The International Journal of Life Cycle Assessment
https://doi.org/10.1007/s11367-019-01601-1

THE FUTURE OF ECOLABELS

Are the existing EU Ecolabel criteria for furniture products too complex? An analysis of complexity from a material and a supply chain perspective and suggestions for ways ahead

Shane Donatello[1] · Mauro Cordella[1] · Renata Kaps[1] · Malgorzata Kowalska[1] · Oliver Wolf[1]

Received: 24 September 2018 / Accepted: 19 February 2019

Abstract

Purpose One possible reason for the poor uptake of the EU Ecolabel for furniture products may be that the criteria are too complex for applicants. Consequently, it was decided to develop a method which quantifies criteria complexity and subsequently, to propose ways for its reduction, which could be considered in future criteria revision.

Methods The requirements behind the voluntary EU Ecolabel criteria for furniture products set out in Commission Decision (EU) 2016/1332 have been scored with a "criteria complexity index" (CCI), based on the answers to a series of six questions that relate to the effort required for proper assessment and verification. The criteria, and associated CCI values, have been grouped on a per material basis, allowing a "material complexity index" (MCI) to be calculated and consequently, a "furniture complexity index" (FCI) has been calculated as a function of the materials in different furniture products.

Results and discussion Overall, it was found that CCI values can differ depending on the actual supply chain scenario, that textiles and leather had much higher MCI values than all other materials and that the FCI was completely dependent on the materials the furniture product was composed of. FCI values were much lower in general for non-upholstered furniture.

Conclusions The FCI scores can be greatly reduced by the following: (i) using fewer materials in the product; (ii) having shorter supply chains; (iii) using uncoated metals, or at least carrying out coating in-house; (iv) using solid wood instead of wood-based panels; and (v) identifying competent and communicative suppliers who are especially well-informed about chemicals used. Since furniture manufacturers only have limited scope to make these changes, it is more effective to change the way the criteria are structured in future revisions in order to make the criteria more fairly balanced and flexible for potential applicants. Key points about any future restructuring would be to make the chemical requirements more SME friendly and to consider moving away from a rigid pass–fail approach to a more flexible scoring approach.

Keywords Assessment · Complexity · Ecolabel · Furniture · ISO type I · Supply chain · Verification

1 Introduction

Growing consumer concerns about the environment have led to companies adopting management and marketing strategies that increasingly involve environmental claims (Mogele and Tropp 2010; Testa et al. 2011). However, there is an apparent gap between consumer concerns about the environment and their actual purchasing behaviour. For example, 87% of EU citizens believe they could play a part in environmental protection but only 17% actually bought products with an environmental label (Testa et al. 2015).

To close this gap, it is necessary to (i) improve trust and awareness of environmental claims and (ii) increase the number of products available to consumers which carry trustworthy environmental claims. Green advertising can tend to project onto a corporate image rather than the actual product being advertised (Banerjee et al. 1995), and examples of "green spinning" and of marketing compliance with mandatory environmental legislation being touted as green claims

Responsible editor: Fabio Iraldo

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s11367-019-01601-1) contains supplementary material, which is available to authorized users.

✉ Shane Donatello
shane.donatello@ec.europa.eu

[1] European Commission, Joint Research Centre (JRC), Circular Economy and Industrial Leadership Unit, Seville, Spain

Published online: 28 February 2019

are well known (Peattie and Crane 2005). Scepticism caused by greenwashing (Ulusoy and Barretta 2016) can be combatted via the use of third-party certified and standardised (ISO 14024) type I environmental labels. All type I labels respect some core principles relating to transparency, independent verification and the criteria setting processes (e.g. that criteria should target the most important environmental issues). A recent EU survey revealed that 78% of consumers that are aware of the EU Ecolabel trust that EU Ecolabel third-party certified products are environmentally friendly (Eurobarometer 2017).

Consumer awareness of environmental claims varies in different Member States (Eurobarometer 2017), and poor awareness is one of the reasons limiting uptake of products with type I environmental labels (Iraldo and Barberio 2017). This may be due to consumer ignorance, a lack of marketing or the actual lack of products with environmental claims on shelves. This last aspect in particular is the focus of this paper, specifically for furniture products and from the perspectives of both the furniture manufacturer and the criteria developer.

1.1 Background to the EU Ecolabel criteria development for furniture

The EU Ecolabel criteria for furniture were adopted for the first time in the year 2009 (EC 2009). The scope of criteria valid until 2016 was essentially limited to products that were ≥ 90% by weight wood and had resulted in two licenses being awarded (one in Italy and one in Poland). One possible reason for poor uptake was considered to be the very narrow scope. Consequently, the currently valid 2016 criteria (EC 2016) allowed for the use of wood, plastic, metal and glass in any quantities and also included criteria for upholstery materials. However, in the 2 years since the decision was published (until September 2018), no new licenses have yet been awarded.

One of the core principles of type I environmental labels is that criteria should cover the main environmental impacts. In this respect, one possibility is to take a life cycle thinking (LCT) approach in the context of the EU Ecolabel (Cordella and Wolf 2015). During the background research for the EU Ecolabel criteria development, an LCT approach was applied to furniture following a review of 82 pieces of LCA-related literature for furniture (Cordella et al. 2015; Cordella and Hidalgo 2016).

The column data in Fig. 1 show the average magnitudes of impact calculated for five subsystems: production and supply of materials, product manufacturing, distribution, use and maintenance and end of life.

Although assumptions and data can vary significantly between different studies, the columns show that, on average, all five life cycle impacts tend to be dominated by the "upstream" part of the furniture life cycle, i.e. the production and supply of materials, which is controlled by material suppliers. A secondary role is played by product manufacturing and distribution, which can be controlled to some extent by the furniture manufacturer. The use phase impacts (generally included as cleaning and maintenance operations) are insignificant while the end-of-life impacts cannot be controlled by the furniture manufacturer but are only of minor significance. Impacts of both stages are subject to the assumptions made in the respective LCA studies. For example, impacts can vary considerably depending on the assumed duration of use and the choice of functional unit for the product.

Setting environmental criteria on the upstream supply chain sends a market signal to suppliers and is justified due to not only the LCA hotspots, but also best practice and legislative considerations on chemical safety that perhaps cannot be well integrated into LCA analysis (Cordella et al. 2009; EC 2010; Klaschka 2017). Given that most LCA impacts are associated with raw materials, it was considered appropriate to set criteria on a material-by-material basis.

1.2 Furniture sector characteristics

Furniture manufacturing is essentially an assembly process where supplied materials may be machined or coated prior to assembly with specific mechanical components such as screws, hinges, handles and springs.

The EU furniture sector consists of approximately 130,000 companies that employ around 1.1 million people and generate an annual turnover of around 96€ billion. The market is dominated by SMEs, which account for around 70% of total added value (CEPS 2014), and which generally have no significant influence on the supply chain.

