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Testing methodology of the Code of Conduct for Energy Smart Appliances

Supporting the development of policy proposals for Energy Smart Appliances

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Abstract

Energy Smart Appliances (ESA) can contribute to demand flexibility of households in the European Union (EU) playing a role for the energy transition. Having detected issues concerning the interoperability among brands and manufacturers of ESA, DG ENER and DG JRC launched an initiative to achieve their interoperability. The main goal is to develop a Code of Conduct (CoC) on energy management related Interoperability of ESA.

The contributions received from various stakeholders (industry, academia, NGOs, etc) together with the high level of participation, accomplished through workshops, surveys and meetings, were crucial to draft the CoC.

This CoC sets out the basic principles to be followed by all actors involved in the development and production of the included ESA. The specific target audience of this initiative are ESA manufacturers, who are invited to adherence to this document (sign the CoC), hence backing the commitments included in it.

In its first version, the CoC's scope covers white goods and heating ventilation air conditioning (HVAC) devices. The approach is based on uses cases (UCs) which need to be mapped into the Smart Applications REFerence (SAREF) ontology. SAREF is a shared model of consensus that facilitates the matching of existing assets in the smart applications domain.

As the principles set in the CoC also need to be checked. The current document aims to develop a testing methodology, so that the signing manufacturers can use it as a guiding reference to comply with the agreed commitments.

Acknowledgements

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We would also like to thank all stakeholders who participated on workshops or contributed to our survey. Thanks to their participation the project is connected with the most recent developments and requirements.

Authors

Andreadou Nikoleta, Gonzalez Cuenca Isabel, Tarramera Gisbert Angel.

[1] https://www.trialog.com/en/home/.

Executive summary

This document aims to develop a testing methodology to check the compliance with the CoC offering to manufacturers guidance and some specifications.

This document has been developed thanks to the contributions received by all the stakeholders involved in the CoC initiative, specifying details about the testing procedure.

It includes a proposal based on 4 phases to execute the tests.

Policy context

This document is part of a broader project in the framework of an Administrative Arrangement (AA) between the DG ENER and DG JRC with the scope to provide technical and scientific assistance. The project is entitled "Support to the development, implementation and review of relevant provisions of EU Energy Efficiency legislative framework, related actions and related governance issues (JRC-TSEED III)", and it is specifically related to WP2 - Technical and scientific support to the review of EU Energy Efficiency legislation including energy performance of buildings and prods under the Task 2.4: Support on the development of policy proposals for ESA.

Likewise, it is important to mention that the European Product Registry for Energy Labelling (EPREL) initiative has a crucial role in the register of the ESA compliant with the CoC, under the umbrella of the EU's ecodesign policy.

Key conclusions

This testing methodology allows manufacturers to test the CoC principles in their own facilities.

Four phases are described to carry out the proposed and a test tool could be developed to automate test performance.

This methodology helps manufacturers, so it also has to be built hand in hand with all the actors involved, for which reason a survey was launched to collect opinions.

The contributions on the methodology have not been very numerous due to the summer period, but the actors involved have contributed ideas on what the test results should be like and where they should be published. They have also offered contacts about laboratories that can carry out the tests.

Related and future JRC work

Regarding the AA with DG ENER, the following step is to focus on the Energy Management System (EMS), which is able to orchestrate all the different devices. Photovoltaic (PV) solutions, and provide an overview of deployment status of Electrical vehicles (EV). Likewise, it is expected to continue working on incorporating new devices and check the deployment of the CoC.

Related to the testing methodology, our Laboratory in Petten (the Netherlands) will work to offer guidance and develop test capacity to check the compliance of ESA with the CoC.

1 Introduction

Achieving interoperability among energy smart appliances (ESA) inside a home means to enable interaction among devices and with the customer, hence improving the energy management and enabling benefits based on flexibility or prices savings. As stated by the CEN-CENELEC-ETSI Smart Grid Coordination Group (SG-CG) [5], this definition is extended to "The ability of two or more networks, systems, devices, applications, or components to interwork, to exchange and use information in order to perform required functions."

For that reason, DG ENER from the European Commission launched an initiative with the support of Joint Research Centre (JRC) to promote the interoperability among different device brands and manufacturers.

Thanks to this initiative, a Code of Conduct (CoC) has been developed in collaboration and with the contributions of manufacturers, academia and associations; representing both Industry and consumers. The document offers a complete guide to develop solutions that address the issue of interoperability.

This CoC sets out the basic principles to be followed by all actors involved in the development and production of the included ESA, white goods and heating ventilation air conditioning (HVAC) devices in its first version. The ESA manufacturers are invited to sign this document hence backing the commitments included in it. The approach is based on uses cases (UCs) which need to be mapped into the Smart Applications REFerence (SAREF) ontology([2]).

SAREF is a shared model of consensus that facilitates the matching of existing assets in the smart applications domain.

The purpose of this report is to provide a testing methodology to check the CoC, offering clear procedures and information to help manufacturers to increase the number of ESA in the European Union (EU) market.

The methodology is arranged in 4 phases, which are explained in section 4, and the structure of the results report is specified in the Annex.

[2] SAREF website: https://saref.etsi.org/

2 Code of Conduct on interoperability for Energy Smart Appliances

As it is mentioned in the introduction of this report, the testing methodology is framed within a project with some deliverables already achieved. These are:

- The first report developed under this project, which was published in July 2022, contains an analysis of the data exchanges and several uses cases (UCs) for ESA.
- Another report was produced that to the participation through a survey about interoperability of ESA.
- Thanks to 3 workshops and 4 surveys, several stakeholders from industry, academia and experts participated actively and the main deliverable was achieved: the first version of the Code of Conduct (CoC). This document is developed to increase the number of interoperable ESA that are placed on the EU Union market.

A summary of the CoC to understand the scope and the commitments expected from manufacturers is provided in the subsection 2.1. In the subsection 2.2, there is a short explanation about the EPREL database which is a crucial approach made in the CoC.

2.1 Code of conduct

The following definition of ESA is provided in the CoC: "Energy Smart Appliances (ESA) are products that provide energy flexibility being capable of automatically (by means of machine to machine –M2M-communication) optimising their consumption patterns (e.g. time or profile) in response to external stimuli, based on user consent permission."

This scope of the CoC covers two device types:

- White Goods
- Heating, Ventilation and Air Conditioning (HVAC)

For each type of device, the manufacturers need to implement some UCs (those flagged as mandatory) and guarantee that their solutions can be mapped into SAREF. Particularly, the CoC requires the use of SAREF4ENER which is the dedicated SAREF extension for the Energy domain.

The UCs indicated in the CoC are:

- Flexible Start.
- Monitoring of Power Consumption.
- Limitation of Power-Consumption.
- Incentive Table based Power Consumption Management.
- Manual Operation.

To understand what it is expected from manufacturers the CoC has the Annex 1 "Mapping of use cases to Energy Smart Appliances" where three level of requirements can be found: mandatory, optional or non-applicable (see Figure 1).

Figure 1. Mapping of use cases to Energy Smart Appliances from the Annex 1 of the CoC.

	Flexible start	Monitoring of Power Consumption	Limitation of Power-Consumption	Incentive Table based Power Consumption Management	Manual operation
White goods					
• washing machines, tumble driers, washer-driers, dishwashers	M	O	O	n/a	M
Heating, cooling, and ventilation appliances					
• heat pumps (delivering heat/cold through air or water)	O	M	M	O	O
• local space heaters	O	M	M	O	O
• water heaters (electric storage, heat pump storage, electric instantaneous)	O	M	M	O	O
• ventilation	n/a	M	O	O	O

Source: Code of Conduct. 2023.

As it can be observed in Figure 1, the mandatory UCs for white goods are "Flexible Start" and "Manual Operation", whilst "Monitoring of Power Consumption" and "Limitation of Power Consumption" are mandatory for HVAC, with the exception of the latter use case (UC) applied to ventilation devices (optional). Therefore, the business organizations that place any ESA compliant to the CoC in the EU market need to make sure that all core elements within this mandatory UCs are present. In the Annex 2 of the CoC, each of the core elements included in every UC (mandatory, optional, and non-applicable –n/a–) is described. In this annex, all organization can find tables containing descriptions, data type or value, and the corresponding SAREF representation of each core element of every UC. It can be observed that the UC "Incentive Table based Power Consumption Management" is optional or n/a for all devices.

