European Commission

bridge

Interoperability of home appliances

Report 2022-2023

Data Management Working Group

May - 2023

AUTHORS

Krzysztof Piotrowski, Leibniz IHP

Olivier Genest, Trialog

Ismini Dimitriadou, Hypertech Energy Labs

Daniel Garrido, University of Malaga

CONTRIBUTORS

Krzysztof Turchan & Igor Koropiecki & Milosz Krysik of Leibniz IHP, Pilar Rodriguez of University of Malaga

Stelios Zikos of Information Technologies Institute (ITI), CERTH, Michalis Iliopoulos of Hypertech Energy Labs

SUPPORT FROM THE BRIDGE SECRETARIAT

BRIDGE Secretariat: Savvas Symeonidis & Ioannis Vlachos, ICCS (NTUA), Martin Bracken, CLERENS, Niclette Zampata & Agnieszka Gierej, ZABALA. BRIDGE Secretariat coordinator: Marcos Jareño, ZABALA.

BRIDGE WG/TF Chairmanship

Olivier Genest – Chair

ACKNOWLEDGEMENTS

The editors would like to acknowledge the valuable inputs from BRIDGE projects and Data Management Working Group members who participated in the meetings and consultation rounds as well as members of the SPRING team, all contributing to this BRIDGE Interoperability of home appliances Report.

EUROPEAN COMMISSION

Directorate-General for Energy
Directorate B – Just Transition, Consumers, Energy Efficiency, and
InnovationUnit B5 – Innovation, Research, Digitalisation, Competitiveness

European Climate, Infrastructure and Environment Executive Agency – CINEA
Department Green Research and Innovation
Unit C2 Horizon Europe Energy

Contact: Mugurel-George Păunescu (DG ENER), Mariana Stantcheva (CINEA)

E-mail: mugurel-george.paunescu@ec.europa.eu ; mariana.stantcheva@ec.europa.eu

European Commission

B-1049 Brussels

Interoperability of home appliances

Report 2022-2023

May 2023

Directorate General for Energy 2023

LEGAL NOTICE

This document has been prepared for the European Commission. However, it reflects the views only of the authors, and the European Commission is not liable for any consequence stemming from the reuse of this publication. More information on the European Union is available on the Internet (http://www.europa.eu).

BOOK	ISBN 978-92-68-07478-7	Doi: 10.2833/168409	MJ-04-23-847-EN-C
PDF	ISBN 978-92-68-07477-0	Doi: 10.2833/619782	MJ-04-23-847-EN-N

Luxembourg: Publications Office of the European Union, 2023

Manuscript completed in May 2023

First edition

INDEX

Executive Summary

Interoperability of home appliances

This initial BRIDGE Report on interoperability of home appliances aims at providing a common view on the issue as well as at showing the first results from investigating the current situation on this aspect within the BRIDGE projects.

In the area of energy flexibility in residential buildings the home appliances constitute to the lowest, but probably one of the most important layers of the system. These appliances are indeed providing the flexibility. The success of the energy management solutions, like algorithms or systems, is highly related to the capabilities of the home appliances, as well as the ability to approach and exploit these capabilities. In that respect, a broader range of appliances providing flexibility and a common way to control these, allows wider deployment of energy management systems and increases the available flexibility of the energy systems.

This report defines some common ground on the interoperability of home appliances and provides insights in the approaches used by the BRIDGE projects, problems they face in that respect and solutions defined to simplify the task of approaching different (home) appliances.

Introduction

This report summarizes the preliminary activities in the Action #5 of the Data Management Working Group (DMWG) of BRIDGE. This action was established as the issue of interoperability of home appliances was recognized as important at the 2021 General Assembly. The scope of this activity relates to all the other actions of the working group – the actions of the Data Management Working Group are very much connected with each other.

Action #1 provides means to collect use cases in a structured way to be able to compare them and identify similarities as well as differences – it allows to investigate the scenarios related to flexibility applied in the BRIDGE projects. With respect to home appliances, it allows to identify and compare the use cases where these appliances are used and look at the reasons behind.

Action #2 covers the data exchange aspects, including protocols, data structures and handling of the data items – it investigates the data plane. From the home appliances perspective, it allows to identify data to be exchanged with these as well as the digital languages (protocols, ontologies) that can be applied.

Action #3 defines the overall framework, taking the central role in the working group. It defines the Generic Business Processes (GBPs) that synthetize the use cases into generic ones, identifying generic/harmonized roles, functions and interfaces that can be applied onto the data plane with use of standards that are investigated in Action #4. Both these actions further explain the use of home appliances for releasing flexibility and the standards that can be applied for that.

In this constellation, Action #5 focuses on the direct interaction with home appliances towards offering flexibility at the level of the prosumer role. This interaction also involves data exchange and is executed to realize (part of) some given scenario, represented by a specific use case or a GBP. In order to follow the generic approach, the interactions with home appliances should also be generic in the sense that the flexibility-related functions provided by the appliances and the approaches to access them shall be generic – or interoperable. This has the aim to reduce the complexity of the control logic and to make the appliances interchangeable. The interoperability can be achieved by common approaches, defined by agreements or standards.

This report presents mainly the state of things in the BRIDGE projects with respect to the interoperability of home appliances, the problems and approaches to cope with them. It will be the base for future activities in Action #5 of the DMWG.

1. Interoperability of home appliances – importance and aspects

In the area of energy flexibility in residential (but not only) buildings the home appliances constitute to the lowest, but probably one of the most important layers of the system. The home appliances are indeed providing the flexibility. The success of the energy management solutions, like algorithms or systems, is highly related to the capabilities of the home appliances, as well as the ability to approach and exploit these capabilities. In that respect, a broader range of appliances providing flexibility and a common way to control these appliances, allows wider deployment of energy management systems and increases the available flexibility of the energy systems.

An energy related **feature** of a **home appliance** is a function related to monitoring and control of the appliance, accessed for **energy management (algorithm)** using some **home appliance API** that includes communication interface and protocol. This API allows to interact with the home appliance and to influence its energy behavior to achieve the flexibility, resilience and other optimization goals. This API is intended to be used for the **automated energy management** and not for direct control of the appliance by the end user (see Figure 1.1). Such home appliances are also referred to as **Energy Smart Appliances (ESA)**.

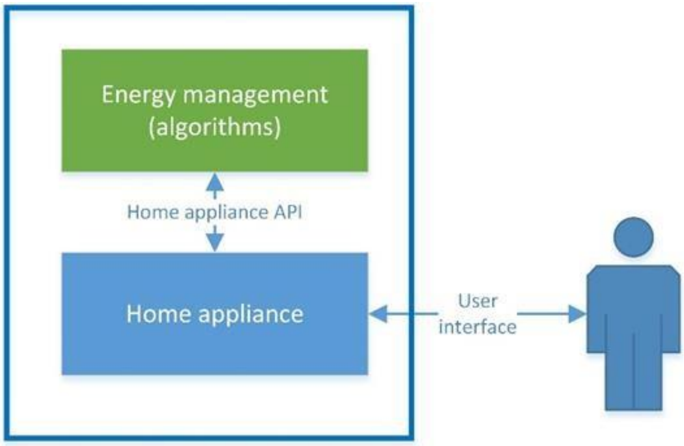

Figure 1.1 The interfaces of a home appliance

The appliance can provide the **home appliance API** directly or via an intermediary component (home gateway or cloud service). The intermediary component communicates with the home appliance using the **internal API**.