Even though there has been a clear market trend towards low-cost, mass-produced furniture in the EU, leading to increases in outsourcing for raw materials and semi-finished parts from lower labour cost countries (eastern Europe or Asia) (CEPS 2014), improved supply chain management seems to be one of the emerging strategies to improve material traceability and justify environmental claims (Frey et al. 2013).

1.3 Main objective

The main objective of this work is to try and understand how difficult it might be for a furniture manufacturer to obtain the required evidence for proof of compliance with the new EU Ecolabel criteria for furniture. In this respect, this paper focuses on the concept of "criteria complexity", how it may be

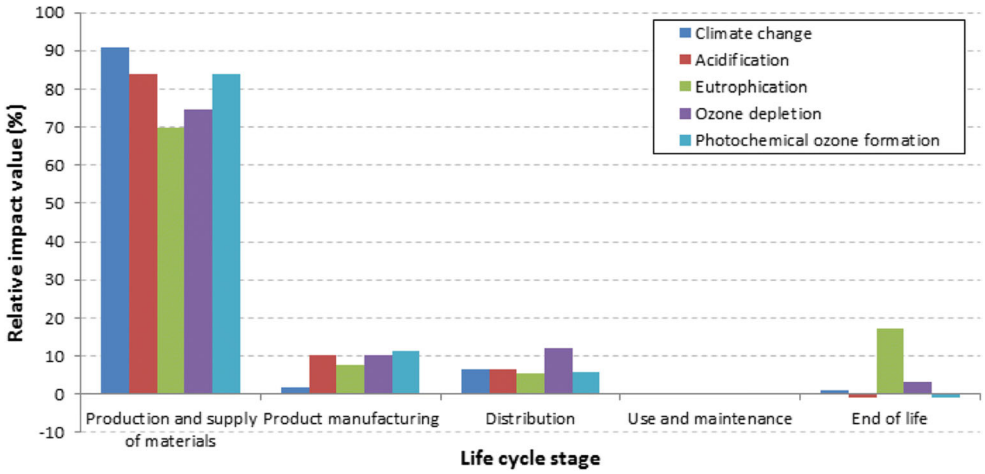

Fig. 1 Average relative impacts calculated for furniture subsystems based on the contribution analysis of selected LCA studies and EPDs. Adapted from data of Cordella and Hidalgo 2016

quantified and how it may be interpreted for different materials, supply chain scenarios and types of EU Ecolabel furniture products. Once quantified, ways to potentially reduce the complexity can be considered.

2 Complexity index: methodology

Before considering the complexity of specific EU Ecolabel criteria for furniture, it is first necessary to consider the overall criteria structure and how many criteria apply to each material that might be used (see Table 1).

When considering complexity for a particular material or product, it is necessary to look beyond the simple "quantity" of criteria and to consider the "quality" aspects too, which could be considered as the total compliance effort required. Consequently, it is necessary to define a method for assessing the degree of complexity, or compliance effort, which might be required for each criterion.

2.1 A scoring system for assessing criterion complexity

For the purposes of this paper, the criterion complexity index (CCI) is defined as:

$$\text{Criterion Complexity Index (CCI)} = A \times B$$

where:

- A is the degree of dependence on the supply chain for demonstrating compliance (ranging from 1 to 7, depending on how dependent the applicant is on suppliers for demonstrating compliance) and
- B is the degree of effort required (time and cost) for suppliers and/or the EU Ecolabel applicant associated with assessment and verification (ranging from 1 to 7).

Scoring of the complexity of EU Ecolabel criteria for furniture was carried out by the authors by answering the associated questions shown in Table 2. Taking solid wood (timber) as an example, four relevant criteria were identified in Table 1, and three different supply chain scenarios were considered (see the top half of Fig. 2). Applying answers to the questions in Table 2 for each relevant criterion and each supply chain scenario, a total of 12 CCI scores were generated for timber in Table 3. Summing the values for the four CCI scores under one of the given supply chain scenarios for a given material will generate what can be called the "material complexity index" (MCI) for that same supply chain scenario:

$$\text{Material Complexity Index (MCI)} = \text{CCI1} + \text{CCI2} + \text{CCI3}$$

The MCI score allows the quantitative aspects of the compliance effort to be captured in the sense that more criteria equate to increased complexity as well. It is interesting to compare different material scores because furniture can be produced with a range of different materials. This analysis permits the authors to conclude if the EU Ecolabel criteria are less complicated for some types of materials and if the differences in verification efforts are justifiable and proportionate.

The main materials covered by the EU Ecolabel criteria for furniture have been analysed. However, for the sake of brevity, only the criteria analysis for wood, plastic and metal is presented in detail. The analysis of leather, textile fabrics, polyurethane foam and glass can be found in the Electronic Supplementary Material (Online Resource 1 2018).

Once the MCI scores for different materials have been compiled, an overall complexity score can be assigned to a particular furniture complexity index (FCI), as a function of the materials the furniture product is made from.

$$\text{Furniture Complexity Index (FCI)} = \text{MCI1} + \text{MCI2}$$

Table 1 Criteria structure for EU Ecolabel criteria

Criterion subject	Solid wood	Wood based panels	Plastic	Metal	Leather	Textile fabrics	Coated fabrics	Latex foam/PU foam	Glass
1. Product description	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2.1. Substances of very high concern (SVHCs)	M	M	M	M	M	M	M	M	M
2.2. CLP restrictions on hazardous substances	M	M	M	M	M	M	M	M	M
3.1. Sustainable wood	M	M							
3.2. Restricted substances in recycled wood and coatings	M	M							
3.3. Formaldehyde emissions from wood-based panels		M							
4.1. Plastic part marking			M						
4.2. Restricted substances in plastic			M						
4.3.Recycled plastic content			M						
5.1. Electroplating restrictions				M					
5.2. Restricted substances in coatings				M					
5.3. Restricted substances in coatings				M					
6.1. Physical durability					M	M	M		
6.2. Chemical residue limits					M	M	M		
6.3. Production stage chemical restrictions					M	M	M		
6.4. Organic/IPM cotton						O			
7.1. Restricted substances and VOC emissions								O	
7.2. Restricted substances and VOC emissions								O	
8. Heavy metal restrictions									M
9.1. Fitness for use	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.2. Extended product guarantee	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.3. Spare parts	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.4. Design for disassembly	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9.5. VOC emissions	O	O		O	M		M		

Cells marked with “M” are mandatory; cells marked with “O” are optional depending on the product specific situation, and cells marked with "n/a" apply at the level of the final assembled product only, independent of the material used

