Energy end-user behaviour characterization

Deliverable D2.1

AUTHORS : JAROSŁAW KOWALSKI ; ZBIGNIEW BOHDANOWICZ ; BEATA ŁOPACIUK-GONCZARYK ; CEZARY BIELE

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PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
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Document history

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Introduction

The acceptance and adoption of any technological innovation is a complex process, influenced by many different factors. The technical efficiency and usefulness of the new solution are important, but there are also other aspects of the process that should be considered. The aim of this document is to describe the individual and social aspects affecting end users in terms of acceptance and use of future Ebalance-plus functionalities.

The document consists of two main parts - the first one contains a description of the results of a quantitative survey conducted on electric energy consumers in four countries (Denmark, France, Spain and Italy). The aim of this part is to build a broader picture of attitudes and habits related to the use of electricity.

The second part is the results of qualitative research - here the source of knowledge is mainly information obtained from facility managers from demo-sites (also from 4 countries: Denmark, France, Spain and Italy). The aim of this part is to take a more detailed look at the specifics of each type of demo-sites, to create a map of stakeholders involved in the functioning of demo-sites and to identify factors influencing their behaviour. Thanks to this, knowledge has been gathered to determine the social context related to the functioning of new functionalities designed and tested within the Ebalance-plus project.

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Key Findings

By taking into account both the perspective of individual electricity consumers and experts managing integrated energy systems in academic buildings, the research project has comprehensively assessed the current state of energy awareness and identified the challenges for the upcoming energy transformation.

The study assesses motivations and barriers to energy saving, factors influencing the equipment of households to generate and store energy and increase efficiency of energy use. The study also presents a valuable perspective of experts who professionally reduce energy consumption in the buildings they manage.

The countries surveyed are diverse - due to the structure of ownership of the properties, the number of people in an average household, the level of income and the equipment of the household with devices increasing energy efficiency and independence. Of course, when considering the potential for specific solutions to increase energy flexibility, it is also necessary to take into account the differences in climate conditions and the specificity of the energy sector in the given country (e.g. nuclear power in France, wind farms in Denmark).

The main implications of the study on the attitudes of individual consumers to enhance the flexibility of their energy demand or reduce energy consumption are summarized in the points below.

Energy efficiency:

- More than 80% of energy consumers in the countries surveyed declare that they want to save electricity and choose energy-efficient devices when buying new electronic equipment for their homes.
- The main factor influencing the willingness to save energy is financial, and ecological considerations are mentioned in second place.
- In the opinion of the respondents, the barrier to effective energy saving is the lack of effective and easy to apply solutions that give a noticeable reduction in energy consumption.
- Larger installations for energy production and storage are currently chosen by a small percentage of households with high income. The challenge is to develop solutions that would increase energy independence of smaller households (both houses and blocks of flats), with more limited financial resources. It would be advisable to prepare solutions dedicated not only to individual consumers, but also to groups of houses or entire blocks of flats, available in financial plans adapted to the capabilities of less affluent people.
- For a major part of people, environmental considerations are an important motivator to change the way they use electricity. Therefore, in a situation where the financial savings resulting from the introduction of solutions limiting and making the demand for energy more flexible are small, it is advisable to focus on environmental benefits in communication.

Car ownership and future purchase plans:

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- In all the countries surveyed, environmental considerations are the main factor in choosing the next car to buy. About half of the people surveyed declare that the next car they buy will be hybrid or electric.
- The cost of electricity at a level equal to the price of fuel for a car with an internal combustion engine is unacceptable to half of those who own or are interested in buying an electric car. Currently, most of these people expect that the cost of electricity to charge the car will be significantly lower than the cost of fuel for a traditional internal combustion engine.

Concepts for smart energy management:

- All the concepts assessed in the study are understandable to about 80% of the respondents, and more than half of the respondents are interested in using such solutions.
- The respondents want to have control over energy management systems.
- The intention to use the concepts is motivated by financial benefits, simple operation, trouble-free (preferably free of charge) installation and positive environmental impact.

Attitudes:

- Attitudes towards technology are usually positive. Technology is usually something that makes life easier, helps, gives access to new information.
- Sense of security and living in respect for nature are important goals in life, mentioned right after health, happiness, family and friends.
- The people surveyed are generally aware of climate change and consider it a serious problem, both for their country and for them personally.

Interviews with facility managers have shown that when introducing a technological innovation on campus, one has to be aware that this is a change that potentially affects many aspects concerning work and study organization. Therefore, it is important to take into account the needs and habits of all campus users, i.e. researchers, office workers and students. In order to minimize the risk of misuse of the technological solution by the users, it is advisable to test it at subsequent stages of its development - concept, prototype and implementation of the finished product.
Moreover, it is advisable to prepare simple, legible information about the new solution and provide technical support in case of problems.
It should also be remembered that the primary objective of facility managers is to guarantee energy security for the campus so that it can function properly. Therefore, solutions that save energy or increase the flexibility of demand must not be associated with difficulties for people using the campus, because in practice it will make them impossible to implement.

It is also important that the energy transformation at universities is not a one-off event, but rather a long, gradual process. Individual universities participating in the study were at different stages of this process and differed in organizational culture, technological competence, budget allocated for energy-saving solutions, etc. Therefore, when preparing smart energy solutions for such institutions, it is advisable to take into account their specific needs and prepare solutions that will be easy to implement in most entities, including those less technologically advanced, and devoting a smaller

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part of their financial and human resources to improve the energy efficiency of their buildings.

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1 The results of the quantitative study

1.1 Methodology

The quantitative survey was carried out in June 2020, in the four countries where the Ebalance-plus pilot sites are located: France, Spain, Italy and Denmark.
The data was collected by an online questionnaire, self-filled by respondents (CAWI), on a random stratified sample (by gender, age, city size, region, and level of education). People who are responsible or co-responsible for paying electricity bills or purchasing electrical appliances in the household were qualified to participate in the survey. A total of 3200 people took part in the survey, 800 in each country.
The data were subjected to quality control and weighed so that the data structure fully reflects the population structure in the surveyed countries, based on censuses. The survey was conducted by an external research agency IQS, which coordinated data collection in four countries.

The sample was gender-balanced (51% women and 49% men), people aged 18-65 years were surveyed (average age in the sample was 42 years). The sample selection was random-quota, the amounts were set for such variables as age, gender, size of the place of residence, education level and region of the country. The sample was weighted to the population structure of a given country (based on census data), the weights used were in the range from 0.7 to 1.3.

The questionnaire has been developed to gather a wide range of information on the use of electricity. The research covered topics such as: equipping the home and work places with electrical appliances, ownership and opinion on electricity production and storage devices, perception of the current level of electricity prices, factors influencing energy saving, potential for purchase of electric cars, attitudes towards technology, environment and energy transformation in the European Union. An important part of the study was the assessment of three concepts of technologies for intelligent management of electricity consumption (Automatic lighting control; External washing machine control; External charging control for an electric car), similar to those to be tested within the Ebalance-plus project.

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1.2 Electric energy use

1.2.1 Use of energy and facilities in the households

Equipping households with installations for heating and cooling of rooms and for generating and storing electricity is shown in the figure below. The households in Italy have the most often the equipment for intelligent management of electricity consumption - 11% of households have photovoltaic panels, 27% have heat pumps and 12% have domestic water heating system. Very few households have electric energy storage systems - most often they are owned by Spanish households (4%).
In general, photovoltaic panels are the most common installation to generate electricity, and water and wind turbines are used considerably less frequently. Approximately one third of the households that are supplied with electricity generation facilities also have systems for storing electricity.

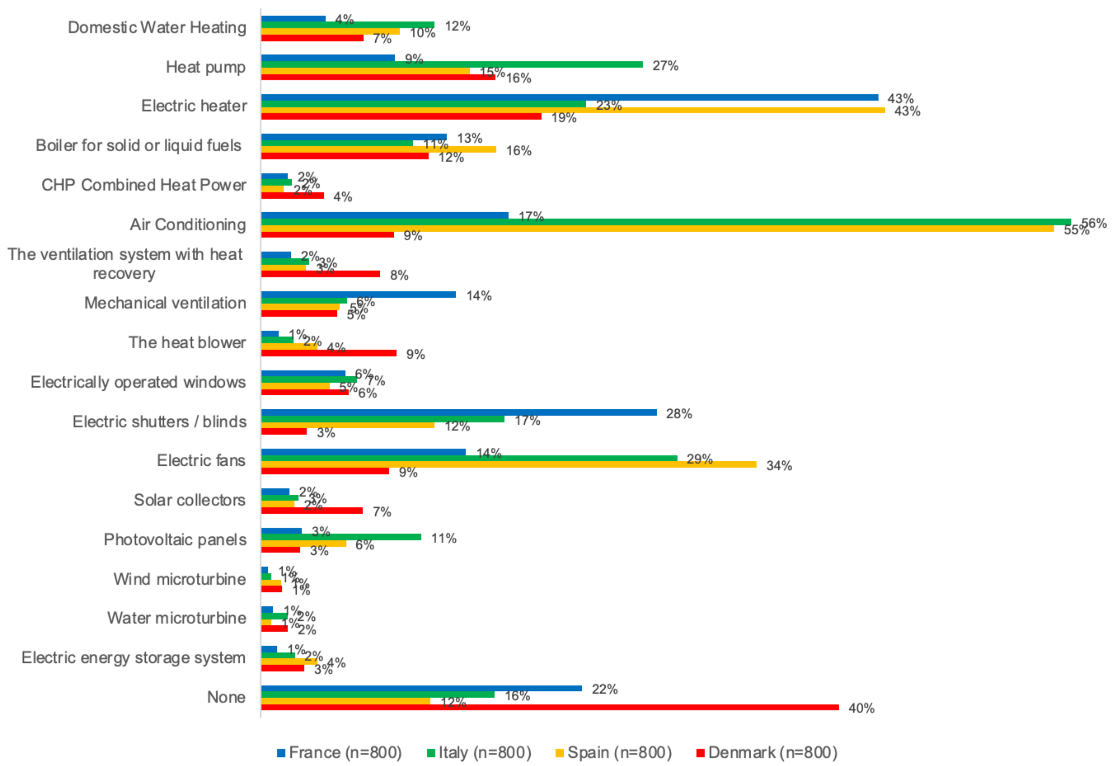

Figure 1: Which of the listed below installations / facilities do you have at home?

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In the countries surveyed, heating of houses is usually provided by traditional technologies. The most commonly used source of heat is a gas stove, especially often used in Italy (43% of households) and Spain (27%). The heating from the city network dominates in Denmark (37%) and in France the heating is the most often electric (31%).

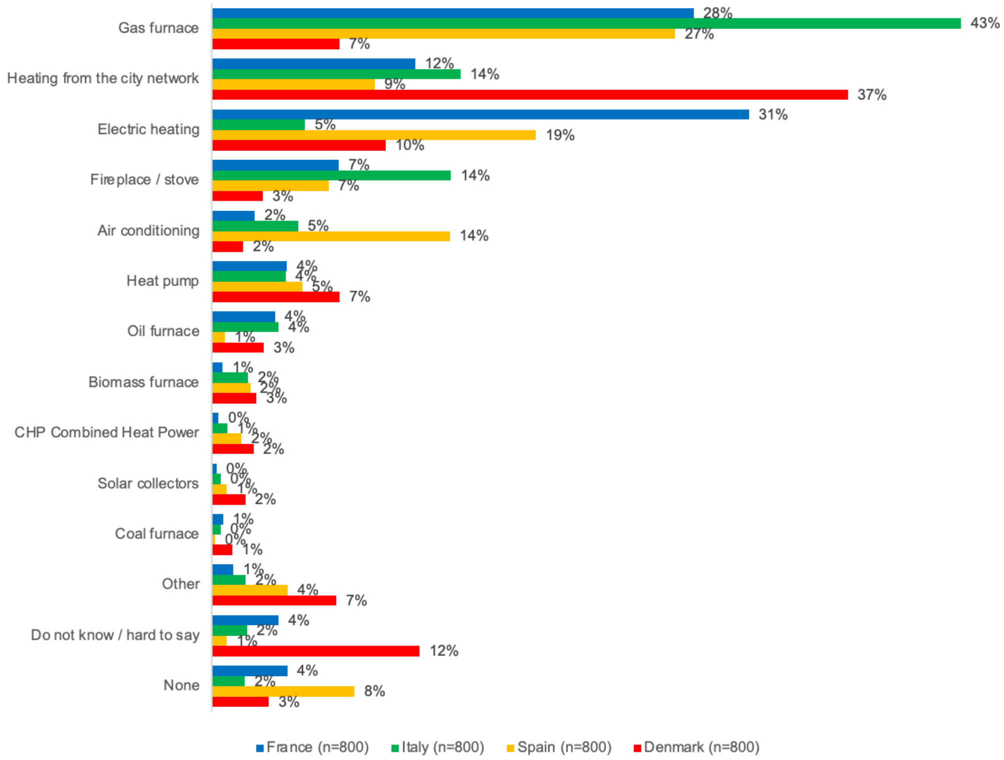

Figure 2: Which is the primary source of heating in your apartment / home?

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Among energy users, we are the most interested in a group of prosumers, i.e. households that have facilities to generate and store electricity (i.e. have at least one of the installations listed: photovoltaic panels, wind microturbine, water microturbine, energy storage system).

In addition to the above mentioned, when analysing the equipment of households with regard to the possession of devices limiting their demand for electricity from the network, we also distinguished solar water heating installations and systems limiting the consumption of energy needed for heating or cooling (heat pumps, recuperators).

The percentage of households with at least one installation in these categories is shown in the figure below. In France, the penetration of equipment to produce electricity energy or reduce demand for electric energy is the lowest (17%) and in Italy the highest (39%). On average, about 20% of the households in the countries surveyed have appliances increasing the energy efficiency of heating or cooling (heat pumps and recuperators), about 11% have systems for heating water with solar energy and about 8% have installations for electricity production. This equipment is more often used by households of wealthy and better educated respondents.

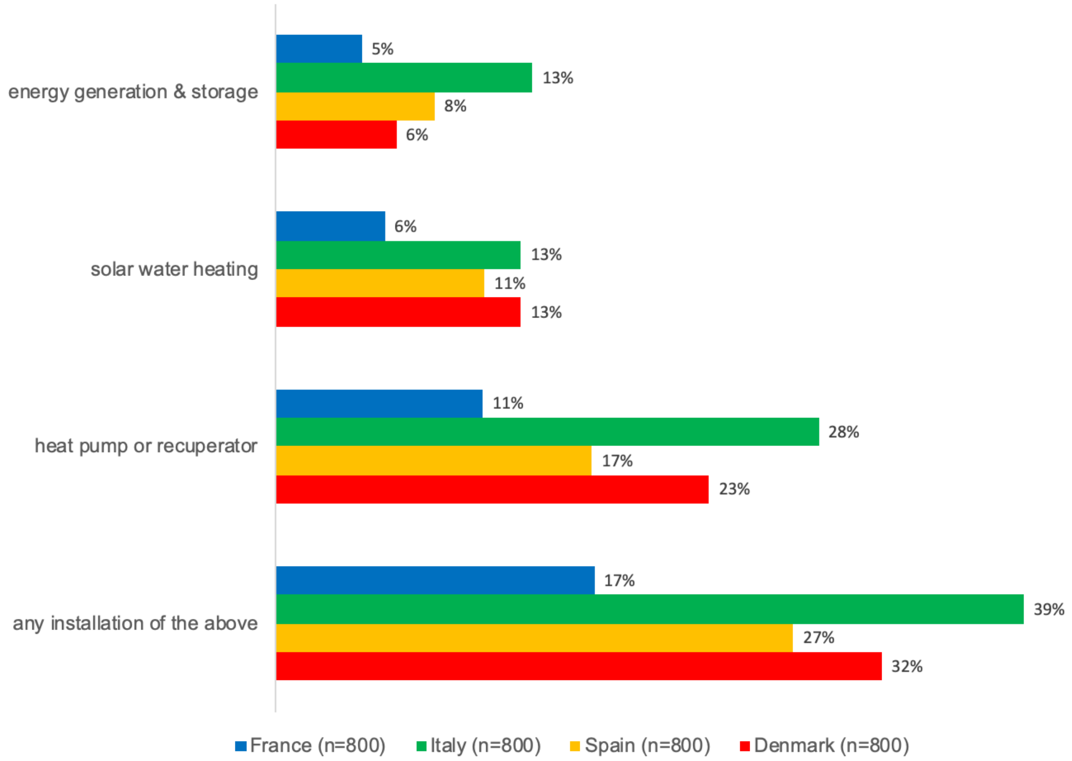

Figure 3: Which of the listed below installations / facilities do you have at home? – equipment with installations for energy generation and storage and for energy savings

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About half of the households surveyed do not intend to buy devices and installations within the next year (43% in Italy, 52% in Spain, 63% in Denmark and 67% in France).

Among the purchase plans, the most frequently mentioned devices are: Air Conditioning - mainly in Italy and Spain (16% each) and photovoltaic panels (16% Italy, 7% Spain). The relatively lower interest in purchasing solar energy production installations in France and Denmark can be explained by the lower sunshine in these countries and the availability of cheap electricity from nuclear power plants in France, or from wind farms in Denmark. The plans to purchase the remaining equipment are mentioned sporadically, by less than 7-8% of the respondents.

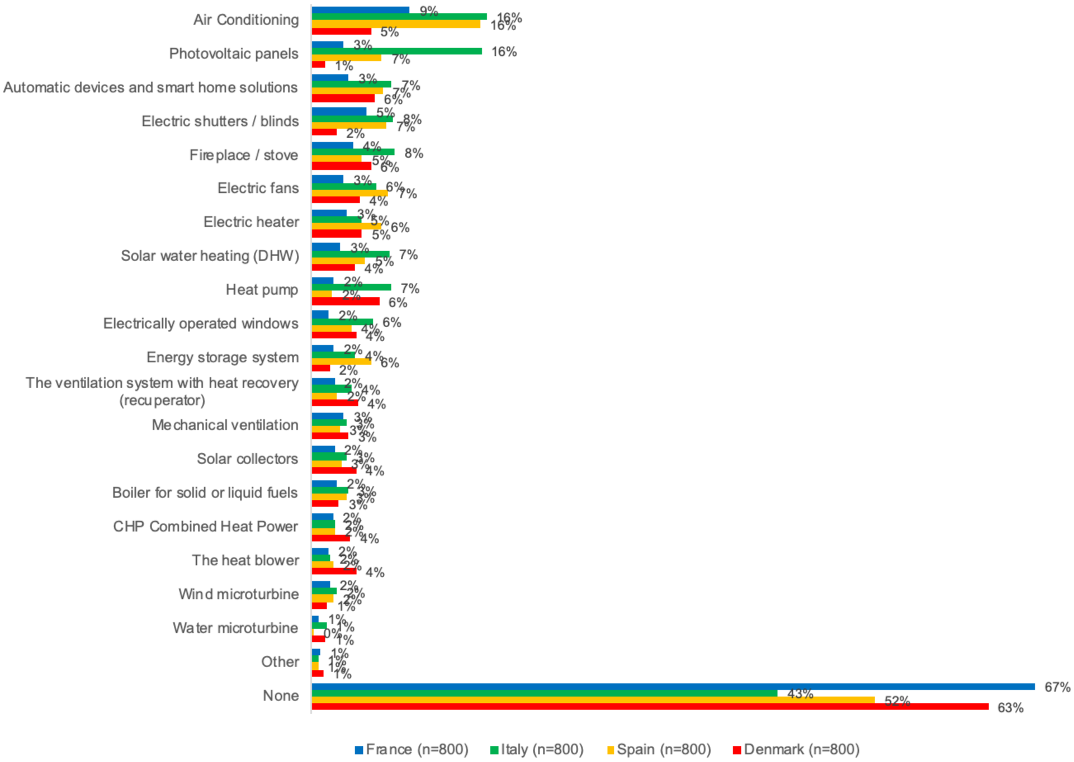

Figure 4: Which of the devices and installations listed below do you plan to buy in the next 12 months?

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Electricity production and storage facilities are used more often in workplaces and study places than at home. In the countries surveyed, between 13 and 20% of people say that such devices are installed in their place of work or study (most in Denmark - a total of 20%, the least in France - 13%). A substantial percentage of the respondents (between 26% and 55%) do not know if their workplaces have electricity production & storage.

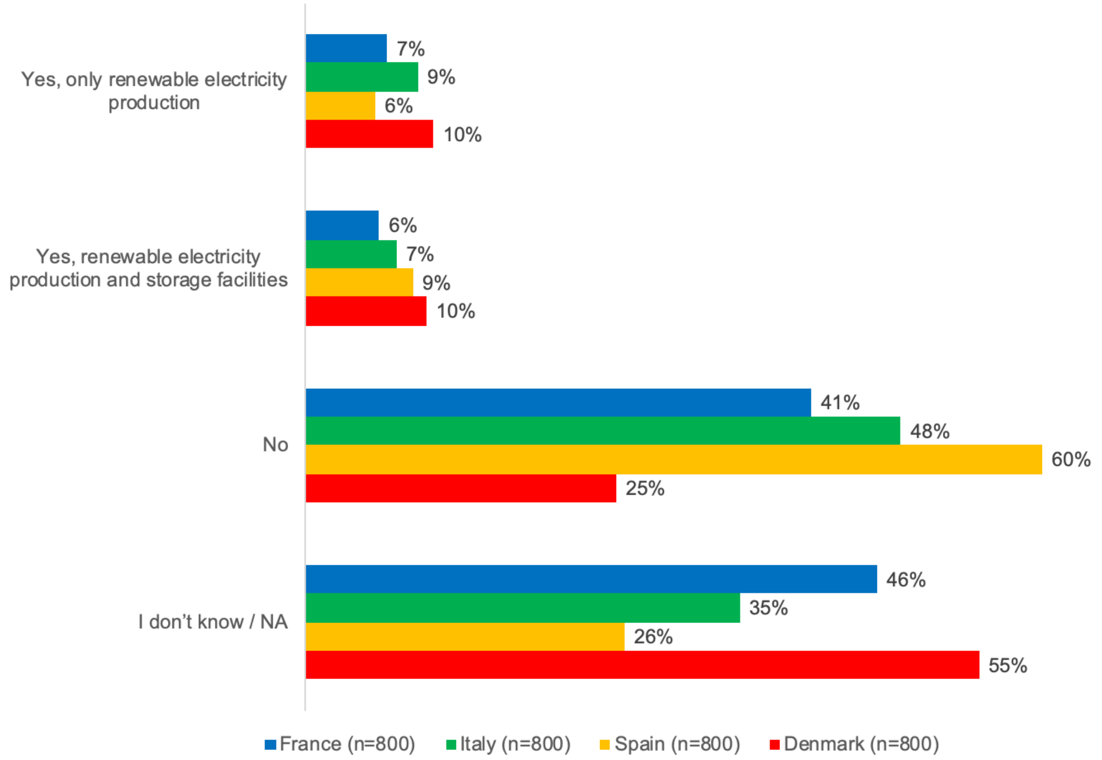

Figure 5: Are renewable electricity production and storage facilities installed in the building where you work or study (in normal situation, not pandemic)?

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Respondents who said there were no renewable energy production facilities installed in their place of work or study were asked if they would support such installations in these places. The highest support was expressed in Italy, where 81% of people are in favour of installing renewable energy equipment in their place of work or study. In the case of Spain it is 68%, in the case of France 66% and in the case of Denmark 43%.

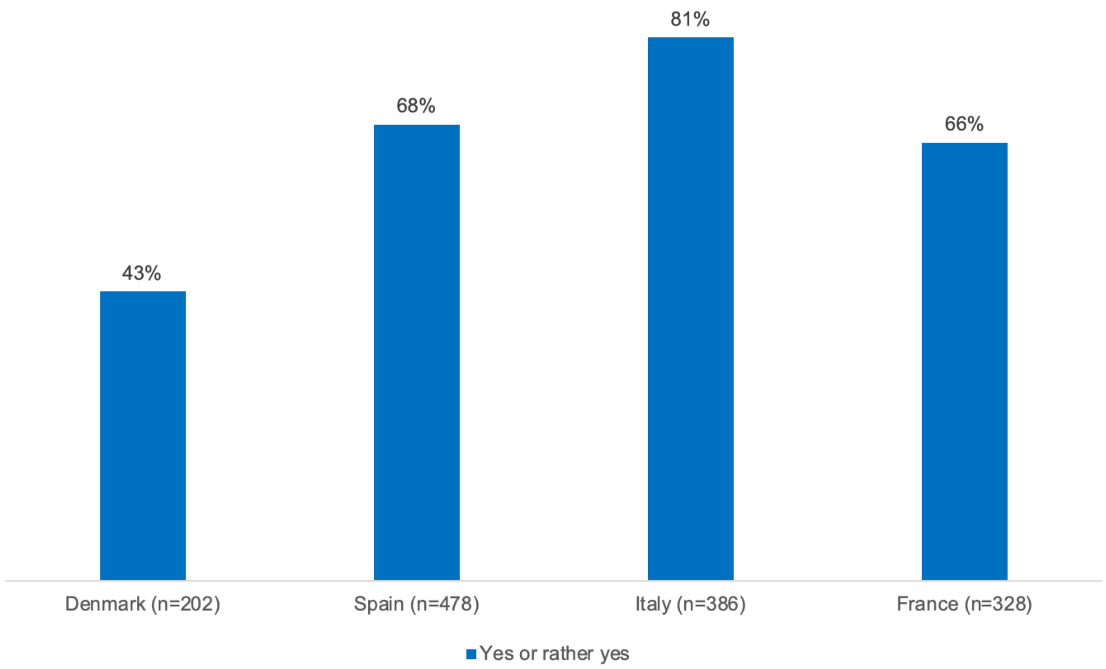

Figure 6: Are you in favour of installing renewable energy production and storage devices in your workplace or study (in normal situation, not pandemic)?

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1.2.2 Expenses and perception of electricity cost

Monthly spending on energy is the lowest in Spain, which is the poorest of the analysed countries. Denmark, on the other hand, despite being the richest country, has access to cheap energy from windmills, which seems to be reflected in the average expenses of households on energy in this country, slightly lower than in Italy and France.
Obviously, the larger the area of the house, the higher the expenses. There is no longer such a simple connection with the number of people in a household, which can be argued by the fact that the largest households are those in which, for example, there are no funds for the self-sufficiency of young people.

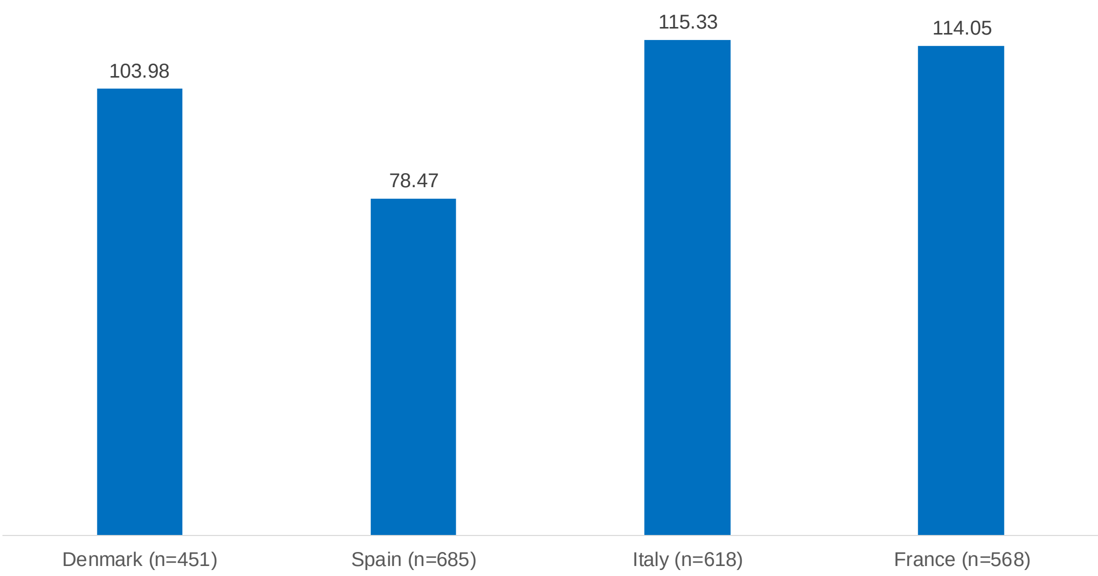

Figure 7: What is the amount of the average monthly electric energy bill in your household (in normal situation, not pandemic)? (Mean, EURO)

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In general, people who are better off spend more on energy than those living modestly or poorly, which is related to their overall higher level of consumption, most evident in Spain and less evident in Italy.

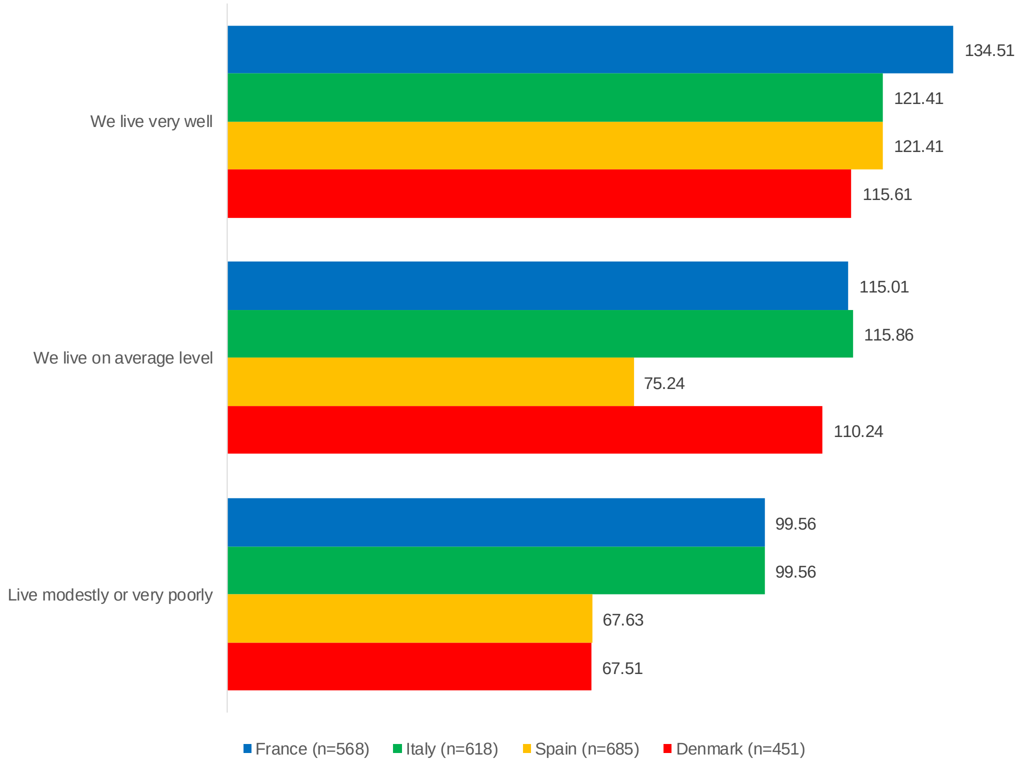

Figure 8: Value of the energy bill (Mean, EURO) vs the perceived financial situation

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Prosumers (energy producers having at least one of the 4 installations: photovoltaic panels, wind microturbine, water microturbine or energy storage system) spend more on energy than no prosumers in all the countries surveyed, which is most evident in Spain and Denmark. This means that the savings they potentially generate do not compensate for their overall higher energy demand.

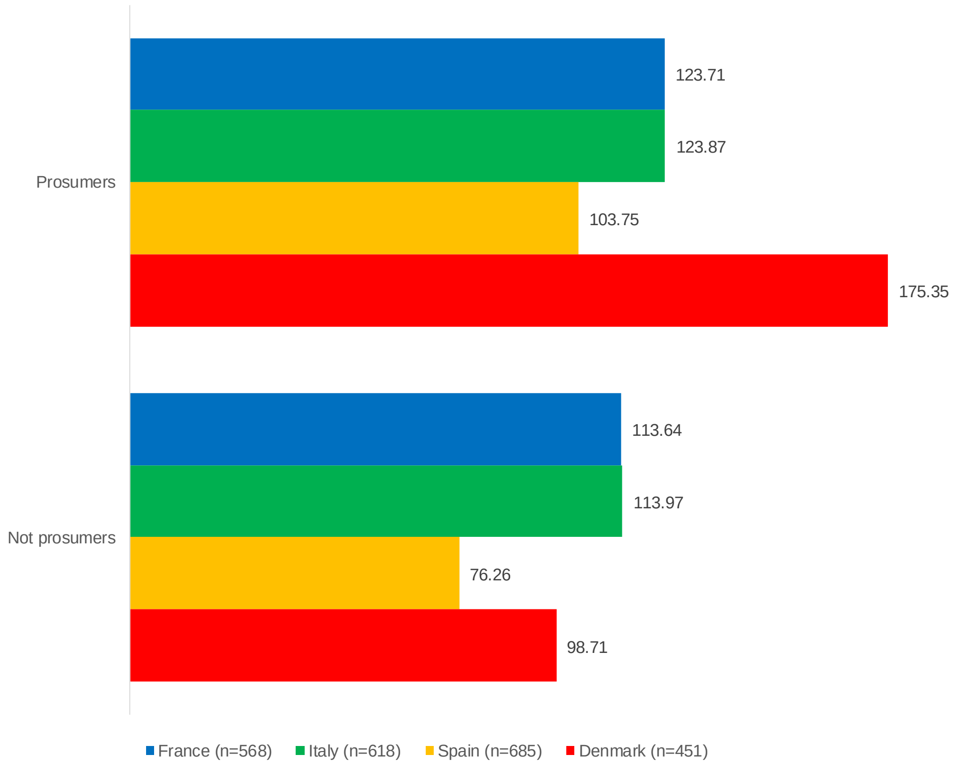

Figure 9: Value of the energy bill (Mean, EURO) vs ownership of energy generation and storage installations

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Different ways of heating the house are combined with different average energy expenses in different countries. In France and Spain oil furnace is relatively cheap, in Italy and Denmark it is heating from the city network, and in Italy it is additionally heating by heat pump.

