Effectiveness of energy flexibility tools in respect to user engagement and increasing energy literacy

Deliverable D2.3

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[1] PU = Public
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RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

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Executive Summary

This document describes the results of the testing of a prototype mobile application that provides interface functionalities designed within the ebalance-plus project. The active participation of end-users is crucial to some of the functionalities and to achieving the full potential of the ebalance-plus flexibility release.

The application was designed based on the findings of deliverable D2.2: *Methodology for user engagement in energy literacy and flexibility*. In addition to providing an interface for various ebalance-plus functionalities, the application also aims to increase end-users' engagement and energy literacy, and to motivate end-users to use the solutions developed and tested within the ebalance-plus project. This includes increasing the flexibility of electricity demand and enabling automatic control of smart appliances.

The application was prepared in two graphic versions. Although their functionality was identical, the versions differed in the colours of their backgrounds and the symbols they presented to users. The standard version was predominantly blue and the eco version green. The eco version also included symbols associated with nature and ecology.

The study indicates that both versions of the prototype application were warmly received by potential users in Italy, France, Spain, and Denmark; it was perceived by the majority of respondents in each country as: 'useful', 'interesting', 'motivating to save energy', 'stylish', 'comprehensible', 'informative', 'motivating to automatically control energy consumption at home', 'motivating to shift electricity use from peak to off-peak hours', 'reliable', and 'encouraging'. This suggests that the application has high potential to be adopted and used by a wider audience in the future.

The survey indicated compelling differences between the eco and standard versions in different countries: the eco version performed better than the standard version in Italy and Denmark and slightly better in Spain. This suggests that by triggering associations with ecology, nature has the potential to pave the way for energy saving and active involvement in the functionalities of ebalance-plus. Only in France did the standard version achieve better results than the eco version. A detailed analysis of the reasons for these differences is beyond the scope of this study; one might speculate, however, that it is related to the social perception of additional taxes aimed at reducing fossil fuel consumption in France, which were associated with the so-called 'yellow vest' protests.

The study also demonstrated that the eco version worked better among individuals who are motivated to save energy for: 1) ecological reasons; 2) the need to control their spending; and 3) the need for rational resource management. A slight advantage of the standard version was revealed among individuals whose main motivation to save energy was financial. Considering that evaluation of the financial benefits of ebalance-plus is highly individual and that purely financial motivations can occasionally have the opposite effect ('I pay the agreed price so there is no problem'), the eco version appears to hold an advantage over the standard one. It should be expected that the eco version will encourage altruistic thinking: social thinking that benefits not only the individual, but also the environment and the biosphere.

Users in all surveyed countries were receptive to messages and notifications that contained energy literacy information. Those messages that included graphical elements were rated slightly higher. The form of the graphic addition was less relevant:

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ecological symbols, technological symbols, mascots, and diagrams that illustrated the notification all demonstrated similar effects.

Acknowledgements

The OPI PIB team wishes to thank its collaborators at *Reengen Enerji Teknolojileri Anonim Sikreti* for their cooperation in developing the energy management mobile application that was tested in the study described in this document.

The authors also wish to thank Karina Maszewska of OPI PIB for preparing the graphics for the testing of the energy management information.

Disclaimer

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Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°864283

Table of figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°864283

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1 Introduction

This document presents the results of our study of a prototype mobile application for the management of electricity use by residential consumers. This step in mobile application development is done to engage potential users at the design stage of the application, to better match it to their needs, and to identify areas for improvement. The prototype application incorporates functionalities that cover four key areas:

a. electricity consumption at home
b. energy consumption flexibility
c. electric car charging management
d. information on electricity consumption.

The purpose of the study was to offer guidance to the designers to better meet the intended objectives of the application. These objectives include:

a. encouraging users to save energy
b. unlocking flexibility in electricity demand
c. increasing users' knowledge of electricity**.**

We sought to discover how useful, valuable, and convenient such an application is from the users' perspective.

The following sections present the methodology of the study and details of the prototype application. We then present the results of the study, along with suggestions for the next steps of the design process. Graphic materials used in the study and supplemental detailed results are included in Appendix 9.

2 Methodology and sample

2.1 Design of the application prototype

The prototype application was prepared based on the methodology described in deliverable D2.2. in cooperation with the ebalance-plus consortium partner, *Reengen Enerji Teknolojileri Anonim Sirketi*.

2.2 Methodology of the research

In December 2021, we conducted a survey using quantitative, computer-assisted web interviews (CAWIs) in the four countries where ebalance-plus pilot sites are located: France, Spain, Italy, and Denmark.

The survey lasted approximately 20–25 minutes and comprised the following sections:

Respondent profile:
Demographic data, which comprised information about respondents, such as their gender, age, number of household occupants, size of residence, education level, occupational statuse, and income.

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A household section that covered information on the property respondents occupied and their electrical appliances, including those for generating and storing energy. This section included information on the types of property and their ownership, and on the respondents' cars
An electricity and attitudes section that covered respondents' attitudes towards energy conservation and knowledge of concepts such as electric grid load, time-of-use tariffs, and electricity demand elasticity.

Mobile Application:
We divided the section in which the application was evaluated into three parts:

Overall evaluation was based on self-reviews of the interactive version of the application. Respondents, who were given a link to the interactive version, explored it independently and rated it in twelve dimensions:

- interesting
- comprehensible
- reliable
- useful
- tells me something new
- overwhelming
- discouraging
- stylish
- I would like to use this application
- motivates me to save energy
- motivates me to shift some of electricity use from peak to off-peak hours
- motivates me to automatically control energy consumption at home.

Detailed evaluation, in which respondents evaluated selected parts of the application in twelve dimensions and marked which elements visible on the screen they liked or disliked. In this part, they evaluated:

- details of energy consumption and temperature settings
- charging of electric cars
- managing the flexibility of electricity demand.

Energy Literacy, in which respondents evaluated five descriptions of how the energy market works. These messages aimed at building energy literacy were evaluated in a way that assesses both the message's content and the potential impact of the context on its reception. Each statement was presented in one of five graphical contexts:

- V1. text only
- V2. with an image that supplements the text
- V3. with an image of a tree
- V4. with an image of renewable energy sources
- V5. with an image of the application mascot (a bee).

The energy literacy messages and graphics are presented in Appendix 9.2 and 9.3.

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2.3 Sample

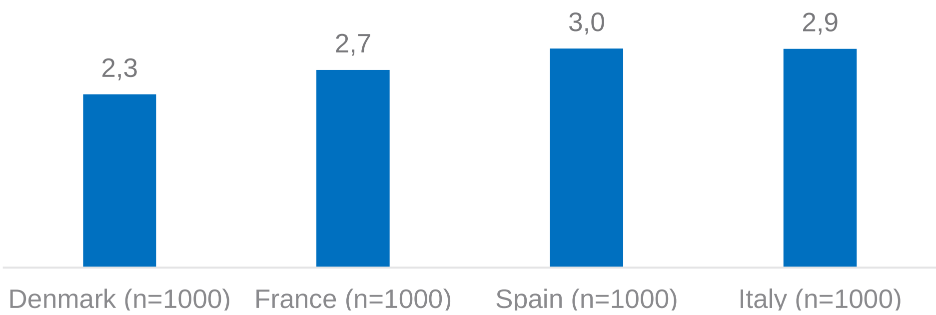
The study sample consisted of adults (median age: 43 years) who use smartphones and are responsible for paying their electricity bills or for purchasing electrical appliances in their households. The total sample size was 4,000 (1,000 each in France, Italy, Spain, and Denmark. The sample was stratified by gender, age, city size, region, and level of education, and was gender-balanced (50% women and 50% men).
The data was subjected to quality control and weighed so that its structure fully reflects that of the populations of the surveyed countries, based on census data. The survey was conducted by an external research agency, IQS, which coordinated data collection in the four countries.

3 Characteristics of electricity users

3.1 Sociodemographic characteristics

This section presents the demographic characteristics of the respondents, based on household size and type, education level, income, and occupation.

Figure 1. 'How many people live in your household (including you)?'



The least numerous households are in Denmark (average 2.3 members) and the most numerous in Spain (average 3.0 members) and Italy (average 2.9 members).

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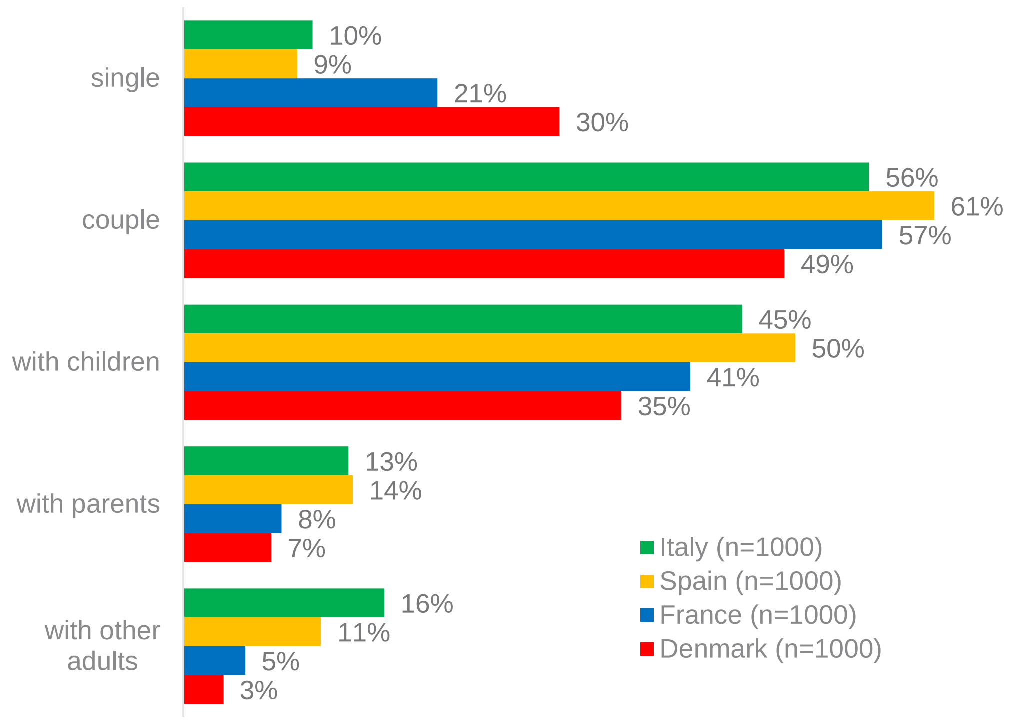
Figure 2. Type of household (depending on the number of residents)



Households that comprise single people are most frequent in Denmark (30%) and France (21%). Italy and Spain have relatively high numbers of households in which adults live together with their parents or other adults.

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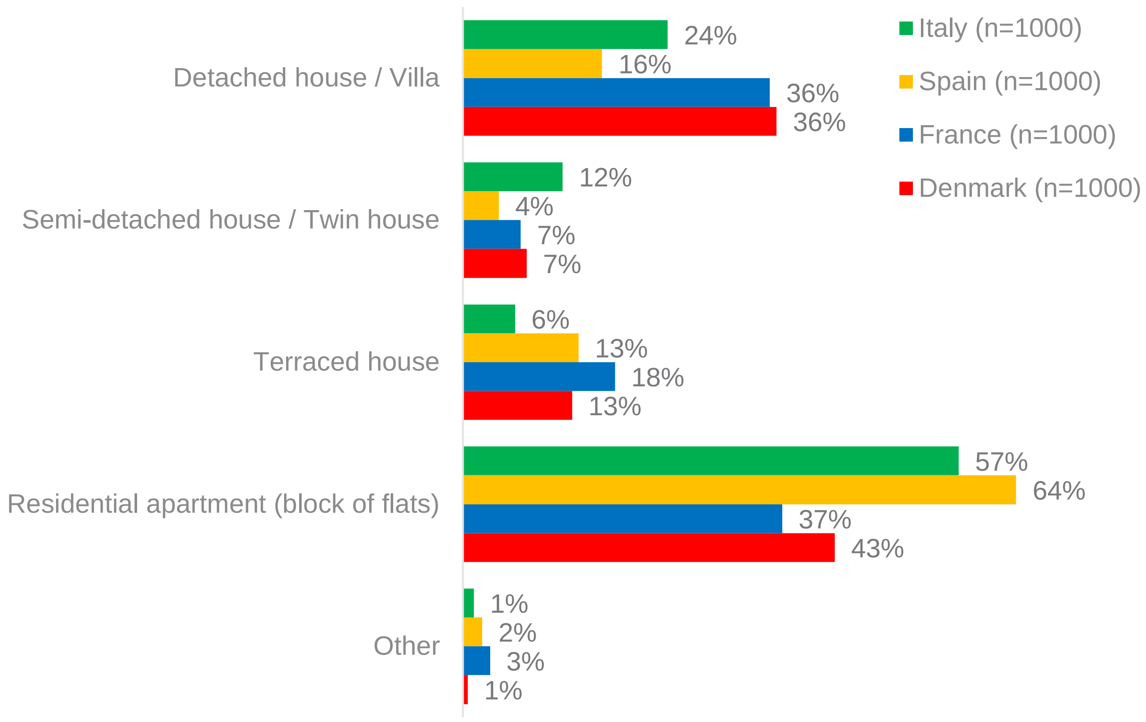
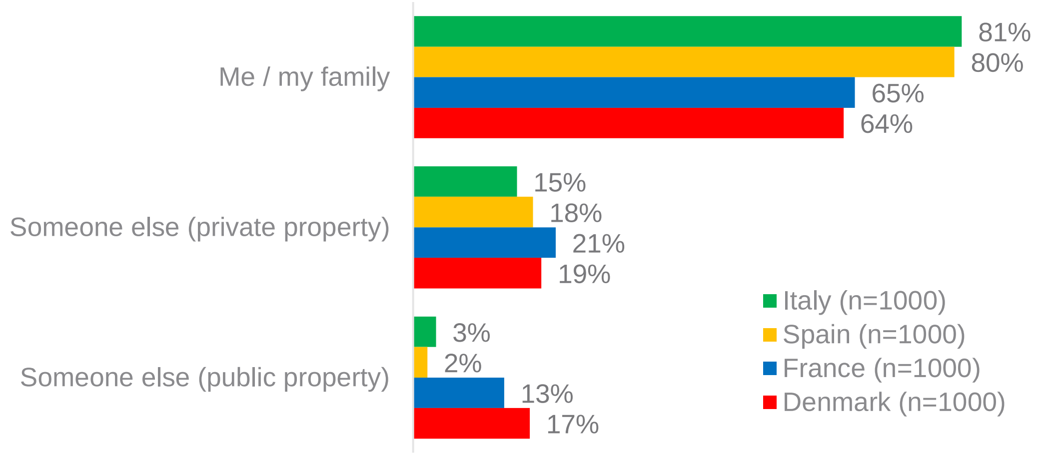
Figure 3. 'Which of the following best describes the type of building in which you currently live?'



Most respondents in Spain (64%) and Italy (57%) lived in residential apartments. High proportions of people who live in houses (detached, semi-detached, or terrace) were found in France (61%) and in Denmark (56%).

Figure 4. 'Who is the owner of the apartment/house where you currently live?'



In Italy and Spain, approximately 80% of properties are owned by their occupiers; for France and Denmark, approximately 65%.

France (13%) and Denmark (17%) are characterised by their large shares of property that is rented from public housing associations.

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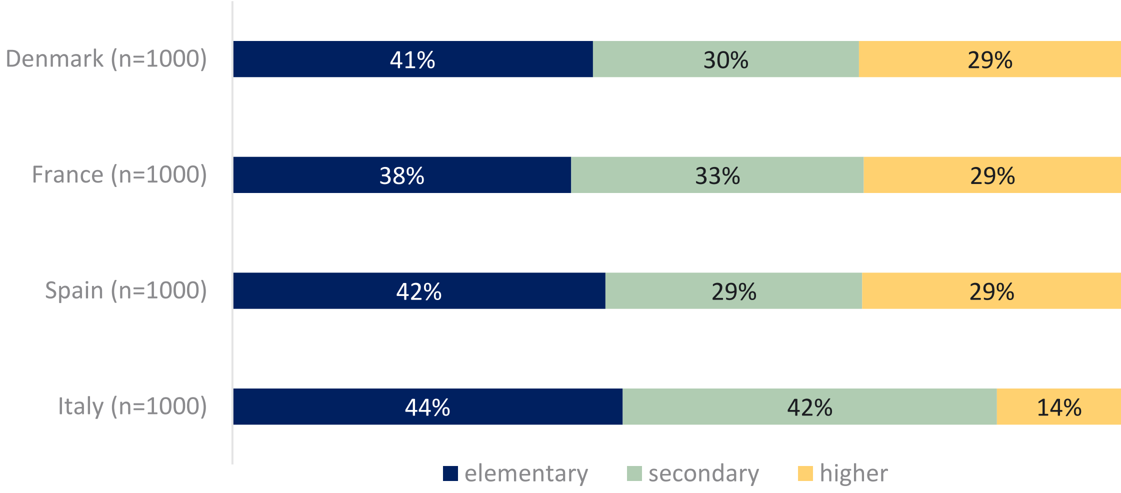
Figure 5. Education



Italy demonstrates a significantly lower percentage of people who have completed higher education (14%), compared to the other countries (29%).

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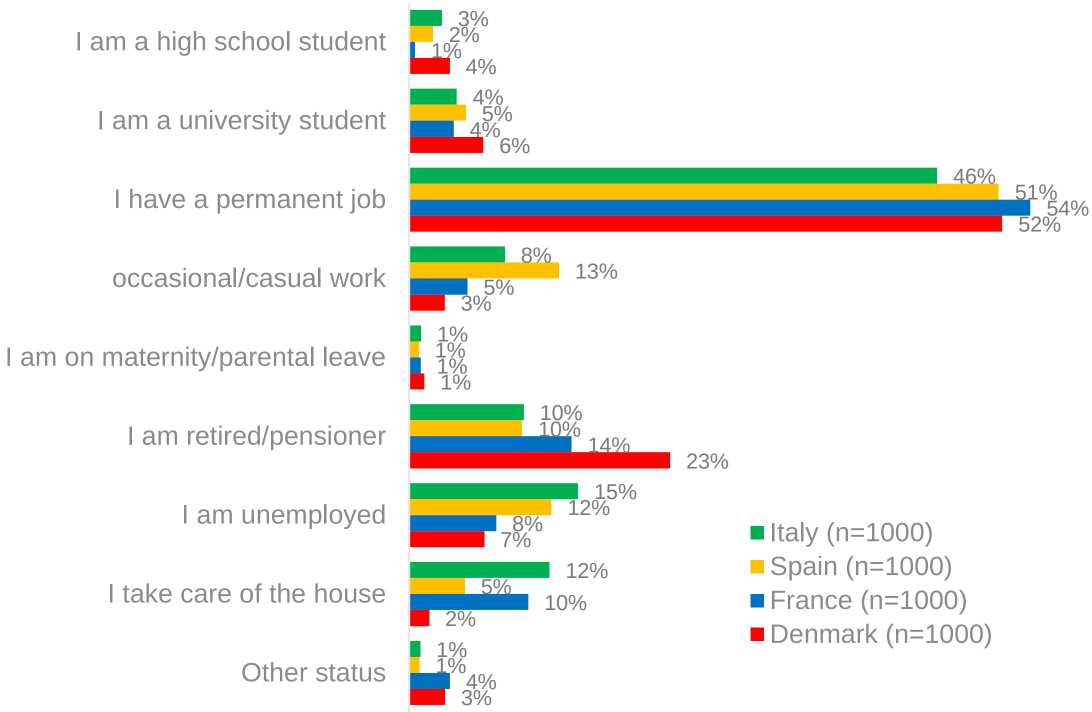
Figure 6. 'Describe your current job status (Select all answers that apply)'



Approximately 50% of respondents had permanent jobs. Denmark stands out for its high proportion of retirees (23%). Italy (15%) and Spain (12%) have significant proportions of unemployed people.