Likewise, it is interesting to mention the Annex 2 of the CoC where the minimal core data elements and SAREF / SAREF4x representation is shown for a UC. The ESA manufacturers are expected to ensure that all relevant information elements used in the implemented use cases as well as in their open protocol have a corresponding SAREF representation, fully compliant with the SAREF framework of ontologies according to the technical specification ETSI TS 103 264 (SAREF core) and ETSI TS 103 410 series (SAREF extensions).

2.2 EPREL database

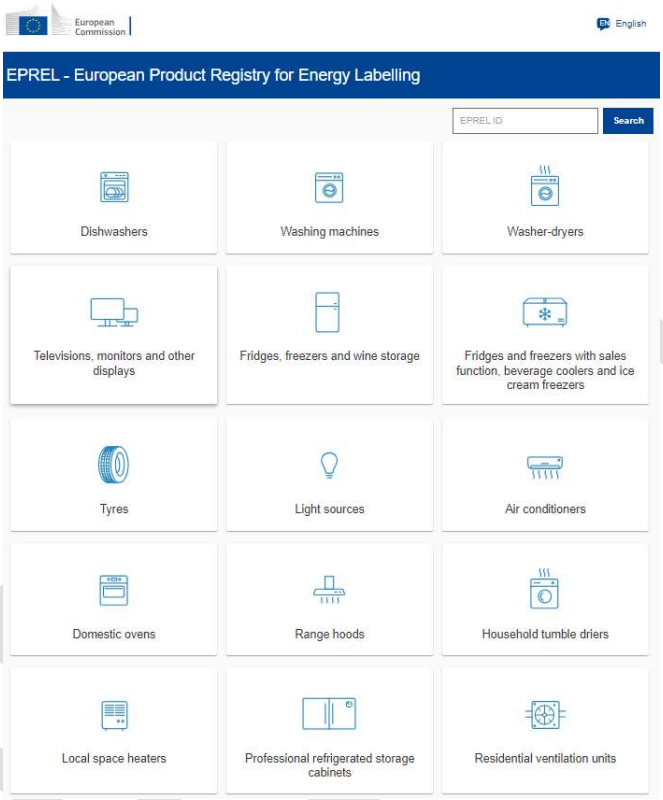
In general, the EU legislation on ecodesign is a tool for improving the environmental impact of products by setting a framework for performance criteria. This eliminates the least performing products from the market, significantly contributing to the EU's energy and climate targets. The ecodesign approach also supports industrial competitiveness and innovation by promoting better environmental performance of products throughout the internal market.

In particular, the EU Energy Labelling Regulation and Ecodesign Directive (EPREL) constitute the EU legal framework that helps to improve the energy efficiency of products on the EU market. The ecodesign directive sets common EU-wide rules for improving the environmental performance of products, by setting out minimum mandatory requirements for the energy efficiency of these products, i.e. it bans the least-efficient products from the EU market. The energy labels may complement those ecodesign demands with mandatory labelling requirements that guide consumers towards the most energy efficient products, i.e. it provides an indication of the energy efficiency and other key features of products at the point of purchase.

Products with an energy label are registered in EPREL. The ecodesign and energy labelling legislative framework cover over 30 different products, which are grouped in 15 categories, including the ESA covered in the CoC, among others ([3]).

Suppliers (manufacturers, importers or authorised representatives established in the EU that place ESA in this market) must register their products in the EPREL database, which is available for public access and consultation ([4]). In this database, the information on a registered product can be reviewed and compared with another one. The appearance of section of the database website is shown in **Figure 5**.

Figure 2. Extract from the current user interface employed in the EPREL database



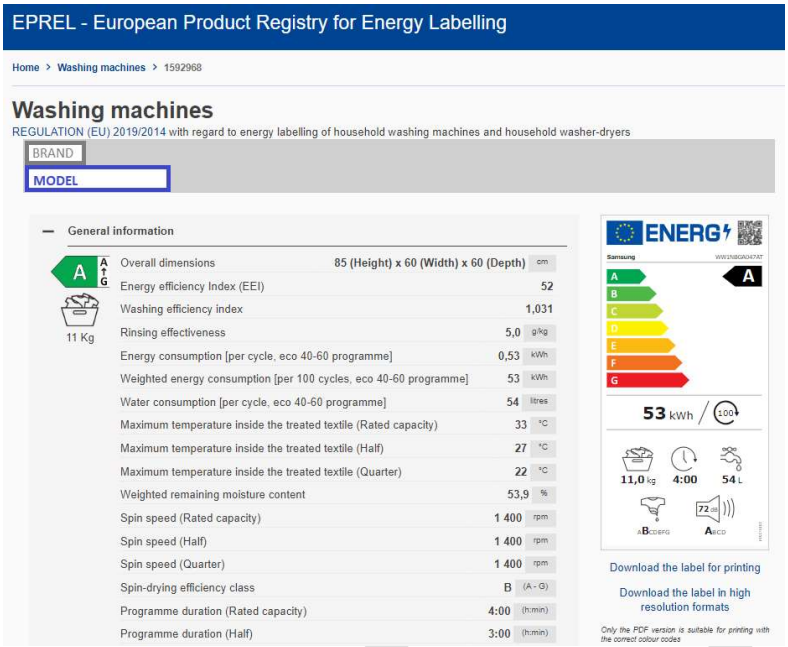
Source: EPREL database website 2023.

The EPREL database offers the possibility to identify which products have the best cost-efficiency ratio for a specific need. Information on other aspects than a product's energy use, such as its water consumption, noise emission, extension of the warranty, availability of spare parts, duration or product support, are also provided. The database supports comparative processes, offering online information about various product's aspects, without taking into account or providing their prices. An example of the list of parameters to be declared when the manufacturer registers a new model of a washing machine can be seen in Figure 3.

[3] Product database general information: https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/energy-label-and-ecodesign/product-database_en

[4] EPREL database website: https://eprel.ec.europa.eu/screen/home

Figure 3 . List of parameter displayed in the EPREL database from a randomly selected washing machine.



Source: EPREL database website 2023.

One of the advantage of adhering to the CoC is that any compliant product will include some additional fields to advertise and to be found in EPREL. It will therefore be possible to filter the products that are interoperable when searching in this database.

If any of these declared parameters changes during the update of the model, including the CoC compliance, the product will have to be registered as a new model.

3 Foundation about methodology

The methodology for testing interoperability for Energy Smart Appliances has been based basically on the JRC methodology for testing smart grid UCs. In section 3.2 the Interconnect project is presented as a good example of some pilots of smart homes and buildings using energy smart appliances and tackling the interoperability issue.

3.1 JRC methodology for interoperability

Testing interoperability requires producing detailed test cases describing how smart grid components are intended to interact with each other. A systematic approach for developing smart grid interoperability tests will facilitate the dissemination of innovative solutions, and the stability and resilience of the smart grid.

The Smart Grid Interoperability Laboratory (SGILab) at the JRC of the European Commission (EC) proposes in this document ([5]) a unified approach towards a European framework for developing interoperability testing specifications. A successful development and deployment of the future smart grid requires, a better understanding of how components interoperate, and how the proposed standards ensure interoperability among those components. Towards this objective a methodology serves as a systematic way to evaluate the interoperability of different subsystems or electric grid components and methodically verify the ability of given equipment under test to communicate effectively with other components. The use of a methodology provides a systematic means to analyse any interoperation flaw against business and user requirements. Further analysis could then be utilised to assess the impact of any inconsistency and propose potential solutions.