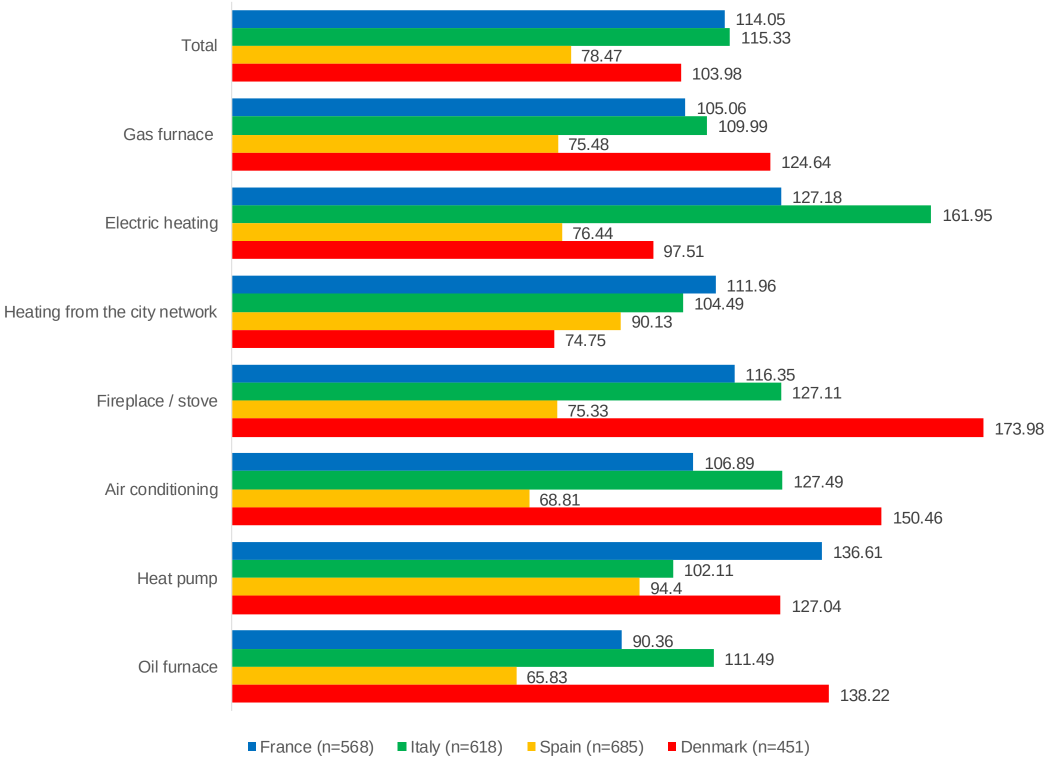

Figure 10: Value of the energy bill (Mean, EURO) vs primary source of heating

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The highest percentage of respondents who think that energy is cheap is in France (20%) and the lowest in Spain (7%). The highest percentage of respondents who think energy is expensive is in Spain (75%) and the lowest in Denmark (30%). In general, respondents more often claim that energy is expensive than cheap, which is most visible in Spain (where average energy spending is the lowest but the country is the poorest) and the least in Denmark (in the richest country with cheap energy from windmills). The next figure presents a detailed structure of the answers to this question.

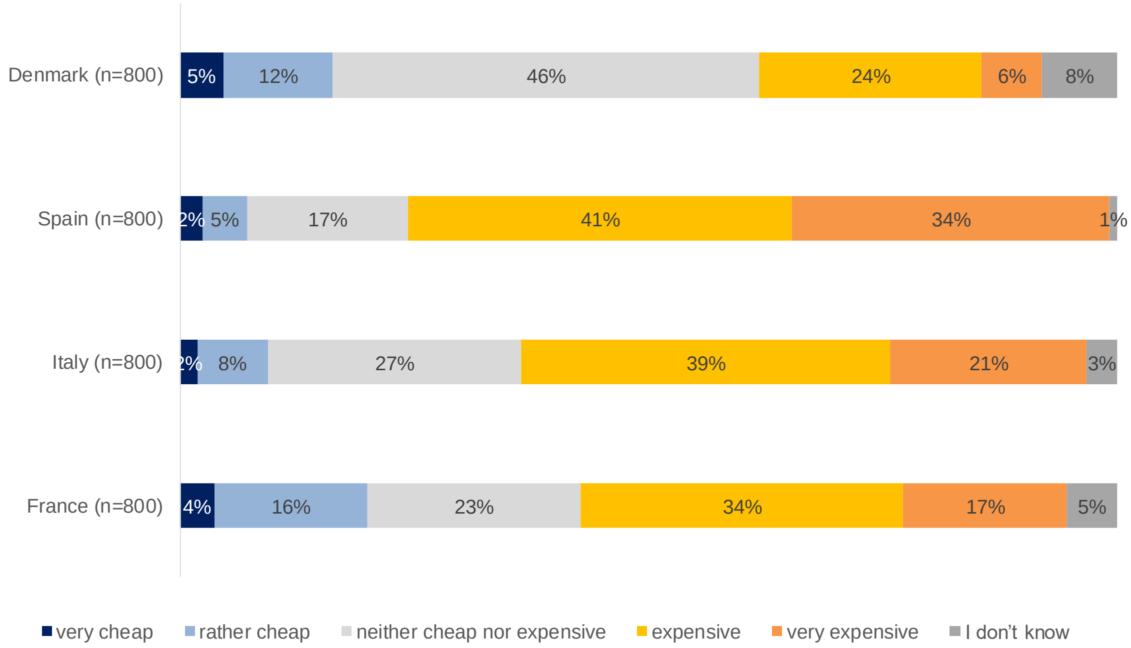

Figure 11: In your opinion, is the electricity cheap or expensive?

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The general tendency, particularly evident in France, Italy and Denmark, is that respondents who pay more for energy consider it more expensive. This is the least visible in Spain, but in this country most of the respondents claim that energy is expensive and among them, those who claim it is very expensive spend more than those who claim it is simply expensive.

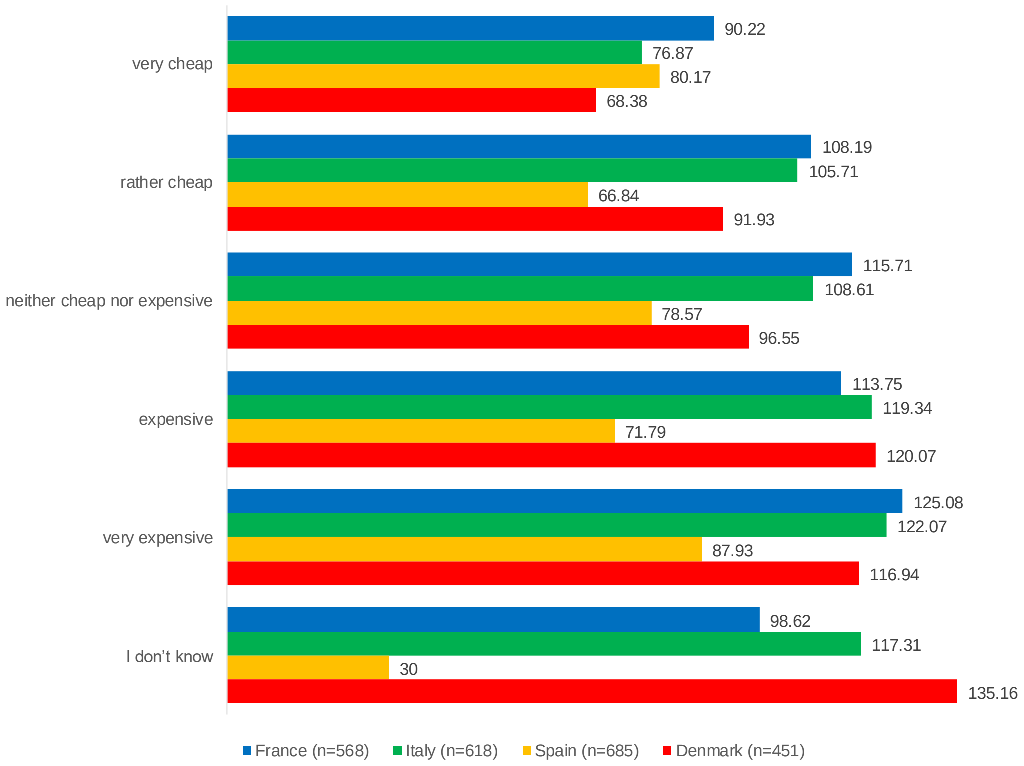

Figure 12: The value of energy bill (Mean, EURO) vs opinion if electricity is cheap or expensive

In general, those who perceive their financial situation the best are more likely to think that energy is cheap, and those who assess themselves to live modestly or poorly are likely to think that it is expensive. The exception is the group of the most well-off Danes, who more often claim that energy is expensive than the average Danes, reminding the group of the least well-off in the country (i.e. in Denmark both those who see their financial situation as the best and the worst more often claim that energy is expensive than the average Danes). At the same time, as it was shown earlier, in Denmark, in comparison to other countries, generally the fewest respondents consider energy to be expensive, which can be seen in all groups, regardless of the level of perceived wealth.

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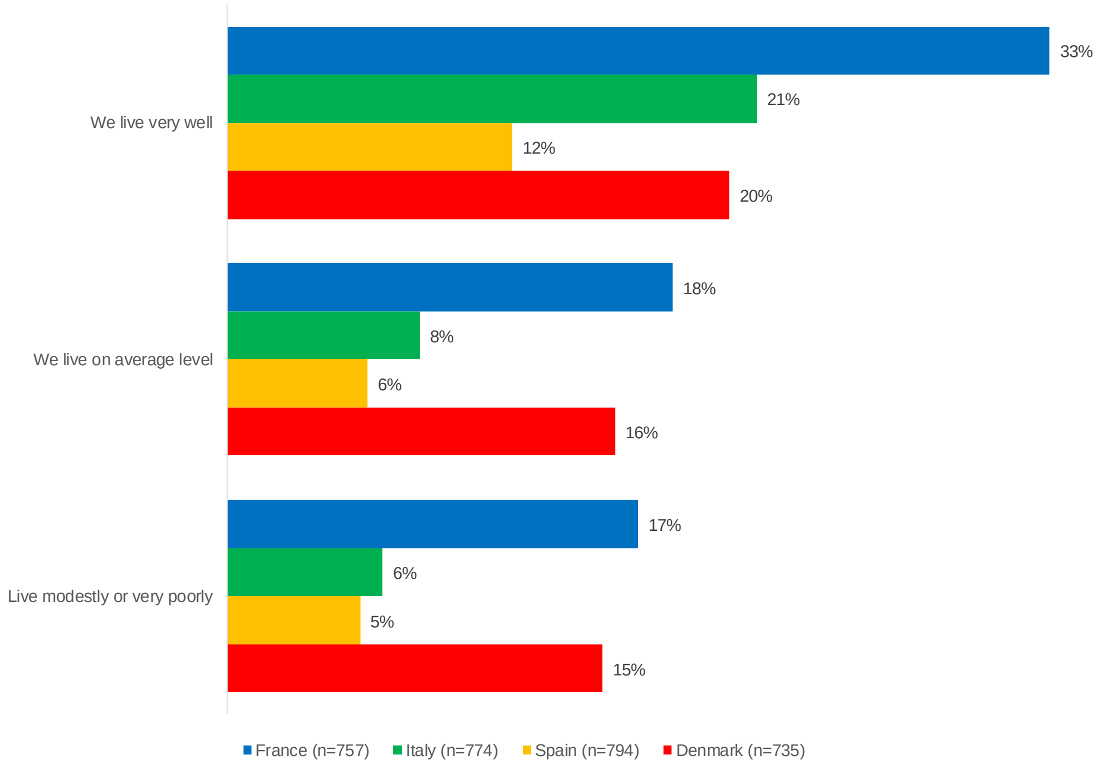

Figure 13: Share of respondents claiming that electricity is cheap or very cheap vs financial situation

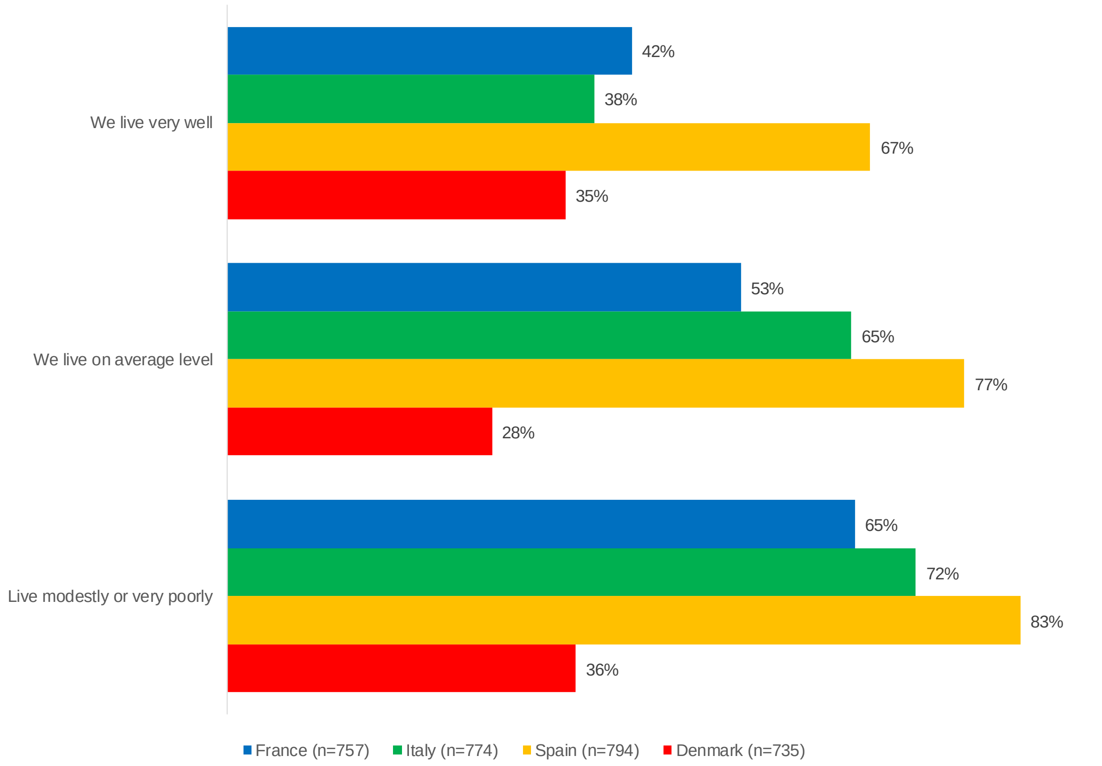

Figure 14: Share of respondents claiming that electricity is expensive or very expensive versus financial situation

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1.2.3 Attitudes towards using and saving energy

Most of the respondents try to save energy, take into account the energy efficiency indicators of the electronic equipment and control their spending on energy. Relatively the least attention to energy bills and the need to save energy is paid by the Danes. Italians seem to be the most concerned about saving energy (they check indications of energy efficiency on purchased products, pay attention to the price of kWh and others).

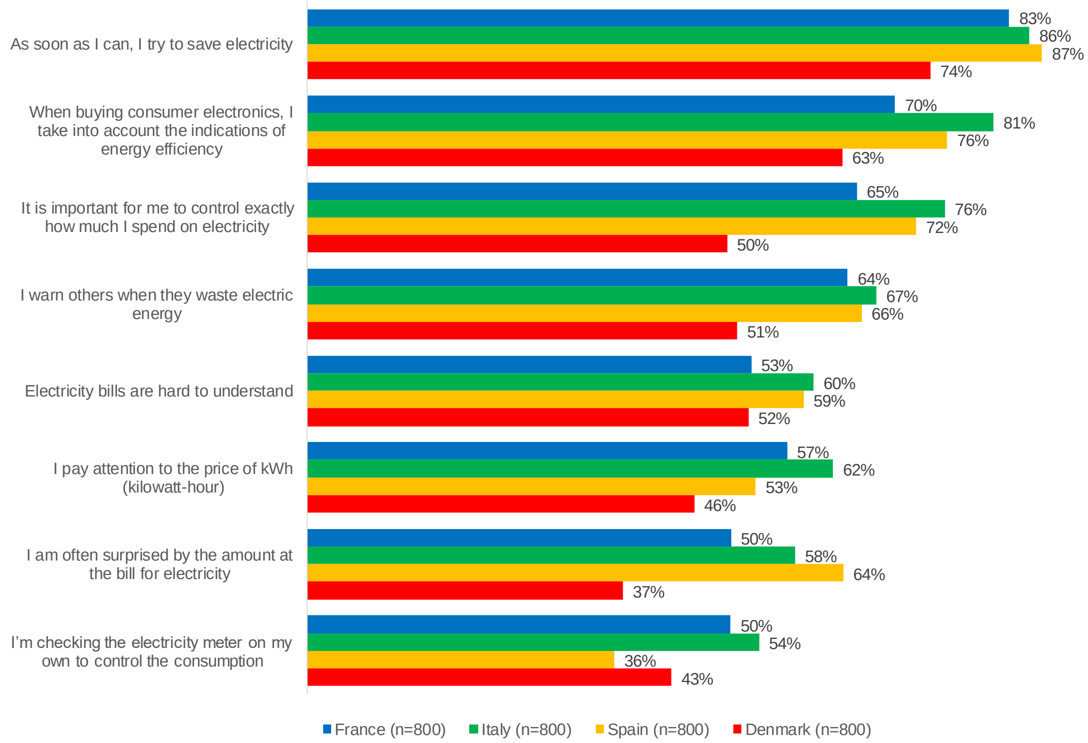

Figure 15: To what extent these behaviours could be described as yours? (share of answers 'yes' and 'rather yes')

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The most frequently indicated reason for saving energy is to reduce bills. Environmental considerations come second. This pattern mainly refers to France, Italy and Spain. In Denmark, environmental considerations are less important, and attempt to reduce bills is followed by explanation of being a frugal person. In all countries the tendency to indicate environmental considerations increases with education. In France and Spain, prosumers are more likely to indicate environmental considerations than non-prosumers, while in Denmark the opposite is true - non-prosumers are more likely to show concern for reducing the negative impact of energy consumption on the environment (while in Denmark, prosumers are more likely to indicate a different environmental motive than non-prosumers - the desire to reduce CO_2 emissions, which may indicate a better understanding of the environmental impact of energy consumption). In Italy, a little more non-prosumers than prosumers indicate a reduction of the negative impact on the environment and this is not a balanced by a choice of the answer regarding the reduction of CO_2 emissions. In all countries, the more frequent indication of the reduction of the negative environmental impact and/or the reduction of CO_2 goes along with the plans to buy or expand the energy production equipment.

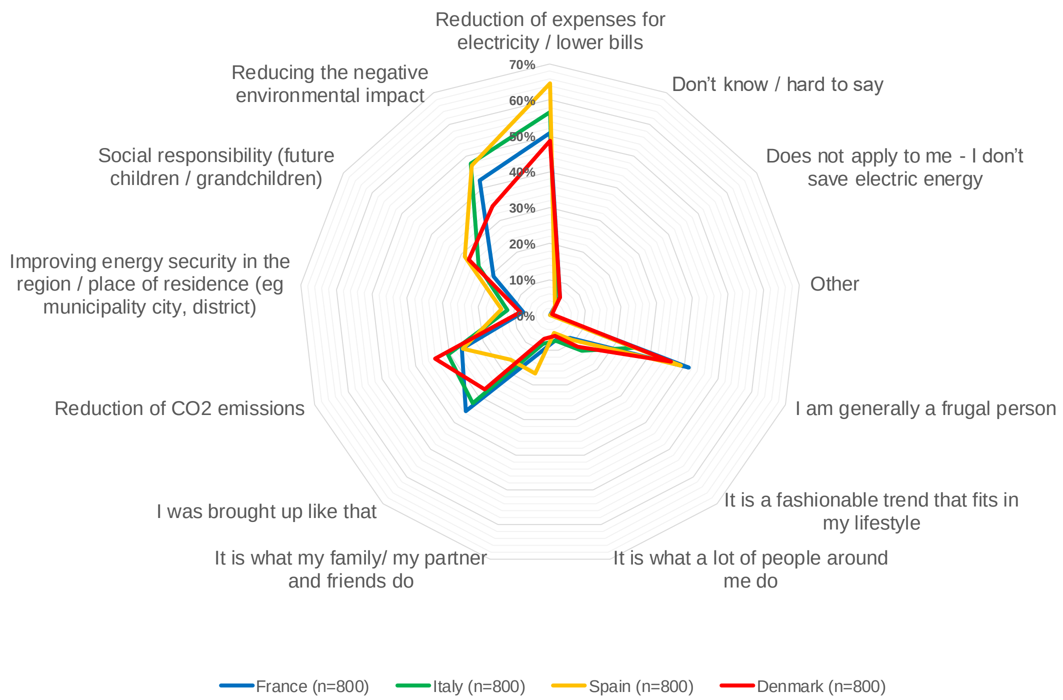

Figure 16: Please mark up to 3 reasons to save electric energy that are applicable to you.

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When it comes to the disincentives to save energy, the answers vary from country to country. An interesting case is Italy, where the most frequently chosen answer was that they always try to save energy, while in other countries this answer was rarely selected.

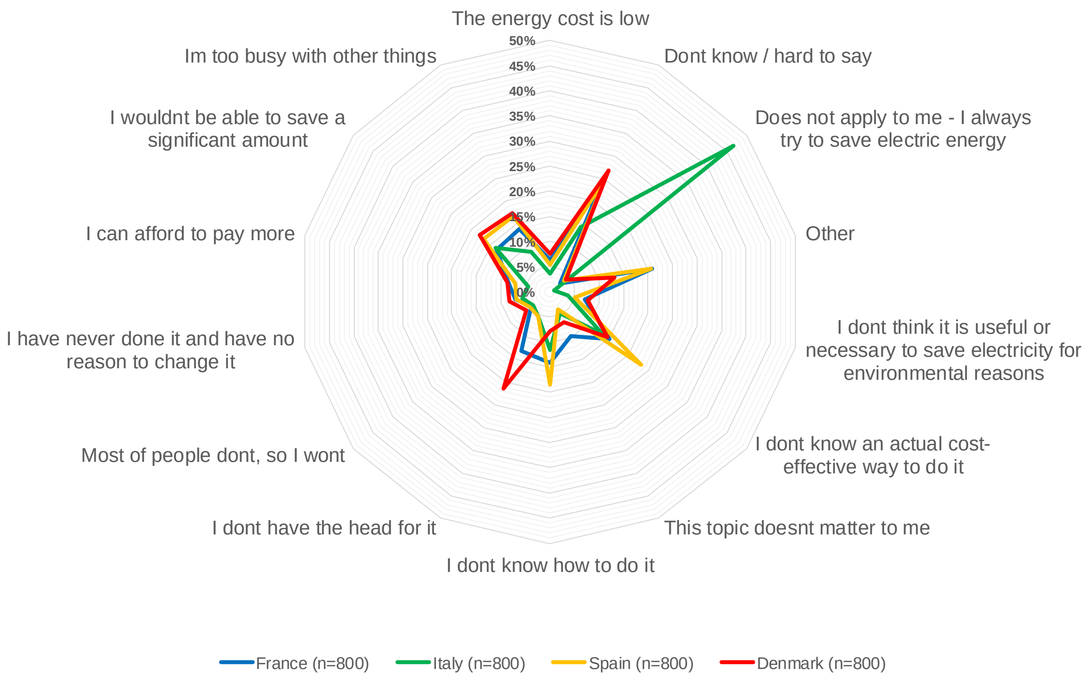

Figure 17: Please mark up to 3 reasons to NOT save electric energy that are applicable to you.

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Among the factors that could lead to energy savings, the reduction of bills (mainly in Italy) and high energy prices (especially in Spain) are particularly important. Environmental considerations play a smaller role and are more important in Spain.

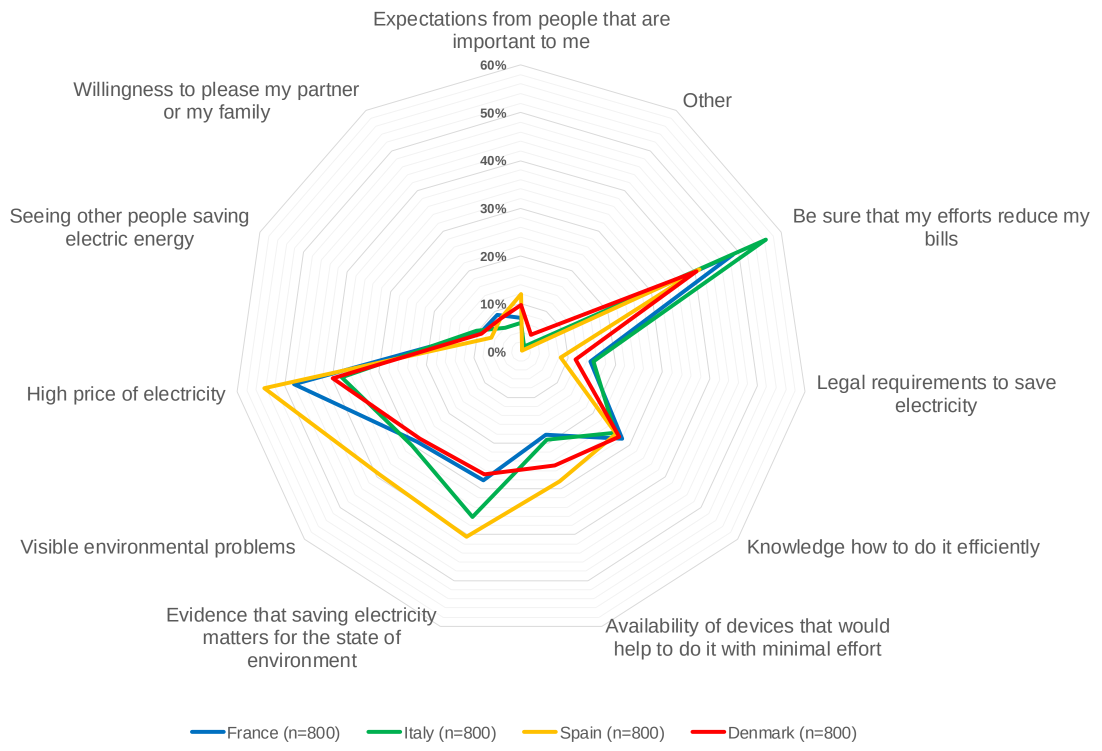

Figure 18: Please mark up to 3 reasons that would encourage you to save more electric energy.

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In all the countries surveyed, "Switching-off appliances when they are not used" was most often indicated as a considered action to reduce energy costs (this is most evident in Spain). In second place was the reduction of consumption without buying additional equipment, followed by replacing the own equipment by energy saving versions of appliances. As far as the installation of photovoltaic panels is concerned, Italy has clearly shown the greatest interest in them. Similarly, in Italy there is the greatest interest in looking for information about ways to save on energy (see next figure).

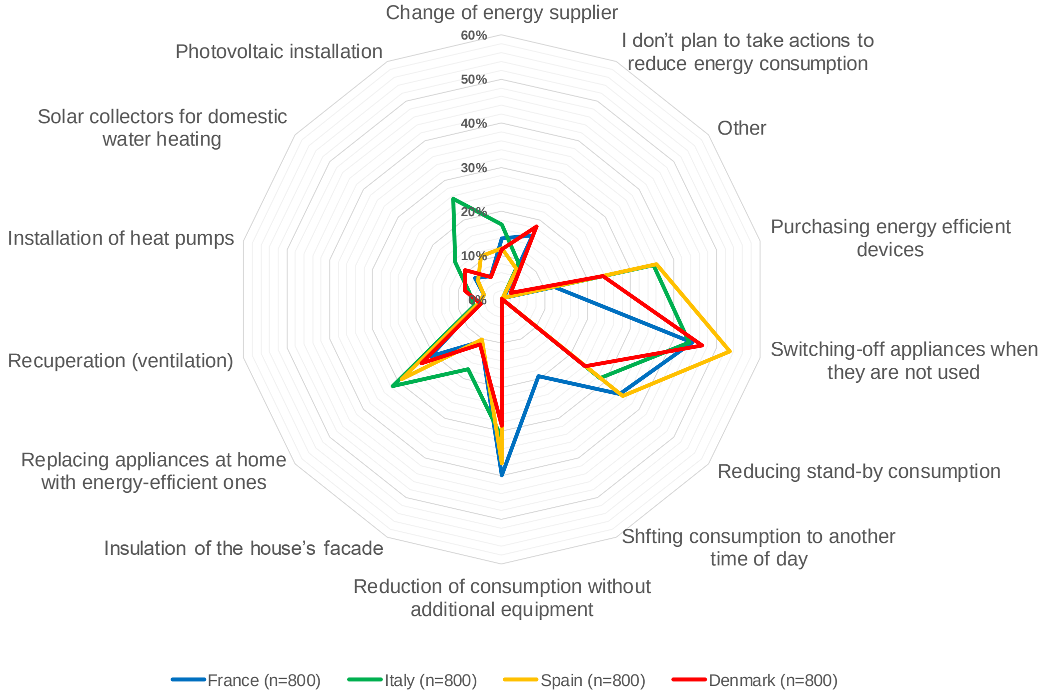

Figure 19: Do you consider taking actions to reduce cost of your energy consumption? What are they?

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In all countries there is a general tendency that this type of information is sought by younger respondents, better educated, better-off, being prosumers and planning to purchase or expand energy production installations.

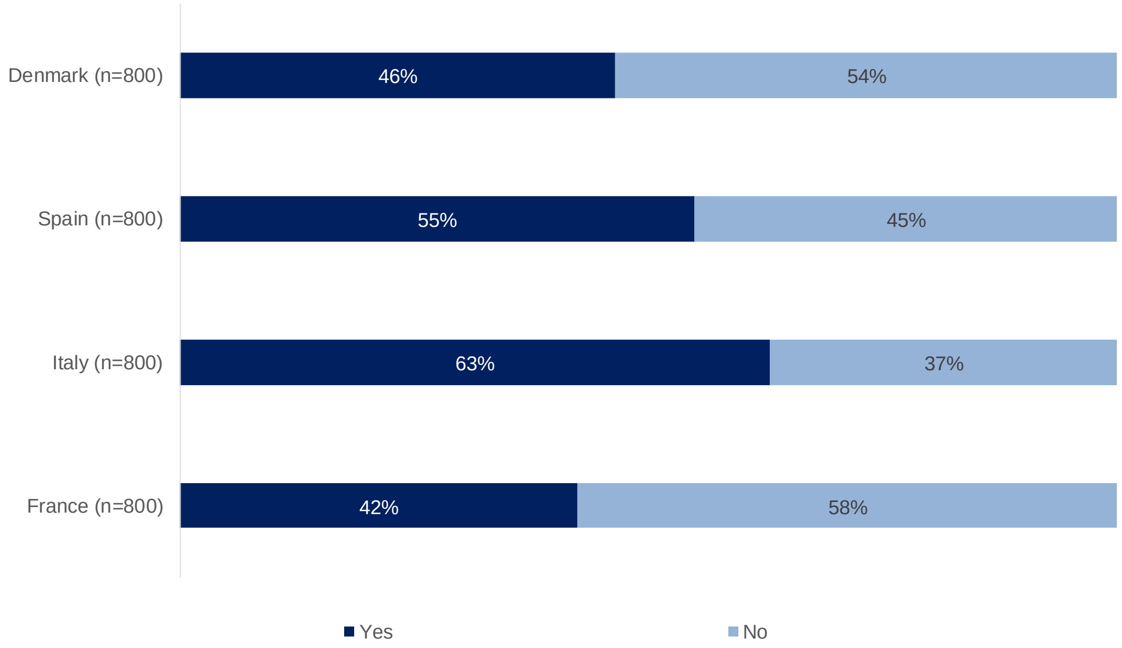

Figure 20: Did you look for an information how could you reduce your energy consumption?

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1.2.4 Ownership of installations for the electricity production and storage

In this section we are particularly interested in prosumers, by whom we mean households having at least one of the following energy production and storage installations: photovoltaic panels, wind microturbine, water microturbine, energy storage system. The share of prosumers among the respondents is low, from 4% in France to 13% in Italy.