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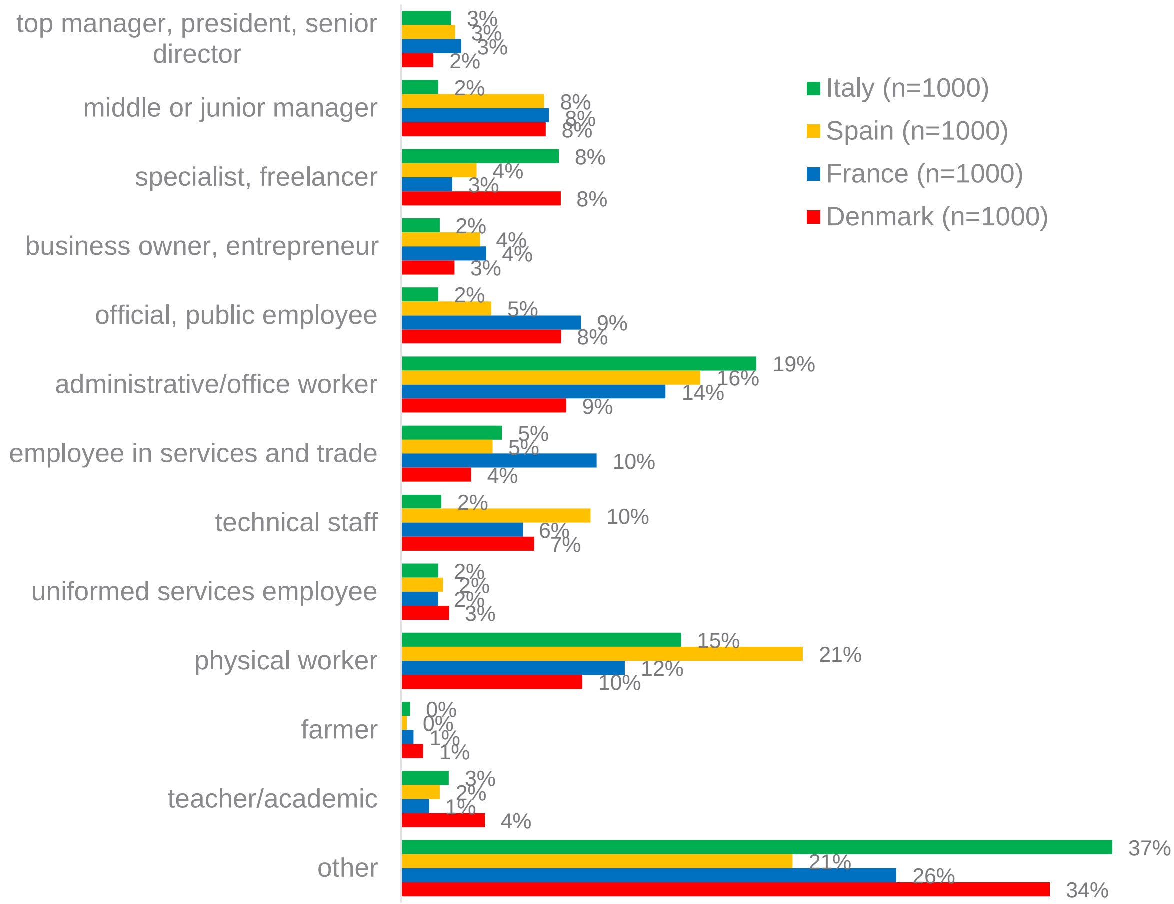
Figure 7. 'Describe your professional status'



The sample included individuals who represent a broad cross-section of occupational groups. The data indicates no significant differences between the occupational profiles of the countries studied.

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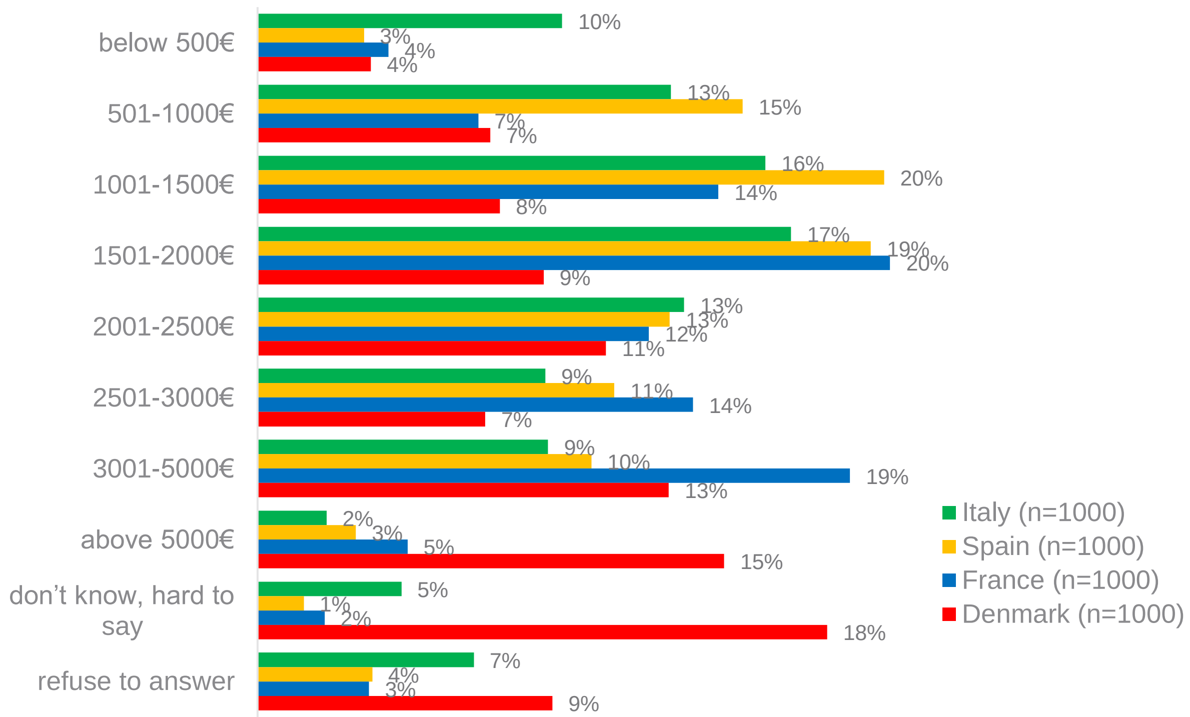
Figure 8. 'State the total monthly net (after tax) income of all members of your household'



The average income, expressed in euros, is highest in Denmark and lowest in Italy.

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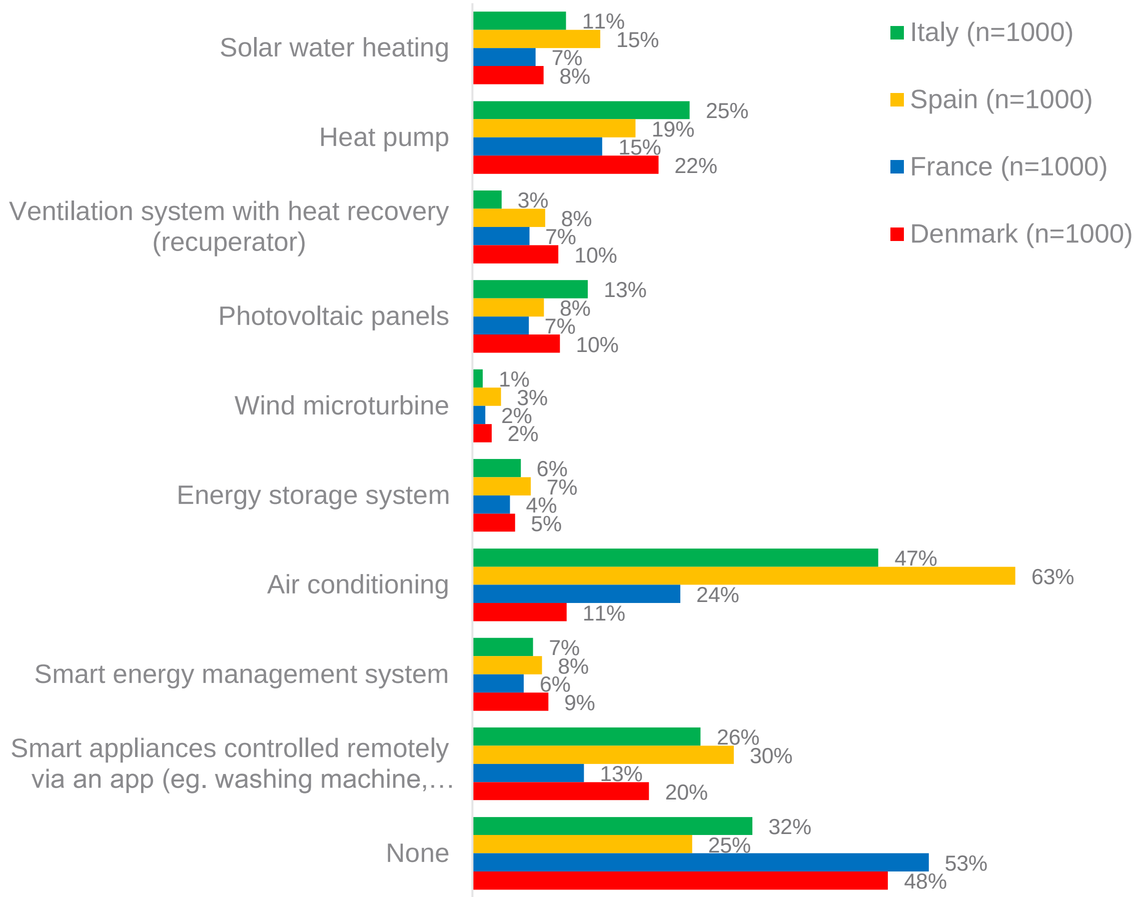
3.2 Household equipment: home installations and cars

3.2.1 Home installations

This section pertains to current and planned ownership of household electrical equipment and cars. We determined the number of current and potential prosumers based on information on current and planned ownership of electricity generation and storage facilities.

Figure 9. 'Which of the installations/facilities listed below do you have at home?'



Air conditioning is the most commonly owned installation in Spain (63% of households), Italy (47%), and France (24%). Less than 15% of households has electric generation facilities (photovoltaic panels or wind microturbine). One in twenty households has an energy storage system. The use of smart, remotely managed devices is most common in Spain (30%) and in Italy (26%), and less so in Denmark (20%) and in France (13%).

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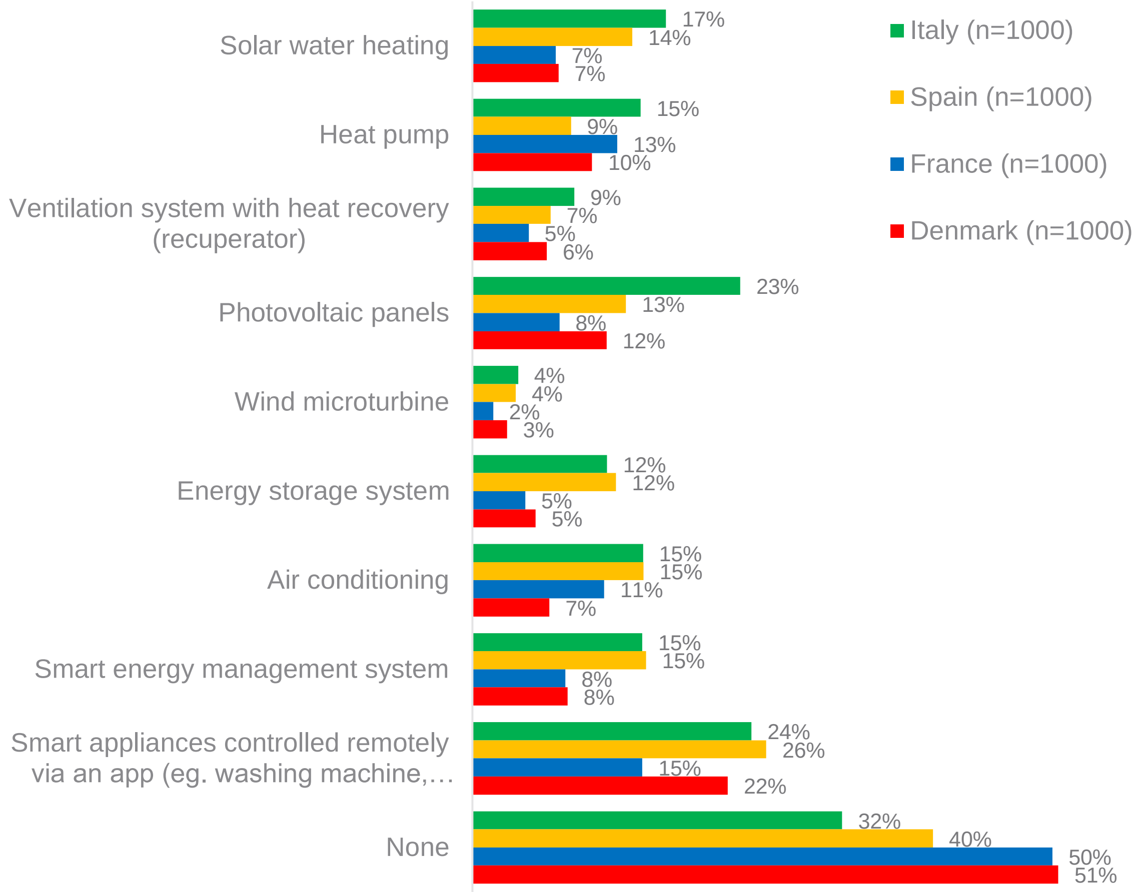
Figure 10. 'Which of the devices/installations listed below do you plan to purchase in the next twelve months?'



Planned purchases of smart appliances are prevalent—particularly in Spain (26%), Italy (24%), and Denmark (22%).

Relatively higher interest in devices that generate, and store electricity is noticeable in Italy and in Spain. This might be explained by the higher potential of solar energy in those countries. The relatively lower interest demonstrated in France and in Denmark might be explained by those countries' already extensive low-carbon energy production (nuclear in France and offshore wind in Denmark).

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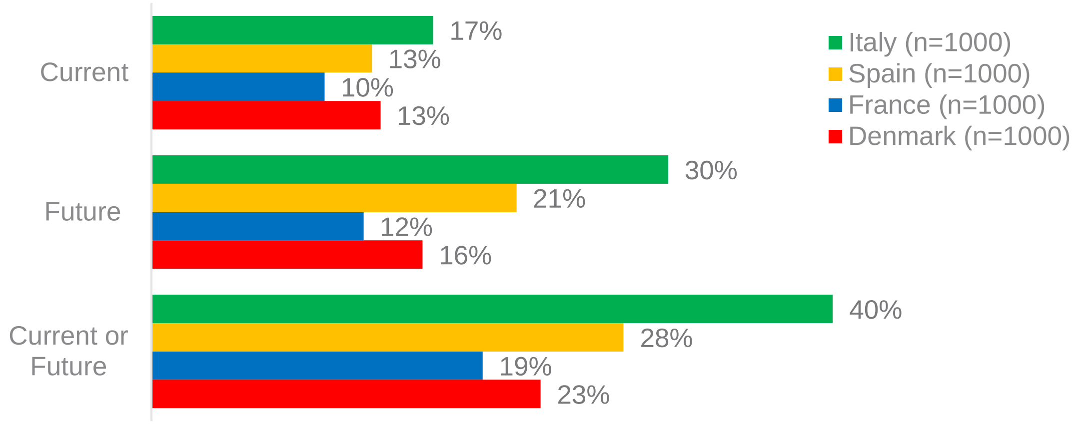
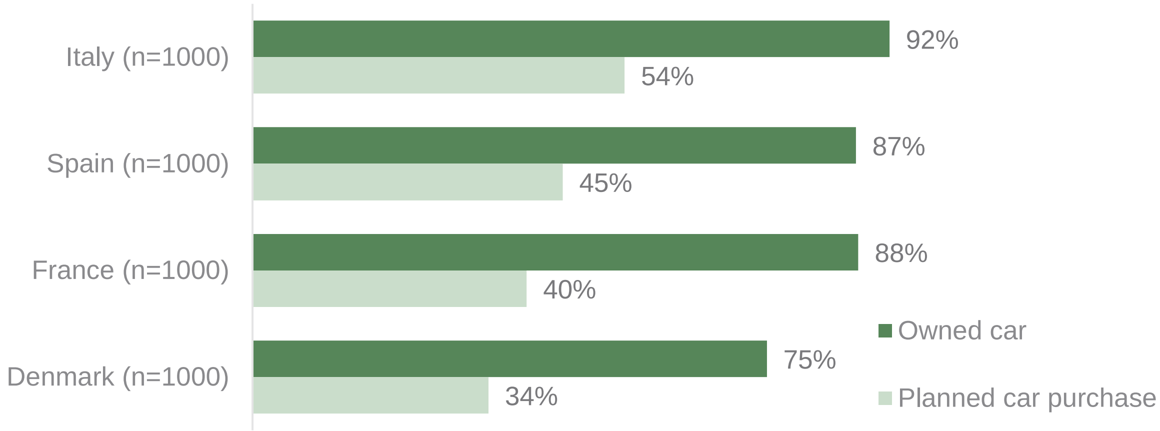
Figure 11. Current and future prosumers



The prosumer market is growing. This is particularly noticeable in Italy and in Spain, where the execution of the expressed intentions to install energy production and storage devices could more than double the countries shares of prosumers (in Italy from 17% to 40%; in Spain from 13% to 28%). Smaller, but also strongly growing prosumer markets can be found in France (currently 10%; growth potential up to 19%) and Denmark (13%; growth potential up to 23%).

3.2.2 Current and planned car ownership

Figure 12. Current and planned car ownership



Respondents in Italy owned the most cars (92%); those in Denmark owned significantly fewer (75%). The distribution of intentions to buy cars looks similar, with the Italians planning to do so the most often and the Danes the least.

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Figure 13. Engine type in owned cars

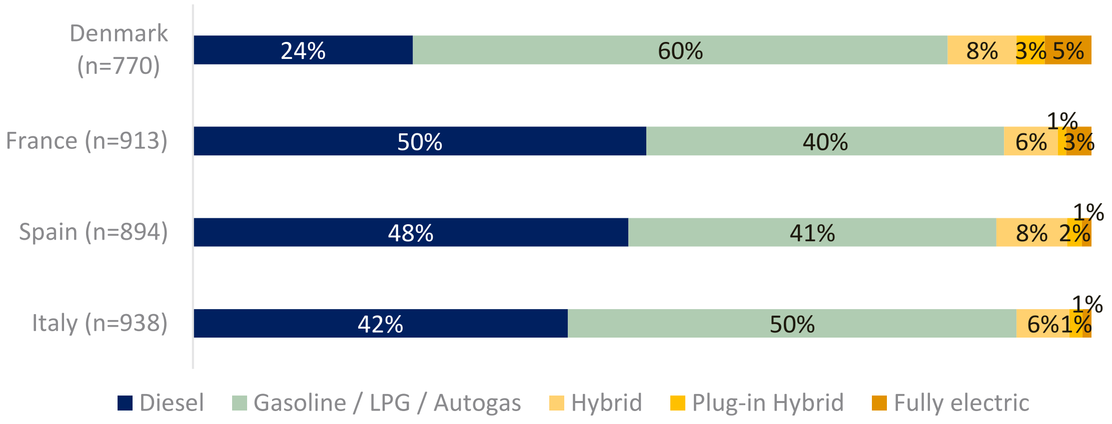
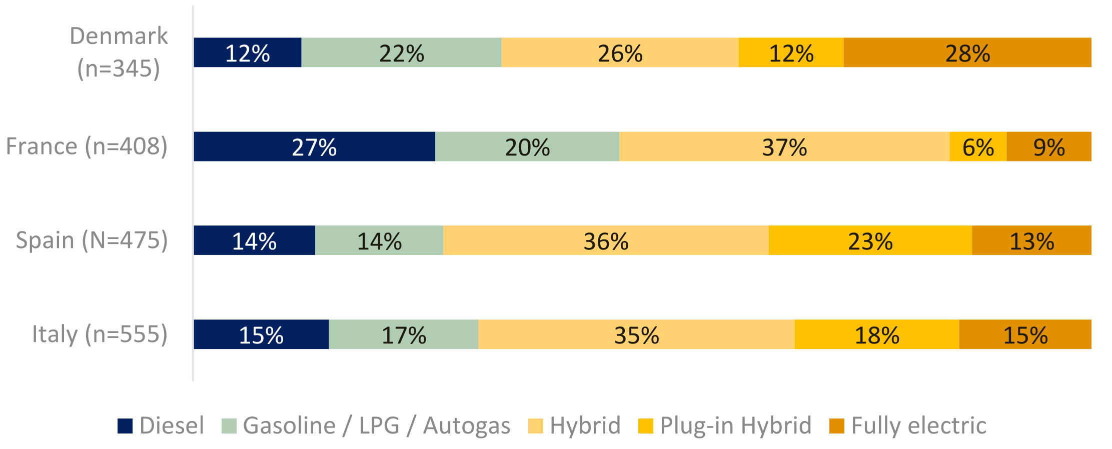


Figure 14. Engine type in planned cars



Data on the engines of both owned and planned cars demonstrate the transformation underway in the automobility sector. Among cars already owned, those with traditional combustion engines dominate; among planned cars, they constitute a minority. Future cars will likely more often have hybrid or electric engines.

