# Sustainable Certification website

A Tool for Matching Sustainability Certifications in Software Development

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## I. Introduction

The importance of sustainability is increasingly recognised across many industries, including the software engineering domain. However, adopting sustainable practices is not always easy or immediately economically beneficial. Therefore, organisations that invest in such efforts should be able to communicate and demonstrate their commitment effectively. One way of achieving this is through certifications.

Certifications provide a structured and recognisable method for organisations to communicate their values and practices to consumers, enabling them to make more informed, value-based decisions. For this reason, certifications are already widely used, such as ISO standards in software and broader sustainability labels like B Corporation and Fair Trade International.

However, the field of sustainable software certifications remains relatively fragmented and underdeveloped. Existing initiatives, such as the Green Software Foundation (Green Software Foundation, 2026), the Blue Angel label for energy-efficient software (Blue Angel, n.d.), and frameworks like IFGICT (International Federation of Global & Green ICT, 2026), are not always easy to find and are often difficult to compare or interpret. As a result, identifying and applying relevant certifications can be time-consuming and challenging for software teams.

To address this issue, we developed a web-based tool that centralises knowledge about sustainable software certifications. The application gathers existing certifications and provides structured summaries, making information more accessible and easier to navigate. Furthermore, it includes a questionnaire that helps organisations and other individuals who want to improve or communicate their existing sustainability efforts identify certifications that are relevant to their context. Given that this domain is still evolving, the platform is designed with adaptability as a core principle. New certifications can be easily added by the organisations themselves. This allows the tool to grow alongside the development of the sustainability certification landscape.

Ultimately, this website aims to encourage the adoption of sustainable software practices by providing organisations and freelancers with a simple and effective way to explore, understand, and communicate their sustainability efforts. In addition, there is a hope that by creating a centralised and structured platform, the development of sustainable software certifications themselves will become better organised.

## II. Background

### A. Existing Technologies

The environmental impact of software systems has led to more research for sustainable software engineering practices. Recent literature highlights that software both contributes to energy consumption and also enables more efficient systems in other domains (Swacha, 2022).

Some recent research explores how sustainability can be integrated into modern software engineering practices, emphasising the need to adapt software architectures and development processes to account for long-term environmental impact (Venters et al., 2023). Conceptual models for green software development identify key dimensions such as governance, infrastructure, tools, and organizational readiness as critical factors influencing sustainable outcomes (Valmohammadi and Mortaz Hejri, 2023).

At the same time, sustainability certifications have been studied as mechanisms to promote responsible practices. Research shows that certification schemes can improve transparency and encourage organisations to adopt sustainability-oriented processes (Martínez-Perales et al., 2018). However, these certification schemes are often complex and difficult to navigate, and their effectiveness depends on factors such as usability, clarity, and relevance to organisational needs (Lambin and Thorlakson, 2018).

In addition, research on software reference architectures highlights that different frameworks are designed with varying goals, contexts, and design principles, which influence their applicability and success (Angelov et al., 2009). This diversity further complicates the process of identifying suitable frameworks, particularly in emerging fields such as sustainable software.

Another prominent initiative is the Green Software Foundation (Green Software Foundation, 2026), which aims to establish standards, tools, and best practices for environmentally sustainable software. One of its key contributions is the Software Carbon Intensity (SCI), a specification designed to measure the carbon emissions of software systems. While SCI provides a structured and quantitative approach to assessing software sustainability, it functions as a measurement framework rather than a certification.

Despite these advances, there remains a lack of centralised tools that integrate sustainability knowledge, certification schemes, and decision support. Existing approaches often focus on individual frameworks or provide static information,

rather than on interactive systems that guide users to relevant certifications. This highlights a gap that this project aims to address by integrating certification data with a survey-based recommendation approach.

### B. Selection of Certifications

The certifications included in this project were selected to represent a broad range of approaches to sustainable software and digital sustainability. Since this field is still relatively new, there is no single standard that covers all aspects of sustainability in software. Instead, there are many different certifications, with differing focus areas such as technical implementation, environmental impact, or organisational policies.

Another important reason for this selection is the goal of this project: developing a survey-based decision-support tool. Because the tool is meant to guide different types of users, it was important to include certifications with varying scopes and target groups. Some certifications focus on developers or software architects, while others are aimed at organizations as a whole. This variety allows the tool to provide more relevant recommendations based on the user's specific needs and context.

*1) Green Software Practices (GSP) Certification:* Green Software Practices™ (GSP™) is a consultancy focused on improving the environmental sustainability of software and AI systems. Its core mission is to "make the software industry sustainable by default" Green Seal, 2026.

The GSP certification is structured around several key assessment areas: Governance & Culture, Measurement & Profiling, Engineering Practices, and Knowledge Sharing Green Seal, 2026. These criteria indicate a strong emphasis on how sustainability is integrated into the software development process, particularly through design and implementation choices. While operational aspects are considered, the primary focus appears to lie on embedding sustainable practices early in the development lifecycle.

Another central focus of the certification is its evidence-based approach, requiring organisations to demonstrate measurable sustainability improvements rather than relying on qualitative claims.

The certification is primarily aimed at technical teams and organisations seeking to reduce the environmental impact of their software systems and substantiate these efforts with credible data. In addition to certification, Green Software Practices™ also provides training and guidance to support organisations in adopting sustainable software practices Green Seal, 2026.

*2) Green Digital Sustainability Certification (Green DiSC):* The Green Digital Sustainability Certification (Green DiSC) is the first open-access certification scheme that provides a roadmap for research groups, computing teams, and institutions aiming to address the environmental impact of their computing activities Software Sustainability Institute, 2026. It is an initiative developed by the *Software Sustainability Institute*. Its main goal is to promote environmentally sustainable practices in the development and use of digital technologies, while also fostering broader sustainability awareness within organisations Software Sustainability Institute, 2026.

A central aspect of Green DiSC is its focus on continuous improvement and organisational engagement. Rather than relying solely on measurable technical metrics, it encourages organisations to reflect on their practices, identify areas for improvement, and progressively enhance their sustainability performance. Similar to GSP, it also promotes evidence-based sustainability efforts, while additionally emphasising the importance of efficient and well-designed infrastructure. Furthermore, Green DiSC adopts a strong community-oriented approach, promoting knowledge sharing and collaboration between organisations. As such, it functions not only as a certification scheme but also as a mechanism for fostering a broader culture of digital sustainability Software Sustainability Institute, 2026.

The certification is aimed at a wide range of organisations, including research institutions, universities, and software development teams seeking to improve the sustainability of their digital practices. Notably, during the course of this project, a target group has been added. They are also working on introducing multiple maturity levels (e.g., bronze, silver, and gold). This development highlights the evolving and emerging nature of the sustainable software certification landscape.

*3) Blue Angel label for energy-efficient software:* The Blue Angel is a German government-backed eco-label that certifies products and services with reduced environmental impact, including software. The label recognizes that software and hardware work together, and although hardware consumes energy, software determines how much energy is actually used.

The certification aims to reduce energy consumption, improve resource efficiency, promote transparent software design, and support longer hardware lifetimes. (Blue Angel, n.d.)

By optimizing CPU, memory, storage, and data usage, and by enabling software to run on older devices, the Blue Angel ensures that hardware lives longer and energy consumption is reduced. Therefore, the Blue Angel certification is strongly focused on infrastructure and hardware management and longevity and end-of-life, reflecting its emphasis on energy efficiency and hardware-related environmental impact.

It also gives moderate attention to data management, implementation and optimization, and measurement and reporting, as efficient software can reduce the energy required for computation and data storage. These criteria promote responsible use of software and inform users, indirectly reducing energy and resource waste, but their environmental impact is less direct than energy optimization and hardware efficiency.

The label further requires independent verification and continuous compliance, ensuring that claimed environmental benefits are real and maintained over time. While this does

not directly reduce energy use, it guarantees that the software meets the sustainability standards consistently.

Compared to other certifications, Blue Angel focuses more on measurable environmental performance and compliance than on organizational or educational aspects.

*4) SASB (sustainability accounting standards board):* The Sustainability Accounting Standards Board (SASB) was developed by the International Sustainability Standards Board (ISSB), which operates under the IFRS Foundation, provides a framework for organizations to disclose industry-specific sustainability risks and opportunities that may affect financial performance over time. Although SASB does not provide a certification itself, its standards are widely used to improve sustainability reporting.

