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Trade-offs in the collaborative design of a B2B eco-label for the European railway sector

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Abstract

As the European railway sector is committed to improving its sustainability, a consortium of railway organizations for the European Union is working on the development of an eco-label for the sector. This paper explores the design choices that present themselves during the co-design of this label, which aims to *track improvements*, *communicate and share*, and *push suppliers* to improve with respect to the three indicators: *GHG/CO_2 emissions*, *circularity*, and *energy efficiency*. The findings highlight the inherent trade-offs in the design of an eco-label and discuss ways to improve the intuitive understanding of these trade-offs within the context of co-design.

Keywords: Design choices; European railway sector; Eco-label goals; European railway sector; Eco-label requirements ; Sustainability communication; Environmental label; Applications; Design for sustainability; Trade-offs

1. Introduction

Eco-labels have been used since the 1940s, according to Dórea et al. [1] as a warning tool before being widely used as the focus on our environment grew in the 1960s. These years saw the spread of energy labelling standards for household appliances [2] and environmental labels in regards to sustainability[1]. The creation of standards helped to define three types of labels from the ISO standards and a fourth defined by the literature [1,3-6]. Type I is an eco-label that is awarded by a third party and looks at the impact of a product or service across its life [4,7]. Type II can be a logo or text showing a particular aspect of the product [3,7]. Type III encompasses environmental product declarations (EPD) verified by a third party that can be compared to products of the same category [5,7]. Type IV is a hybrid label that includes type I and III elements, giving more choices on the format [6].

The European railway sector wants to improve its impact by introducing a business-to-business (B2B) label that would affect the tendering of its rolling stock and infrastructure. This eco-label would be created with the help of co-creation, a participatory approach that encourages participants to develop their label instead of creating it for them [8-11]. By doing this, the authors can act as facilitators on this co-creation journey, taking the consortium members along the design process and discussing options and choices until they reach their final goal. The participants of this consortium hope to foster innovation by introducing this comparison system. The consortium working to establish this comprises experts from sixteen rolling stock and infrastructure companies, including manufacturers, operators, and managers.

Throughout this paper, we will explore the series of decisions that need to be taken during the creation of the label to examine their potential impacts on the label itself. These trade-offs are what we will be exploring in this paper.

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2. Theoretical background

2.1. Previous work

Eco-labels can be defined as per a previous paper as an "environmental label that can communicate the environmental impact or sustainability of a product or service during its lifecycle to change consumer behavior [12,13] and to promote change by introducing new standards [13]." [14, p. 443]

An exploratory case study was carried out to determine the sector's goals in creating an eco-label as part of the problem identification phase of the design science research methodology. The European railway sector wants to introduce eco-labels to (i) track progress and benchmark, (ii) communicate and share, and (iii) push suppliers to improve [14]. After determining their priorities for the sector, a consortium of experts from the rolling stock and infrastructure part of the European railway sector gathered to decide on the indicators that should be included on the label and settled on three: (i) greenhouse gas (GHG)/ carbon dioxide (CO_2) emissions, (ii) circularity, and (iii) energy efficiency [15].

Choices like the label's intended use, users, audience, label types, and level of information can significantly affect the final design of the label. On the other hand, an eco-label needs to be concise, which requires the consortium to scope down the information in the label as part of the co-design process.

By deciding that the eco-label will be done in a B2B capacity, the consortium has already chosen to forego the influence on the consumer as of now and focus on the decision-making during the tendering process. In the literature, B2B labels are not as prevalent and reported on as business-to-consumer (B2C). The latter presents some significant academic research on the decision-making of consumers and the design principles of a good label [12]. However, though the choice of a B2B eco-label is a significant step in the design, the consortium still needs to make plenty of other choices. We aim to present a number of these choices to help them grasp the classification of eco-labels and how some of these choices are interconnected. The main dependencies that were gathered can be seen in Figure 1.

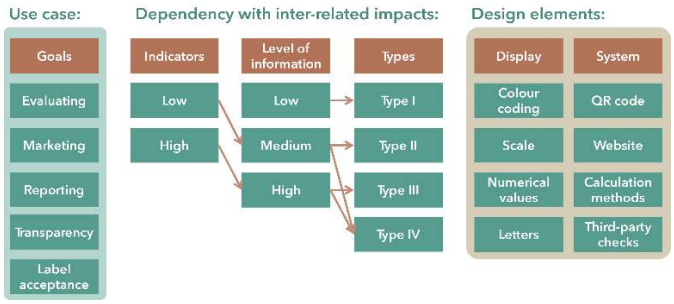

Figure 1: Multiple choices of the eco-label design with inter-related impacts.

