ANTICSS Project, Task 2.4:
Analysis of the relation between 'smart' products and circumvention

30 June 2019

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1 About the ANTICSS project

Objective of the research project 'Anti-Circumvention of Standards for better market Surveillance (ANTICSS)' is to assess and clearly define 'circumvention' in relation to EU Ecodesign and Energy labelling legislation and relevant harmonised standards.

The analysis of circumvention will be based on collecting and learning from cases of circumvention by literature research and dedicated expert interviews, as well as analysing existing EU Ecodesign and Energy labelling legislation and standardisation for possible loopholes. Also the potential relation between circumvention and so called 'smart' products with specific embedded software will be addressed by the project. Alternative test procedures to better detect circumvention by testing shall be developed and through testing a certain number of appliances within the ANTICSS project, the impacts 'if' and 'how much' energy consumption and/or functional performance modifications could be ascribed to circumvention will be assessed.

Based on the results, ANTICSS will provide practical capacity building measures for key actors of market surveillance and test laboratories, support communication and collaboration platforms between major stakeholders and provide policy recommendations for policy makers and standardisation bodies to prevent future circumvention under EU Ecodesign and Energy labelling. ANTICSS project is also designed to provide reliability to manufacturers by specifying potentially vague legislation and standards which might be interpreted differently by market actors and some of them taking unfair advantages so far. By overall awareness raising on circumvention among stakeholders, ANTICSS is supporting an effective EU legislation enforcement and thus increasing acceptance and trust of market actors and civil society into the Ecodesign and Energy labelling legislation.

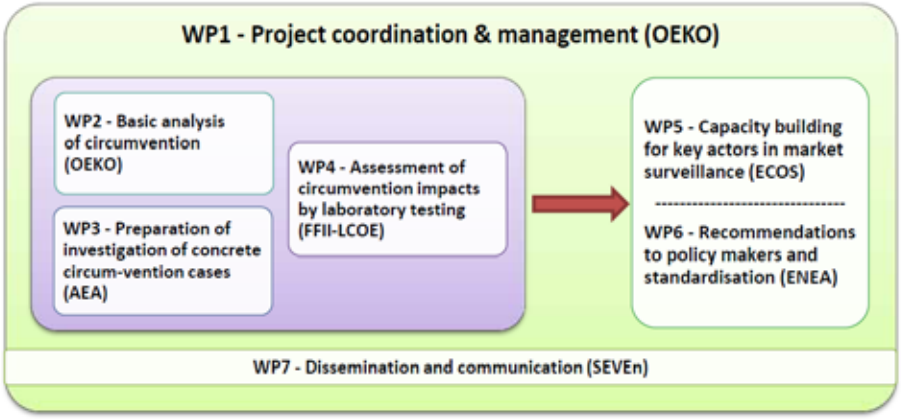

Figure 1-1: ANTICSS Work Packages

2 Background and objective of this working paper

Increasingly, appliances contain sensors that provide information about the operation and processes being performed by the appliance, which are managed by an on-board processor or even a computer. The purpose is to achieve an adjustment or modification of the operation of the appliance, in response to internal or external operating conditions, e.g. load size in washing machines, soil level in dishwashers, or adjustment of the inside temperatures in refrigerators according to door openings or external ambient conditions. These controls generally provide more sophistication in the appliances' response to different situations and adapting the functionalities and/or energy consumption to real life conditions. Further, with rising availability of electricity generated by renewable energy sources, also the importance of demand side flexibility of all equipment increases. Thus, self-sustaining communication between appliances and the electricity grid or electricity supplier is also expected to be of notable relevance in future.

So called 'smart' appliances are in most cases promoted as providing overall benefits to consumers like optimizing functional performance, increasing the energy efficiency or offering demand side flexibility. On the other hand, smart functionalities and 'intelligent' software adapting functionalities to certain conditions might also create challenges for legislation, standards, as well as market surveillance and test organisations: Sophisticated management systems (smart controls) can result in changes in performance or operation as the appliance adapts to specific conditions and/or learns how to respond not only to real life usage but also to the test conditions during test procedures. The first issue to consider is that there may be some variability in the measured parameters due to the on-going adaptation of the appliance itself, since it may take some time for the appliance to reach a stable or consistent response to a specific condition. Secondly, sophisticated on-board controls might also be used to alter the appliances' operating characteristics specifically during a test procedure, with the aim of reaching a more favourable level for any of the parameters to be declared by the manufacturer according to EU legislation, unrepresentative of the appliance's true characteristics during intended use, under comparable conditions.

Aim of this ANTICSS working paper is to provide a more detailed analysis of the potential of so called 'smart' products using 'intelligent' software for circumvention of EU Ecodesign and Energy labelling legislation and the according harmonised standards. Initially, the working paper will introduce how the latest updates of EU Ecodesign and Energy label regulations address the issue of software related and connected (defeat) devices and possible circumvention. Further, the definition of circumvention and jeopardy effects as elaborated within the ANTICSS project is presented. In a second step, an understanding of 'smart' products and their different communication and technical operating principles will be developed and analysed with regard to their potential ability to detect a test situation and alter the operation and performance of the product under test. This analysis shall provide indications for market surveillance and test organisations how to detect possible circumvention and - if necessary - provide further recommendations for policy and standardisation how to approach the phenomenon of circumvention based on smart appliances.

