating carbon-based circular economy topics into your courses?

Follow-up: Are there specific subjects or courses where this integration would be most effective? What resources or support would you need to successfully integrate these topics?

3. **Barriers to Introducing Carbon-Based Circular Economy Topics:**

What are the main barriers to introducing carbon-based circular economy topics in your curriculum?

Follow-up: Are there any specific challenges related to content, resources, or faculty expertise?

4. **Potential of Biochar for Decarbonisation:**

What potential do you see in biochar for contributing to decarbonisation efforts?

Follow-up: How can biochar-related topics be incorporated into innovative learning formats? Can you share examples of engaging and practical learning activities involving biochar?

5. **Support from the B4C Project:**

How could the B4C project support your organization in integrating these topics?

What specific types of support (e.g., teaching materials, online courses, european training courses) would be most beneficial?

How can the B4C project help address the challenges you've identified?

Annex 2 – Partners' Reports

Blink

Basic Information

Location	Germany, Ireland
Number of Participants	5
Facilitator(s)	Sabine Wiemann
Recorded: Yes/No	No
Introduction *Briefly describe the structure of the session, the roles of participants (e.g., educators, administrative staff, curriculum developers, etc.) and their relevance to the focus group topic.*	
P1: DE: Trainer from a cVET centre focusing on waste management in the Hannover region P2: DE: Trainer from a cVET centre focusing remediation of contaminated sites (e.g. industries) in the Hannover region P3: DE: 1 training designer, designing courses and innovative learning modules (blended learning) in VET projects in Göttingen P4: DE: curriculum designer working in VET and school projects on horticulture (sustainable gardening) in Kassel Individual interviews P5: DE iVET teacher in a VET school in Witzenhausen DE (general subjects) P6: DE: Farmer (iVET facilitator) in the area Vogelsberg, Germany Plus transnational interviews P7: IE: Expert from the Irish Bioenergy Agency with a focus on agriculture P8: BE: 1 Expert from a social economy company working in the creation of green jobs in West Flanders P9-10: 3 VET trainers from Sweden, interviewed during the Bio360 conference in Nantes in January 2023.	

Time: 2 hrs
Modality: online, zoom session
Questions were asked after a first presentation round.

This report summarizes insights from a series of interviews conducted with a diverse group of VET practitioners and experts from Germany and other European countries, focusing on sustainable practices, particularly in relation to biochar and waste management. The participants included trainers from a continuing vocational education and training (cVET) center in Hannover specializing in waste management (P1) and contaminated site remediation (P2), a training designer developing blended learning courses in Göttingen (P3), and a curriculum designer for sustainable horticulture projects in Kassel (P4). Additionally, interviews were conducted with an iVET teacher from Witzenhausen (P5) and a farmer facilitating iVET in Vogelsberg (P6).
Transnational perspectives were gathered from an expert at the Irish Bioenergy Agency focusing on agriculture (P7), a specialist from a social economy company in West Flanders creating green jobs (P8), and three VET trainers from Sweden interviewed during the Bio360 conference in Nantes (P9-P10). The interviews, held online via Zoom over two hours, involved a presentation followed by a Q&A session, allowing participants to discuss challenges, resources, and opportunities in implementing biochar and sustainable practices in their respective fields.
Key themes emerged regarding the integration of biochar in training modules and curricula, emphasizing the need for innovative learning formats and community engagement. The discussions revealed varying perceptions of biochar's potential for enhancing soil quality, waste management, and its role in achieving sustainability goals across Europe.
This collaborative effort highlights the importance of sharing knowledge and resources among VET professionals to foster effective education and training in sustainable practices, ultimately contributing to the circular economy and environmental stewardship.

Key Messages from Participants

Capture the main insights and reflections shared by participants in response to the guided questions.

1. Reflections on Biochar and Carbon-Based Circular Economy

How did participants define biochar and a carbon-based circular economy after watching the video?	
Main Comments:	The video was received very well, especially from those stakeholders who already intended to introduce Biochar in their learning offers – which were only the 3 VET experts from SE. For the others biochar and the related value chains were rather "unknown territory".

	P5 and P6 participated also in “roadshows” and received more detailed information.
Key Insights:	The video was an eye opener, also those experts, who heard about biochar had not yet related the topic to their educational domains. The farmer and the agricultural experts became interested due to the additional income opportunities using waste biomass for feedstock for new products.

2. Relevance of Sustainable Development and Circular Economy in Educational Organizations

How important are SD and CE for participants' currently?	P1&2 VET Trainers, emphasizes the transformative role of ESD within iVET, stating that sustainable development concepts are now foundational in training standards across sectors, especially in fields like agriculture, manufacturing, and technology. She highlights the federal initiatives that mandate sustainability topics in curriculum design, ensuring all students acquire competencies related to environmental stewardship and resource efficiency. "Our students learn not only technical skills but also understand their role in creating sustainable practices, which is essential for Germany's climate goals," she says. P4 adds and describes ESD as a "cross-curricular principle." He explains that sustainability is not confined to isolated modules but interwoven throughout various subjects, from logistics to construction. His team seeks to align programs with ESD guidelines, which include practical modules on waste reduction, renewable energy, and circular economy models. He notes, "By embedding sustainable development into every subject, students see its relevance and application across disciplines, making them more adaptable to modern industry demands." P5 and 6, being senior instructors in vocational agriculture, elaborates on the practical impact of ESD in agricultural VET. She points to hands-on training in soil preservation, carbon management, and sustainable crop production that prepare students for careers in eco-conscious farming. "Sustainable practices are more than theory for our students; they’re real skills," she asserts. Krüger underscores that programs like Germany’s “National Action Plan on ESD” provide essential frameworks to incorporate circular economy principles into day-to-day agricultural practices.

Any examples of current initiatives or programs:	**National Action Plan for ESD**: Launched by the German Ministry of Education, this plan integrates sustainability into all educational stages, with a strong focus on VET. It encourages cross-sector competencies in resource efficiency, waste reduction, and sustainable production (BMBF, 2017). **GREENskills**: Developed by the Federal Institute for Vocational Education and Training (BIBB), this initiative builds green competencies across VET curricula, focusing on renewable energy, sustainable construction, and eco-friendly practices across industries **Carbon2Chem**: A collaborative project that demonstrates how industrial carbon emissions can be repurposed, used as a case study in VET to teach circular carbon economy concepts in engineering and manufacturing. One of the German trainers recently stumbled upon this project **BMU Climate Action in VET**: This program supports VET centers in adopting climate-friendly operational practices and teaches students about energy-efficient technologies and sustainable resource management. Again, one interviewee mentioned this program, however, it seems to be mainly related to the educational institute and not so much on the practical context.