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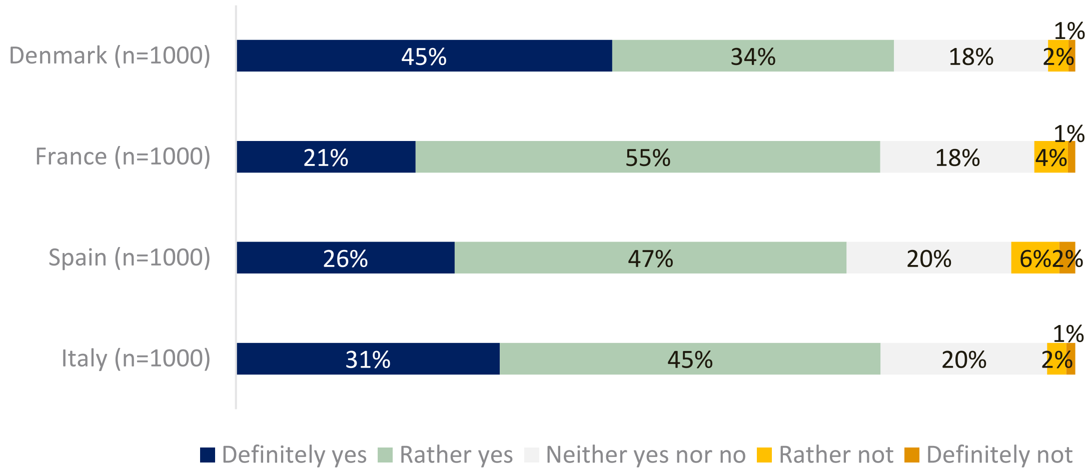
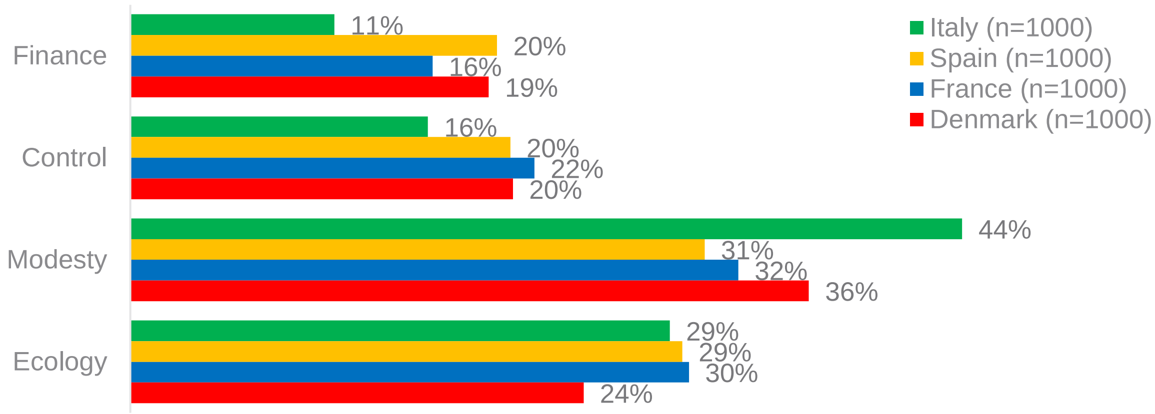
3.3 Attitudes towards saving energy

Figure 15. 'Do you save electricity in your home?'



About three-quarters of respondents in the countries surveyed make efforts to save energy. The highest number of respondents who indicated 'definitely yes' could be found in Denmark, where electricity is the most expensive.

Figure 16. 'Which of the following best describes your reasons for saving energy in your home?'



Users' motivations were determined by their responses to a question in which they chose a phrase that best described their motivation for saving energy.
Users selected one of the following phrases:

- *I have more money for other expenses because of this* (motivation category: Finance)
- *I feel that it gives me more control over my spending* (motivation category: Control)
- *I believe that we should try to live frugally and not waste the things we use, like energy — even if we can afford them* (motivation category: Modesty)
- *I am concerned about the state of the environment and the climate; by reducing my electricity consumption, I try to limit my negative impact* (motivation category: Ecology)

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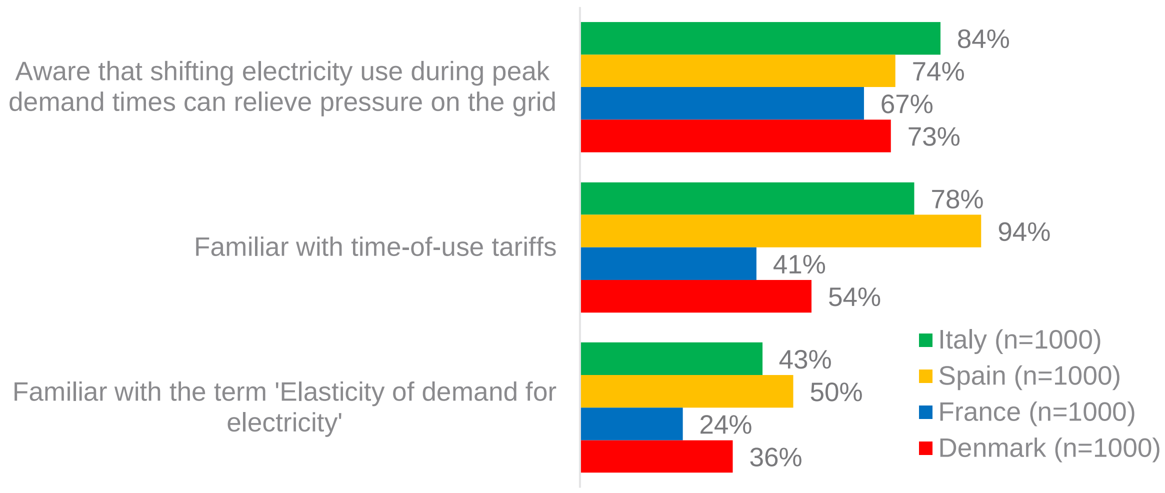
Figure 17. Familiarity with electric energy management concepts



The full wording of the questions on knowledge of electricity management terms was as follows:

Peak electricity demand and pressure on the grid: '*Have you heard that by shifting your electricity use during the day so that you use less electricity at peak demand times (usually evening hours), you can relieve pressure on the grid?'*

Time-of-use tariffs: *Have you heard of time-of-use tariffs, in which the price of electric energy depends on the time of use? (Usually lower at night, and higher during the daytime)'*

Elasticity of demand for electricity: *The shift in electricity use over time is often called the "elasticity of demand for electricity" . Are you familiar with this term?'*

Overall, awareness that peak demand for electricity strains on the grid is high in all of the countries surveyed: positive responses ranged between 67% in France and 84% in Italy. In contrast, awareness of the concept of elasticity of demand for electricity is significantly lower: positive responses ranged between 24% in France and 50% in Spain. This indicates that although users are aware that high peak demand for electricity is a burden on the electricity grid, the concept of demand elasticity for electricity is new to the most of them. The high awareness of time-of-use tariffs in Spain (94%) is probably due to the solution's wide adoption in that country. This may also be reflected by the Spaniards' indicating of the highest familiarity with elasticity of demand for electricity (50%). It should be noted, however, that elasticity of electricity demand is a new concept; one that fundamentally alters the established paradigm of electricity use (in which only the amount of electricity used, not the time of use, counts). The percentage of respondents familiar with elasticity of energy demand is relatively high in each of the countries surveyed (positive responses ranged between 24% in France and 50% in Spain), and is highest in the countries where familiarity with time-of-use tariffs is also highest (Italy and Spain).

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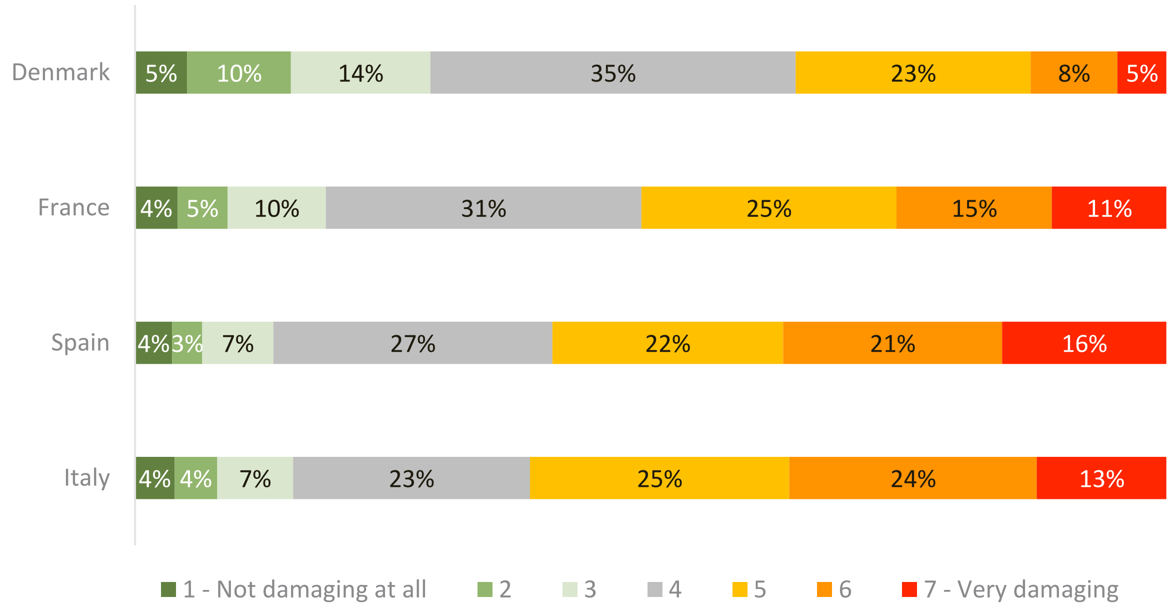
Figure 18. 'To what extent do you think current electricity generation in your country damages the environment and the climate?'



Greater awareness exists of time-of-use tariffs and elasticity of demand for electricity Italy and Spain —the countries in which relatively greater conviction exists on the harmful impact of energy production on the environment and climate. In the case of Italy, the belief that electricity production is more harmful is justified by the real, comparatively high emissions associated with it in that country. According to electricitymap.org, the actual emissions in the countries studied are approximately 420g/kWh in Italy, 280g/kWh in Denmark, 180g/kWh in Spain, and 110g/kWh in France. It is worth noting that the Danes' conviction that electricity generation is relatively less harmful for the environment is not confirmed by the actual carbon intensity of electricity generation, which is quite high in Denmark compared with the other countries surveyed.

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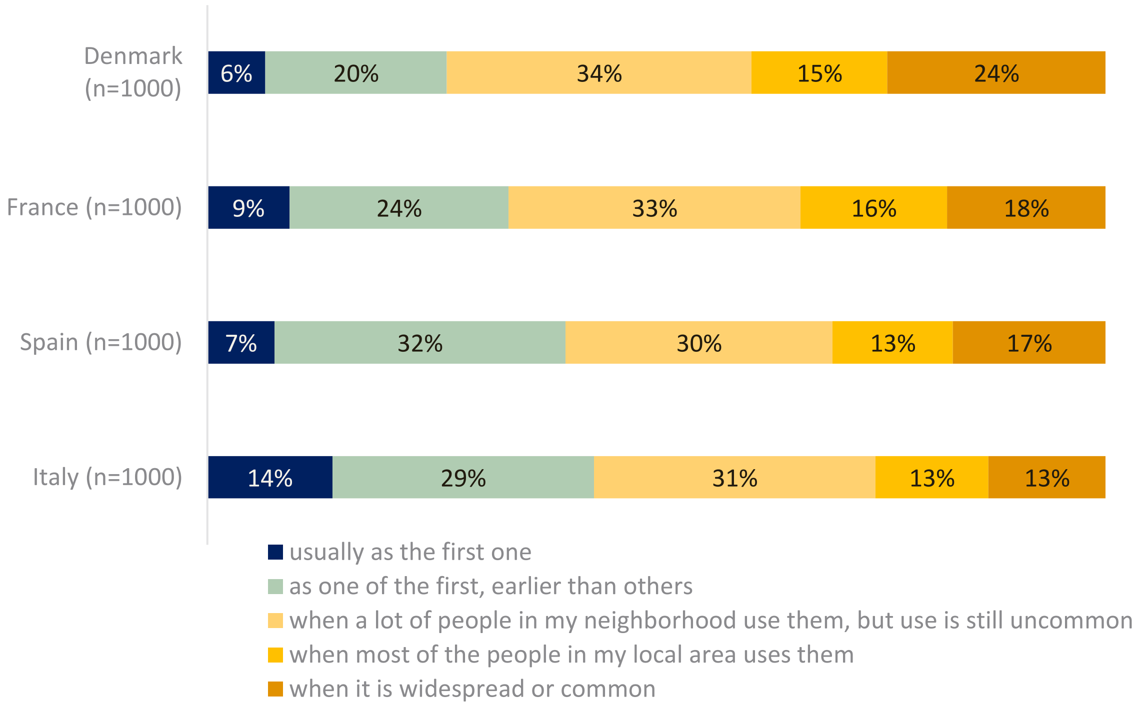
Figure 19. 'Compared to people you know (friends, family, or colleagues), when do you start using new solutions and products?'



Respondents varied considerably in the extent of their adoption of new solutions and products. Although early adopters are a minority, a significant number of respondents are ready to start using new solutions before they become common; this is indicated by the sum of those who selected one of the first two answers ('*usually as the first one'* and '*as one of the first, earlier than the others*'). These responses accounted for 26% of respondents in Denmark, 33% in France, 39% in Spain, and 43% in Italy.

The above suggests that a large group of electricity users is open to adopt new solutions which provides a good basis for implementing innovations in the field of electricity management.

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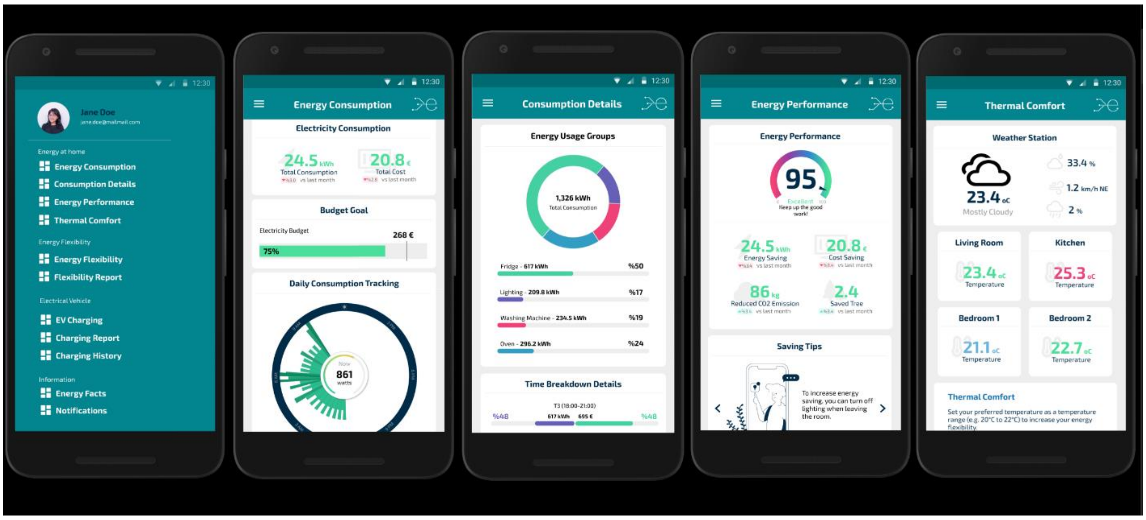
4 Evaluation of the mobile application prototype

The respondents evaluated the application in several steps, which are described below. The application was evaluated in four language versions that reflect the local languages of each of the countries studied. The English-language version of the application is shown in this document.

Initial reaction. The respondents first reviewed the interactive version of the application (most often, they spent 10–15 minutes reviewing it), before rating the application based on their overall impressions.

Energy at Home. Next, the respondents viewed screenshots of the application regarding home electricity management and rated that section, which includes information on energy consumption, energy performance statistics and a panel for managing the room temperature.

Figure 20. Screenshots from the prototype application: Energy at Home



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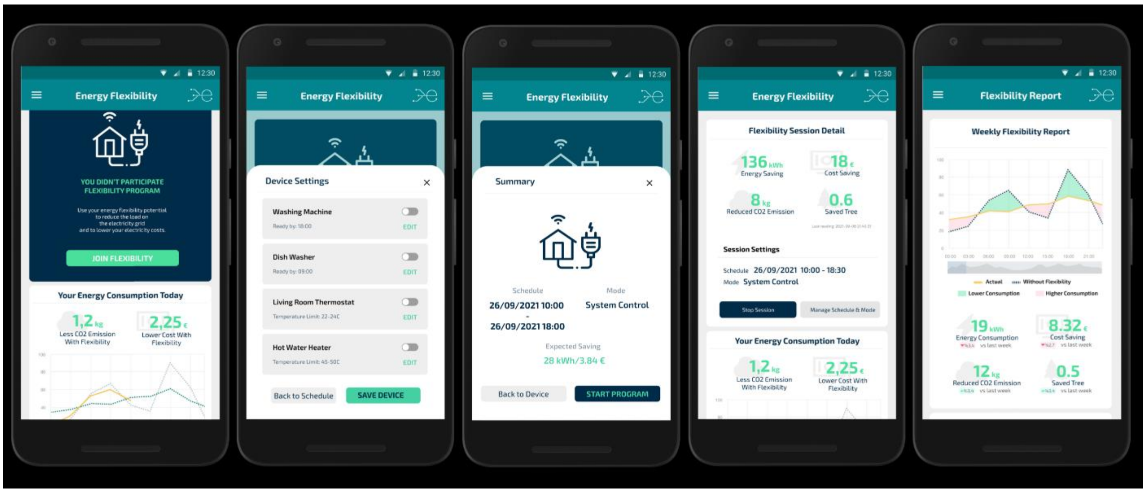
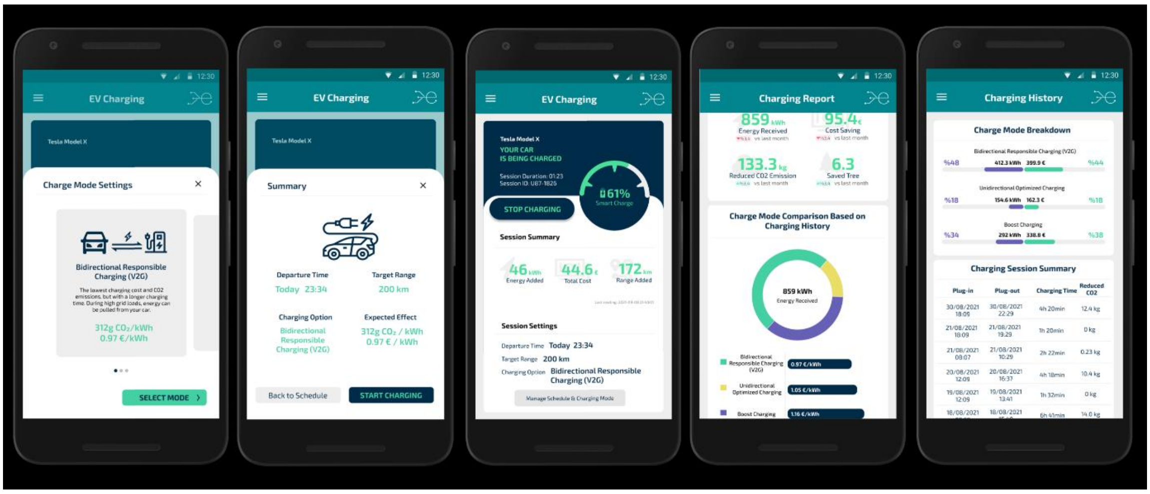
Energy Flexibility. In this section, the respondents evaluated functionalities related to flexible energy management, including participating in the energy flexibility programme, the setting of device parameters, and energy consumption statistics.