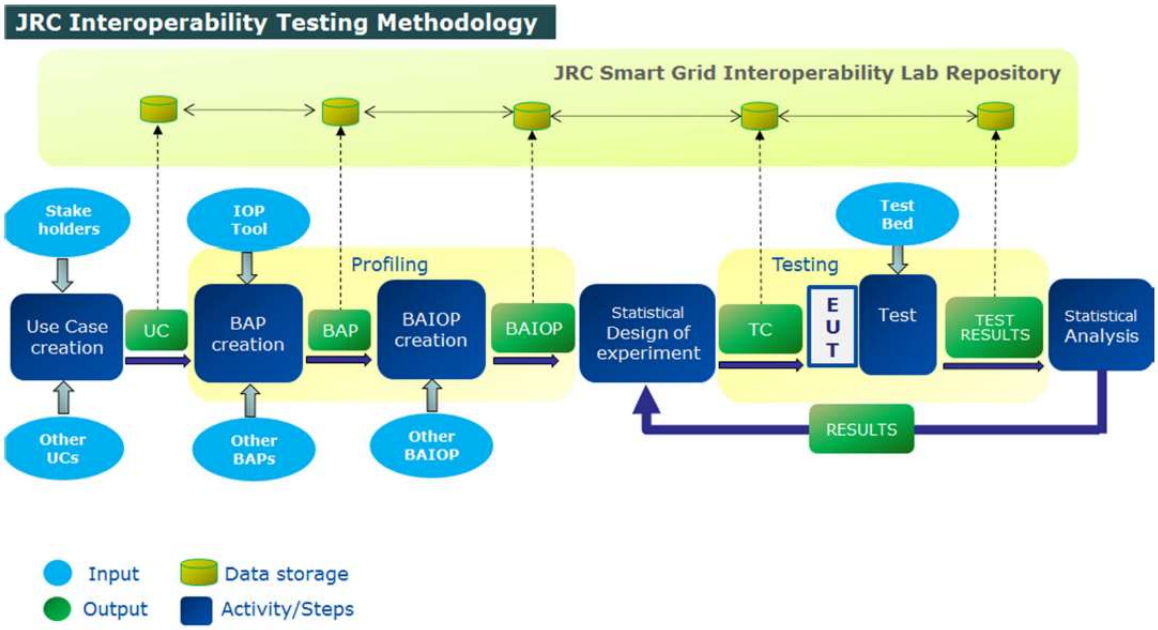
Designing interoperability tests is not straight forward. The testing specifications should be carefully defined in a way to maximise the possibilities of finding potential inconsistencies, shortcomings or errors. The methodology interoperability testing methodology guides the specification developer on how to build a successful interoperability testing exercise. It facilitates the developer in including all the necessary steps while insuring reliable results. The success of a smart grid interoperability test depends on how well this is achieved.

The methodology summarises a set of best practices that a developer could follow to complete in a smooth way a smart grid interoperability test. Ad-hoc developments without the use of any methodology could potentially lead to lack of reproducibility and benchmarking, bad quality, longer development time and higher cost. Moreover, the methodology helps the user through a step by step process to create smart grid interoperability testing UCs, Basic Application Profiles (BAP) and Basic Application Interoperability Profiles (BAIOP). It keeps track of the testing specifications along the development of the testing process from conception to realization.

The methodology is used mainly as a common framework for interoperability testing and consist of five stages; UC creation, BAP creation, BAIOP creation, Design of Experiments (DoE), Testing and Analysis of Experiments (AE). Each stage allows the developer to select certain features then used in the subsequent stage. During the completion of all stages, the developer can select relevant standards, their options, test beds with all qualified and test equipment as well their attributes or functions used during the testing.The block diagram of the JRC Interoperability Methodology (including, inputs, activities, outputs and data storage) is depicted below in (add cross reference).

[5] Interoperability testing methodology: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC110455/kjna29416enn_final.pdf

Figure 4. Interoperability Testing Methodology and its various steps



Source: JRC interoperability testing methodology.

3.1.1 Use Case Creation

As a first step, a smart grid interoperability test case needs to be defined. For this action, it is important to define the following:

- The actors that interact with each other. By actors, it is meant the systems, infrastructure, software, and physical entities that are involved in the smart grid interoperability test case. Physical entities can be also people responsible for systems' interaction and data processing.
- The messages exchanged among all actors and the nature of their interaction.
- The definition of the testbed and the equipment under test. For every test case, only one equipment/system/software is considered as equipment under test, whereas the rest are considered to be as testbed. The connections among the actors of the testbed are considered to be set and functioning. Only the equipment under test is the one to be tested and particularly one connection between the tested equipment and another critical actor.
- The representation of the UC on the Smart Grid Architecture Model (SGAM), which is set according to CENCENELEC-ETSI documents ([6]). This three-dimensional architecture framework can be used to model interactions between different entities located within the smart energy arena, which contains five business domains (Generation, Transmission, Distribution, DER, Customer premises) and six architecture zones (process, field, station, operation, enterprise, market) for each of the five interoperability layer (component, communication, information, function, business). The representation of a UC on the SGAM is fundamental to help the reader understand the interactions of actors and their role in the system overall.
- The definition of the sequence with which messages are exchanged among the various actors and the objective of the test case.

[6] CEN/CENELEC website: https://www.cencenelec.eu/.
ETSI website: https://www.etsi.org/.
SGAM documentation: https://syc-se.iec.ch/deliveries/sgam-basics/

3.1.2 Basic Application Profile creation

After the UC creation, the next step is to create the BAP, which consists of the following steps:

1. List all possible standards or options of standards that can be used for each link, including the links among actors of the testbed and the link under test referring to the equipment under test.
2. Define the selected standard or option of standards that are used for the links among actors comprising the testbed. Only one standard or option of standard is selected for each link. Since these links are part of the testbed, the standards or options of standards are considered to be functioning and no testing is performed for them.
3. Define the selected standard/ option of standard for the link under test that refers to the equipment under test. This standard/ option of standard is the one to be tested for interoperability purposes.

Step 1 serves in order to help the reader understand the options for the various links of operation and also help in understanding why the specific standards have been selected.

In this work, for the energy smart appliances, as we mainly have one link of operation between the Energy smart Appliance and the actor controlling it, Step 1 can be omitted to simplify the whole process.

3.1.3 Basic Application Interoperability Profile creation

The BAIOP stands for Basic Application Interoperability Profile. The BAIOP defines the exact steps of the test case. It is actually the definition of the test case: the objective of the test case, the steps of the tests and how the desired outcome is judged: the conditions under which we have a PASS or FAIL in the interoperability tests.

3.1.4 Design of experiments

The Design of experiments is not always applicable for the interoperability test cases. Whereas the BAIOP is evaluated through a PASS-FAIL examination of interoperability for the equipment under test, the design of experiments goes deeper, investigating under which conditions interoperability is preserved when the default parameters are modified. For example, the frequency of "interrogation" of the ESA can be one parameter.

An example is given to understand the details of this step:

- Let us suppose that for a specific test case, the frequency of "interrogation" plays an important role.
- A default frequency is used for the basic "PASS" or "FAIL" interoperability tests, i.e. a frequency that is mostly used in practice. For instance, the ESA is asked to communicate data every 12 hours).
- The design of experiments changes this parameter (the frequency) and checks if interoperability is preserved when another value is applied. For example, the ESA is asked to communicate data every 1 hour, 2 hours, etc.)
- Tests under design of experiments should give a curve (or multiple curves) showing the dependence of interoperability with respect to critical parameters. It is obvious, that in some UCs, the design of experiments is not applicable, as not all test cases entail such parameters.
- The Design of experiments is only applied when it makes sense to test the effect of critical parameters on the interoperability tests.

3.1.5 Test Execution

This step is actually the test execution according to what has been defined in previous steps and the analysis of results.

3.2 Interconnect project

The other main foundation for this document is the interconnect project as an example of having achieved interoperability among devices.

The project started to acknowledging the conditioning that digitalisation imposed on the EU energy market, and that new rules and technological developments allow the proliferation of energy service providers with users having full knowledge and control over their ESA. It also recognized the serious problem that interoperability among ESA represents, e.g., a change of provider could mean the replacement of installations.

The EU-funded InterConnect project proposes effective energy management using a resilient and practical ecosystem that is user-centric and market-driven ([7]).

InterConnect gathers 50 European entities to develop and demonstrate advanced solutions for connecting and converging digital homes and buildings with the electricity sector. The project places the foundation for the future of smart energy management solutions by seven connected large-scale test-sites in Portugal, Belgium, Germany, the Netherlands, Italy, Greece and France. Via these seven pilots, they intend to showcase an effective digital market for ensuring energy-efficiency at reduced costs that is beneficial to end-users

The project targets at bringing efficient energy management within reach of the end-users.

The solutions developed within its scope target the digitalisation of homes, buildings and electric grids based on an Internet of Things (IoT) architecture. It also aims to guarantee the interoperability between equipment, systems and privacy/cybersecurity of user data by including digital technologies (Artificial Intelligence, Blockchain, Cloud and Big Data) based on open standards, such as SAREF ([8]).

All these information and additional details can be extracted from the dedicated website of the project ([9]), and it is also possible to have a quick overview watching its promotional presentation video ([10])

[7] CORDIS EU research website: https://cordis.europa.eu/project/id/857237
[8] Interconnect website about section: https://interconnectproject.eu/about/
[9] Interconnect website: https://interconnectproject.eu/
[10] Interconnect presentation video: https://www.youtube.com/watch?v=X3nSsEUJ5zg

4 Proposal: Four consecutive phases.

The proposal for performing interoperability testing for ESA aims, first of all, to complete the CoC and offer a tool for manufacturers to test their devices for interoperability. This proposal is based on the JRC methodology for interoperability testing (see 3.1), which is adapted to the needs of the CoC for ESA.

