Supplementary Material: a brief explanation of each method

Please refer to Section 3 in the Manuscript.

In the following paragraphs there is a brief explanation of the 29 methods found in the literature review.

The first method identified in the literature was proposed by Hochman and O'Connell (1993). The authors state that the purpose of the method is to improve the quality, speed, and costs of implementation of ecodesign initiatives, i.e., reduce environmental impacts in the product life cycle. This proposal differs very little from the traditional QFD matrix, and the environmental requirements are contained in the same matrix with product specifications.

The second QFD method for ecodesign is the Green QFD-II developed by Zhang et al. (1999), whose purpose is to integrate environmental and cost-related issues in QFD matrices using Life Cycle Cost (LCC) and Life Cycle Assessment (LCA) techniques. Green QFD-II also proposes a concept selection matrix that relates conventional product specifications, environmental issues, and costs, as well as the joint and individual analysis of those requirements.

Quality Function Deployment for Environment (QFDE) proposed by Masui et al. (2001) is one of the most frequently cited methods in the area of environmental QFD. It is based on other environmental QFD methods such as '"3D-QFDE," "Eco-VOC," "QFDE/LCA," and the integration of "QFDE/LCA/TRIZ". Its objective is to identify which functions and components must be prioritized to satisfy a customer concerned with environmental issues, in addition to helping engineers unfamiliar with environmental sciences. As a fundamental difference, QFDE presents a set of 15 environmental requirements and 15 engineering measures that must be incorporated to meet the required quality and quality characteristics.

Wong and Juniper (2002) developed Green Quality Function Deployment (GQFD). This method correlates environmental requirements and required quality with product specifications. This proposal points out the importance of considering all stakeholders in the process of obtaining VoC, although it does not differ significantly from the traditional QFD.

Rahimi and Weidner (2002) proposed the QFD-DfE, which aims to relate customer requirements, cost reduction, and environmental impacts with design characteristics, considering the product's entire life cycle. Its application involves three distinct design phases: 1) definition of the product as a whole, 2) definition of its components, and 3) the product's attributes. Although the QFD-DfE method considers environmental issues and costs, similarly to Green-QFD II, they differ because QFD-DfE does not use LCA and LCC.

In addition, Trappey et al. (2011) developed an eco- and inno-product design system using QFDE and TRIZ methodology. The model created was named eco-inno-design information system (EIDIS) and was applied in two eco- design cases of power adaptor.

The Environmental QFD developed by Kato and Kimura (2003) aims to systematize environmental and technological issues. Required quality is divided into three types of requirements: from the perspective of the user, society, and the company. Only the latter is related to environmental requirements. Quality characteristics are also divided into groups and related to the product life-cycle phase: definition of raw material, design, manufacturing, sales, use, recycling, and reverse logistics. A new contribution of these authors is the use of a 'type IV quantification theory' that allows for the analysis of matrix results on a two-dimensional diagram.

Eco-VoC was developed from QFDE by Yim and Herrmann (2003). Its objective is to present an alternative that facilitates identification of the 'environmental voice of customer,' called the 'eco-voice.' The eco-voice extraction process is based on three steps. After defining the environmental voice of customer, the authors (Yim and Herrmann, 2003) propose the use of a simplified version of the QFDE proposed by Masui et al. (2001).

Ernzer et al. (2003) presented the EI2QFD, an ecodesign method based on QFD aimed at identifying the "voice of environment." The "voice of environment" represents environmental needs for a product and it is taken from Eco-indicator 99, a method used in LCA. To do so, the EI2QFD uses a QFD structure consisting of two "environmental matrices". Both these matrices establish as demanded quality the results from Eco-indicator 99; the first group comprises requirements related to the use stage in the first matrix, while the production requirements and end-of-life strategies are considered in the second matrix.

Sakao et al. (2003) present a QFD method based on the "Receive State Parameter" (RSP). As described by the authors, the method proposes the design of environmentally conscious services using QFD. Therefore, the main contribution of this method is the design of more environmentally friendly services rather than of products, which is the case of most of the other proposals.

Ernzer and Birkhofer (2003) proposed another method called "Eco-QFD," which is aimed at translating market needs into design requirements, taking into account the product's environmental issues. The structure of Eco-QFD does not differ from traditional QFD in the way it is applied.

Shih and Liu (2005) published another ecodesign method based on QFDE proposed by Masui et al. (2001), which they called 3D QFDE. The 3D QFDE analyzes a number of product designs from three distinct perspectives: quality, costs, and environmental issues. The results of product design considering the three perspectives are plotted in a pyramid, where each vertex represents quality, costs, and environmental issues, in order to assist in selecting the best product design.

The proposal of Sakao et al. (2005) is aimed at integrating LCA in QFDE matrices. Consequently, QFDE is to be used in the initial stages of new product development, and when more data and information are available, a qualitative assessment is made of environmental impacts based on LCA.