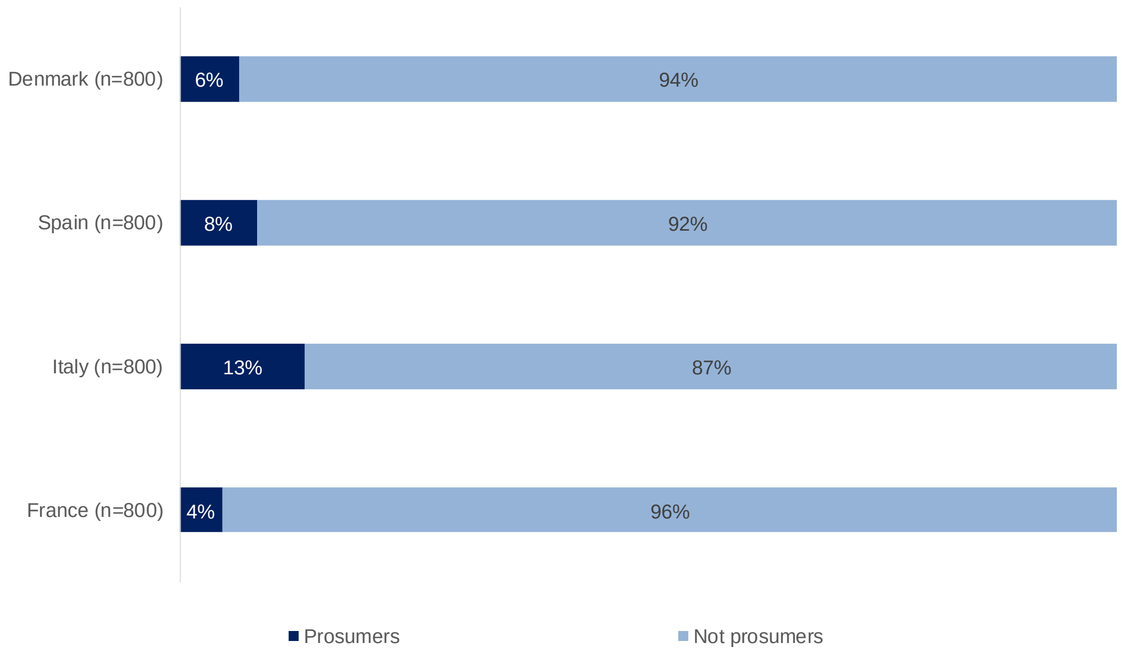

Figure 21: Share of prosumers in the sample

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The most often prosumers are younger people (i.e. between 18-29 and 30-44), better educated, more often families with children than singles, more often living in houses rather than apartments, with a larger homes (except for Denmark), better off (except for Denmark), more often in a big city than in the countryside (except for France).

We asked the respondents about their satisfaction with their energy production installations. Due to the small number of people in the sample who have devices to generate and store energy (defined as prosumers), we also analyzed here the responses of people who have solar water heating and systems to reduce energy consumption for heating or cooling (i.e. heat pumps).

Overall, the respondents are satisfied with their energy production equipment, the most visible is in Spain (71% satisfied) and the least in France (48% satisfied).

The most important benefit of using energy production facilities, as perceived by respondents, is the saving on energy bills (especially in Spain). However, in the second place, there are environmental benefits reported. In general, the distribution of the indicated benefits is similar between countries, with minor differences. For example, France has the highest number of respondents indicating that they earn money from the energy they produce, and in Denmark there are more often mentioned environmental benefits than savings on their bills.
The chart below shows selected groups that differ from the average.

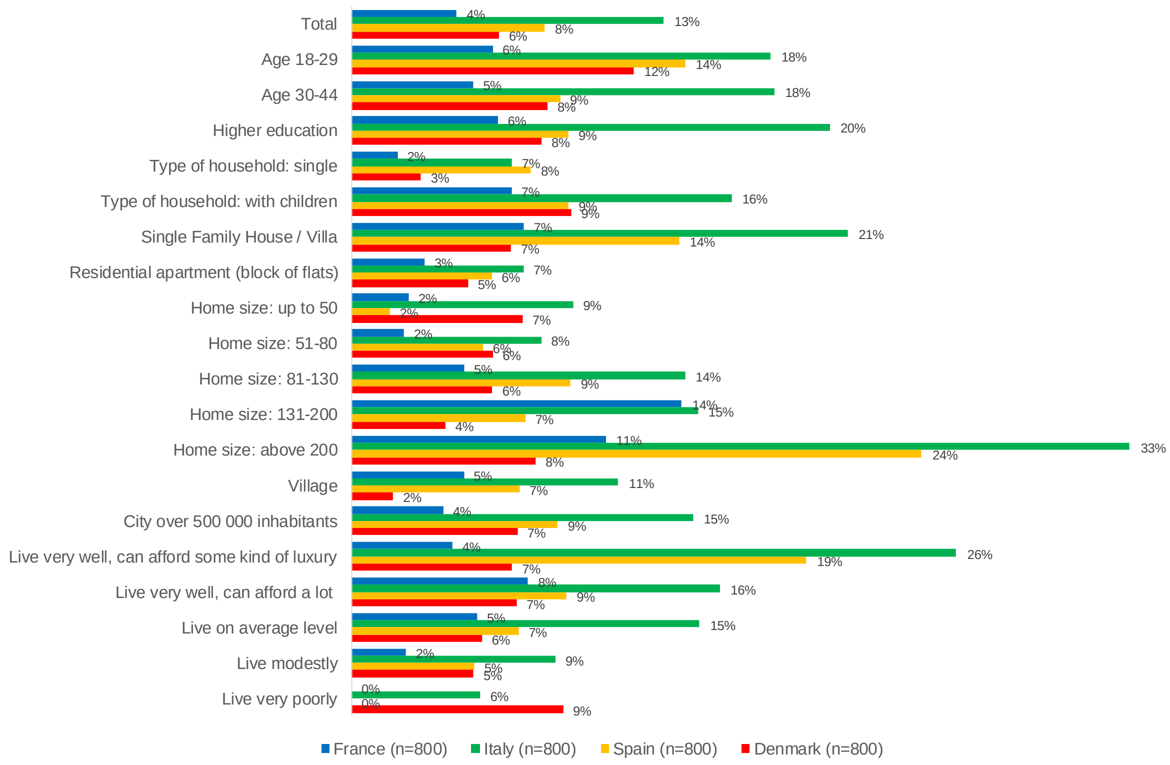

Figure 22: Share of prosumers among different groups

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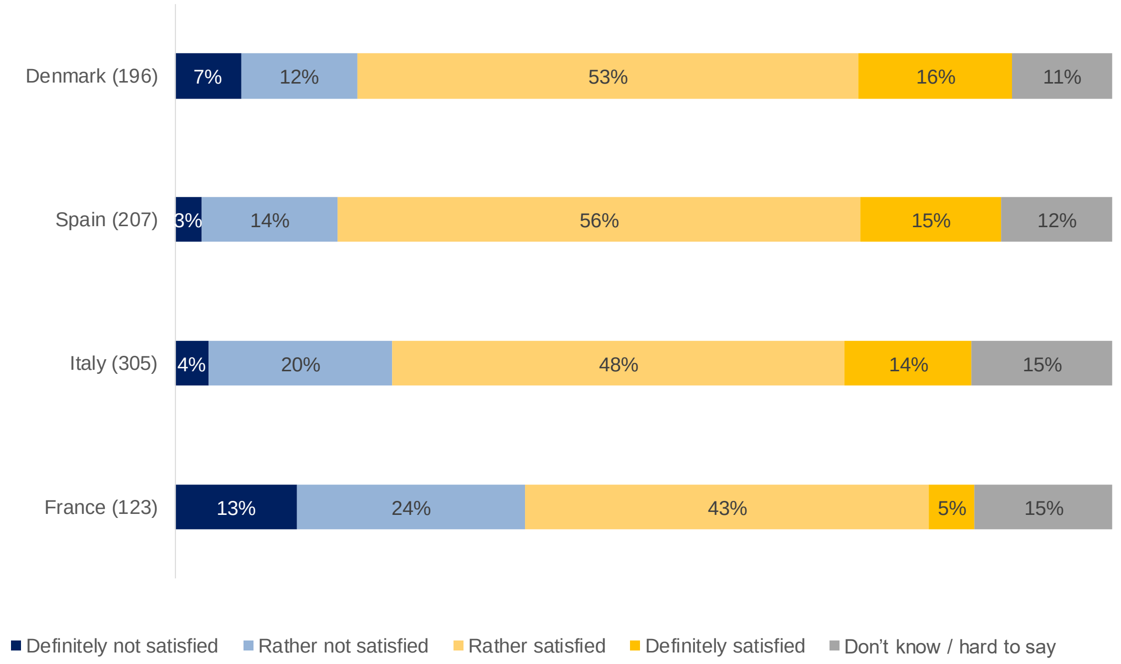

Figure 23: Think of your experience with devices for the production of energy in your household. To what extent are you satisfied or not satisfied with usage of these devices?

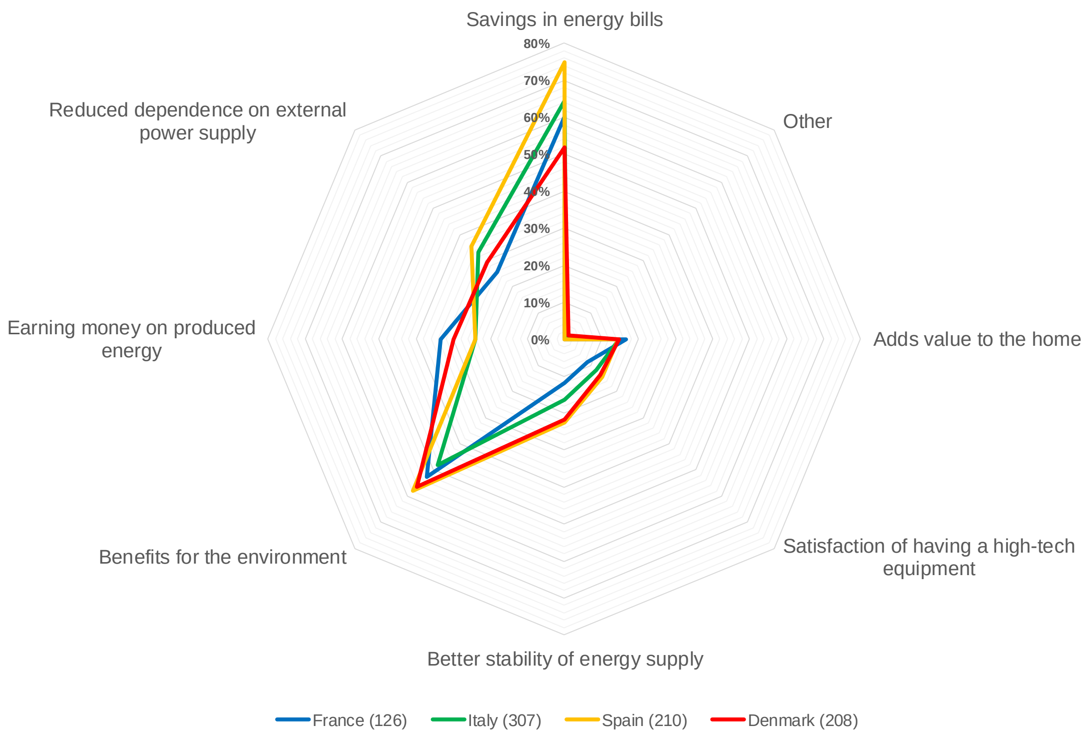

Figure 24: What are the most important benefits of using energy production facilities in the household that you see?

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Most often the problems with power generation equipment were reported by the French and the Danes, and rarely by the Spanish. Schedules of reported problems differ between countries. In Italy and Spain, the most frequently indicated problem was the high cost of maintenance. In France and Denmark these were frequent breakdowns that needed to be repaired, and in Denmark there was also a need for help from others during use and low quality of service, and in France additionally the low additional energy supply was mentioned.

The following analysis is no longer limited to the group of current energy producers. Questions about the assessment of the potential profitability of energy generation and storage equipment, as well as plans to purchase this type of equipment (or to expand the existing one) were directed to a group of house-owners, for whom these issues have a practical reference.

The investment in renewable energy production and storage equipment is considered economically justified mainly by young, better educated respondents, prosumers (having at least one of the following energy production and storage equipment: photovoltaic panels, wind microturbine, water microturbine, energy storage system), well-off, having bigger houses, talking about energy production, satisfied with energy production and planning to buy/expand energy production equipment and interested in the presented concepts referring to the solutions proposed by the Ebalance-plus project. This point of view was most often shared by the Spanish (61%) and the French (59%), and the least frequently by Danes (51%) and the Italians (52%).

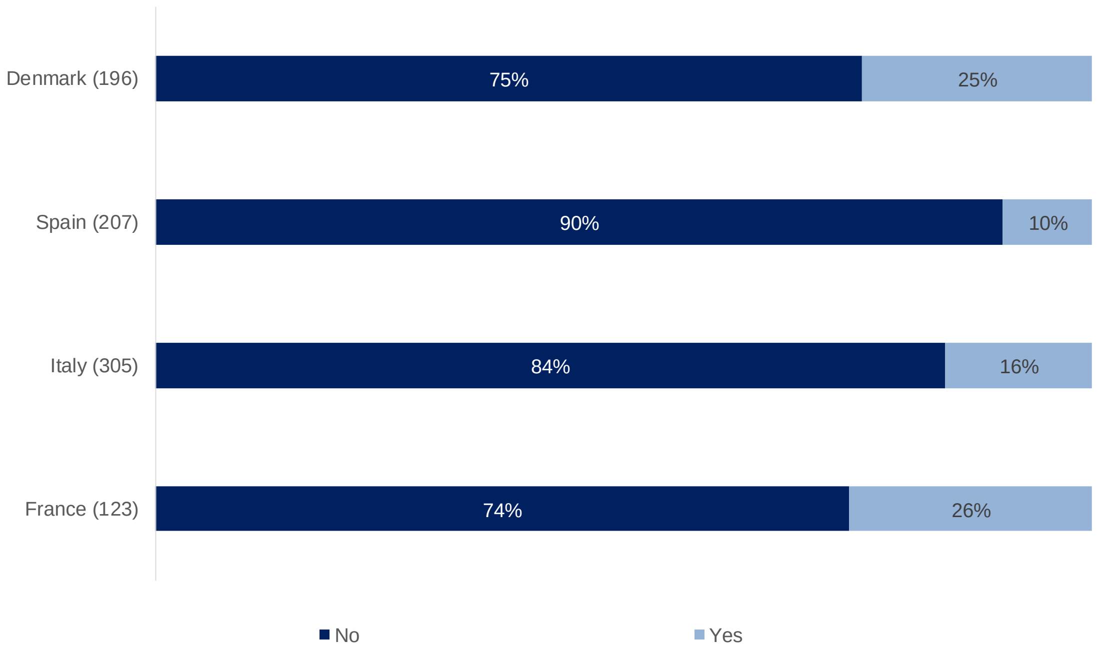

Figure 25: Did you have any problems with the equipment for the production of energy in your household?

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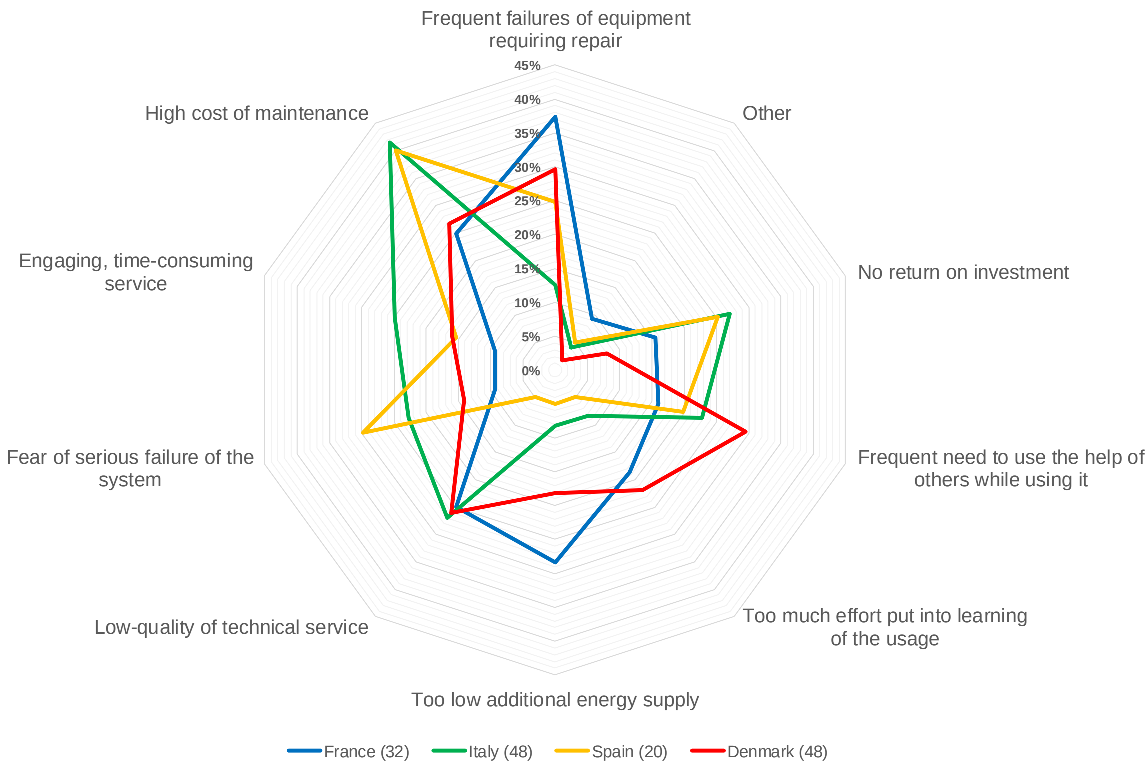

Figure 26: What problems with the equipment for the production of energy did you have?

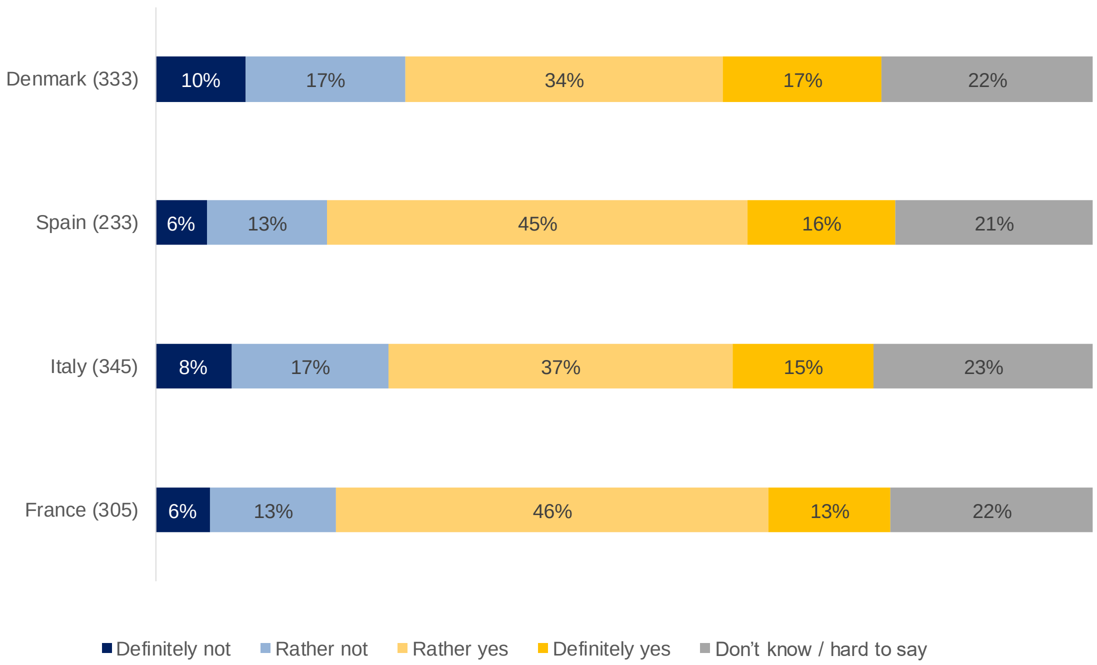

Figure 27: Do you think that installing renewable energy production and storage equipment can be economically justified?

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Expansion or purchase of energy production equipment is most often planned by: younger respondents, talking about energy production, satisfied with energy production, thinking that energy is cheap and interested in the presented concepts of the e-balance project. In general, the Spanish are the most interested and the French are the least interested.

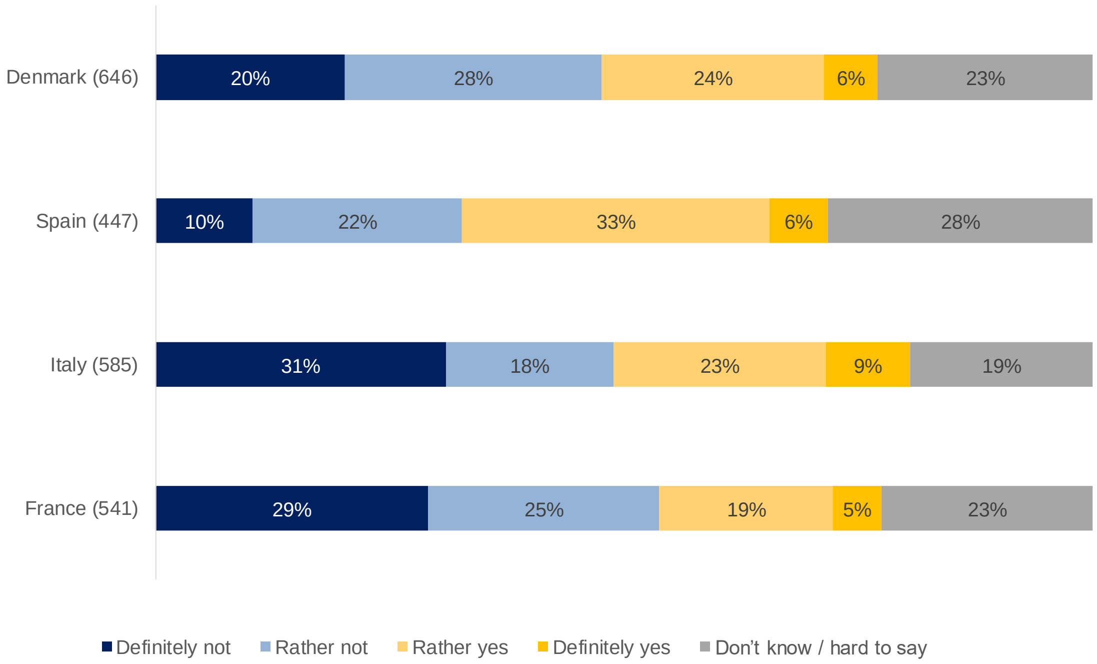

Figure 28: Are you going to install an energy production and storage devices in your home or do you plan to add new equipment for energy production (eg. by adding new devices and new functionalities)?

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Among the reasons indicated for the intention to purchase energy production equipment was the desire to save on energy bills (mainly in Spain), followed by environmental reasons (mainly in Italy and Spain). The distribution of reasons in different countries was very similar, only in Italy more often than in other countries the desire to make money on the energy produced was indicated, and this motive was the least frequent in Spain. This is probably related to the technological possibilities available in these countries.

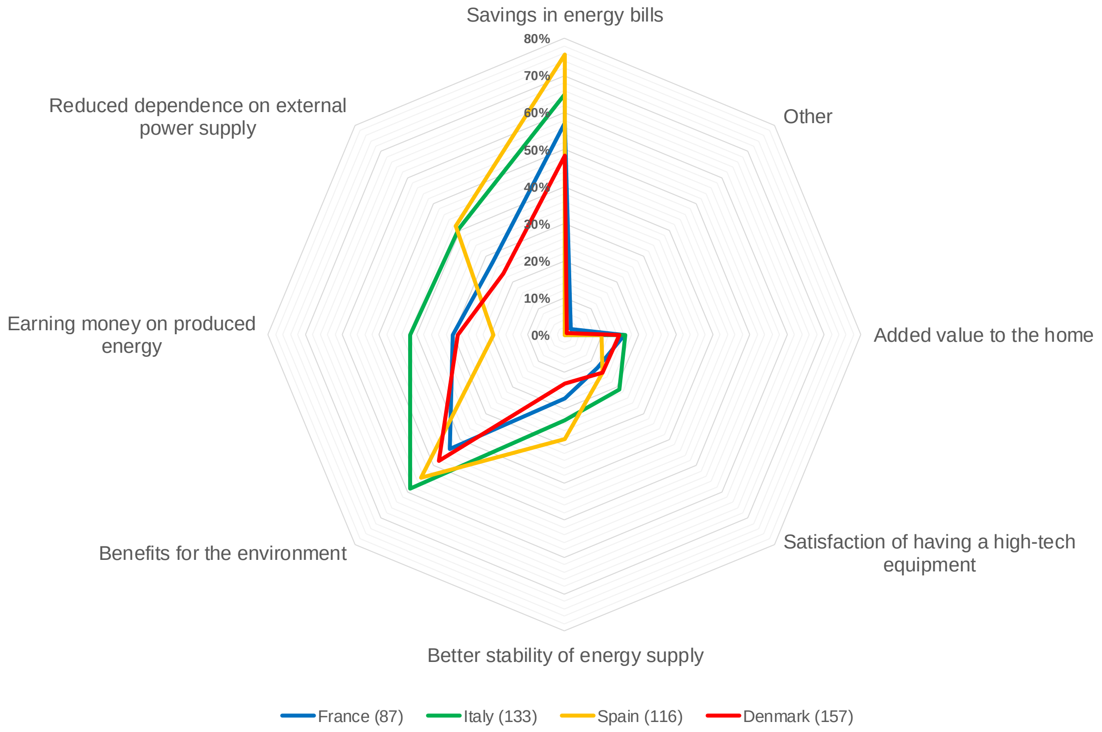

Figure 29: Why do you plan to buy (add new) equipment for energy production?

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1.3 Social Network Effects

As for the question of whether the friends of the respondents take action to reduce energy costs, the percentage of respondents in case of whom at least some friends or family members take such action is the highest in Spain and Italy. In these countries there are also the fewest answers indicating a lack of knowledge on this matter. These are also the countries where the smallest group of respondents indicated that they do not consider taking any actions to reduce cost of energy. Own actions go hand in hand with actions in the immediate environment, as well as interest in whether such actions are taken by family and friends.

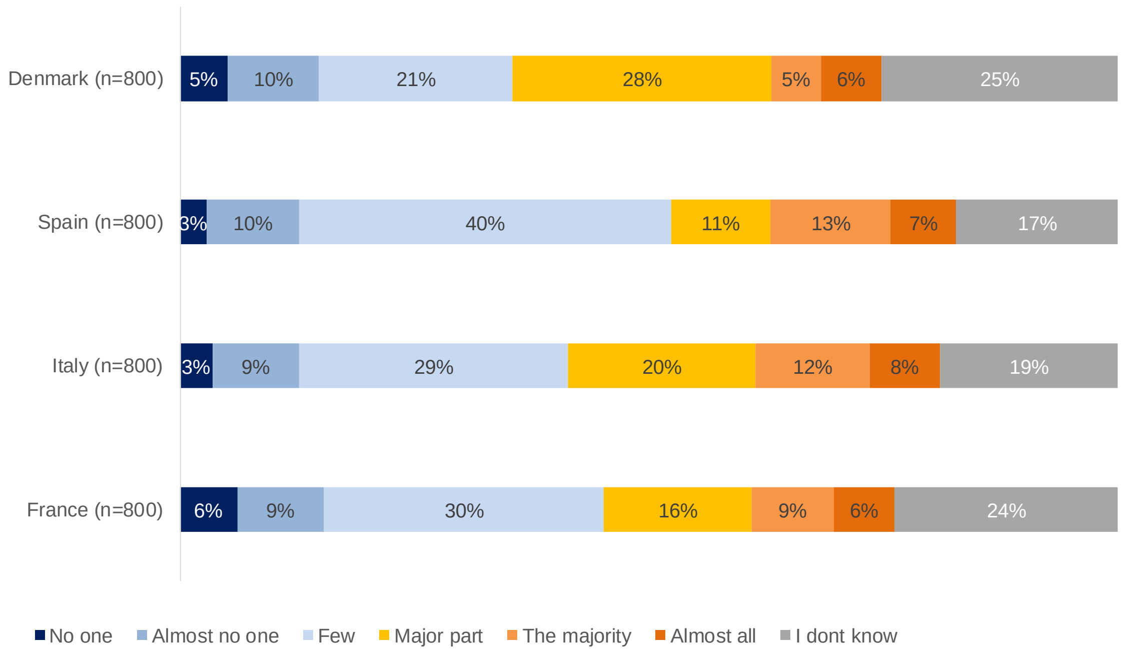

Figure 30: Do your friends and family take actions to reduce cost of energy consumption?

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The distribution of types of actions aimed at reducing energy costs observed among friends and family is similar to those that respondents consider themselves, i.e. mainly: "Switching-off appliances when they are not used" (observed more often than regarded by the respondents themselves in Denmark), reduction of consumption without purchasing additional equipment (especially in Spain), as well as replacement of appliances with energy-saving versions. Reducing stand-by consumption seems to be important in France. Photovoltaic panels are observed most often in Italy, and solar panels and heat pumps in Denmark, but they are relatively unpopular compared to the previously mentioned actions.
Around a third of Spanish and a fifth of French users note that the people around them shift their energy consumption to a different time to reduce its cost.

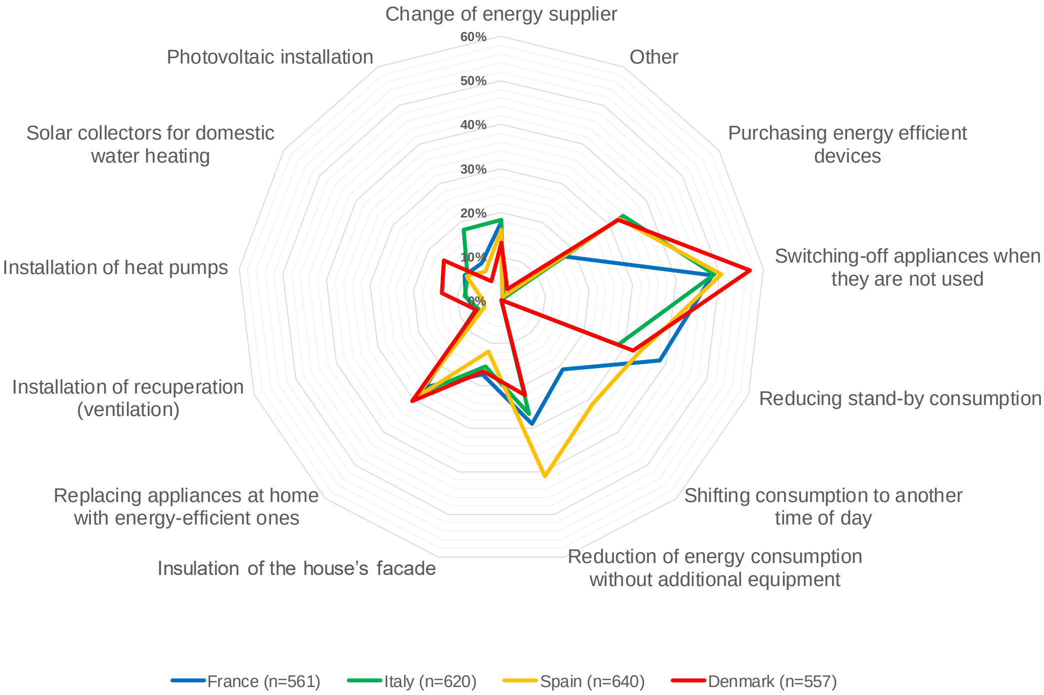

Figure 31: What actions do they take?

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In all countries surveyed, more than half of the respondents talk about saving energy with other people, the most in Spain (70%) and the least in France (55%).

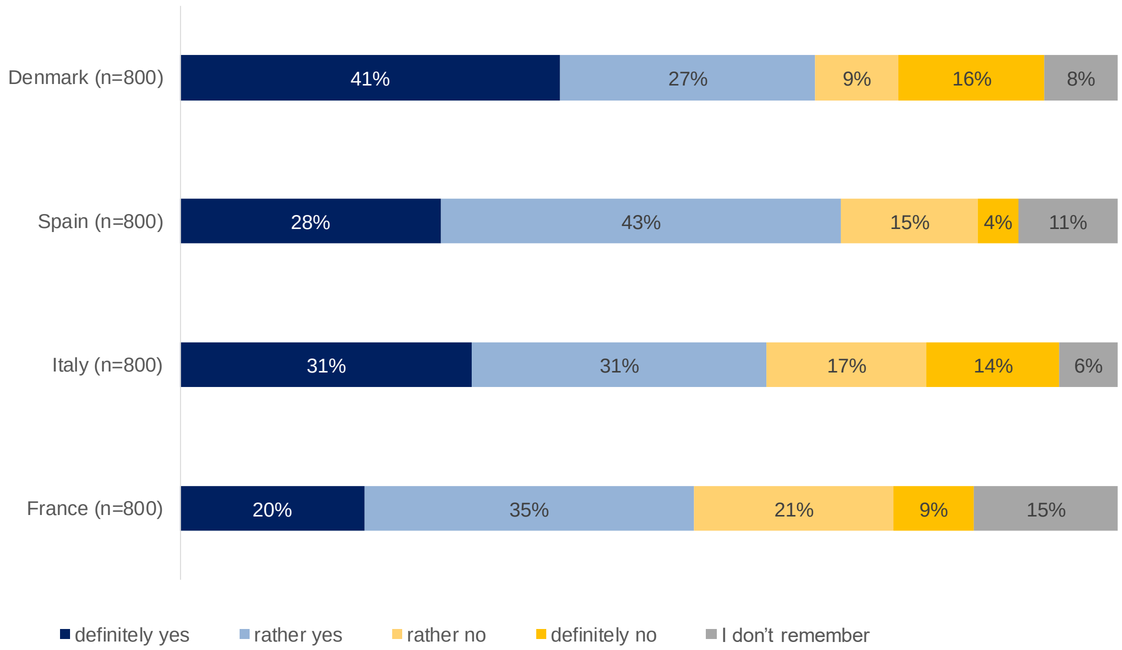

Figure 32: Have you ever talked about saving electricity with other people?