These standards help organizations disclose industry-specific sustainability risks and opportunities that may affect financial performance over time. They also support identifying sustainability issues that are most relevant to investors. (IFRS Foundation, 2026)

The SASB framework mainly focuses on governance and policy, organizational culture, and environmental impact and emissions. It also places strong emphasis on measurement, monitoring, and reporting, as well as infrastructure and hardware management, supporting its role in structured sustainability disclosure. These areas are prioritized because they can be quantified, verified, and compared across organizations, making sustainability performance decision-useful for investors.

While it does not address software development directly, it plays an important role in organizational accountability, encouraging companies to track energy use, resource consumption, operational risks, and environmental performance.

As a result, SASB places a higher weight on the areas that are measurable and can be improved directly, being relevant both to environmental and financial outcome.

*5) ISAQB GREEN training:* The iSAQB GREEN course is an advanced-level training module aimed at software professionals, particularly developers and software architects, focusing on the design of energy-efficient software architectures that reduce $CO_2$ emissions. (Tecnovy, 2025) The course emphasises sustainable software architecture, exploring how design decisions influence energy consumption and environmental impact.

The curriculum covers a range of technical topics, including cloud-native architectures, Green IT patterns, energy-efficient algorithms, and methods for measuring and monitoring energy consumption. In addition, it addresses the role of data management, distributed systems, and infrastructure in building scalable and resource-efficient applications. Through this, participants learn to design systems that are not only energy-efficient but also scalable and resilient.

Overall, the certification is strongly technically oriented, with a primary focus on software design and architecture, while placing comparatively less emphasis on governance and organisational policy.

The iSAQB GREEN module forms part of the Advanced Level certification (CPSA-A) and follows a structured training and assessment approach. After completing the course, participants are required to complete a project-based assignment that is evaluated by iSAQB experts. This approach emphasises both theoretical knowledge and practical application.

*6) IFGICT Green IT Certification:* The IFGICT Green IT Professional certification equips IT professionals with the knowledge and skills needed to implement sustainable IT practices within organizations. Similar to iSAQB, this certification is aimed at individuals rather than organizations. (International Federation of Global & Green ICT, 2026)

The IFGICT certification demonstrates a strong and well-balanced focus on governance and policy, infrastructure and hardware management, data management, and organisational culture. This broad scope reflects its target audience, which includes a wide range of IT professionals such as system administrators, network engineers, IT consultants, and IT managers.

Overall, IFGICT can be considered one of the more comprehensive certifications compared to the other certifications in this overview. The course covers a diverse set of topics, ranging from the role of IT professionals in Green ICT to life cycle assessment and CO emissions calculation. Through this content, the certification aims to equip participants with the knowledge and skills required to become Green IT leaders and reduce IT's environmental impact.

The certification follows a training-based approach, where participants are provided with course materials and access to an e-learning platform, and are required to pass an examination to obtain the certificate. As such, it primarily focuses on learning and skill development. At the same time, the certification can serve as a formal credential that may enhance career opportunities, particularly in organisations that prioritise sustainability.

As an individual training certification, IFGICT focuses on developing professional competencies rather than directly assessing or certifying organisational practices. While this makes it valuable for capacity building within teams, it is less suited as a standalone mechanism for organisations to communicate their overall sustainability performance.

*7) Route to Net Zero Standard (Carbon Trust):* The Route to Net Zero Standard, developed by the Carbon Trust, provides a structured, tiered certification framework for organisations aiming to demonstrate their progress toward net-zero emissions. Organisations receive a certification level (e.g., Taking Action, Advancing, Leading), which can be used to communicate their climate commitments (Carbon Trust, 2026).

The standard places a strong emphasis on environmental impact, particularly greenhouse gas emissions. Each certification level is associated with specific emission reduction targets, ranging from initial reduction efforts in the Taking Action tier to achieving net-zero emissions at the Leading level. In addition, the framework highlights the importance of governance and policy, requiring organisations to implement advanced CO management practices to reach higher certification levels.

The certification supports organisations in measuring and managing their emissions, as well as in developing and aligning carbon reduction strategies. As part of the process, emissions data and progress are independently verified, providing credibility to reported results. Organisations also receive guidance on further steps toward decarbonisation, enabling continuous improvement over time.

However, compared to other certifications listed in this overview, the Route to Net Zero standard has little focus on technical areas such as software design and data management, as these topics are not mentioned on their official website.

## III. Implementation

This section describes the main design choices and the development of the website.

### A. Questionnaire Design

The core concept of the questionnaire design is based on the use of *labels*. These labels act as an intermediary layer connecting questionnaire questions to multiple certifications. Each question is associated with a label, and based on the participant's response, a score is assigned to that label. All the questions are multiple choice, so the participant is supposed to select the answer most in line with their current practice. An overview of this mechanism is illustrated in Figure 1.

By completing the full questionnaire, the participant obtains a normalised score between 0 and 1 for each label. These scores indicate the extent to which the participant aligns with each label, representing different aspects of sustainable software practices.

Certifications are summarised by the same labels in combination with a weight. The weight corresponding to a label indicates its importance to that specific certification. The overall alignment score for a certification is computed by multiplying each label's score by its corresponding weight and summing the results. The formulation is shown in Equation 1.

$$aS_j = \sum_{i=1}^{n} score_i \cdot weight_{i,j} \tag{1}$$

- $score_i$: normalised score for label i
- $weight_{i,j}$ weight of label i for certification j
- $aS_j$: alignment score for certification j

Based on these scores, the users are shown on which aspects they already align with the certifications and where improvements are needed to fully meet their requirements.

In addition to the certification alignment scores, the participant also gets recommendations on what they could perhaps improve in each specific sustainability aspect. These recommendations are provided based on the answers to the survey questions. The questions themselves also highlight different aspects of that sustainability goal, which makes it possible to provide targeted and actionable feedback for specific areas.

By combining alignment scores with qualitative recommendations, the tool identifies relevant certifications but also supports users in understanding how to improve their sustainability practices.

This design allows for a compact and flexible questionnaire that can map to multiple certifications. It also provides the scalability needed to align with the evolving field of sustainable software certification without requiring major structural changes.

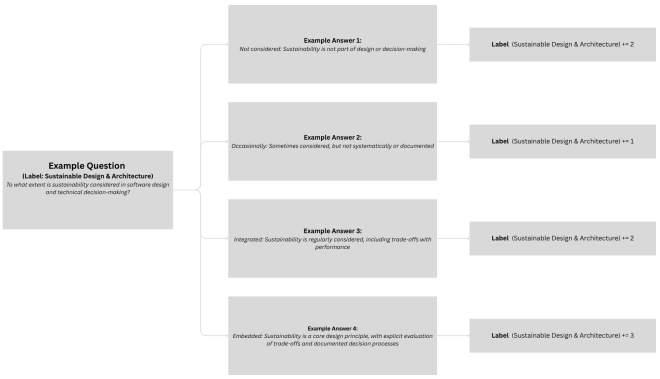


Fig. 1: Structure of the questionnaire question and label mapping mechanism

### B. Creation of Labels

The construction of labels was performed in multiple steps. First, each certification was analysed individually, resulting in a set of *local labels* that capture its specific requirements and characteristics. This analysis involved reviewing the official certification website, as well as any additional resources referenced therein, such as documentation describing detailed criteria.

For example, Green DiSC provides a link to a GitHub repository (Cambridge Sustainable Computing Lab, 2026) containing its full set of criteria and guidelines. Based on these sources, local labels were manually constructed to represent both overarching themes and specific requirements.

Each local label was also accompanied by proposal questionnaire questions.

Next, similar local labels across different certifications were grouped together into broader categories, referred to as *global labels*. In total, 17 global labels were created. These global labels form the basis of the questionnaire structure and enable comparison across certifications.

To support this process, both a manual clustering approach and an AI-assisted method were used to group and refine the labels. The final set of global labels was determined through evaluation and comparison of the results from both approaches. The final questionnaire questions were then derived from the initial questions associated with the local labels, ensuring that the resulting questionnaire reflects the combined requirements of multiple certifications.