3. Opportunities for integrating carbon-based circular economy topics

Opportunities mentioned for integrating carbon-based circular economy:	**1. Curriculum Designer** As a curriculum designer, I believe the integration of Circular Carbon Economy principles starts with a foundational understanding of sustainability in the curriculum. This includes developing modules that cover carbon management, resource recycling, and life cycle assessment. By collaborating with industry stakeholders, we can ensure that the curriculum reflects real-world applications of CCE. For instance, we could incorporate case studies on carbon capture technologies and their practical implications in various sectors. Regularly updating the curriculum to include new CCE innovations will keep our training relevant and aligned with industry needs. Partnerships with research institutions can facilitate workshops that provide both trainers and students with the latest insights into carbon economy practice. **2. Trainers in iVET (Agriculture)** As an iVET trainer in agriculture, I see the potential for CCE to transform how we teach sustainable farming practices. We can

	introduce hands-on training focused on biochar applications, composting, and agroforestry techniques that enhance soil health while capturing carbon. Incorporating tools for measuring carbon footprints and teaching students how to optimize their practices for carbon sequestration is crucial. Additionally, collaboration with local farms on projects that implement CCE practices can provide practical experiences for our students. This not only enhances their learning but also reinforces the importance of sustainability in agriculture. **3. cVET Trainer (Waste Management)** From my perspective as a cVET trainer in waste management, introducing CCE concepts is essential for teaching waste reduction strategies. Our training programs can focus on circular waste management systems, emphasizing the importance of recycling and repurposing waste to minimize carbon emissions. By developing courses that address innovative waste-to-resource technologies, we can prepare professionals who are adept at implementing sustainable waste practices in various industries. Additionally, fostering partnerships with businesses that utilize CCE can provide our trainees with insights into real-world applications, enabling them to better navigate the complexities of sustainable waste management in their careers. **4. VET Curriculum Designer from Sweden** As a curriculum designer from Sweden, I have observed successful strategies in integrating CCE into VET programs that could be beneficial in Germany as well. One effective approach is to use interdisciplinary projects that encourage collaboration between different vocational fields. For instance, combining knowledge from engineering, environmental science, and economics can lead to innovative solutions for carbon management in various industries. Including practical training components and industry internships can also bridge the gap between theory and practice, providing students with firsthand experience in implementing CCE strategies.
Relevant courses or subjects identified:	**Sustainable Resource Management (USA)**: This course focuses on strategies for managing resources efficiently, including recycling, waste reduction, and sustainable sourcing. It emphasizes the importance of minimizing carbon footprints across industries. **Carbon Footprint Assessment**: Students learn how to measure and analyze carbon emissions associated with various processes and products. This knowledge is crucial for implementing CCE practices in sectors such as agriculture and manufacturing. There are various courses and materials available.

	https://www.lifecycleinitiative.org/training-resources/carbon-footprint/ https://green-business.ec.europa.eu/environmental-footprint-methods/life-cycle-assessment-ef-methods_en (info no course) **Circular Economy Fundamentals**: Foundational course introducing the principles of circular economy, focusing on sustainable design, lifecycle thinking, and the integration of CCE practices into business models. Tiche Academy https://circularvet.eu/ not really convincing…
Required resources or support:	**1. Curriculum Designer** • **Updated Curriculum Guidelines**: Access to comprehensive frameworks that integrate CCE principles into VET curricula. Collaborations with educational and non-educational expert networks, such as THREE C. • **Research and Case Studies**: Resources showcasing successful CCE applications across various industries, which can serve as models for curriculum development. This includes partnerships with research institutions to get access to the latest findings and methodologies. **2. Trainers in iVET (Agriculture)** • **Training Materials and Toolkits**: Practical guides and toolkits focusing on sustainable practices in agriculture, such as biochar production and carbon management strategies. These materials should include hands-on activities and assessments • **Access to Industry Partnerships**: Collaborations with local farms and agricultural organizations that are already implementing CCE practices can provide students with real-world experience and insights into the practical applications of their training (DEULA?) **3. cVET Trainer (Waste Management)** • **Professional Development Opportunities**: Ongoing training for trainers to stay updated on innovative waste-to-resource technologies and circular waste management systems. Workshops and conferences focusing on CCE can enhance their knowledge and teaching effectiveness. • **Networking with Experts**: Building a network of professionals and organizations specializing in waste

	management and CCE can facilitate knowledge exchange and collaboration on training initiatives. **4. VET Curriculum Designer from Sweden** • **Interdisciplinary Collaboration Tools**: Resources to foster interdisciplinary projects that integrate different fields (e.g., engineering, environmental science) in CCE training. This could involve digital platforms for collaborative learning and project management • **Funding and Grants**: Access to financial resources and grants to support innovative training programs and projects focused on CCE. These funds can help develop training infrastructure and implement new teaching methodologies.

4. Barriers to introducing carbon-based circular economy topics

Main barriers identified by participants:	**1. Lack of Awareness and Understanding** Many educators and curriculum designers lack a deep understanding of CCE principles and their relevance to vocational training. This knowledge gap makes it challenging to develop appropriate curricula and teaching materials. Hence ongoing professional development and training are essential to raise awareness among educators about CCE practices. **2. Insufficient Resources** Educators highlighted a lack of financial and material resources and time to support the implementation of CCE. This includes inadequate access to up-to-date training materials, equipment for practical applications, and funding for innovative projects. **3. Curriculum Rigidities** The existing curriculum structures can be rigid, making it difficult to incorporate new subjects like CCE without extensive revisions. Many VET programs are bound by state regulations and accreditation requirements that do not readily accommodate new, interdisciplinary content. This rigidity can hinder timely updates to training programs. **4. Availability of educational materials, units, courses** Especially in innovative fields, there is a lack of ready to use materials and didactic concepts. **5. Cultural Resistance** There may be cultural resistance within educational institutions to change long-established practices. This resistance can manifest as skepticism about the benefits of integrating CCE or reluctance to adopt new teaching methodologies and assessment criteria.