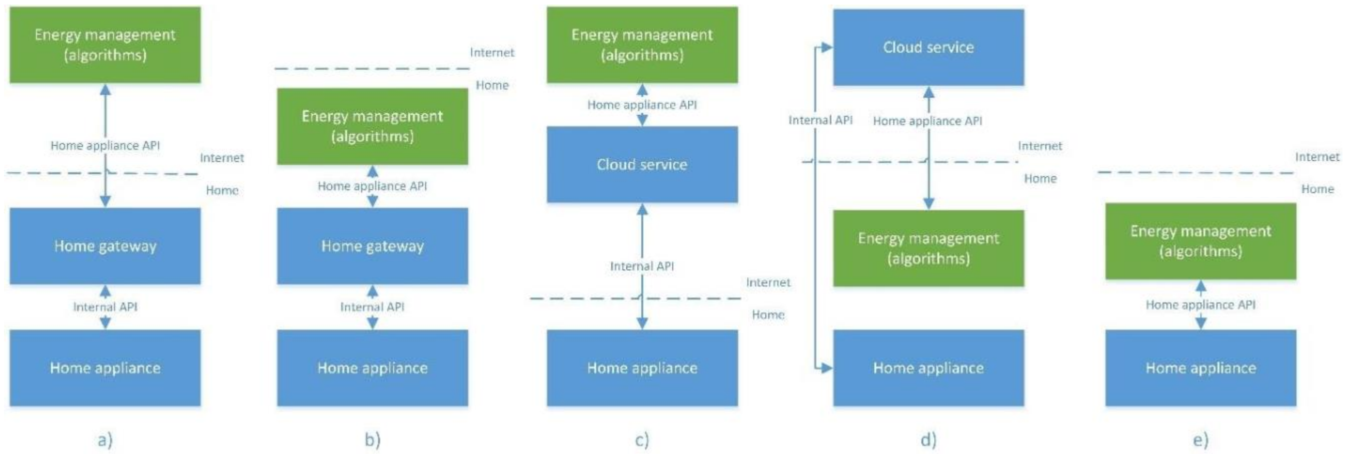

Figure 1.2 Possible ways for the interaction between the home appliance and energy management (algorithm)

Figure 1.2 presents the five (5) main ways for the interaction between the energy management (algorithm) and the home appliance. The examples a), b), c) and d) depict the approach with an intermediary component that communicates with the home appliance using an internal API and provides the home appliance API to the energy management (algorithm). It is important to mention that the internal API can be closed or open (as it can also be proprietary or standard) and that the energy management does not use it directly. The home appliance API is provided for the energy management, but it can also be open or closed, i.e., available for every owner of the supported home appliances or only for chosen users, like energy management providers.

In the examples a) and b) this intermediary component is a home gateway, located within the home where the home appliances are located as well. In c) and d) the intermediary component is a cloud service. To distinguish further, a) and c) depict the case where the energy management (algorithm) component using the home appliance API is located outside the home, while b) and d) depict the case where the energy management is located at home, for both options of the intermediary component.

The fifth example e) depicts the case where the home appliance provides the home appliance API directly, allowing the locally located energy management to access its energy related features. In this case, accessing the home appliance is only possible from inside the home, if the energy management shall be located outside the home, the home appliance had to actively connect to it and to maintain the connection.

The **features** mentioned here, cover **monitoring and control** of the home appliance. These features include a broad set of functions. They can include simple monitoring, like reading the energy consumption, or reading the state of the appliance. But they can also cover simple control, like switching on or off, as well as complex control like shifting load in time or controlling the consumed (and/or produced) energy in other way. The set of features depends on the **home appliance class** (or category), and example classes are washing machine, dryer, dishwasher, oven, air conditioner, etc. just to name a few. Some **specific features** can also be available only for a given **sub-class**, e.g., condenser dryer vs. heat pump dryer. For the sake of the home appliance interoperability analysis, it is important to know how the logic behind more complex features is distributed between the intermediary component and the home appliance itself. But the details on energy management (algorithm) are less important here, even if the intermediary components are part of the energy management solution, for instance, the home gateway device runs the energy management algorithms. It is anyway important to define where the home appliance API is located and what functions it provides.

In order to allow the energy management (algorithm) to achieve the best results, it is crucial that it operates on home appliances that offer the most meaningful features. Moreover, it is meaningful that similar features offered by different appliances are offered in a similar way, so that there is no need to change or implement the energy management (algorithm) specifically for each home appliance. Thus, besides providing meaningful features, **interoperability** of home appliances is crucial. The intermediary component can be a solution provided by a specific home appliance manufacturer, but it can also be a solution supporting multiple manufacturers and can be considered a framework or platform. This latter solution already supports interoperability.

Even if the energy management consists of multiple layers, for the sake of Action #5 we only consider it as a single layer that interacts with the home appliance using the home appliance API.

Finally, a controllable home appliance can consist of a non-controllable part (non-smart home appliance) and a device that provides control, like a smart plug. In this case, such a combination can be considered as one controllable home appliance. Further, a solution (e.g., a software driver) providing complex energy related features, based on the knowledge about the appliance attached behind the smart plug, can be considered as the intermediary component. There are ongoing activities that target the issue of interoperability involving many different device classes. On the level of the European Commission (DG ENER) it is, for instance, the Code of Conduct for energy smart appliances proposed by the Joint Research Centre[1], or the Horizon 2020 project InterConnect[2].

[1] https://ses.jrc.ec.europa.eu/development-of-policy-proposals-for-energy-smart-appliances

[2] https://interconnectproject.eu

2. The experience of BRIDGE projects

Within the Action #5 a survey was executed to capture the state of things in the running BRIDGE projects. The questions asked by the survey are given in Appendix 1. The aim of the survey was to collect in a structured and comparable way the most relevant information about the use of **home appliances** and their energy-related **features** within the projects. An introduction similar to Section 1 was provided to support that by agreeing on and explaining the common naming and understanding of the points covered by the survey.

The survey constituted of two parts. They were the project level part and the device level part. The first one covered high-level aspects, while the latter asked about the device specific individual details of the used home appliances. Indeed, the aim of the detailed part was to be a base for the future repository / data base of home appliances that can be used by other and/or new projects. Unfortunately, very few projects responded to this part of the survey and collection of that kind of information will be continued in the following period of Action #5.

The aim of the project level part of the survey was to get an overview on the state of things within the BRIDGE projects with respect to use of home appliances; how the projects structure their approaches, what are the used solutions and which problems they encountered.

The survey was answered by 18 BRIDGE projects. Of these, 13 (or over 72%) involve home appliances and are, thus, somehow affected by the problem of accessing their energy-related features and the interoperability of home appliances (see Figure 2.1). Based on their answer conclusions on the set of involved appliances and the solutions used to implement interoperability can be drawn.

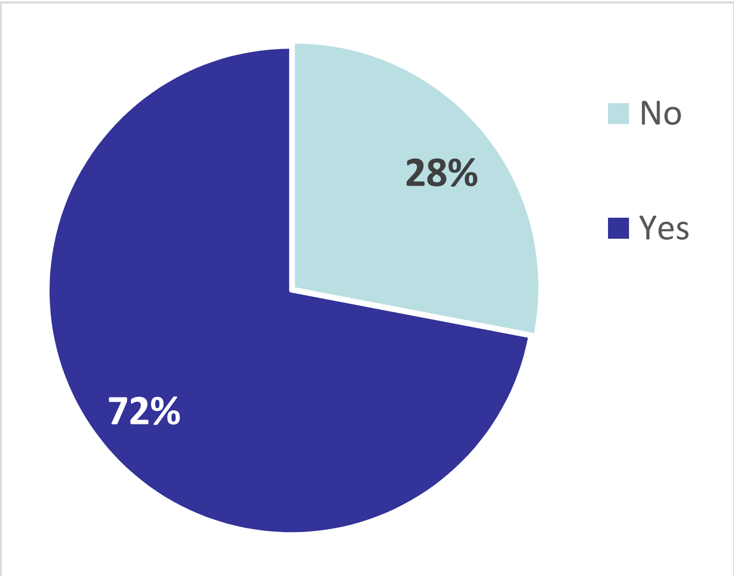

Figure 2.1 The partitioning of projects participating in the survey based on involving home appliances

From the interoperability point of view, it is very interesting to observe that most of the projects involve a wide spectrum of appliances. Considering the main appliance categories: HVAC, white goods, EV charging, PV inverters, energy storage, IoT sensors, etc., their involvement in the projects is given in Figure 2.2 with the X-axis showing the number of projects involving the given category. It is visible that almost all projects involve some form of HVAC and other categories are also pretty much represented. The distribution of the categories of appliances is also worth mentioning - Figure 2.3 shows how many projects involve how many appliance categories. The highest number reaches seven (7), while only one project uses only a single appliance category, two appliance categories are used by four projects, and eight projects use at least three appliance categories. But even if a project focuses on a single appliance category it may support many different classes and sub-classes of that category and many individual devices from that class. This induces that many BRIDGE projects need to address a diversity of home appliances and thus, need to address interoperability.