Most often, people with higher education and rather better financial situation talk about saving energy, more often from big cities than from the countryside. In all countries, these are more often prosumers than not prosumers, those who plan to buy or expand energy production facilities, but also, interestingly, among energy producers, these are more often unhappy with energy production facilities, the effect being most visible in France, while the opposite tendency is in Spain).

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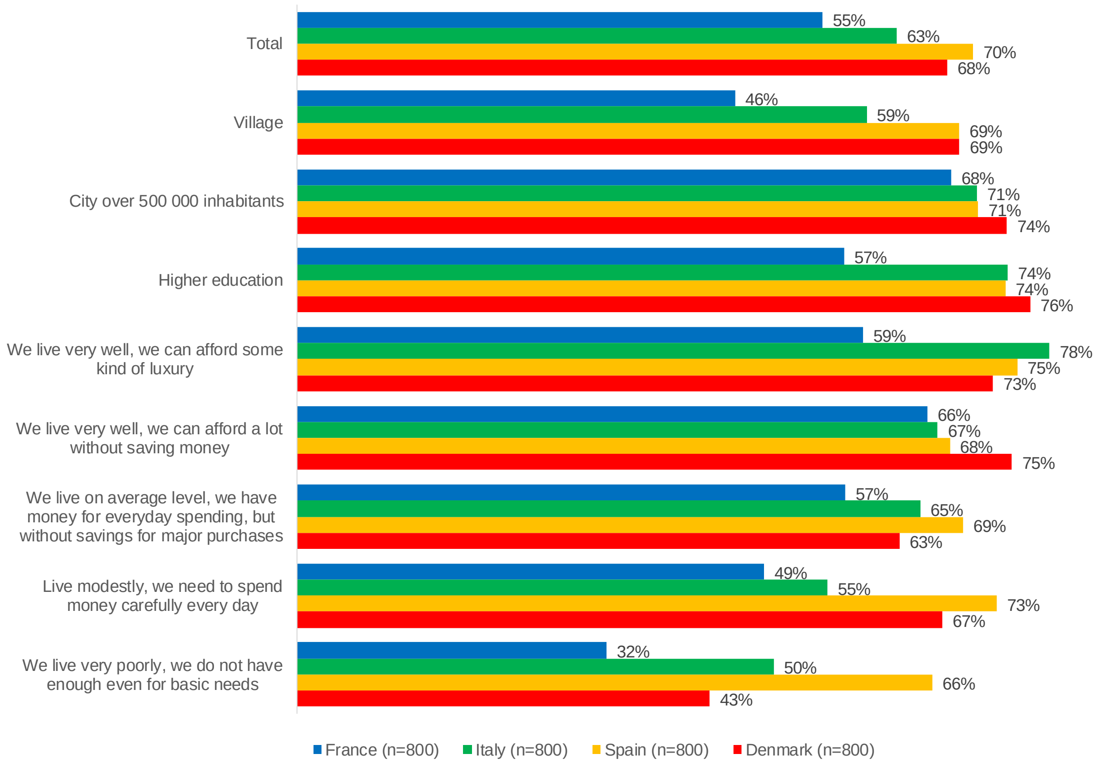

Figure 33: Share of respondents who talk about electricity savings with other people

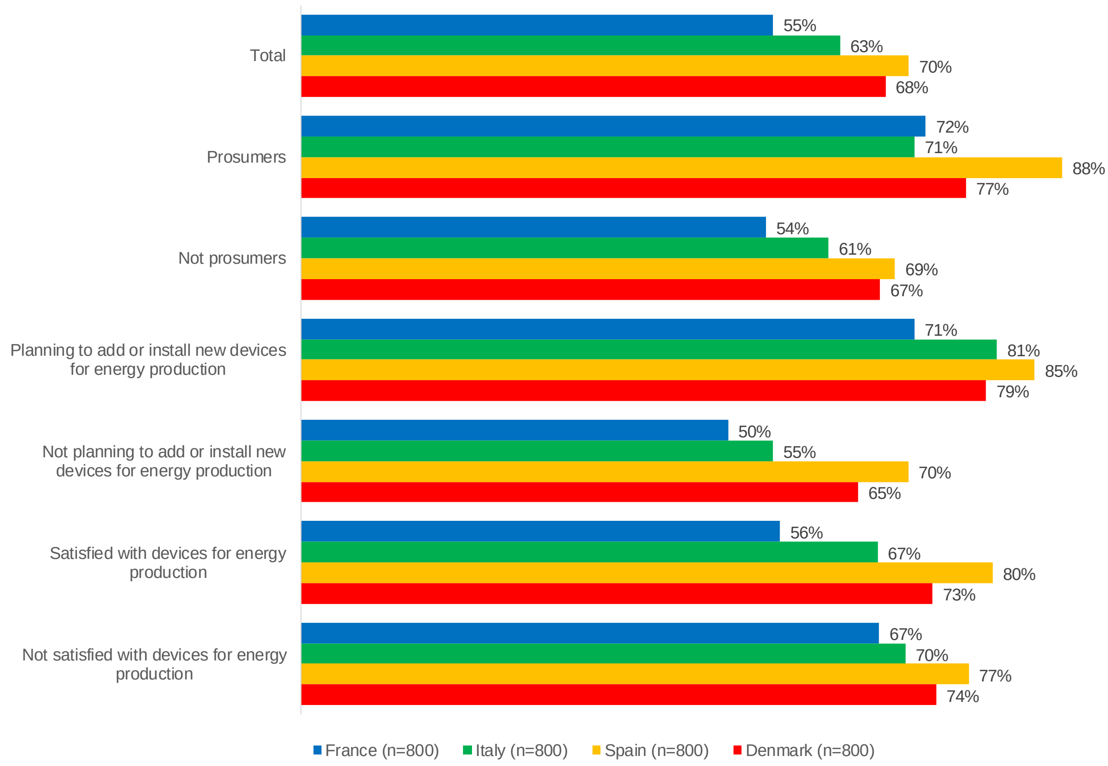

Figure 34: Share of respondents who talk about electricity savings with other people (continued)

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The discussions about saving energy are most often held with members of the household (in particu in Spain and Italy), spouses/partners and closest friends, and rarely with salesmen/technical adviso Such conversations are therefore encouraged by strong ties and frequent contact.

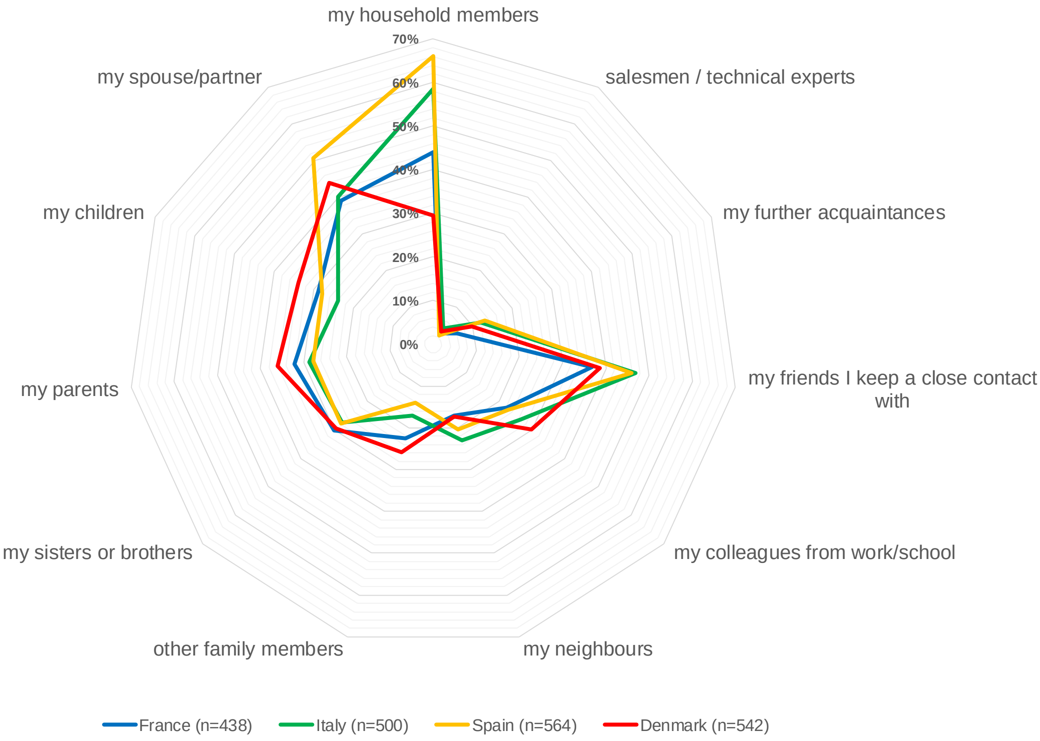

Figure 35: Who are those people? (the same group of people can belong to more than one category, please mark all applicable)

It can be assumed that talking about saving energy is an important form of searching for information on the subject. In fact, those looking for information on how to reduce energy consumption in all countries are mostly people who talk about it with other people. Those looking for information talk a little more with their families than with those outside the family, although in Denmark this trend does not occur. They are definitely proactive people, prosumers and those planning to expand or purchase energy production or storage equipment.

Participation in social networks is not only a potential source of knowledge about energy saving methods, but also a channel through which energy saving can be popularized. Among the answers to the question, asking to indicate 3 reasons for energy saving, it was possible to choose two options indicating the potential influence of family and friends, as well as people from further surroundings. As it can be seen in the figures below, the people choosing these answers are young people, often from the group assessing themselves to be the best financially situated (except for Italy, where no respondent from this group chose the influence of family and friends as the reason for energy saving), more often prosumers than not prosumers, and among energy producers, rather people not satisfied with their equipment. Interestingly, stating to be influenced by family, friends or other people does not clearly correlate

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with talking about saving energy or planning to buy or expand energy production and storage facilities. Individuals who are socially influenced regarding the energy saving, especially when it is done through strong ties (due to the influence of family and friends), do not have to be proactive when it comes to implementing new methods of energy saving, they may be more likely to be those applying existing solutions than looking for new ones. However, it should be remembered that social impact as one of the 3 most important reasons for saving energy was one of the least frequently mentioned factors, as economic and environmental issues dominated. What is more, the following analysis is based solely on the declarations of the respondents, therefore it should be treated with great caution.

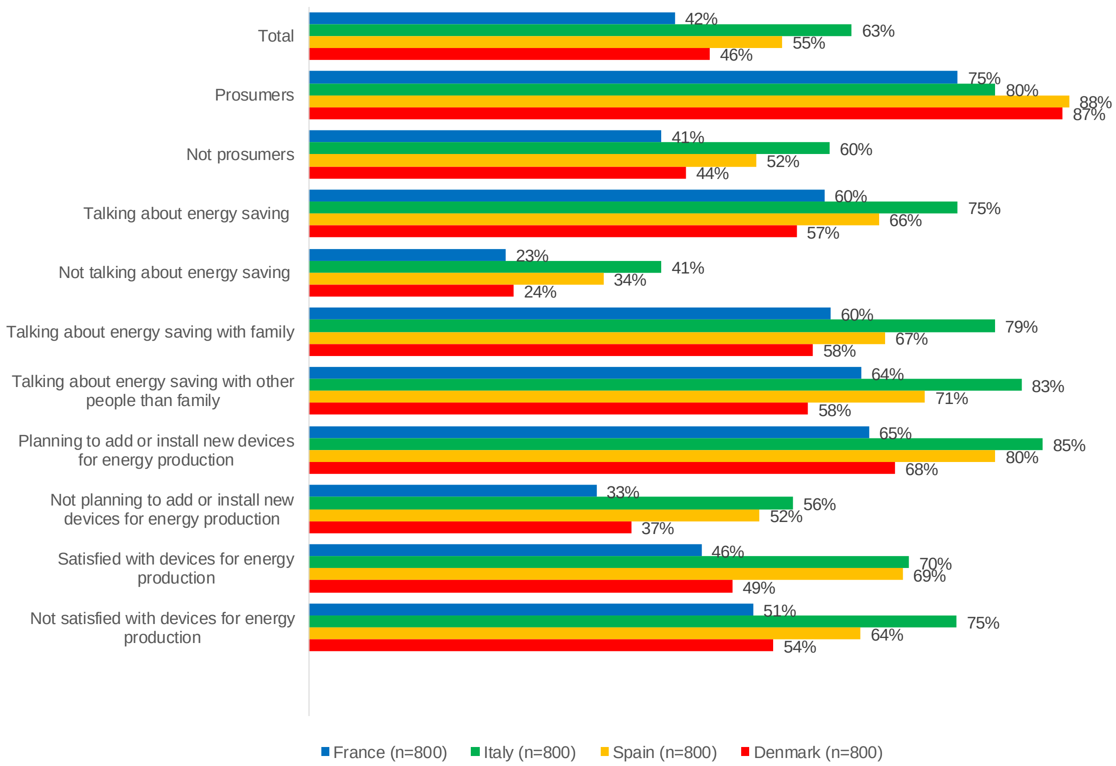

Figure 36: Did you look for an information how could you reduce your energy consumption? (share of respondents looking for this type of information)

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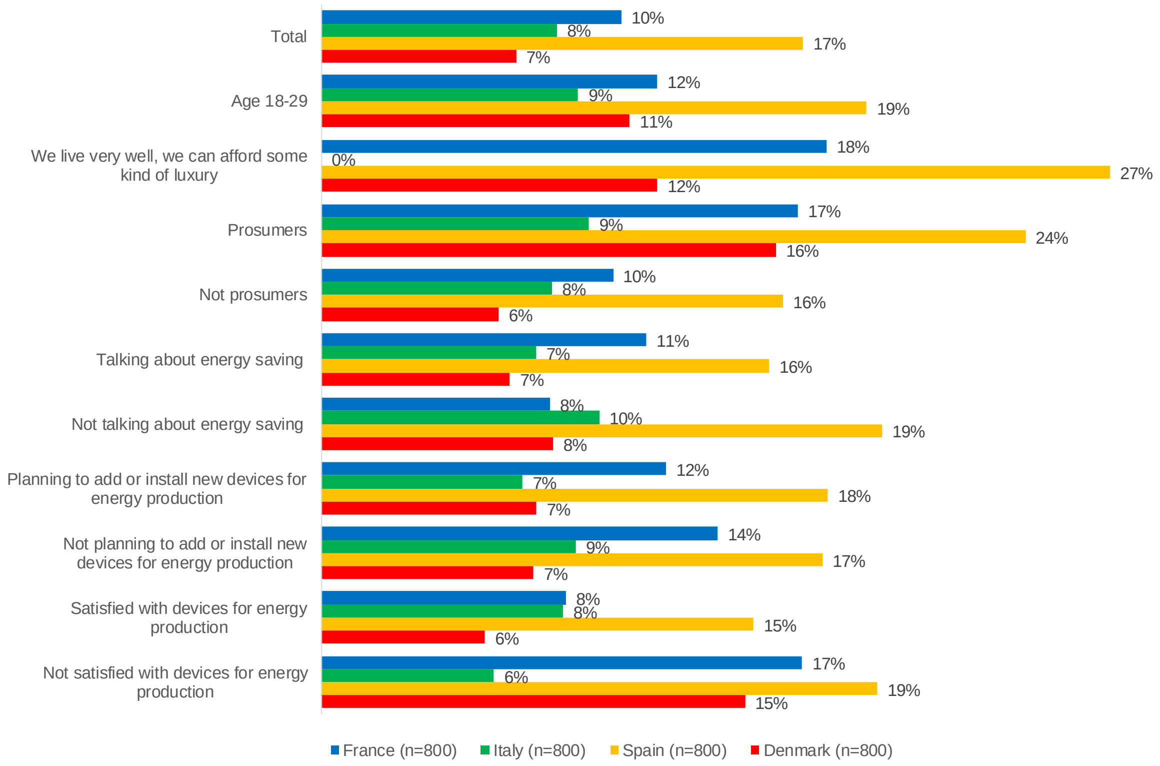

Figure 37: Statement "It is what my family/ my partner and friends do" - indicated as one of 3 reasons for saving electric energy

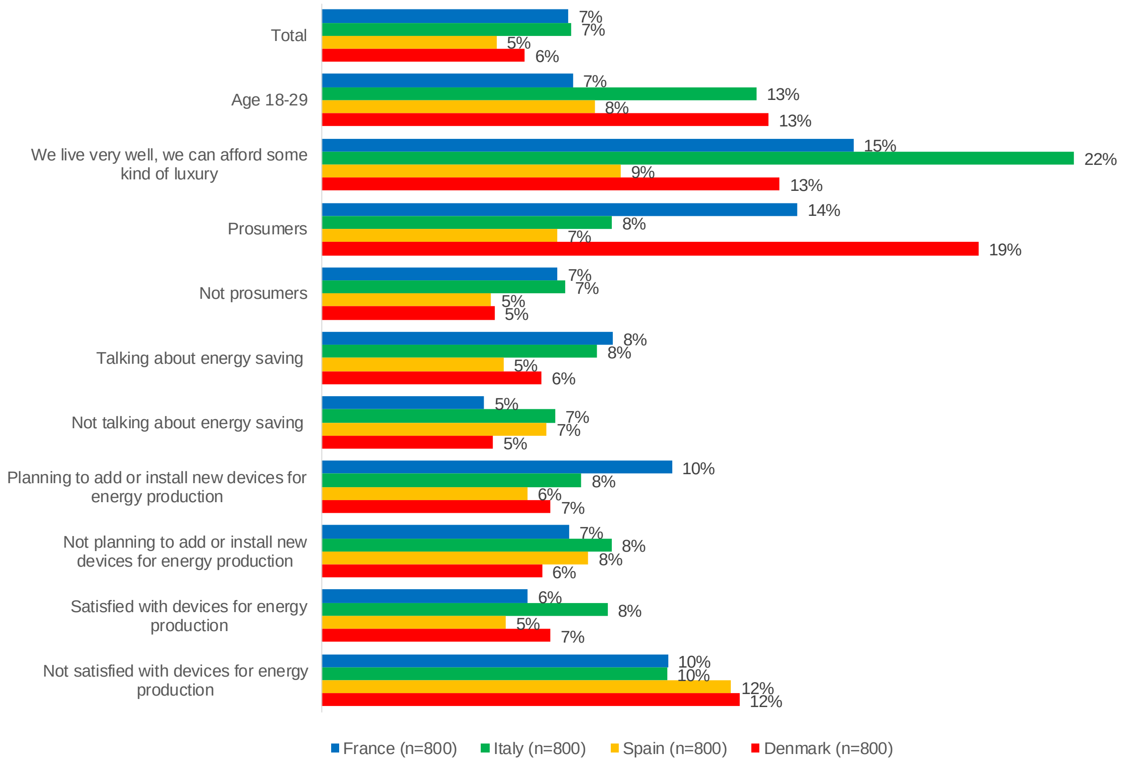

Figure 38: Statement "It is what a lot of people around me do" - indicated as one of 3 reasons for saving electric energy

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1.4 Cars – ownership, evaluation and plans

Most households in the countries surveyed have at least one car. The most in Italy (93% of households), a little less in Spain (86%) and France (81%), and the rarest cars are owned by Danes (69%). The average number of cars owned is about 1.4, the most in Italy (1.43) and the least in Denmark (1.34).

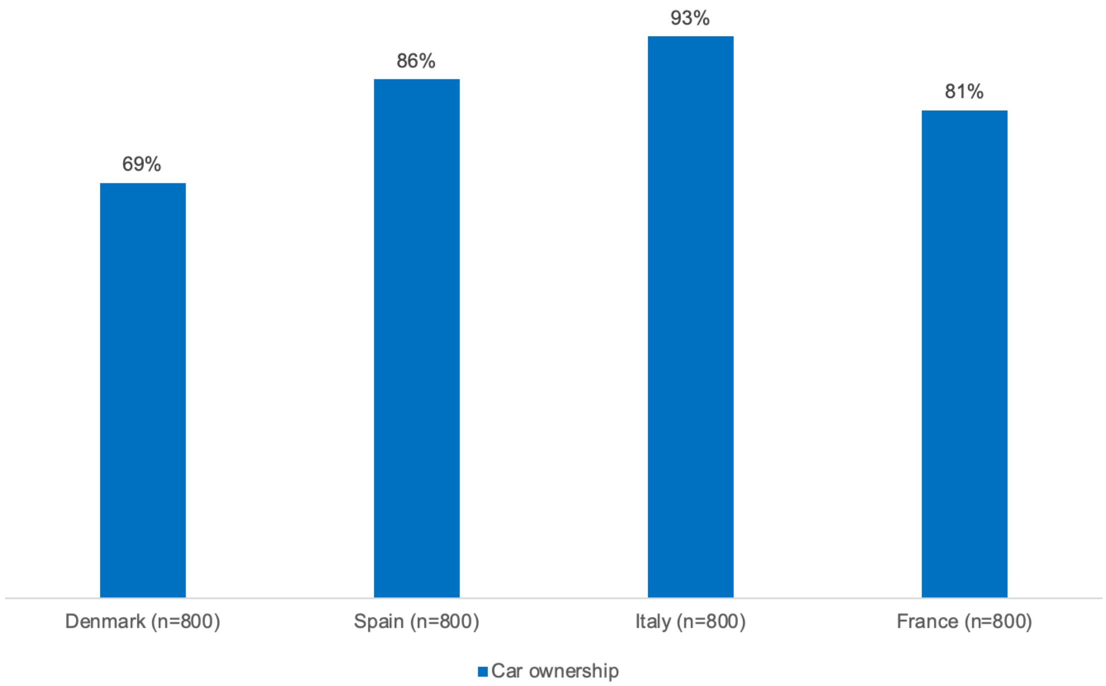

Figure 39: Do you have a car?

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Among owned cars, those with diesel engines (especially in France and Spain) and petrol engines (especially in Denmark and Italy) dominate. Hybrid cars are still rare - in France and Spain it is 3% of the total number of cars, in Italy 5% and in Denmark 6%. Electric cars and plug-in hybrids are rare in all countries. Electric cars are mostly owned by young people (as many as 10% of 18-29 year olds in Denmark), better educated and living in big cities (as much as 16% in Copenhagen).
Respondents were asked to list all cars that they have in the household. In Denmark among the cars mentioned on the first place only 1% were plug-in hybrids and 2% were fully electric. Share of electric cars was significantly higher among cars mentioned on the second or further place. So, it seems that electric cars usually have the role of an additional vehicle in a household.
In general, owned cars do not create problems for their owners. In each of the countries surveyed, 95% of car owners claimed to be satisfied with their cars.

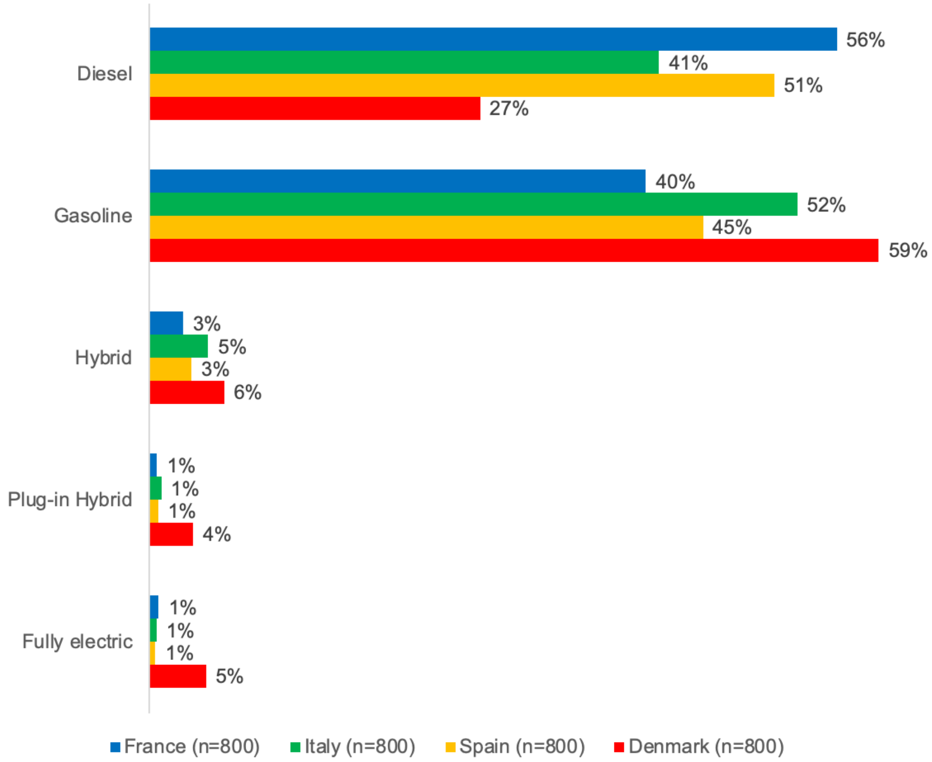

Figure 40: What type of engine this car has?

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About half of the people surveyed say they intend to buy a car within the next two years. There is a significant change in the types of cars that respondents intend to buy compared to their own.

Most people declare that their next car will have a hybrid drive - every third in Italy and Spain, every fourth in Denmark and every fifth in France. It is often planned to buy a plug-in hybrid car (most often in Italy - 19%, the rarest in Denmark - 7%) or a fully electric car - the most in Spain and Denmark, 14% and 13% respectively, and 6% each in France and Italy.

Traditional engines (diesel and petrol) are still often chosen (52% in France, 41% in Denmark, 32% in Italy and 27% in Spain in total), but the share of such types of engines among the planned cars is much smaller than in the case of owned cars.

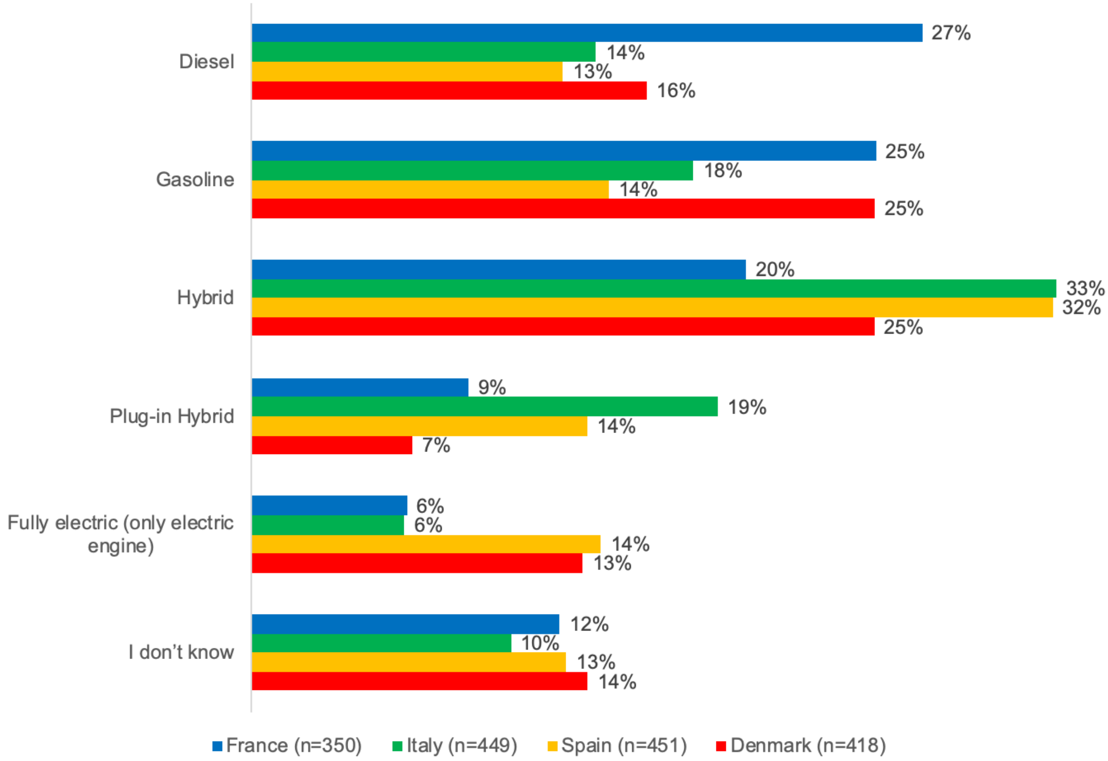

Figure 41: What type of engine is in the car you are going to buy?

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Among the reasons for choosing a particular type of car, the main criterion mentioned is environmental considerations (59% in Spain, 49% in Italy, 45% in Denmark and 38% in France). In Denmark and Italy low running costs are similarly (although slightly less) important as environmental reasons. Reliability and the distance between refuelling or charging the car are mentioned less often and aesthetic aspects are of least importance.

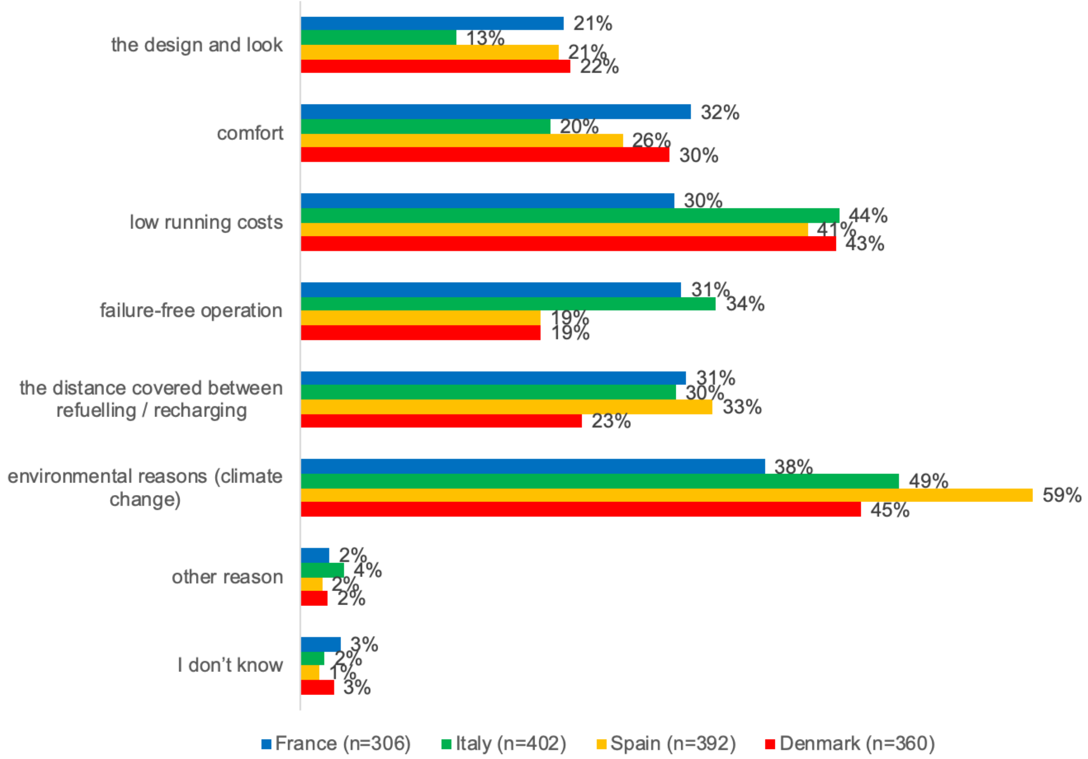

Figure 42: Why do you plan to purchase this type of a car? (please mark up to 3 reasons)

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People with fully electric or plug-in hybrid cars (total in the whole sample n=49) usually charge these cars at home (more than half of the cases) or at charging stations, public or private (every fifth case). Charging a car at the workplace or study is rare, only every tenth owner of such a car usually charges it there.
Please note that due to small sample, the results on the chart below should be only treated as a rough estimate.

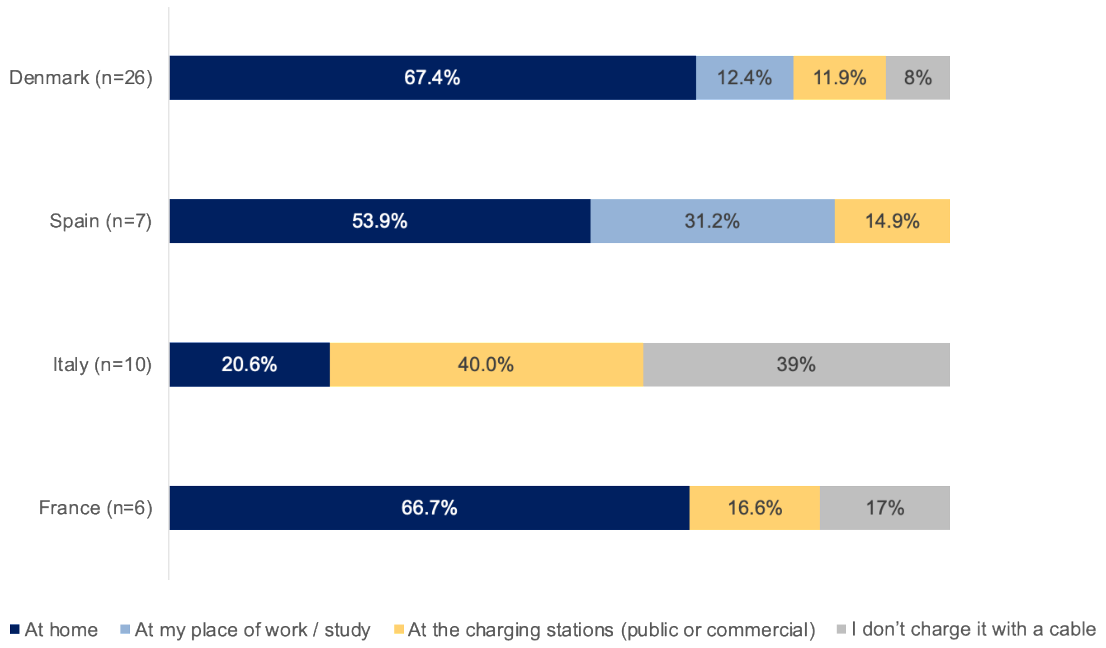

Figure 43: Where do you usually charge your plug-in hybrid or fully electric car?