By following this methodology, all analysed certifications contributed to the definition of the global label set. The complete list of global labels is shown in Table I. Additionally, the local labels assigned to each certification and the grouping

of the local labels into global labels can both be seen in Appendix A.

### C. Certification Modelling

Each certification is represented as a weighted combination of global labels. These weights indicate the relative importance of each label for a given certification and together define its overall profile.

An example of such a representation is shown in Table II. GSP assigns the highest, equally distributed weights to the global labels *Sustainable Design & Architecture* and *Measurement, Monitoring & Reporting*, which aligns with the findings presented in Section II. The subsequent labels are largely related to organisational culture, indicating a broader emphasis beyond purely technical aspects. This consistency between the initial findings and assigned weights suggests that the labelling process was carried out in an effective manner.

A similar pattern can be observed for the Green DiSC certification. Green DiSC allocates the highest, equally distributed weights to the global labels *Implementation & Optimisation* and *Data Management & Lifecycle*. This reflects its strong focus on continuous improvement, as captured by the emphasis on optimisation and infrastructure-related practices. Additionally, *Knowledge Sharing* receives a relatively high weight, highlighting Green DiSC's emphasis on collaboration.

The complete weight assignments for all certifications are provided in Appendix A

### D. Extensibility: Adding New Certifications

The system is designed with extensibility as a core principle. Due to the label-based structure, new certifications can be added without modifying the existing questionnaire.

To include a new certification, the certification provider assigns an importance value to each global label. This is done on a scale from 0 to 10, where 0 indicates that a label is not applicable and higher values indicate greater importance. These values are then normalised to derive the corresponding weights for the certification.

This approach allows new certifications to be easily integrated, ensuring that the platform can evolve alongside the certification landscape.

### E. Webpage design

*1) Front-end:* The Verdi platform is organised into multiple pages, each serving a distinct role in the overall user flow. The main components of the interface are:

- Home page
- Questionnaire
- Summaries

**Home Page:**
The home page introduces the concept and importance of sustainability within software engineering. It serves as the entry point to the platform, providing users with contextual information before interacting with the system.

**Questionnaire:** The questionnaire page is the main interaction component of the platform. The interface presents one question at a time to maintain clarity and focus during the process. A progress bar is displayed to indicate the user's progression through the questionnaire. After answering all the questions in the survey, the results provide personalised recommendations based on the user's answers. It highlights suitable certifications, shows how well the user matches each one, and indicates both achieved aspects and areas that need improvement. Additionally, a colour-coded system is used for labels to express how well each label is represented, where red indicates poor representation (below 20%), orange and yellow indicate moderate representation, and green reflects strong representation (above 80%).

**Summaries:** The summaries page provides an overview of available sustainability certifications. Users can browse and select a certification to view its full summary. Certifications can be searched directly or explored using filters, allowing users to identify certifications based on relevant categories. Each summary follows a consistent structure, including information about the organisation, an overview of the certification, who it applies to, the associated global labels ordered by weight, and a link to the official website. This structure is enforced for all certifications, including newly added ones.

**Add Certification:** Certifications can be added by certification providers through a dedicated interface within the summaries section. All global labels are displayed, each accompanied by an input field in which a weight between 1 and 10 can be assigned. Additional fields are provided for the certification title, organisation description, certification summary, applicability, and the official website link.

*2) Back-end:* The backend architecture of the platform is structured using JSON files to separate questionnaire logic, certification definitions, and presentation content.

The questionnaire is defined in `questions.json`, where each question contains the question text, a set of predefined answer options, and for each answer both a numerical score contribution and a corresponding recommendation. Certifications are defined in `certification.json` as a combination of relevant labels and corresponding weights. The label names are stored in `labels.json`. The `summaries.json` contains the summaries and links to the official websites.

This modular approach makes it understandable and allows the system to remain easily maintainable and extensible.

## IV. Evaluation

To determine the value of the produced alignment and recommendation tool, an evaluation was performed. The main objective of this evaluation is to determine whether the proposed matching algorithm provides relevant and meaningful alignment with certification and recommendations for sustainable improvement based on user input.

| Category | Description |
|---|---|
| Sustainability Awareness | General awareness of sustainable software principles |
| Infrastructure & Hardware Management | Infrastructure and physical systems |
| Data Management & Lifecycle | Efficient data handling |
| Implementation & Optimization | Efficient software implementation |
| Longevity & End-of-Life | Long-term usability |
| Sustainable Design & Architecture | Design decisions |
| Measurement, Monitoring & Reporting | Metrics and tracking |
| Knowledge Sharing & Leadership | Sharing and external engagement |
| Documentation | Sustainability information documented and accessible |
| Organizational Culture | Encouraging sustainable behavior |
| Responsibility & Roles | Assigned ownership |
| Training & Education | Formal and informal training |
| Onboarding Awareness | Introducing sustainability to new employees |
| Continuous Improvement | Iteration and optimisation over time |
| Hiring & Skills | Sustainability in hiring and skill evaluation |
| Governance & Policy | Policies, frameworks, and accountability |
| Environmental Impact / Emissions | Measurement and reduction of environmental impact (e.g., $CO_2$, energy) |

TABLE I: Software sustainability assessment categories and descriptions

| *Labels* | *GSP* | *Green DiSC* |
|---|---|---|
| Sustainable Design & Architecture | 0.182 | 0.000 |
| Measurement, Monitoring & Reporting | 0.182 | 0.000 |
| Documentation | 0.091 | 0.118 |
| Organizational Culture | 0.091 | 0.118 |
| Training & Education | 0.091 | 0.000 |
| Continuous Improvement | 0.045 | 0.000 |
| Data Management & Lifecycle | 0.045 | 0.176 |
| Hiring & Skills | 0.045 | 0.000 |
| Implementation & Optimization | 0.045 | 0.176 |
| Knowledge Sharing & Leadership | 0.045 | 0.118 |
| Onboarding Awareness | 0.045 | 0.059 |
| Responsibility & Roles | 0.045 | 0.059 |
| Sustainability Awareness | 0.045 | 0.000 |
| Infrastructure & Hardware Management | 0.000 | 0.059 |
| Longevity & End-of-Life | 0.000 | 0.118 |
| Governance & Policy | 0.000 | 0.000 |
| Environmental Impact / Emissions | 0.000 | 0.000 |
| *Total* | *1.000* | *1.000* |

TABLE II: Distribution of weights across labels for the GSP and Green DiSC certifications.

### A. Evaluation Methodology

We adopt a Human-Computer Interaction (HCI)-inspired evaluation approach, combining scenario and persona-based testing. This approach is well-suited for systems where user context and goals play a critical role, and where there is a lack of well-established ground truth.

Rather than relying on quantitative metrics, we simulate use cases through designed personas. Each persona represents a distinct type of organisation with specific goals and constraints. For each persona, we define: **organisational characteristics**, **objectives** and an **expected outcomes**. The expected outcomes will be used to evaluate the actual output of the tool

The evaluation process consists of the following steps:

1) Mapping each persona to a set of survey responses
2) Running the matching algorithm to generate recommendations
3) Comparing the output with the expected certifications
4) Determining the relevance and quality of the outputs

### B. Personas and Scenarios

The personas were defined to reflect distinct user groups within the sustainable software domain. Each persona is constructed to capture their goals and contexts, ensuring that the evaluation focuses on how well the system supports concrete user needs. By using these types of personas, the tool is validated in a realistic manner.

*1) Startup with Limited Resources:* This persona represents a small startup that focuses on being sustainable. The organisation operates under tight financial constraints, which limit its ability to engage with complex sustainability efforts or dedicate personnel to sustainability reporting.

The primary objective of the startup is to improve its sustainability practices while maintaining focus on core product development. At the same time, the company aims to obtain a certification without creating substantial overhead. They are aware that sustainability considerations are becoming a factor in purchasing decisions, so they explore certification options, but face uncertainty regarding which certifications are feasible.