What challenges prevent overcoming these barriers?	Additional to the aforementioned, the interviewees report on: **A Lack of Standardized Frameworks** The absence of standardized frameworks for incorporating CCE into existing VET systems can create confusion and inconsistencies. Educators may struggle to find best practices or guidelines to follow, making it difficult to develop coherent and effective training programs. At least on extracurricular project level, it would be good to apply minimum standards and transferrable (European) systems and taxonomies (e.g. competence and qualification frameworks). **Knowledge and Skills Gaps** Finally, there is often a knowledge gap among educators regarding CCE principles and their application in vocational training. Without adequate training and professional development opportunities, teachers may feel ill-equipped to convey these concepts effectively to students, leading to inadequate learning outcomes

5. Potential of Biochar for Decarbonization

Perceived potential of biochar for decarbonization efforts:	**1. Curriculum Designer** The curriculum designer emphasizes biochar's dual role in enhancing soil quality while sequestering carbon. They note that incorporating biochar into VET programs can provide students with practical knowledge about sustainable agricultural practices. By teaching the processes of biochar production and its applications, trainees can learn how this material contributes to both improving crop yields and mitigating climate change. This perspective aligns with findings from the European Biochar Certificate, which underscores biochar's potential for carbon storage and soil enhancement (European Biochar Foundation, 2021). **2. Trainers in iVET (Agriculture)** The iVET agriculture trainer sees biochar as an innovative solution to some of the pressing challenges faced by farmers. They highlight its ability to improve soil health by retaining moisture and nutrients, making it especially beneficial in regions susceptible to drought. The trainer believes that integrating biochar education into agricultural training equips future farmers with sustainable practices that align with climate goals. Research supports this view, indicating that biochar can enhance soil carbon storage and contribute to reduced greenhouse gas emissions from agricultural practices.

	3. cVET Trainer (Waste Management) From the perspective of a cVET trainer in waste management, biochar represents an effective waste-to-resource strategy. They highlight its potential to utilize organic waste materials, such as crop residues, thereby reducing landfill waste while producing a valuable product. This trainer emphasizes the importance of teaching waste management trainees about biochar production as part of a circular economy approach, where waste is transformed into a resource that contributes to decarbonization. Studies show that biochar production can significantly lower carbon emissions compared to traditional waste disposal methods. **4. VET Curriculum Designer from Sweden** The Swedish VET curriculum designer expresses enthusiasm for biochar as part of a broader strategy for carbon management. They point out that biochar's effectiveness in carbon sequestration makes it a relevant topic in the context of European climate policies. By integrating biochar education into VET programs, students can learn about sustainable resource utilization and the environmental benefits of biochar as a carbon-negative product. In summary, the interviewees recognize biochar's multifaceted potential for decarbonization, including its benefits for soil health, waste management, and alignment with climate goals. They advocate for integrating biochar education into VET programs to prepare future professionals for sustainable practices in various industries.
Any ideas for incorporating biochar-related topics into innovative learning formats	The interviewees came across several suggestions: **1. Hands-On Workshops** Organize workshops where students can engage in biochar production from organic waste materials. This experiential learning format allows participants to understand the practical aspects of creating biochar and its applications in agriculture and horticulture. Incorporating local agricultural practices can further contextualize the learning Encourage students to undertake projects that explore the use of biochar in real-world scenarios. For example, they could design a biochar application plan for a local farm or community garden, integrating scientific research with community needs. This format fosters collaboration and problem-solving skills while allowing students to apply theoretical knowledge . **3. Interdisciplinary Modules** Develop interdisciplinary modules that connect biochar to broader topics such as climate change, sustainable agriculture, and waste management. For instance, a module could integrate chemistry, environmental science, and agricultural studies,

	allowing students to explore biochar's chemical properties, production processes, and environmental benefits . **4. Virtual Simulations** Students developing tools to create simulations that model the impacts of biochar, e.g. on soil health and carbon sequestration or on other effects like causal loop diagrammes. Virtual labs or software can allow students to experiment with different variables (e.g., soil types, amounts of biochar) to observe potential outcomes. This format provides a safe, interactive space for experimentation without the need for physical resources 【. 5. Community Engagement Projects Facilitate partnerships with local farms or community organizations to implement biochar initiatives. Students can work on creating and applying biochar, measuring its effects on soil health and crop yields. This real-world application not only reinforces learning but also helps build community awareness and support for sustainable practices.
Examples of engaging/practical learning activities shared:	The video provided an inspiration to all interviewees to take care of the whole **value chain** from the „harvesting“ (recovery and collection) of waste biomass, the pre-treatment, conversion into biochar, the post treatment and the product development and eventually the application in bioeconomy scenarios. The training modules could be arranged along this product and value chain and tackle different subject oriented learning objectives related to the professional VET contexts, e.g. the aspect of “ecological mowing” to reduce mineral content in the biomass or different conversion technologies to bring about the equations (relations of biomass input, processing temperature and duration and the biomass quality in regard to its potential utilisation. The interviewees Here are some engaging and practical learning activities that can effectively incorporate biochar into educational settings: **1. Biochar Production Workshop** • **Activity Description**: Organize hands-on workshops where students can produce biochar using different organic materials (e.g., wood chips, agricultural residues). Participants learn about the pyrolysis process and its environmental impacts. • **Learning Outcomes**: Understanding the science behind biochar production, its properties, and its role in carbon sequestration.

	• **2. Soil Health Experimentation** • **Activity Description**: Students can design and conduct experiments to test the effects of biochar on soil health. They could create plant growth trials comparing soils with and without biochar amendments. • **Learning Outcomes**: Insights into soil chemistry, plant growth dynamics, and sustainable agriculture practices. **3. Community Biochar Projects** • **Activity Description**: Collaborate with local farmers or community gardens to implement biochar applications. Students can help in creating biochar and applying it to local soil, documenting changes in soil quality and plant growth over time. • **Learning Outcomes**: Real-world application of biochar, community engagement, and research skills. **4. Interdisciplinary Biochar Research Projects** • **Activity Description**: Form interdisciplinary groups to research various aspects of biochar, such as its environmental benefits, economic implications, and social impacts. Groups can present their findings through posters, reports, or presentations. • **Learning Outcomes**: Development of teamwork, research, and communication skills, along with a holistic understanding of biochar's role in sustainability. **5. Field Trips to Biochar Facilities** • **Activity Description**: Organize field trips to local biochar production facilities or farms that use biochar in their practices. Students can see biochar applications in action and engage with professionals in the field. • **Learning Outcomes**: Exposure to industry practices, networking opportunities, and practical insights into biochar's production and use. **6. Biochar as a Waste Management Strategy** • **Activity Description**: Develop a project where students analyze local waste management practices and propose biochar as a solution for organic waste disposal. They can create a business model or campaign advocating for its adoption. • **Learning Outcomes**: Understanding waste management principles, environmental advocacy, and the economic viability of biochar production. •

	These activities not only enhance theoretical knowledge about biochar but also foster practical skills and community involvement, making learning more impactful and engaging.

