



# HOUSEFUL

## D2.1: Report on end-users requirements and Circular Economy Business Opportunities on residential buildings

***WP , T 2.1***

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LEITAT



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## 0 Abstract

The present report outline the results of a consultation process carried out to stakeholders of the housing value chain with the aim to identify which are the requirements that increase end-users' satisfaction when defining the methodology for evaluating the circularity level of residential buildings.

Circular buildings can be defined as buildings that are designed, constructed/refurbished, used and demolished in a resource efficient way, minimizing the environmental impacts in terms of energy, materials, water and waste produced during the entire building lifecycle. Circular buildings are constructed in an economically feasible way, taking into account also social aspects.



## 1 Methodology for identifying end-user requirements

The Kano model has been used to identify users' requirements for developing the methodology to evaluate the circularity level of buildings. The Kano process is used to determine users' satisfaction with having a functionality in a product or a service. The Kano model (named for the Japanese professor, Dr. Noriaki Kano) is a quality measurement tool used to determine which features/requirements are important (Heidi Maria Rasmussen. Department of Technology and Innovation University of Southern Denmark). All identified requirements may not be of equal importance to all users. Kano analysis can help rank requirements to determine which have the highest priority.

To find a users' perceptions towards the features of the methodology, the Kano survey ask them a pair of questions for each feature considered as a requirement. The question pairs need to be in the format of:

- 1) How would you feel if the feature is present?
- 2) How would you feel if the feature is absent?

The first question is called the positive or functional form and the second one is the negative or dysfunctional form. The questions must not be open-ended. There are very specific options to be used. Kano questionnaire is created based on the questions which are developed according to the model indicated in *Table 1.1*.

|           | Positive dimension  | Negative dimension  |
|-----------|---|---|
| Questions | How do you feel if the feature is present?  | How do you feel if the feature is absent?   |
| Answers   | A. I like it<br>B. I expect it<br>C. I am neutral<br>D. I can live with it<br>E. I dislike it | A. I like it<br>B. I expect it<br>C. I am neutral<br>F. I can live with it<br>D. I dislike it |

*Table 1.1: Questions and answers in Kano questionnaire.*

The Kano model encompasses six categories (Mandatory, Linear, Exciter, Questionable, Reverse and Indifferent) which are used to assess the customer satisfaction for each of the requirements/features defined:

- *Mandatory (M)*: these are the requirements which are expected by the users. If the methodology does not have them, dissatisfaction can be produced. This type of feature is also called "Must" or "Basic". These are expected features but they cannot increase satisfaction.
- *Linear (L)*: some requirements behave as how we might intuitively think that satisfaction works. The more is provided, the more satisfied the users become.
- *Exciter (E)*: there are unexpected requirements which when presented cause a positive reaction to users. If the requirement is absent, it does not cause



dissatisfaction, but it will delight clients if present. These are usually called Attractive or Delighters.

- *Questionable (Q)*: occurs when the user on the one hand shows satisfaction with one particular feature/requirement, yet, on the other hand, he/she is not sure of this and shows dissatisfaction. When responses are such as “I like it” and “I like it” to both questions, then you have a questionable answer. Some of these are to be expected to the results, but if there is a majority of users with Questionable answers, there is probably something wrong with what is being asked.
- *Reverse (R)*: the requirement causes dissatisfaction. If someone dislikes the functional form and likes the dysfunctional form, this user is clearly not interested in the feature offered, and perhaps actually wants the opposite.
- *Indifferent (I)*: when the user finds the feature does not make a real difference in users’ reaction towards the service.

Once the surveys are fulfilled, the answers to each functional-dysfunctional question pair are cross-referenced using the Kano matrix (*Table 1.2*), and the perceptions are thus evaluated into the six previously described categories (M, L, E, Q, R and I).

|                                  |           | Dysfunctional (requirement absent) |           |         |           |         |
|----------------------------------|-----------|------------------------------------|-----------|---------|-----------|---------|
|                                  |           | Like it                            | Expect it | Neutral | Live with | Dislike |
| Functional (requirement present) | Like it   | Q                                  | E         | E       | E         | L       |
|                                  | Expect it | R                                  | I         | I       | I         | M       |
|                                  | Neutral   | R                                  | I         | I       | I         | M       |
|                                  | Live with | R                                  | I         | I       | I         | M       |
|                                  | Dislike   | R                                  | R         | R       | R         | Q       |

Table 1.2: Kano evaluation matrix. (Source: adapted from Kano et.al, 1984).



## 2 Questionnaire for collecting end-users' requirements

With the method outlined in Chapter 1, an online Kano questionnaire was devised with a view to identify individual requirements to be taken into account when developing the methodology for evaluating the circularity level of residential buildings. The questionnaire was created with a specific online software tool<sup>1</sup> which is used for developing Kano surveys.