The proposal has been based on a suggestion made in the framework of Interconnect project by one of its partners, Trialog. It consists of 4 parts, here called phases, which allowed to implement the test of compliance with the CoC. In the Figure 4, these phases are illustrated, whereas in the following subsections, we explain each phase in detail.

Figure 5. There are four Phases in the testing proposal.

Source: Trialog

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4.1 Phase 1. Reference specifications

The first phase defines the prerequisites for performing interoperability tests. The first version of the CoC indicates that compliance with SAREF4ENER is mandatory. The reason is because an ontology such as SAREF4ENER defines the concepts, relations and constraints for ESA and their communication with other actors.

In this phase, the reference to test the interoperability of ESA is agreed. That is why it is based on two very well-defined pillars: CoC and SAREF4ENER. The first one has been extensively discussed and well defined with dozens of stakeholders, and the second one is a reference ontology supported by the ETSI SmartM2M standard.

During a testing exercise, this first phase is performed only once. Since the scope of the CoC includes white goods and HVAC, the selected reference is already fixed in the v1.0 of the CoC. However, once this text targets a broader spectrum of devices, other subset ontologies of SAREF may be added. As soon as the reference specifications are established, we are ready for the next phase for compliance testing.

Figure 6 shows this first phase and how it is applied for the CoC v1.0.

Figure 6. Phase 1: Reference specifications

Source: Trialog

4.2 Phase 2. Reference for implementation (profile)

For the second phase of the testing process, and after having set the proper reference specifications, it is fundamental to define the following:

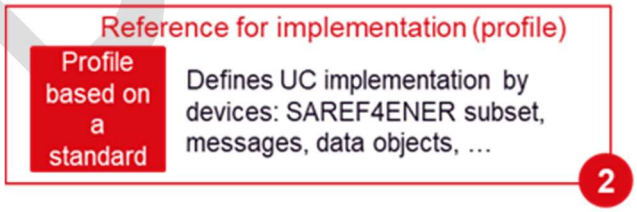
- A standard chosen by the manufacturer with which, the ESA will communicate its data.
- The messages that need to be exchanged and the data models both contained in the CoC.
- The mapping of the defined data models and messages of the selected standard to the classes and properties defined in SAREF4ENER. To assist this step the triples present in Annex 2 of the CoC can be employed to complete the data model required. Concerning the exchange messages required from the ESA a message sequence diagram can be of service.

The messages and data models are expected to be defined in this phase, and the outcome of this procedure is a (testing) profile. In other words, the profile defines the implementation of a selected UC and how to map the chosen standard to be used to SAREF4ENER.

It is possible to use several standards, which force the actor performing the test to create several profiles; one profile for each standard. Therefore, unlike the first phase, this one can be applied several times, also depending on the subsets of SAREF4ENER that are selected. Figure 5 shows the highlights of the concept contained in this Phase 2.

The requirements set by a UC of the CoC, here a profile, need to set both a point of observation and a point of control to be able to check an agreed model.

Figure 7. Phase 2: Reference for implementation



Source: Trialog

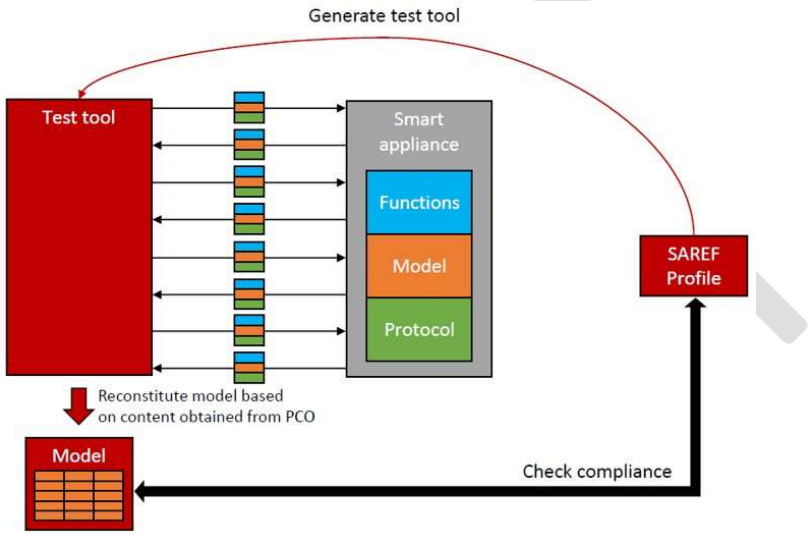
Linking this phase to the JRC methodology, it corresponds to the BAP creation step (see Section 3.1.2), which is particularly the selection of a standard done by the manufacturer. The step related to the UC generation has no correspondence because they are already defined by the CoC itself. On the other hand, the step of mapping the chosen standard to SAREF4ENER is considered part of the BAIOP, as this is a fundamental part for the successful execution of the tests described in the next phases. The correct mapping of the chosen standard(s) to SAREF4ENER can be considered the pre-testing/ verification part of interoperability checking for the ESA.

4.3 Phase 3. Implementation

Once a profile has been created and defined, the third step, or Implementation phase, comes into play. The ESA is implemented based on the profile, as this is defined in the previous phase (e.g. mapping of the chosen standard to SAREF4ENER)

The proposal contains a key element, the test tool, which is important to define. This tool needs to be able to reconstitute a certain model based on the specifications and on the profile; each profile is defined following a different UC implemented in the CoC. The main idea is to generate a test model for each profile. The information that can be retrieved from each of these core elements needs to be implemented or included in the model, that is then added to the test tool. When performing the test, the tool inspects if the information received (for every core element) coincides with the model.

Figure 8. Test tool proposal.



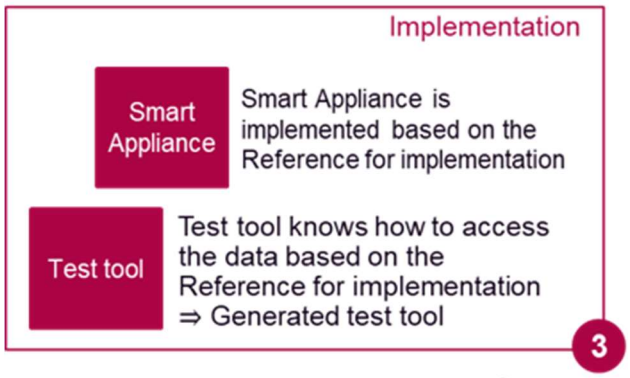
Source: Trialog

A schematic diagram can be found in Figure 5. The diagram shows the test tool connected to an ESA and performing the check above described. The test tool reconstitutes the model obtained when connected to the ESA and compares it with the correct one, generated previously considering the SAREF triple specifications. The specifications for every UC can be found in Annex 2 of the CoC.

This phase is expected to be performed for each of the profiles generated in the previous phase.

The test tool should be developed based on a profile already defined. The main scope of this tool will be to access the device and check the communicated messages using the observation and control point established in a profile. Effectively, the test tool will act as a verifier of the retrieved information using an implemented point of observation from the ESA that will match to a point of control following a predefined model. **Figure 9** shows in a nutshell the fundamentals of this phase. When linked to the JRC methodology, this phase corresponds to BAIOP creation, and particularly, to the part where the test steps are described.

Figure 9. Phase 3: Implementation



Source: Trialog

4.4 Phase 4. Test execution and compliance check

In this final phase 4 it is where all the previous phases come together and allow to achieve the final goal, the execution of the test and the final compliance check of one of the UCs described on the CoC. Therefore, it is the stage at which the developed test tool is employed to check if the ESA under test is interoperable according to the requirements of the CoC.