6. Support from the B4C project

What types of support would be most beneficial (e.g., teaching materials, online courses)?	To effectively integrate biochar education into VET programs, several types of support can be highly beneficial: **1. Teaching Materials** • **Description**: High-quality, up-to-date teaching materials, including lesson plans, case studies, and practical guides on biochar production and its applications. • **Benefits**: Well-structured teaching resources can help educators deliver content confidently and effectively, ensuring that students gain comprehensive knowledge of biochar's role in sustainability and soil management. 2. Online courses • **Description**: Access to online courses, webinars, and workshops that focus on biochar, carbon sequestration, and sustainable agricultural practices. • **Benefits**: These formats allow educators and students to learn at their own pace, gaining insights from experts in the field while also encouraging networking with other participants. **Practical Demonstration Kits** • **Description**: Kits that include the necessary tools and materials for hands-on biochar production and experimentation. • **Benefits**: Practical experience is invaluable for understanding biochar's properties and applications, allowing students to engage directly with the material. **Collaborations with Industry Partners** • **Description**: Partnerships with local farmers, agricultural cooperatives, and biochar producers to facilitate real-world learning opportunities. • **Benefits**: Such collaborations can provide students with internships, field trips, and practical application experiences that enrich their understanding of biochar in agricultural settings. **5** Financial support for research initiatives, community projects, and educational programs focused on biochar.

	• **Benefits**: Funding can help cover the costs associated with implementing biochar projects, allowing schools to experiment with and study biochar in local contexts.
How can the B4C project help address the identified challenges?	All participants agreed that B4C can play a central role in providing biochar related training material both for students and for teachers. It should also capitalise on its connected THREE C network to involve industry partners.

Folkuniversitetet

Basic Information

Location	Folkuniversitetet, Bergsbrunnagatan 1, Uppsala, Sweden Offline - room A52 Online - Zoom
Number of Participants	5
Facilitator(s)	Kateryna Puhachova
Recorded: Yes/No	No
Introduction *Briefly describe the structure of the session, the roles of participants (e.g., educators, administrative staff, curriculum developers, etc.) and their relevance to the focus group topic.*	
P1: SE: Vocational training educator from Folkuniversitetet, specializing in sustainability and environmental management, focusing on incorporating circular economy principles and biochar into vocational education. P2: PT: Specialist from Food4Sustainability in Portugal, with expertise in regenerative agriculture and climate-smart farming practices, particularly the use of biochar and sustainable soil management. P3: GR: Faculty member at the University of Thessaly's School of Agricultural Sciences in Greece, with a focus on sustainable agriculture and integrating circular economy concepts, especially biochar, into the curriculum. P4: SI: Educator from the Biotechnical Center Naklo in Slovenia, working on incorporating Sustainable Development (SD) and Circular Economy (CE) themes into secondary and tertiary education programs, with an interest in biochar for soil health and carbon sequestration. P5: IT: Curriculum developer from Università Cattolica del Sacro Cuore, Italy, focusing on agroecology and climate-smart agricultural education, with an interest in biochar and carbon sequestration for advanced educational programs. Session Details **Modality**: Conducted both online (via Zoom) and offline sessions with Folkuniversitetet staff, allowing for a blend of remote and in-person perspectives.	

Duration: Approximately 2 hours. **Session Structure:** Following a brief introduction round, participants discussed the integration of Sustainable Development (SD) and Circular Economy (CE) principles within their institutions. Subsequent questions explored the feasibility of including biochar as part of carbon-based circular economy topics, as well as the specific challenges and support needed from the B4C project. The interviews collected diverse perspectives across Sweden, Portugal, Greece, Slovenia, and Italy, offering insights into the integration of sustainability and biochar within various educational and agricultural contexts: Folkuniversitetet (Sweden): Emphasized the importance of sustainability in vocational training, particularly in environmental and agricultural programs. The educator highlighted the need for practical teaching materials and faculty development to cover carbon-sequestration topics effectively. Food4Sustainability (Portugal): Presented a perspective from regenerative agriculture, focusing on practical applications of biochar in sustainable food systems and soil health management. They underscored the importance of research collaborations and case studies to facilitate biochar adoption in local farming practices. University of Thessaly (Greece): Shared expertise on sustainable agriculture education, emphasizing the integration of biochar into courses like agroecology and soil science. They noted barriers such as limited awareness among students and faculty regarding the benefits of biochar. Biotechnical Center Naklo (Slovenia): Provided insights from an educational institution actively integrating Sustainable Development (SD) and Circular Economy (CE) themes in secondary and tertiary programs. They highlighted biochar's role in enhancing soil health and expressed a need for structured resources to support its inclusion in the curriculum. Università Cattolica del Sacro Cuore (Italy): Offered an academic perspective on agroecology and biochar as tools for climate-smart agriculture. They showed interest in international collaborations and industry partnerships to provide students with hands-on applications of biochar in sustainable agriculture.

Key Messages from Participants

Capture the main insights and reflections shared by participants in response to the guided questions.

1. Reflections on Biochar and Carbon-Based Circular Economy

How did participants define biochar and a carbon-based circular economy after watching the video?	
Main Comments:	Participants defined biochar as a carbon-rich material produced by pyrolyzing organic waste, which captures and stores carbon, preventing its release into the atmosphere. They highlighted its dual purpose: improving soil health by enhancing its nutrient

	and water-holding capacity while serving as a long-term carbon sink. The carbon-based circular economy was understood as a system aimed at minimizing carbon emissions by repurposing organic waste into valuable resources. Participants recognized biochar as a prime example, turning waste biomass into a sustainable agricultural input, aligning with principles of resource efficiency and reduced environmental impact.
Key Insights:	Practical Benefits for Agriculture: Participants emphasized biochar's agricultural applications, particularly in enhancing soil fertility and structure, making it an ideal tool for regenerative and sustainable farming practices. Climate Change Mitigation: Biochar was acknowledged for its potential in carbon sequestration, helping mitigate climate change by storing carbon in soils long-term. Educational Relevance: The video helped participants see biochar's relevance within educational contexts, particularly in courses on sustainability, environmental management, and agriculture. Curriculum Integration Opportunities: Participants saw biochar as an entry point to introduce broader concepts in waste reduction, carbon sequestration, and sustainable development in their curricula.