The survey was composed by 10 questions/requirements which were answered in two dimensions: the positive one - when a given requirement/feature is present and fulfills its task correctly and the negative dimension - when a specific requirement/feature does not exist or if it does, it is not in a satisfactory way. The questions included in the questionnaire were the following:

### Question 1 of 10

the methodology combine Key Performance Indicators (KPIs) related to energy, water, waste and materials aspects, and use weighting factors to calculate the circularity level of buildings

How do you feel if this feature is PRESENT?

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

How do you feel if this feature is ABSENT?

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

### Question 2 of 10

the methodology for evaluating buildings' circularity provides the possibility to carry out different levels of assessment: from a basic assessment based on few simple data and key KPIs to a more accurate and advanced assessment

How do you feel if this feature is PRESENT?

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

How do you feel if this feature is ABSENT?

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

<sup>1</sup> <http://www.kanosurvey.com/>



### Question 3 of 10

the methodology considers the use of Life Cycle Assessment (LCA) indicators (e.g. Global Warming Potential, ozone depletion, etc) to assess the environmental performance of buildings in the different life cycle stages (planning, design, construction, operation and deconstruction)

**How do you feel if this feature is PRESENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

**How do you feel if this feature is ABSENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

### Question 4 of 10

the methodology takes into account inputs obtained from innovative approaches such as Material Passport and Building Information Modelling (BIM)

**How do you feel if this feature is PRESENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

**How do you feel if this feature is ABSENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

### Question 5 of 10

the methodology includes not only technical KPIs, but also economic indicators

**How do you feel if this feature is PRESENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

**How do you feel if this feature is ABSENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

### Question 6 of 10

the methodology to assess the circularity level of buildings includes not only technical KPIs, but also social indicators

**How do you feel if this feature is PRESENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

**How do you feel if this feature is ABSENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way



### Question 7 of 10

the methodology to evaluate the circularity level of the residential buildings refurbishment always includes the deconstruction stage (end of life of the adopted solution)

**How do you feel if this feature is PRESENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

**How do you feel if this feature is ABSENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

### Question 8 of 10

the methodology to evaluate the circularity level of residential buildings refurbishment always includes the maintenance stage

**How do you feel if this feature is PRESENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

**How do you feel if this feature is ABSENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

### Question 9 of 10

the methodology allows to benchmark the circularity level of different residential buildings introduced by the user, including buildings located in different regions

**How do you feel if this feature is PRESENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

**How do you feel if this feature is ABSENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

### Question 10 of 10

the methodology takes into account country (or region) specific habits in terms of use of resources (water, energy and materials), generation of waste and recycling to evaluate the circularity for a building in a specific country

**How do you feel if this feature is PRESENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way

**How do you feel if this feature is ABSENT?**

- I like it this way
- I expect it this way
- I am neutral
- I can live with it this way
- I dislike it this way



The questionnaire was produced in English and translated into Spanish and German.

The survey was aimed to architects, engineers, construction companies, building owners, housing agencies, sustainability experts, and any stakeholder belonging to the housing value chain interested in using the methodology for evaluating the circularity of residential buildings. The survey was send to HOUSEFUL partners' contacts and was posted in some relevant websites (e.g. [Construction21](#), [Cordis](#), [ECTP](#), [HOUSEFUL](#)) and in LinkedIn.