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The current cost of charging an electric car is, according to the respondents, much lower than the cost of fuel for a car with an internal combustion engine. This question was asked to people who own such cars or intend to buy them. According to 9 out of 10 people, the cost of charging is 75% or less of the cost of fuel for a car with a combustion engine, and according to almost half of them it is only 25% or less.

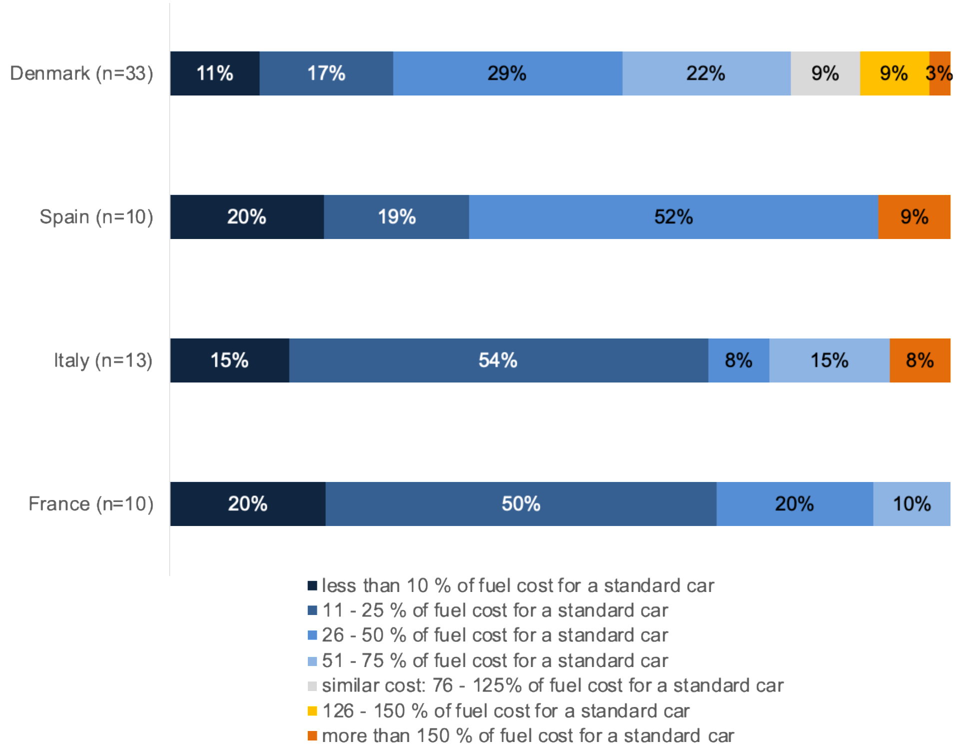

Figure 44: What is the cost of electric energy that you use to charge a car, comparing to the cost of fuel for a similarly sized standard car?

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It is likely that in the future the cost of charging electric cars will be higher. That is why we asked people who have or intend to buy an electric car or a plug-in hybrid if it would be acceptable for them to charge their car at the same cost as it currently costs fuel for a car with a combustion engine. Opinions on this subject are divided. Almost half of the people would accept such a cost, a similar number of people would not, and a small percentage of respondents do not have an opinion on the subject.

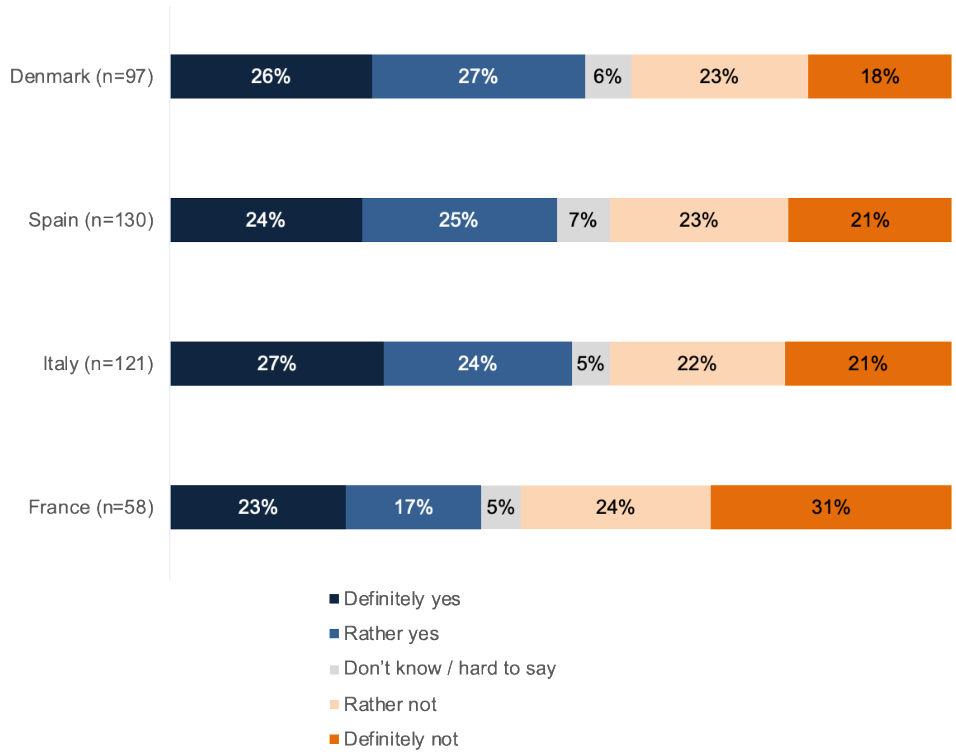

Figure 45: Would you agree to pay the same amount for charging an electric car as for fuel for a standard petrol car? (answering – electric car owners or those who plan to buy such a car)

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1.5 Concepts of technologies for intelligent management of electricity

The study evaluated three technologies that were presented to the respondents in such a way:

Automatic lighting control in the apartment/house.
The system consists of sensors detecting human presence, which are located in all rooms of the flat or house. Based on this information, the automatic system can switch on the lighting in the rooms where someone is staying and switch it off when leaving. This means that you do not need to use switches to light each room and you can reduce your electricity consumption.

External washing machine control.
In this solution, the user of the washing machine decides not the moment when the laundry starts, but the time at which the laundry is to be finished (e.g. in the morning, before going to work the user loads the washing machine and decides that the laundry is to be finished by 17.00). The system controlling the start of the washing machine will switch it on at the most convenient time for the whole power network, i.e. when the total demand for electricity is low. Thanks to this solution, it is possible to postpone electricity consumption for a period of lower demand and reduce the total energy consumption from the area during peak hours. This reduces the load on the power grid and reduces the cost of electricity.

External charging control for an electric car.

Imagine you have a fully electric car that you are charging from an outlet in your home or from a charging station near your apartment. In this solution, once the car is connected to a charging station, you determine by which time the car should be fully charged. For example, when you return home, you connect the car to the power supply and decide that it should be ready to drive the next day at 7.00am. The control system will decide on the exact time to start charging the car's battery so that this will take place at the most convenient time for the entire electricity grid, i.e. when the total demand for electricity is low. With this solution, it is possible to shift electricity consumption to a period of lower demand and reduce the total energy consumption of the area during peak hours. This reduces the load on the power grid and reduces the cost of electricity.

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The concepts presented in the study were in the vast majority easy to understand for the respondents. Of the three evaluated technologies, the most comprehensible is the automatic control of lighting, a little less external control of the automatic washing machine, and relatively least external control of electric car charging.

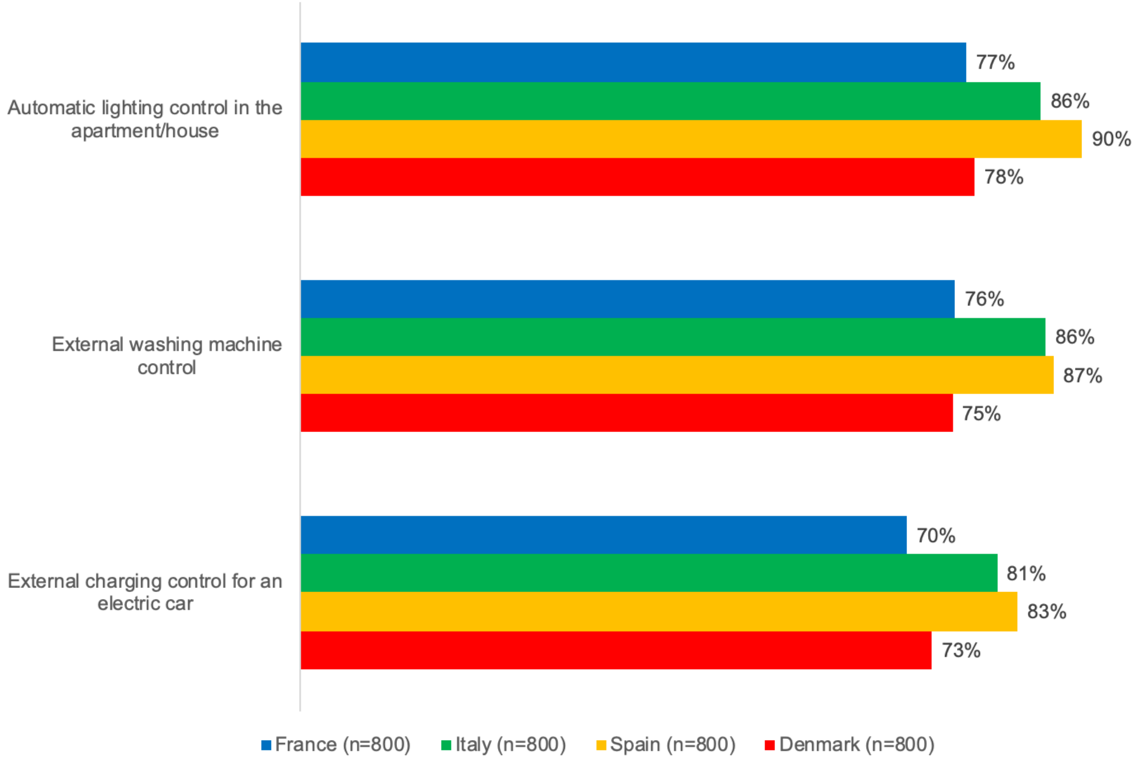

Figure 46: Is it easy to understand how the technology described above should work? (share of answers ‘easy’ and ‘rather easy’)

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More than 60% of the respondents from Italy and Spain and about half from France and Denmark are interested in using the solutions described in the concepts. The differences in the declared level of interest between the concepts are small, which indicates that those expressing interest in the concepts are generally interested in new energy saving solutions, regardless of the details of the technology.
The most interested in these solutions are the elderly, those living alone and in a worse financial situation and paying the lowest electricity bills. This indicates that the main factor influencing the interest in these technologies is the need to save money. This is confirmed by the differentiation of support between the examined countries - the greatest interest in the technologies described in the concepts is in relatively lower income countries among the examined countries (i.e. Spain and Italy).

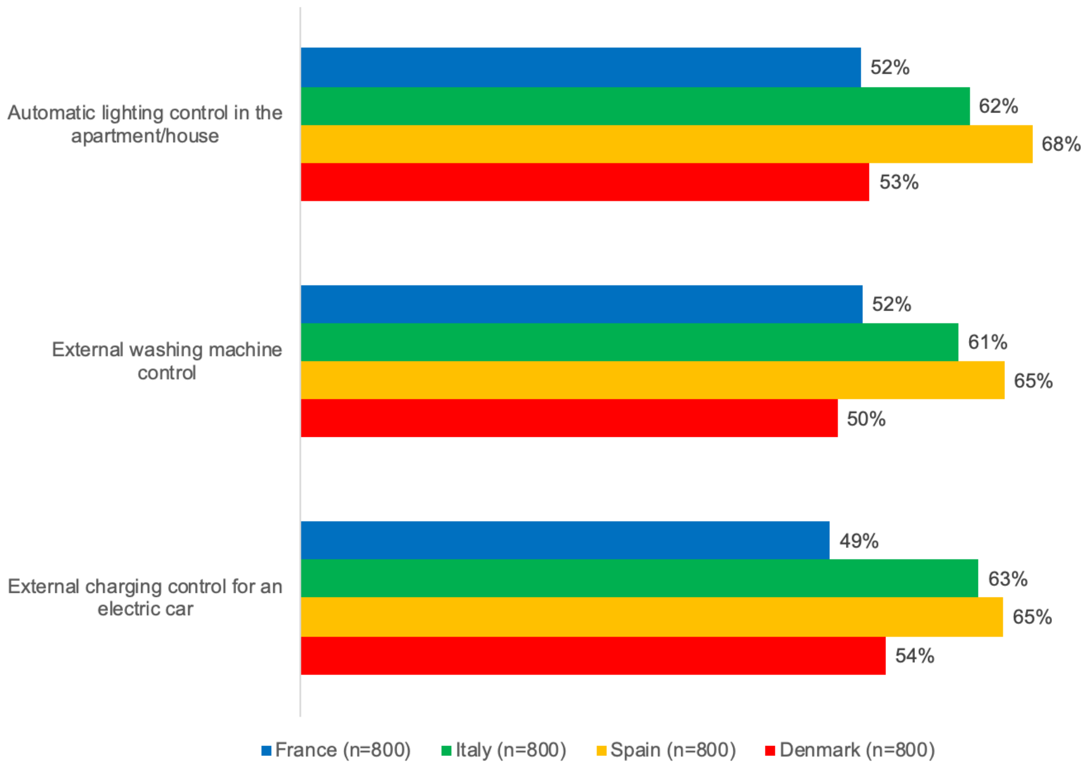

Figure 47: Would you be interested in using such a system for yourself? (share of answers 'yes' and 'rather yes')

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For all evaluated concepts, roughly 50% of respondents expect to be able to independently control devices and the system that manages them, using an advanced or simple interface. Only about 25% of the respondents do not want to control the technologies described in the concepts, and about 20% have no opinion about it.

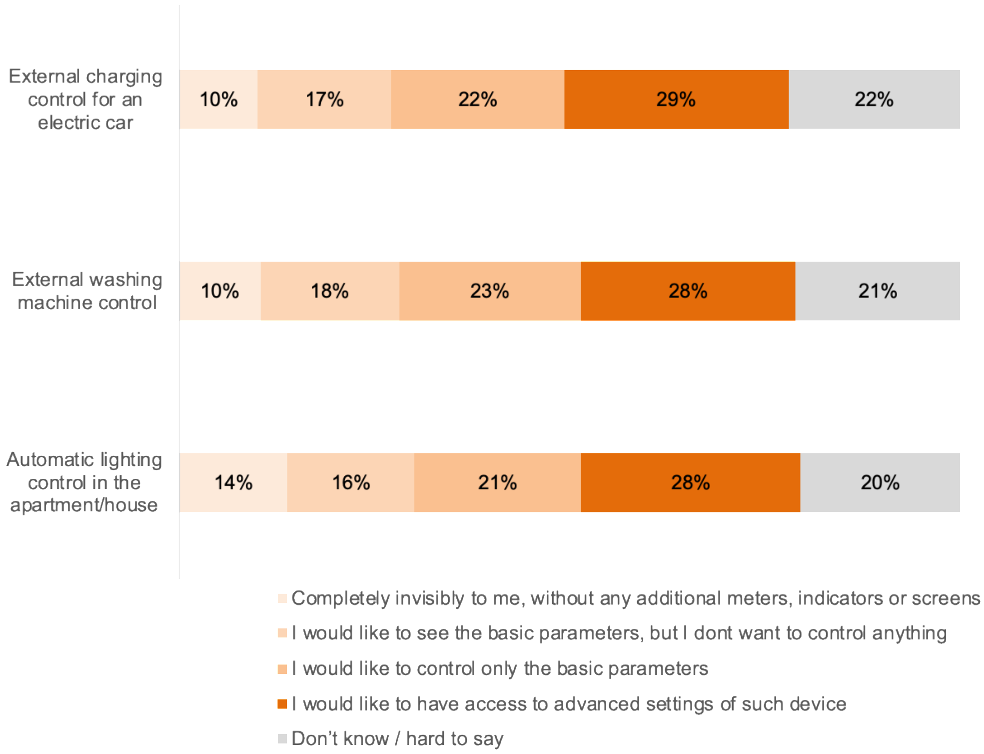

Figure 48: How do you think such technology should be controlled?

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1.5.1 Automatic lighting control in the apartment/house.

The respondents claim that the use of automatic lighting control technology would encourage them above all: reduction of electricity bills, free installation of the system, simple and commitment-free current system operation. Also environmental aspects, such as the possibility of reducing the negative impact on the environment or reducing CO_2 emissions, were highly rated.

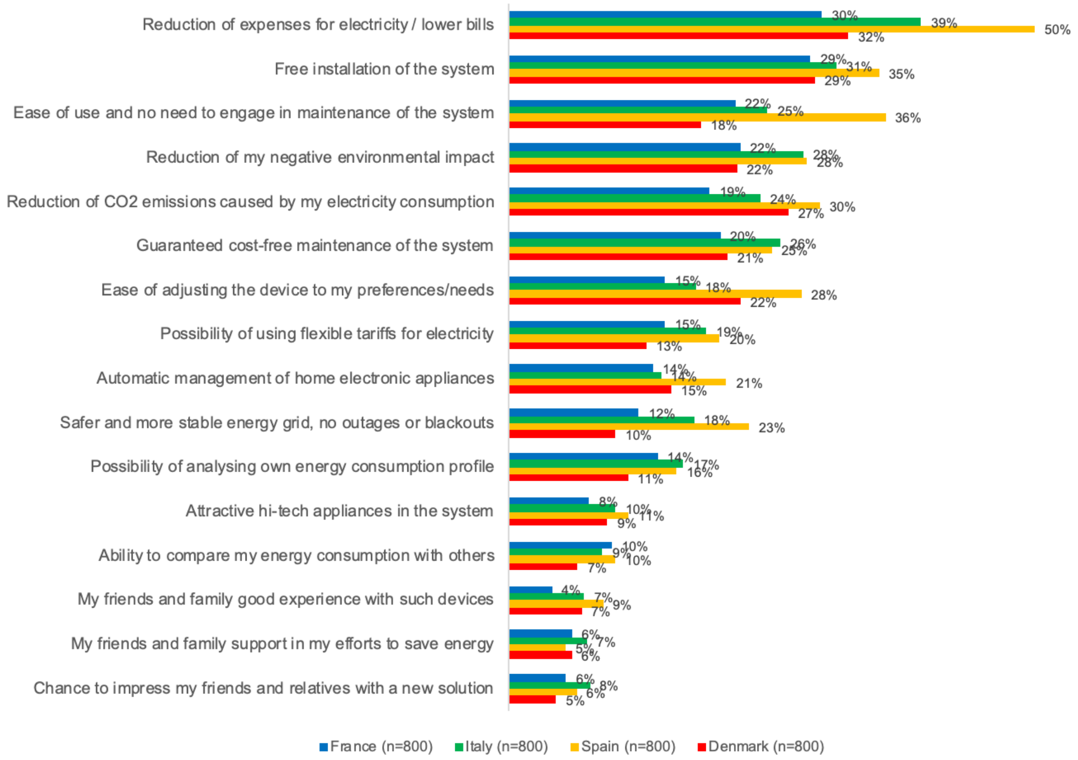

Figure 49: What would encourage you to use such technology? - Automatic lighting control in the apartment/house.

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Concerns about the automatic lighting management system mainly concern cost and service issues: respondents were concerned about the high cost of installation, expensive repairs, complicated installation and maintenance. They also often feared, at a less extend, that the financial benefits might be too small and that their privacy would be at risk.

Figure 50: What concerns do you have, when you think about using such technology? - Automatic lighting control in the apartment/house.

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1.5.2 External washing machine control

The financial aspects - reduction of electricity bills and free installation of the system - would encourage the respondents to use an external washing machine control system. Also very important, in all countries, were environmental considerations and simple system operation. The possibility to compare consumption with other households or modern control interfaces do not encourage the use of this solution. The possibility of impressing others or the influence of the experience of people close to them and their families is, according to the respondents, of little importance.

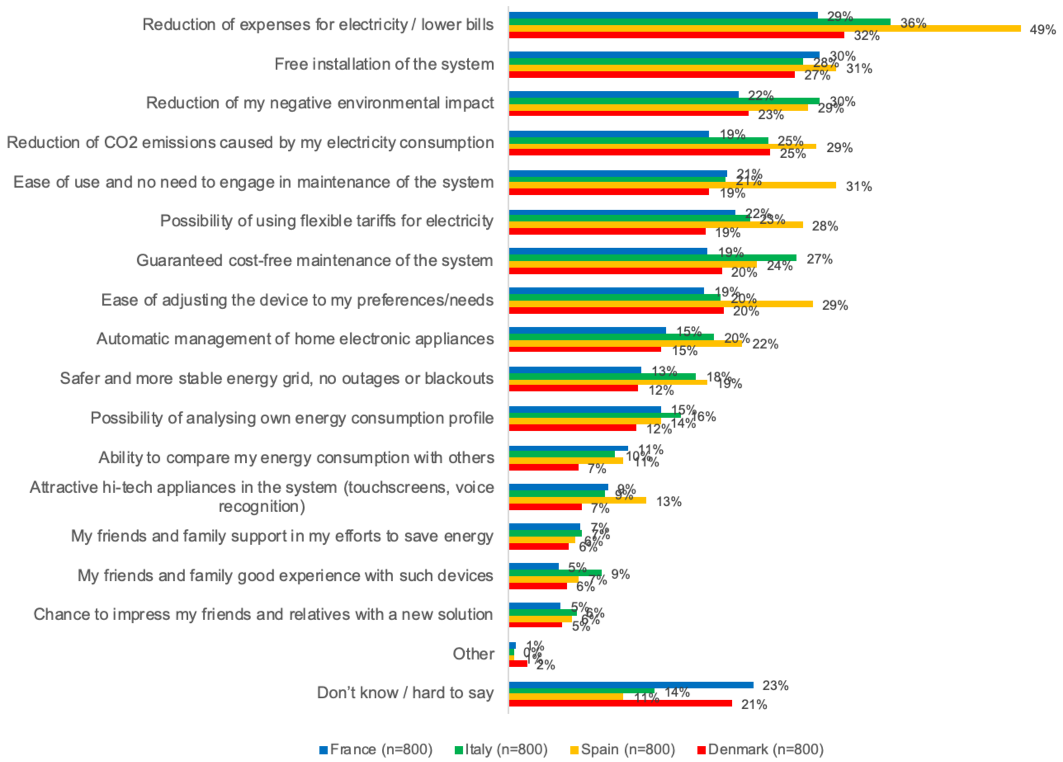

Figure 51: What would encourage you to use such technology? - External washing machine control.

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Among the concerns related to the use of external control of the washing machine, the respondents mention: high cost of installation and repairs, complicated maintenance and installation. They also fear that the financial benefits will turn out to be too small and that they will find it difficult to learn how to operate the system and the technical support will be insufficient. Slightly less often there are concerns about losing control over the equipment and privacy.

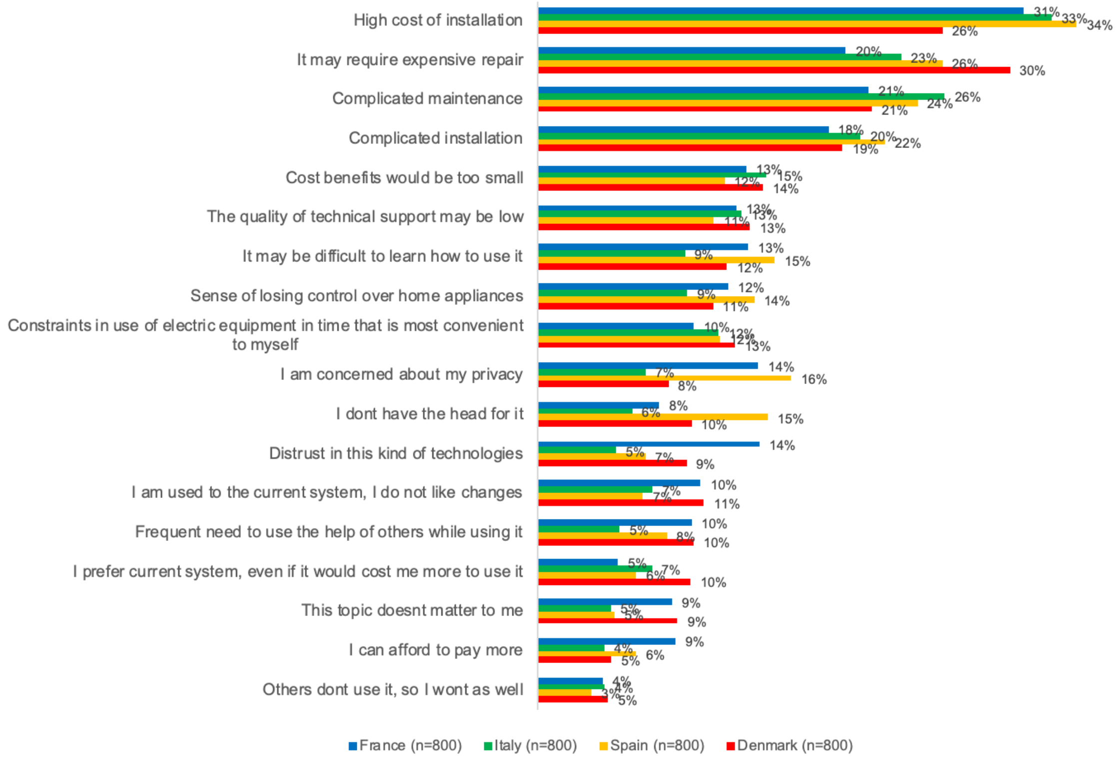

Figure 52: What concerns do you have, when you think about using such technology? - External washing machine control.

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1.5.3 External charging control for an electric car.

The factors encouraging the use of external control for an electric car are, as in the case of the other two technologies, the possibility to reduce electricity expenditure and the free installation of the system. The environmental benefits and the reduction of CO_2 emissions are also important. Other frequently mentioned factors include: the guarantee of free system service, easy, low maintenance and the possibility of using flexible tariffs.

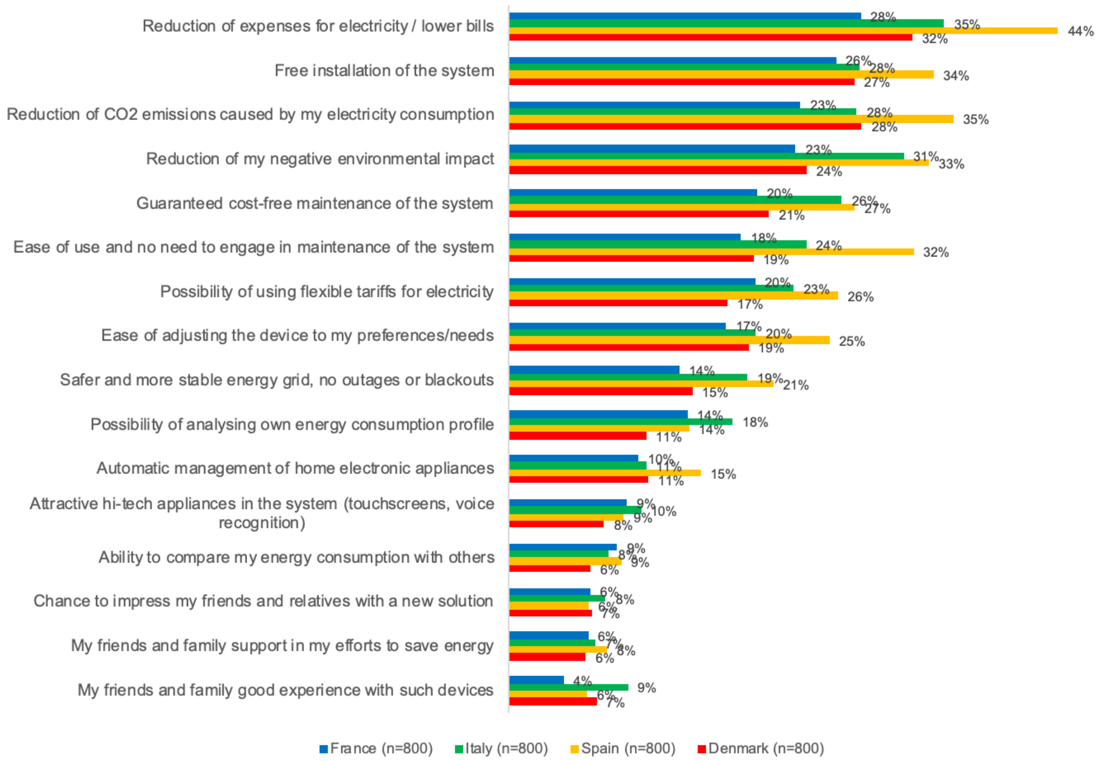

Figure 53: What would encourage you to use such technology? - External charging control for an electric car.

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Concerns related to the external control of electric vehicle charging are - as in the case of other assessed technology concepts - related to the high cost of installation and repair and too complicated installation and maintenance. Other concerns, such as those related to the quality of technical support, learning how to operate, or restrictions on the free use of the equipment, are clearly less frequently mentioned.

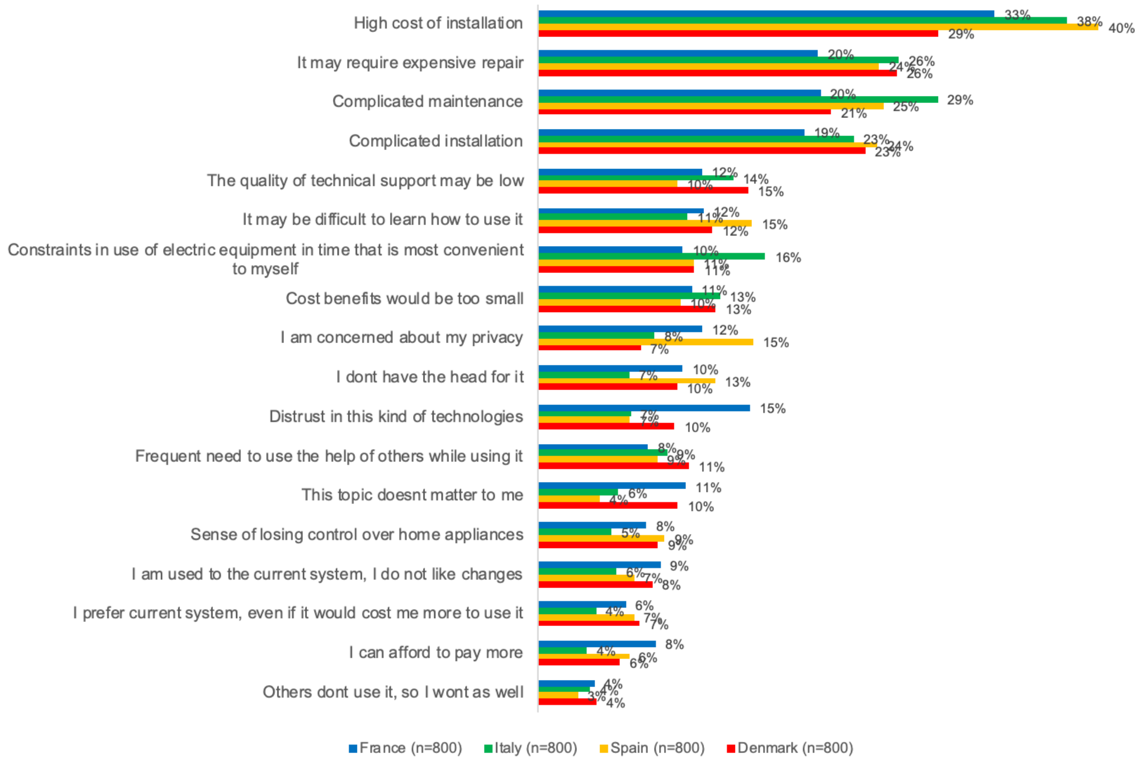

Figure 54: What concerns do you have, when you think about using such technology? - External charging control for an electric car.

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1.6 Attitudes

1.6.1 Leisure time and work

The pandemic has changed the way we spend our free time. In countries where relatively much time was spent at home (France, Denmark), the behaviour during the pandemic did not change significantly. A big change took place in Italy and Spain, which before the pandemic were distinguished by the fact that more than 70% of their inhabitants spent their free time away from home, while during the pandemic only less than 40% of people spend their free time away from home. Such a response can be attributed to the fact that individual countries were affected by the pandemic to different degrees. In Italy and Spain, the consequences of the pandemic appeared more serious than in France and Denmark.