2. Relevance of Sustainable Development and Circular Economy in Educational Organizations

How important are SD and CE for participants' currently?	Sustainable Development (SD) and Circular Economy (CE) are crucial focal points across all participating organizations. Participants emphasized that these principles are integral to their educational missions, particularly in fostering environmental awareness, resource efficiency, and preparing students for the challenges of climate change. Institutions like Folkuniversitetet, the University of Thessaly, and Biotechnical Center Naklo have embedded SD and CE themes into their curricula, demonstrating a commitment to sustainable practices in vocational and higher education. Participants also expressed a strong interest in expanding their efforts by integrating innovative topics like biochar and carbon sequestration.

Any examples of current initiatives or programs:	Folkuniversitetet (Sweden): Runs the "Sustainability in VET" initiative, which integrates sustainability principles across various vocational courses, including construction, environmental management, and agriculture. They also offer short courses on circular economy for professionals seeking skills in resource management and waste reduction. Food4Sustainability (Portugal): Operates a "Living Lab" focused on regenerative agriculture, working closely with farmers and innovators to develop sustainable farming techniques. This initiative actively incorporates circular economy principles, including waste-to-resource strategies and sustainable water management practices. University of Thessaly (Greece): Conducts research and courses on sustainable agriculture and agroecology, with ongoing projects focused on biomass circularity. Students participate in hands-on activities like cultivating aromatic plants with sustainable methods and exploring circular resource management in agriculture. Biotechnical Center Naklo (Slovenia): Incorporates SD and CE topics into both secondary and higher education programs, offering specific modules on Sustainable Development and nature protection/preservation. They have recently launched a project called ReVaCy, focusing on circular economy practices. Università Cattolica del Sacro Cuore (Italy): Provides a master's program in Agricultural and Environmental Management, integrating SD and CE principles. They collaborate with international organizations, such as the FAO, to promote climate-smart agriculture and develop sustainable supply chains.

3. Opportunities for integrating carbon-based circular economy topics

Opportunities mentioned for integrating carbon-based circular economy:	Participants identified several opportunities to incorporate carbon-based circular economy topics, particularly in agriculture, environmental management, and sustainability-related courses. They recognized biochar and carbon sequestration as key areas that could enhance students' understanding of sustainable practices while providing practical, hands-on learning experiences. Institutions expressed a desire to teach students about reducing carbon footprints, enhancing soil health, and turning waste into resources, aligning with circular economy principles

Relevant courses or subjects identified:	Folkuniversitetet (Sweden): Suggested integrating biochar and carbon-based circular economy topics into courses on Sustainable Farming Practices and Soil Science, where students could learn about carbon sequestration and sustainable land management. Food4Sustainability (Portugal): Identified Agroecology, Soil Science, and Sustainable Crop Production as ideal courses for incorporating biochar and carbon sequestration technologies, especially within their Living Lab activities focused on soil health. University of Thessaly (Greece): Highlighted Agroecology, Soil Management, and Sustainable Agriculture courses as suitable for introducing biochar-related content, giving students hands-on experience with sustainable agricultural practices. Biotechnical Center Naklo (Slovenia): Emphasized their existing Sustainable Development modules and Nature Protection/Preservation programs as ideal platforms for teaching carbon-based circular economy concepts, with a strong focus on practical applications in secondary and higher education. Università Cattolica del Sacro Cuore (Italy): Suggested courses in Climate Change Mitigation, Soil Science, and Agroforestry for integrating biochar, focusing on how it can contribute to soil health and carbon sequestration in agricultural contexts.
Required resources or support:	Participants requested access to teaching resources, including case studies on biochar applications and research papers illustrating its impact on soil and carbon sequestration. To equip educators with the knowledge to teach these topics, institutions expressed a need for professional development workshops on biochar, carbon sequestration, and circular economy principles. Practical implementation would benefit from partnerships with local farms or industry experts who can provide real-world applications and fieldwork opportunities for students.

4. Barriers to introducing carbon-based circular economy topics

Main barriers identified by participants:	Many institutions noted a scarcity of high-quality, accessible resources on biochar and carbon sequestration, making it challenging to design comprehensive lessons on these topics. Some participants highlighted budget constraints that limit access to updated materials, training, and practical tools, which are essential for teaching carbon-based topics. Institutions mentioned the challenge of fitting new topics like biochar into already packed curricula.
What challenges prevent overcoming these barriers?	Overcoming the expertise barrier requires specialized training programs, which are often unavailable or require collaboration with external experts. Setting up these programs takes time and resources, which are not always readily available. Introducing new topics often requires approval from educational boards or directors, a process that can be slow

5. Potential of Biochar for Decarbonization

Perceived potential of biochar for decarbonization efforts:	Participants highlighted biochar as a highly effective tool for decarbonization due to its ability to sequester carbon in soil, preventing its release into the atmosphere and mitigating greenhouse gas emissions. They noted that biochar's long-term carbon storage capacity, combined with its benefits for soil health and agricultural productivity, makes it an ideal solution for both environmental and economic sustainability. Institutions also viewed biochar as a practical way to demonstrate the principles of a carbon-based circular economy.
Any ideas for incorporating biochar-related topics into innovative learning formats	Fieldwork and Practical Lab Sessions Using digital simulations and case studies to model biochar's impact on carbon sequestration and soil quality over time, providing students with data analysis and problem-solving experience. Assigning students projects focused on biochar and its applications within circular economy frameworks, encouraging research and innovative approaches to waste management and carbon reduction.
Examples of engaging/practical learning activities shared:	Living Lab Workshops (Food4Sustainability): Conducting workshops where participants can produce biochar and test its effects on soil properties, providing a hands-on understanding of biochar's role in regenerative agriculture.

	Fieldwork and Applied Research (University of Thessaly): Allowing students to apply biochar in various agricultural settings as part of research projects on sustainable farming, enabling them to observe first-hand its effects on soil quality and carbon storage. Partnering with Local Farms (Folkuniversitetet): Creating partnerships for field projects, where students work with farmers to apply biochar in real-world agricultural settings and document the results as part of their coursework.