A successful outcome is one in which the tool identifies which certificates already most align with their current sustainability practices, needing no or slight improvements to be able to apply for it. Furthermore, the company should be able to choose which improvements to make based on the recommendations in alignment with the global labelling order. Thereby supporting its goal of localising its most achievable certification and improving its sustainability practices

*2) Large Enterprise Under Regulatory Pressure:* This persona represents a big IT enterprise with established engineering processes and dedicated sustainability teams. Unlike smaller organisations, this company possesses the resources to engage with complex sustainability analysis

This company's objective is to obtain sustainable software certifications to establish itself as a recognised name in this field and to appeal to other organisations that prioritise sustainability. Although the company is already well aware of major advancements in sustainability, it is also interested in exploring smaller, incremental changes that could further enhance its current sustainability efforts.

A successful outcome in this case would be that the company is able to identify which certifications it already aligns with and to determine small, actionable changes that could further improve its sustainability efforts.

*3) Independent Software Engineer:* This persona represents an individual software engineer, such as a freelancer, who is interested in improving their knowledge of sustainable software practices. Due to limited time and resources, their sustainability efforts are not always structured or formally documented. Nevertheless, they actively strive to make sustainable choices where possible, for example by optimising for energy efficiency and making conscious hardware decisions.

The primary objective of the individual is to increase their awareness of sustainability software engineering practices and to possibly acquire certifications. This could enhance their professional profile, improving employability and differentiating themselves on the market. However, they are uncertain regarding which certifications are relevant and worth pursuing, given the limited time.

A successful outcome would be that the freelancer receives actionable sustainability improvement recommendations that are feasible to implement at an individual level, and is able to identify which certifications they are most likely eligible to obtain. The expected behaviour of the system is to recommend certification that prioritises awareness over documentation.

### C. Results

This section presents the results obtained from applying the questionnaire and matching algorithm to the three defined personas. The outputs consist of recommended certifications, associated relevance scores, and performance breakdowns in the established categories (labels). The reproduction package with the answers used in the questionnaire, as well as the webpages with results for each scenario, are publicly accessible in our github repository in the 'evaluation' directory[1].

*1) Startup with Limited Resources:* For the startup persona, the system recommended the *Blue Angel label for energy-efficient software* with an overall relevance score of 42%, followed by the *Green DiSC (Digital Sustainability Certification)*.

The label-based breakdown shows relatively stronger performance in *Longevity & End-of-Life* (66%) and *Implementation & Optimization* (50%), while significantly lower scores are observed in *Governance & Policy*, *Documentation*, *Measurement, Monitoring & Reporting*, and *Environmental Impact / Emissions* (all approximately 33% or lower).

The system presents the results in a structured manner by separating areas where the startup already performs relatively well from those requiring improvement. Categories such as *Longevity & End-of-Life* and *Implementation & Optimization* are marked as achieved. In contrast, other categories are highlighted as areas for further development. If impossible is possible within a certain area, the system provides concrete, actionable recommendations, such as formalising sustainability policies, organising documentation, and introducing monitoring dashboards.

In addition, the interface provides direct access to relevant external resources like official certification pages and detailed criteria documents. This allows the user to further explore the requirements and implications of the recommended certification without additional search effort. As a result, the output combines high-level guidance with actionable detail, supporting the user in both understanding and initiating improvements in their sustainability practices.

*2) Large Enterprise Under Regulatory Pressure:* For the enterprise persona, the system recommended the *Route to Net Zero Standard (Carbon Trust)* with a high relevance score of 80%, followed closely by the *SASB (Sustainability Accounting Standards Board)* framework at 79%.

The label breakdown indicates very strong performance in *Responsibility & Roles* and *Continuous Improvement* (both 100%), as well as high scores in *Governance & Policy* (84%) and *Implementation & Optimisation* (83%). Moderate scores are observed in *Organisational Culture*, *Environmental Impact / Emissions*, and *Measurement, Monitoring & Reporting*.

The system shows that most categories fall within the achieved range, reflecting the enterprise's high level of maturity. Categories with slightly lower scores are identified, and targeted recommendations can be read through. These include actions such as aligning with standardised reporting frameworks, improving integration of monitoring into workflows and embedding sustainability into KPIs.

In addition to these recommendations, the system provides direct access to official certification resources, including links to the *Route to Net Zero Standard* and *SASB* documentation. The presented output, therefore, combines a high-level assessment of organisational readiness with concrete steps, supporting the enterprise in progressing towards formal certification and strengthening its sustainability reporting and compliance.

*3) Independent Software Engineer:* For the individual persona, the system recommended the *ISAQB GREEN training* with a relevance score of 52%, followed by the *IFGICT Green IT Certification* at 47%.

The results show strong performance in *Sustainability Awareness* (83%), and moderate scores in *Continuous Improvement*, *Implementation & Optimisation*, and *Sustainable Design & Architecture* (approximately 60-70%). Lower scores are observed in *Measurement, Monitoring & Reporting* (17%), as well as in *Knowledge Sharing & Leadership* and *Responsibility & Roles* (0%).

Competencies such as sustainability awareness and design practices are highlighted as strengths, and weaker areas are grouped under actionable "TODO" items. These include introducing basic measurement practices or organising documentation.

### D. Validation of Results

In this section, we evaluate whether the system's outputs align with the goals and constraints of each persona. We

[1]Reproduction Package

assess its effectiveness in addressing the problem of identifying relevant sustainability certifications and giving actionable recommendations for improving sustainability practices.

The evaluation demonstrates that the system produces differentiated outputs that align with the distinct contexts of each persona. Rather than providing generic recommendations, the system adapts both the type of certification and the suggested improvements based on the specific user answers.

*1) Start-up:* The startup persona requires affordable and practical certification pathways. The system recommends the *Blue Angel label for energy-efficient software*, which is well-suited to this context. This certification places strong emphasis on concrete, measurable actions, encompassed by the labels *Environmental Impact / Emissions*, *Infrastructure & Hardware Management*, and *Longevity & End-of-Life*. The startup already demonstrates an initial commitment to sustainability. This focus resulted in sustainable implementation choices, but they are not formally documented nor supported by dedicated structures such as a sustainability team. Based on our research, Blue Angel certification provides a practical and action-oriented framework that aligns well with the startup's level of maturity.

The recommendations highlight that the start-up has not yet formally documented its sustainability efforts. Within the Blue Angel framework, the start-up scores relatively low on *Infrastructure & Hardware Management*, which is identified as an important category based on its weighting. The system therefore provides targeted recommendations for improving performance in this area, such as *Include energy sourcing in infrastructure decisions* or *Define formal lifecycle management processes*. By implementing these measures, the start-up can make focused improvements and increase its eligibility for obtaining the certification.

Overall, the outputs demonstrate that the system successfully identifies a certification that closely aligns with the start-up's context, while also providing actionable recommendations with varying levels of size. These recommendations can be selectively implemented based on the start-up's priorities and resources, supporting a structured and achievable path toward certification.

*2) Enterprise:* For the large enterprise the system recommends the *Route to Net Zero Standard (Carbon Trust)* and *SASB*, both of which align well with the organisation's current working

The Route to Net Zero Standard is particularly well suited to this persona due to its strong emphasis on *Environmental Impact / Emissions* and *Measurement, Monitoring & Reporting*. As a big enterprise that cares about sustainability, this persona already does a lot of monitoring. This certification would enable the enterprise to formally demonstrate its decarbonisation efforts.

The SASB framework, on the other hand, complements this by focusing on structured, industry-specific sustainability disclosure. Its strongest focus is on *Organizational Culture*, *Infrastructure & Hardware*, and *Governance & Policy* align closely with the enterprise's established internal structures. SASB serves as a widely adopted reporting standard that enhances transparency and comparability, which allows the organization to better identify sustainability risks and opportunities and thereby strengthening investor communication and regulatory compliance.

The recommendations reflect a high level of organisational maturity, where most competency areas are already well developed. The relatively lower scores in environmental impact measurement and reporting highlight opportunities to further integrate standardised frameworks such as SASB and Route to Net Zero into existing processes.

*3) Independent Software Engineer:* The individual persona aims to build knowledge through accessible certifications. The system recommends *ISAQB GREEN training* and *IFGICT Green IT certification*, which both directly match the persona's objectives. Both certifications are aimed at individuals aiming to expand their knowledge in sustainable software engineering rather than organisational compliance.