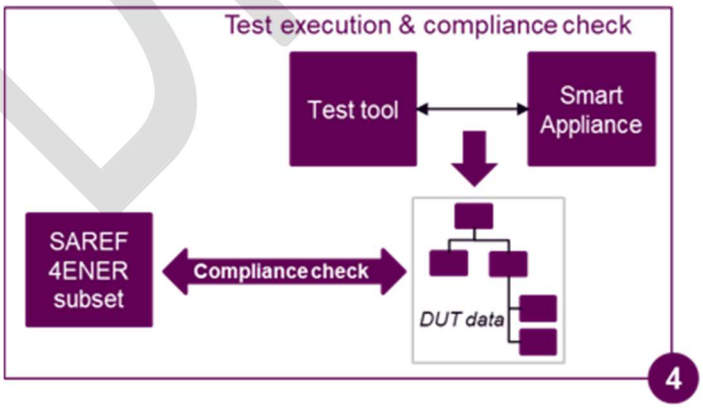
In this step it is necessary to perform a compliance checking with the rules set by the reference ontology chosen (e.g. SAREF4ENER). This means verifying:

- if the mandatory properties of the exchanged messages are present,
- if the information contained in them is compliant with the selected reference ontology
- if the extracted information has the correct format and
- If this information is within a correct range value

A diagram sketch of this phase can be found in Figure 9.

As it is mentioned before, a testing tool needs to be developed, and for the time being self-testing is expected. As a consequence, there might be different testing tools emerging so that each manufacturer (or entity placing an ESA in the EU market) is able to test its own devices. Figure 9 summarises this phase.

Figure 10. Phase 4: Test execution



Source: Trialog

The testing tool can be defined in a short explanation as a software connected to an ESA that is able to interrogate this device, and compare the information retrieved from the replies received with a predefined model representing a specific UC described in the CoC, hence checking the correct SAREF mapping

representation of a concrete standard. The focus of the test is on the results: the information of the replied messages received after a requirement.

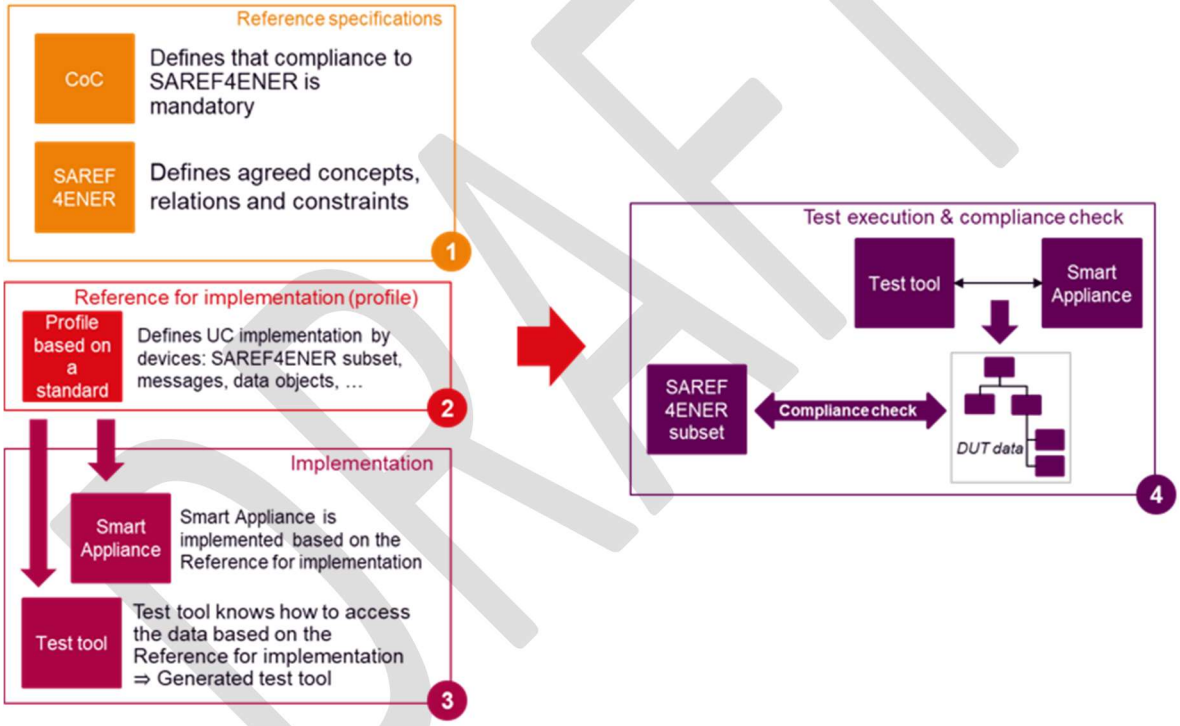
The template for the result of the tests is proposed in the Annex of this document.

4.5 Overview of all four phases

A general overview of the testing procedure is displayed in Figure 10. The figure puts together the already introduced Figures 6, 7, 8, and 9, respectively displayed in in Sections 4.1, 4.2, 4.3, and 4.4, to represent all the phases of this testing methodology. The phases include:

1. Reference specifications.
2. Reference for implementation (profile).
3. Implementation.
4. Test execution and compliance check

Figure 11. Overview of all four phases.



Source: Trialog

The four phases presented can be developed by the interested actors in the way that suits them better. However, the possible *ad-hoc* solution generated (test tool) cannot disregard other solutions. This means that when the ESA under test is properly connected to another test tool, it should still provide the correct information accordingly.

This process might be automatized once a testing procedure has been performed for a new UC of the CoC regarding a specific ESA. Considering that the standard selected to be mapped into SAREF is kept unchanged and no updates are introduced in the regarded UC.

Although the test tool is the masterpiece of the methodology, its development is in a very early stage. It requires an additional network of certification laboratories or facilities and actors that can develop it. It will need to be developed in the upcoming months to have it ready for testing the first ESA that will come up after signing the CoC. In an initial phase, the EC (DG ENER & DG JRC) have agreed that manufacturers perform self-testing. Through this self-testing several test tools may emerge, but they should be able to test the same

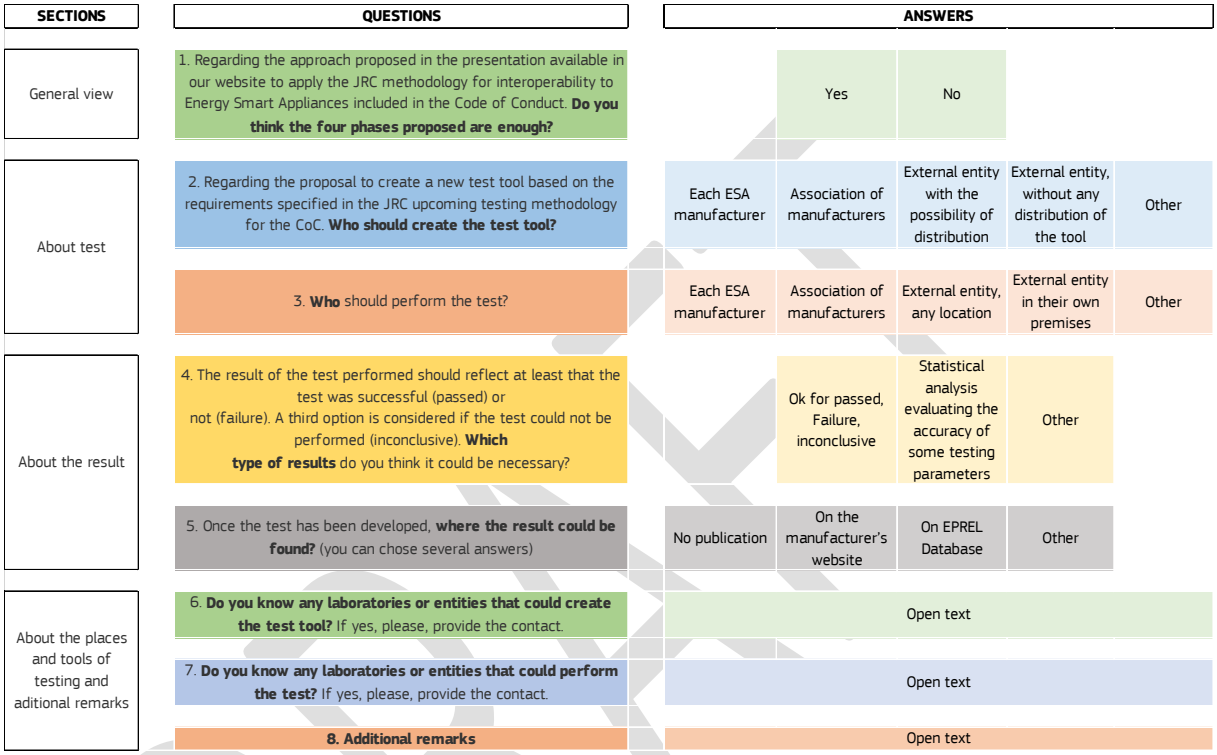
principles. The scope of this document is limited to present the fundamentals of the methodology for interoperability testing of ESA and give the details of the way this is expected to become. In the near future, the actual implementation of the test tool described here, is anticipated together with its usage for the interoperability tests. It is highlighted that this test tool is a proposal on behalf of the EC to facilitate interoperability tests. Dialog with stakeholders and negotiation will still continue in order to ensure interoperability tests for ESA are performed in a smooth and correct way.