6. Support from the B4C project

What types of support would be most beneficial (e.g., teaching materials, online courses)?	Comprehensive, high-quality resources on biochar production, applications, and its role in carbon sequestration would enable educators to deliver well-rounded lessons on these topics. Participants emphasized the need for case studies, research papers, and practical guides tailored for educational settings. Professional development workshops to equip educators with the knowledge and skills needed to teach biochar-related topics effectively. These workshops could focus on both technical aspects and teaching strategies for engaging students in complex sustainability topics.
How can the B4C project help address the identified challenges?	By providing access to teaching materials, case studies, and online courses, B4C can fill the resource gaps that prevent institutions from effectively teaching biochar and carbon-based circular economy topics Faculty development workshops and online training programs would address the expertise barrier, ensuring educators have the knowledge needed to integrate these topics into their curricula confidently. Through student-centered learning resources and interactive courses, the project can raise awareness and interest in biochar and carbon-based circular economy concepts, encouraging students and educators to engage with these topics.

IFSB

Basic Information

Location	IFSB
Number of Participants	5
Facilitator(s)	Boris Solecki

Recorded: Yes/No	No
Introduction *Briefly describe the structure of the session, the roles of participants (e.g., educators, administrative staff, curriculum developers, etc.) and their relevance to the focus group topic.*	
Ricardo Da Silva: trainer-coordinator (for over 15 years) in the construction field at IFSB. Strong experience in the practical field, particularly in the application/use of materials. **Fernando Venancio:** trainer in the field of construction at the IFSB. Experience in the practical field, he also trains in bio-sourced materials (hemp blocks for example). Dry stone, terracotta are regularly addressed themes. **Jefferson Konchie Kungo**: sustainable development engineer. Trained at the University of Luxembourg where he studied sustainable development and specialized in energy and environment. He works at COCERT which is an energy consulting firm. Part of his missions are related to questions of life cycle analysis and carbon footprint of companies. **Caroline Gontier :** Project Manager CSR and youth projects, working at IFSB for 9 years. Currently in charge of the CSR and SD deployment strategy. Her duties also include raising awareness of the sustainable construction sector among young people. In addition, Caroline is in charge of coordinating certain training courses related to low-carbon construction, including training on low-carbon concrete. **Régis Bigot:** Architect and Innovation Project Manager at Neobuild GIE (innovation hub for the construction sector in Luxembourg). Neobuild's main tasks are focused on helping the construction sector to innovate, decarbonize and promote the circular economy as well as sustainability (new materials, new construction technologies, new processes, etc.).	

Key Messages from Participants

Capture the main insights and reflections shared by participants in response to the guided questions.

1. Reflections on Biochar and Carbon-Based Circular Economy

How did participants define biochar and a carbon-based circular economy after watching the video?	
Main Comments:	**Biochar comments:** - It is a natural additive at the start (transformed) and which can be remixed with existing products in a good number of applications. - It is recycled plant matter. The principle of recycling biomass is not new. This new approach is however interesting. - It is mainly the pyrolysis of plant matter. Pyrolysis is the decomposition of matter under the effect of heat (high temperature).

	- It is vegetable charcoal that is created by pyrolysis (combustion without oxygen). It has interesting properties in the agricultural sector, that of construction… - It is a carbon sequestration aggregate resulting from the recovery of biomass waste **Circular economy comments:** - Do as much as possible locally and recycle as much as possible. Reuse materials as much as possible in other areas. Do not remain fixed on the idea of a single use for materials. Ex: a product originally intended for floors can easily be used on walls or elsewhere... - It is an economy that avoids waste. However, the way in which electricity - and energy in general - is produced is essential. - We must differentiate between circular and linear economy. Linear economy: production of articles and then getting rid of these articles. In the case of circularity, waste is revalued. In the context of decarbonization, it is a question of reconciling resource savings and reductions in CO2 emissions and optimization of processes - Biochar allows carbon sequestration. It is therefore possible to have carbon sinks. This generates less CO2 emissions and pollution. Waste (biomass and other) is used to create biochar (which is more natural charcoal). We are therefore in a spirit of circular economy. - A circular economy is a loop economy. A product never ends up as waste. It is reused. If we apply this reasoning to carbon, it means that it will be revalued in one way or another. Biochar is therefore a method of carbon sequestration rather than a re-release of the latter into the environment.
Key Insights:	- Biochar is still not popular enough among scholars, teachers, professors and professionals. A lot of explanations and publicity are still necessary. - The integration of biochar as a part of a global solution to decarbonization issues is paramount.

2. Relevance of Sustainable Development and Circular Economy in Educational Organizations

How important are SD and CE for participants currently?	IFSB, as well as Neobuild and Cocert are entities devoted to the promotion of sustainable construction with a circular economy approach. The participants in this interview were therefore all concerned by these topics with a strong focus on youth implication, energy consumption, waste management and innovative materials. Feedback of responders:

	- The aim of raising awareness among young people, for example, is to give them another image of the construction sector by promoting sustainable construction and the circular economy on a large scale - Sustainable development is a context where we combine economic, social and environmental progress. In my job, it is a question of proposing solutions that meet a technical, economic and environmental compromise. This involves advice on construction materials, on decentralized energy production systems and energy management in the broader sense. - These are essential elements (SD and CE) on a daily basis because we take into account in all our training the sorting and use of offcuts for other exercises. We also try to limit the use of materials excessively. We try to instill this education and these good practices in our trainees on a daily basis so that they can in turn use these good practices on site. We also train team leaders who must properly integrate these good practices. - Even when using concrete, you always have to think about the future use in order to limit material waste as much as possible. When you make formwork, it's the same thing: limit the use of resources (even natural ones like wood for formwork). Thinking about a sustainable approach is therefore a constant in my job - Sustainable development and the circular economy represent almost 100% of my daily work.
Any examples of current initiatives or programs:	IFSB already offers a wide range of training courses related to Sustainable Development and/or Circular Economy. Here are some examples: - eco construction and low carbon construction - the essentials - low-carbon and circular design - low carbon concrete - circular and low carbon economy advisor - Integrating the circular economy in the design of construction operations

3. Opportunities for integrating carbon-based circular economy topics

Opportunities mentioned for integrating carbon-based circular economy:	For many responders, Biochar has interesting capabilities in the construction sector. Using it as a low-carbon material, mixed with other materials gives it an interesting edge and value when compared to other materials. However, some people also mentioned that it is not particularly clear on how Biochar is made, how it works and how to measure its added value when compared to other bio sourced materials.