Table 2 Criteria complexity scoring system

Score A: supply chain dependence		Score B: assessment and verification effort (time and cost)	
Aspects	Score	Aspects	Score
1. How far upstream does the applicant need to go?	Tier 0 or 1=1 point; Tier 2=2 points; Tier 3=3 points; Tier ≥4=4 points	1. What is the assessment and verification effort required?	Declarations only=1 point Safety data sheets=2 points In-house testing=3 points External testing=4 points
2. Are there any exceptions when the criteria shall not be applied?	Yes=0 points No=1 point	2. Can it be verified by testing of the supplied material?	Yes=0 points No=1 point
3. Are third-party verified systems necessary? Or commonly used?	Yes, international=0 points Yes, national=1 point No=2 points	3. Testing costs?	≤100 €/test=0 points ≥100 €/test=1 point ≥500 €/test=2 points
Total	Possible range=1–7 points	Total	Possible range=1–7 points

2.2 Walk through of scoring methodology

The following is an example of the scoring approach for "A" of criterion 3.1 of the EU Ecolabel criteria (EC 2016): sustainable wood, cork, bamboo and rattan:

- A1: How far upstream in supply chain? At least two tiers (sawmill and forest operator) but intermediaries likely too, such as merchants and wood-based panel producers (score = 3 or 4 points, depending on the scenario).
- A2: Any exceptions for application of criterion? Yes, when wood content is < 5% of the total furniture weight (score = 0 points).
- A3: Are third-party systems commonly used? Yes, international FSC and PEFC schemes (score = 0 points).

So, the score for A is either 3 or 4 depending on the number of actors in the supply chain. This score would then be multiplied by score "B" to produce a criterion score for a particular supply chain scenario.

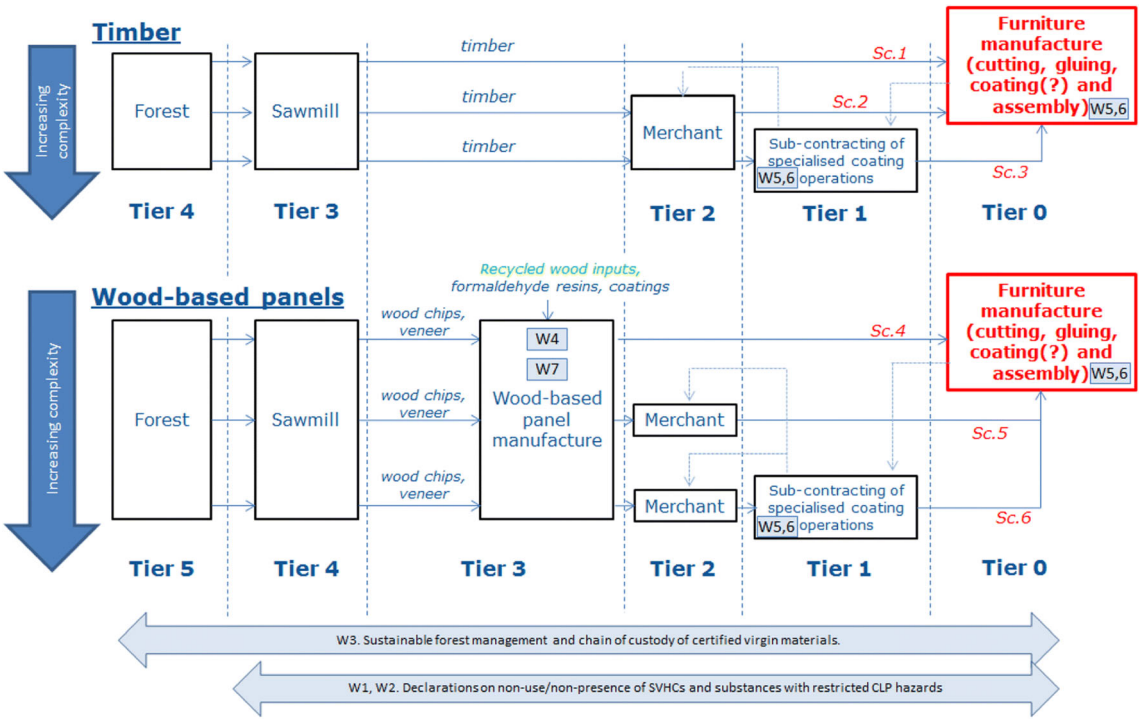

Fig. 2 Wood supply chain for the furniture industry under six different supply chain scenarios, denoted Sc. 1–6. W1–W7 indicates where EU Ecolabel sub-criteria apply. See Table 3 for details of sub-criteria

3 Scoring of EU Ecolabel criteria for materials in furniture

For the sake of brevity, the exact wording of relevant EU Ecolabel criteria (EC 2016) has not been reproduced. Instead, the criteria and sub-criteria have been broken down into abbreviated descriptions of the main requirement(s) for each material. There are also some horizontal criteria on hazardous substance restrictions that apply to all materials. These have also been translated into individual requirements for each material.

3.1 Wood and wood–based panels

3.1.1 Supply chain for wood and wood–based panels

The wood supply chain differs depending on if timber or wood-based panels are procured. Furniture companies tend to take responsibility for any final cutting, machining, gluing and assembling of wooden components. In some cases, the furniture manufacturer will also carry out coating in-house. The supply chain perspective for large companies will differ significantly to that for SMEs.

Six different wood/wood-based panels supply chain scenarios of differing complexity are illustrated in Fig. 2. After the forest and sawmill, supply chains vary by involving intermediary merchants/retailers and the possible sub-contracting of coating operations to specialists (sub-contracting could be requested directly by the furniture manufacturer or by an intermediary).

3.1.2 EU Ecolabel requirements for wood and complexity scoring

There are seven sub-criteria that may apply to wood or wood-based panels used in EU Ecolabel furniture which are briefly described in Table 3 (EC 2016).

The overall complexity score for wood can vary significantly (from 53 to 139 points). Using timber instead of wood-based panels is simpler because there is no need to demonstrate compliance with W4 and W7. The decrease in criteria complexity when the coating operation is carried out by the furniture manufacturer can be seen by comparing the results of scenario 1 (53 to 70) with those of scenarios 2 (65 to 88) and 3 (73 to 102) or by comparing the result of scenario 4 (85 to 102) with scenarios 5 (100 to 123) and 6 (110 to 139). The variation in complexity scores for each scenario is due to the different approaches that are allowed to demonstrate compliance with volatile organic compound (VOC) restrictions in W6.

3.2 Plastics

3.2.1 Plastic supply chain for the furniture industry

The supply chain illustrated in Fig. 3 goes back to the oil refinery. Although the current EU Ecolabel criteria for plastic do not go this far back, it is worth mentioning that if any future criterion on bio-based plastic content were to be introduced, this would require assessment and verification efforts to reach further up the plastics supply chain (to the refinery and to the raw material inputs to that refinery).