5 Survey about testing methodology

On July 2023, a survey was carried out to collect suggestions and contributions from all stakeholders involved in the CoC project.

The survey has 4 sections: General view, about test, about the result and about places and tools and additional remarks. The survey has as well 8 questions with multiple choice options or open text. In the figure XX the questions and the answers are shown.

Figure 12. Testing methodology survey structure launched in July 2023.



Source: JRC, 2023.

Not many contributions have been received likely due to the holiday period in which the survey was launched.

Up to 11th August, in total 52 responses have been received.

However, many of the contributions were sent from the same entity, so the contributions that were not repeated have been selected and we are left with a total of 12 responses.

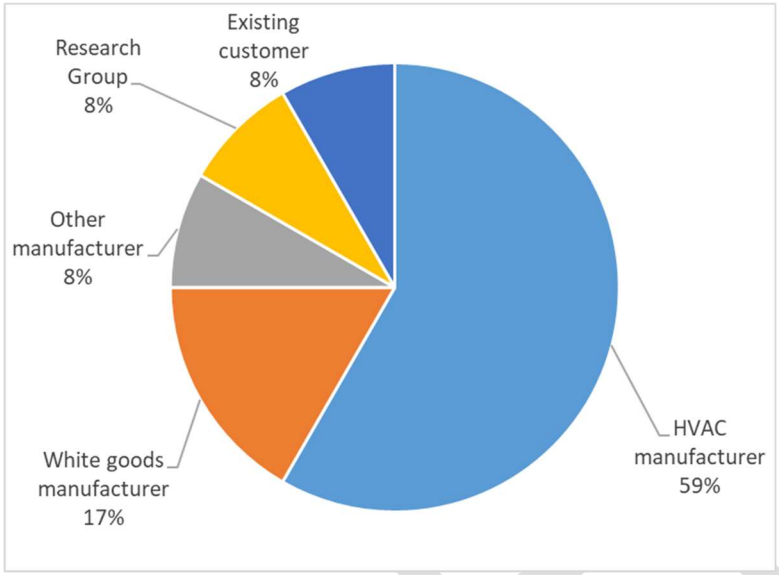
Table 1 shows the distribution of the type of entity among those responses.

Table 1. Survey participants and the categorization of their business expressed.

Type of entity	**Number**
HVAC manufacturer (or professional associations)	7
White goods manufacturer (or professional associations)	2
Other manufacturer (excluding White Goods and HVAC) (or prof. association)	1
Research Group	1
Existing customer - user i.e. Customer, consumer, user, flexibility owner.	1

Source: JRC, 2023.

Figure 13. Survey participants and the categorization of their business expressed in percentage (%).



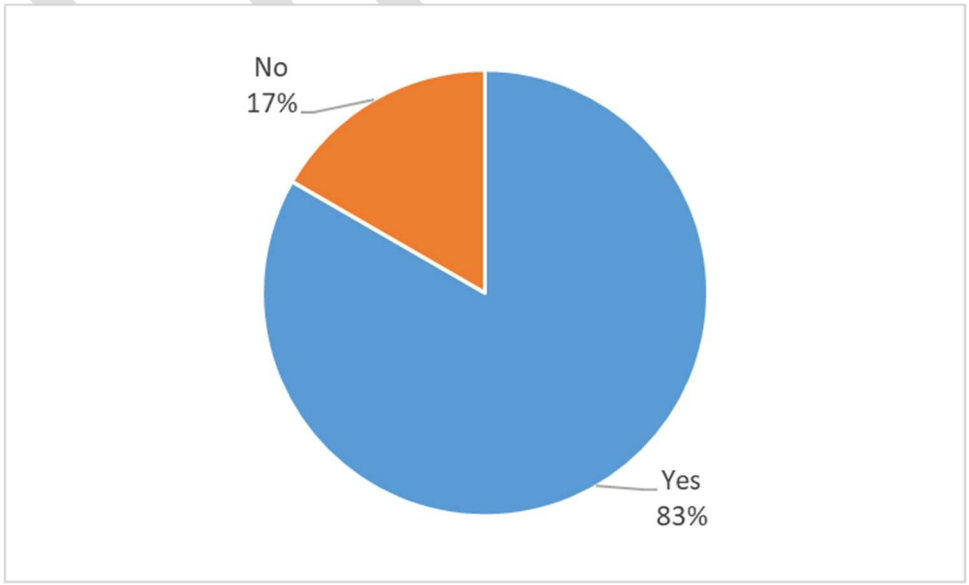
Source: JRC analysis, 2023.

5.1 General view. Question 1.

As we illustrated in figure XX the first question was "Regarding the approach proposed in the presentation available in our website to apply the JRC methodology for interoperability to Energy Smart Appliances included in the Code of Conduct. Do you think the four phases proposed are enough?"

The answers received related to that question are mostly positive, having 10 replies of "Yes" and 2 answering "No".

Figure 14. Answers Yes or No about question 1, enough information about the four phases proposed for the testing methodology.



Source: JRC analysis, 2023.

If the answer was “No” the contributor could provide a reason. We have received these two answers that are shown in the Table 2.

Table 2. Answers why not in question 1

Answer why not in question 1.
The PPT presentation on the verification mechanism given at the third stakeholder meeting on 23 June 2023 is not sufficiently substantiated to give a positive answer on whether "the four phases proposed are enough".
The four phases definition are not very clear and too theoretical. We suggest that JRC propose a final validation process after the test tool will be design."

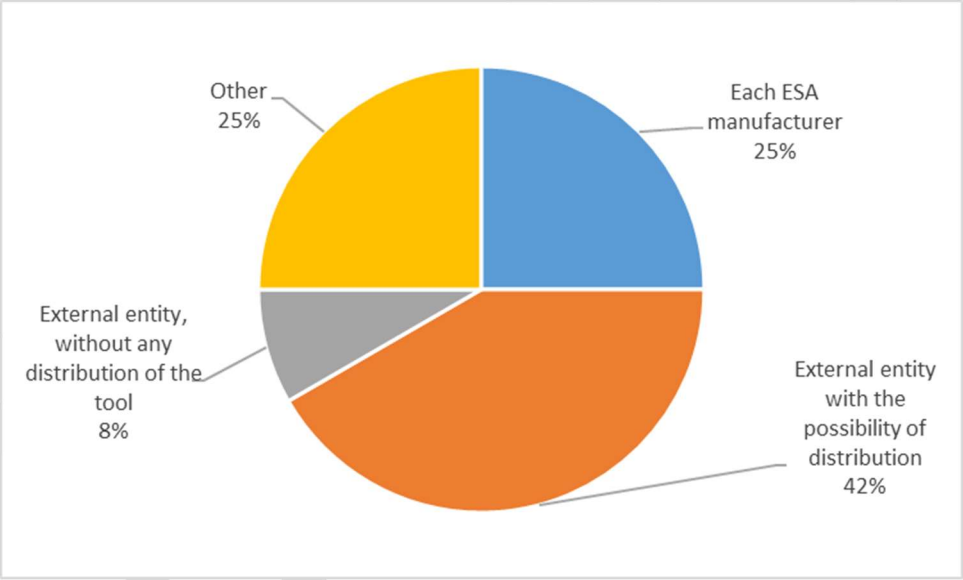
Source: JRC, 2023.

The conclusion is that the information about the 4 phases for the testing methodology is enough but due to some of the contributions further explanation might be provided.

5.2 About the tests. Questions 2 and 3.

The second question was about the best entity to develop the testing tool. The answers are illustrated in **Figure 15**.

Figure 15. Answers to question 2 about who should create the test tool.



Source: JRC analysis, 2023.

When the answer was “Other” the participant was asked for specifying, the details provided are shown in **Table 3**.