The ISAQB GREEN training is particularly suited to the persona's technical profile, as it focuses on software architecture decisions, energy-efficient design, and emphasises Green IT patterns and energy measurement. Its focus on *Sustainable Design & Architecture* and *Environmental Impact & Emissions* corresponds strongly with the persona's desire to make conscious, technically informed sustainability choices. In addition, the certificate provides actionable insights that an independent engineer can directly apply within their own projects.

The IFGICT Green IT Certification on the other hand offers a broader, more general overview of sustainable IT practices. Its coverage of governance, infrastructure, and organisational considerations aimed at individuals helps expand the engineer's conceptual understanding beyond purely technical aspects. This aligns with the persona's goal of increasing overall sustainability awareness.

Overall, the recommendations reflect a balanced combination of technical depth and general awareness. The results indicate that both certifications are appropriate for an independent engineer seeking to build sustainability competence in a self-directed manner. At the same time, the system's profile highlights strengths in awareness and design-related competencies, while identifying weaker areas such as measurement, monitoring, and structured knowledge sharing. These gaps suggest opportunities for further development, particularly through complementary practices that introduce lightweight measurement and documentation approaches alongside certification-based learning.

## V. Discussion

Across all three cases, the system produces differentiated recommendations and the matching result. By providing answer-based recommendations and improvement steps, the tool reduces the cognitive and informational burden for each of the crafted personas.

Furthermore, the combination of relevance scores, category-level breakdowns, and sustainability recommendations enables users to both understand their current position and identify appropriate certification pathways. It also allows

them to select target improvements based on the certification they desire

Overall, the evaluation provides evidence that the tool is functional and useful in realistic scenarios

### A. Limitations

*1) Limitations of the Research:* It is important to recognise that, due to the structure of the certification landscape, certifications are not all equally transparent regarding their assessment procedures, evaluation criteria, and internal processes. Many certifications are issued by private organisations, often operating within a commercial model. As a result, the verification process is typically conducted by experts with domain-specific knowledge that is not always publicly available.

This lack of transparency made it challenging to accurately differentiate between certifications and to identify their primary focus areas. Consequently, the derivation of the local labels was based on interpretation and approximation, and thus also affects the mapping between certifications and global labels

To address this constraint, we relied on the most complete publicly available descriptions of certification goals and requirements. Where possible, multiple sources were cross-referenced to reduce ambiguity. However, some level of approximation in the mapping remains unavoidable due to the limited availability of detailed pubic information for some certifications.

*2) Limitations of the Labelling Approach:* As discussed previously, the labelling process was performed based on the interpretation of the available information. However, the decision to use labels as an abstraction mechanism in itself introduces several limitations.

The labelling inherently involves reducing complex concepts into a small number of words, which can lead to a loss of nuance and detail. As a result, certain aspects of a certification's requirements may not be fully captured by a single label.

In addition, the labelling process is subject to interpretation. Within this project, the task of assigning labels to certifications was distributed among multiple authors without a predefined structured process. This introduces the possibility of inconsistency, as different authors may have applied varying methodologies or used different labels to describe similar concepts.

To mitigate this issue, the proposed questionnaire questions were used as a reference point to guide the labelling process. However, despite this effort, some degree of variation may remain. This could impact the overall accuracy of mapping certifications to the defined global labels. This trade-off was accepted since it allows for a modular design

*3) Limitations of the Questionnaire Design:* The design of the questionnaire also introduces certain limitations. As mentioned in Section III-A, questions were derived from the example questions from the local labels and the overarching goals of the global label they belonged to. However, these questions were designed by not necessarily experts in the field of sustainable software engineering. As a result, the questionnaire may not fully capture all relevant aspects or nuances required for a comprehensive assessment.

### B. Future Work

A key objective for future development is to make the system more dynamic and adaptive to the certifications. To achieve this, there are structural changes needed. This section outlines potential directions for future work.

The questionnaire can be extended by introducing user-specific questions, which would further match the user to a certain type of certification. For instance:
*What best describes you/your company?*

1) *Individual / Freelancer*
2) *Startup (less than 10 employees)*
3) *SME*
4) *Large enterprise*

During the research, it was identified that the target group differed between certificates, but this was not completely implemented into the questionnaire. This should be a doable next step for the system.

The biggest improvements can be made by direct collaboration with certification providers. In such a setup, certification organisations could be asked to map their requirements to the defined global labels. A structural framework, including clear definitions of each label and corresponding maturity levels, could be supplied. Certification providers could then indicate the expected level of maturity required for each label in order to qualify for their certification. This approach was initially considered in this project. However, due to the limited availability of detailed and public information, it was not feasible to accurately determine the required maturity levels for each certification.

In addition, the design of the questionnaire could be optimised by involving domain experts, as well as collaboration with certification providers, to ensure accuracy and completeness. Furthermore, the questionnaire should not remain static over time. As the sustainability certification landscape evolves, both the questions and their underlying assumptions should be continuously updated in collaboration with new certifications. Without updates, the relevance and accuracy of the questionnaire degrade over time.

The recommendations could also be updated to be more dynamic. Right now, the recommendations are static and do not adapt based on the specific certifications. In a more advanced implementation, certification providers could contribute tailored recommendations based on the participant's achieved maturity level for each label. This would allow the feedback to better reflect the specific requirements and expectations of each certification. Additionally, a large language model (LLM) could be employed to aggregate and synthesise individual recommendations into a coherent and structured summary. This would improve readability and provide users with more holistic and actionable guidance.

As a more advanced approach, instead of direct certification scoring, a representation-based approach could be implemented, where both users and certifications are modelled

as representation vectors. The resulting certification ranking would be made according to the similarity of each certificate with the user (e.g., cosine similarity).

Finally, to further expand the idea of user representations, collaborative filtering can be implemented in the system. The system would have to keep track of users, their vector representations, as well as what certifications they selected, clicked, completed, pursued, etc. Based on this information, users could be recommended certifications that prove to be relevant to similar users.

## VI. Conclusion

The project tackles the challenge of finding relevant sustainable certifications in an area that is quite difficult to navigate. To address this, a web-based tool was built to bring the certifications together in one place and help users to find suitable options through a survey.

The results indicate that the proposed system addresses the problem identified for this tool to solve: the difficulty of identifying and adopting relevant sustainability certifications in the software domain. By translating questionnaire responses into structured label and certification scores, the tool reduces the complexity of navigating a fragmented certification landscape.

Across all evaluated personas, the system recommends relevant certifications and also provides feedback through targeted recommendations on how to proceed. This enables users to understand both their current situation and the specific steps required to progress toward certification.

As a result, the tool has practical use cases as a decision support mechanism. It supports organisations and individuals in making informed choices about sustainability certifications while also guiding them toward actionable improvements. By combining certification matching with concrete next steps, the system contributes to lowering the barrier to entry and facilitating the adoption of sustainable software practices.

In the future, we hope that certification will be willing to work on improving the tool and make use of ”Adding New Certifications” feature, to promote and help to navigate this growing field of sustainable software engineering certifications.xoxo