Figure 21. Screenshots from the prototype application: Energy Flexibility



Electric Vehicle (EV). In this section, the respondents evaluated an electric car charging control interface, charging parameters, and charging history statistics that considered various charging modes.

Figure 22. Screenshots from the prototype application: Electric Vehicle (EV)



We presented the application in two graphic versions: standard and eco. The versions were functionally identical and differed only in colour scheme and background graphics. Below we present the mean of respondents' overall assessment of the application and of its individual functionalities, without differentiating between the variants each respondent evaluated. A description and comparison of the results for the two graphic versions can be found in section 4.1.

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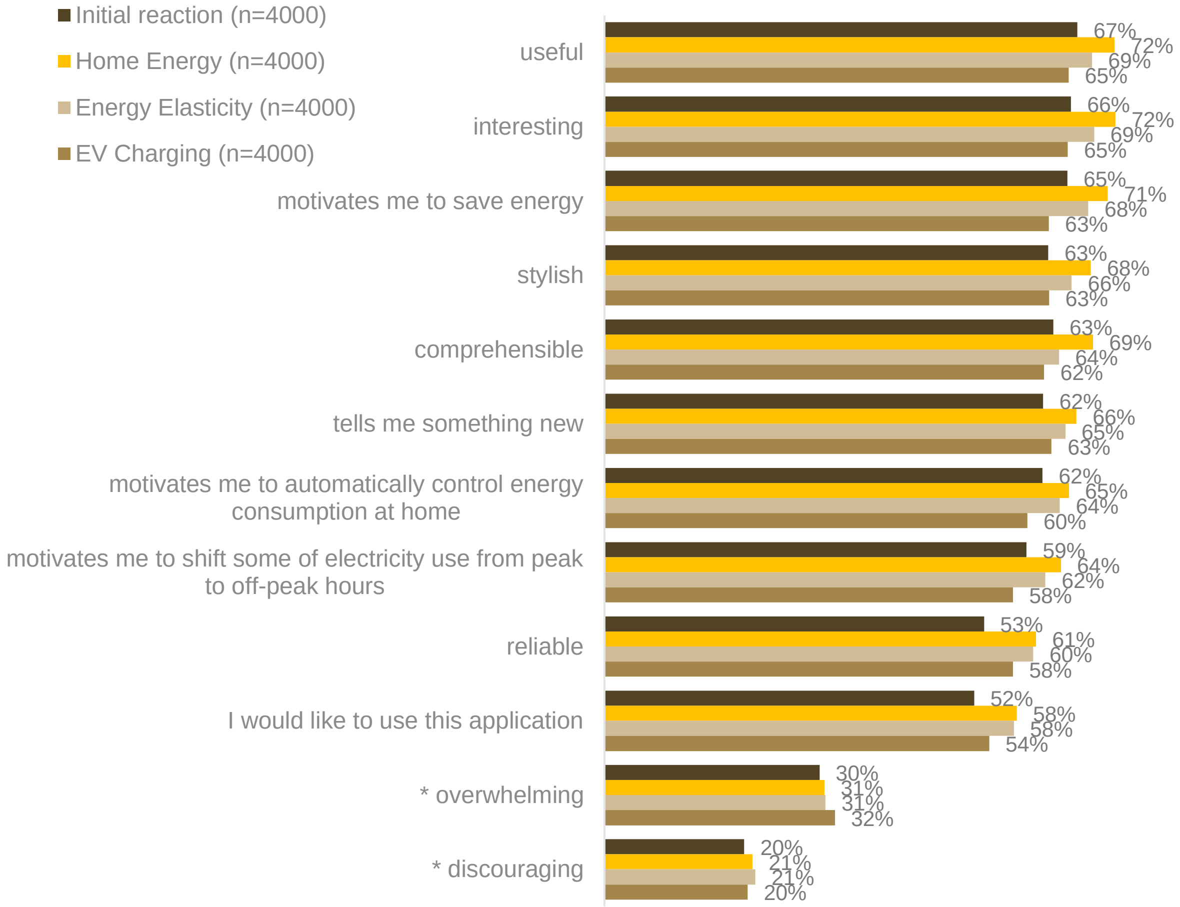
Figure 23. Results of Application prototype evaluation (total sample)

Percentage of respondents who selected responses of 4 (rather yes) or 5 (definitely yes) on a scale of 1 to 5.



The overall evaluation of the prototype application is high: two-thirds of the respondents rated it ‘good’ or ‘very good’ on dimensions such as ‘useful’, ‘interesting’, ‘motivates me to save energy’, and ‘stylish’. Approximately 60% believed that the application motivated them to make their energy demand more flexible, e.g. by time-shifting their consumption and by using solutions that automatically control energy consumption at home. Approximately 30% of the respondents found the application ‘overwhelming’ and 20% found it ‘discouraging’.

Of the modules in the application, the home energy management section was rated the highest and the car charging section the lowest. These were not sizeable differences and might be attributed to differences in respondents' familiarity with the functionalities (the highest for home appliances and the lowest for electric car charging), rather than to differences in the refinement of the different sections of the application.

Overall, the application was evaluated highly positive and seems to achieve its goals: it has the potential to motivate most users to make their electricity demand more

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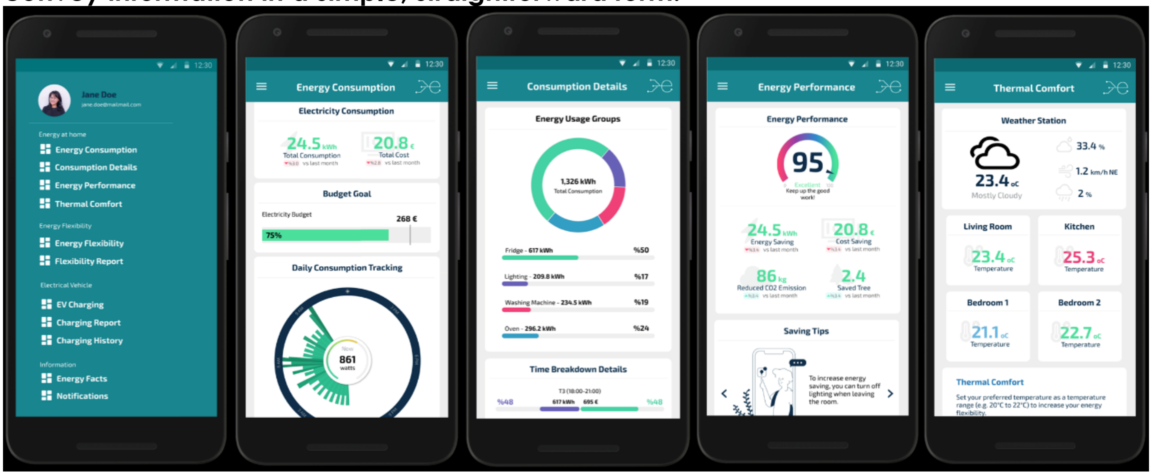
flexible and to save energy. It was assessed as useful and well designed, and almost 60% declared that they would like to use such an application.

4.1 A detailed evaluation of the two graphical versions of the application by country and by reason to save energy

This section presents detailed evaluations of the application, while taking into account the differences between the graphic versions of the application tested and the respondents' countries of residence.

We presented two separate versions of the application. Each was identical in function but differed in its graphical appearance. Images of both versions are presented below. During the survey, each respondent viewed only one randomly selected version of the application; the results below apply to separate groups of users.

The standard graphical version. Its colour scheme creates a neutral context. its purpose is to convey information in a simple, straightforward form.



The eco graphical version. It is functionally identical to the standard version. A green colour scheme and a leaf symbol are incorporated to create an ecological context and trigger relevant associations in its users.

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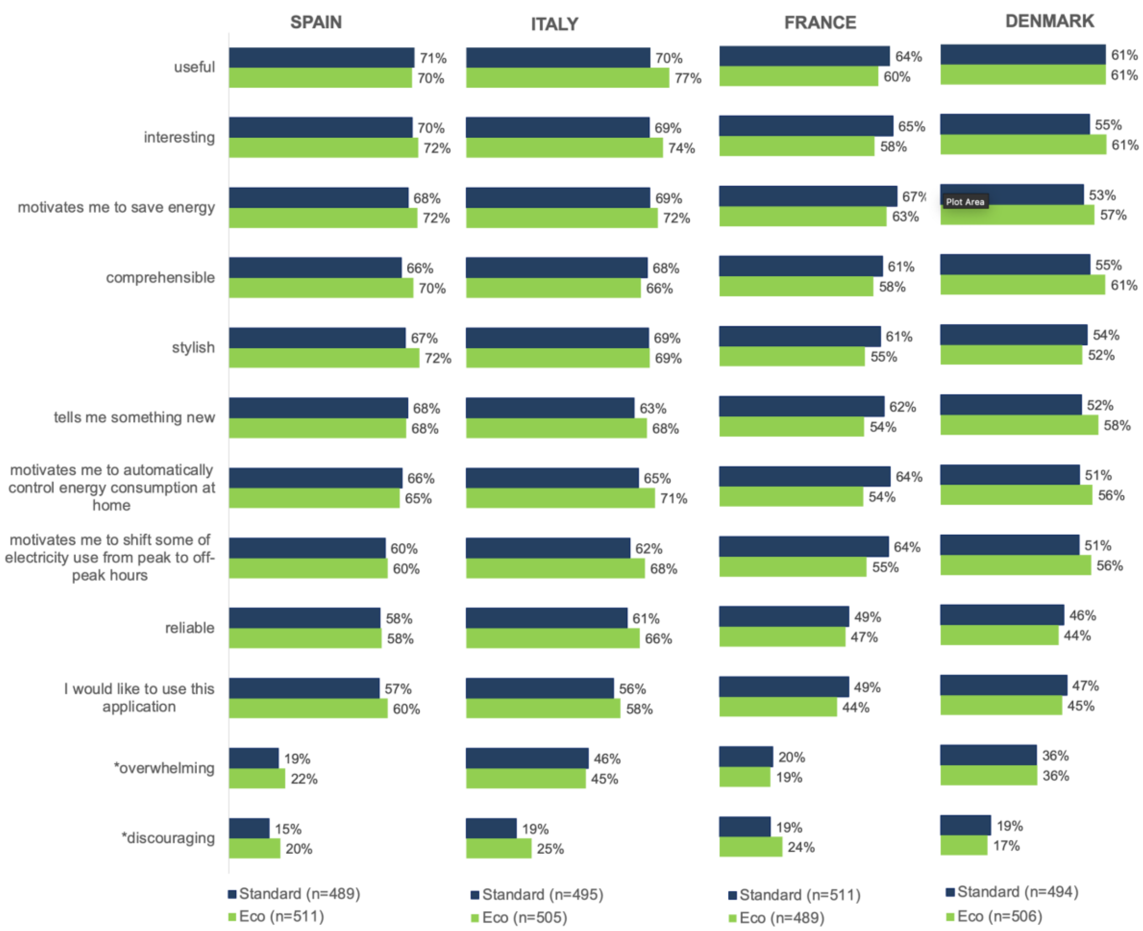
4.1.1 Assessment of the standard and eco application variants by country

The chart below presents the overall ratings the respondents awarded the application after exploring its interactive version on their own.

Figure 24. Initial Reaction to the application in each country

Percentage of respondents who selected responses of 4 (‘rather yes’) or 5 (‘definitely yes’) on a scale of 1 to 5.



The application was assessed slightly more favourably in Spain and Italy than in France and Denmark. The differences in these ratings are consistent with prosumer penetration and interest in purchasing energy production and storage facilities in those countries. The highest numbers of both current and future prosumers were found in Italy and in Spain; familiarity with time-of-use tariffs and elasticity of demand for electricity followed the same pattern.

The comparison of the standard and eco versions of the application works to the advantage of the eco version in all countries except France. The consistently high scores in Denmark, Italy, and Spain indicate that the **environmental context raises users’ interest both in using the application and in using electricity flexibly and efficiently.**

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The inverse relationship observed in France might be explained by cultural specificities in that country. Although the study did not collect data that directly identifies the cause of such approaches, we may speculate that it relates to the 2018 ‘yellow vest’ protests against green taxes. For this reason, a large part of French users might associate the ecological context with the green taxes against which they have recently protested.

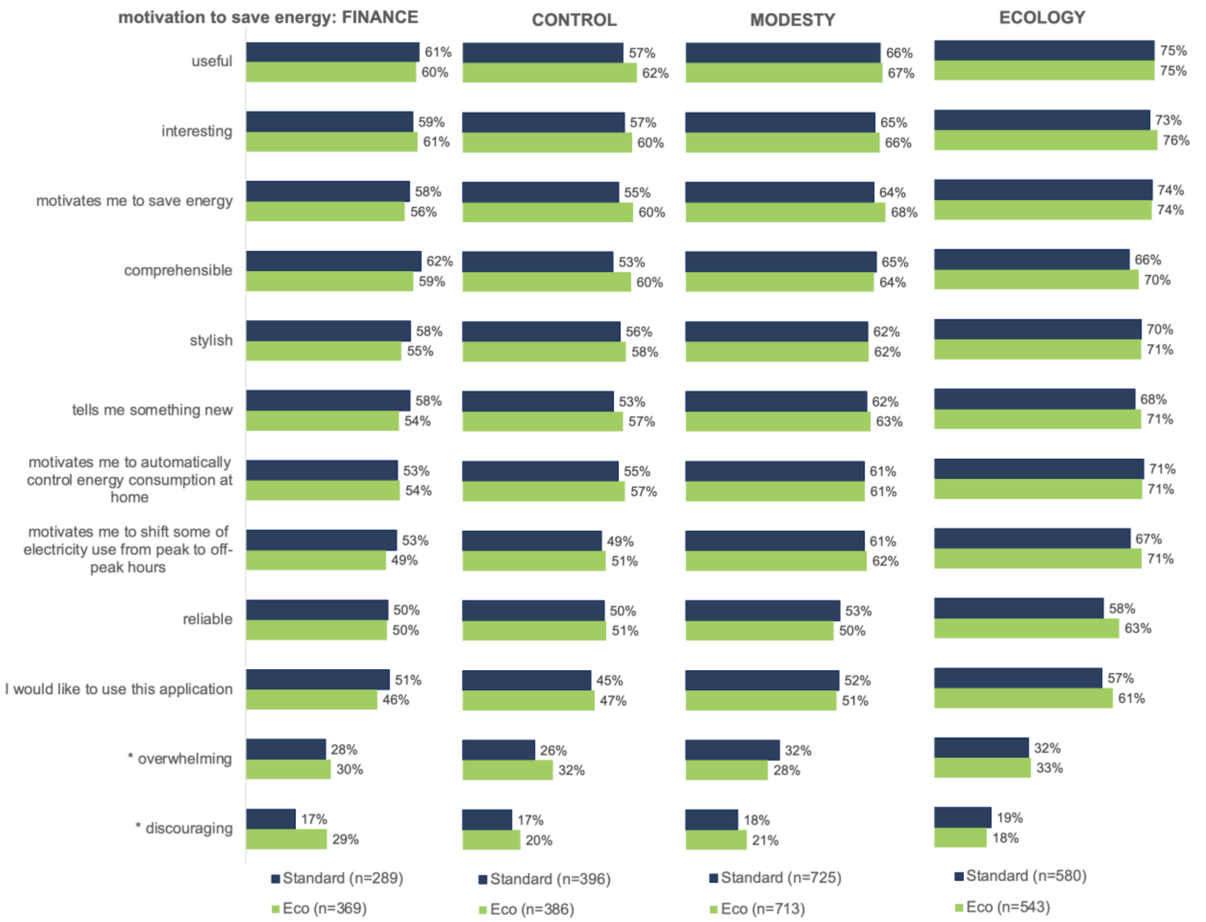
4.1.2 Assessment of the standard and eco application variants by motivation to save energy

The respondents were asked to select one of four statements that most accurately described their motivation to save energy:

- *I have more money for other expenses because of this* (motivation category: Finance)
- *I feel that it gives me more control over my spending* (motivation category: Control)
- *I believe that we should try to live frugally and not waste the things we use, like energy — even if we can afford them* (motivation category: Modesty)
- *I am concerned about the state of the environment and the climate; by reducing my electricity consumption, I try to limit my negative impact* (motivation category: Ecology)

Figure 25 presents the ratings of the application according to respondents’ key motivations for saving energy.

Figure 25. Initial reaction to the application by reason to save energy. Percentage of respondents who selected responses of 4 (‘rather yes’) or 5 (‘definitely yes’) on a scale of 1 to 5.



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The highest ratings of both variants were observed among respondents who save energy for environmental reasons: three-quarters of them found the application ‘useful’, ‘interesting’, and ‘motivating to save energy’. Among those who save energy so as not to needlessly waste resources (Modesty), the ratings were slightly lower, with the above-mentioned positive features indicated by two-thirds of respondents.
The lowest (although positive, nevertheless) ratings were observed among respondents who save energy for financial reasons and to feel in control. In these groups, nearly 60% of respondents indicated positive characteristics of the application.

The percentage of respondents who indicated negative features was similar in all groups: approximately 30% found the app ‘overwhelming’, and 20% found it ‘discouraging’. One notable difference can be observed within the latter group: in the group that is motivated to save energy by financial concerns, the eco version of the application is clearly more often rated as 'discouraging' (29%) than the standard one (17%) is.

The overall assessment of the application in terms of motivations to save energy indicates that respondents who save energy for financial reasons (Finance) rated the standard version slightly higher. In the case of motivations that stem from frugality in the use of resources (Modesty), both versions were rated similarly. In the case of the remaining motivations (feeling of control over expenses: ‘control’, and ecological reasons: ‘ecology’), the eco version was rated higher.

Respondents´ ratings of each section of the application (Energy at Home, Energy Flexibility, and Electric Vehicle [EV]) by country and by motivation for energy savings can be found in Appendix 9.4.

5 Energy literacy

The study tested five messages that conveyed facts in simple language on power generation and transmission, the importance of variations in energy demand to power providers, and the use of smart devices. A list of these messages is presented below.

A – Energy balance
‘The amount of energy produced and consumed must always be in balance.
We do not have energy storage, so it is important to use renewable energy when it is available (e.g., when the sun is shining or the wind is blowing), and, on the other hand, to limit our use of energy when it comes from burning fossil fuels. Try to use electricity efficiently when it comes from renewable sources, such as when the weather is sunny. This reduces energy costs and greenhouse gas emissions.

B – Energy flexibility
‘You can contribute to reducing greenhouse gas emissions and the cost of energy production by shifting some activities that require energy to times of day when energy is produced from renewable sources. For example, doing laundry during the day (when the sun is shining) rather than in the evening (when energy comes from the burning of coal or gas)’.

C – Smart devices

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‘There are already smart home appliances that can automatically adjust their power consumption according to the current grid situation, so as to make the most of renewable energy, which is cheaper and produces lower greenhouse gas emissions than energy generated from fossil fuels.

This way, you do not have to adjust appliances, such as fridges, air conditioning units, washing machines, dishwashers and boilers yourself; they will automatically use energy in a smart way’.

D – Peak demand
‘Most of us start using a lot of electricity when we get home in the evening. This causes a large peak in demand for electricity from the grid. Supplying this energy is expensive and requires large amounts of fossil fuel-powered capacity.

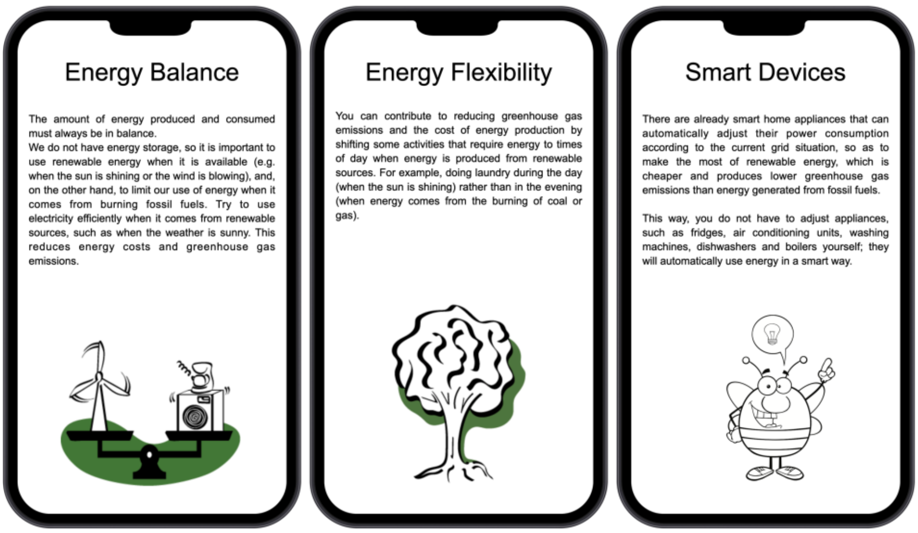
Shifting the use of some appliances to different times (e.g. turning on the washing machine or dishwasher at a different hour) reduces energy flows on the grid and causes us to use less fossil fuel. This reduces the cost of energy production and greenhouse gas emissions’.