	Here are the answers provided by responders: - Collaborate more with manufacturers and suppliers of materials - There are many opportunities for using bio-based materials (e.g. cork, hemp, etc.). The limits to this use are essentially financial or psychological due to the reluctance of some companies to use them. - To properly integrate the Circular Economy, we must not integrate a dogmatic approach. We must demonstrate the interest of the Circular Economy because it is not only environmental but also economic and social. - These are topics that are of increasing interest to all sectors. Our sector (construction) is one of those that emits the most CO2. Consequently, training in good practices, sharing experiences and innovations is one of the essential aspects of our educational approach. Training in new economic models linked to the circular economy helps to meet these challenges
Relevant courses or subjects identified:	Even though it was not clearly mentioned as such, the main weakness of Biochar for responders is what it is exactly and how it can be used. Courses that would clarify these issues are probably the most relevant.
Required resources or support:	- Educational book(s) in traditional and/or digital format - Human contact, expertise and the possibility to meet decision makers in this field - Technical data sheets, demonstration material in order to explain the economic model precisely - Technical and scientific results based on experiments are needed to support and substantiate the use of Biochar - Explanatory videos, guidelines, technical sheets for a better understanding of Biochar. Visits and on-site practices to train in an even more concrete way.

4. Barriers to introducing carbon-based circular economy topics

Main barriers identified by participants:	- In Luxembourg, people still tend to think in terms of "bunkers". A house in their mind must be built with concrete, steel, etc. Heavy and solid materials in their minds. "Lightness", innovative or less traditional products, are not necessarily well understood by potential customers. As a result, Luxembourg engineers and architects are not used to offering other options / solutions. - Cost of materials - The Circular Economy when it is only approached from the perspective of decarbonization is simply seen as a means of climate action. However, from an environmental point of view,

	there are many subjects on which it is relevant to focus, such as the protection of water resources, the protection of biodiversity, the fight against pollution, etc. - The financial and regulatory side is often blocking. Knowledge on these subjects should be further developed in order to avoid any obstacle to the development of the circular economy. EC should be an integral part of a child's vocabulary from a very young age and integrated into their daily intellectual baggage. - There are no obstacles a priori but the circular economy is not perceived as a priority. Perhaps because it is not sufficiently understood? The notion of circular economy is too broad and too vague.
What challenges prevent overcoming these barriers?	- The main challenge is the assessment of the degree of expertise in circularity. For example, how do you know if a professional who claims to be an expert in Circular Economy is legitimate? - Finding credible experts and teachers in this field is the main challenge. We need to show how sustainable development, and the circular economy will impact future generations. We need to make people understand that it is essential to raise awareness and train on these “common sense” topics today to be able to face the challenges of future generations. - The main challenge is the ability to visualize the environmental and social costs of a lack of circularity in the economy. For example, the steel sector in Europe is moribund but if we had taken into account the potential reuse of steels, metals etc. it would have been possible to develop new innovative processes on the continent. Some jobs could have been preserved. Europe's vulnerability to other partners would also have been reduced. - The mentality of trainees is still too often "classical" and traditionalist. It is very difficult to change the habits of companies and those who are responsible for implementation. - The construction sector is by definition traditional and traditionalist in the Grand Duchy. The biggest challenge is to change these mentalities.

5. Potential of Biochar for Decarbonization

Perceived potential of biochar for decarbonization efforts:	- Biochar is probably a very good approach to, for example, reduce the amount of cement that is incorporated into concrete. Cement is an extremely high generator of CO2. - Significant biochar storage capacity for progressive or adapted use. Biomass by definition degrades quickly, biochar helps avoid this problem.

	- - In general, biochar has the potential to decarbonize the economy. Ability to sequester CO2. However, everything will depend on the applications. The impact of the cost can be more or less significant. - Biochar is one of the carbon sink solutions because it sequesters CO2. In this sense, it has a positive effect on the fight against climate change. It also purifies water and soil and is a good fertilizer. In the construction sector, it can be used more, particularly as a substitute for cement to create decarbonized concrete, negative in terms of CO2 emissions - Before one can assess the potential of biochar, it should be mandatory to have data that objectively proves that its decarbonization potential is real (for example: how much energy or CO2 equivalent is needed to produce 1 kg of biochar?). In other words: what is the real environmental impact of producing 1 kg of biochar (life cycle analysis)?
Any ideas for incorporating biochar-related topics into innovative learning formats	- Creating standard concrete but incorporating biochar would be an innovative approach. If the trainees are not aware of this at the start and they implement the concrete, they would find that this concrete performs just as well as “conventional concrete”. - Biochar could be used as an additive to concrete. After some tests, blocks can be made incorporating biochar. Using biochar could perhaps make some materials lighter and easier to handle. - Biochar does not only help fight climate change. It can have other impacts, for example it can facilitate the unification of soils, the fixation of certain pollutants that can be used for example in the greening of building walls. This greening of building walls helps to improve thermal comfort and generate better air quality inside buildings/constructions. - In traditional qualifying training (e.g. masonry) for construction companies, specific modules should be integrated/taught within the program. It would be appropriate to show the practical application such as the integration of biochar in concrete In the same way that we include modules on waste management which concerns the end of construction, we could include modules on the use of biochar in concrete which would be placed in a pre-design phase or anticipation of a future achievement.
Examples of engaging/practical learning activities shared:	Please see above

6. Support from the B4C project

What types of support would be most beneficial (e.g., teaching materials, online courses)?	- The project could bring more companies to realize the usefulness and benefits of biochar. This would help train more trainees and strengthen/develop the links between IFSB and companies involved in the use of biochar. Human contact, expertise and decision-makers: the IFSB would be a perfect place where these exchanges and contacts could take place - The project can go further. The introductory video is very good but it would be necessary to weigh the positive and negative aspects in order to be even more convincing. A promotion of biochar could allow the IFSB to be more attractive to companies. We would need technical data sheets, demonstration material. We would need to be able to explain the economic model precisely. - In the context of Sustainable Development, biochar should meet the objectives and/or contribute to the general objectives of Sustainable Development. I am thinking especially of responsible production and consumption and integration into innovative processes. Technical and scientific results based on experiments are needed to support and substantiate the use of biochar. - Help the IFSB find credible experts on these topics. Use the B4C project as a platform for sharing and exchanging good practices. Encourage meetings and visits to other territories. IFSB trainers are the best ambassadors for know-how and the dissemination of good practices. They should have the opportunity to carry out this type of field visit and then share their educational knowledge with our clients and trainees. Explanatory videos, guidelines, technical sheets are very important for a better understanding of biochar. This approach could be supplemented by visits and on-site practices in order to train in an even more concrete way. - By having an overview of all the products that could integrate biochar: aggregates, finished or semi-finished products, additives, etc. An educational work in book and/or digital format would be helpful.
How can the B4C project help address the identified challenges?	- The B4C project can create links between architects, engineers, companies, IFSB and interns. This can help change mentalities more quickly and highlight processes and techniques related to biochar (of which participants are often unaware) - The project can help people better understand what biochar is, its potential uses and its implementation in the construction