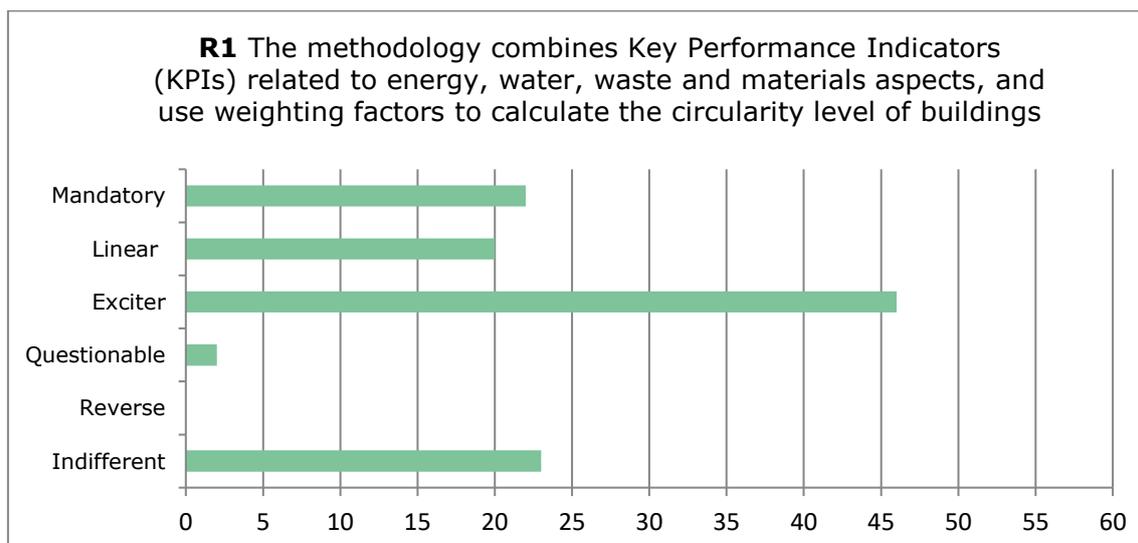


### 3 Results evaluation

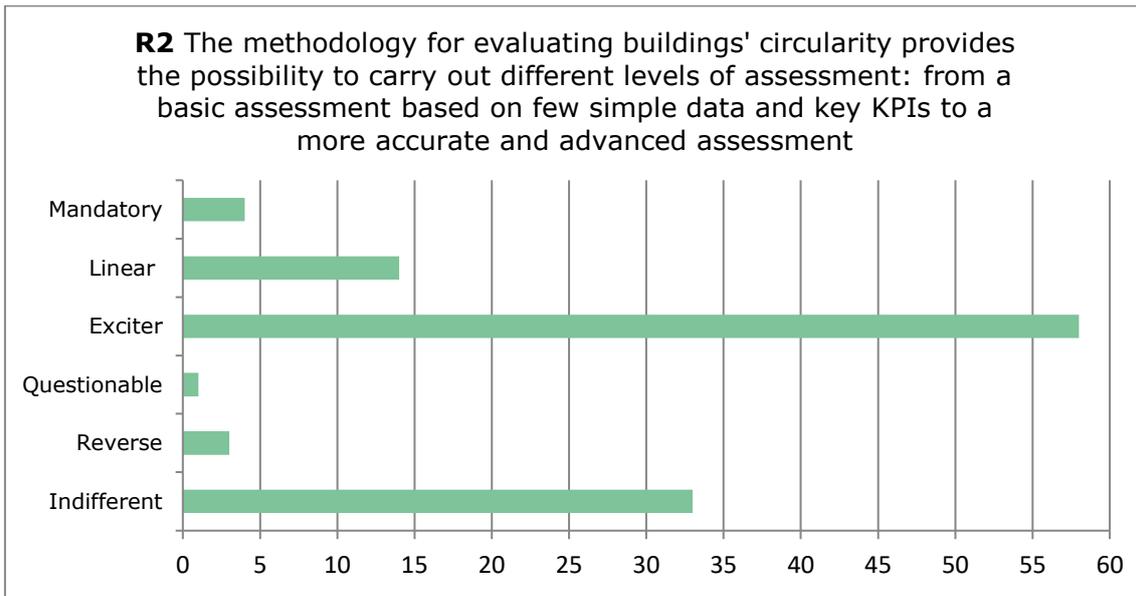
In total 113 stakeholders answered the survey. In this chapter, the results of the 10 questions/requirements raised are presented and analyzed.

#### 3.1 Kano results evaluation

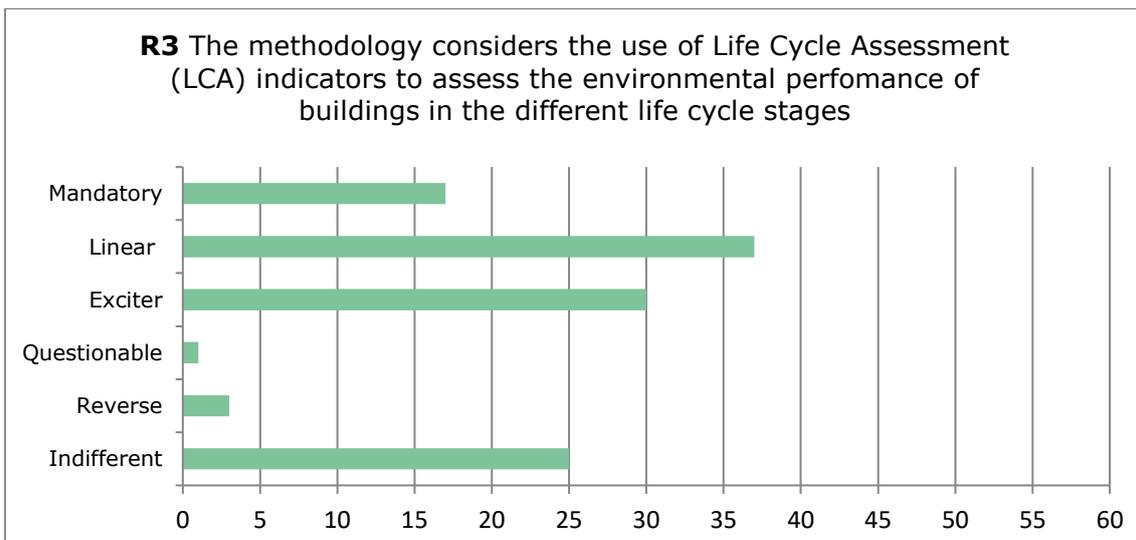
The first phase consists in analyzing the data collected from the surveys by using the Kano method, which is based on evaluating and classifying each requirement in the six categories according to absolute frequencies.