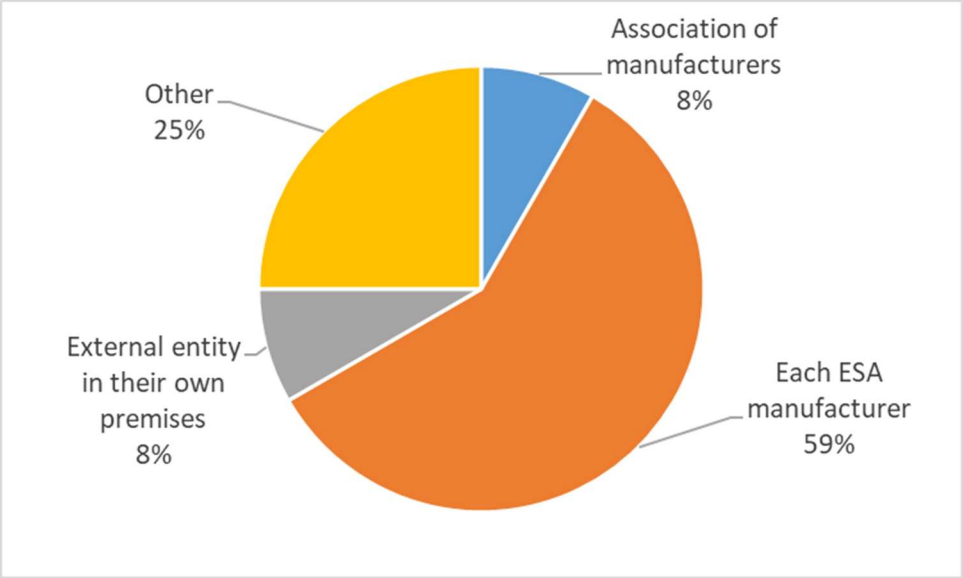
Table 3. Details provided after answering “Other” in question2.

Details provided after answering “Other” in question 2.
There should not be a single test tool, but multiple equivalent test tools capable of manipulating the semantic model. Completeness and compliance make the difference, not the tool's manufacturer
Association of manufacturers" - (See question Nr. 6)
Will need to be 'Each ESA manufacturer' & an agreed external entity

Source: JRC, 2023.

The question 3 tries to find the best entity to perform the tests and the results are illustrated in **Figure 16**

Figure 16. Which entity should perform the test?



Source: JRC analysis, 2023.

Table 4. Details provided after answering "Other" in question 3.

Details provided after answering "Other" in question 3.
"Each ESA manufacturer in a chosen certified lab, or external entity in their own permises"
"Maybe both: - ESA manufacturer can do self-testing (⇒ ""qualified"") - External entity can perform the test in their own test facilities (⇒ ""certified"")"
Will need to be 'Each ESA manufacturer' & an agreed external entity.

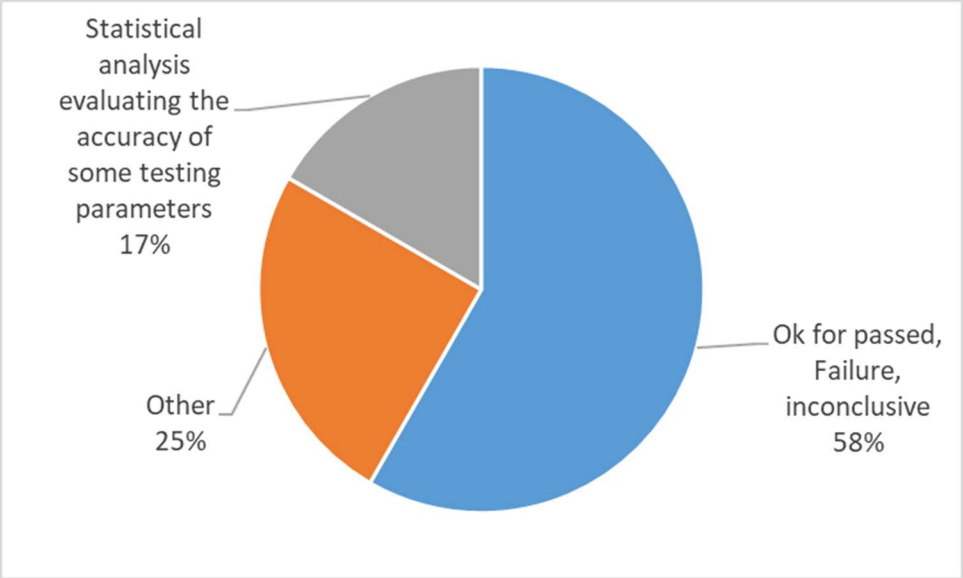
Source: JRC, 2023.

The conclusion of this subsection is that each ESA manufacturer should perform the test (question 3) and they might be supported by an external entity, mainly for the creation of the test tool (question 2).

5.3 About the results. Question 4 and 5.

The question 4 was: "The result of the test performed should reflect at least that the test was successful (passed) or not (failure). A third option is considered if the test could not be performed (inconclusive). Which type of results do you think it could be necessary?".

Figure 17. Answers to question 4 about the results



Source: JRC analysis, 2023.

The majority of the participants (58%) have considered ok for Passed/Failure/ Inconclusive. Likewise some interesting contributions were provided when the participant chose "Other" as it is illustrated in

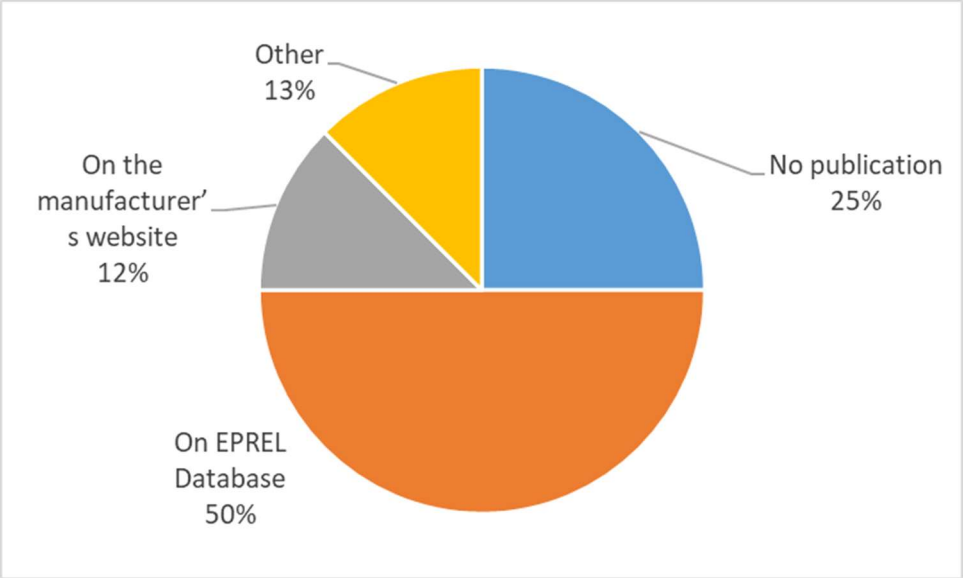
Table 5. Details provided after answering "Other" in question 4.

Details provided after answering "Other" in question 4, about the type of results.
Both
The ambiguity of consequences by statistical/inconclusive results creates confusion and a lack of consensus. The interoperability of the overall system requires specific tests. It's enough OK / KO.
Indication of the reasons why the test could not be performed.

Source: JRC, 2023.

The question 5 was about where the result should be found once the test has been developed, and the participants could chose several answers. Counting on all the responses received, the results are shown in the figure **Figure 18**, being the most frequently answered option "On Eprel Database" with a 50% in percentage.

Figure 18. Answers about question 5 about where the results should be published.



Source: JRC analysis, 2023.

Table 6. Details provided after answering "Other" in question 5, about the publication of the results

Details provided after answering "Other" in question 5, about the publication of the results
The relevant use-cases should be shown by the registered ESA
"Comments in Additional remarks: EPREL for development partners / business to business? Manufacturer's website for business to consumer?"

Source: JRC, 2023.

We can highlight as conclusion that the level of result of Passed/Failure/Inconclusive are considered enough by participants. Likewise they consider that the publication on Eprel Database is the best option to publish the results.

5.4 About the places and tools of testing and additional remarks. Questions 6, 7 and 8

Regarding the places and tools of testing, participants provided some entities and remarkable information to consider. We can highlight some of those ideas:

- The interconnect project reports and conclusions are addressed several times, indicating the type of device and asking if a cloud is set or not.
- The idea of performing the test in a manufacturer premises but remotely monitored by an association is as well explained as an option.
- In further steps, a certification system might be developed and thus, the main entities of certification. But for the time being, the participants consider that the test tool should be independent from the test lab, i.e. every test lab has access to the same tool and with the same level of information (which might not be the case if one of the test labs is also the test tool manufacturer).