E – Differences in emissions from different electricity sources
‘Electricity can come from different sources that have different environmental impacts. For example, when it is produced using coal, it can be up to twenty times more damaging to the environment than when it is produced using hydroelectric power.

By using more of your energy from low-emission sources, you reduce the cost of energy production and the environmental impact’.

Each of the statements was shown to the respondents in five graphical contexts. Each respondent viewed and evaluated the statements once, in a randomly selected graphical context. The statements could be shown as text only (Information only), together with an image related to its content (Drawing), with an image of a tree (Ecological Icon), with an image that depicts solar panels and windmills (Renewable Energy Icon), or with an image that depicts a positive mascot—in this case, a bee (Mascot). Using these images, we tested under different scenarios whether supplementing the statements with graphics altered respondents’ evaluation of them.

Below are examples of combinations of statements and graphical elements as they were presented to the respondents.



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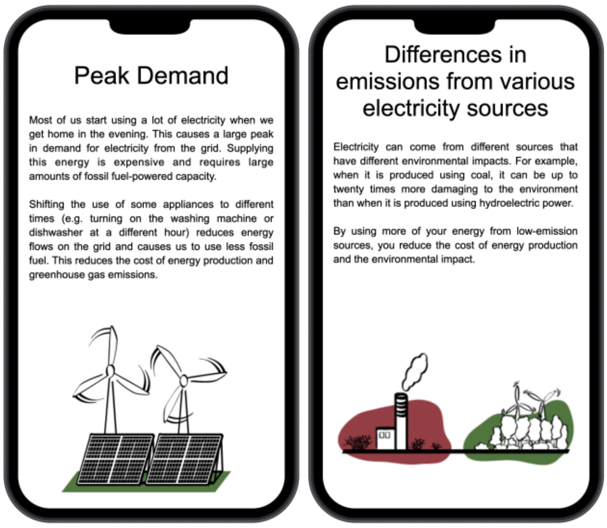
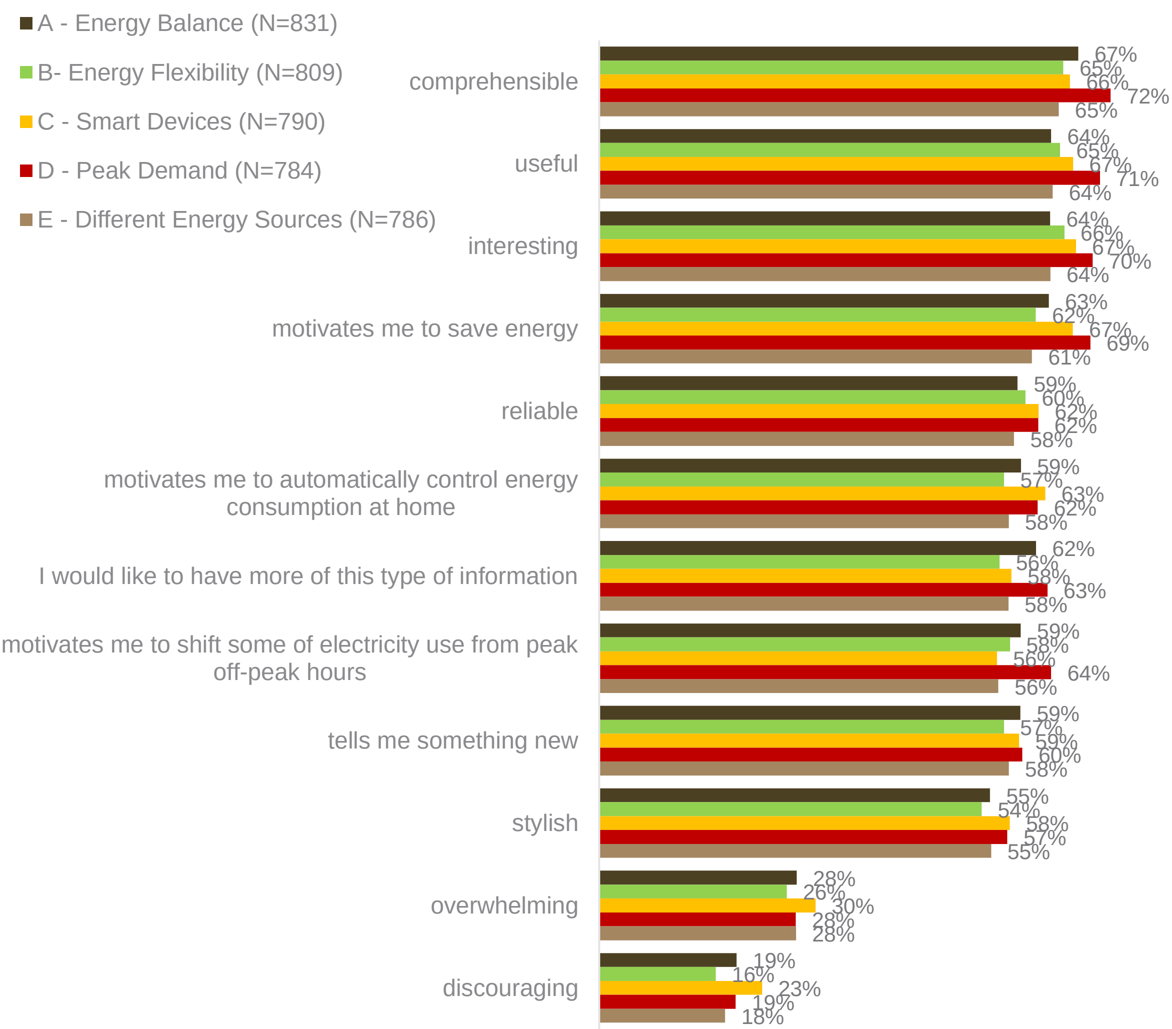


5.1 Energy literacy statements

Figure 26. Overall evaluation of individual energy literacy statements (text only)



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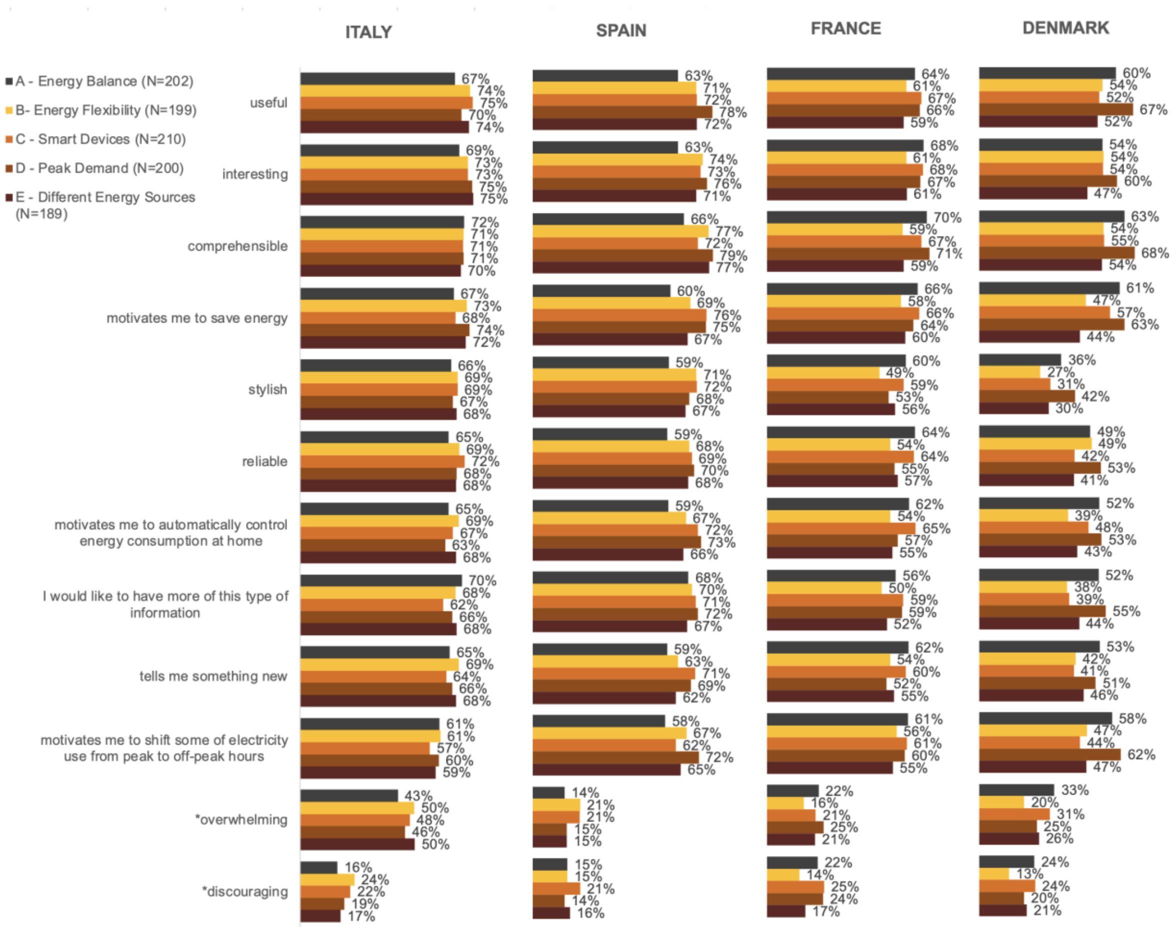
The statements were evaluated positively: two-thirds of the respondents found the information ‘comprehensible’, ‘useful’, ‘interesting’ and ‘motivating to save energy’. Negative terms, such as ‘overwhelming’ and ‘discouraging’ were assigned by significantly smaller percentage of people (overwhelming – below 30%; discouraging – between 16% and 23%).

Peak demand was rated slightly higher than the others, as more ‘comprehensible’, ‘useful’, ‘interesting’ and ‘motivating to save energy and shift demand to other times’. The remaining statements demonstrated inconsistent differences in their ratings.

Figure 27. Overall evaluation of individual energy literacy statements by country (text only)



The ratings for each country indicate differences between them. In Italy, all of the statements were rated similarly, regardless of their content. In Spain, Energy Balance was rated noticeably lowlier than the others, while Peak Demand stands out positively. In France, Energy Balance and Smart Devices were evaluated rather highly compared to the other countries. Denmark presented the most marked diversity in its evaluations: Peak Demand and Energy Balance were evaluated significantly higher than the other statements.

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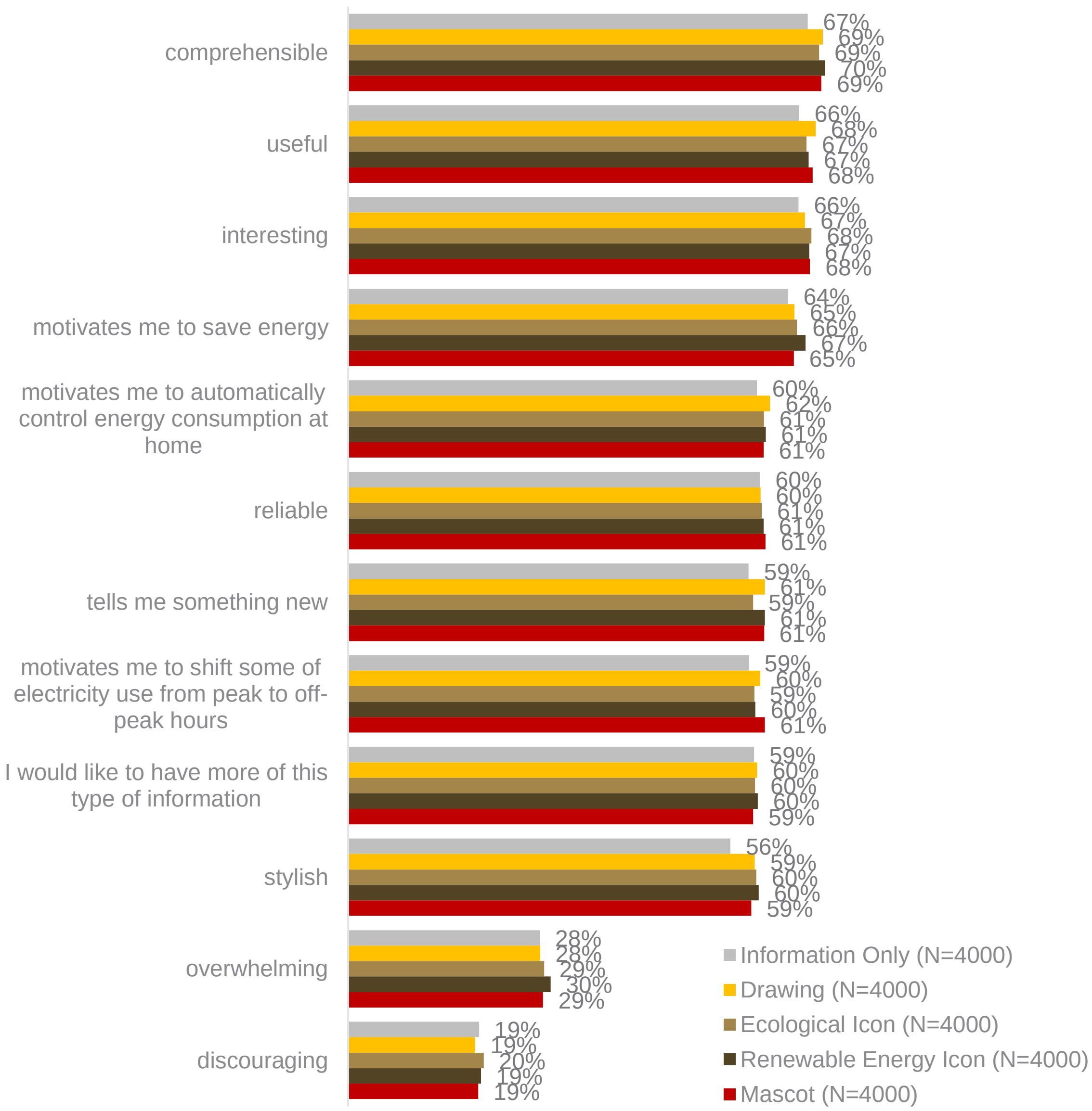
5.2 Effect of graphical context on the statements

The study also examined whether supplementing the statements with graphical elements altered their perception among respondents. Below is a comparison of the ratings of the statements presented in different graphical contexts, without regard for the content.

Figure 28. A cumulative comparison of graphical contexts for all energy literacy statements



The results indicate that in terms of the total sample, graphical context affects respondents’ perception of the statements with which they are presented. The statements presented without graphical context (Information Only) were rated slightly lower in terms of ‘comprehensible’, ‘useful’, ‘interesting’, ‘motivates me to save and control energy consumption’, and ‘stylish’— although the differences are minor.

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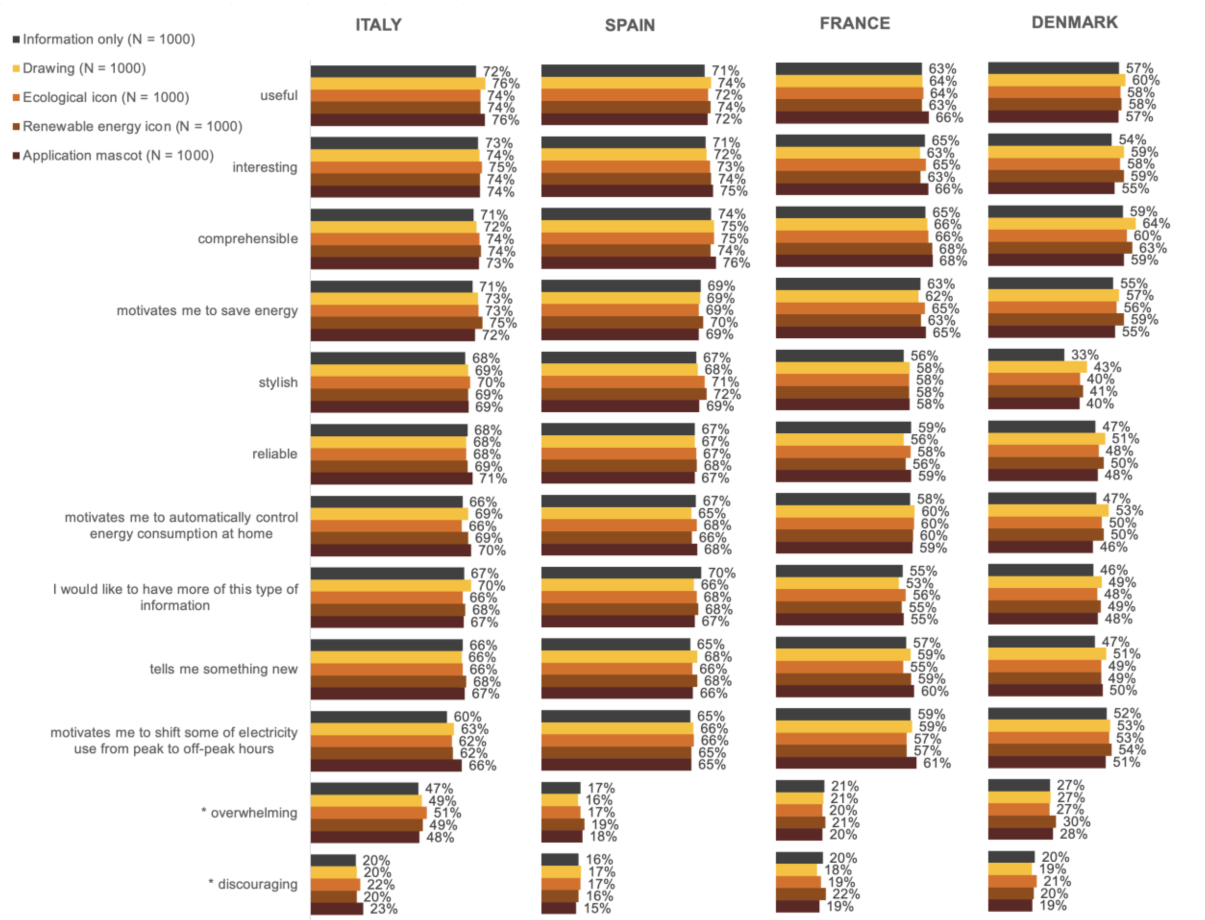
This data suggests that users’ perception of information can be improved slightly by the addition of graphical elements (such as the Ecological Icon, the Renewable Energy Icon, and the Mascot); the selection of the graphic, however, is rather insignificant.

The preparation of dedicated images that relate to the content of each statement requires more time and effort than the placing of an image that carries more general meaning (e.g. the Renewable Energy Icon), and the results indicate that this additional work fails to translate into higher ratings. For this reason, we recommend placing simple graphical elements with general meanings next to text statements.

Figure 29. A cumulative comparison between graphical contexts in the countries surveyed for all energy literacy statements



Data demonstrates that supplementing text information with graphical elements has either neutral or slightly positive effects in some dimensions in the countries surveyed. It seems advisable that text is presented together with simple illustrations. This seems an easy way to slightly improve users’ reception of the intended message.