The plastic supply chain can be shorter or longer depending on the in-house technical capacity and competency of the furniture manufacturer:

- Scenario 1: shorter supply chain: direct purchase of resin and in-house conversion into plastic furniture (more likely when furniture producer is making 100% plastic furniture, e.g. garden furniture).
- Scenario 2: intermediate supply chain: when the furniture manufacturer sub-contracts the production of specific plastic components according to their own aesthetic and technical requirements.
- Scenario 3: longer supply chain: when furniture manufacturer purchases standard, mass-produced plastic components such as screws and caps from a retailer.

When the supply chain is shorter (e.g. scenario 1), the effort required to assess and verify compliance with criteria is reduced because the EU Ecolabel applicant has full knowledge and control over the recycled content and additives used.

3.2.2 EU Ecolabel requirements for plastic and complexity scoring

The six requirements (P1–P6) for any plastic used in EU Ecolabel furniture are briefly described in Table 4 together with complexity scores for the three scenarios.

P1, P3, P4 and P5 apply to all plastics meanwhile P2 is not intended for components < 25 g when they do not come into contact with users during normal use. This is to avoid a disproportionate assessment and verification effort for small plastic fittings such as screws, caps and hinges. P6 only applies when plastic is a significant contributor to the overall weight of the furniture product (i.e. > 20% *w*/*w*).

The results in Table 4 show that the complexity score for plastic ranged from 48 to 72. The vast majority of compliance control rests in the hands of the plastic converter. Consequently, when the furniture manufacturer is also the plastic converter (i.e. scenario 1), compliance is simpler to demonstrate.

Table 3 EU Ecolabel requirements for wood and wood–based panels with complexity scoring

Criterion	Assessment and verification needed	Complexity score, scenario					
		Timber			Wood-based panels		
		1	2	3	4	5	6
W1. Non-presence of substances of very high concern (SVHC) in component parts and materials >0.10% *w/w*	Applicant declaration plus any relevant supplier declarations	10	12	14	12	14	14
W2. Non-use of adhesives, varnishes, paints, wood-stains, biocidal products, primers, flame retardants, waxes, oils, joint-fillers, sealants, and resins with defined CLP hazards (when wooden component is >25 *g*)	Applicant declaration plus a list of relevant chemicals used and their safety data sheets and/or declarations from chemical suppliers	15	18	21	18	21	21
W3. Use of minimum 70% sustainable virgin and/or recycled material (when wood accounts for >5% of product weight)	Applicant declaration, FSC and/or PEFC Chain of Custody certificate, FSC and/or PEFC product label	16	20	20	20	20	20
W4. Low contamination (with Hg, F, Cl, PCP1 and benzo(a)pyrene) of any recycled wood fibres or chips used in wood-based panels (when recycled fibres or chips are used)	Declaration from wood-based panel supplier supported by test reports according to EPF standard or equivalent	n/a	n/a	n/a	9	12	15
W5. Non-use of paints based on Cd, Pb, Cr(VI), Hg, As or Se (when wood is painted)	Declaration from the paint supplier(s) that the paint formulation does not contain any Cd, Pb, Cr(VI), Hg, As or Se at concentrations exceeding 0.010% *w/w* on an as metal basis.	8	10	12	10	12	14
W6. Limited use of volatile organic compounds (VOCs) in paints, varnishes and primers (when coated components account for >5% of product weight)	Applicant declaration supported by either: (i) SDS of coating formulations showing that VOC content is <5% w/w; (ii) Calculations showing that less than 30 g VOC/m^2 coated area was used; (iii) Calculations showing that less than 60 g VOC/m^2 coated area was used and test reports for coated surface durability according to EN 12720, 12,721, 12,722 and 15,186; (iv) Chamber test results according to ISO 16000 or CEN/TS 16516 that show low VOC emissions from coated components or the entire furniture product	4 to 21	5 to 28	6 to 35	4 to 21	5 to 28	6 to 35
W7. Formaldehyde emissions from wood-based panels (when formaldehyde-based resins are used and panel weight is >5% of the product weight)	Applicant declaration supported by wood-based panel supplier declaration plus test reports according to either EN 717, EN 120, ASTM E1333, ASTM D6007 or JIS A1460	n/a	n/a	n/a	12	16	20
Total		53 to 70	65 to 88	73 to 102	85 to 102	100 to 123	110 to 139

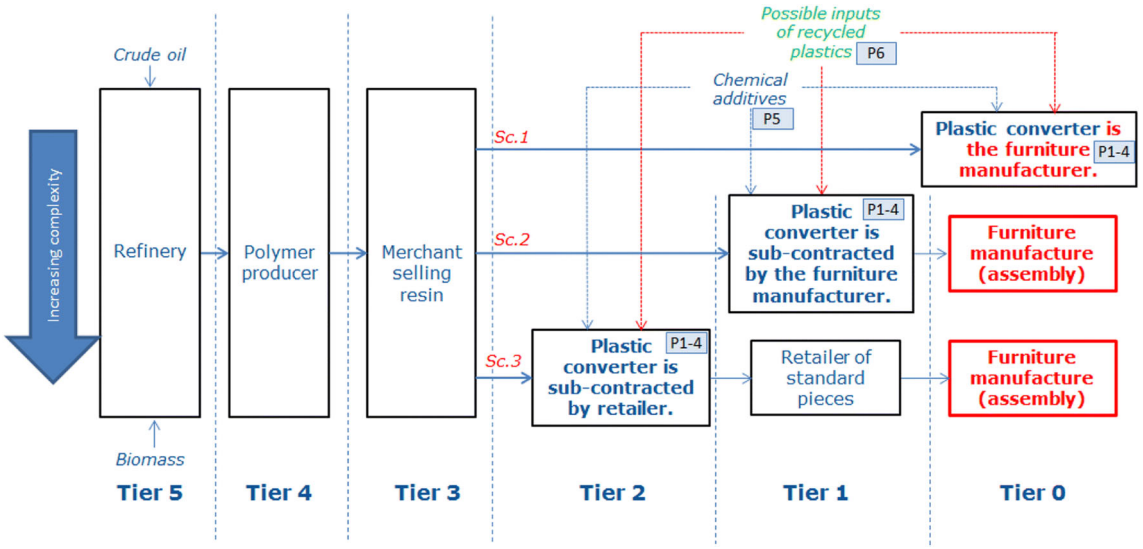

Fig. 3 Plastic supply chain for the furniture industry under three different supply chain scenarios, denoted Sc.1–3. P1–P6 indicates where EU Ecolabel sub-criteria apply. See Table 4 for details of sub-criteria

3.3 Metal components

3.3.1 Steel supply chain for the furniture industry

The supply chain illustrated in Fig. 4 goes back to the steel furnace. If any criteria were to be set for a minimum recycled content of steel, it would be necessary to go back all the way to the furnace and track the relative inputs of steel scrap and virgin materials.