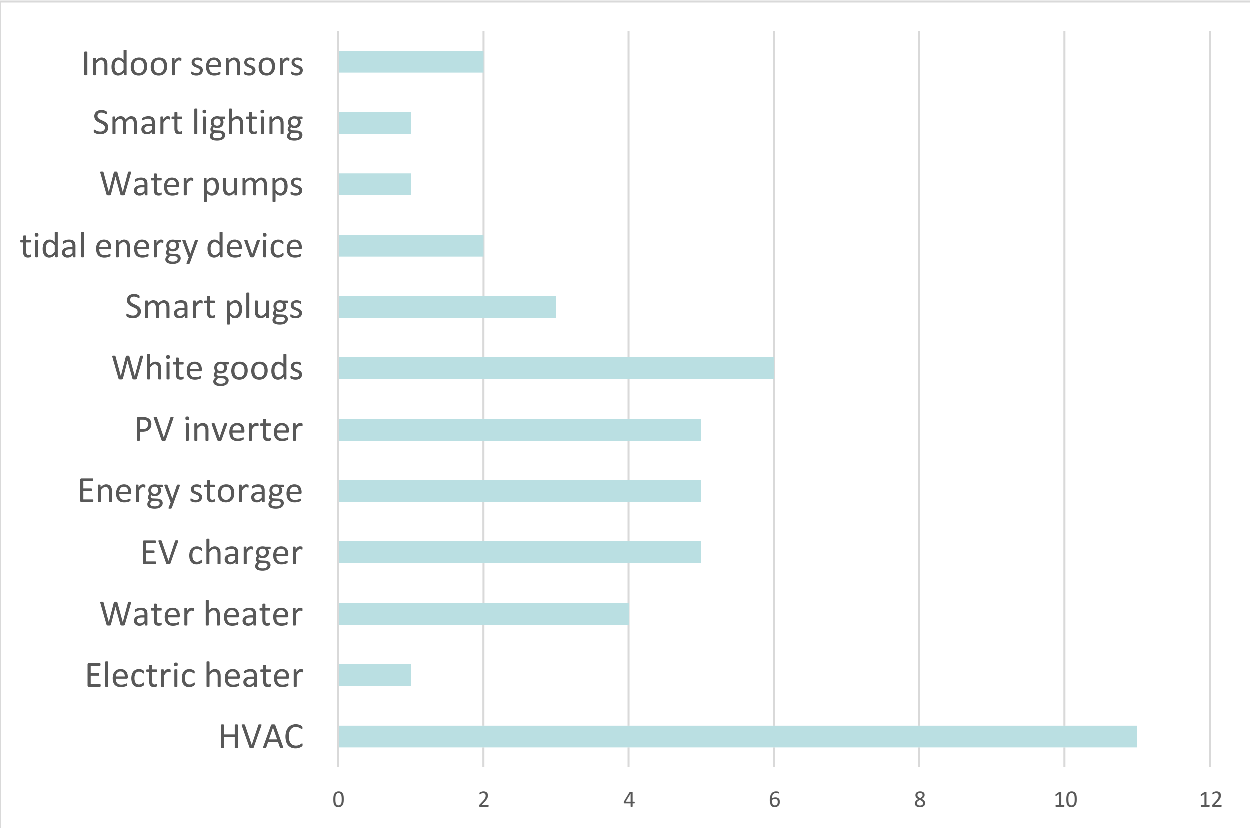

Figure 2.2 Number of projects involving appliance categories (multiple choice, 13 projects in total)

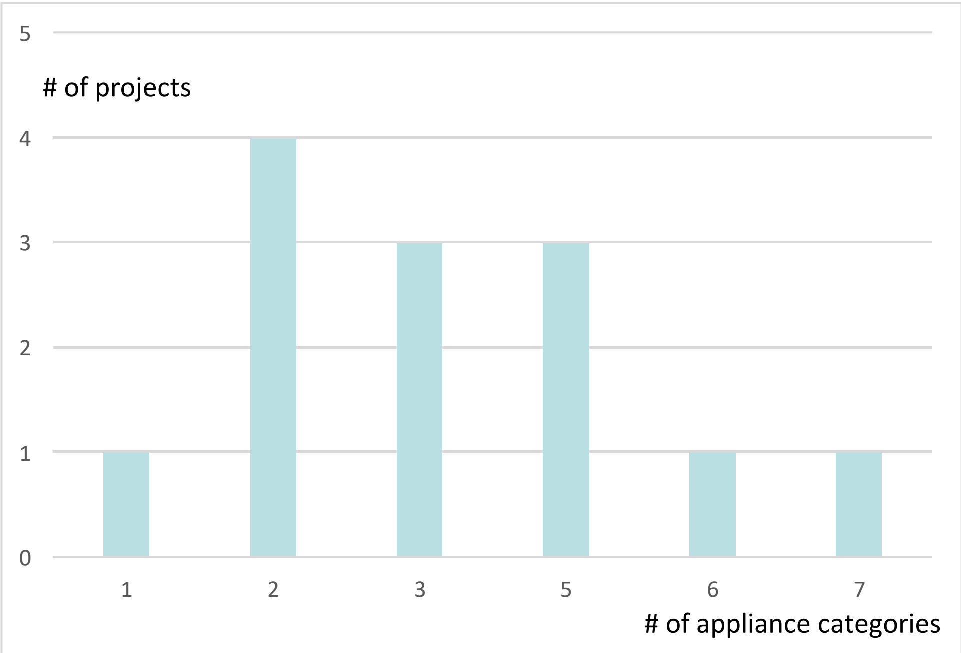

Figure 2.3 The distribution of appliances over the projects (# of appliance categories used by # of projects)

Another outcome of the survey is related to the way the projects approach the involved home appliances. Out of the 13 relevant projects that use home appliances, two (2) use the direct home appliance API, seven (7) use cloud-based API and 11 use the home gateway approach (see Figure 2.4). This indicates that in most of the cases an intermediary component is applied. This means that in these cases there is an additional layer above the home appliances that might be even further extended increase the appliance coverage and improve interoperability from the energy management point of view. Additionally, some projects use multiple approaches, what means that the applied energy management solutions are already able to approach the home appliances over a diversity of APIs.