The use case of the label guides the design choices being made, and the choices together can affect how well the goal is met or if another goal appears instead. Following a previous case study [14], a few goals appeared: evaluating, marketing, reporting, transparency, and label acceptance. The evaluation goal aims to assess the product through the three indicators with potential comparisons. The design could show how relatively good or bad the product is faring on a scale; this would involve comparison and having to determine a scale. Marketing would put forward the product's functionalities and use the indicators to highlight in which category they perform better in an effort to convince the manager or operator of the product; comparison could play a role here. Using pictograms or writing could explain the results obtained (i.e., consumption versus amenities). Reporting has a strong link to compliance but also accounts for the impacts of a product to tally it as part of a larger picture; it could be presented in relation to time. Transparency and label acceptance are two important considerations. They allow the user to trust the label by referring to a system (e.g., calculation methods) and actively use it as part of the procurement process. Transparency could be achieved by showing more information on the label, but this may have a negative effect on its readability. This could be solved by relying on a system like an EPD, a website, or a quick response (QR) code instead. The acceptance of the label will be heavily linked to its intended and actual use in a real-life context. Implementing KPIs that the supply chain can improve could help its acceptance. The level of readability will be paramount in ensuring the experts can use the label in a procurement process.

2.2. Dependency with inter-related impacts

The relative number of indicators is linked to the label's complexity. A higher number of indicators will present a more holistic picture of the product's sustainability but will require an expert to better understand how to read the label. A lower number of indicators will be easier to grasp but might threaten the representativeness of the environmental impacts.

The number of indicators directly affects the information level, ranging from *low* to *high*. It explores how a descriptive logo can show affiliation to an organization, a *medium* can present some indicators on a scale, and a *high* level of information could be a more descriptive label with indicators and sub-indicators that detail the product and its features.

This brings us to the four labeling formats that could be used with their visual identity, ranging from a logo to extensive documentation like an EPD. The type of label affects the range of information presented on the label. Though we expect this label to be used by a more experienced audience, a type I label might be best if the aim is to show compliance. A visual stamp of approval (i.e., logo) that proves that the product fulfills a set of requirements and is given by a third party. A logo could be paired with documentation to transparently inform the public about the product's impact. If the consortium wants to compare with proof and numbers, then a type III label might be more appropriate, though more complex to understand. If that is the case, three indicators might not be enough to paint the bigger picture. On the other hand, a label like the European energy label might be between the two, with some information on the product, a scale for comparison, and a link to a system. The format will affect how the label is perceived and used [16].

A consortium could make the choices by first deciding the type, the level of information, or the indicators. In our case, the indicators were chosen ahead of time following the research on the sector's goals. This will thus influence the level of

information and the type of label to be used, though the consortium could decide to pivot.

2.3. Further (cumulative) choices: display and system

Though the previous decisions had a significant incidence on the rest of the choices, the display and the system are design elements that could reinforce some aspects of the label. Apart from content, the design elements could influence the reader's perception by including color coding and different representations [16]. It could be reminiscent of other schemes like European energy labelling [17] or the Nutri-Score [18] especially with the inclusion of scales with letters. Scales and letters would bring the need to assess current products' upper and lower boundaries and the rate of future innovation. While using a traffic light color scheme may recall the energy labels and bring an idea of good versus bad grading. A scale with a good versus bad could carry the risk of minimizing the rate of innovation if a product lands within acceptable boundaries. On the other hand, just using the numerical value could make it hard for the reader to interpret the numbers or more tangible for an expert to assess the product's impact. Combining some choices may help evaluate the product and link it to actual values, but this could also make the label very busy visually. This will be done depending on how the consortium envisions the goals of this label and its format.

Though the label should be able to provide information as a standalone tool, other solutions could be paired with it to provide additional information, like a system. This system would allow the user access to further information about the label, allowing the label to only contain a low to medium level of information. A QR code could follow the idea of digital product passports and energy labels [17,19] to follow European standards and provide other types of information stored in the QR code directly. Should more information be needed, the QR code could link to a website or database instead with more information on the third-party checks and calculation methods for increased transparency. The responsibility behind storing and updating such information will then be a topic of discussion. The calculation methodology could be available and standardized, while the calculation results would only be available to the reviewer. This would protect the confidentiality of the data while still ensuring transparency through third-party checks. They would bring greater trust in the label; this could be done as a validation step of the voluntarily computed label before being finalized, or it could be a third party awarding the label after the companies have applied for it. For B2C labels, readers tend to trust a label more if it comes from a third party rather than the government or a company [12]. However, since companies are the end-users, the third-party check might lengthen the accreditation process that some organizations already have to go through, making it best as a validation step.