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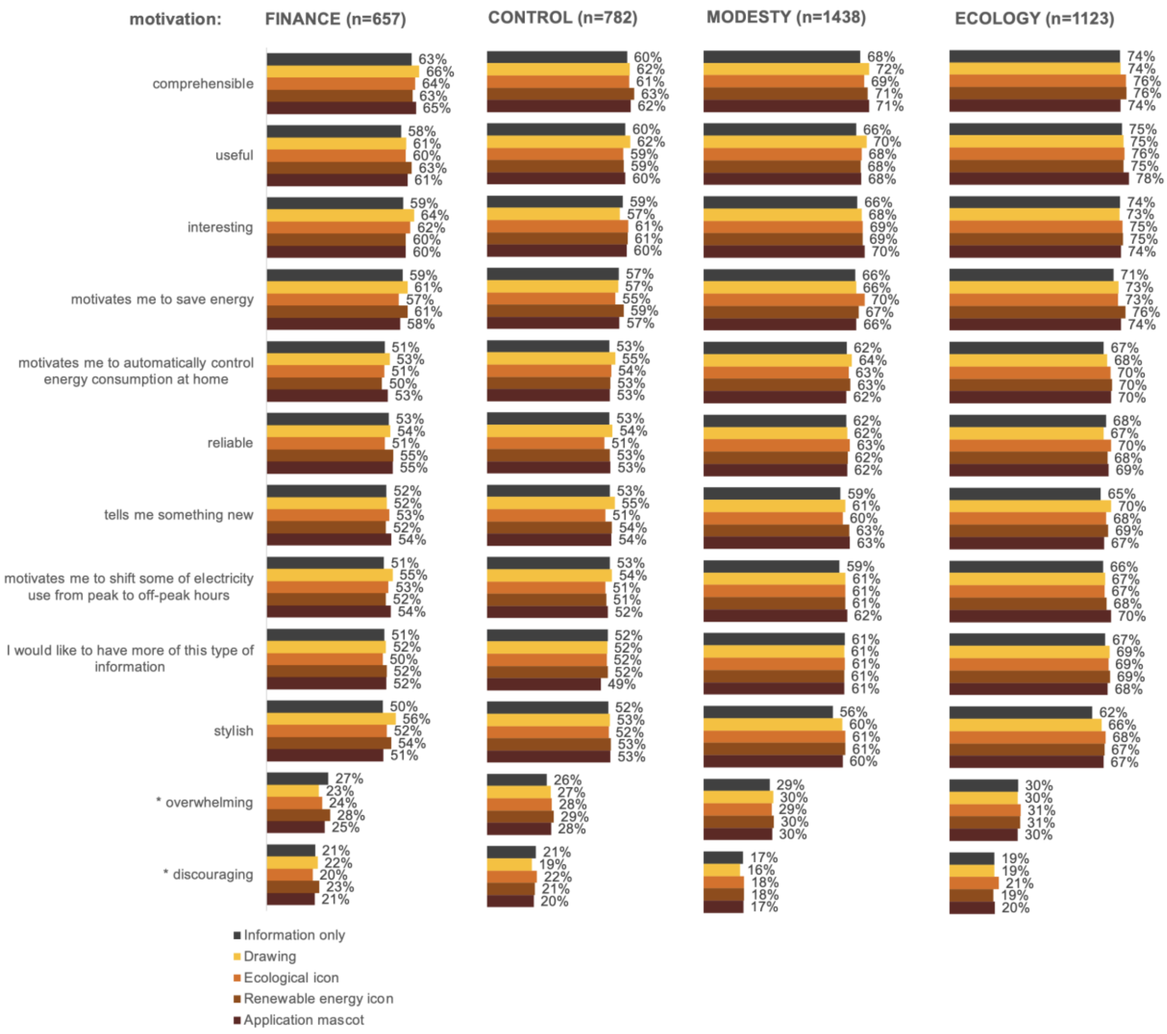
5.3 Type of graphic element in the message versus motivation to save energy

In this section, we examine whether the different types of drawings placed next to an energy literacy building message are perceived differently among people with different motivations to save energy (according to statements described in Section 4.1.2).

Figure 30. A cumulative comparison between graphical contexts for groups of users with different motivations to save energy, for all energy literacy statements



Overall, we can see that the type of drawing itself only slightly affects the perception of the message, slightly paving its reception in the context specified by the drawing.
The effectiveness of adding a drawing to a message is slightly higher among people who save energy due to the desire to protect the environment (Ecology) or who try to reduce the unnecessary waste of resources (Modesty). In these groups, information accompanied by drawings tended to score 2-3 percentage points higher than text alone.
For those motivated to save energy by possible savings (Finance) or the need to control spending (Control), adding drawings to the information did not produce a noticeable change in perception. In these groups, scores for information with drawings

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are mostly the same or 1 percentage point higher than for information without drawings.

The differences in scores between the different types of drawings are too small to make recommendations based on them indicating a particular graphic context. The above results show that for a large group of users (with Modesty and Ecology motivations and constituting the majority in the sample) adding a graphic element raises a little the ratings of the message and increases the motivation to use energy more economically and flexibly. For the remaining users (Finance and Control), this treatment does not worsen but also does not significantly improve the ratings of the information.

In case of such a procedure as adding a picture to the information content, one should not expect large differences in the ratings, but these are relatively simple changes that may improve the effectiveness of the message. Therefore, we recommend supplementing the messages with simple graphic elements, generally referring to the content, because it slightly improves the perception of the provided content among a considerable part of users.

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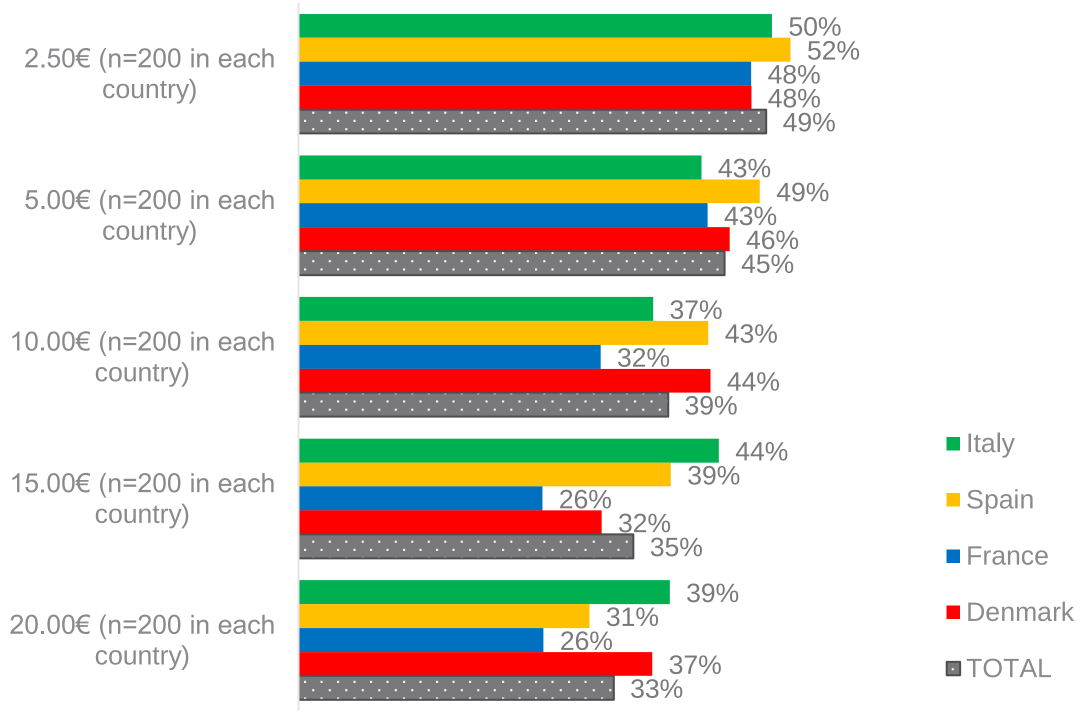
6 Economic valuation of the application

The study also assessed the perceived value of the application to the study participants. This was performed using a common method in economics known as contingent valuation, which helps the perceived value of a good to be assessed.
The respondents indicated whether they would be willing to purchase an application like the one evaluated in the study for a specified price. Each respondent answered this question once, and one random value (€2.50, €5, €10, €15, or €20) euros was specified in each case.

Figure 31. 'Would you be willing to pay € [2.50/5.00/10.00/15.00/20.00] to purchase an application for the management of energy consumption (a one-time payment for unlimited use)?'

Percentage of 'yes' answers



The survey results demonstrate that a large proportion of the respondents were willing to pay for this type of application: from 49% if the price were €2.50, to 33% if the price were €20.00. In other words, 51% of people were not willing to buy such an app at a price of €2.5, and 67% at €20.
A comparison of the results in the countries surveyed indicates that the lowest relative intention to purchase such an application can be found in France. In all countries the willingness to buy an application clearly falls when the cost rises from €2.50 to €5.00, and from €5.00 to €10.00. A further increase in price lowers the intention to buy the application in Spain and France, but for Italy and Denmark this effect is not that clear anymore.

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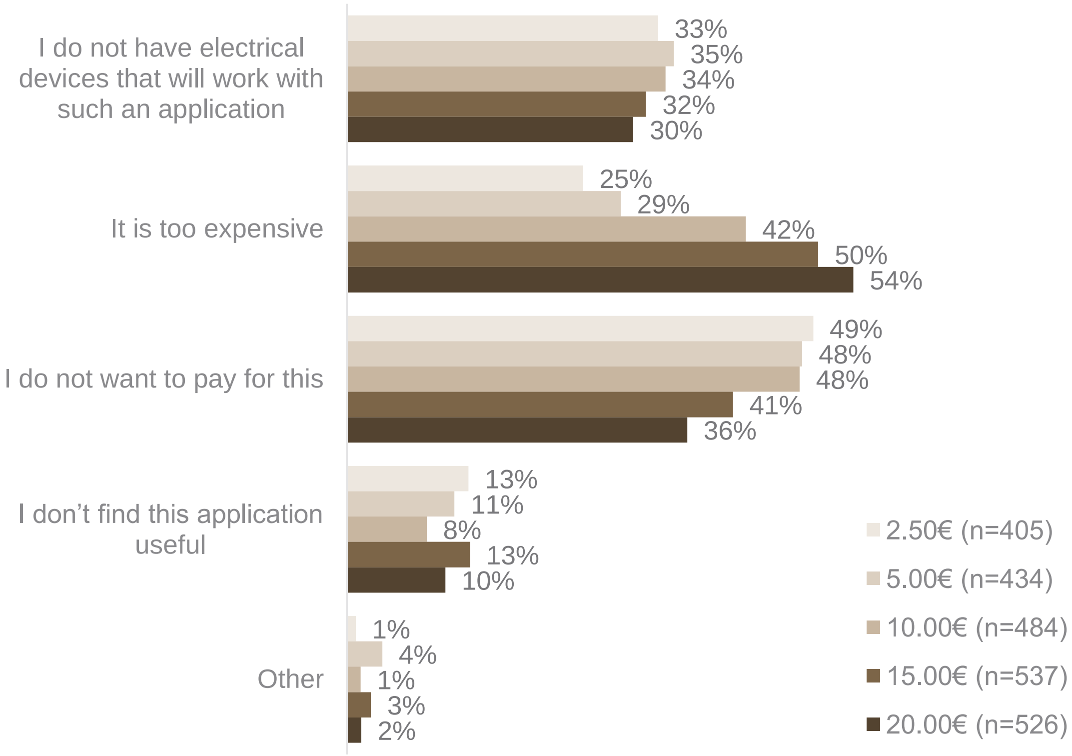
Figure 32. Reasons for declining to purchase a comparable application

(Asked if respondent answered 'no'; data for all countries)



Approximately one-third of the respondents would not wish to purchase a similar application to manage their electricity consumption because they do not have devices that such an application could control. For some respondents, the specified price was too high (ranging from 25% when the price was €2.50 to 54% when the price was €20.00); others would decline to purchase such an application regardless of the price (from 49% when the price was €2.50 to 36% when the price was €20.00). Only 10% of the respondents who did not wish to purchase such an application selected the answer 'I don't find this application useful'. This could be seen as confirmation of the high evaluations of the application observed in the other survey results.

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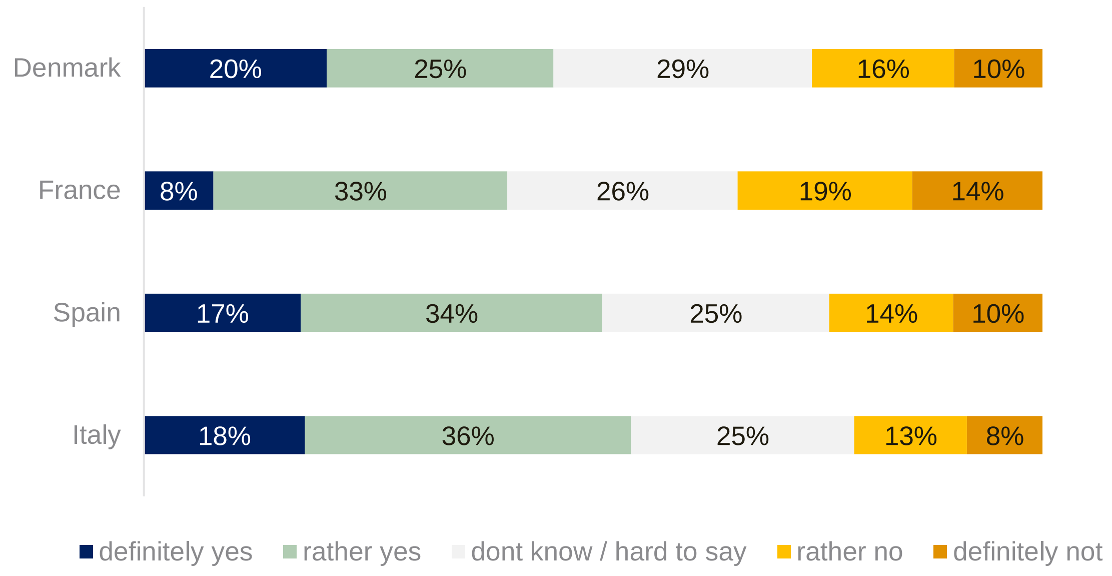
7 Concepts for electric vehicle charging in vehicle-to-grid mode

Respondents evaluated two concepts of electric vehicle (EV) charging. They were asked whether, assuming they owned an electric car, they would be interested in using the following solutions:

Concept A. ‘Suppose you own an electric car. There is a charging station in the car park of your workplace. The station works in such a way that it charges faster when there is power in the grid (during sunny or windy weather) and slower when less power is available from renewable sources. The electricity that is used in this station comes from low-carbon sources and is less harmful to the environment. There may be times when you plug in your car to charge, but it doesn’t charge at all that day. Would you be willing to plug in your car in there?’

Concept B. ‘Now, suppose that the charging station can discharge your battery to some extent (but never below half of its capacity). Over the following days, you would be able to get this borrowed energy back for free plus an additional [2.5/5/10/15/20] % free. Would you be willing to plug in your car there?’

Figure 33. Concept A: intention to use electric car charging stations



Respondents’ intentions to use such stations, in which the pace of charging depends on the current situation in the power grid, is quite high: approximately half of the respondents declared that they would or rather would be willing to use such stations. The highest interest can be observed in Italy (54% indicated 'definitely yes' or 'rather yes'), and in Spain (51%). The lowest can be observed in France, where only 8% would be willing to use such a station and 33% probably would.

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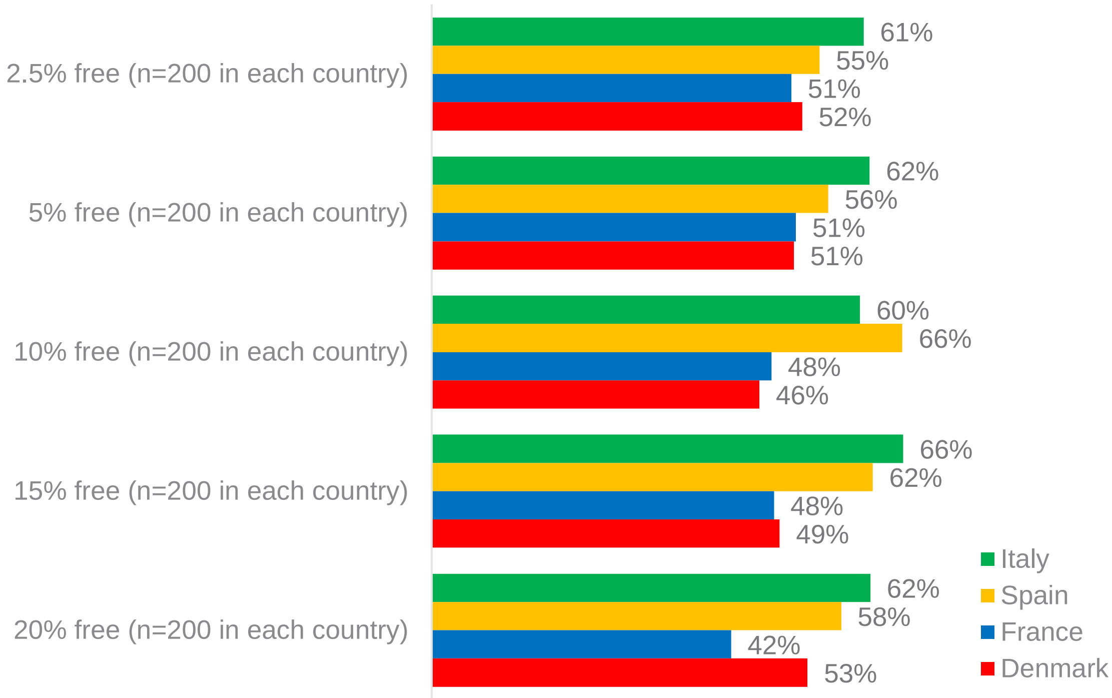
Figure 34. Concept B: intention to use electric car charging stations, depending on the reward for the energy borrowed

(Sum of answers 'definitely yes' and 'rather yes')



Respondents' acceptance of an electric car charging model in which, in certain cases, their cars can return part of their energy to the grid before recovering it later does not depend on the size of the energy bonuses offered as rewards for their consent. The highest acceptance for such a solution could be found in Italy and in Spain (approximately 60%); France and Denmark indicated approximately 50% acceptance.

It should be noted that this question entailed difficulty for the respondents, as it required them to imagine a situation that was completely unfamiliar to them; it involved not only owning an electric car and charging it at a station, but also assessing the specific billing rules for such charging. For this reason, it would be advisable to verify respondents' understanding of this concept in qualitative interviews during future studies.

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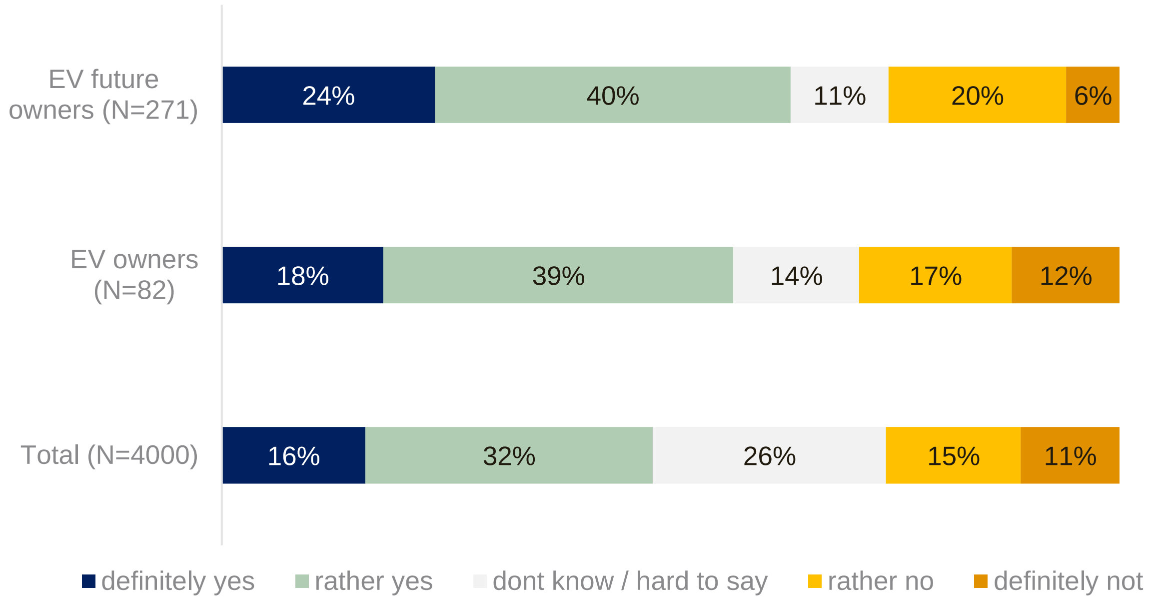
7.1 Evaluation of electric vehicle charging concepts among respondents who own or intend to purchase electric cars

Below are the evaluations of both concepts for EV charging (described in section 7) among respondents who are current users of electric cars and those who declare interest in purchasing such vehicles.