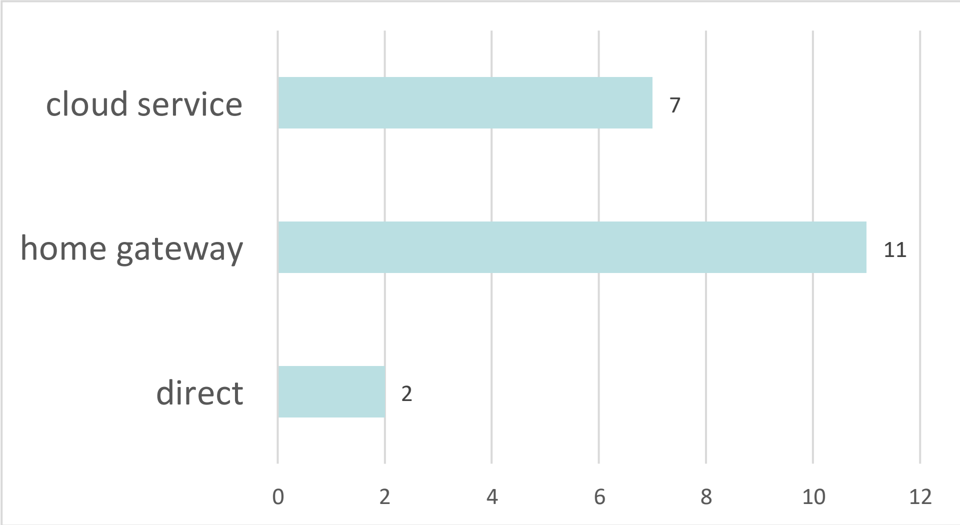

Figure 2.4 Location of the home appliance API in the BRIDGE projects (multiple choice and 13 projects in total)

It is also important to know if the interfaces used by the project were provided by the device manufacturers or if they required customization to access the energy related features of the home appliances. The customization may be realized in different ways, including application of additional hardware to monitor and control the home appliance. Figure 2.5 shows the numbers of projects using interfaces provided by the manufacturers, as well as these using interfaces that were customized. It shows that almost every project was usingcustomized interfaces (11 from 13 projects). This might have been caused by the lack of availability of smart homeappliances on the market and the necessity to obtain smart home appliances able to be monitored and controlled.It also indicates that the projects potentially developed and used several custom and own approaches that were probably not compatible and interoperable with each other.

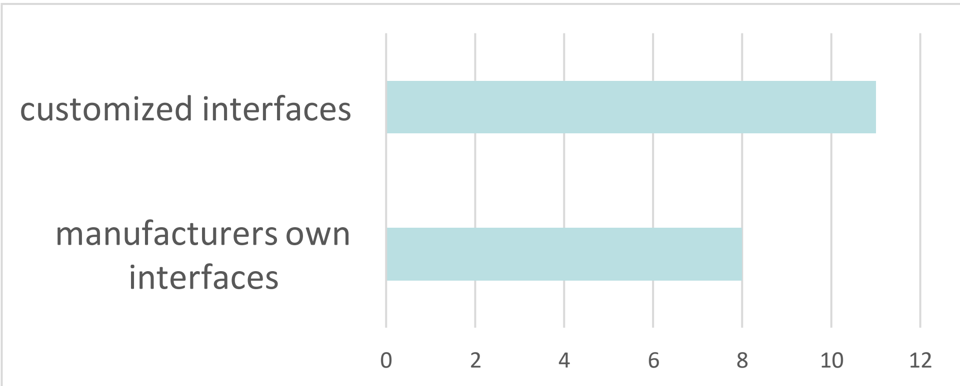

Figure 2.5 Usage of interfaces provided by the appliances (multiple choice and 13 relevant projects)

The home appliances can be used for different purposes (scenarios and use cases) and their different energy related features can be involved to implement these scenarios. From the responses of the survey, we have learned that the BRIDGE projects implement a full spectrum of use cases and scenarios and usually use similar energy related features provided by the home appliances. These features are de facto defined by the class of the device and its working characteristics, but we also observed that some projects use some more detailed energy related features, addressing the monitoring and control of the appliances more granularly. This issue indicates that defining the right granularity of the energy related features is crucial for the interoperability – more detailed monitoring and control usually comes at a higher home appliance development cost, but more fine granular control may allow to achieve better optimization results. In this case finding the golden middle is necessary.

In order to capture the home appliance diversity within the projects it is also good to know it the projects use devices offered by a single manufacturer or by many of these. The outcome from the survey was that out of the 13 relevant projects only one is using home appliances from a single manufacturer only. The remaining 12 projects are.

using appliances from different manufacturers (see Figure 2.6). This means that, assuming that the manufacturers providing the home appliances for a project are not relying on the same platform or ecosystem, each of the projects has to cope with different approaches here. This also gives some idea about the complexity the projects need to face to control the home appliances.

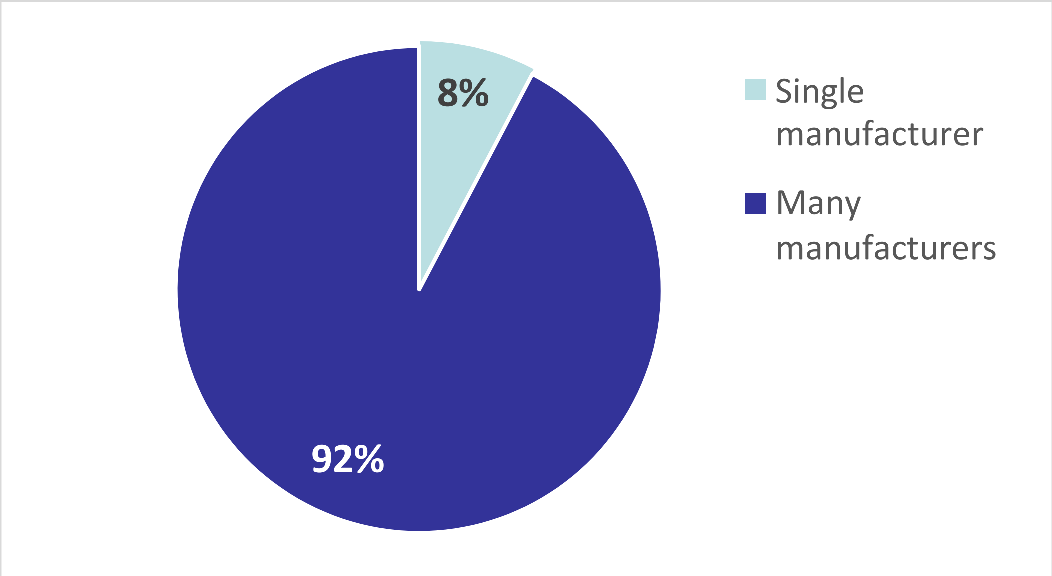

Figure 2.6 The diversity of home appliance manufacturers in the BRIDGE projects

Another important aspect is the availability of the used home appliance. This information is a valuable hint for other running projects or new projects that are looking for home appliances to be used in their research or pilots. The relevant projects participating in the survey reported that for three (3) of them the devices are not available on the market yet (they are thus experimental), but ten (10) projects reported that the devices they use are already available on the market, thus they can be acquired by any project that needs controllable home appliances (see Figure 2.7). This is already a good information, but it could be even better if there would be some open source of information, like a database, with the list of home appliances and the features these home appliances provide.