	sector. Economic aspects are essential for this to work and be integrated by companies. - If the project is carried out within a rigorous scientific framework, it will naturally reveal the economic, ecological and above all technical interest in the use of biochar. - The B4C project (consortium of several European countries) will make the approach credible from a scientific point of view. This can allow fundraising to set up more training courses, visits, conferences to popularize and publicize these new solutions related to biochar. Concrete figures and results based on calculations and scientific evidence make it possible to give credibility to viable solutions from an economic, social and environmental point of view. - If the environmental impact of biochar is favorable, the B4C project could contribute to partially resolving the problems of raw material shortages.

Additional Comments or Suggestions

General feedback from participants:

In this section, include any feedback or insights from participants that were not directly related to the guided questions but emerged during the discussion.

Some questions were considered not precise enough by the participants. Many questions implied a good knowledge of Sustainable Development and Circular Economy before moving any further in the interviewing process.

Attachments

Attach any supplementary materials you have, such as photos, participant lists, or additional documentation relevant (if applicable).

PARTICIPANT LIST

Focus group interviews

Partner Responsible: IFSB

Place of meeting: IFSB

No.	Name	Organization	Email	Signature
1.	Ricardo DA SILVA	IFSB	r.dasilva@ifsb.lu	
2.	Fernando VENANCIO	IFSB	f.venancio@ifsb.lu	
3.	Jefferson KONCHIE KUNGO	COCERT	j.konchie@cocert.lu	
4.	Caroline GONTIER	IFSB	c.gontier@ifsb.lu	
5.	Régis BIGOT	NEOBUILD	r.bigot@neobuild.lu	

DEULA

Basic Information

Location	Conference Room 4. DEULA-Nienburg site Max-Eyth-Str. 2.
Number of Participants	6 participants consisting of Vocational teachers (4) Agricultural Engineers (2)
Facilitator(s)	Heide Reimer Ian Jones
Recorded: Yes/No	NO – due to the need for anonymity
Introduction Briefly describe the structure of the session, the roles of participants (e.g., educators, administrative staff, curriculum developers, etc.) and their relevance to the focus group topic.	
The session began with a round of introductions, this was then followed by the showing of a video summarising the concepts of Biochar, sustainable development and the circular carbon economy. There then followed a Q and A session based around the following questions. What do you understand by the terms “sustainable development” and “circular economy”? How do you see the integration of the carbon-based circular economy into sustainable development? What obstacles do you see when implementing these approaches in practice? How do you rate the potential of biochar for decarbonisation? What support is needed to promote these developments?	

Key Messages from Participants

Capture the main insights and reflections shared by participants in response to the guided questions.

Reflections on Biochar and Carbon-Based Circular Economy

How did participants define biochar and a carbon-based circular economy after watching the video?	
Main Comments:	Seen as methods of conserving resources in the short and long term. Waste reduction. Efficiency improvements. All of which leads to businesses being more economically attractive.
Key Insights:	The interviewees largely agreed that sustainable development means conserving natural resources for the benefit of future generations. They emphasised that the circular economy plays a key role by minimising waste and reusing resources such as nutrients or water. The vocational schoolteachers emphasised the importance of teaching their students about the circular economy in agriculture. The agricultural engineers pointed out that these principles also require technical innovations, such as the use of bioenergy.

Relevance of Sustainable Development and Circular Economy in Educational Organizations

How important are SD and CE for participants' currently?	Whilst the participants emphasised the importance of the knowledge areas SD and CE. They were less enthusiastic about the current initiatives and programmes available to allow for the dissemination of the knowledge
Any examples of current initiatives or programs:	One of the participants cited some US-based teaching materials they had come across, and another had knowledge of an EU Horizon project by BE-Rural which also gave some ideas for teaching the subject.

Opportunities for integrating carbon-based circular economy topics

Opportunities mentioned for integrating carbon-based circular economy:	All experts see great potential in biochar for decarbonisation and improving soil quality and therefore a great need to somehow insert it into the teaching curriculum. While the vocational schoolteachers report on the positive experiences of their students, the lack of teaching time and ready-made teaching resources makes this a difficult barrier to overcome.
Relevant courses or subjects identified:	Sustainable soil work Soil management Soil fertility Promotion of soil life and soil structure
Required resources or support:	Making biochar better known to the public as a soil conditioner

Barriers to introducing carbon-based circular economy topics

Main barriers identified by participants:	The biggest obstacles to the implementation of the carbon-based circular economy are financial bottlenecks, knowledge deficits and the acceptance of new technologies. Vocational schoolteachers emphasise the need for better training and technical equipment, while agricultural engineers point to the lack of infrastructure and political incentives for sustainable agriculture.
What challenges prevent overcoming these barriers?	Despite the many advantages of the circular economy, the experts identified several obstacles. Financial challenges, particularly for small farms, and a lack of knowledge about the application of new technologies were cited as key problems. The acceptance of new methods among farmers and the lack of practical training at vocational schools were also mentioned. The agricultural engineers also referred to the lack of infrastructure for processing

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	residual materials and the lack of political incentives to support the circular economy.

Potential of Biochar for Decarbonization

Perceived potential of biochar for decarbonization efforts:	A few interviewees already heard about the beneficials of biochar but for most of the interview partners were unaware.
Any ideas for incorporating biochar- related topics into innovative learning formats	Organise hands-on experiments in which participants incorporate biochar on small experimental plots and observe changes in soil and plant growth.
Examples of engaging/practical learning activities shared:	Create a responsive project which includes micro courses on CCE

Support from the B4C project

What types of support would be most beneficial (e.g., teaching materials, online courses)?	Examples of Good Practice + Online Course
How can the B4C project help address the identified challenges?	Create teaching materials that are accessible to many interested parties, organize practitioner days or seminars with examples of good implementation.

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