The steel supply chain is simpler when dealing with stainless steel since this material will not normally be coated or electroplated. There are a variety of coating techniques for low-carbon steel such as electroplating (with Ni, Cr or Zn), galvanisation (with a thicker layer of Zn), and transparent coating with a polyurethane polymer or painting of the surface. The coating operations may be carried out prior to mechanical forming and joining of the metal or afterwards or both. Specialist companies may offer services to form, join and coat metal pieces as per the furniture manufacturer's specifications. Alternatively, the furniture manufacturer may carry out some or all of these operations in-house (i.e. coating, forming or joining).

The forming operations will depend on the type of steel that is purchased (e.g. tubular or coiled sheet) and the geometrical and technical properties required for the final piece. Forming operations require the use of skilled labour and specialised equipment and include shearing, blanking, press-baking, bending, folding, roll-forming, deep-drawing and spinning.

Table 4 EU Ecolabel requirements for plastic

Criterion	Assessment and verification needed	Complexity score, scenario		
		1	2	3
P1. Non-presence of SVHCs in component parts and materials >0.10% *w/w*	Applicant declaration plus any relevant supplier declarations	8	10	12
P2. Non-use of pigments, plasticisers, biocidal products and flame retardants with defined CLP hazards (when plastic component is >25 g)	Applicant declaration plus a list of relevant chemicals used and their safety data sheets and/or declarations from chemical suppliers	12	15	18
P3. Non-use of PVC	Declaration from the furniture manufacturer	4	5	6
P4. Marking of plastic parts (if >100 g in weight)	Applicant declaration and visual evidence of markings to be provided. Any non-marking must be justified and information provided elsewhere.	4	4	4
P5. Non-use of Cd-, Cr(VI)-, Pb-, Hg- or Sn-based additives	Applicant declaration plus analytical test reports	8	10	12
P6. Average plastic recycled content of >30% (when furniture product consists of at least 20% by weight)	Applicant declaration plus relevant declarations from plastic supplier(s). Where the applicant produces the plastic, delivery records of plastic recyclate should be provided	12	16	20
Total		48	60	72

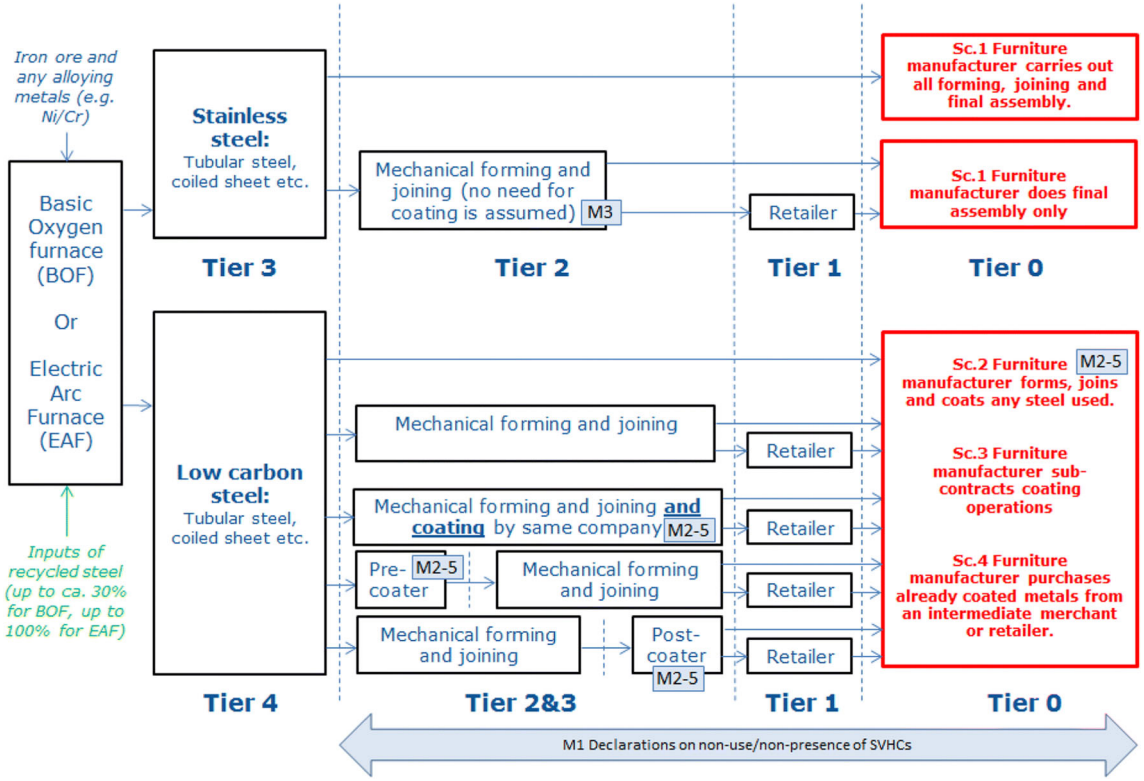

Fig. 4 Steel supply chain for the furniture industry under four different supply chain scenarios, denoted Sc.1–4. M1–M5 indicates where EU Ecolabel sub-criteria apply. See Table 5 for details of sub-criteria

Joining operations may be mechanically based, use adhesives or use welding techniques.

Especially for smaller companies, there is the possibility that pre-formed, pre-joined and/or pre-coated metal pieces are purchased via intermediary retailers or specialist companies.

3.3.2 EU Ecolabel requirements for metal and complexity scoring

The five requirements for any metal used in EU Ecolabel furniture are briefly described in Table 5. The M3 requirement only applies when metal has been electroplated or when stainless steel has been used; M4 only applies when the metal has been painted, and M5 applies when paints, primers or varnishes have been used.

The results in Table 5 show that the complexity score for metal can range from 20 to 104. The very low score of 20 was associated with stainless steel and due to the presumed avoidance of coatings. Scores for coated steels are lower if metals are electroplated (M3) instead of painted (M4+M5).

3.4 Other materials

Material complexity indices (MCIs) were also estimated for leather (186 to 238), textile fabrics (144 to 214), polyurethane foam (47 to 81) and glass (36 to 63). Further details of the scores can be found in the supplementary material. The much higher scores associated with textile fabrics and leather were due to the much higher number of requirements and the fact that vast majority of them cannot be directly verified by the furniture manufacturer via testing of the final material.

4 Discussion

Each material has its own sector-specific issues which may impact upon EU Ecolabel criteria. Aspects such as raw material sourcing (e.g. virgin versus recycled), the degree of familiarity between the furniture sector, and suppliers about criteria and the criteria ambition are discussed below for chemicals in general, and then specifically for wood, plastic and metal.