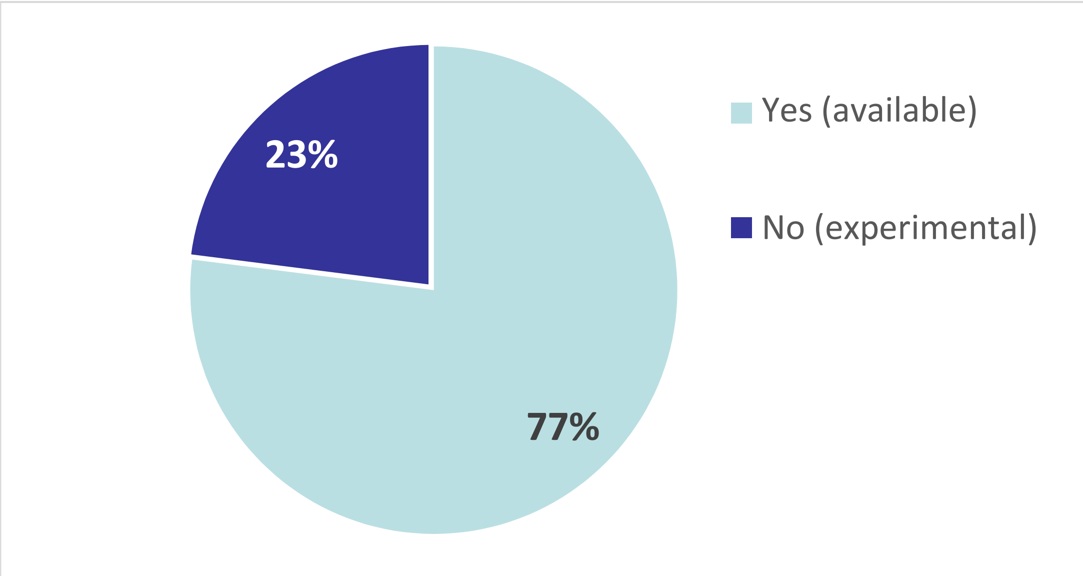

Figure 2.7 The market availability of home appliances applied in the projects.

But even if the home appliances are available on the market, to apply them in energy management, it is crucial to know if their energy related features can be easily approached. Eight (8) of the participating projects that apply home appliances reported that they use home appliances that offer closed monitoring and control interfaces.

This means that to use the energy related features there is a need, for instance, to approach the manufacturers or the service platform operator/owner and obtain the access and/or the explanation on how to use the devices. Such an approach makes the applicability of these home appliance rather complicated, dependingon the rules that apply for getting the access and/or details. On the opposite side, ten (10) projects reported that the devices they use provide open interfaces to access their energy related features. That is a positive outcome, considering that there are in total 13 relevant projects, i.e., only three (3) of them were using only appliances with closed interfaces. Anyways, this relation could still be improved in the future, to have even more appliances with open interfaces.

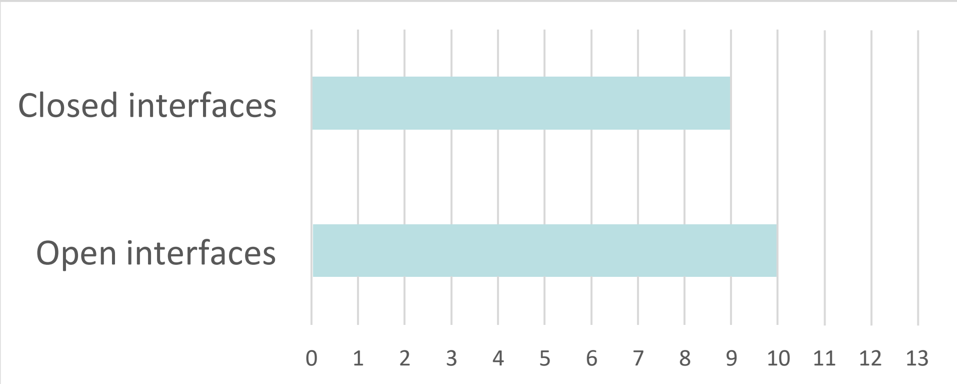

Figure 2.8 The interfaces of appliances used in the projects (multiple choice and 13 relevant projects)

Considering the numbers on appliances with open and closed interfaces together with their market availability, reported by the projects, we can gather the high-level information on the availability of home appliances with open interfaces (see Figure 2.9). The figure shows that for the three (3) projects that work with experimental appliances these offer both open and closed interfaces. For the total of ten (10) projects that use appliances available on the market, three (3) use only devices with closed interfaces, other three (3) use devices with both closed and open interfaces, and finally, four (4) use only appliances that offer open interfaces. This means that seven (7) projects use appliances that are both available on the market and offer open interfaces to control them. This is slightly above the half of the number of relevant projects (13). The detailed interpretation of this result depends on the exact numbers of the appliances used by the projects that fall into each of the category shown in Figure 2.9, but unfortunately, we are not having such detailed information. We plan to gather such data in the following year.

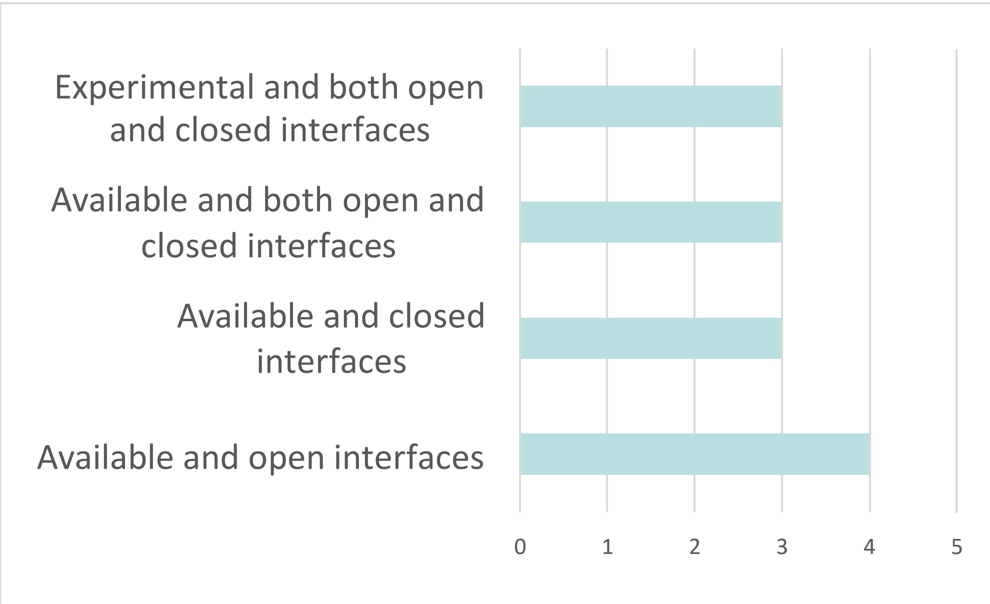

Figure 2.9 Number of projects according to the combination of availability and openness of interfaces of the home appliances

The interfaces the appliances offer is crucial for their use. An interface defines the communication details: the physical layer that is used to exchange data with the appliance, as well as the low level and high-level protocols. As we defined in the introduction (see Section 1) we consider the appliance API that is provided to the energy management and, in case there is an intermediary component (cloud service or home gateway) there is also the internal API that is used for the communication between the appliance and the intermediary component.

From the energy management point of view the appliance API is crucial, but the knowledge about the used internal API may help for developments of intermediary components that support interoperability by covering more appliances. From the survey outcome we could identify some solutions that are used by many projects, like MQTT for the appliance API and MODBUS for the internal API, but in general, large number of diverse approaches is in use by the projects. Figure 2.10 and Figure 2.11 show an indicative presentation of approaches used by the projects at the appliance API and the internal API, respectively.

Figure 2.10 The indicative presentation of the solutions used by the projects at the appliance API level.

While the approaches for the internal API are based on a diversity of solutions working on top of different wired, wireless or even optical communication technologies with rather low-level protocols, the appliance API solutions are rather shifted towards the data plane on top of TCP/IP communication. But on both API levels many projects are still using proprietary solutions. It is to be investigated if these proprietary solutions were developed to optimize some standard ones, or if they do not provide any added value and could easily be replaced by some standard solution increasing interoperability. Such investigation is planned for the following year.