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# APPENDIX A
# LABELING

## A. Local Labeling

| *Anouck* | | | |
|---|---|---|---|
| *Green Software Practices (GSP) Certification* | | *Green DiSC (Digital Sustainability Certification)* | |
| **Size** | Company size ? | | |
| **Sustainable Awareness** | We have internal awareness of software sustainability principles. | | |
| **Design** | Resource efficiency is explicitly considered during software and AI architecture and design decisions. | | |
| | We consider trade-offs between performance and sustainability | | |
| | We implement optimisation to improve resource effincy | | |
| | We conduct performance and resource profiling at defined stages of the development lifecycle (e.g., testing, CI/CD, or production monitoring). | | |
| **Consideration** | Sustainability is considered in technical decision-making. | | |
| **Documentation awareness** | New technical employees are introduced to documented resource-efficient development guidelines during onboarding. | **Documentation awareness** | Are sustainable computing practices included in onboarding or induction materials for new starters? |
| **Documentation relefancy** | We maintain and actively update documented best practices or internal guidelines for energy-efficient software and AI | | |
| **Documentation** | We have a clear centralized page where the information surrounding sustainable practices and ideas get shared | **Documentation** | Is there documentation describing how electronic waste is handled in your group or institution? |
| **Encouragement** | Developers are encouraged to consider resource efficiency. | **Promote** | Does your group actively promote or discuss the sustainability program with other groups in the institution? |
| **Repesentative** | Someone in the organisation is responsible for software sustainability. | **Repensentative** | |
| **Training** | We provide formal training on green software and/or green AI to relevant roles. | | |
| **Hiring** | We consider resource-efficient software or AI development skills or awareness in hiring or recruitment processes. | | |
| **Development** | Sustainability improvements made get noticed | | |
| | We consider resource-efficient software or AI development skills or awareness in proffesional assesments | | |
| | | | |
| **Measuring** | We systematically measure and store resource usage metrics (e.g., CPU, memory, storage, and network) for our software systems. | | |
| **Monotoring** | We monitor energy consumption and/or carbon footprint of our software using measurement or estimation tools. | **Monotoring** | Does your group track computing pipelines and identify which ones are the most resource-intensive? |
| **Display** | We maintain automated dashboards or tooling that continuously visualize and alert on resource usage and/or energy-related metrics. | | |
| **Reduction** | We actively reduce unnecessary computation, data transfer and data storage in software and AI systems. | | |
| **Research** | We make sure to look into improvements made by other companies or within the sustaibility software field in general | | |
| | | **upkeep** | Does your group regularly clean data directories to remove temporary or outdated files? |
| **upkeep** | Employees are expected to partake in periodically revisit software and AI design or architectural decisions affecting resource efficiency. | | |
| **Forerunner** | We share our lessons learned | **Forerunner** | Does your group share sustainability resources or materials with other groups or institutional teams? |
| | | **Infrastucture** | |
| | | **identification** | Does your group maintain a list of computing pipelines and identify the most resource-intensive ones? |
| | | **Internal sharing** | Does your group share sustainability-related resources or materials with other groups or institutional teams? |
| | | **Inventory** | Does your group maintain an inventory of major datasets used or managed by the group? |
| | | | Does your group maintain a list of unused computing equipment and planned actions for reuse, repurposing, or disposal? |
| | | | Does your group maintain an updated inventory of computing hardware used by the group? |
| | | | Does your group maintain a list of computing infrastructures used (e.g., institutional clusters, servers, or cloud providers)? |

| ***Vasil*** | | ***Moniek*** | |
|---|---|---|---|
| ***Blue Angel label for energy-efficient software*** | | ***ISAQB GREEN training*** | |
| **Resource & Energy Efficiency** | Is the software measured and optimized for energy efficiency? | **Individual** | |
| **Hardware longevity** | Could the software (updates) require a hardware update? | **Course / training** | Are you already proficient in the topic? |
| **Interoperability** | | **energy efficient** | |
| **Transparency** | Are the APIs clearly documented, and do they correspond to open standards? (should be) | **eco-friendly** | |
| **Continuity** | Is it possible to use the software product over a long period of time without any serious disadvantages arising (especially problems related to IT security)? (5 years for PC device or server device; 3 years for mobile device) (should be) | **sustainability** | |
| **Uninstallability** | Is it possible to completely remove the software product from the computer platform after the end of its operating life without leaving any unnecessary traces of data? (should be) | **co2 emmissions** | |
| **Modularity** | Does the software product have a modular design, i.e. basic functionality that can be enhanced where necessary with the installation of additional modules? (should) | **co2 reduction** | |
| **No advertising/tracking** | Does the software product apply advertising or tracking? (should not be) | **carbon footprints** | |
| **Documentation** | Is the software product provided with documentation that enables long-term and resource-conserving use of the product? (should be) | **Green IT patterns** | |
| | | **IT systems** | |
| | | **cloud technologies** | |
| | | **data management** | |
| | | **resource-saving** | |
| | | **scalable software systems** | |
| | | **software architectures** | |
| | | **measuring tools** | |
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| *SASB (sustainability accounting standards board)* | | *Route to Net Zero Standard (Carbon Trust)* | |
|---|---|---|---|
| **Reporting standard** | Are you reporting on energy consumption / sustainability? | **Historical tracking** | Do you have a defined baseline year for emissions / Have you reduced emissions compared to a baseline year? |
| **Sustainable documentation** | | **GHG emissions measuremen** | Do you currently calculate greenhouse gas emissions? |
| **energy consumption** | | **GHG reduction** | Have you implemented actions to reduce energy use or emissions? |
| **renewable electricity** | | **CO2 management** | Is there a person or team responsible for carbon management? |
| **water consumption** | | **Science-aligned** | Is your emissions reduction target aligned with science-based targets? / Have you reduced emissions compared to the science-based targets? |
| **data centre** | | **Net zero** | Have you reached a net zero emissions target? |
| **data privacy** | | | |
| **targeted advertising** | | | |
| **user information** | | | |
| **data security** | | | |
| **data breaches** | | | |
| **personal data** | | | |
| **diversity** | | | |
| **gender representation** | | | |
| **diversity group representation** | | | |
| **anti-competitive behaviour** | | | |
| **performance issues** | | | |
| **service disruptions** | | | |
| **business continuity risks** | | | |
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|---|---|
| ***Maksym*** | |
| ***IFGICT Green IT Certification*** | |
| **Green awareness** | |
| **Training** | Do employees receive training on sustainable IT or green computing practices? |
| **Policy** | Does your organization have formal policies for sustainable IT practices? |
| **governance frameworks** | |
| **lifecycle management** | Does your organization track hardware lifecycle (reuse, recycling, disposal)? |
| **data management** | Do you manage data to minimize unnecessary storage and duplication? |
| **organizational level** | Are you looking for certifications applicable at the organizational level? |
| **esg goal** | Is your organization aligning IT practices with broader sustainability goals? |
| **e-waste management** | Do you track and manage electronic waste? |
| **infrastructure sustainability** | do you optimize infrastructure for energy efficiency? |
| **energy monitoring** | Do you monitor energy consumption/carbon footprint of your systems? |
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*B. Local to Global Labels*

| **Global Labels** | GSP | Green DiSC | Blue Angel | ISAQB | SASB | Route to Net Zero | IFGICT |
|---|---|---|---|---|---|---|---|
| Sustainability Awareness | Sustainable Awareness | | | Sustainability<br><br>Eco-Friendly | Sustainable Documentation<br>Reporting Standard | Green Awareness | |
| Infrastructure & Hardware Management | | Infrastructure | Hardware Longevity<br>Resource & Energy Efficiency<br>Hardware Longevity | IT systems<br><br>Cloud technologies | Data centre<br><br>Energy Consumption<br><br>Renewable Electricity | | Infrastructure Sustainability<br>Lifecycle Management |
| Data Management & Lifecycle | Reduction | Upkeep<br><br>Dataset Inventory<br>Unused Equipment Inventory | Uninstallability | Data Management | Data Centre | | Data Management<br>Minimize Storage |
| Implementation & Optimization | Optimise | Monitoring<br><br>Identification<br><br>Inventory | Resource & Energy Efficiency | energy Efficiency<br><br>Resource Saving<br>Scalable Software Systems | Performance Issues | GHG Reduction | |
| Longevity & End-of-Life | | Documentation<br><br>Inventory | Continuity<br><br>Hardware Longevity<br>Uninstallability | Scalable software systems | | | Lifecycle Management<br><br>e-waste management |
| Sustainable Design & Architecture | Sustainable Design<br>Performance Design Consideration<br><br>Trade-off | | Interoperability<br><br>Transparency<br><br>Modularity | Software Architectures<br>Green IT Patterns<br>Scalable Software Systems<br>Eco-Friendly | Targeted Advertising | | |
| Measurement Monitoring & Reporting | Measuring<br><br>Monitoring<br><br>Display<br><br>Resource Profiling | | Resource & Energy Efficiency | Measuring Tools | Reporting Standards<br><br>Energy Consumption<br>Water consumption | GHG emissions<br><br>Historical Tracking | Energy Monitoring |
| Knowledge Sharing & Leadership | Forerunner | Forerunner<br><br>Internal Sharing | Transparency | Green IT Patterns | | | |
| Documentation | Documentation<br><br>Documentation Relevancy | Internal Sharing<br>Inventory | Documentation<br><br>Transparency | Green IT patterns<br>Reporting Standards | Sustainable Documentation | | |