4.1 Criteria relating to chemicals

4.1.1 Horizontal chemical requirements

Every material used in EU Ecolabel furniture has two common requirements (e.g. W1–2, P1–2 and M1–2), which are based on horizontal hazardous substance restrictions set out in

Table 5 EU Ecolabel requirements for metal and complexity scoring

Criterion	Assessment and verification needed	Complexity score, scenario			
		1	2	3	4
M1. Non-presence of SVHCs in component parts and materials >0.10% *w/w*	Applicant declaration plus any relevant supplier declarations	8	8	10	12
M2. Non-use of paints, primers or varnishes with defined CLP hazards (when metal component is >25 g)	Applicant declaration plus a list of relevant chemicals used and their safety data sheets and/or declarations from chemical suppliers	n/a	12	15	n/a to 18
M3. Non-use of Cr(VI) and Cd in electroplating. Limited use of Ni	Declaration from the supplier of any electroplated components, with test reports according to EN 1811 when Ni is used. Also applies to stainless steel	12	12	16	20
M4. Non-use of paints based on Cd, Pb, Cr(VI), Hg, As or Se	Declaration from the paint supplier(s) that the paint formulation does not contain any Cd, Pb, Cr(VI), Hg, As or Se at concentrations exceeding 0.010% *w/w* on an as metal basis.	n/a	8	10	n/a to 12
M5. Limited use of VOCs in paints, varnishes and primers (when coated components account for >5% of product weight)	Applicant declaration supported by either: (i) SDS of coating formulations showing that VOC content is <5% *w/w*; (ii) Calculations showing that less than 30 g VOC/m^2 coated area was used; (iii) Calculations showing that less than 60 g VOC/m^2 coated area was used and test reports for coated surface durability according to EN 12720, 12,721, 12,722 and 15,186; (iv) Chamber test results according to ISO 16000 or CEN/TS 16516 that show low VOC emissions from coated components or the entire furniture product.	n/a	12 to 28	15 to 35	18 to 42
Total		20	52 to 68	66 to 86	50 to 104

Article 6(6) of the EU Ecolabel Regulation (EC 2010), which states:

> "The EU Ecolabel may not be awarded to goods containing substances or preparations/mixtures meeting the criteria for classification as toxic, hazardous to the environment, carcinogenic, mutagenic or toxic for reproduction (CMR), in accordance with Regulation (EC) No 1272/2008… nor to goods containing substances referred to in Article 57 of Regulation (EC) No 1907/2006."

For practical purposes, the term "containing" is considered to refer to substances present in any individual furniture component or material in concentrations exceeding 0.10% *w/w*. For substances of very high concerns (SVHCs) (see Article 57 of EC 2006), this threshold fits well with the existing communication requirements set out in the REACH Regulation (see Articles 7 and 33 of EC 2006), where suppliers or retailers must inform their customers, within 45 days upon request, about the presence of any SVHCs present in any articles in concentrations exceeding 0.10% by weight and any relevant instructions for safe handling of the supplied goods. The SVHC requirement accounts for 8 to 14 points, equating to 10–40% of the criteria complexity for wood, plastic and metals, depending on the supply chain scenario.

However, the horizontal classification, labelling and packaging (CLP) restrictions (defined in criterion 2.2 of Decision (EU) 2016/1332) are more challenging because there is no similar communication responsibility under REACH for hazardous substances that are not SVHCs but which are restricted by Article 6(6) of the EU Ecolabel Regulation. Consequently, the furniture industry is not familiar with screening and assessment for non-SVHC substances in their products and in supplied materials. In an attempt to simplify the requirement, CLP restrictions were set at the level of the chemical product used (i.e. regardless of whether or not it remains in the final product). However, it could be argued that such an approach goes beyond the requirements of the EU Ecolabel Regulation, which focuses only on hazardous substances "contained" in the product in concentrations exceeding 0.10% *w/w* at the level of the individual component or material. The horizontal requirement on CLP restrictions equates to 12 to 18 points, accounting for 0–28% of the overall complexity of wood, plastic and metals, depending on if a coating was used and on the supply chain scenario. The only exemption is for parts that weigh less than 25 g and do not come into direct contact with users.

4.1.2 Specific chemical requirements

Beyond the horizontal requirements, there are a number of other requirements relating to specific chemicals and

substances. For example, W5–6 for wood, P5 for plastic and M3–5 for metal. Identical requirements are set out for metal and wood-coating chemicals since the purpose of the coating is the same, and similar ranges of coating formulations and technologies are used. The main concern is to restrict the use and/or emission of VOCs, and a flexible approach allows one of four criteria of varying complexity to be complied with.

The simplest option would be to only use low VOC (≤ 5%) coating formulations. The most complex option would be to calculate the quantity of VOCs consumed during the coating operation (expressed as g VOC/m^2 coated area) and, in cases where the value is between 30 and 60 g/m^2, and provide test reports that demonstrate a minimum physical durability of the coated surface. The latter option requires detailed knowledge about the coating operation.

Another option is to submit the coated component(s) to costly chamber testing for VOC emission (up to 5000€/test). Although expensive, this option may already be part of a company's marketing strategy to distinguish itself on the market.

Restrictions on the use or emission of hazardous substances dominate the EU Ecolabel criteria for furniture (6 out of 7 requirements for wood were like this, 3 out of 6 for plastic, 5 out of 5 for metal, 5 out of 5 for glass, 12 out of 13 for leather, 9 out of 11 for textiles and 5 out of 5 for foams).

The adverse impacts associated with the use of hazardous chemicals are not typically well captured by LCA methodology, but are being tackled by numerous legislative and voluntary initiatives (EC 2010; Klaschka 2017; Zachary and Whittaker 2017; Bodar et al. 2018). Moreover, requirements on hazardous substances can potentially be assessed and verified by supply chain actors without the need for special skills or competencies.

4.2 Material specific issues

4.2.1 Wood

The main environmental concern about wood is unsustainable deforestation, considered to account for some 12% of anthropogenic greenhouse gas emissions during 2000–2009 (Smith et al. 2014) and which leads to myriad impacts on biodiversity, soil erosion and freshwater balances (Nepstad et al. 2008). In response to these concerns, two main sustainable forest management schemes (namely Forest Stewardship Council (FSC) and Programme for the Endorsement of Forest Certification (PEFC) have been establish for over 20 years and which are global in their reach. According to FSC and PEFC statistics (FSC 2017; PEFC 2017), and accounting for any double certification (FSC and PEFC 2017), it can be estimated that approximately 62% of Europe's productive forests are certified as being sustainably managed (Eurostat 2016). Recycled wood has obvious environmental benefits, but supplies are variable in both quantity (due to competition from the energy sector) and quality (due to the variety of coatings and treatments that wood may have been subjected to in its previous life). One major benefit of the FSC and PEFC schemes is that they include auditing of the supply chain right through to the final product. Consequently, the entire supply chain and furniture manufacturers are highly familiar with these schemes. By matching the ambition of the EU Ecolabel criteria to the requirements for FSC and PEFC labels, assessment and verification can be as simple as checking that the organisation chain of custody certificate is still valid and that the furniture product label appears in the public database of the relevant scheme. Sustainable wood requirements equate to 16 to 20 points, accounting for 18–30% of criteria complexity for wood, depending on the supply chain scenario. The requirements can be exempted when wood accounts for less than 5% of the product weight.