Figure 35. Concept A: intention to use electric car charging stations



Current and future EV users evaluate the concept of charging an electric car with an intensity that is dependent on the situation in the power grid more favourably than the overall survey sample does. The percentage of undecided respondents is also significantly lower than in the overall sample. These results confirm the high attractiveness of concept A: flexible modification of car charging intensity depending on the situation in the electricity grid.

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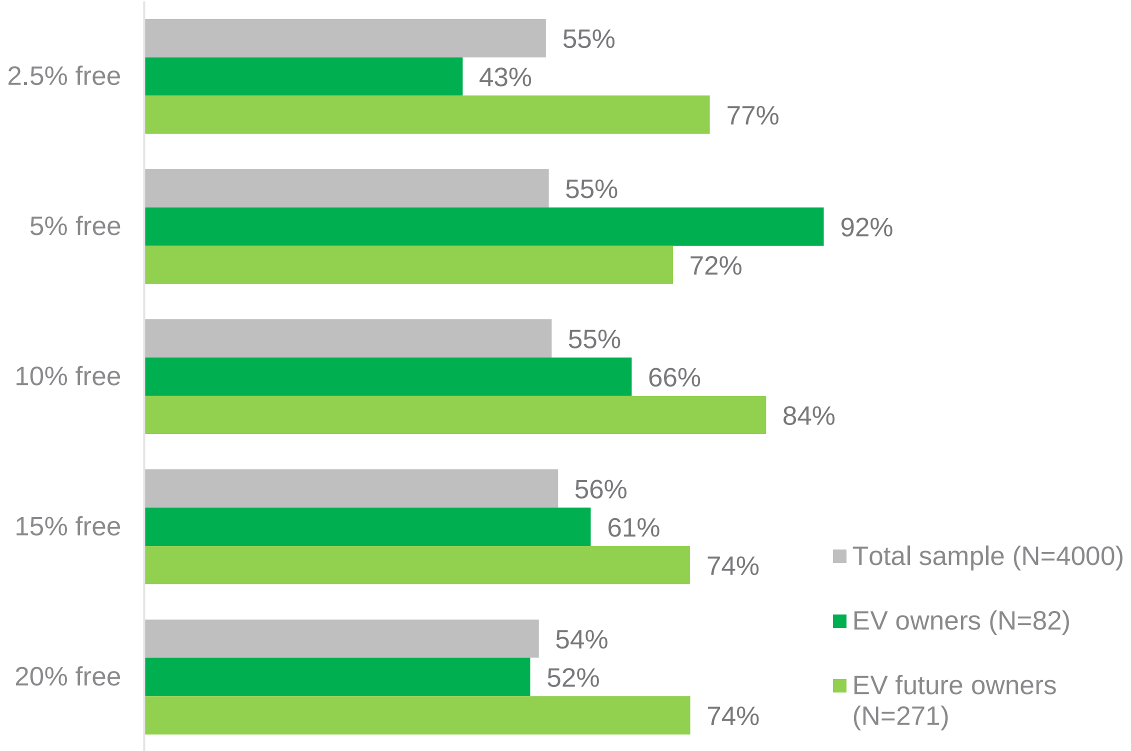
Figure 36. Concept B: intention to use electric car charging stations, depending on the reward for energy borrowed

(Sum of answers 'definitely yes' and 'rather yes'; respondent group counts (total; EV owners; EV future owners) refer to all reward values. Each respondent saw only one randomly selected reward value.)



Interest in concept B (the possibility of giving part of the energy stored in their cars to the grid, and later recovering it with a bonus) is higher among both current and future EV users than in the total sample. The high variability of results in the group of current EV users can be explained by their low numbers: 82 respondents for all variants of bonus energy value.

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8 Well-liked elements of the application

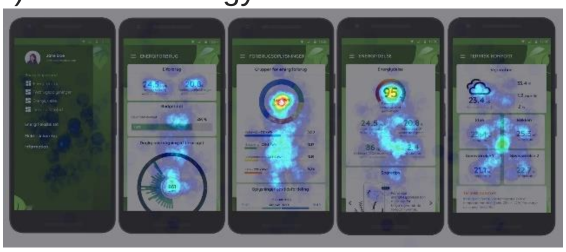
The respondents were asked to indicate which elements of the application they liked. The following screenshots depict the areas that the respondents found attractive.

All the responses are shown in the form of heat maps. Red indicates the highest number of favourable responses; blue and violet indicate the lowest.

It can be seen that respondents' attention was drawn to graphs, large numbers, and graphical elements. It is worth noting, however, that the graphical elements that differentiated the standard and eco versions of the application did not attract respondents' attention and were not consciously indicated as positive or negative elements of the application.

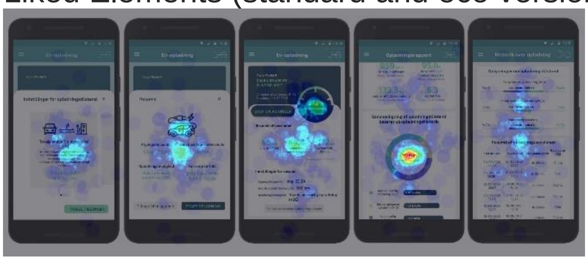
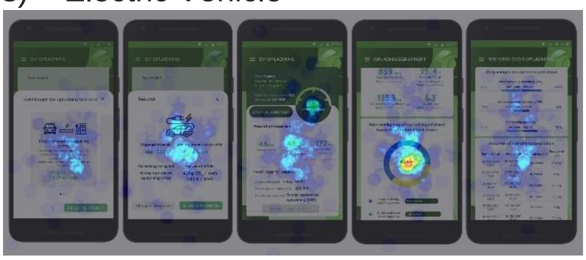
8.1 Denmark

Liked elements (standard and eco versions) – Home Energy

Liked elements (standard and eco versions) – Energy Flexibility


Liked Elements (standard and eco versions) – Electric Vehicle

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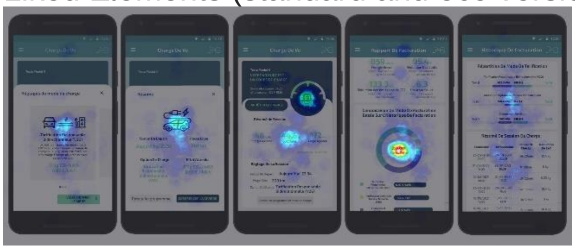
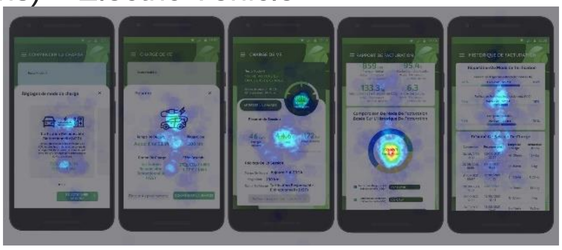
8.2 France

Liked elements (standard and eco versions) – Home Energy


Liked elements (standard and eco versions) – Energy Flexibility

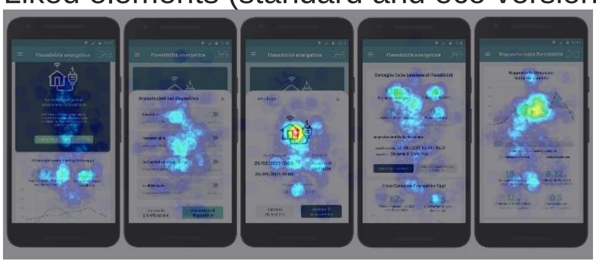
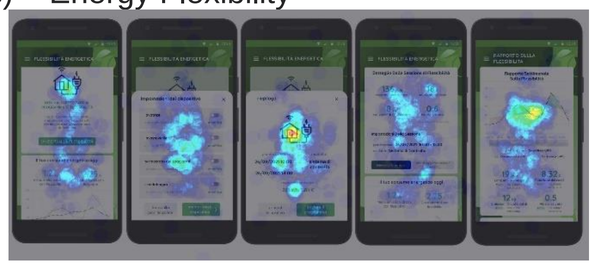

Liked Elements (standard and eco versions) – Electric Vehicle

8.3 Italy

Liked elements (standard and eco versions) – Home Energy


Liked elements (standard and eco versions) – Energy Flexibility

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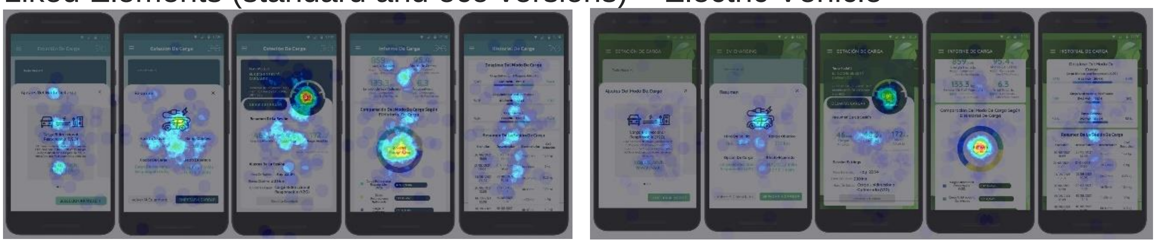
Liked Elements (standard and eco versions) – Electric Vehicle

8.4 Spain

Liked elements (standard and eco versions) – Home Energy

Liked elements (standard and eco versions) – Energy Flexibility

Liked Elements (standard and eco versions) – Electric Vehicle



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9 Conclusions

Most electricity users are making efforts to save electricity, with over 70% of people in all countries surveyed declaring this. Among the reasons for saving, those related to resource use or the environment predominate (about 60% in total). Saving energy to have more control over expenses or to have more money for other expenditures is less common (around 40% in total).
In the context of such widespread interest in saving energy, an application to manage energy consumption could potentially be of interest to a wide range of electricity users.

The mobile application prototype tested in the study was highly rated in all countries surveyed. According to about 60% of users, it is useful and motivates them to save energy and use energy more flexibly.
A significant part of the users declare that they would be interested in buying such an application (from ca. 30% of the users at the price of 20.00€, to ca. 50% at the price of 2.50€). People who are not interested in buying the application do not evaluate it negatively, but they are not interested in it because they do not have devices that the application could control or the cost of the purchase is a barrier.
Evaluation of individual elements of the application shows that graphic elements - icons, diagrams, drawings, large numbers - are particularly positively evaluated. Such elements make the application more visually attractive and are worth using to increase user engagement.
In the study the application was evaluated in two graphic versions - base and ecological. The results suggest that the app with graphics referring to ecological themes has more potential, which may be due to the fact that most users are trying to save energy due to ecology or resource conservation. In this - numerically dominant - group, financial motivation is less important.

Several different ways of building energy literacy were also evaluated in the user study. This was done using five pieces of information about electricity, which were shown in several visual variations (without a picture or with one of the four pictures).
The results indicate that information about the functioning of the energy system is interesting for about two-thirds of the users, for about a quarter it is overwhelming, and for less than 20% it is discouraging.
Adding a graphical context to the information does slightly improve its reception among users, so we recommend supplementing energy literacy information with a drawing. However, we find that the type of drawing does not matter significantly - users rated the content similarly in any of the four graphic variants tested.

Finally, the study tested concepts for new ways of charging electric cars, in which the rate at which the car is charged depends on the current situation on the electric grid.
The results indicate that about half of the people would be interested in using a charging station that charges the car faster when the electricity comes from low-carbon sources and slower when the electricity generation requires high CO2 emissions.
Similar preferences persists when assessing the concept of a car charging station with the V2G option, in which, in specific situations, energy may be taken from the car's battery. In this case, about half of people declare their interest in using such a station, regardless of the level of compensation for the energy made available. This indicates that the incentive to use this solution is not financial, but more important is responsible and more efficient use of energy.

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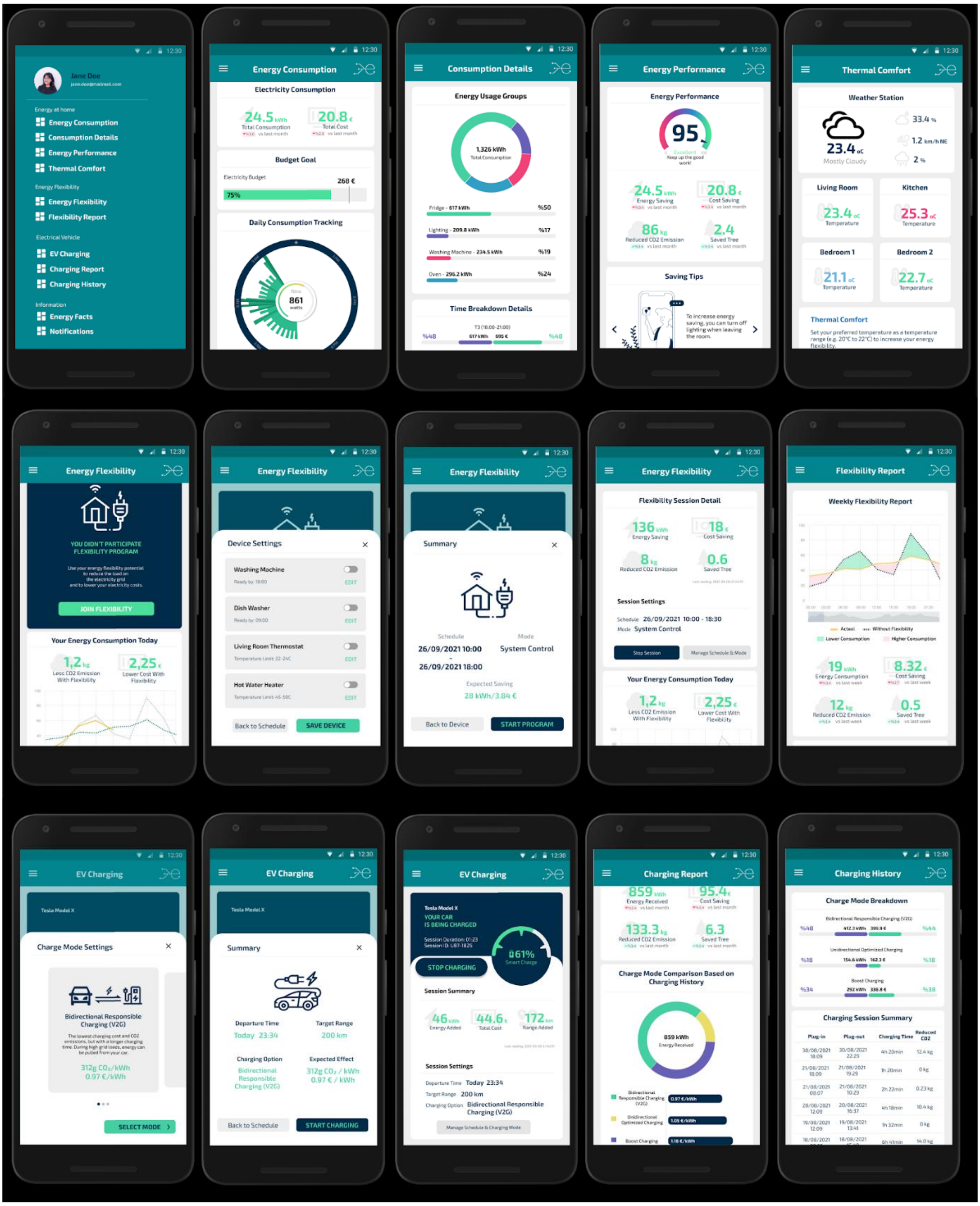
10 APPENDIX

10.1 Interactive prototype of the application

We prepared the interactive application in two graphic versions: standard and eco. Below are screenshots of both versions that were tested during the study.

Standard version:



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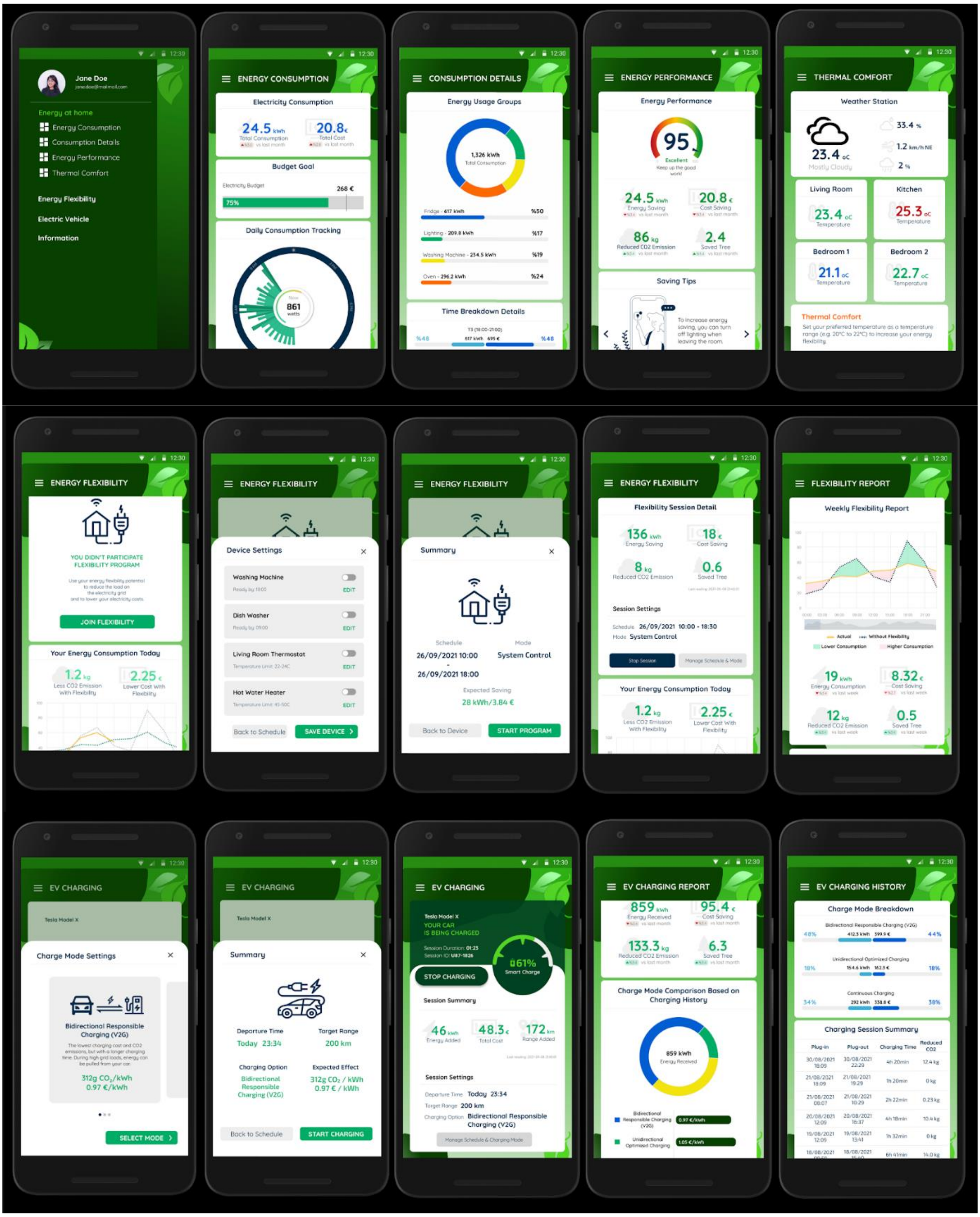
Eco version:



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10.2 Energy Literacy

List of Energy Literacy messages tested in the research.

A – Energy balance
'The amount of energy produced and consumed must always be in balance.
We do not have energy storage, so it is important to use renewable energy when it is available (e.g., when the sun is shining or the wind is blowing), and, on the other hand, to limit our use of energy when it comes from burning fossil fuels. Try to use electricity efficiently when it comes from renewable sources, such as when the weather is sunny. This reduces energy costs and greenhouse gas emissions'.

B – Energy flexibility
'You can contribute to reducing greenhouse gas emissions and the cost of energy production by shifting some activities that require energy to times of day when energy is produced from renewable sources. For example, doing laundry during the day (when the sun is shining) rather than in the evening (when energy comes from the burning of coal or gas)'.

C – Smart devices
'There are already smart home appliances that can automatically adjust their power consumption according to the current grid situation, so as to make the most of renewable energy, which is cheaper and produces lower greenhouse gas emissions than energy generated from fossil fuels.