3. Method

Trade-offs imply that prioritizing one trait means another trait is less present. Several trade-offs can be found in the literature, with characteristics being prioritized or seen as desirable. Trade-offs were identified through the literature and by linking some of the principles to examples of existing labels. Ideally, a designer would want to find the optimal choices for an optimal label. As we are designing with inherent trade-offs, we can optimize for a range of different characteristics. The Pareto optimum can help visually represent the complexity of optimizing for two characteristics; it demonstrates how the optimization of one trait will make another lower [20]. As the eco-label design involves at least seven trade-offs, the complete optimization of all elements is near impossible. Thus, integrating multiple design objectives makes this a multi-dimensional design problem. Instead, the goal is to investigate how to represent these trade-offs to foster an understanding of the design trade-offs as part of the co-design.

One could try to use mathematical theories like Censi [21] to co-design, but this requires quantifying our system's trade-offs and its abstract nature, which may not be compatible with reaching an intuitive and shared understanding of the design trade-offs in a consortium.

The label may incorporate multiple goals and stages, so it is paramount that the participants think about the desirable characteristics they want to highlight and how they will function together. A common way to deal with this multidimensional complexity is to make design choices that prioritize specific design characteristics. Design for X performs this by interchanging the X with a perspective that can help prioritize a specific aspect, such as maintainability, sustainability, cost, etc. [22] However, considering specific characteristics helps participants foresee how prioritizing one trait influences the overall utility of the label.

Highlighting trade-offs can be done by visualizing the characteristics and functionalities to create an intuitive and shared understanding within a consortium [23]. This visual should represent the different consequences of the design choices to support the discussion on the trade-offs and their effects. To do this, examples of existing labels can be mapped on a spider diagram to explore the choices made for each design. The idea is to present in the co-design session that there may be different objectives for one label that can be satisfied with different trade-off optimization.

4. Results

The many choices listed above can impact the label and introduce trade-offs, which will be discussed in the next section. To support this, three labels are used to highlight these examples, as seen in Figure 2: the Nutri-Score label [24], the European energy label [25], and the EnergyGuide label in combination with the EnergyStar accreditation [26]. The Nutri-Score logo is affixed to food to help consumers choose which food is better for their health with a letter scale ranking. The European Union energy label is a label produced for household appliances with a colored scale and letter grade that evaluates how the product is doing in comparison to the sector's standard. Multiple indicators are sometimes shown on the product with values or grade scales; these labels sometimes have a link through a QR code. The United States government supports the EnergyGuide label and uses costs to assess the product's energy consumption with values and explanations shown on it. In this example, it is coupled to the EnergyStar,

which is given for a product if it checks a list of requirements and has a link for more information on the initiative.

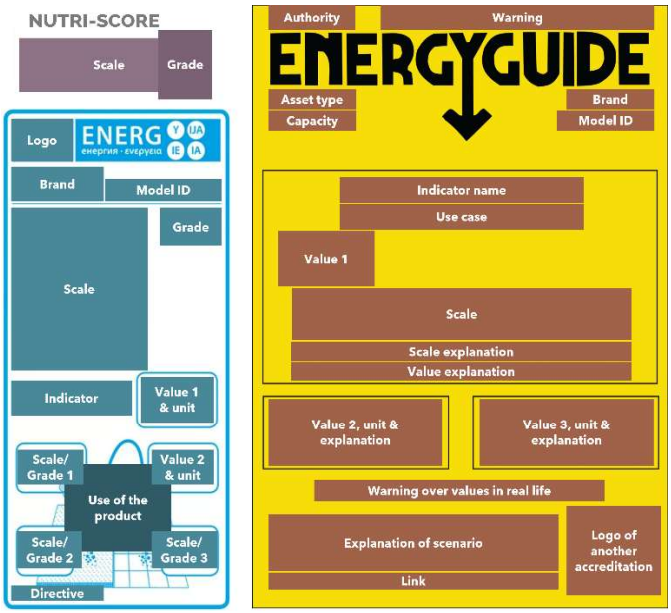

Figure 2: The design elements of the Nutri-Score, European energy label, and EnergyGuide label with the Energy Star.