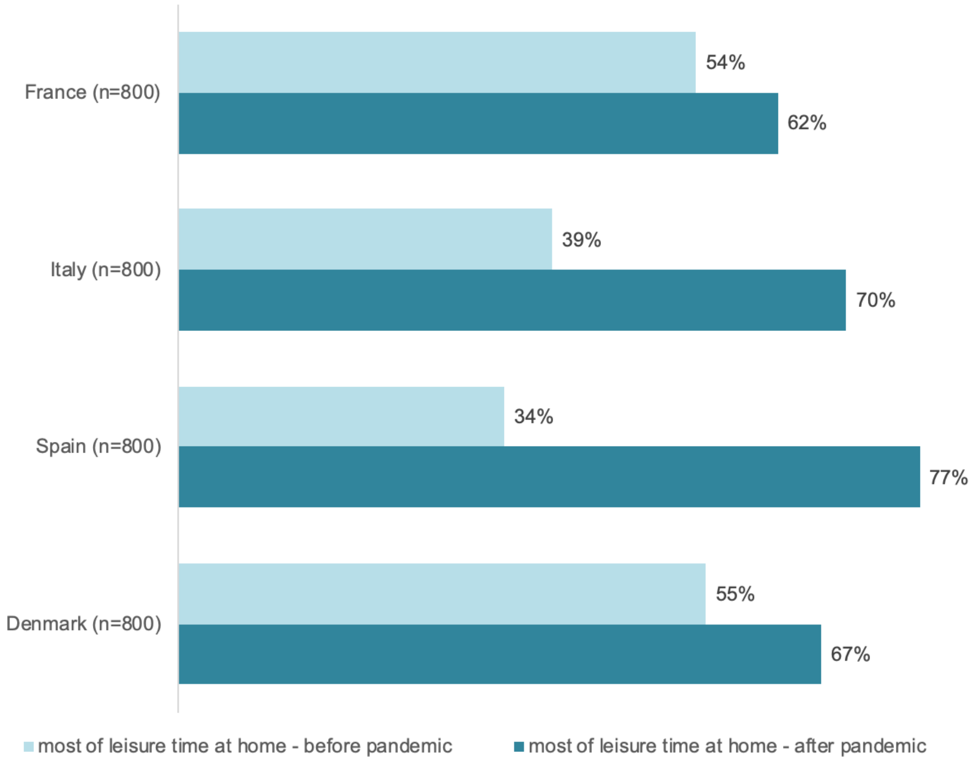

Figure 55: How much of your leisure time do you spend in your household?

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After the restrictions related to the COVID-19 pandemic have ended, most of the respondents intend to commute to work by car or on foot. A significant proportion of Danes intend to go to work by bicycle (40%). Public transport will be chosen by about 20% of respondents (the least in Italy - 11%, the most in Spain - 25%).

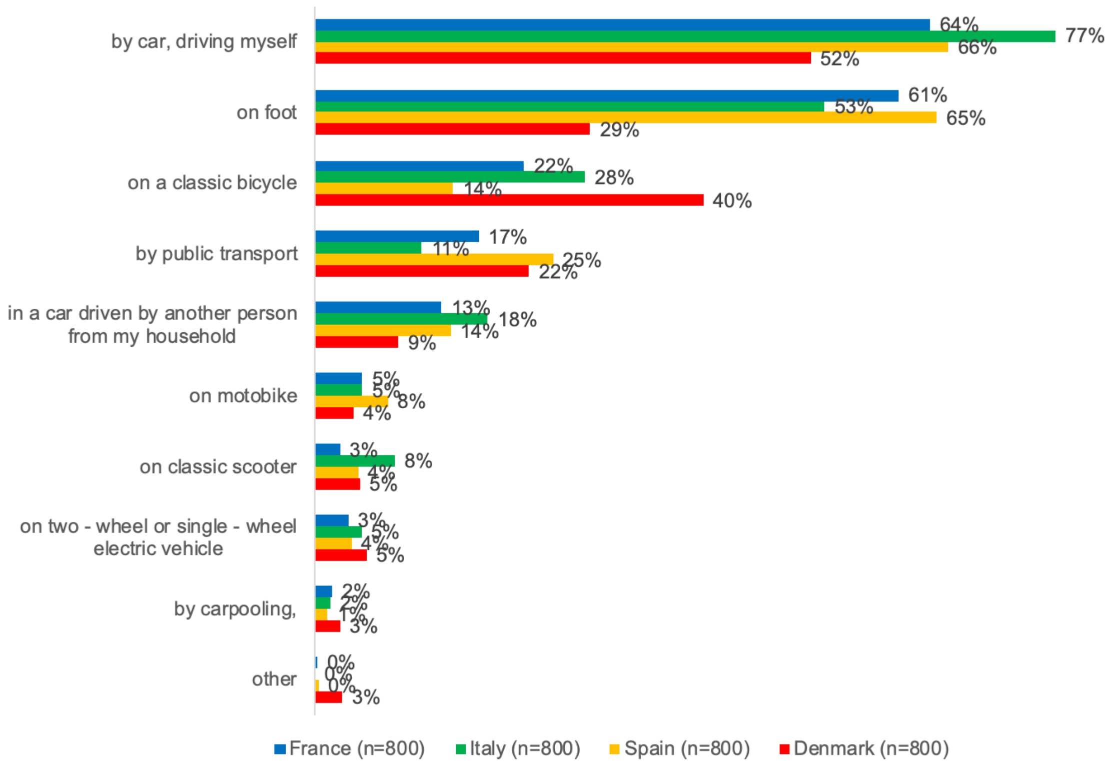

Figure 56: How do you plan to commute when the COVID-19 restrictions are lifted? (please indicate up to three main means of transport)

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1.6.2 Opinions about Life goals, Technology and Natural environment

Among the life goals, considered important by the inhabitants of the countries under study, it is worth noting that the goals that can be associated with the energy transformation towards reducing greenhouse gas emissions, i.e. *security, no fear about the future* and *recognition and respect of the environment* are considered important by 7 out of 10 people.
Other important values include: *health, family, joy, love, intellectual development*. The least frequently chosen values are *prestige, competition, success, enjoying the charms of a big city* and *being respected and admired by other people*.

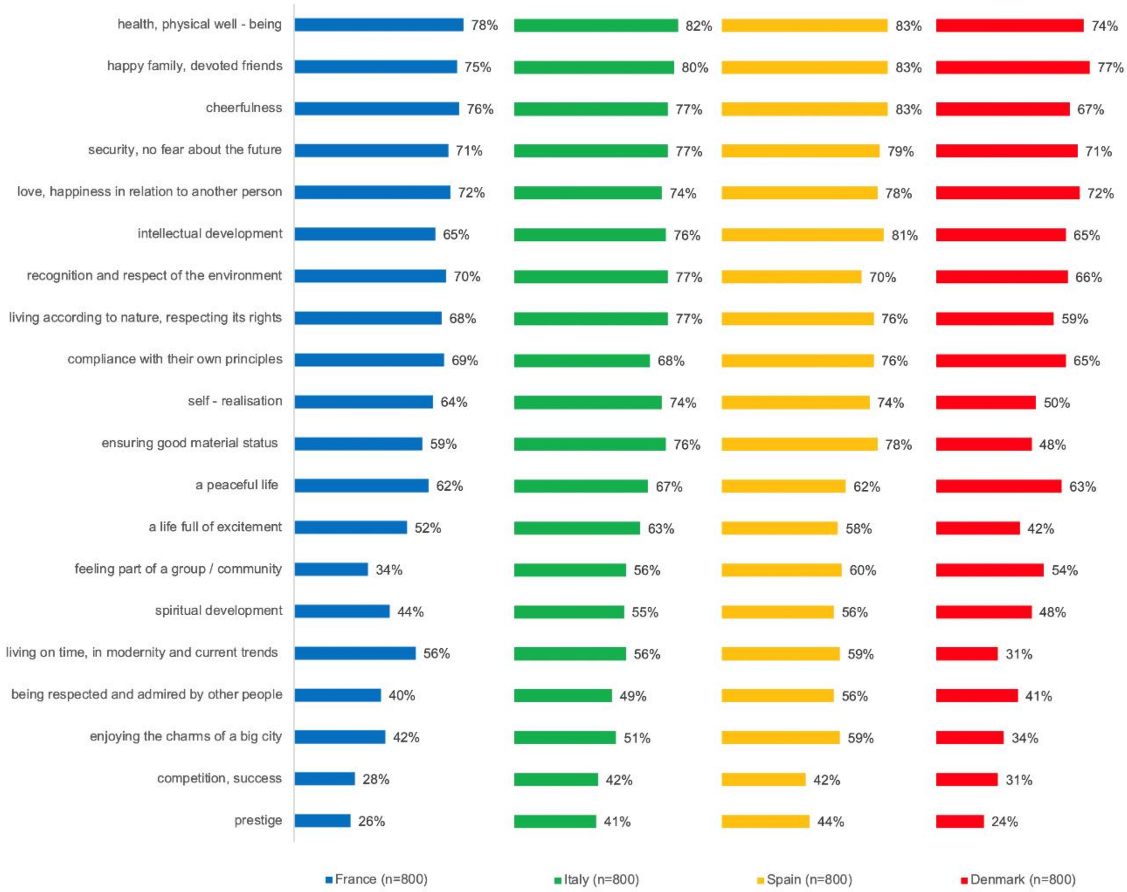

Figure 57: How important are the following goals for you? (Top 2 boxes).

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A positive attitude towards technology prevailed in all countries surveyed. In the question assessing the attitude to technology, the respondents most often agreed with such statements as: *Technology facilitates access to information*, *makes my life easier, allows me to do what I want more easily*, while the least often agreed with such statements as *I feel that I am too dependent on technology, technology controls my life* or *The more I use new technology, the more I become a slave to it*.

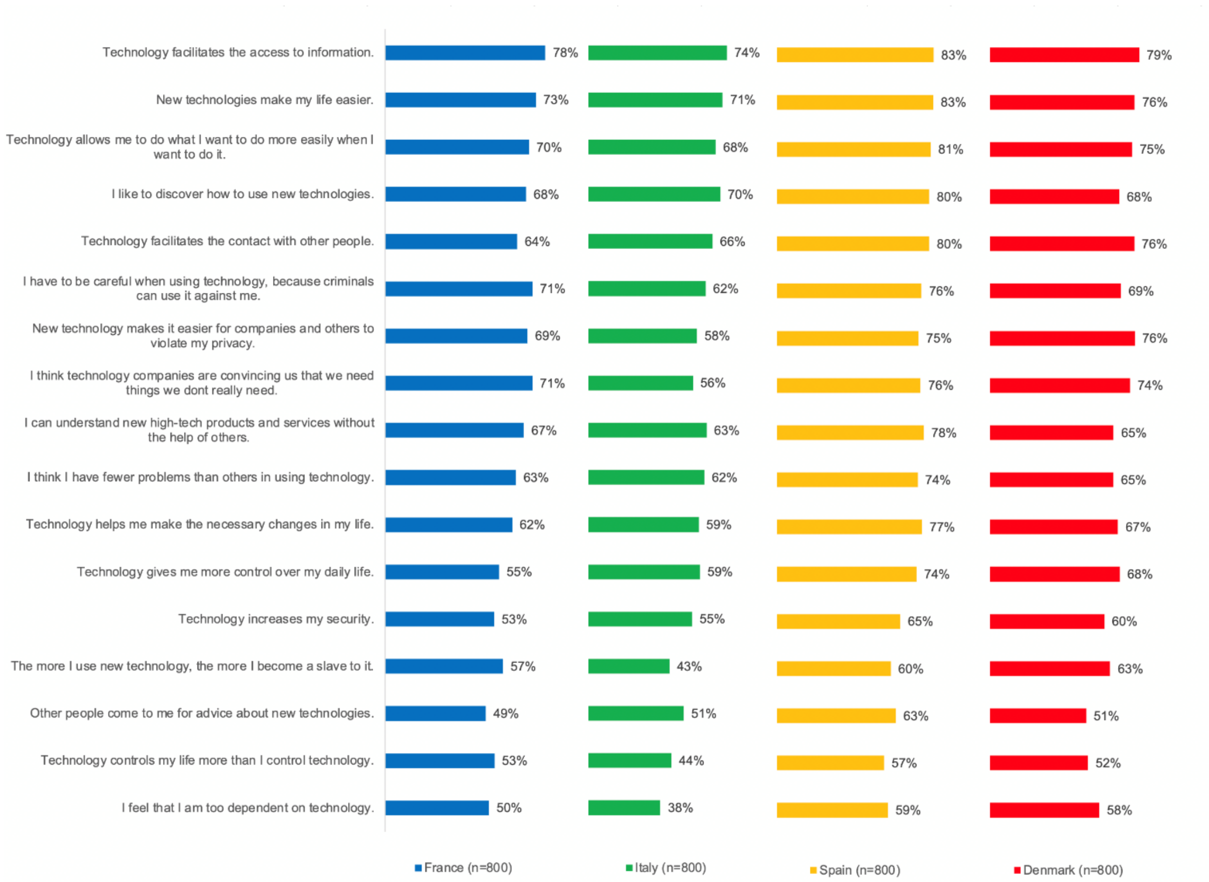

Figure 58: To what extent do you agree or disagree with the following statements regarding technology? (Top 2 boxes)

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The question evaluating the openness to new technological solutions and products shows that the most open to new solutions are the Spanish - 25% of respondents say that they are usually the first ones to try new things. In the case of Italy it is 21%, France 18% and Denmark 15%.

People with higher openness to new technologies are usually younger, better educated, living in cities, and better off financially.

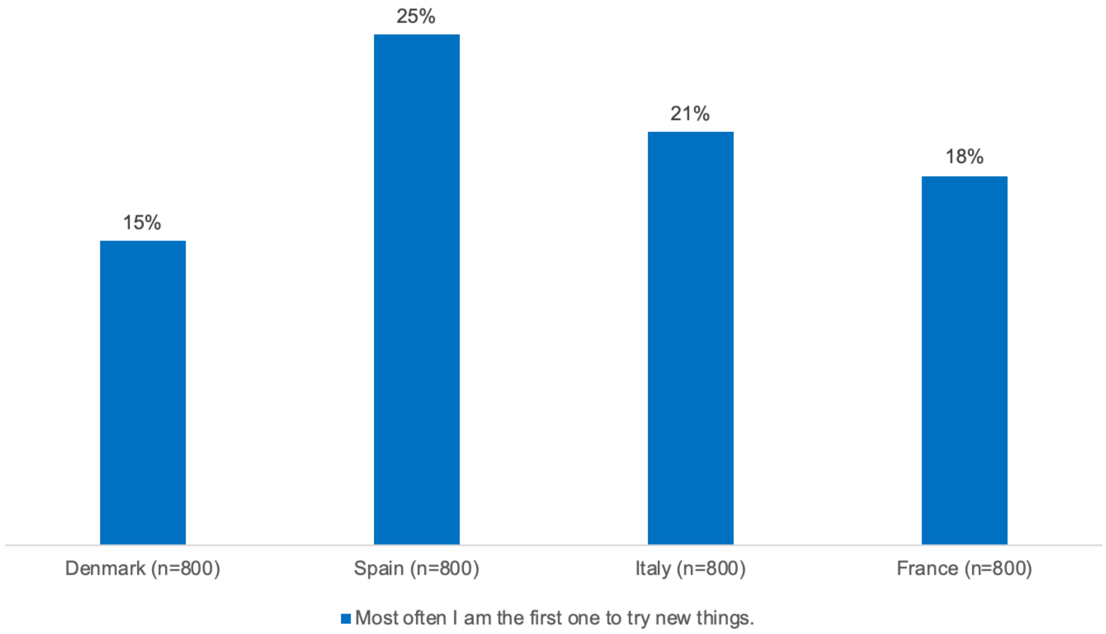

Figure 59: Taking into account people you know: friends, family, colleagues, when do you start using new solutions, products?

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Answering the question about attitudes towards technology, most respondents claim that they like to try new things and take matters into their own hands. About half of the people try to stand out from the crowd, and also half of the people try to follow the trends.

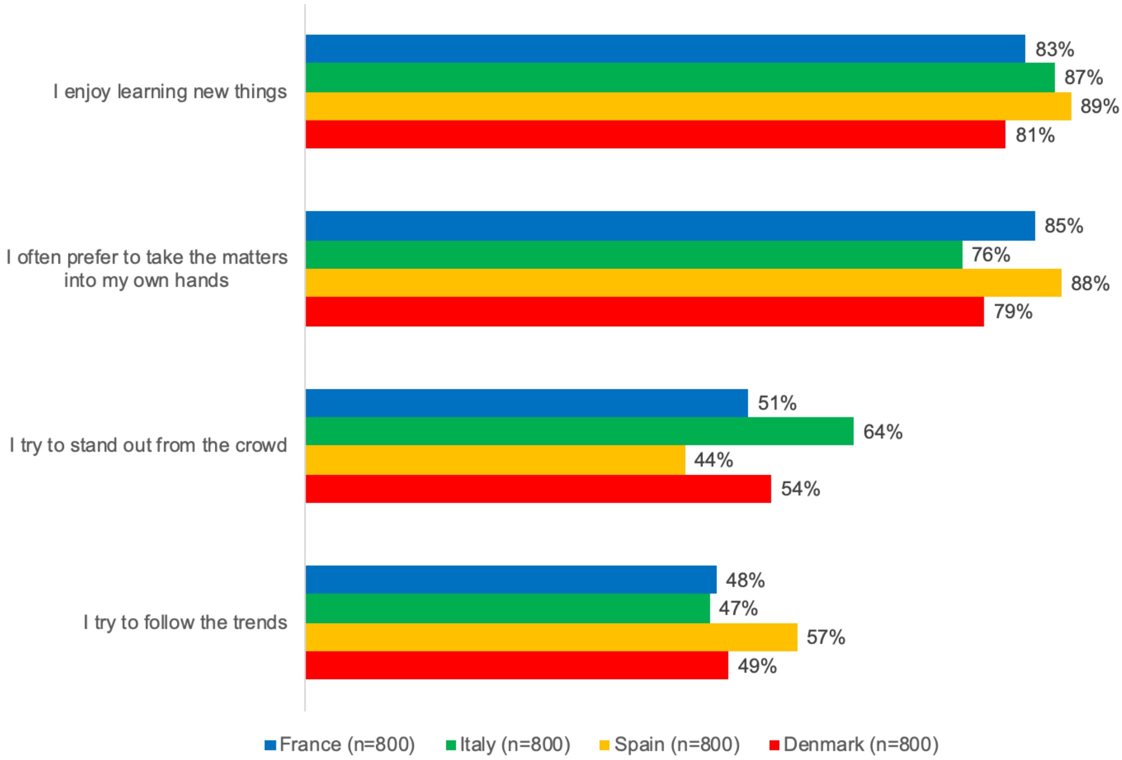

Figure 60: To what extent do you agree with the following statements? (share of answers 'yes' and 'rather yes')

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When asked to assess the consequences of climate change, the vast majority of respondents are convinced that they will be serious. About 80% of people in all countries surveyed believe that it will be a serious problem for plants, animals and ecosystems, and believe that climate change will cause serious weather disturbances and natural disasters in their country. More than two thirds of people think that climate change will have a negative impact on their health and be a serious problem for them and their families. About half of the respondents agree that climate change will bring new business opportunities (most in Denmark - 67%, least in Italy - 42%), less than half believe that climate change will have a positive impact on food production in their country (most in Denmark - 50%, least in Italy - 35%).

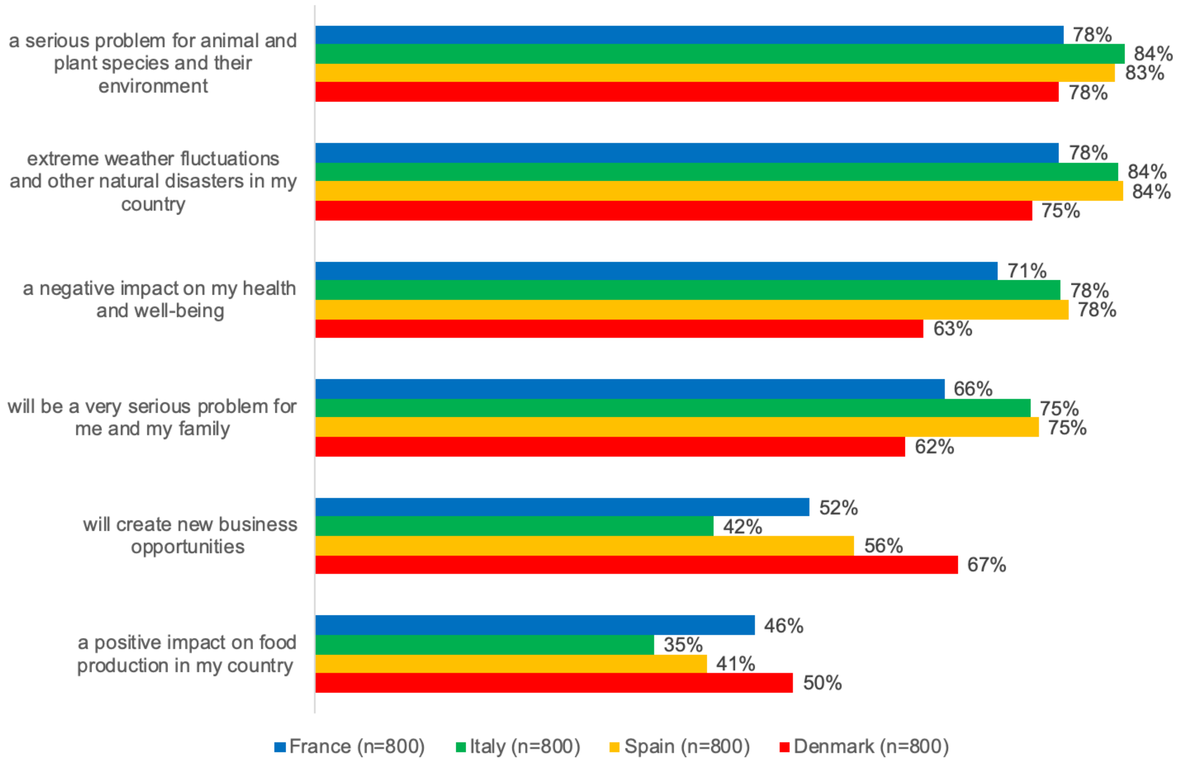

Figure 61: What do you think might be the consequences of climate change? Please indicate how likely you consider the following phenomena to occur in the future. (share of answers ‘yes’ and ‘rather yes’)

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Residents of the countries surveyed on the one hand fear the future consequences of climate change (about 70% of people in all countries surveyed), but on the other hand believe that every problem can be solved (about 80% of people), but about 40% of people believe that little can be done to reduce climate change. Slightly more than half of the people feel personally guilty for environmental problems caused by humanity.

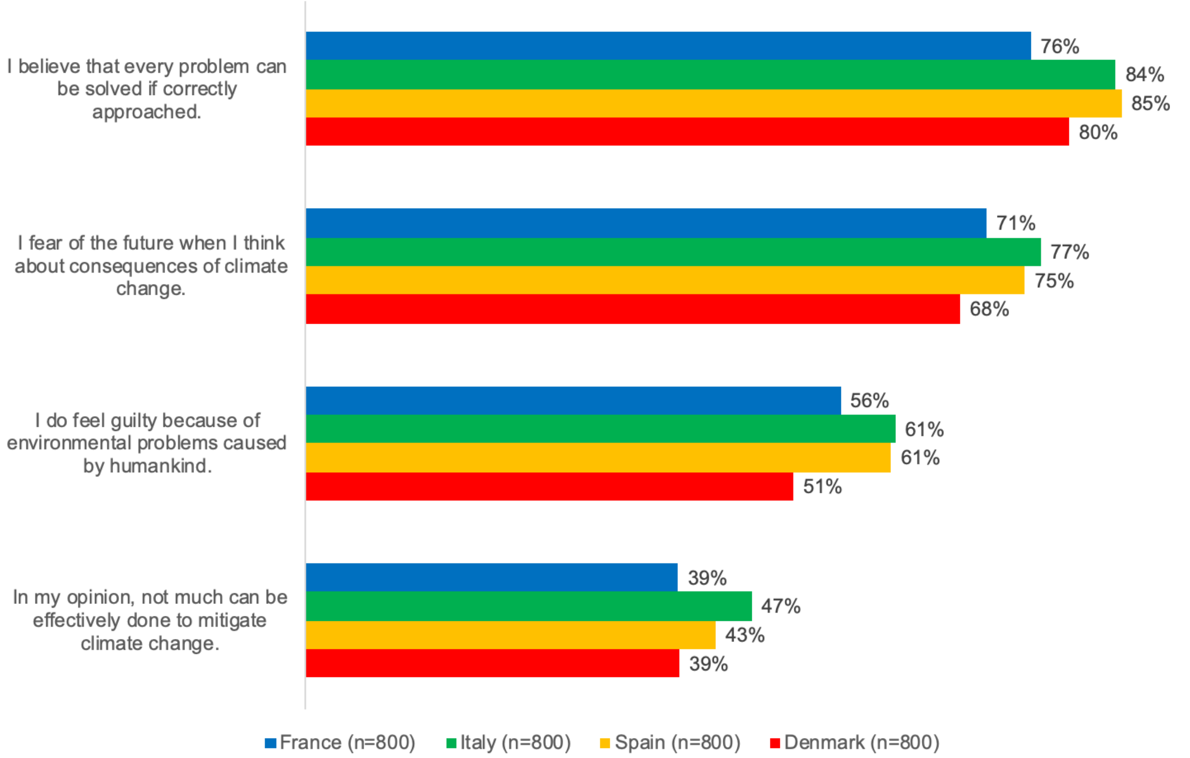

Figure 62: Please indicate your opinion on the following statements: (share of answers 'yes' and 'rather yes')

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1.7 Socio-demographic data on electricity users

The structure of population distribution in relation to the size of the place of residence is similar in all countries studied. Slightly more than half of the people live in villages or towns of up to 50 thousand inhabitants. Against this background, Spain stands out with a significantly higher percentage of people living in urban centers (32% of people in cities with more than 200 thousand inhabitants, 43% in villages and towns with up to 50 thousand inhabitants).

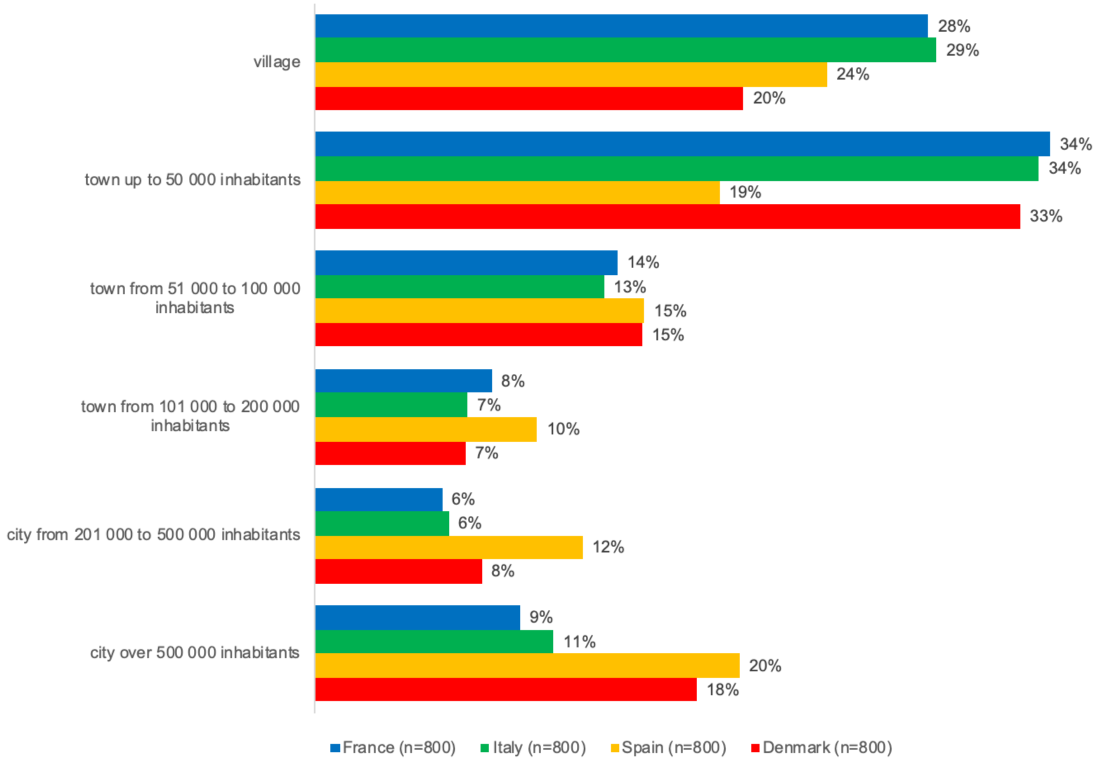

Figure 63: Please, indicate the size of the place in which you currently live

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Looking at the surveyed households in terms of area, we can see that the smallest are in France, where as much as 55% are smaller than 80 sq. m, and only 10% have an area greater than 130 sq. m. Large households are the most common in Denmark - 26% have an area above 130 sq. m. In Italy and Spain, the dominating households are medium sized - between 81 and 130 sq. m.

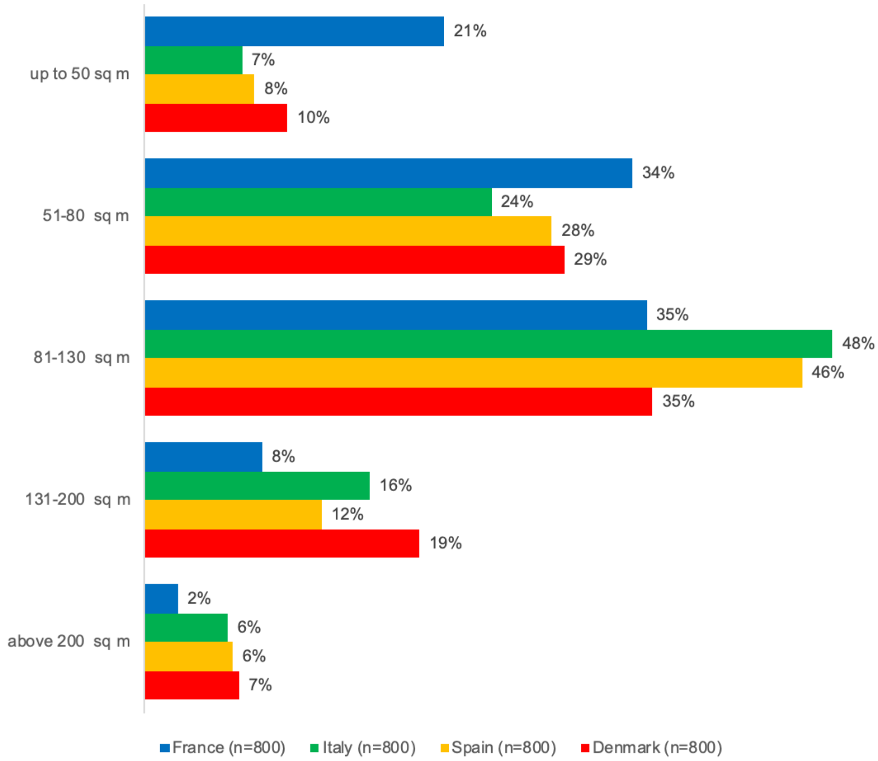

Figure 64: How many square meters - approximately - has a flat / house in which you currently live?

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Among households, in all countries surveyed, two or more people are predominant, most often to a household where partners/spouses with children live.
In Denmark and France there are much more households inhabited by singles than in other countries (33% in Denmark and 26% in France). Spain is distinguished by a high percentage of traditional partner/spouse households (63%) and children (55%). Italy is distinguished by a high percentage of households with parents (20%).

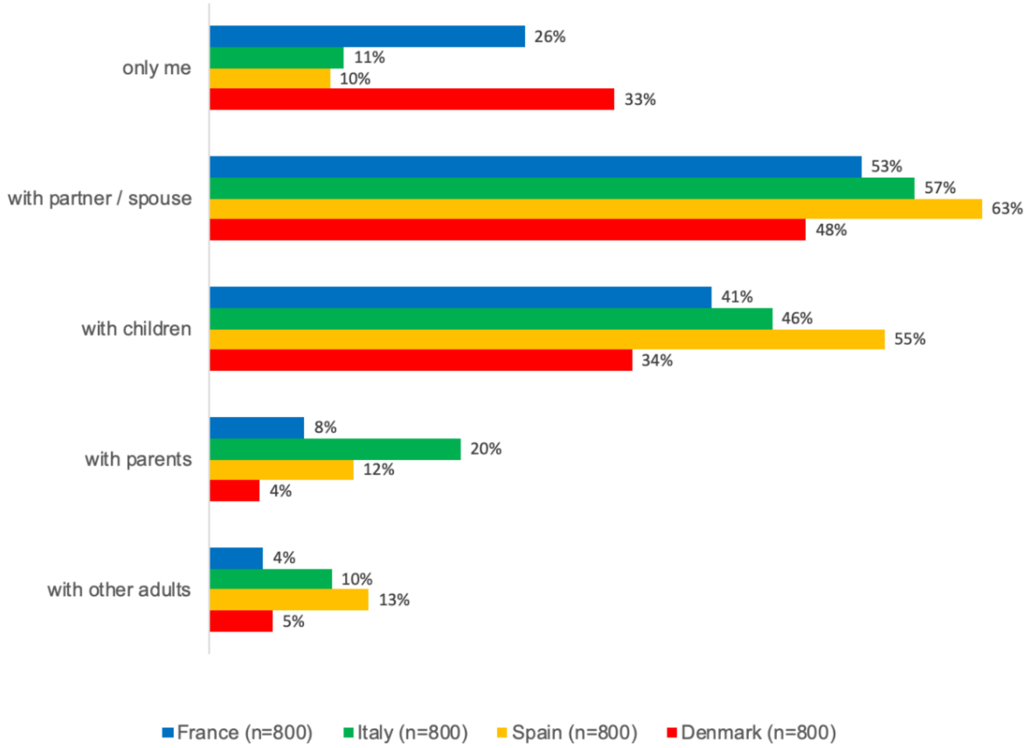

Figure 65: With who do you live in your household?