TABLE IV: Local labels per certification mapped to the global labels part 1

| **Global Labels** | GSP | Green DiSC | Blue Angel | ISAQB | SASB | Route to Net Zero | IFGICT |
|---|---|---|---|---|---|---|---|
| Organizational Culture | Encouragement<br>Development | Promote<br>Internal Sharing | No advertising / tracking | Sustainability<br>Eco-Friendly | Diversity<br>Gender Representation<br>Diversity Group<br>Anti-competitive | Science-Aligned<br>Historical Tracking | ESG goal<br>Policy |
| Responsibility & Roles | Representative | Representative | | Individual | | CO2 management | |
| Training & Education | Training<br>Upkeep | | | Training<br>Pre-training | | | Training |
| Onboarding Awareness | Documentation<br>Awareness | Documentation<br>Awareness | | | | | |
| Continuous Improvement | Research | | | Green IT patterns<br>Resource saving | | GHG reduction | |
| Hiring & Skills | Hiring | | | | | | |
| Governance & Policy | | | No advertising tracking | | Reporting standards<br>Data Privacy<br>Data security<br>Anti-competitive behaviour<br>Targeted Advertisement | Science aligned<br>Net zero<br>Historical tracking | Policy<br>ESG goal<br>Governance frameworks |
| Environmental Impact & Emissions | | | Resource & Energy Efficiency | CO2 emissions<br>CO2 reductions<br>Carbon footprints<br>Energy efficient | Energy consumption<br>Renewable electricity<br>Water Consumption<br>Carbon footprints | GHG monitoring<br>GHG reduction<br>CO2 management<br>Historical tracking<br>Net zero<br>Science-aligned | Energy Monitoring |

TABLE VI: Local labels per certification mapped to the global labels part 2

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### C. Weight assignment

| Category | GSP | DiSC | Blue Angel | SASB | ISAQB | IFGICT | Net Zero |
|---|---|---|---|---|---|---|---|
| 1. Sustainability Awareness | 0.045 | 0.000 | 0.000 | 0.080 | 0.074 | 0.067 | 0.000 |
| 2. Infrastructure & Hardware | 0.000 | 0.059 | 0.231 | 0.120 | 0.074 | 0.133 | 0.000 |
| 3. Data Management & Lifecycle | 0.045 | 0.176 | 0.077 | 0.040 | 0.037 | 0.133 | 0.000 |
| 4. Implementation & Optimization | 0.045 | 0.176 | 0.077 | 0.000 | 0.111 | 0.000 | 0.063 |
| 5. Longevity & End-of-Life | 0.000 | 0.118 | 0.231 | 0.000 | 0.037 | 0.133 | 0.000 |
| 6. Sustainable Design & Arch. | 0.182 | 0.000 | 0.000 | 0.040 | 0.148 | 0.000 | 0.000 |
| 7. Measurement & Reporting | 0.182 | 0.000 | 0.077 | 0.120 | 0.037 | 0.067 | 0.125 |
| 8. Knowledge Sharing & Leadership | 0.045 | 0.118 | 0.000 | 0.000 | 0.037 | 0.000 | 0.000 |
| 9. Documentation | 0.091 | 0.118 | 0.077 | 0.080 | 0.037 | 0.000 | 0.000 |
| 10. Organizational Culture | 0.091 | 0.118 | 0.077 | 0.160 | 0.074 | 0.133 | 0.125 |
| 11. Responsibility & Roles | 0.045 | 0.059 | 0.000 | 0.000 | 0.037 | 0.000 | 0.063 |
| 12. Training & Education | 0.091 | 0.000 | 0.000 | 0.000 | 0.074 | 0.067 | 0.000 |
| 13. Onboarding Awareness | 0.045 | 0.059 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 14. Continuous Improvement | 0.045 | 0.000 | 0.000 | 0.000 | 0.074 | 0.000 | 0.063 |
| 15. Hiring & Skills | 0.045 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 16. Governance & Policy | 0.000 | 0.000 | 0.077 | 0.200 | 0.000 | 0.200 | 0.188 |
| 17. Env. Impact / Emissions | 0.000 | 0.000 | 0.077 | 0.160 | 0.148 | 0.067 | 0.375 |
| **Total** | **1.000** | **1.000** | **1.000** | **1.000** | **1.000** | **1.000** | **1.000** |

TABLE VII: Comparison of Green Software Certifications and Standards

## APPENDIX B
## PLANNING AND TEAMWORK

| Component | Task | In order of input | | |
|---|---|---|---|---|
| Tool | Project setup | Moniek, Anouck | | |
| | Certification research | Anouck, Moniek | Maksym | |
| | Local labeling | Moniek | Anouck | Maksym, Vasil |
| | Global labeling | Anouck | | |
| | Recommendations | Anouck | | |
| | Questions | Anouck | Moniek, Vasil | |
| | Backend | Vasil | | |
| | Frontend | Alexandru | | |
| | Webdesign | Moniek, Alexandru, Maksym, Anouck, Vasil | | |
| Report | Introduction | Anouck | Maksym | |
| | Background | Moniek | Anouck | Alexandru |
| | Implementation | Anouck(A-F) | Moniek(A&C) | Vasil(F), Alexandru(E) |
| | Evaluation | Anouck | Maksym | |
| | Discussion | Anouck | | |
| | Conclusion | Alexandru Maksym | Anouck | |
| Video | Development | Moniek | Anouck | |
| | Script writing | Moniek | | |
| | Recording | Moniek | Anouck | |
| | Editing | Moniek | | |
| Communication | Planning | Anouck | Moniek | |
| | Meeting notes | Maksym | | |

TABLE VIII: Project Task Overview

## APPENDIX C
## CODE REPOSITORY

The full implementation and supporting code for this project can be found at https://github.com/vasilchirov/susti-certification, and the README contains detailed instructions on how to run it.

## APPENDIX D
## SURVEY QUESTIONS

| Global Label | Question | Answer Options |
|---|---|---|
| Sustainability Awareness | Are sustainable software principles (e.g., energy efficiency, resource usage) recognized within the organization? | Not recognized: These principles are not known<br>Minimally recognized: Some individuals are familiar with them<br>Moderately recognized: Principles are generally understood<br>Fully recognized: Principles are widely known and clearly understood |
| | Is there general awareness of sustainability as a relevant topic in software development? | Not relevant: Sustainability is not seen as relevant<br>Slight awareness: Some awareness of relevance exists<br>Clear awareness: Sustainability is recognized as relevant<br>Strong awareness: Sustainability is widely recognized as an important aspect of software development |
| Infrastructure & Hardware Management | Does your organization consider the use of renewable energy in infrastructure (e.g., green cloud providers)? | Not considered: Renewable energy is not a factor<br>Limited consideration: Occasionally considered<br>Considered: Included in infrastructure decisions<br>Prioritized: Renewable energy is a key factor in infrastructure selection |
| | How does your organization manage hardware lifecycle (reuse, recycling, disposal)? | No management: No structured approach to hardware lifecycle<br>Basic management: Some informal reuse or disposal practices<br>Managed lifecycle: Processes exist for reuse, recycling, and disposal<br>Optimized lifecycle: Lifecycle is actively managed and optimized for sustainability |
| Data Management & Lifecycle | Are outdated, temporary, or unused data regularly cleaned up? | No cleanup: Data is rarely or never removed<br>Occasional cleanup: Cleanup happens irregularly<br>Regular cleanup: Data is periodically reviewed and cleaned<br>Continuous cleanup: Automated or structured processes ensure ongoing data cleanup |
| | Do you maintain an inventory of your data assets (e.g., datasets, storage locations)? | No inventory: No overview of stored data<br>Partial inventory: Some datasets are documented<br>Maintained inventory: Most data assets are tracked<br>Comprehensive inventory: All data assets are systematically documented and maintained |
| Implementation & Optimization | Is scalability considered to ensure efficient resource usage as the system grows? | Not considered: Scalability is not addressed<br>Minimally considered: Some awareness of scalability issues<br>Considered: Scalability is part of system design<br>Fully optimized: System is designed for efficient scaling with minimal resource waste |
| | Is your software actively optimized for performance and resource efficiency? | Not optimized: No active optimization is performed<br>Limited optimization: Optimization happens occasionally<br>Regular optimization: Performance and efficiency are considered during development<br>Continuous optimization: Software is systematically optimized for efficiency throughout its lifecycle |