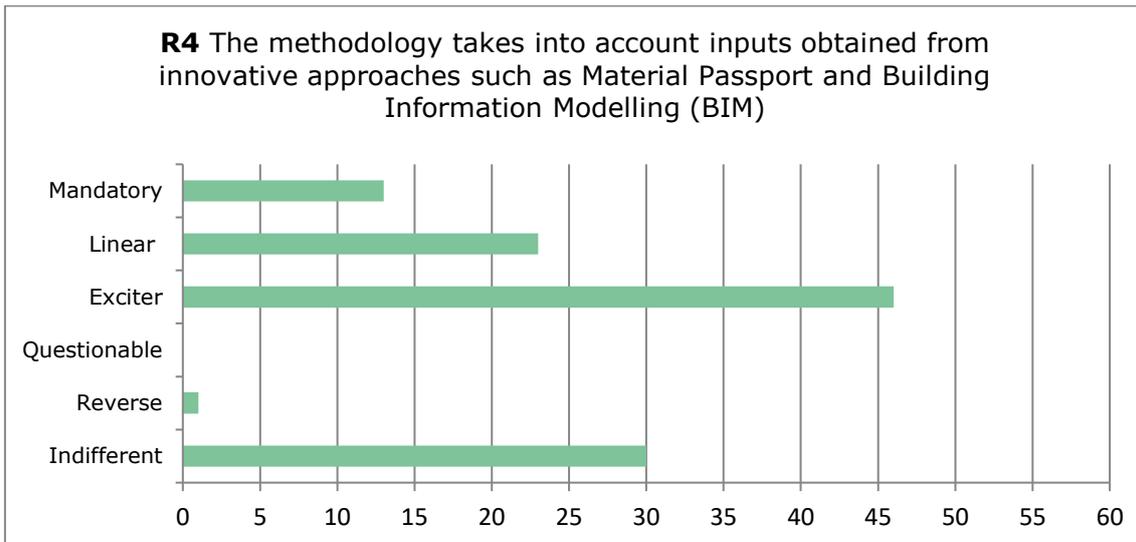
The first requirement (R1) included in the questionnaire was that the methodology would use KPIs related to different environmental aspects such as energy, water, waste and materials to determine the circularity level of buildings. After applying the Kano evaluation matrix, it is possible to determine that most of the respondents (46) consider this feature as an exciter requirement.



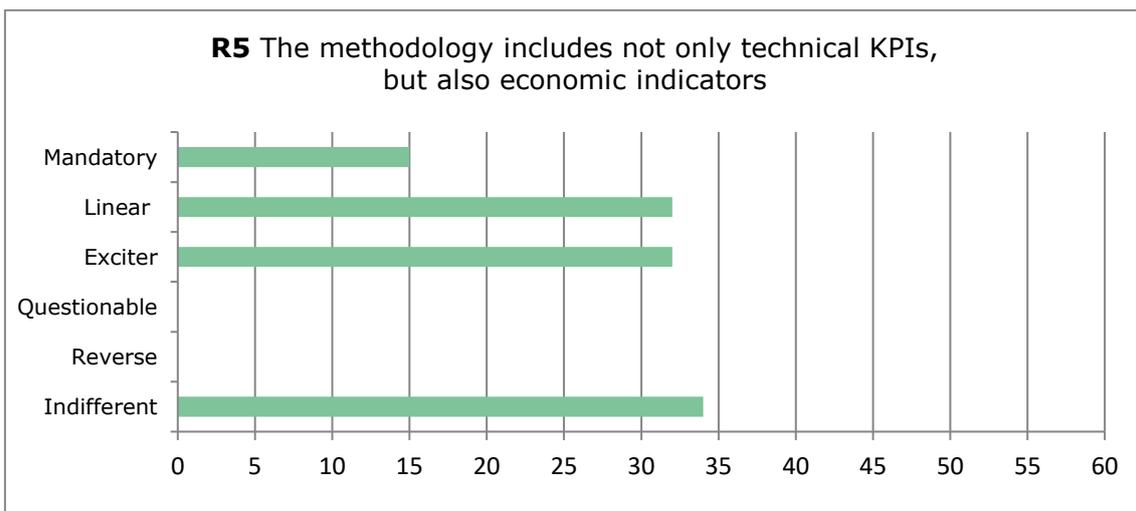
The second requirement (R2) indicated the possibility to carry out different levels of assessment -from basic assessments to more accurate and advanced assessments- when evaluating buildings' circularity. This requirement caused a positive reaction in most of the respondents, classifying this feature under the category *Exciter*.