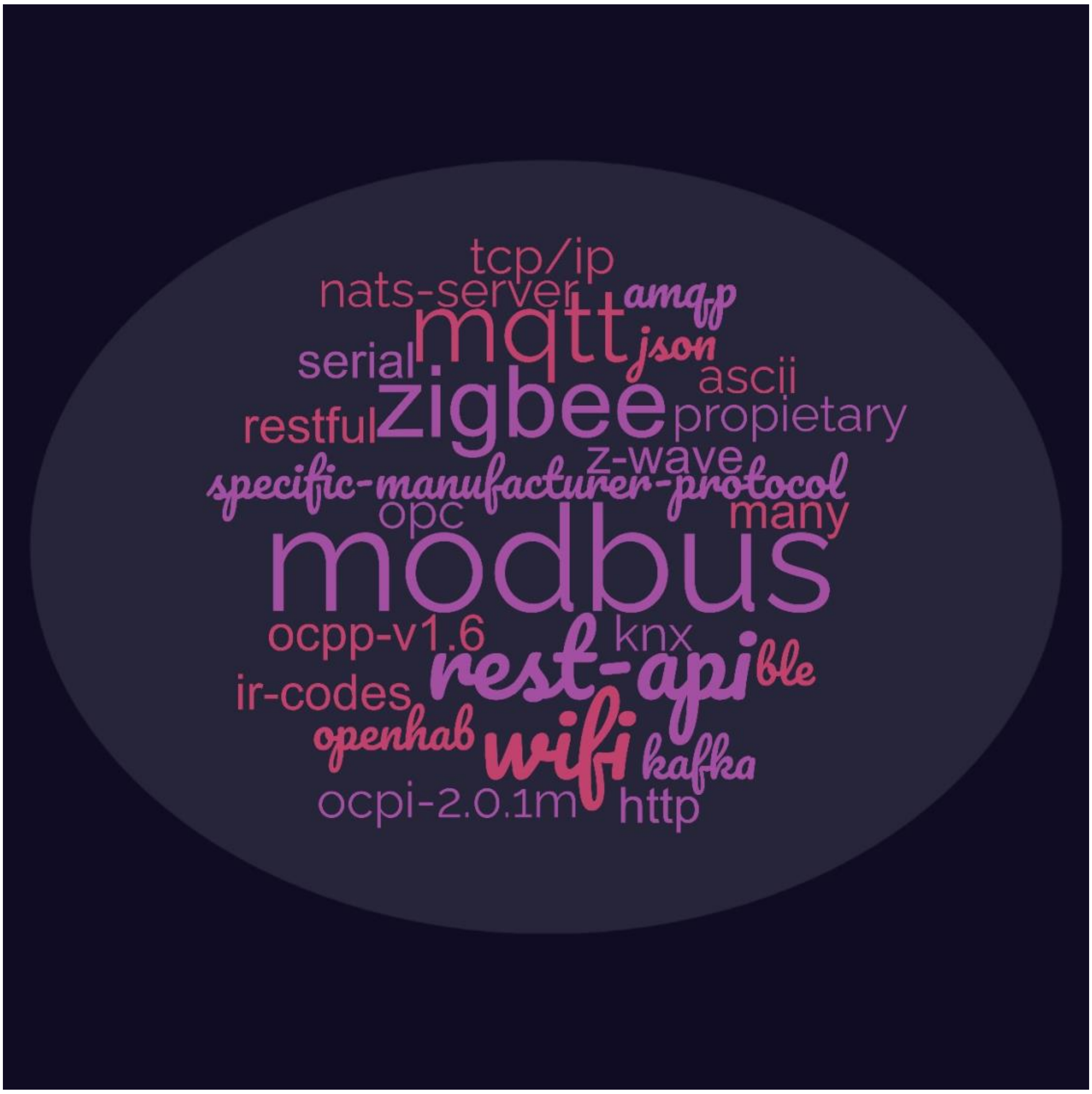

Figure 2.11 The indicative presentation of the solutions used by the projects at the internal API level

When it comes directly to addressing interoperability, there are many different approaches followed by the BRIDGE projects. But most of the approaches tend to create a form of interoperability layer. This is for instance realized by using as many as possible available standards, using data concentrators, creating custom gateways, using drivers / (interoperability) adapters, or relying on existing solution. These are the approaches for the interoperability layer, which seem to focus on the interaction down to the appliances. There are also other approaches for achieving this layer that seem rather to focus on the other direction, i.e., to the energy management and the interfaces they offer on that side. These approaches include proposing a canonical information model, implementing a semantic interoperability framework, developing a common information model (CIM). There are also approaches that seem to follow a more monolithic approach, where the control algorithms are simply adapted to the protocols offered by the appliances.

On the question regarding the specific framework used by the project to achieve the interoperability goals the answers were rather mentioning project own solutions. Some of these were developed over some project generations. There were also some commercial (things board) and open-source (def-pi) solutions. It would be very interesting to deeper investigate the features of each of the solutions and be able to compare them with each other, define complementary solutions, etc. This is planned in the next year of the Action #5.

In order to investigate the differences and similarities of the projects' energy management approaches and their relation to home appliance interoperability, we also asked about the way the home appliances are aggregated into units controlled by a single energy management entity in the project approach. For the aggregation we defined four levels: 1) local, where the devices are located, so at the customer premises/household; 2) higher, like at the building level; 3) higher, like at the neighborhood level; and 4) cloud level. Most of the projects (11) aggregate the appliances at the local level, approximately the half at the building (6) and cloud (7) level and only three (3) also in the middle between these latter two – at the neighborhood level (see Figure 2.12).

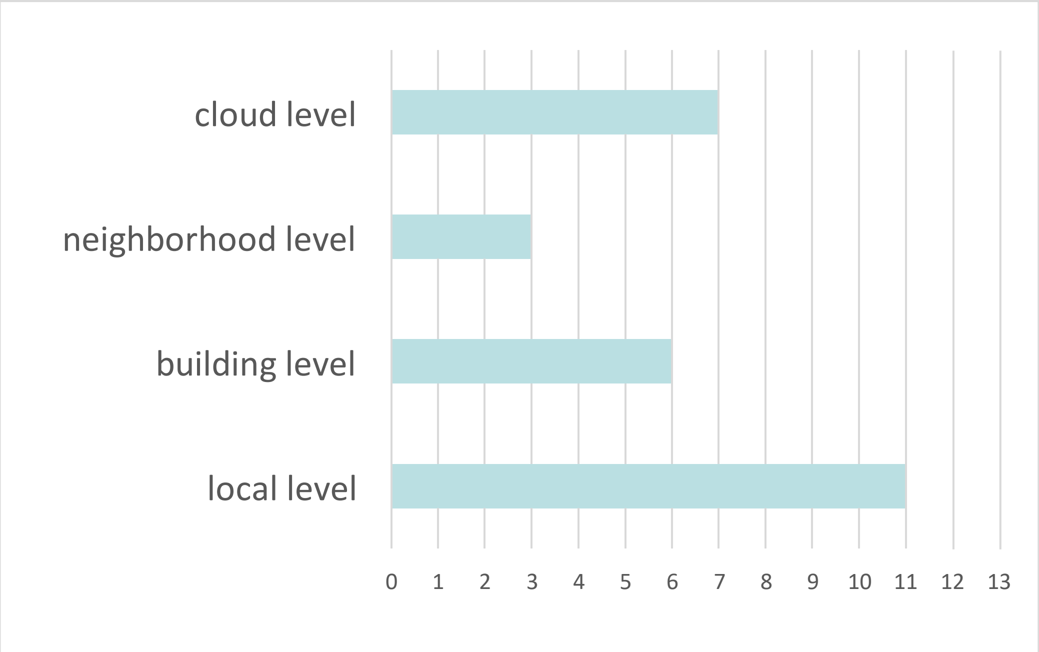

Figure 2.12 Number of projects operating on given levels (multiple choice)

It is also interesting how the different levels are combined by the individual projects. There were only five (5) combinations indicated by the project and the distribution between them is pretty equal (see Figure 2.13).