TABLE IX: Sustainability Assessment Questions and Scoring part 1

| Global Label | Question | Answer Options |
|---|---|---|
| Longevity & End-of-Life | How well does the software support long-term use without requiring unnecessary hardware upgrades? | Poor: Frequent updates require hardware upgrades or limit usability over time<br>Limited: Some effort to maintain compatibility, but hardware upgrades are often needed<br>Good: Software remains usable for expected lifespan (e.g., 3–5 years) with minimal hardware changes<br>Excellent: Designed for long-term use, scalable across systems, and avoids unnecessary hardware upgrades |
| | How effectively can the software be removed at the end of its lifecycle? | Not removable: Cannot be fully uninstalled or leaves significant residual data<br>Partial: Uninstall possible but leaves some unnecessary data or dependencies<br>Mostly clean: Can be removed with minor traces remaining<br>Fully clean: Completely removable with no unnecessary residual data |
| Sustainable Design & Architecture | To what extent is sustainability considered in software design and technical decision-making? | Not considered: Sustainability is not part of design or decision-making<br>Ad hoc: Occasionally considered, but not systematically or documented<br>Integrated: Sustainability is regularly considered, including trade-offs with performance<br>Embedded: Sustainability is a core design principle, with explicit evaluation of trade-offs and documented decision processes |
| | To what extent is the software designed to be modular and interoperable with other systems? | Closed: Monolithic design with little or no interoperability<br>Limited: Some modular components or limited interoperability<br>Flexible: Modular design and supports integration with other systems<br>Highly flexible: Fully modular architecture with strong interoperability and easy extensibility |
| Measurement Monitoring & Reporting | How effectively are resource usage and energy metrics monitored and made visible? | No monitoring: No continuous monitoring or visualization<br>Limited: Some monitoring exists, but not continuous or not easily accessible<br>Active: Continuous monitoring with dashboards or tools for key metrics<br>Advanced: Real-time monitoring with automated dashboards, alerts, and actionable insights |
| | To what extent are measurement insights used to optimize software efficiency across the development lifecycle? | Not used: No optimization based on measurements<br>Reactive: Occasional optimization based on identified issues<br>Integrated: Regular profiling and optimization during development and operations<br>Proactive: Continuous optimization embedded in workflows (e.g., CI/CD), with clear efficiency targets |
| Knowledge Sharing & Leadership | To what extent does your organization share sustainability knowledge and practices internally? | None: No sharing of sustainability knowledge or resources<br>Informal: Occasional or ad hoc sharing within teams<br>Structured: Regular sharing through meetings, documentation, or internal platforms<br>Embedded: Systematic and organization-wide sharing integrated into workflows and culture |
| | To what extent does your organization share sustainability knowledge and collaborate with external groups? | None: No external sharing or collaboration<br>Limited: Occasional sharing (e.g., informal exchanges or isolated initiatives)<br>Active: Regular sharing of resources, lessons learned, or participation in collaborations<br>Leading: Proactively shares knowledge, contributes to communities, and supports other organizations |

TABLE X: Sustainability Assessment Questions and Scoring part 2

| Global Label | Question | Answer Options |
|---|---|---|
| Documentation | Is sustainability information documented and accessible within your organization? | Not documented: No sustainability information is documented or accessible.<br>Limited documentation: Some information exists, but not necessarily structured and must be aware to find it.<br>Accessible documentation: Sustainability information is documented and accessible to relevant stakeholders.<br>Centralized & maintained: Documentation is centralized, well-structured, and regularly updated. |
| | Do you maintain and update sustainability-related documentation (e.g., best practices, guidelines)? | No documentation: No documented practices or guidelines exist.<br>Static documentation: Documentation exists but is not often updated.<br>Regular updates: Documentation is reviewed and updated occasionally.<br>Actively maintained: Documentation is continuously updated and reflects current best practices. |
| Organizational Culture | Are employees encouraged to consider sustainability in their daily work? | Not encouraged: Sustainability is not part of daily work.<br>Some encouraged: Sometimes when it is clearly relevant.<br>Actively encouraged: Sustainability is regularly encouraged within teams.<br>Embedded culture: Sustainability is a core part of daily decision-making. |
| | Are sustainability initiatives recognized within the organization? | Not recognized: Sustainability efforts are not necessarily acknowledged.<br>Occasionally recognized: When a major improvement is made.<br>Regular recognition: Big efforts are recognized and supported.<br>Actively promoted: Sustainability efforts, no matter the size are actively celebrated. |
| | Are sustainability values (e.g., ESG, diversity, ethics) integrated into your organization? | Not integrated: No clear integration of sustainability values.<br>Integrated: Some Values are embedded in multiple areas of the organization.<br>Fully embedded: Sustainability, diversity, and ethics are core organizational principles. |
| Responsibility & Roles | Are sustainability responsibilities clearly defined across the organization? | Not defined: No clear responsibilities.<br>Partially defined: Some key roles include sustainability responsibilities.<br>Fully defined: Sustainability responsibilities are clearly defined and integrated organization-wide. |
| Training & Education | Is your organization open for sustainability training: | No, we do not want that.<br>Yes we are open to receive sustainability training as part of the process of obtaining a specific certification |
| | Do employees receive training on sustainable IT or green software practices? | No training: No training is provided.<br>Limited training: Training is occasional or optional.<br>Regular training: Training is available for relevant roles.<br>Structured training: Training is formalized and regularly updated. |
| | Are sustainability topics integrated into professional development and learning paths? | Not included: Not part of development programs.<br>Integrated: Included in structured learning paths.<br>Core component: A key part of professional development. |
| Onboarding Awareness | Are new employees introduced to sustainable development practices during onboarding? | Not included: No sustainability content in onboarding.<br>Limited introduction: Yes it is mentioned introduction.<br>Comprehensive onboarding: Clear guidelines, resources, and expectations are provided. |

TABLE XI: Sustainability Assessment Questions and Scoring part 3

| Global Label | Question | Answer Options |
|---|---|---|
| Continuous Improvement | Do you actively research and stay updated on sustainability improvements relevant to your field? | We do not actively follow sustainability developments.<br>We occasionally come across sustainability improvements, but there is no structured effort to stay updated.<br>We regularly follow sustainability trends, research, or industry developments.<br>We have a structured approach (e.g., assigned roles, scheduled reviews, subscriptions, or communities) to stay updated. |
| | How do you improve sustainability performance over time? | We do not actively work on improving sustainability<br>Improvements are occasional and informal<br>We regularly review and implement sustainability improvements<br>We continuously optimize systems based on structured processes and feedback |
| Hiring & Skills | Are sustainability skills considered when hiring new employees? | Sustainability skills are not considered during hiring.<br>Sustainability might be talked about but not actively evaluated.<br>Sustainability skills are considered when relevant to the position.<br>Sustainability skills are an important and consistent part of hiring decisions. |
| Governance & Policy | Does your organization have formal policies for sustainable IT practices? | No sustainability policies are in place.<br>Policies exist but are informal or undocumented.<br>Policies are documented but not consistently enforced.<br>Policies are enforced, monitored, and regularly updated. |
| | Do you have defined sustainability goals (e.g., emissions reduction targets aligned with science-based targets)? | No goals: We do not have defined sustainability goals.<br>Informal goals: We have informal or unclear sustainability goals.<br>Defined goals: We have clear and measurable sustainability goals.<br>Science-based goals: Goals are aligned with recognized standards (e.g., science-based targets, net-zero). |
| Environmental Impact & Emissions | Do you measure greenhouse gas (GHG) emissions or carbon footprint? | We do not measurement<br>Some is measured<br>We perform regular measurement of emissions<br>We systematically measure emissions using standardized methods |
| | Do you take action to reduce environmental impact? | No action: We do not actively reduce environmental impact.<br>Opportunistic action: We reduce impact only when convenient or as a side effect of other changes.<br>Planned action: We take deliberate actions when clear opportunities arise.<br>Continuous reduction: We actively and continuously reduce environmental impact through structured initiatives. |
| | Does your organization have environmental targets (e.g., net-zero)? | No we do not have targets<br>We have some informal targets<br>We have defined targets and known targets (e.g., reduction goals)<br>Science-based or net-zero aligned targets |

TABLE XII: Sustainability Assessment Questions and Scoring part 4