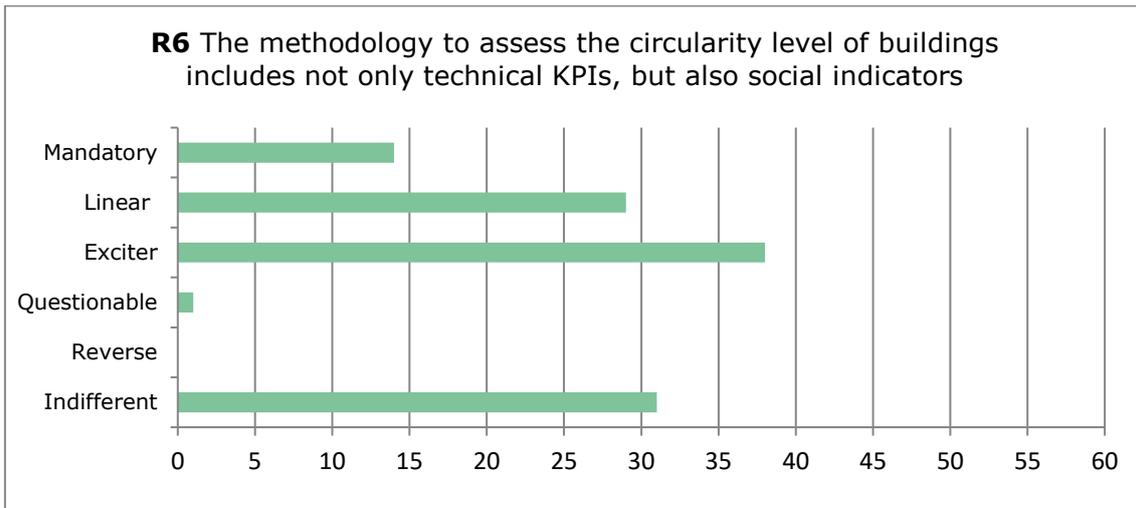
Requirement 3 (R3) proposed to consider LCA indicators such as Global Warming Potential, ozone depletion, etc to assess the environmental performance in the different life cycle stages of buildings. The category with a highest frequency of answers is Linear, which means that the satisfaction level of the customer is increased when the requirement is met, whereas satisfaction is decreased when the requirement is unmet.



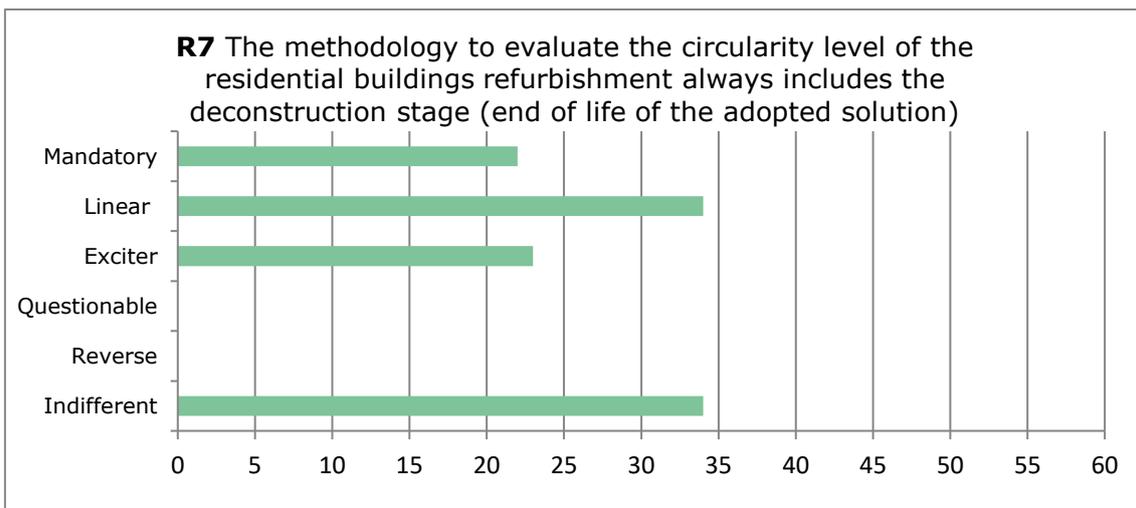
Requirement 4 (R4) considers to use data obtained from Material Passport and Building Information Modelling (BIM) when determining the circularity level of buildings. Exciter is the category with a highest frequency, causing a positive reaction when this requirement is present.