Cagno and Trucco (2007) proposed Integrated Green Quality Function Deployment (IGQFD), an ecodesign method based on QFD aimed at improving some of the limitations of Green-QFD II. The main changes consist of excluding cost analysis and simplifying the LCA procedures. The quality matrix is divided into four parts, where the voice of customer is related to quality function and to the environmental goals, and the voice of environment is related to quality function and to environmental goals, allowing for the individual analysis of each requirement.

In addition to the integration of LCA into QFDE, Sakao (2007) proposes the integration of the Theory of Inventive Problem Solving (TRIZ) to QFDE. LCA is initially used in early product design when customer and environmental issues and their impacts are determined. This is followed by QFDE phases I and II, when quality product characteristics are defined. TRIZ is applied in the third phase to come up with design solutions. Phases III and IV of QFDE are then applied in product concept evaluation, followed by phase V, which is applied in product detainment. Finally, LCA is applied again to evaluate the proposed environmental improvements.

Wolniak and Sędek (2009) present another version of environmental QFD to list ecological information FOR product and service alternatives. From this list, they identify parameters that are critical from the environmental standpoint. However, Wolniak and Sędek's method does not appear to differ much from the traditional QFD proposal, except for some environmental requirements applicable to either products or services.

Kuo et al. (2009) developed an environmental QFD that uses fuzzy logic to identify and weight the level of importance of customer requirements, including environmental ones. Each required quality is evaluated and transformed into a fuzzy output, a task that is performed by a group of experts. The requirements are related to product specifications (quality characteristics) in the different product life cycle stages, namely: definition of raw material, design and manufacturing, distribution, use and recycling.

Another method was proposed by Utne (2009). According to this author, its main objectives are to improve the performance of fishing fleets and to help manage activities. This is accomplished by considering environmental issues, costs, and stakeholders.

Chen and Liu (2003) developed an eco-innovative design method containing elements of green QFD table and the TRIZ engineering parameters. The method presented by Chen and Liu (2003) intends to provide a support tool in order to develop new products with the least potential environmental impact.

The ECQFD method proposed by Vinodh and Rathod (2010) consists of integrating environmentally conscious QFD and the LCA technique to ensure sustainable product design. The ECQFD involves four phases based on the traditional QFD method, and the integration of a simplified LCA to assess environmental options in product design.

QFD method for ecodesign found in the literature review was proposed by Subramaniyam et al. (2011). This QFD is part of a set of activities aimed at implementing Design for Recycling (DfR) in the company. The method basically consists of a matrix relating environmental, governmental and market demands (VoCs) with environmental and product engineering metrics.

The LCA and Function-Component Matrix+E-QFD, proposed by Devanathan et al. (2010) assesses the environmental impacts of each function of a product. The aim is to determine the environmental impacts of each component and its characteristics, identifying the critical components of a product to be redesigned.

The method proposed by Yu et al. (2015), the QFD with Modularity for the EoL, aims to increase variety, recyclability and reusability of a product family. Eco-modules are obtained from an extended QFD and the eco-modules for the product family are identified using a Design Structure Matrix (DSM) with fuzzy logic. The eco-products family is established by the eco-modules and the Degree of Modular Variety (DMV), which is calculated from QFD.

Bereketli and Genevois (2013) proposed the method QFDE+FAHP to provide a methodology integrated to product development prioritizing economy, quality, environmental issues and obtaining improvements for ecodesign, contributing to a sustainable production.

The method ECQFD, TRIZ and AHP, proposed by Vinodh, Kamala and Jayakrishna (2014) aims to combine and integrate ECQFD, TRIZ and AHP to a design approach towards innovation and sustainable development of products.

Romli et al. (2015) developed the Integrated Eco-design Decision-Making (IEDM) methodology, which comprises three stages: (i) conducting an LCA on the product system; followed by an (ii) eco-design process (Eco-Process) and; an (iii) enhanced eco-design QFD process.

The QFDE+FANP method, proposed by Younesi and Roghanian (2015) integrates QDFE, Fuzzy Dematel and Fuzzy Analytic Network Process (FANP) to a sustainable development of products, assisting companies to identify the best design to specific products.

Proposed by Wood et al. (2016), the House of Quality Green Design (HOQGD) uses end-user's requirements to build a House of Quality relating quality elements with demand quality (at first and second levels).

The EcoCSP-QFD, proposed by Popoffa and Milleta (2017) uses CSP optimization and QFD to generate an optimized model during the early design stages of a product. Weights to the optimization's sub objectives derive from the QFD matrix. For multiple performance optimization, the variables of the model allow creating impact functions (IF) for environmental impacts, costs, etc. for every life cycle phase.