One of the main additional remark is about the deadline of the project, because setting a network of laboratories to test the CoC would take time. For that reason, one of the manufacturer consider crucial to star with the self-declaration level.

Other participant is concerned about the Communication Layer, as the CoC doesn't address it.

Regarding the test tool the remarks are proposing that it must be free of charge and maintained by an external entity.

6 Conclusions

Flexibility and demand response are vital components of the modern energy landscape in the EU. They enable the grid to adapt to changing conditions, such as the integration of renewable energy sources, while empowering consumers to actively manage their electricity usage in response to real-time signals or grid demands. This synergy fosters a more resilient and sustainable energy future, driving the EU's commitment to a greener and smarter energy grid.

Aiming to attain such ambitious goal, it is important to progressively transform the traditional EU energy grid into a smart grid, so that all technological progress can be easily implemented. A fundamental key element is interoperability between the devices (or ESA) integrating this ecosystem, regardless of their purpose and/or the brand that developed or commercialized them. They all need to work in synchronicity and harmonically to satisfy the needs of the consumer while considering the local and temporal constrains of the grid.

The CoC is a remarkable achievement for this project and therefore, it is needed to develop a methodology to test it.

The foundations of the JRC methodology and the interconnect project are a good base to have developed the four phases proposed in this methodology.

In the same way as in the rest of this project, the collaboration of the stakeholders has been requested to provide their suggestions and contributions to the methodology. However, the results of the survey launched might not be final because many stakeholders did not have time to provide their feedback due to the summer leave period.

Some of the conclusions for the time being would be that the four phases proposed are considered enough but further information might be provided. In addition, participants consider that the creation of the test tool should be developed by an external entity but each ESA manufacturer should perform the test. REgardin ghte testing results the level of Passed/Failure/Inconclusive is considered enough by participants. Likewise they consider that the publication on Eprel Database is the best option to publish the results.

In summary, this report provides a guide of the procedure that a manufacturer (or an entity), who wants to place an ESA in the EU market, will need to follow to declare this device as interoperable in the EPREL database. The description of the phases to execute the test and the template of the results are expected to help manufacturers to comply with the CoC and improve the interoperability of their devices.

References

CENELEC, CEN. 2017. CENELEC prEN 50631-1 (TC59 WG7) Household appliances network and grid connectivity. s.l. : CEN CENELEC, 2017.

Ectors, D., Gerard, H., Rivero, E., Vanthournout, K., Verbeeck, J., Virag, A., Huang, B., Viegand, J., Stamminger, R., Geppert, J., Perret-Gentil, M., Rivière, P., Götz, T. 2018. Ecodesign Preparatory study on Smart Appliances (Lot 33), Tasks 7, Framework contract ENER.C3.2012-418-lot 1 2014/TEM/R/. Boeretang 200 – 2400 MOL – BELGIE : VITO NV, 2018.

ETSI, CEN-CENELEC. 2016. Smart Grid Set of Standards version 4.0 final. s.l. : CEN CENELEC, 2016.

—. 2017. Smart Grid Set of Standards version 4.1. s.l. : CEN CENELEC, 2017.

IMARCgroup. 2022. Home Energy Management System Market Size and Share 2022-2027. IMARCgroup. [Online] 2022. https://www.imarcgroup.com/home-energy-management-systems-market?msclkid=5440b237b02f11ecae445030f049ab37.

INESCTEC,VLF,TNO,TRIALOG - Interconnect. 2020. D5.2 Data Flow Management. s.l. : VLF, 2020. WP5 – Digital Platforms and Marketplace.

InterConnect. InterConnect. InterConnect. [Online] https://interconnectproject.eu/about/.

Papaioannou I., Tarantola S., Lucas A., Kotsakis E., Marinopoulos A., Ginocchi M., Masera M. 2018. Smart grid interoperability testing methodology. s.l. : Publications Office of the European Union, 2018.

Statista. 2022. Smart Home - Energy Management. Statista. [Online] 2022. https://www.statista.com/outlook/dmo/smart-home/energy-management/europe#smart-homes.

The British Standards Institution - PAS1878:2021. 2021. PAS 1878:2021. Energy smart appliances – System functionality and architecture – Specification. s.l. : Published by BSI Standards Limited 2021., 2021. ISBN 978 0 539 05131 5. ICS 03.100.70; 27.015; 91.140.50.

Union, Official Journal of the European. 2018. Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings. [Online] 2018. https://eur-lex.europa.eu/eli/reg/2017/1369/oj.

—. 2009. Directive 2009/125/EC of the European Parliament and of the Council if 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy related products. [Online] 2009. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0125.

—. 2018. Official Journal of the European Union. Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action. [Online] 2018. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.328.01.0001.01.ENG.

—. 2018. Official Journal of the European Union. Directive 2012/27/EU on energy efficiency. [Online] 2018. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.328.01.0210.01.ENG.

—. 2017. Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU. [Online] 2017. https://eur-lex.europa.eu/eli/reg/2017/1369/oj.

Valdez, A., Thakkar, M., Nubbe, V., Reich, J., Goetzler, W. 2020. Energy Applications within IoT and Digitalisation Strategies. s.l. : Guidehouse Inc., 2020. Prepared for: The Electronic Devices & Networks Annex of the IEA 4E Technology Collaboration Programme.

WP1 Pilot Partners - InterConnect. 2021. D1.2 Mapping between use cases and large-scale pilots. s.l. : EEBUS INITIATIVE E.V., 2021. WP1 – Use Cases, Business Models and Services.

CEN-CENELEC-ETSI Smart Grid Coordination. SG-CG/M490/I_Smart Grid Interoperability Methodologies to facilitate Smart Grid system interoperability through standardization, system design and testing. 2014

ftp://ftp.cencenelec.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/SGCG_Interoperability_Report.pdf

CEN-CENELEC-ETSI Smart Grid Coordination Group – Sustainable Processes. 2012

ftp://ftp.cen.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/Sustainable%20Processes.pdf

CEN-CENELEC-ETSI Smart Grid Coordination Group, SG-CG/M490/L_ Flexibility Management, Overview of the main concepts of flexibility management, 2014

ftp://ftp.cencenelec.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/SGCG_Methodology_FlexibilityManagement.pdf

CEN-CENELEC-ETSI Smart Grid Coordination Group, SG-CG/M490/F_Overview of the SG-CG Methodologies

ftp://ftp.cencenelec.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/SGCG_Methodology_Overview.pdf

List of abbreviations and definitions

AA	Administrative Arrangement
API	Application Programming Interface
APP	Application
BACS	Building Acquisition Control System
CFL	Compact fluorescent light
CoC	Code of Conduct
CRA	Cyber Resilience Act
DSF	Demand Side Flexibility
EC	European Commission
EEA	European Economic Area
EMS	Energy Management System
ESA	Energy Smart Appliance
ESAs	Energy Smart Appliances
ESP	Energy Service Provider
EV	Electric Vehicle
FSP	Flexibility Service Provider
GDPR	General Data Protection Regulation
GLS	General lighting service
HID	High intensity discharge lamp
HVAC	Heating, Ventilation and Air-Conditioning
IOP	Interoperability
IoT	Internet of Things
JRC	Joint Research Centre
LED	Light emitting diode
LFL	Linear fluorescent lamp
NGO	Non-Governmental Organisation
PV	Photovoltaic
RES	Renewable Energy Sources
SAREF	Smart Applications Reference
SARE4ENER	extension of SAREF for the energy domain
SGAM	Smart Grid Architecture Model
TR	Technical Report
UC	Use Case
UCs	Use Cases
VPP	Virtual Power Plant

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Annex. Testing format report

The result of the test is expected to provide a clear information about the result of the test and enable manufacturers to upload in the Eprel Database

Table 7. Test report summary

TEST REPORT SUMMARY: «NUMBER/YEAR»	
GENERAL DATA	
Manufacturer	
Contact details	
Device type	
Model	
Comments	

Source: JRC elaboration

Table 8. Summary of the testing

DATA OF TESTING	
Date of test	
Place of testing	
Entity of testing	
Comments	

Source: JRC elaboration

Table 9. Test report summary

CORE ELEMENTS OF THE USE CASE	
Use Case	
General Result	Passed/Failure/ inconclusive
Result of «Core element 1»	
Result of Core element 2	
Result of Core element n	
Additional comments	

Source: JRC elaboration

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