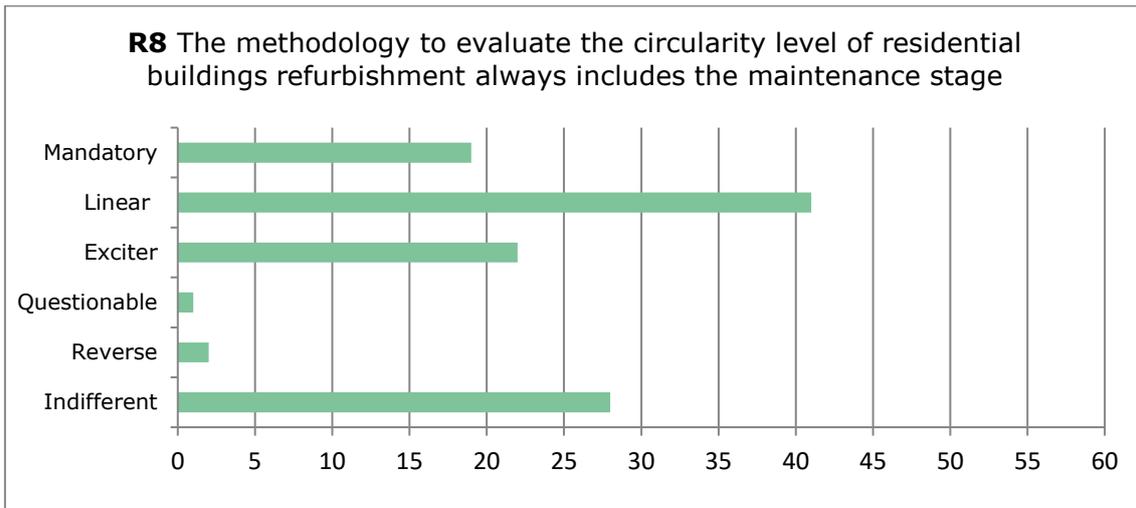
Requirement 5 (R5) raises the issue to include in the methodology not only technical KPIs related to energy, water, waste and materials, but also economic indicators. Similar results are obtained among the categories Indifferent, Linear and Exciter.



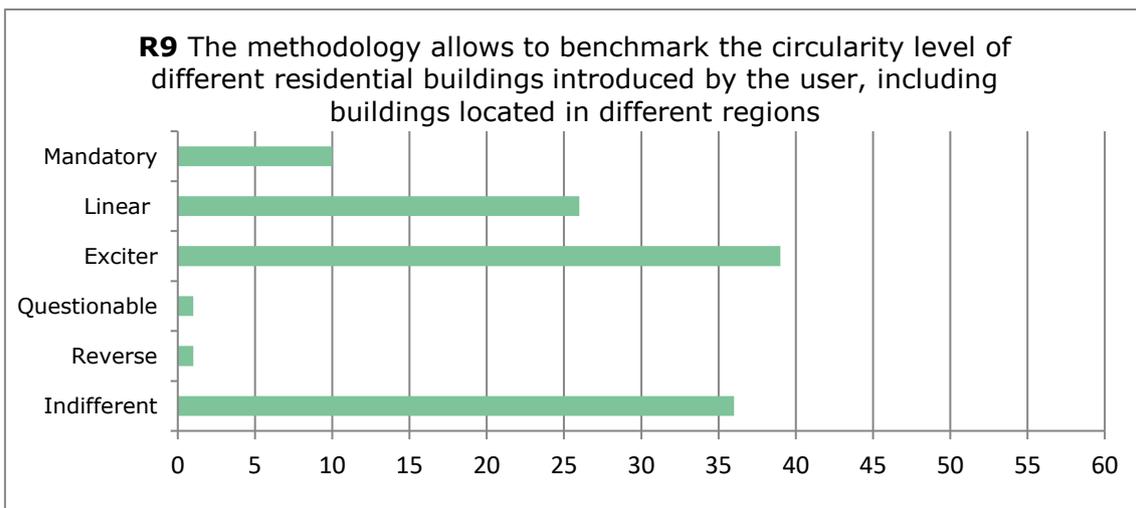
Requirement 6 (R6) proposes to consider not only technical KPIs, but also social indicators such as thermal comfort, air quality, adaptability, *housing for all*, etc. This requirement classified as Exciter increases users' satisfaction when it is present.



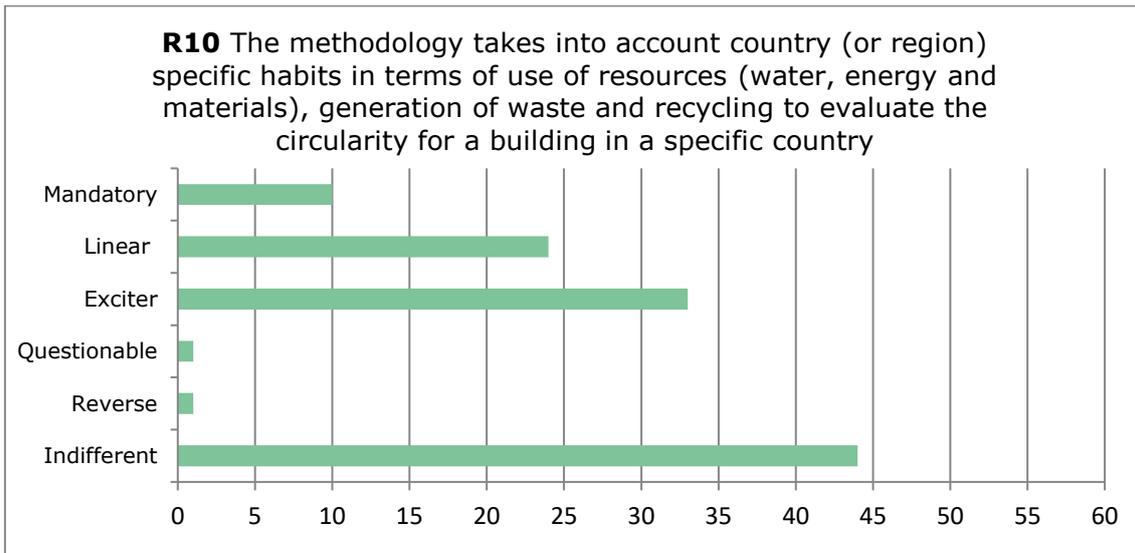
Requirement 7 (R7) considers to take into account the deconstruction stage in the development of the methodology for evaluating the circularity of buildings. The results show that both categories *Linear* and *Indifferent* have the same frequency of answers. However, it is important also to take into account the impact of mandatory and exciter categories in user satisfaction, which have also significant values for this requirement. To do that, it has been calculated the coefficient of satisfaction (explained later).