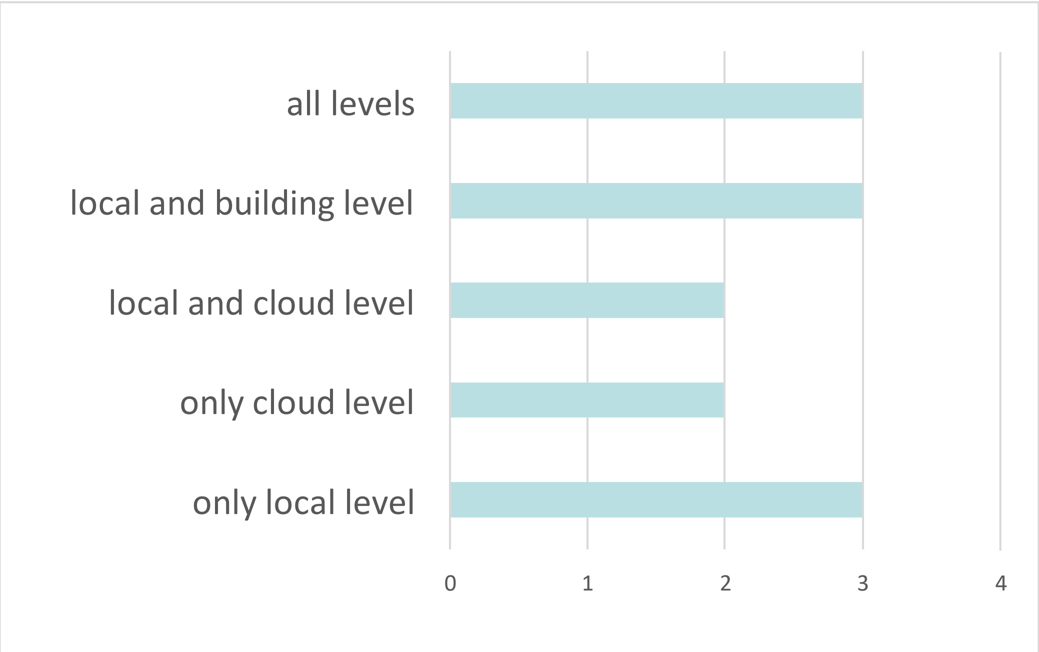

Figure 2.13 Number of projects operating on combinations of levels.

Security is a crucial issue in the digital era. Improper security can demolish the best energy management approach idea. The BRIDGE projects are aware of that and apply security approaches to provide privacy protection, access control and data protection. In most of the cases standard approaches are applied. It can be further investigated in the following year, what are the security features the projects' solutions use.

Regarding the home appliance interoperability there are activities that need to be realized on different SGAM layers. The projects indicated that the two most problematic layers are the Information layer and the Communication layer, followed by ex aequo the Function layer and the Business layer (see Figure 2.14). The reasonsfor the choices were also very similar. The identified problems on the Information layer are common APIs and interoperability between stakeholders and their systems, using common data models/formats. The Communication layer was problematic because of the diversity of the used technologies, interfaces and protocols that need to be handled.

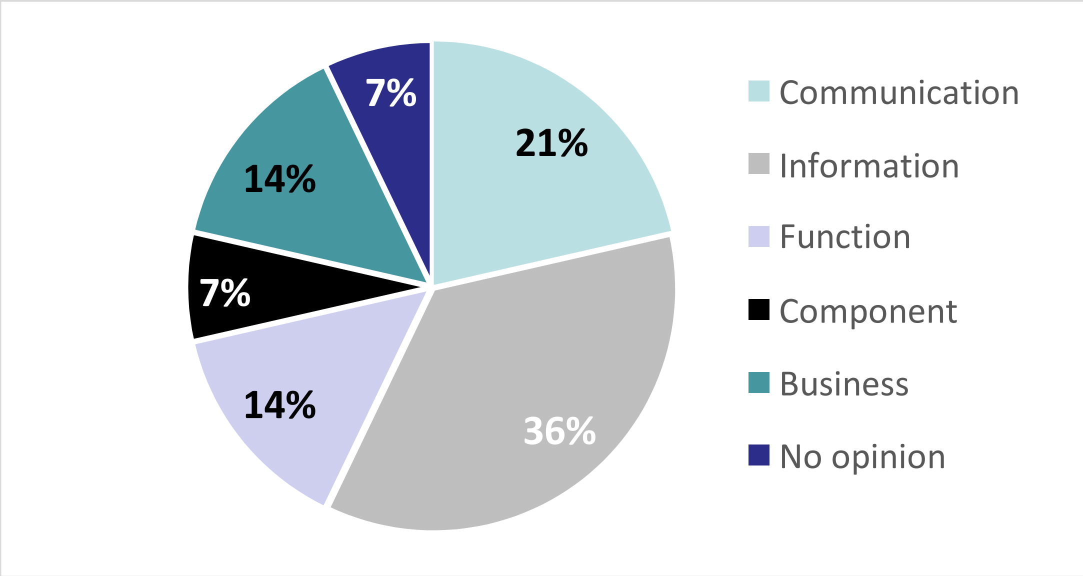

Figure 2.14 Percentage of projects' opinions on the most problematic SGAM layer for home appliance interoperability

Finally, when it comes to the features of home appliances that the projects consider missing, there are mainly wishes that the home appliances provide energy related futures at all, and that these are as accurate as possible. More specific wishes will probably arise with the experience of the projects and the real evaluation of the influence of the features on the energy management results. This process of defining reasonable energy related features may also establish once the market offers more devices and these can be evaluated. However, there were alsoopinions from projects that the features provided at the moment are already sufficient.

Similar, with respect to the problems with accessing the energy related features experienced or foreseen by the projects mainly the early childhood illnesses are mentioned: closed interfaces and similar limitations. With respect to the experienced or foreseen problems with interoperability of home appliances, many projects mentioned standards and open interfaces (mainly on the manufacturer level) as a potential remedy for interoperability problems.

The survey maybe did not provide us with all the information we wanted to gather at the beginning, but it gave us a good overview of the current state of things within the BRIDGE projects. It was realized as the initial activity of Action #5 and defines the direction for next steps.

3. Conclusions and next steps

This is the first report of the Action #5 in the Data Management Working Group. The issues related to interoperability of home appliances were identified as important and it was decided that we need to investigate this area and identify what can be done here to make the work in the projects easier. We run the survey to gather the status of the matter and the outcome of the survey is the input for the further steps in Action #5.

What can be seen from the results of the survey is that the BRIDGE projects are on different stages of addressing the issue of home appliance interoperability. This diversity comes mainly from different scopes of the projects and different stages of the projects' progress as well. The latter point causes that there are new projects potentially not aware yet of the issues they may be facing soon, but the sooner they recognize that and the more informed they will be, the easier the problem may be to face. But the former point is more interesting to investigate in the following year of Action #5 – the scope of the projects defines their relation to the home appliance interoperability problem. And we can identify three (3) groups of projects with that respect.

There are BRIDGE projects that do not involve home appliances at all, and they are not interested in that aspect of energy management, it is out of their scope. These projects are not in our focus, but it is good to monitor their achievements to have an overview on the full picture. These projects can also consider energy management aspects on a high level and even though these projects do not directly use home appliances, they may probably define the context in which these are used.