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In Italy and Spain, about 80% of the respondents live in their own properties and the remaining 20% rent them from private owners.
In France and Denmark there is a relatively large share of properties rented from the State (more than 20% in both countries), just over half of the people live in their own homes and apartments (55% in France and 59% in Denmark) and the rest rent from private owners (25% in France and 18% in Denmark).

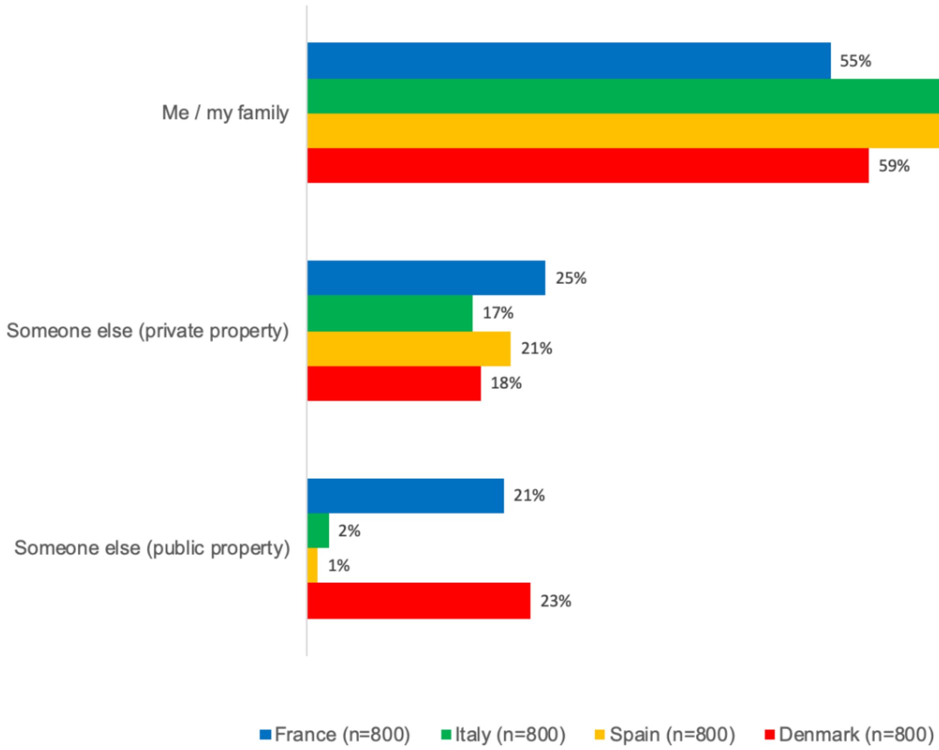

Figure 66: Who is the owner of the apartment / house where you currently live?

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Inhabitants of the countries surveyed live approximately half of the time in residential apartments and half in houses (detached, semi-detached or terraced). Spain stands out against this background, where two thirds of people live in apartments and only one third in homes.

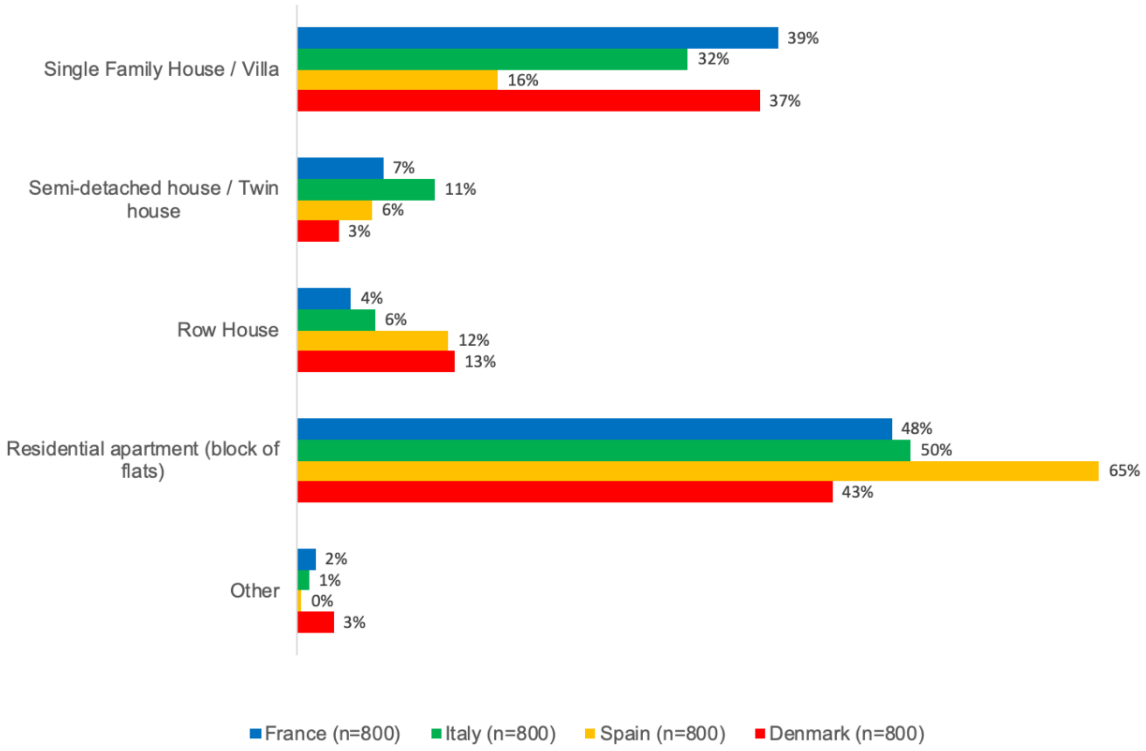

Figure 67: Which of the following best describes the type of building in which you currently live?

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About half of the households in Italy, Spain and Denmark and one third of the households in France have at least one electronic device, controlled remotely by software on a smartphone, tablet or computer. Most often it is a TV or audio system (on average in about 20% of the households), followed by voice assistants, who have an average of 17% of the households.
Most often such devices are owned by young, better educated, more affluent people, living in a household of 3 or more people and owning the property they live in.

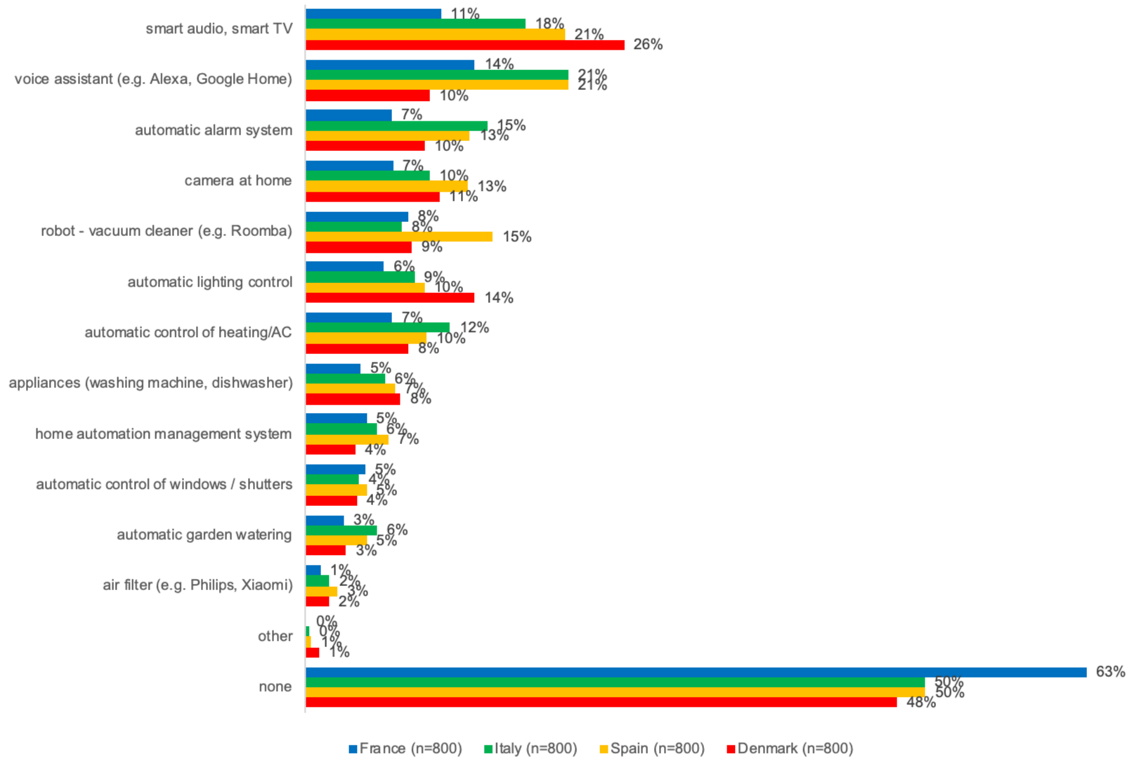

Figure 68: Which of the following electronic devices, controlled by a smartphone, computer or a tablet, do you have in your household?

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We asked the respondents what devices they think are necessary to maintain survival functions. In all countries, the most frequently mentioned device is a refrigerator (9 out of 10 respondents in France, Italy and Spain, 8 out of 10 in Denmark).
The next devices that are mentioned are: lighting, washing machine, heating. Electronic devices are also frequently replaced: cell phone, computer, TV set.
There are big differences between the countries - the French and the Spanish consider it necessary to use the largest number of devices (on average they mention 6). Italians mention an average of 5.2 items, and Danes only 4.2 items.
The number of items listed, necessary to maintain survival functions, changes with age. Young people list 5 devices on average and older people list 6. Older people more often claim that they need not only lighting, heating and air conditioning, but also a computer and a TV set. A cell phone is mentioned similarly often by all age groups (50-60%).

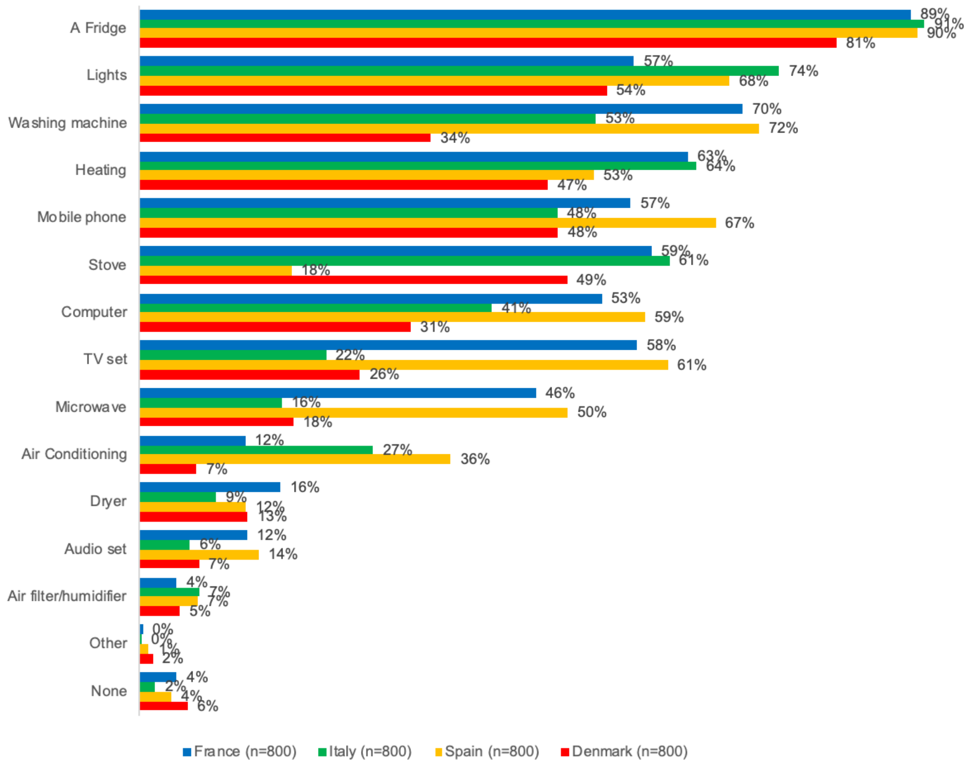

Figure 69: Which of the following devices do you consider as necessary to maintain survival functions?

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1.8 Summary of the quantitative study

There are some differences between countries in the households' possession of equipment that enables for energy saving and in the support for the installation of electricity production and storage facilities. Generally, the lowest level of possessing such equipment is observed in France that may result from a relatively large number of one-person households and many people renting and not owning apartments. The lowest support for installing renewable energy production and storage devices in the buildings of work or study is found in Denmark which is the best equipped in this matter, so it seems the Danes may not perceive the need for further developments of renewable energy installations.

Households that have facilities to generate and store electricity compose a small share of respondents, from 5% in France to 13% in Italy. If we additionally take into consideration devices limiting the demand for electricity from the network, such as solar water heating installations, heat pumps and recuperators, the share of the penetration of such equipment is still low, from 17% in France to 39% in Italy. Devices for energy generation and storage and those limiting the demand for electricity from the network are more often used by wealthier and better educated respondents.

The higher energy spending goes hand in hand with the prosperity of the respondents. The most economically affluent people perceive the energy as the cheapest, but at the same time, those respondents who spent the least think the energy is the least expensive. Prosumers spent more on energy than other households, so the savings they generate do not compensate for their bigger energy consumption.

Most respondents have a positive attitude towards energy saving. The main reason to save energy is financial, but the second reason given is the concern for the environment. Declarations of support towards energy saving are not followed by taking more sophisticated actions that could bring noticeable results. Actions that are considered the most often are those which do not require much time and effort, like: "Switching-off appliances when they are not used" or "Reduction of consumption without additional equipment".

Those who have decided to install energy production and storage equipment are usually satisfied with it. They pay attention to reducing of costs and positive impact for environment. These two reasons, in the same order, are also given as justification for plans to develop current installations or invest in new devices for energy production and storage. Installation of renewable energy generation equipment is usually perceived as economically viable.

Big share of respondents looks for information regarding the ways to save energy and talks about it with friends and family. Social networks, especially those created by strong ties with people with whom much time is spent, are not only source of knowledge how to save energy but also, at least to some extents, they influence the choice of solutions implemented.

Hybrid and electric cars are rarely owned by respondents, but often mentioned in plans of purchase. In such case the main reason provided is about the care for environment.

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The presented technological solutions are assessed similarly by respondents and at least half of them show their interest in the concepts. The most often given reason for such interest is economical, and this interest is often showed by low-income people. The respondents indicate that they want to be able to control even the advanced functions of the proposed solutions.

Respondents generally express positive attitude towards technology and concern about problems connected with climate change. Most of them believe that it is possible to solve these problems by taking adequate actions.

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2 Results of the qualitative study

2.1 Methodology

The aim of the study was to gather opinions of the end users of the designed system in order to understand the system’s broad operational context. This part of report focuses on one of the user categories: facility managers. This group is particularly important for the implementation of the project. Facility managers are people who:

- are an important target group that will benefit from the Ebalance-plus solutions
- have impact on the decision to purchase / characteristics of various technological solutions – they are advisers to the campus management
- have detailed knowledge of the technological solutions currently in use;
- have knowledge of usage patterns regarding other end-user groups (students; staff; researchers/ lecturers)

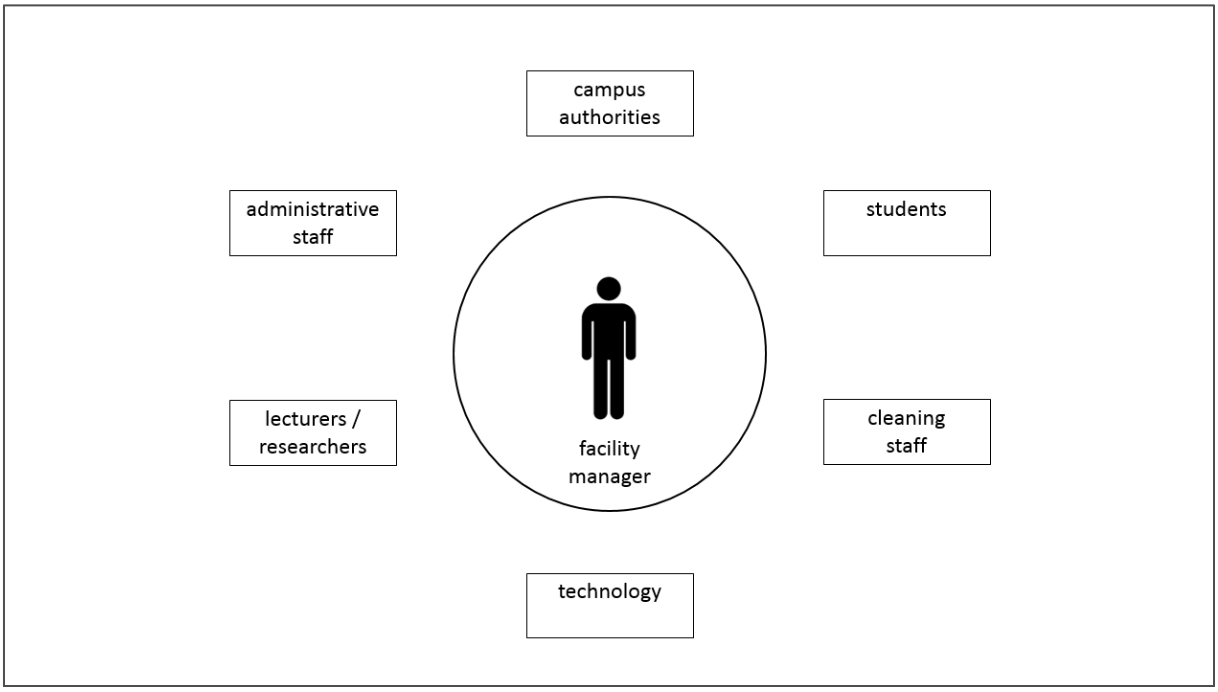

Figure 70: The facility manager interacts with a number of stakeholders on campus

Taking their opinions into account may contribute to a better identification of the needs of this key group of users, getting their opinions about effectiveness of present technologies and a more detailed diagnosis of potential barriers to the introduction of Ebalance-plus solutions to the market.

As the aim of the survey was to acquire a deeper understanding of the perspective of facility managers, in this module we used a qualitative study carried out by means of individual in-depth interviews. The interviews were conducted on the basis of a scenario which had been developed in advance. A total of 5 interviews with facility managers were conducted on YNCREA, UNIVERSITY OF MALAGA, and

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UNIVERSITY OF CALABRIA campuses in June-July 2020. Each interview took about 2 hours to complete and was conducted in local language.

Please note that in this study we do not refer to any particular campus for confidentiality reasons. This study is a collection of insights from various demo-sites, forming a basis to develop a general model of potential users' behaviour. The intention of the study is to create a description of various features of the social environment in which the technological solutions developed under the Ebalance-plus project will operate, as well as mapping out best practices impacting the future adoption of the system.

2.2 Results – campuses demo-site

2.2.1 The organisational environment

The description of the outcomes of the study should start by noting that the **status of the institutional actor (facility manager) may vary** significantly across different organisations. Such a person (or team of persons) can be a powerful actor who advises the university authorities and management, has a large budget at their disposal, and exerts real influence on the shape of the technical solutions applied. He or she may also be a weak actor, in which case his or her influence on the applied solutions is small, turning the facility manager into a maintenance person looking after what is already available, without the possibility of having a real influence on the shape of the applied solutions while the decisions on software and hardware are made by someone else.

The facility manager (or a facility management team) may also have **different scopes of tasks and responsibilities**. These may include tasks related to maintaining the facility's status quo (repair works; maintenance, ensuring failure-free operation), but also forward-thinking and actively seeking solutions to reduce the institution's operating costs (seeking cost savings), participating in the planning and organisation of new investments, paying attention to the convenience of stakeholders (the facility's users), and, finally, taking into account climate-related issues (e.g. evolutionary change of the solutions applied in the facility to meet CO_2 reduction objectives).

One of the components of the institutional environment is also the **organisational culture** which defines to what extent the ideas of facility managers are taken into account by university authorities, and to what extent the cooperation is based on dialogue. Communication between facility managers and university management communication can be unidirectional (facility managers follow the instructions of their superiors) or bidirectional – facility mangers can submit their own ideas with a possibility of implementation. The organisational culture dimension can also include attention paid within the organisation to the convenience of end users and to green energy as well as CO_2 emissions.

Another dimension that constitutes a differentiating factor across the universities in the study and has a potentially very significant impact on the performance of facility managers is the **technological sophistication of the facility management solutions used on campus**. The degree of the sophistication varies a lot. For example, information about power output from PV panels may be available as a total presented once a month, but it may also be available as real-time minute-by-minute data. Saturation with information has a great influence on the flexibility of the system's management, and response time and mode in the case of unusual events.

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Another parameter that can influence the technical aspect of installations and their mode of governance is the **skills and resources held internally within the institution**. For example, within the campus, in the same urban island, the Catholic University (economy, human sciences, etc.) and Yncréa (engineering school) are present. It is the existence of such an ecosystem with a University Federation (bringing together the University, Yncréa, etc.) very committed to reducing its carbon footprint, and teaching engineers (experts, available, researchers, research work for their students, etc.) that promotes diversity, technicality and mastery of various technical decisions. These in-house skills help to anticipate the problem of information saturation. At the beginning a lot of data is processed, then there is a sorting according to what is important or not. This context also promotes cost control because there is better anticipation of needs based on the available budget.
A separate issue and another differentiating factor is the **type of control software for the different systems used on campuses** (water supply, electricity, gas, heat, air conditioning, technical faults e.g. lifts, window and door statuses (open/closed), carbon dioxide levels; PV power output, status of charging stations, etc.). Each of these separate sub-systems may be monitored centrally from a computer; but sometimes it is not. Centrally controlled systems may have separate software dedicated to particular sub-systems, or a single global control software for controlling multiple subsystems (a Building Management System). The collection of different data in one place (software) facilitates management and saves time.

The data from our interviews show that on different campuses there are different rules of access to the control software. On some campuses, the **software is accessible to all stakeholders** (it is relatively easy to obtain a licence if someone from the team needs one), on other campuses the licence is for one workstation only, and only one person has it (e.g. the manager, leading to situations where it is problematic for the technical team to access the software). The software's functionalities are not always available online – they may be assigned to a particular computer.
An important factor impacting the efficiency of facility managers is the organisation's **influence on the functionality of the building's management software**. Sometimes the software is purchased from an external provider and is a closed system which cannot be extended, modified, changed, or supplemented within the organisation. Only the provider of the software can introduce changes upon request. As a rule, the change request and implementation procedure is highly time-consuming and involves contacting a company representative, sometimes located in the head office in another city; some providers may no longer exist a few years after the software's purchase. Modifications to the software also mean additional costs. On the other hand, the organisation using the software (a campus, a university) can sometimes have influence on modifying the IT solution used to manage and control the building. This involves access to the source code, the possibility of extending the software as well as maintaining IT resources (IT staff able to modify the solution on an ongoing basis), but it also offers the organisation a great deal of flexibility.
A building management and control system with various parameters is usually not a 'closed box' solution which does not allow modifications. It is expected that the system will evolve to take into account new functionalities, technological standards and environmental requirements. Additionally, such systems need to monitor new types of information. The system is therefore, by its nature, flexible and evolutionary. If an organisation is not able to shape the software as required, it loses some of its agency.

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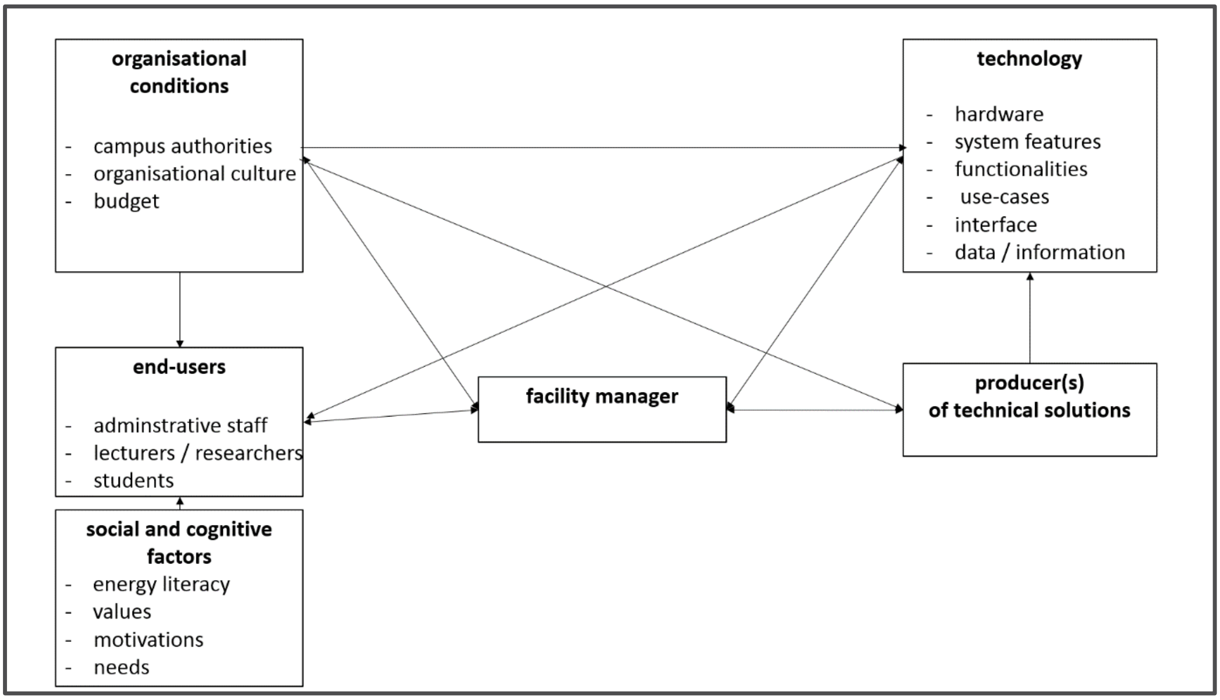

Figure 71: Facility manager as a part of social and technical environment

To sum up this part, we can say that the **organisational power of a facility manager** is closely related to his or her responsibilities, agency and impact on decision making within the organisation. This is often related to the availability of appropriate budget and job positions.

2.2.2 Different types of users

A successful implementation of technological innovation requires an understanding of the social environment in which it will operate. Organisations as large and complex as the university campus are diverse systems with many types of users with different rights and responsibilities. These groups of users vary in the scope of activity and functionality required. Students have their rights responsibilities, as do office staff, administrative staff and other users such as researchers, professors, and lecturers. The presence of multiple user groups creates additional challenges. The extent to which particular groups make use of the campus varies and often yields practical consequences.

- Students - weak influence on making decisions / not decision-makers. They have an opinion about how devices work. By numbers, the largest group of end-users.
- Lecturers / researchers - control lighting, heating in rooms, are users of control interfaces.
- Administrative staff - are users of systems, often spend more time at the university than students (they work in the office).
- Cleaning staff – in some campuses they could be "invisible" people: working very early in the morning or late in the evening. In others – they could be included into process of change and even take the role of supervisors in the context of the energy use.
- Facility managers – small number. Potential influence on decisions about system framework.

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2.2.3 Mental maps, habits

Introducing a new functionality into any space redefines the space because it lends it new properties. If different parts of the campus (different types of rooms) are equipped with different functionalities, it means that they have different properties. The principles behind defining particular groups of rooms are often unclear for users. They have to learn the properties of each room from scratch and recognize the rules applied in different rooms.

This phenomenon of ‘split spaces’ is best explained on an example. A new lighting control system was introduced on one of the campuses after the renovation of the building. Before the renovation, lights were turned on and off with a switch at the door, which is a standard protocol used for decades now. The principles of this protocol are usually learned in childhood – it is the default answer to the question ‘how to turn on the light in the room?’. In our example, three types of rooms were distinguished on the campus: 1) lecture rooms where classes are conducted for students; 2) meeting and conference rooms; 3) offices for campus staff. Each room had its own lighting control solution. In the lecture halls light was turned on/off with a switch, and the intensity of lighting could be adjusted; in the conference rooms the light switched on automatically when someone entered the room (motion sensor). It was not possible to regulate the light intensity in the conference rooms, but it was possible to regulate the temperature, which was confusing for the users. In the offices, in turn, neither temperature nor light could be regulated.

The example quoted above shows that a space that used to have universal properties and a single logic (on/off light switch without regulation of intensity; temperature - controlled by thermostats on the radiators) was later divided into sub-sectors with different properties. This made it difficult to understand on two levels. Firstly, due to the change itself, things started to work in a new and different way. Secondly, there were in fact different changes introduced into different spaces. The changes led to a lot of user enquiries and interventions because the users did not fully understand the difference between the functionalities across the different room types, and the principles according to which the rooms were split into different categories.

Human behaviour (Norman 1988) is to expect the relationship between the desired effect and the action that will cause it. Every user also has an a priori idea about such a relationship (e.g. I turn the light on with a switch, it will be on until I use the switch again). Designing the system in a way that introduces a different mode of operating the system in each room type means that instead of one universal map of reality, the users must have many different mental maps in their heads.

Another example of how deeply rooted mental maps are is the change in the lecture hall heating control introduced on one of the campuses. At the start of the new academic year, a new heating control was introduced in one of the buildings. The main change was that each time any window was opened, the heating turned off automatically. By their very nature, lecture halls filled with fifty or more students can get stuffy. When windows are opened in order to ventilate the room, the heating turns off and the room gets cold very quickly. In our example, the consequence was that vary many users complained about the cold radiators, and interpreted them as a defect of the heating system.

The example above shows that any changes to the way in which different installations operate, and any introduction of new functionalities or properties, must be implemented taking into account the fact that users need time and information to change their mental

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maps and understand the logic of the new system. It also shows, that it cannot be assumed that different users groups have the same goals, preferences and priorities as creators of the system. Of course, we can imagine an ideally conducted process of technology adoption, where end users are informed in advance of the changes, trained and given time to create a new mental map. Thanks to the earlier information campaign, they are prepared for new system functionalities.
Variety of ways in which spaces operate may be a factor of disruption, overconsumption, annoyance and lack of achievement of the targeted objectives. But in contradiction this variety can also strengthen energetic intelligence and awareness. In fact the problem is in the failure to warn of complexity than in the existence of that complexity.

2.2.4 Habits and conventional actions

In considering the relationship between the user and the various campus functionalities, it is worthwhile paying attention to human habits. In general we are not aware of our habits and customary behaviours. They are a transparent filter that mediates our relationship with the world. We only start to notice this filter when reality does not respond in the way we think it should.
An example of this is when door keys in one of the campuses were replaced with electronic cards. In order to open the door, a card had to be placed in the reading panel. Electronic cards quickly began to be treated as ordinary keys: the users (i.e researchers, lecturers) attached keyrings to them, they were carried in pockets or on a lanyard, fastened to clothes. It is clear therefore that the habit of treating an object that works like a key accordingly worked here.
This change produced its problems, too. It was often reported that the card did not work. It turned out that users put it into the reader for not long enough. Another habit may have worked: the users used their mental maps of “how long I need to hold the card in the reader” and determined the duration time on the basis of a habit developed when using contactless payment cards. Eventually, special labels were put on the doors to indicate that the cards had to be held in the reader for a little longer.
Another example of how habits work is when a central switch was introduced which cut off power in all of the room’s sockets. This was intended to make savings because equipment left in standby mode still uses power. The light in the rooms with the central cut-off switch was switched on automatically and controlled by a motion detector, so there was no dedicated light switch there. As the cut-off switch was located at the entrance and misleadingly similar to a light switch, the users would switch it on automatically – and automatically cut off electricity in all installations in the room – very often during the working day.
In order to deal with this issue, labels with relevant information were placed next to the switch to prevent it from being used unintentionally. The end result was that no one cut off the power from the devices in standby mode anymore. The cut-off switch is simply not being used.
The example described above shows how a certain functionality was applied (power cut-off switch) but it was done in such a way that stimulated the users to automatically run a script they had been using since childhood. The existing interface (plastic switch at the door) was given other functions through the change, but the solution did not bring the expected result because the change was made against the users’ habits and the mental maps.

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2.2.5 Social conventions

Another aspect affecting the adaptation of technical solutions is social conventions. In one of the campuses, in a renovated building, the control system was configured in such a way that the ventilation and heating system required closed doors to function properly. The doors to the rooms were installed and adjusted in such a way that they would close automatically. As it turned out, both students and academics had a strong tendency to leave the doors open. A professor working in his office signalled with an open door that s/he was available for consultation, and that students could come in. Also, during lectures, open doors made it easier for those who were late to enter the room with minimum noise and distraction for the lecturer and the students. In short, it turned out that the ‘open door’ is a deeply rooted social convention with important functions.

The usefulness of this convention was apparently so significant that students and lecturers implemented many practices that made it impossible for doors to close: they would stop them with chairs or put various objects under the door and even create their own ‘door stoppers’, hand-made of strings or other materials.

The findings presented here so far lead us to the conclusion that in order for the system to be successfully implemented and adopted, it is necessary to get to know the users in depth and to describe them not only in socio-demographic terms, or in terms of the number of system functionalities they will use, but also psycho-socially. It is extremely important to diagnose their habits, social conventions and mental maps as well as the social consciousness, as these are the foundation of the default ways in which humans interact with technology.