This way, you do not have to adjust appliances, such as fridges, air conditioning units, washing machines, dishwashers and boilers yourself; they will automatically use energy in a smart way'.

D – Peak demand
'Most of us start using a lot of electricity when we get home in the evening. This causes a big peak in demand for electricity from the grid. Supplying this energy is expensive and requires large amounts of fossil fuel-powered capacity.

Shifting the use of some appliances to different times (e.g. turning on the washing machine or dishwasher at a different hour) reduces energy flows on the grid and causes us to use less fossil fuel. This reduces the cost of energy production and greenhouse gas emissions'.

E – Differences in emissions from different electricity sources
'Electricity can come from different sources that have different environmental impacts. For example, when it is produced using coal, it can be up to twenty times more damaging to the environment than when it is produced using hydroelectric power.

By using more of your energy from low-emission sources, you reduce the cost of energy production and the environmental impact'.

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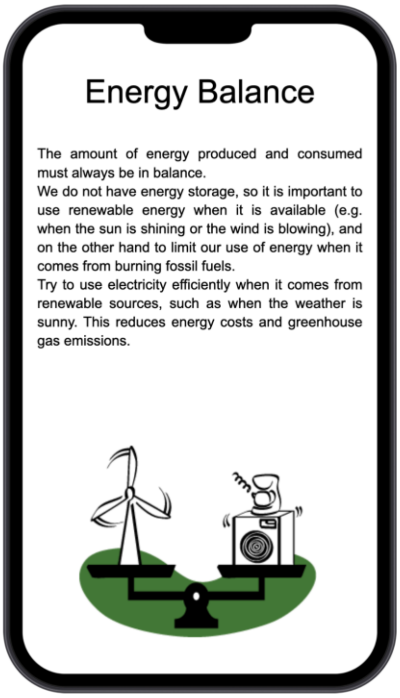
10.3 Graphical presentation of the energy literacy messages

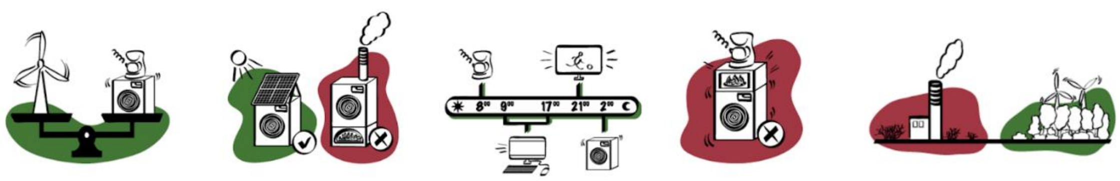
1. Each message was presented in the format shown below. The information consisted of a title, text, and (optionally) an image.



2. Each message was presented in one of five conditions:

   a) text only

   b) text with an image related to the information, as shown below:



1. Energy Balance 2. Energy Flexibility 3. Smart Devices 4. Peak Demand 5. Differences in emissions from various electricity sources

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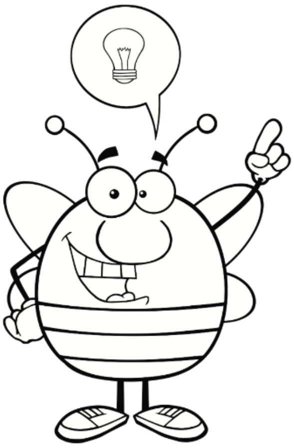
c) text with an image that introduces the ecological context:

d) text with an image that introduces the context of renewable energy sources:

e) text with an image that depicts the application's mascot:



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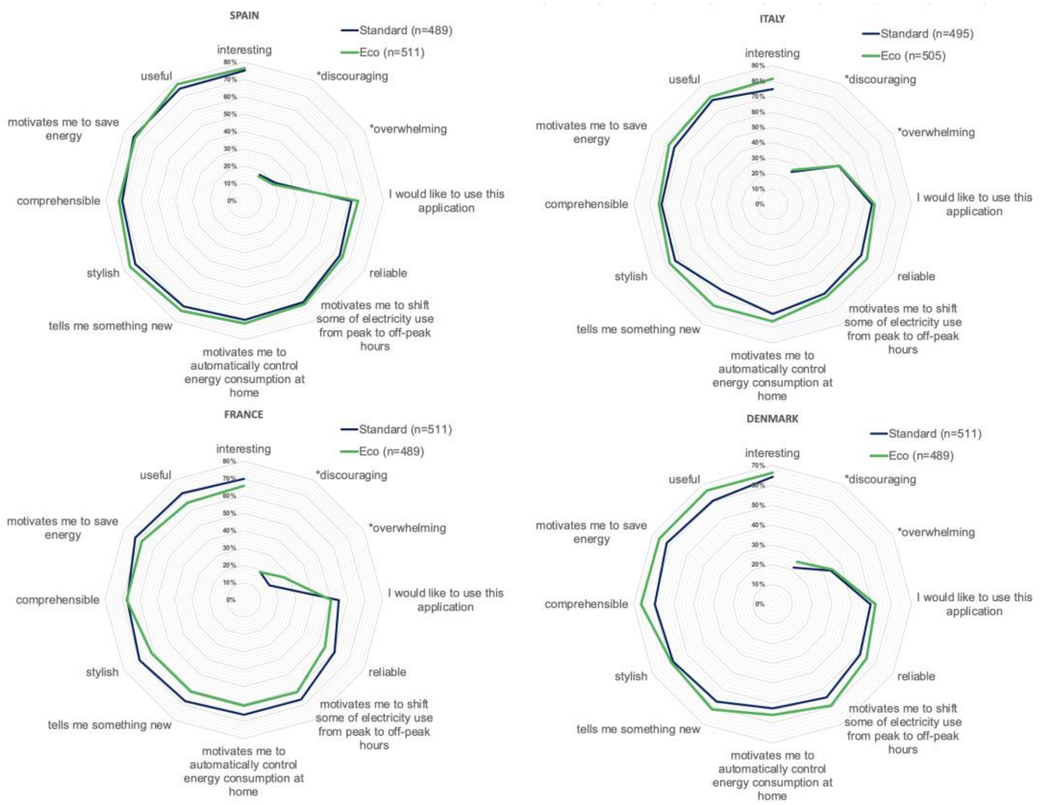
10.4 Ratings of each section of the application (Energy at Home, Energy Flexibility, and Electric Vehicle) by country and motivation for energy conservation

10.4.1 Detailed evaluation of the application: Energy at Home

1a. Evaluation of the 'Energy at Home' functionality by country. Percentage of respondents who selected responses of 4 ('rather yes') or 5 ('definitely yes') on a scale of 1 to 5.



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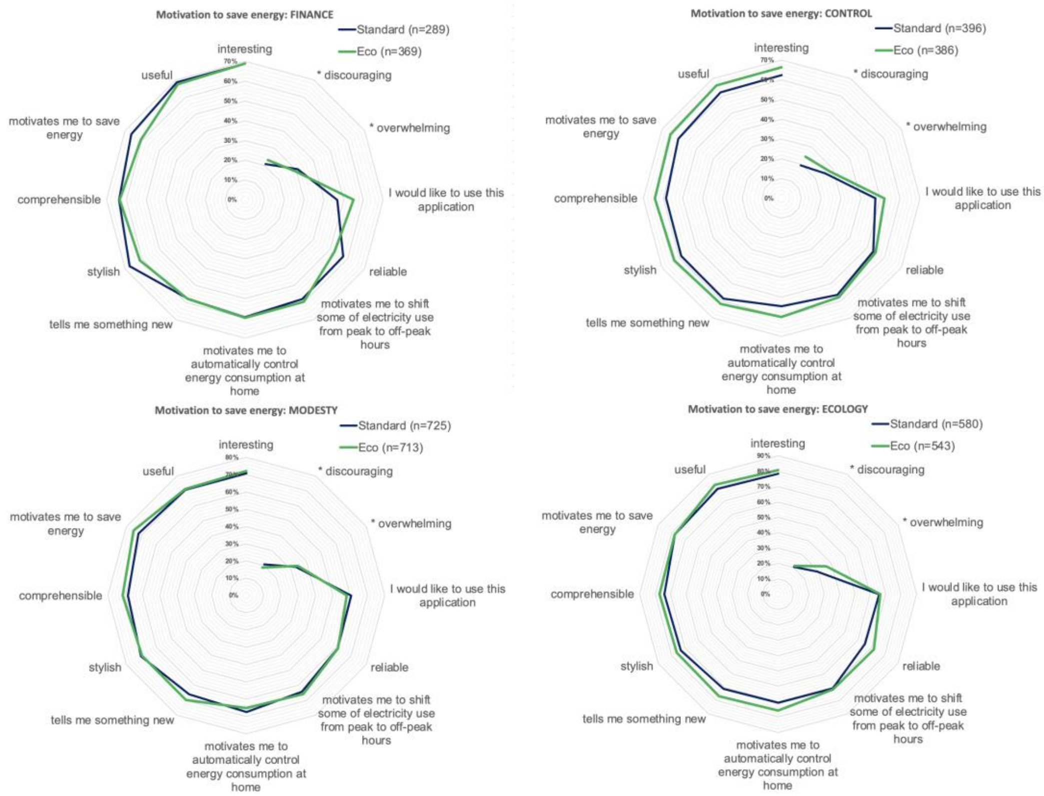
1b. Evaluation of the 'Energy at Home' functionality by reason to save energy. Percentage of respondents who selected responses of 4 ('rather yes') or 5 ('definitely yes') on a scale of 1 to 5.



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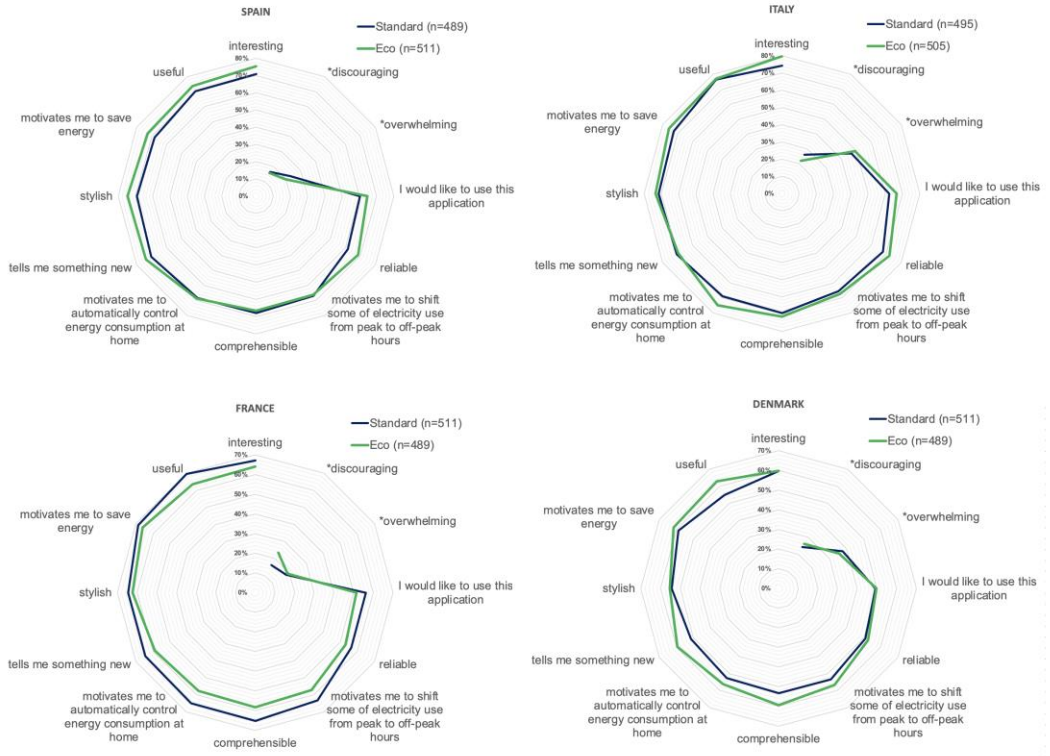
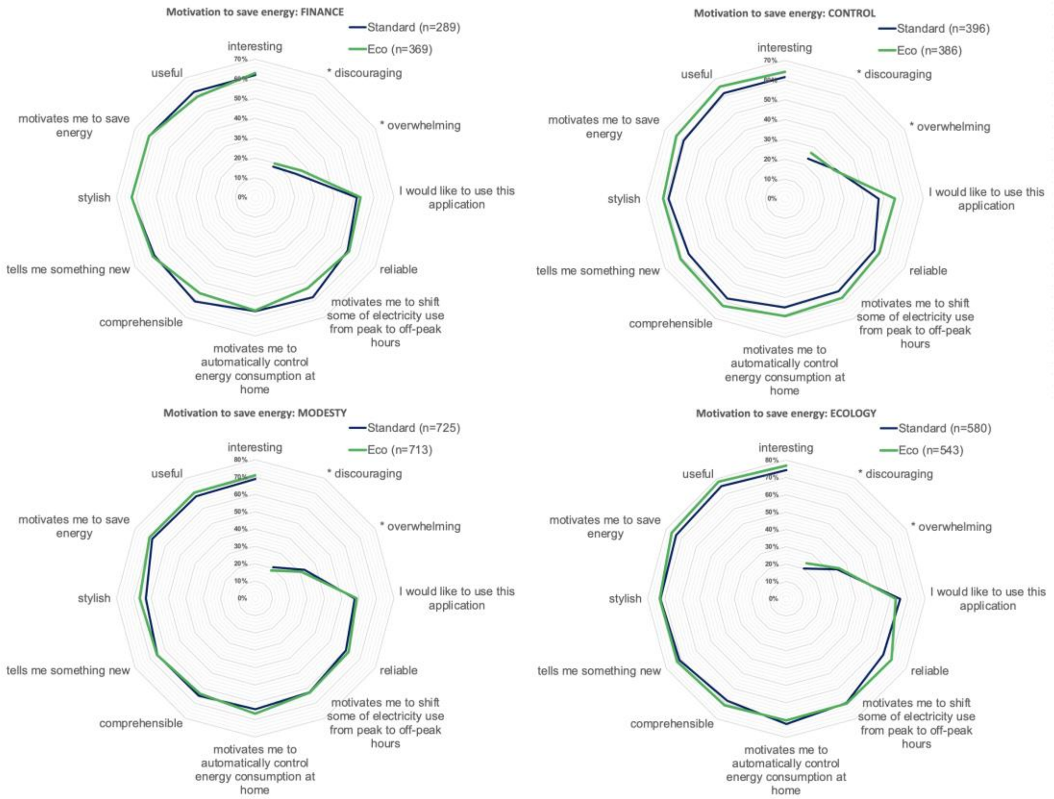
10.4.2 Detailed evaluation of the application: Energy Flexibility

2a. Evaluation of the 'Energy Flexibility' functionality by country



2b. Evaluation of the 'Energy Flexibility' functionality by reason to save energy



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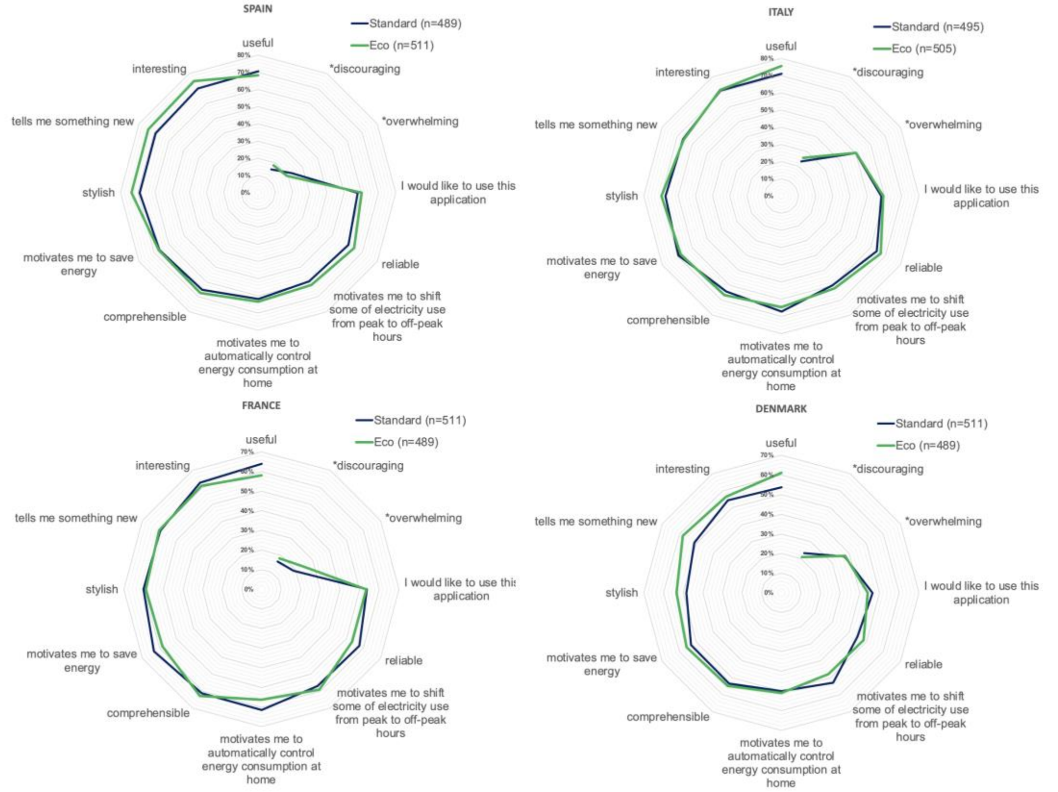
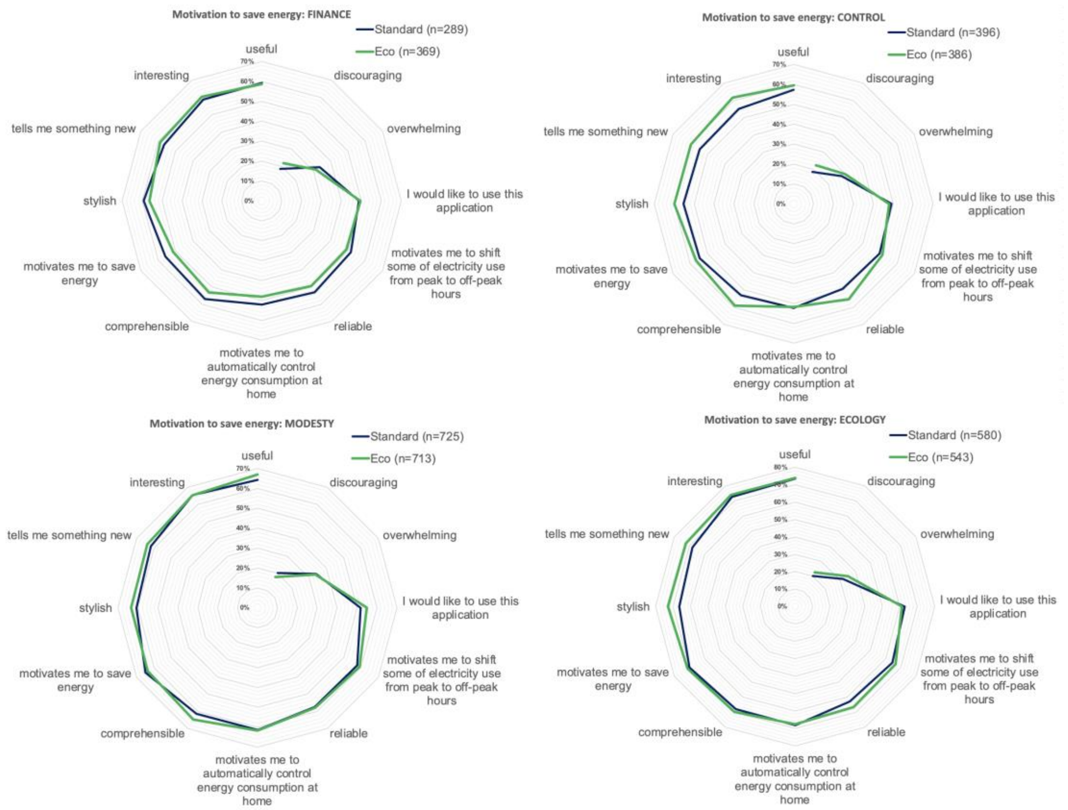
10.4.3 Detailed evaluation of the application: Electric Vehicle

3a. Evaluation of the 'Electric Vehicle' functionality by country



3b. Evaluation of the 'Electric Vehicle' functionality by reason to save energy



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