The other major criteria for wood relates to formaldehyde emissions from panels and contaminants in recycled wood used in panel manufacture. Both formaldehyde and the contaminants can have impacts across the entire life cycle of the product, but especially at the end-of-life, when formaldehyde-based resins may be hydrolysed and broken down into free formaldehyde and when heavy metal contaminants may be leached or volatilised when waste wood is landfilled or incinerated. The EU Ecolabel criteria for formaldehyde and contaminants was set using the same testing methodology as defined for voluntary industry standards recognised by the European Panel Federation (EPF 2002). The EU Ecolabel ambition level goes well beyond the E1 requirement for formaldehyde emissions but simply matches the contaminant thresholds defined by the industry standards. In both cases, panel suppliers should be well aware of the criteria.

The requirements for contaminants (0–15 points or 0–14%) only apply when recycled wood is used, and the requirements for formaldehyde emissions (0–20 points or 0–18% of complexity) can be exempted when these materials account for less than 5% of the product weight or when solid timber is used instead of wood-based panels.

4.2.2 Plastics

Environmental concerns with plastics have recently received much attention. Of particular relevance to furniture are concerns about recycled plastics (Milios et al. 2018) and bio-based plastics (CEN 2011).

Despite much work having already been carried out relating to emissions during production of virgin polymer resins (EC 2007) and the elaboration of eco-profiles for plastics (Plastics Europe 2011; Lithner et al. 2011), there is still further work needed to identify and quantify the importance of potential environmental trade-offs of promoting bio-based plastics versus fossil-based ones (Cordella et al. 2013, 2015; Cordella

and Kaps 2018). Even once these trade-offs are well understood, issues of cost, market availability and proof of biomass-based origin would also need to be considered. For these reasons, bio-plastics were not specifically promoted by the EU Ecolabel for furniture.

With recycled plastics, there are obvious environmental benefits over virgin plastics (whether of fossil or biomass origin). Nonetheless, plastic recycling has the following main challenges:

- Poor economics of recycled plastics (collection, transport and sorting/cleaning) compared to virgin resin materials and competition from energy recovery
- Concerns about technical properties due to impurities in recyclates (e.g. unknown additives)
- Potential aesthetic concerns due to mixed colours

The potential unknown content of hazardous substances, especially in post-consumer plastic (Lithner et al. 2011), may be a concern from the point of view of inherent safety (Cordella et al. 2009) and exposure risk to consumers of the wider environment. Some of the better known concerns are with cadmium-based UV stabilisers, lead-based pigments, DEHP plasticisers and HBCDD flame retardants in certain plastics (RIVM 2016).

Unlike wood materials, there is no international, third-party verified scheme to certify the movement of recycled plastics through the supply chain and allocate them into final product outputs. Neither is there an industry-wide agreement for acceptable levels of contaminants in recycled materials. The closest existing example to these approaches that the authors are aware of is the Belgian Quality Association (BQA-CER), which applies to companies that handle recycled plastics and textiles, certifies recycled content claims, quality assurance and, for higher-level checks, the absence of certain hazardous substances from recyclates.

The EU Ecolabel criteria for hazardous substances in plastics and recycled plastics was related to existing knowledge about test methods and metals of concern already identified under preliminary research for the Toys Directive (RIVM 2008) and a lower ambition level set for recycled plastics, which mirrors the logic of the Cadmium Regulation (EC 2011). In the absence of suitable third-party certified schemes, proof of recycled content must be linked to delivery invoices and mass balances of the production facility that are to be audited by the Competent Body if deemed necessary. The ambition level for recycled plastic is conditional on the actual plastic content of the furniture product. Only if the product is > 20% by weight plastic would a minimum overall recycled content of plastic of 30% be required. In these cases, this criterion would account for 25–28% of complexity.

4.2.3 Metals

The main metals used in furniture are steel (carbon steel or stainless), aluminium and to a lesser extent iron. For brevity, the analysis in this paper focuses on the steel supply chain but the EU Ecolabel criteria apply in the same way, regardless of the actual metal in question.

As with wood and plastics, there are obvious environmental benefits associated with recycled metal, especially recycled aluminium (Hillman et al. 2015). However, unlike wood and plastic, there is no recognition or minimum requirement for recycled metal content. Arguments against a minimum recycled content for metal in EU Ecolabel furniture were:

- that the furniture sector does not exert any influence on primary metal producers,
- that with steel and aluminium being internationally traded commodities and with a lack of chain of custody schemes linking a metal back to its production site, it would not be practical to verify recycled contents.
- that it is common for companies to use sectorial average recycled contents in environmental declarations instead,
- that recycling rates for metals are already high due to the economic value of the waste metal.

Considering the above points, it was argued that setting EU Ecolabel requirements for minimum recycled metal content in furniture (or any other product) would not increase recycling rates any further but instead, at best, would only encourage the shifting of recycled material from one sector to another and increase assessment and verification efforts significantly. However, this may be an undesirable outcome to a furniture producer that has taken efforts to use 100% recycled metal and would like to use the EU Ecolabel as verification of the claim.

4.3 Translating criteria complexity from the material level to the product level

At the level of individual materials, the complexity results presented in Sect. 3 show that, ignoring the exceptionally simple case of aluminium, there is almost a factor of 10 differences in the simplest material (stainless steel, 20 to 104 points) and the most complex (leather, 186 to 238 points). At the level of the furniture product, the complexity increases as more materials are used, especially when the furniture is upholstered, as illustrated in Fig. 5.