New solutions should be designed according to these conventions by:

- taking into account available user knowledge at the solution designing level
- testing the planned solution before extensive implementation
- monitoring the usage of the system – to what extent it is used as intended, whether it achieves its goals, whether the results are improving.

2.2.6 Mental maps of designers

Besides discussing the mental maps of users, it is also worth considering the mental maps of engineers and designers of technological solutions. If mental maps are a set of beliefs, an invisible filter that mediates how we interpret the world around us, then we should also apply to system designers. Indeed, it turns out that there are many ways of thinking about technology, which lead to specific solutions that are not always optimal for the end user.

One of such ways is thinking about functionalities in a zero-one way (binary, on/off). An example of such thinking is the assumption that ventilation can only have two modes: on and off. On one of the campuses we investigated, it turned out that it would be useful to regulate the intensity of air exchange to enable ventilation at night with better energy efficiency and at lower intensity.

Another example we came across in our study is the idea that heating needs to be turned down to a minimum at weekends (when there are no classes) and turned back to regular temperature on Monday morning. In the winter months, it turned out that the system described by our interviewees had its inertia – when the heating resumed, some time passed before the rooms got warm again. This meant that it was very cold on the Monday after the weekend before noon, as the system required time to reach

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its weekday temperature levels. After some time, the algorithm was refined in such a way that the heating did not start on Monday morning but a few hours earlier.
The examples quoted above show how a zero-one mental map works. Even if some function of the system works a certain way, it does not mean that the final usability (e.g. a certain level of temperature) will work based on the same principle, too. The second example illustrates the way of thinking about technical solutions as something fundamentally different from the daily experience of users. In the world we experience (the physical world) but also in the social world, different things can occur at different intensities. Rain can be light, or it can be a downpour. The sun may shine more or less brightly. Noise can be produced at different levels. This is the natural way reality works, therefore people expect things and functions to be adjustable.
Sometimes engineers forget about natural mental maps when redesigning technical systems and their thinking revolves around technology and the cold, bivalent ‘zero-one’ logic.
The interviews we carried out show that very often the first version of various technological solutions is based strictly on the logical, zero-one approach, and in the course of system use, after confronting various situations, it is gradually enriched with algorithms that take account of concrete situations and events. Consequently, the system is gradually turned into a more flexible solution: it adapts to a reality that is rarely unambiguous and more often – changeable and chaotic. An example of such an expansion can be the data gathering needed to manage air-conditioning, initially from one temperature sensor, then from a battery of sensors (measuring both temperature and wind) located in several places (both exposed to sunlight and wind and shaded or shielded from wind). The triangulation of several measurement methods made the system more flexible and allowed for better management of air conditioning processes in the building.

There is a natural tendency to think of technology as a tool that the user must learn to use. This way of thinking dominates, although it is only partly true. The user is not only about pure reason but also about habits, social conditions and mental maps (assumptions about how things work). If we treat the user as a white card (tabula rasa), then the process of adoption of technology can be significantly extended. The ‘tabula rasa’ approach, therefore, suggests that the user is to blame for his/her possible failure to adopt the technology successfully.
Ideally, users should be involved as early as possible for a detailed understanding of their needs and expectations. The habit of architects is to focus solely on technical performance whereas there a social and technical coherence is needed. It may be achieved by permanent negotiation between technicians and users.

2.2.7 Campus as a sociotechnical system

Summing up the above, we can claim that energy management systems on university campuses are complex. Their complexity exists on many levels. Such systems:

- have different user groups that may have different expectations and needs
- collect different types of information originating from:
  - different buildings
  - different sub-systems (e.g. power supply, gas, air conditioning, etc.)
- often need to cooperate with several computer programmes (software) available in different configurations on different computers (licenses) for different people,

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Since the system is a social actor, it is worth thinking of it not only as a technological solution (with its hardware and software), but also as an element of a wider whole with its social dimension. The ultimate success of any innovation is not just a matter of its effectiveness and efficiency, but is negotiated and socially constructed[1]. The SCOT (Social Construction of Technology) theory claims that different stakeholder groups and users have different interests, and these interests must be reconciled in negotiations and discussions. As soon as the discussions are over, the final form of the invention is ‘closed’. An example of how the functionality of an energy management system can be ‘negotiated’ socially is the way the users in one of our examples tackled their need to leave the doors open or used the power cut-off switches against the original intention.

One may consider an energy management system on a university campus an example of a socio-technological system, as Thomas Hughes (Hughes 1990) described it. Hughes points out that the study and description of the history of technology, the history of tools, and the history of objects cannot take place without taking into account other areas. His term refers to a complex system in which many aspects (social, technological, political, cultural, etc.) form part of a larger network. The final shape of an invention, a tool or an innovation is the result of the forces with which its various elements interact.

Adopting technology and introducing it into everyday life is not a simple process in which the user reads the manual. Rather, it is a complex process in which various factors and activities collide, and the technological factor is only one of many elements of a larger whole. The strength of non-technological factors is demonstrated by the fact that greater efficiency and effectiveness of innovation does not necessarily mean market success. An example here can be the QWERTY keyboard, which is not the best keyboard arrangement in terms of efficiency (speed of typing), or the VHS video cassette standard, which dominated for many years and, despite its poor sound and image quality, outran its rival, the Betamax standard. The social factor played an important role in the market success of both these technological solutions.

[1] On how the final shape of the bicycle was socially negotiated – see (Pinch, Bijker 1987); also, the ultimate spread of alternating current was a result of a dispute between Tesla and Edison (Hughes 1979).

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2.2.8 Evaluation of use case concepts

Electric car charging stations

Demo-sites where electric car charging stations are planned for installation already have some experience regarding the application of this solution. After presenting the description of the concept to our interviewees, various insights into the functioning of this innovation emerged. The following aspects were mentioned:

1. **The ethical problem.** It was pointed out that charging stations currently provide electricity for free. In a situation where electric cars are expensive, this means that their wealthy owners are additionally supported. This is in fact another privilege for those who are already privileged (economically), which leads to another aspect:

2. **The legal problem.** It is the result of a paradox. The campus, thanks to its large number of photovoltaic panels, generates electricity and is a power supplier. From the legal point of view, however, it is not treated as a power supplier, and is prohibited from profiting from the distribution of power. Therefore, the campus cannot sell the electricity it produces – it can only make it available for free. The interviews conducted in the course of our study show that, ultimately, university management would like to sell power, but this must be preceded by changes in legislation.

3. **The issue of efficiency in the use of charging stations.** The specificity of the operation of charging stations means that typically someone drives up in the morning, connects to the station and leaves (disconnects) after work, in the afternoon. This means that the station is occupied much longer than necessary to recharge the car. Developing a way to solve this bottleneck would greatly improve the efficiency of use of charging stations. The relevant ideas offered by the interviewees included the possibility to disconnect an already charged car or notify (e.g. by SMS) the driver that their car has already been charged.

4. **The problem of network loading.** A large number of cars connected to charging station at the same time can overload the network in some situations. At critical moments, it can be a difficult decision for the power supply manager: ‘do I channel the power from PV panels to the facility or to the charging stations?’ – a challenging dilemma for the power supply manager. Another problem is how to communicate with users if the car has not been recharged. Leaving the car for charging is a kind of a contract, whereby the user expects his/her car to be charged. Breaking this contract can have major consequences for the user (e.g. when s/he arrives on an almost empty battery and intends to go on a long holiday after work).

5. **Technical challenge** - connecting many cars to the network requires major changes in the power transmission infrastructure. These are huge amounts of energy and can be much higher than the entire current consumption.

6. The solution to this problem must be **good communication with the user**. Again, this need is satisfied differently on different campuses. Our interviews show that charging station interfaces for communicating with the user offer a lot of possibilities. In such interfaces it is possible to communicate e.g. different charging modes. On one of the campuses there were 3 types of charging modes: standard (normal); express

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(boost; allowing for charging with maximum efficiency for a short period of time); and low emission (using energy from PV panels only).
The functioning of the very attractive 'boost' mode for rapid charging raised questions, of course, about how to distribute this 'rare commodity'. The interviewees offered ideas such as communicating the environmental cost of a boost charge on the display, or to limit it using the campus space – for example, boost charging can only be available at stations located further away from the campus. Another idea was to limit fast charging – for example, to 5 recharges per month, or to allow charging car batteries to 80% only (rather than 100%).

7. Therefore, it seems now that the challenge is to communicate with the user – and to find ways of explaining the costs in such a way that the user is willing to accept certain restrictions (e.g. slower charging) for the sake of benefits for the society. One idea is to get the user accustomed to the idea that free energy at charging stations is only a temporary solution. This can be achieved by providing information on the environmental and real (financial) cost of charging. The user will first see the estimated cost, and then the actual cost (expressed in Euro and CO_2) after recharging the car. They will also receive information on the expected duration of the re-charge. If the user has more time, s/he will be able to opt for slow/standard charging or for fast charging if s/he is in hurry.

8. The key to a successful adoption of the system is efficient, clear and easy-to-understand communication. This means that a clear and comprehensible interface is extremely important. It should be based on an understanding of the psychosocial and motivational mechanisms that guide users.
Among the technical challenges the interviewees pointed out the following:

- a large variety of types of charging sockets. The need to develop a standard was mentioned as an important issue
- earmarking resources to manage the hardware, not just the control system and the data. A large number of charging stations means that there are a lot of duties related to hardware maintenance, too.

During the interviews we also presented the concept of using the batteries of cars connected to the charging station as a temporary power storage. According to the concept, cars and their batteries will facilitate two-way flow of energy. It will be possible both to charge cars from the station and to use the current from the batteries of the connected cars to charge other cars at the same charging station, or to power the building. The following example was presented to the interviewees: someone leaves the car for charging from 9:00 a.m. to 4:00 p.m. with a 20% battery status at the beginning of charging. From 9:00 a.m. to 2:00 p.m., when electricity is cheaper, the car will be charged to 70%; from 3:00 p.m. to 4:00 p.m., when electricity is more expensive, another car will get some of the previously charged car's energy. Finally, at 4:00 p.m., the first car's battery will be at 60%, i.e. at a lower level than possible – but another car has been able to use cheaper electricity thanks to the first car's battery. Cars on campus will be charged in a smart way by ensuring the best possible use of cheap power.
The concept described above was approved by the interviewees (as an interesting solution optimising energy management on a wider scale), but potential difficulties were signalled:

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- The idea is that the user does not need a 100% charge. This is not true – as a rule, users want to recharge their batteries to the maximum.
- The user should be able to select the charging mode. We should consider the fact that not everyone will like this idea.
- Not being able to charge the battery to 100% can easily be confused with a system failure.
- The key to success is communication transparency: the user needs to know what charging mode s/he wants to choose and what the consequences are. It is very important to communicate with the user so that s/he is fully aware of the choice of charging mode.
- In a way, this brings us back to the question of a mental map, i.e. the way in which the operating mode of a charging station is reflected in the user's mind. Tackling this challenge will require great care, because the charging station will not work in accordance with the user's mental map (in fact – it will work in the opposite way) – as the system will at times draw energy from the car's battery rather than charging it.
- Repeated charging and discharging of electric car batteries can have a negative impact on their durability. This is why users may disagree with this solution, because they are concerned about the durability of the batteries in their cars.

System interoperability

One of the use cases which will be tested within the framework of the Ebalance-plus project will be a test of cooperation between the new solutions developed in the project and those used today. During the discussion on this part of the project, the interviewees reported the following aspects which require special attention:

- The operation of the technological solutions applied on campus is linked to the software system. Each manufacturer offers their own software (application). In more advanced systems, different functionalities are combined in one central Building Management System. Such a system is usually a closed ecosystem within which there are established protocols / rules for the exchange of information between the different sub-systems. Each device has a different protocol for the output and use of information. It will be necessary to unify the protocols or create inter-protocol interfaces so that the devices / functionalities can work together.
  The technical challenge is to introduce new functionalities in order to achieve compatibility with existing solutions so that the introduction of new elements does not take away anything that the system already offers and that is working well.

- The challenge is also the question whether new functionalities will appear in the new interface. Will the currently existing dashboards, charts, visualizations be able to use the information and parameters that will be provided by the new solutions? The ideal scenario is when it is possible is to access all information from a single application.

- A greater number of functionalities means there will be more information exchange nodes between the subsystems. As the degree of complexity

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increases, so does the system's vulnerability to hacking. The challenge will be to anticipate all weak links and safeguard them so that the system as a whole is not susceptible to unauthorized external interference. The threat posed by hackers may lead to blackouts and attacks on facilities.

- It would be good to design the system in a way that facilitates its extension with new functionalities and/or new sub systems. This will make it possible to avoid problems in the future. The system's architecture must be open.

- Interoperability is not only about cooperation in terms of engineering and technology. It is also about tapping into the synergies in the area of interaction and communication with the end user. An example of such use of communication can be, for example, directing cars that need to be recharged quickly to stations with more energy due to a larger number of PV panels they are connected to.

Smart Energy Management

The following concept was presented to the respondents:

An energy management system will be installed on the student campus in the student dormitory (student rooms). Thanks to sensors, it will be able to control electricity consumption (e.g. turn off the light when no one is in the room, control the heating). It will also show how much energy has been used by different devices. Rooms will be equipped with smart devices (fridges, washing machines, dishwashers). The system will manage these smart devices as defined by the students living in the room.

- *the start and end times, the range of temperature and so on*
- *at first, it is planned to install devices (e.g. smart plugs) to manage the energy use of appliances, not smart appliances themselves.*

Students will be able to get various rewards for using the system and for saving energy.

The idea received favourable comments from the interviewees. According to them, the main advantage was the fact that decisions related to the use of electricity were linked with positive reward. At present, there are no such rewards because electricity bills are settled after many weeks. By linking information on power consumption to real-time consumption, students will be able to challenge one another and save money. An additional incentive system (rewards for savings) could provide an additional stimulus. This assessment is in fact another example of how mental maps work.

During the interviews, attention was drawn to the following:

- When designing a system of LED lighting it should be noted that everyone has their own individual level of optimal lighting. The system should take this into account and provide the users with the possibility to adjust the light intensity within a specific range.
- It is also important to ensure that the system is intuitive. Ideally, it should use existing habits or mental maps. Paradoxes that mislead users and hamper their use of the system should be avoided. An example of such an unintended effect can be the previously mentioned central heating example (heating turns off when a window is opened). Another example is the impossibility of dimming the

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lights (to get a better contrast for the slides displayed from the projector) because the system works on the zero-one principle (switch on / switch off, with no intermediate steps).

The key to good system functioning is communication. On the one hand, good communication means explaining to students how the various functionalities work and what they depends on; on the other hand, it also means explaining the objectives and the reasons why changes have been introduced.

Values are particularly important here because the energy management system can redefine the perception of electric power and its use. Today, electricity is something that remains undefined in consumer's eyes - for example, it is not entirely clear whether it is a product or a service. In general, consumers generally do not fully know how much power they consume. For them, electricity is something abstract and intangible. With the introduction of electricity consumption management functionality available to end users (students), electricity becomes something 'visible' that can attract the user's attention (thanks to consumption level displays). The user can see the differences in electricity consumption across different devices, which can minimize and optimize consumption.

Another important factor is also comfort of the end-users. It is worth distinguishing between two types of solutions to make energy demand more flexible:

1) Invisible to the user - e.g. flexible management of the operation of a refrigerator or air conditioning (within a certain temperature range) may be invisible to the user, does not require the user to 'remember' to control the system, nor does it have to reduce the user's comfort.
2) Visible and limiting comfort. The delay of switching on the laundry, reduction of the power of the kettle, vacuum cleaner, light intensity, etc. during peak periods is visible and may be disturbing.

Demand Response

During the discussion on this use case, attention was drawn to a potential difficulty for the facility manager (a dilemma): which part of the network load do I switch off when calling the operator? Such a problem may occur when an energy supplier calls for a reduction in electricity consumption (and, for example, presents additional rewards for such a reduction).

As pointed out by the respondents, campuses and the universities provide a public service. Any limitation of this service is always debatable. A separate problem that will have to be tackled is how to explain the lack of a specific service to the end user.

The perspective of a facility manager is to fulfil his or her basic duties:

1) Provide service for end-users
2) Ensure that all systems are operational (eliminate faults and defects)
3) Try to introduce solutions that generate savings.

These will always be fundamental objectives. As facility managers focus on them, they are less interested in the demand response function because it hinders them from performing the key tasks, and people's satisfaction levels go down.

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2.3 Results – Holiday cottages demo-site

Demosite in Denmark is different from the others. It is not located on a university campus but has the character of a group of cottages scattered all over Denmark.

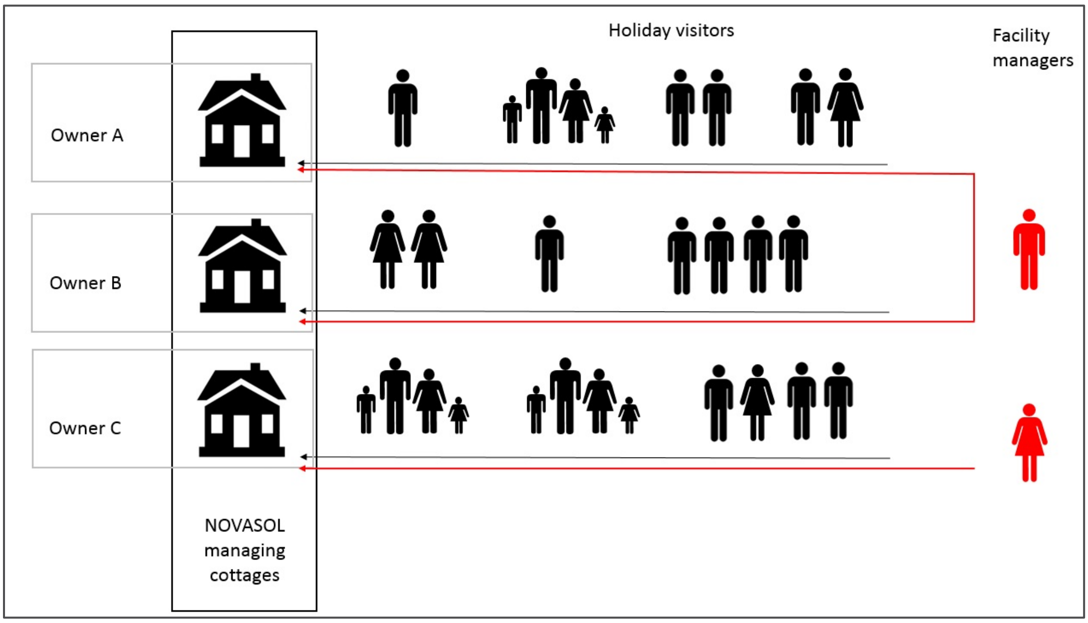

Figure 72: Position of facility managers in demo-site

The opinions collected from the cottage managers allowed to describe the basic hopes associated with the installation of use-cases of e-balance+ system:

- Currently the cottages are not equipped with any system for remote monitoring of parameters (energy, humidity, etc. meters). This means that in order to control the energy consumption the facility manager must appear in person in the cottage. On a scale of 1000 houses scattered across Denmark, this means thousands of working hours and generates high costs. Equipping the houses with a system of sensors and activators that will enable remote monitoring will make big savings for the company because a technician's visit to the house to write down the meter will be not needed.
- Currently, the entire water heating system is characterized by high inertia. To heat up the water in the pool to the right temperature, comfortable for the users (vacation makers), about 12 hours are required. Starting the heating must be done with a switch located physically in the house. This means that the technician must appear in person in the cottage. Because the technicians work on weekdays (Monday-Friday); if guests arrive on Monday, such activation must take place on Friday. In many cases, therefore, there is a situation where the pool is heated to the right temperature much earlier than necessary (48, 72 hours earlier and kept there). The ability to remotely monitor and turn on and off the heating of the pool on a scale of 1000 houses and 12 months a year can result in large energy savings.
- Heating the water in the pool is energy intensive. This makes a company with 1000 houses, many of which are equipped with swimming pools, a big player in the market to offer Demand Side Management service to power operators. This service can be an additional source of income - which the owners of the company and the owners of the houses count on.

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- In addition, Ebalance-plus functionalities will perhaps make it possible to closely link the power consumption to the guest feedback. At present, there are no smart devices or other functionalities in homes that can help to visualize power consumption. Energy consumption is therefore not directly related to energy costs. The specific situation of the demosite makes that currently the main actors (guests) are not interested in reducing consumption - from their point of view the energy is already included in the price of his stay, which has already been paid for.
- The attractiveness of Ebalance-plus functionality for the demosite operator is also due to the expected legislative changes. In the current situation the introduction of innovations related to energy saving is associated with large investment outlays. The expected savings are relatively small. Companies like NOVASOL count on tax reliefs, without which the attractiveness of such solutions may be low.

To sum up - from the point of view of technicians, the most attractive is the saturation of the houses with sensors, so that they become network links that can be supervised, switched on and off at a distance. On a large scale (1000 houses scattered throughout Denmark), this will allow for large savings. The system will also report on the status of the various devices. It will be easier to track a failure to delegate it to a technician.

2.4 Good practices for adopting an energy management system on campus

2.4.1 The perspective of engineers and designers

- Take into account the complexity of the system, and the different actors with their own goals and interests,
- Remember that campuses can vary greatly in terms of their current technological solutions and their level as well as their limitations (related to budget or staff),
- At the solution design stage, try to ‘walk in the user's shoes’ as often as possible: create models; test prototypes of interfaces or even physical solutions. For example, on one of the campuses sockets in one of the lecture halls were installed under the desks for students in such a way that students had to pull them out before use; but when they pulled them out many times they gradually broke the sockets. This could have been avoided by creating a simple model to show clearly at what angle the sockets must be pulled out.
- Do not assume that the system will be self-explanatory – create touch points where you can explain something to the user. For example, at the charging station, opt for a user interface with charging mode selection rather than cards.
- When designing, use the available knowledge about end users, their behaviour, habits, needs. Then, test the prepared solutions before introduction (at the level of the concept itself and demo versions of solutions).

2.4.2 Facility manager's perspective

- Do not assume that there is a simple tool-human relationship;

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- Be aware that the adoption of the campus energy management system is a process - people's mental maps need to change and users have to learn new ways of interacting with solutions.
- Try to actively change mental maps – proactively explain how the system works. A number of communication solutions can be applied here:
  - Posters, e-mails,
  - Training (a group of change leaders among students who actively pass on knowledge to others)
- Be patient (e.g. remember that every year a certain number of students who already know how the system works leave the campus, and new students arrive)
- At the first stage of change it is worth introducing a contact person who will be the first point of contact for students and staff when it may seem that technology has failed. If something does not work, users tend to think that there is a failure, but sometimes it simply takes someone to explain the logic of the system to them, and help them create a new mental map.
- Avoid dividing the space into separate sectors where the logic of the system is different (e.g. in some rooms you can regulate the heating yourself and in some rooms you cannot)
- Avoid the trap of thinking that information or data alone is control. True control is when you can use the information to actually do something (react, fix, change). Therefore, agency and authority (budgets, job positions, resources, decision-making) are just as important as information.
- Monitor system operation. Check if it works as intended, if it achieves its goals, if users use it correctly. Improve the observed imperfections and check the effects of changes.
- It cannot be assumed that if there are no complaints, there are no problems and the system is optimized and effectively solved. This is not enough.

2.4.3 End-user's perspective

Things work better when:

- The solutions are in line with current habits, and mental maps of users
- There is a direct link between the action and the result (e.g. the savings in power consumption in the dormitory are shown on the display)
- The system's performance and characteristics are rooted in end-user's values and motivations.
- An example: on one of the campuses, air conditioning was abandoned, and the explanation used were environmental concerns (instead, a more economical air exchange system with heat recovery was used).
- From the beginning there is clear and understandable information and a contact person is available in case of problems.

In summary: the success of the solutions designed within the framework of Ebalance-plus depends not only on their technical efficiency but also on a number of characteristics of the organisations in which the solutions will be implemented.

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2.5 Recommendations

The interviews carried out have shown that a successful adoption of new functionalities will be fostered by treating innovation not only as a technological tool, but also as a system which has an important social dimension.

The proposed solutions should therefore:

- Have an open structure, offering not only the possibility to connect to existing systems in technical terms, but also to take advantage of possible information synergies. Combine new data and information with the data that are already in the system, and present them in the form of clear dashboards, charts, analyses.
- Provide an opportunity for future expansion
- Facilitate the use of existing mental maps of users, which will significantly shorten the process of adopting the system and learning how it works.
- Take advantage of the possibilities offered by mobile technology – for example, some functionalities can be made available through smartphone applications.
- When designing, take into account everything we know about end users (their needs, habits, mental maps, habits), and then test the resulting solution, if possible in several stages (concept, prototype, finished solution)
- Monitor the effects of the introduced innovation - both on the level of impact on energy consumption and user behaviour (whether they understand the system operation, whether they use it correctly, whether the system is convenient and useful for them). Correct the observed imperfections and again - monitor the effect of changes.
- Reconcile different goals of different user groups, be flexible if these goals change in the future.
- It is useful when facility manager combines technical mastery and the ability to interact with users in order to understand their needs and translate them into technical factors, and is aware of the limits of the technology.

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3 Summary of the deliverable

Electric Energy

The results of the survey indicate significant differences between the countries. Households in Italy, Denmark and Spain are most equipped to produce electricity and improve its efficiency. The low level of equipment in France may result from a relatively large number of households inhabited by only one person and from the fact that in France relatively many people rent apartments - from commercial entities or from the state.

Support for the installation of electricity production and storage facilities is highest in Italy (81%), average in Spain (68%) and France (66%), and lowest in Denmark (43%). The reasons for the low score for Denmark should be checked in subsequent qualitative studies. One of the hypotheses is that Denmark has the most developed network of offshore wind turbines in Europe and perhaps the Danes believe that the development of renewable energy installations in their buildings of work or study is no longer needed.

The energy expenditure is positively correlated to the prosperity of the respondents. Most people who think electricity is expensive are in Spain, where the income level is relatively low, and the least people think electricity is expensive in Denmark, which is the richest of the countries surveyed. Electricity generation and storage facilities are most often chosen by the households of economically affluent people, who consume relatively much energy.

The attitude to saving energy is generally positive, more than 80% of the people surveyed declare that they are trying to save electricity, most take energy efficiency into account when buying new appliances for their homes.

The main reason for saving is financial, but the second most important reason is to reduce the negative impact on the environment. In practice, there is a lack of simple to apply and effective solutions for more efficient energy saving. People declare that they want to save energy, but they lack effective solutions that will bring a noticeable positive result and do not require much time and effort.

Commitment to energy saving would increase high electricity prices, certainty that the effort would bring noticeable financial savings and certainty that energy saving would help the environment.

Energy is usually saved by simple, easily accessible means - by switching off unused devices, consciously reducing consumption or choosing energy-efficient devices when buying new ones. Larger installations (photovoltaic panels, recuperation, heat pumps) are chosen by a small proportion of more affluent households.

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Those who have decided to install energy production and storage equipment are usually satisfied with it, enjoy reduced energy cost and environmental benefits. Most of them think that installing renewable energy generation equipment is economically viable.

In the case of the new solutions that will mainly result in the reduction of greenhouse gas emissions related to energy consumption and the financial savings will be less than 10% of the total costs, it is advisable to use in communication arguments about environmental rather than economic benefits for end-users.

Social Network Effects

Most people talk about saving energy, usually with those from the closest circle - family, friends, acquaintances. These discussions are a source of knowledge about ways to save energy, and influence the applied solutions. Most often, information about energy saving is sought by younger, economically active people with higher income and consuming more energy in the household.

Although such factors as the influence of friends, family, social norms - at least at the consciously declared level - are mentioned less frequently than financial and ecological factors, the fact that the topic of energy saving is often the subject of discussions is of great importance for the implementation of solutions prepared within the Ebalance-plus project. This is particularly important when implementing new solutions shared by a group of connected people - e.g. in university campuses, blocks of flats and housing estates, that is where the decision to implement the solution is made collectively.

Electric Cars Purchase Intention

Half of the participants of the study intends to buy a car in the future with a modern, less harmful to the environment engine (hybrid, plug-in hybrid or electric). Such declarations are made not only in Denmark, where there are currently most such cars, but also in Italy and Spain. Only in France, petrol and diesel engines still make up the majority of the cars planned for purchase.

What is more, the respondents claim that environmental reasons are going to be the most decisive for choosing their future car, and the traditionally mentioned reasons such as low maintenance costs, comfort and reliability are mentioned in further places.

However, the positive attitude towards electric cars may change strongly when the price of charging such cars increases. At present, there are few charging stations for cars and car owners often benefit from lower charging prices at new, pilot filling stations. Also, the electricity that recharges these cars at home is much more favourably taxed (or even subsidized by the state) than fuels for traditional engines.
That is why we asked people who have an electric car or are considering buying it, if they would agree to pay the same amount (per kilometre driven) for fuel in the form of electricity, which they currently pay for fuel for traditional engines. It turns out that for half of them such a fuel cost would not be accepted. This is an important conclusion in the context of the inevitable increase in the cost of charging electric cars in the near future.

Concepts of technologies for intelligent management of electricity

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The understanding is good for of all three concepts, only the concept associated with external charging control for a car is slightly more difficult. The data for each country shows that the concepts are a bit better understood and more interesting for Italians and Spaniards.

Regardless of the evaluated concept, the respondents want to be able to control energy management systems, moreover, the group that expects to be able to control advanced functions is the most numerous.

For the use of the concepts, the main incentives are financial benefits, simple operation and trouble-free (preferably free of charge) installation and positive environmental impact. Most interest in the concepts is expressed by the low-income people. Although these people consume substantially less energy than the wealthy, the possibility of reducing the cost of energy is important for them.

Respondents are concerned about the costs associated with the installation, repair and maintenance of devices. They are also concerned about the complicated, difficult to learn operation of the devices. The fears about the actual financial benefits, about privacy, and a fear of losing the sense of control over their devices are mentioned in further places.

Attitudes towards technology

The **life goals** of the subjects most often concern health, happiness, family and friends. It is significant, however, that right behind these values, safety now and in the future and living in respect for nature and in accordance with its laws are important.

The attitude to **technology** is generally positive. Technology is usually something that makes life easier, helps, gives access to new information. Concerns related to technology appear, but are mentioned less often.

About 80% of the sample believes that climate change is a serious problem for the environment and their country in general, and about 70% feel anxiety about it and think it will also be a problem for them personally or their family. More than half of the people feel responsible for the environmental problems caused by humanity (the higher the income, the greater the feeling). About half of the people believe that climate change will also have positive consequences, such as new business opportunities or increased agricultural production.

The majority of people (about 80%) are convinced that every problem can be solved and however, about 40% think that little can be done to effectively reduce climate change.

Qualitative Interviews with Facility Managers on Campuses

The introduction of technical innovation on campus has special characteristics because universities and campuses are complex institutions with many actors. There are many user groups (with their own specificity) in institutions of this type. Furthermore, each group has its own assumptions about how the system works, its own mental maps and habits.

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The university / campus can be regarded as a socio-technical system. It is a complex system in which technological factors (devices, functionality, software) are intertwined with social conditions. It is worth noting that the properties of the system, use cases are socially negotiated – are used within the context of habits, previous experiences and social conventions.

Since the social factors are very important for the success of the introduction of technology, it should be taken into account:

- When implementing innovations of this type, it is extremely important to take into account the needs and points of view of users, and to map potential barriers. This should take place at various stages of project development (idea, creation of use-cases, interface projects, prototype). The designed solutions should be tested and confronted with users as soon as possible (even at the stage of concept-tests or mock-ups).
- The assumption that designers know how users think and act should be avoided. Mental maps of users and their way of thinking about the system's operation are very often different from those of the designers.
- Clear and understandable information and a contact person available in case of problems are very helpful.

The success of the solutions designed within the framework of Ebalance-plus depends not only on their technical efficiency but also on a number of characteristics of the organisations in which the solutions will be implemented and the way of introduction of the solution to the social actors.

Campuses may differ in their approach to energy-saving innovations. This is influenced by many different factors, i.e.: organisational culture, technological sophistication of the facility management solutions used on campus, skills held internally within the institution, available budget and recourses, status of facility manager as institutional actor, scopes of tasks and responsibilities.

The functionalities implemented within the framework of Ebalance-plus should not be thought of as a technical solution implemented on a one-off basis, but more as a new system feature implemented in process. This process takes time and should be conducted in dialogue with users. They need time to know and understand the changes, change habits and mental maps. This is particularly important for new technologies.

According to facility managers' opinions, one of the perceived barriers to the functioning of the energy management system on campuses is an imaginable conflict of interest. This may be the case, for example, when energy operator requires power reduction (Demand Side Management use case). In such a situation, the facility manager has the dilemma of which goal to pursue first, which is more important - campus operation and user comfort, or reduction of consumption. Another example is overloading of the network when many cars are connected to a charging station.

The analysis carried out showed that some of the designed features of the system may seem hard to understand to users, or may not work in accordance with rooted mental maps. An example of this is the treating of cars as energy stores and, in some cases, drawing power from already charged batteries. People will currently find it difficult to

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accept such functionality, as they assume by default that charging stations will charge batteries to 100%.

In such a situation, it is extremely important to communicate well with the user through an interface, design effective way of engagement and to embed functionality in values. Such way will enable to motivate the user to give up part of his own comfort up to benefits for society (better use of resources, low-carbon economy, environmentally friendly system).

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