Requirement 8 (R8) proposes to consider the environmental footprint in the maintenance phase of buildings when evaluating the circularity. The category most voted is *Linear*, meaning that the presence of this feature would increase the satisfaction of users.



Requirement 9 (R9) deals with including a functionality to compare the circularity level of different typologies of residential buildings, including those located in different climatic regions. Most of the respondents are delighted to include this requirement.



Requirement 10 (R10) proposes to weight the impact of different indicators depending on the region and habits of use of resources, generation of waste and recycling rates to evaluate buildings' circularity. Most of the respondents do not care whether this requirement is present or not.

### 3.2 Refinement of the Kano results

Due to some Kano model limitations were detected in the evaluation phase presented in subchapter 3.1 (e.g. each requirement is classified in a category based only on the frequency of answers), in this subchapter the Satisfaction Coefficient (CS) for each requirement according to Berger et al. (1993) is calculated with the aim to take into account the views expressed by different respondents (Huang, 2017). The CS provides the average impact of a requirement on the satisfaction of all respondents. The CS explains whether satisfaction can be increased by meeting the requirements or whether meeting the requirements just hinders the users from being satisfied. It gives an indication of how strongly a feature may impact on user satisfaction or on the other hand, how strongly the non-fulfillment of a feature may influence user dissatisfaction. The coefficient of satisfaction (CS) is calculated as follow:

$$SI = (E+L)/(E+L+M+I)$$

$$DI = (M+L)/(E+L+M+I)$$

where SI is the Satisfaction Index, DI is the Dissatisfaction Index, E is Exciter, L is Linear, M is Mandatory and I is Indifferent.

Table 3.1 reveals the extent of users' satisfaction and dissatisfaction with regards when the requirements are met and unmet respectively.

| Requirement | Frequency of answers classified in Kano categories |    |    |   |   |    | Total answers | Coefficient of satisfaction |      |
|-------------|--|----|----|---|---|----|---------------|-----------------------------|------|
|             | M  | L  | E  | Q | R | I  |               | SI                          | DI   |
| R1          | 22   | 20 | 46 | 2 | 0 | 23 | <b>113</b>    | 0,59                        | 0,38 |
| R2          | 4  | 14 | 58 | 1 | 3 | 33 | <b>113</b>    | 0,66                        | 0,17 |
| R3          | 17   | 37 | 30 | 1 | 3 | 25 | <b>113</b>    | 0,61                        | 0,50 |
| R4          | 13   | 23 | 46 | 0 | 1 | 30 | <b>113</b>    | 0,62                        | 0,32 |
| R5          | 15   | 32 | 32 | 0 | 0 | 34 | <b>113</b>    | 0,57                        | 0,42 |
| R6          | 14   | 29 | 38 | 1 | 0 | 31 | <b>113</b>    | 0,60                        | 0,38 |
| R7          | 22   | 34 | 23 | 0 | 0 | 34 | <b>113</b>    | 0,50                        | 0,50 |
| R8          | 19   | 41 | 22 | 1 | 2 | 28 | <b>113</b>    | 0,57                        | 0,55 |
| R9          | 10   | 26 | 39 | 1 | 1 | 36 | <b>113</b>    | 0,59                        | 0,32 |
| R10         | 10   | 24 | 33 | 1 | 1 | 44 | <b>113</b>    | 0,51                        | 0,31 |

Table 3.1: Results of Kano’s analysis broken down by requirements.

Creating Coordinate System (see Figure 3.1) in which, X-coordinate is for SI and Y-coordinate is for DI, help to figure out the importance of the requirements. Figure 3.1 shows the categorization of each requirement. The requirements in first quadrant stand for Linear requirements, the requirements in second quadrant stand for Mandatory requirements, the requirements in third quadrant stand for indifference requirements; and those in fourth quadrant stand for Exciter requirements.