Some common design elements can be found on the labels, such as the label's name, scale, and grade. The only time this might not appear would be for a type I label like the Energy Star accreditation, where the logo being affixed functions as a recommendation by authorities or an evaluation body. Usually, the name and logo would be the only things present. The European energy and EnergyGuide labels present a primary grade or value using a scale with visually smaller sub-indicators. They also have elements such as the name or image representing the authorities, which legitimizes the label, the brand, and the ID model of the product, with sometimes a bit of explanation about the context through writing or using images to illustrate.

4.1. Trade-offs

Meis-Harris et al. describe six principles for a "good" eco-label scheme while considering the effect on the consumer and the decision-making of the company: "trust, visibility, environmental credibility, values clarity, market penetration and policy integration" [12, p. 15]. This review encompasses the schemes that eco-labels are a part of, and thus, the principles tend to have more of a B2C focus with some guidelines for companies. This project aims to design an eco-label that shall fit a scheme. So, the label should fit the needs of a European Union eco-label scheme and the railway sector. To do this, we explore the first three conditions [12] which discuss trust, transparency, accuracy, dissemination and visibility, and credibility.

We introduce seven trade-offs based on the literature and the observation of existing labels: clarity, visualization, data processing, goal-centeredness, specificity of purpose, transparency, and fixity of a label [27]. Under *trust, transparency, and accuracy*, our trade-offs are the clarity, visualization, transparency, and fixity of the label. For *dissemination and visibility*, our trade-offs are data processing and goal-centeredness. Finally, for *credibility*, the fixity of the label and specificity of purpose play a role. The trade-offs are explored by using the examples in Figure 2 and mapping them on a diagram, as seen in Figure 3 to make the trade-offs clear. Each trade-off is a scale with opposites at each end (0 to 5); these opposites and their implications are further explored in the next section.

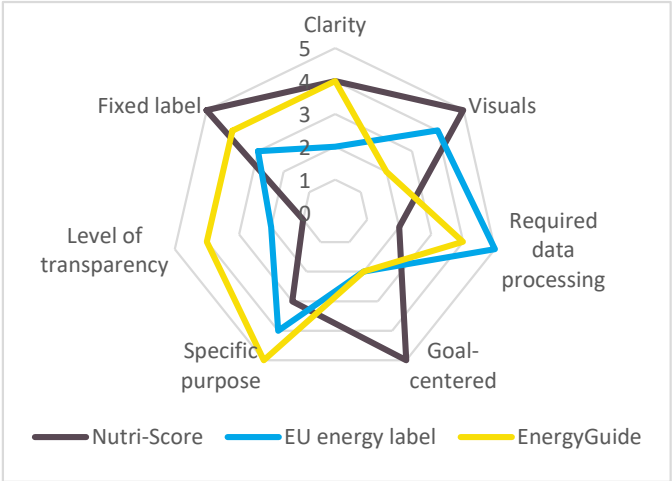

Figure 3: Depiction of the Nutri-Score, European energy label and the EnergyGuide against their trade-offs.

5. Discussion

The idea of the Pareto optimum is to compare one criterion against another to have an idea that tries to maximize these parameters. Such modeling can be extensive, but in our case, it is not viable as we have seven perspectives to account for, which would considerably increase the complexity of the model. A spider diagram like in Figure 3 can help eliminate sub-optimal design options, even if it is not Pareto modeling per se. This can avoid creating a design that is demonstrably worse in multiple categories. The idea of optimizing the design is to follow the model's curve and focus on finding "good" options by eliminating sub-optimal options. The goal is to identify the most optimal design that meets the criteria as well as potential gaps in the eco-label design prototypes.

5.1. Clarity versus Informational

When looking at the trade-offs between clarity and informational labels, one can look at the Nutri-Score for a highly legible label with a low amount of detailing. Consumers must look for more information on how to read the label or how this rating was given. The energy labels are legible in different ways. The European one uses pictograms to visualize the indicators, while the American one details information by writing the context directly on the label. The European one may still be difficult for an inexperienced reader as pictograms are not always evident, while the writing on the other label indicates what is measured. The EnergyGuide also links to a website with information about the scheme. By showing more than one indicator, the energy labels increase legibility and detailing. However, at first glance, it is still unclear if the primary indicator aggregates the rest into it.

5.2. Visuals versus Written-content

As mentioned under clarity, visualization would help the label be more communicative, while written information can be more informative. However, pictograms in the European label can be vague for a reader with no context or background. With written content, the EnergyGuide may be more informative as it increases a reader's level of detail and comprehension. When such labels allow access to the methodology behind the label, the clarity of the label increases compared to a more streamlined and simplified label such as the Nutri-Score.