The second group of projects are those projects who focus on some aspect of energy management and need home appliances to implement that. These projects were somehow forced to address the issue of home appliance interoperability and maybe even provided some meaningful solution to address that issue, but it was not the main scope of these projects and may be only focusing on some special case. These projects can be considered as home appliance interoperability clients, i.e., if there were established solutions available, these projects could focus on their main goals. It is anyway interesting to investigate the potential of the solutions that these projects generated, not to miss valuable results.

The third group include projects which focus mainly on the interoperability. They may try to identify all the special cases and aim at defining generic solutions that will in the end fit all the needs. But these projects may also focus on some special aspects of the home appliance interoperability, like some special home appliance class or specific application scenarios. In general, these projects can be considered as the providers of home appliance interoperability. And it is crucial to investigate their outcomes and make them available, so that the interoperability clients can benefit. It is thus crucial for the following year to collect and publish this information in a consistent and structured form.

It is also important for the next steps in Action #5 is to identify and approach the stakeholder groups relevant for the interoperability of home appliances. The requirements coming from and going to these groups should be named and evaluated. It is also important to observe potential clustering within these groups that may cause these groups to be a set of smaller ones with different requirements and goals. To be more specific, we can mention here the appliance manufacturers as an example of such a group. The manufacturers are interested in running their businesses, i.e., they want to sell their products and that is their main goal. In order to make it happen, there is a need for a meaningful relation between the development and material investments and the final price of the appliances, the clients are ready to pay. The manufacturers are also forced to fulfil a set of technical and organisational requirements and regulations to be allowed to sell their products. Thus, to put it short and maybe simplified, home appliance manufacturers aim at developing solutions that are not too complex (to limit costs), provide all the needed features and being attractive to the customers. What we have already identified is that manufacturers usually cluster around their specific home appliance classes. This may cause clustering in the interoperability activities, but if done properly in each cluster, can be still a great outcome.

On the other hand, we have the new stakeholder group gathering relevance, let us call them the energy managers. This group uses the interfaces offered by the home appliances in order to implement and run energy management solutions with a diversity of goals. This group can be clustered around the more specific sub activities within the group, like the aggregators (or other stakeholders running energy management) or energy management algorithms developers. They may differ in the needed knowledge on the details related to the interaction with home appliances, e.g., the aggregators operating on higher level of abstraction, while the algorithm developers interacting directly with appliances. In general, this group may define the desired set of energy related features provided by the home appliances, together with the definition of preferable interfaces that are used to approach these features.

And of course, the aggregators operate for the customers and, e.g., to achieve for them some defined goals and fulfil regulations that are defined for them. Customers also define their requirements and constraints, like the ease of use and allowed costs.

Not all these relations are critical for our case, but some of them may be interesting to observe in order to explain the reasons behind specific issues and/or progress in defining and implementing solutions for home appliance interoperability.

During this year we observed and participated in activities related to support home appliance interoperability, like the DG ENER and JRC European Code of Conduct for Energy Smart Appliances Interoperability[3]. This is a great example on how the manufacturers can be brought together to provide common way for accessing their home appliances. We plan to monitor and support similar activities in the following years.

To summarize, in the next years we plan to work in the Action #5 on the following points towards interoperability of home appliances:

- Identification of relevant outcomes / products from BRIDGE projects, creating a library / repository with the products generated by the projects related to home appliance interoperability (description for comparison, potential reuse by others);
- Identification and monitoring / supporting activities towards harmonisation / standardisation in this area;
- Identification and monitoring of relevant standards and solutions. Creating a list and description of standards related to home appliance interoperability, together with their characteristics;
- Creating a multi-class smart appliance database with list of energy related features and interface description.

[3] https://ses.jrc.ec.europa.eu/development-of-policy-proposals-for-energy-smart-appliances

Appendix 1. Action 5# survey questions

Q 1. Please name your project (or projects if they share the way to use home appliances)
Q 2. Do you involve approaches for control and monitoring of home appliances in your project?
Q 3. What are the home appliance classes* (and subclasses if applicable) you are using in your project? Please provide comma separated. Example of home appliance classes are: washing machine, dishwasher, water boiler. Subclasses define finerdifferences, like condenser dryer vs. heat pump dryer.
Q 4. What is/are the home appliance API location(s) in your project?
Q 5. Do the home appliances provide manufacturers own interfaces or you use customized control? interfaces and extensions (like a smart plug)?
Q 6. What are the features of the home appliance classes that you use in your project? Please sort by home appliance class (e.g., washing machine: shifting washing, pausing; HVAC: settingtemperature, reading energy consumption; Fridge + Smart Plug: switching on/off, reading power parameters, etc.)
Q 7. For which use cases/scenarios implemented/considered in your project do you use the features of the home appliances? Please sort by use case (e.g. Energy flexibility – VPP: switching on/off, shifting load;)
Q 8. Do you use home appliances by a single manufacturer or by many manufacturers?
Q 9. Are these home appliances available on the market or are experimental ones?
Q 10. Do these home appliances provide open monitoring and control interfaces and protocols?
Q 11. Which home appliance API interfaces and protocols are used in your project?
Q 12. Which internal API interfaces and protocols do these appliances use?
Q 13. How do you cope with interoperability? What is your approach to use appliances by different vendors? and use their features? Provide short description, like use of adapters, appliance specific drivers, etc.
Q 14. Do you use any specific framework/solution for controlling and monitoring the home appliances? Which one?
Q 15. What is the level where your energy management (algorithm) aggregate a group of appliances in a single unit controlled by one controller? The level where you collect monitoring/status data and generate the control signals for the home appliances in your project approach.
Q 16. What are the security means applied in the home appliance API? What mechanisms are used for authentication, authorization, confidentiality (data protection)? Are these available at home appliance level or e.g., at the cloud service level?
Q 17. Related to the SGAM model, what is the layer that you see as the most problematic from the interoperability point of view?
Q 18. Why do you see this layer as the most problematic?
Q 19. What are the home appliance features that you miss for useful use cases? Please sort according to use case (e.g., use case: device class: feature1, feature2;)
Q 20. Are there any issues related to accessing the features of the home appliances you experienced or foresee?
Q 21. Are there any issues related to interoperability of home appliances you experienced or foresee?
Q 22. Can we ask you additional questions related to the survey? (e.g., per e-mail)
Q 23. Could you please provide an Email address so that we can contact you directly for questions?

Model (and vendor)
Class and subclass (if apply)
Features provided directly by the appliance – please list them
Is the home appliance used with additional hardware?
Features provided with additional hardware – please list them
Application in use case (what are the features used for)
Home appliance API level (direct / home gateway / cloud service / other)
Communication technology (internal API)
Protocol (internal API)
Is the internal API open?
Communication technology (home appliance API)
Protocol (home appliance API)
Do you apply any framework for that device? Please name it.
What is the security in the home appliance API? (For communication / authorization / access control related)
Does the manufacturer allow to install own software on the home appliance
Have you developed any home appliance specific driver / adapter?
Are you interested in providing the adapter/driver for the appliance to the community?
What is the licensing scheme you plan for the driver/adapter?

List of figures

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centers. You can find the address of the center nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

– by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

– at the following standard number: +32 22999696, or

– by email via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications

You can download or order free and priced EU publications from: https://op.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information center (see https://europa.eu/european-union/contact_en).

EU law and related documents

For access to legal information from the EU, including all EU law since 1952 in all the official language versions, go to EUR-Lex at: http://eur-lex.europa.eu

Open data from the EU

The EU Open Data Portal (http://data.europa.eu/euodp/en) provides access to datasets from the EU. Data can be downloaded and reused for free, for both commercial and non-commercial purposes.

MJ-04-23-847-EN-N

Publications Office
of the European Union

ISBN 978-92-68-07477-0