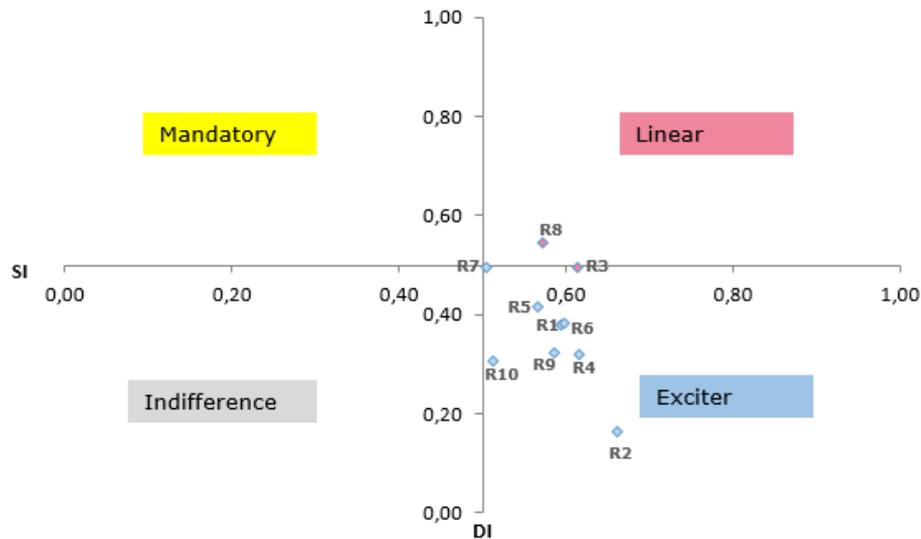


Figure 3.1: Coordinate system with the classification of the requirements evaluated.

The analysis done of the coordinate system shown in Figure 3.1 shows that most of the requirements (R1, R2, R4, R5, R6, R7, R9 and R10) are seen as exciter requirements and would enhance the user degree of satisfaction. Two requirements (R3 and R8) are classified as linear requirements, meaning that the satisfaction level is increased when the requirement is met, whereas satisfaction is decreased when the requirement is unmet. According to the analysis done, none of the requirements are considered indifferent. However, this information should be analyzed carefully since these requirements are located in the coordinate system close to other categories and it is possible that categorization could change with a higher sample of respondents.

## 4 Conclusions

This report examines which requirements should be taken into account with regard to the methodology to be developed in HOUSEFUL project for evaluating the circularity level of residential buildings. A consultation process with stakeholders of the housing value chain was conducted in order to determine which of the initial 10 requirements proposed should be considered in the methodology in order to arouse the greatest possible users' interest. To do that, the Kano method in combination with the coefficient of satisfaction has been used as a quality tool to prioritize a preliminary list of requirements to be taken into account when developing the methodology. The requirements have been classified in four different categories: Mandatory (M), Linear (L), Exciter (E) and Indifferent (I).

The results based on 113 answers received reveal that:

- there are two lineal requirements (R3 and R8), which indicates that these features are quality enhancer and they can proportionately increase the satisfaction of users when incorporated into the methodology, and their absence would greatly dissatisfy users. R3) considers LCA indicators to assess the environmental performance in the life cycle stages of buildings; and R8) considers the maintenance phase of buildings a relevant stage when assessing the circularity level.
- eight of the ten requirements are classified as *Exciter*, which shows that though its absence in the future service may not cause dissatisfaction, its presence on the other hand will delight users: R1) the methodology to evaluate buildings' circularity should combine KPIs covering different environmental aspects such as energy, water, waste and materials; R2) offers the possibility to assess the circularity at different levels, from a basic assessment to more accurate and advanced assessments; R4) refers in using data from Material Passport and BIM when determining the circularity level of buildings; R5) proposes including not only technical KPIs related to energy, water, waste and materials, but also economic indicators; R6) deals with incorporating not only technical indicators but also social indicators in the methodology; R7) should consider the impacts associated to the deconstruction stage of buildings; R9) provides the possibility to benchmark the circularity level of residential buildings, including those located in different climatic regions; and R10) proposes to weight the impact of different indicators depending on the region and habits of use of resources, generation of waste and recycling rates to assess the circularity level.
- None of the requirements are classified as *Mandatory* or *Indifferent*.

A strategy to prioritize the requirements to be considered consists in applying the rule "M > L > E > I" (Emmanuel O.C. Mkpojiogu, 2016). Therefore, linear requirements should be considered to increase users' satisfaction and to differentiate from other should the exciter requirements be fulfilled. *Figure 4.1* shows the requirements to be prioritized according to the results obtained.





*Figure 4.1: Prioritization of requirements.*

The study is however limited in the sense that the sample size was small and the online Kano tool employed does not allow knowing the characteristics of respondents (e.g. type of stakeholder, age, etc). The results of the survey do not represent the perceptions of all housing value chain, but provide first insights of the requirements to be considered when elaborating the methodology to evaluate buildings' circularity.

## 5 References

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