The data in Fig. 5 shows how the simplest furniture products made of only one material are the simplest to assess and verify. A data point for uncoated aluminium was also added (score of 10) because it would only be necessary to demonstrate compliance with M1 in such cases. Aluminium does not need to be coated as it is inherently corrosion resistant. A

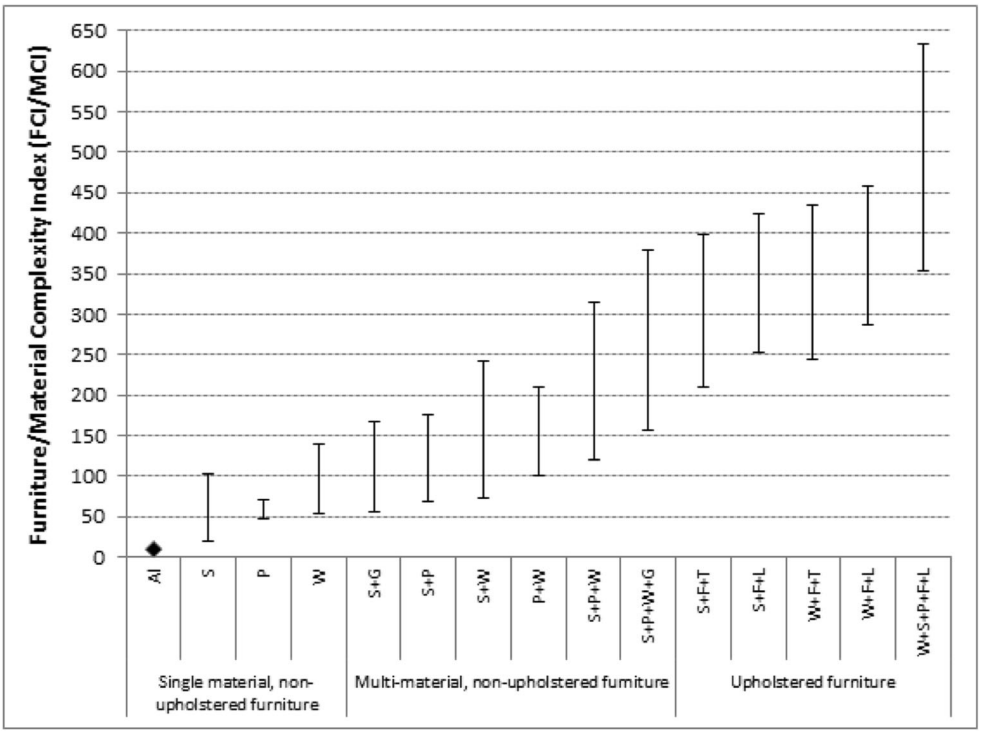

Fig. 5 Influence of material composition on furniture complexity index where Al aluminium, S steel, P plastic, W wood, G glass, F foam, T textiles and L leather

major increase in complexity happens when upholstery material (F+L or F+T) is involved.

4.4 Experience and feedback from industry about EU Ecolabel criteria

Discussions with industry stakeholders revealed that the complexity of the EU Ecolabel criteria was found to be a major disincentive for SME companies to apply. The main stumbling blocks were the highly detailed restrictions on chemicals, which require some expertise and understanding of REACH and CLP Regulations (EC 2006, 2008). Larger companies have an advantage because they may be able to (or need to) hire a REACH or CLP expert due to the large volumes of chemicals they handle.

However, criteria complexity is just one important aspect of whether or not the EU Ecolabel can be successful in the furniture sector. To a certain extent, it could be accepted that criteria become more complex as a product becomes more complex. During the criteria revision process, it was clear that certain larger furniture companies were happy to monitor he criteria development process but with no intention of ever applying for the EU Ecolabel because it simply was not part of their marketing strategy. Other labels also compete with the EU Ecolabel, such as FSC/PEFC, which are inherently simpler but only focuses on wood sourcing, or the FEMB sustainability standard for office furniture (FEMB 2014), which takes a more flexible approach and uses a scoring system for multiple criteria, but does not cover domestic or outdoor furniture. In terms of the EU Ecolabel fitting into marketing strategies, this issue stretches beyond the EU Ecolabel policy tool and would require positive market signals coming from the demand side. The implementation of relevant Green Public Procurement criteria by public authorities and recognition of EU Ecolabel furniture in Green Building Assessment schemes are two highly relevant external influences.

5 Concluding remarks and possible ways ahead

The paper presented an evaluation of the complexity of assessing and verifying compliance with recently published EU Ecolabel criteria for furniture and its relevant materials. The following ranking was yielded (potentially simplest materials first): steel (20–104), glass (36–63), foam (47–81), plastic (48–72), wood (53–139), textile fabrics (144–214) and leather (186–238). The pass–fail nature of the criteria and the very limited scope for exemptions (e.g. < 5% wood to be exempt from sustainable wood requirement, < 25 g and not in direct contact with users to be exempt from CLP restrictions) mean that as more materials are included in a furniture product, the furniture complexity index (FCI) increases by a fixed amount, almost independently of the quantity of that new material added. The existing set of EU Ecolabel criteria (EC 2016), as it is currently structured, can therefore be

considered as a disincentive to producers of more complex furniture products.

Complexity can be reduced by the following: using fewer materials, having shorter supply chains, using uncoated materials (or at least carrying out coating operations in-house), using solid wood instead of wood-based panels and selecting well-informed and communicative suppliers. However, most furniture manufacturers have limited scope to make these adjustments. Instead, it would be much more useful to consider how to reduce the complexity of the EU Ecolabel criteria per se in the future (with the next revision is due to begin in 2020).

Potential ideas that could be applied in the revision to simplify the criteria may include:

- Increasing the mass thresholds under which materials may be exempted from certain requirements (e.g. currently 5% for sustainable wood, 25 g for horizontal CLP restrictions) and/or introducing additional exemptions
- Focussing mainly on upholstery materials in upholstered furniture
- Moving away from a rigid approach to CLP restrictions to industry-best practice restricted substance lists for relevant materials
- Moving away from a pass–fail approach to a flexible scoring approach that is also weighted based on the material composition of the furniture product
- Using furniture product composition and a generic LCI screening tool, to decide on relevant criteria and associated weightings in the context of minimum EU Ecolabel scoring requirements

The work carried out here has shown that the current EU Ecolabel criteria for furniture is a clear case of a comprehensive approach based at the material level leading to a set of criteria that cause a disproportionate increase in complexity for multi-material furniture products. Any revision of EU Ecolabel criteria in the future should seek to simplify the criteria and/or make the routes to demonstrating compliance more flexible. A more flexible approach could allow individual applicants who have taken great effort to achieve specific, but challenging environmental goals (e.g. verified recycled glass, plastic or metal contents) to be proportionately rewarded without making the EU Ecolabel impossible to achieve for other companies that were unable to do this, but which have taken other environmentally beneficial actions. A flexible scoring system based on the individual furniture composition and generic LCIs for defined materials would be the ideal approach since EU Ecolabel criteria could be set that adapt automatically to the (generic) environmental footprint at the individual product level—an important consideration with a product group that is as heterogeneous as furniture.

Compliance with ethical standards

Disclaimer The opinions expressed in this manuscript are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

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