5.3. Required data processing

The resources needed to obtain values might be significant depending on the standards set for the indicators. In the case of Nutri-Score , the food producers need to submit an Excel sheet with values, which then computes and attributes a letter for a given product. The simplification of such a label requires work ahead of time to summarize a lot of information into a few indicators or visualizations. Though the aggregation itself may be intensive to process, this is made easier by the tools put in place. On the other hand, an energy label may need to be backed by tests and a full life cycle assessment, which is data and resource-intensive. This intensity can also be linked to the number of indicators, the aggregation into a more significant grade, the level of information, and the scale (i.e., European label). Though this data can then be simplified visually, the computation, responsibility for storage, and upkeep of the data make the workload more critical over time and will have a link to the fixity of a label. The required data processes are also affected by how we see a product in itself and how we wish to depict it as part of this label: different requirements, manufacturability of the label, and how easy it is to get information. This may also change during the label's lifetime to ensure increased conciseness, like reworking the scale after a couple of years to reflect the innovation in the sector.

5.4. Goal-centered versus Multiple goals

If the label is tailored to one goal, the design will prioritize some elements that may be more targeted for the need. In Nutri-Score, promoting better food habits is the core goal, reflected by the focus on one aggregated indicator meant to assess with a scale and color how good or bad the product is. In energy labels, the consumer's selection of more energy-efficient appliances is promoted by considering energy consumption cost savings, electricity use, and noise level. At the same time, innovation on the corporation’s side is achieved by benchmarking against the competition. This means that the information level can be used to convince some specific target users: consumers to choose the “better option” and corporations to push for improvement.

5.5. Specific versus Generic purposes

It seems that in the example of the energy labels, the EnergyGuide provides more context-oriented cues. In contrast, the European label and Nutri-Score use standardized scenarios that make the label less information-heavy. However, though this increases the visual clarity, the details of the context may be lost on the consumer unless they go through the documentation themselves to get an explanation about the testing on the label. This might make the EnergyGuide label more relatable to a real-world context for the user.

5.6. Level of transparency

Though this label should be as transparent as possible to ensure a high level of trust for the user, this also means the information needs to be credible and clear [12], which may be challenging to balance with confidentiality for some corporations. Companies could use standard calculations to make their label, which would be available as part of a system to the public, while the more sensitive information would be shared with the reviewer. It is paramount that companies disclose if the data was primary or secondary by discussing the availability of information in documentation. Third-party checks can also help to provide trust while protecting the companies' confidential information. The Nutri-Score scores very low on transparency as no information or link is available to the reader, making it look like a black box for the user. The European label provides more information by including values and a breakdown of the product impact. The EnergyGuide performs the best in this category due to the use of numerical values and written content that compares the efficiency of a product in a specific context.

5.7. Fixed versus Dynamic

The ‘fixity’ of a label discusses the potential for a label to be immovable, changed over time [27] or even reflecting the impacts of a product at a given time. The question of a fixed or dynamic label also brings about the question of data availability, the centrality of the data under a system, and its maintainability (i.e., upkeep and storage). A fixed label would be calculated at set times of the lifecycle of the product over time which is sensitive to the market average. This is already a high workload, which can be made higher if enough information is available, a dynamic system, and calculations are in place. This would allow the impact of a product to reflect its actual use during service; this would, however, add a layer of complexity to it. The Nutri-Score and EnergyGuide are fixed, while the European label may be recomputed after a number of years to update the scale.

6. Conclusion

This research set out to better understand design choices by using the concept of trade-offs in eco-label design. Visualization of trade-offs helps depict the choices and their link to the design elements found in existing labels as part of an intuitive and shared understanding. It also helps to communicate the effects of certain choices in a collaborative design process. The essential design trade-offs were clarity, visualization, data processing, targeted goal(s), specificity of purpose, level of transparency, and label dynamicity. A spider diagram can support this discussion by using prototypes to

visualize the combination of design trade-offs to check if they fulfill requirements or can be used to see the gaps in the eco-label design. The proposal for different trade-offs in the diagram was demonstrated using existing eco-labels, thus facilitating a shared exploration of the consequences of design choices.

It is understood that there will be inherent trade-offs during this design process. However, we can optimize for a range of different characteristics seen as desirable by the consortium. The objective of the co-design session will be to find an optimal design for the consortium, which may differ from the theoretical optimal. This difference is due to the simplification from a multi-dimensional space since prioritization is needed between trade-offs. However, creating one eco-label as the consortium wants is still possible, which may tackle multiple goals into one "smart" design for a label. By visualizing trade-offs, we can represent the different consequences of the design choices and many elements to design for so participants can intuitively understand the design trade-offs.

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