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3 Latest[1] development of EU legislation: defeat devices and circumvention

3.1 Regulation on type approval of motor vehicles: 'Defeat devices'

Starting from the so called 'diesel scandal', a term often used in the context of circumvention triggered through smart functionalities is '**DEFEAT DEVICE**'. Regulation (EC) No 715/2007 on 'type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information' provides the following definition of defeat devices (European Parliament 2007):

'Defeat device' means any element of design which senses temperature, vehicle speed, engine speed (RPM), transmission gear, manifold vacuum or any other parameter for the purpose of activating, modulating, delaying or deactivating the operation of any part of the emission control system, that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use.

The use of defeat devices that reduce the effectiveness of emission control systems shall be prohibited. The prohibition shall not apply where:

a) the need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle;

b) the device does not function beyond the requirements of engine starting; or

c) the conditions are substantially included in the test procedures for verifying evaporative emissions and average tailpipe emissions.

Further, in order to clarify the exceptions provided for by Regulation (EC) No 715/2007, the Commission published in 2017 – not legally binding – guidelines for specifying the conditions for the application of these defeat devices or auxiliary emission control strategies.[2] The Commission Notice shall assist authorities and operators by presenting good practices for an effective implementation of the applicable law.

[1] Status: End of February 2019

[2] Commission Notice of 26.1.2017: Guidance on the evaluation auf Auxiliary Emission Strategies and the presence of Defeat Devices with regard to the application of Regulation (EC) No 715/2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6), http://ec.europa.eu/docsroom/documents/26183

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Although the Regulation relates to type approval of motor vehicles, two aspects of this Guidance document might be transferable also to the regulations on Energy related products: Part A inter alia deals with *information that the manufacturer needs to provide to the Type Approval Authority and how this information will be used in order to assess whether the Auxiliary Emission Strategy (AES) is acceptable or not, taking into account the prohibition of defeat devices*, and Part B deals with *ways to identify possible cases of defeat devices* through targeted emission tests as part of Member States' market surveillance obligations.

Information requirements:

According to the Commission Notice, the manufacturer shall provide an **EXTENDED DOCUMENTATION PACKAGE** to the approval authority with information on the operation of all emission strategies including a description of the parameters that are modified by any Auxiliary Emission Strategy and the boundary conditions under which the AES operate, and indication of the Emission Strategies which are likely to be active under the conditions of the test procedures set out in the Regulation. In the third Commission Regulation concerning real-driving emissions from light-duty vehicles (RDE 3) as voted in TCMV on the 20th December 2016, the AES/BES requirements were regulated in further detail in Appendix 3a, see extract below:

> *The extended documentation package shall include the following information on all AES:*
>
> *(a) a declaration of the manufacturer that the vehicle does not contain any defeat device not covered by one of the exceptions in Article 5 (2) of Regulation (EC) 715/2007;*
>
> *(b) a description of the engine and the emission control strategies and devices employed, whether software or hardware, and any condition(s) under which the strategies and devices will not operate as they do during testing for TA;*
>
> *(c) a declaration of the software versions used to control these AES/BES, including the appropriate checksums of these software versions and instructions to the authority on how to read the checksums; the declaration shall be updated and sent to the Type Approval Authority that holds this extended documentation package each time there is a new software version that has an impact to the AES/BES; […]*

When issuing a type-approval, Type Approval Authorities are required to assess, on the basis of the technical information contained in the extended documentation package, whether the emission control strategy constitutes a defeat device, and, if so, whether this is justified pursuant to the Regulation, or whether the approval must be refused due to the existence of a prohibited defeat device.

Alternative testing protocol for defeat device recognition

In order to detect the presence of defeat devices, the Commission Notice further proposes that vehicles should be tested under variations of the standard testing conditions ('modified testing

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conditions') which is not fixed but kept open due to the need to detect specific technology behaviours in response to a complex set of parameters and the need to keep a non-predictable character. To facilitate the evaluation of the modified tests conditions, it is recommended to develop testing thresholds corresponding to acceptable emissions increases per combinations of pollutants, technologies and conditions. Any emission test that falls above those testing thresholds should be classified as a 'suspicious' case.

3.2 Regulation on compliance and enforcement

Recital (30) of the introduction of the forthcoming 'Regulation (EU) 2019/... of the European Parliament and of the Council on market surveillance and compliance of products and amending Directive 2004/42/EC and Regulations (EC) No 765/2008 and (EU) No 305/2011'[3] points out:

> *Special attention should be given to emerging technologies, taking into account that consumers are increasingly using* ***CONNECTED DEVICES*** *in their daily lives. The Union regulatory framework should therefore address the new risks to ensure the safety of the end users.*

Although only the safety aspect for end users is explicitly addressed, also the external communication possibilities and software updates of connected devices might be relevant for market surveillance.

3.3 Energy labelling regulation

According to the European Commission website on the energy labelling[4], the new framework *'bans the use of* **'DEFEAT DEVICES'***, which alter a product's performance under test conditions.'*

Regulation (EU) 2017/1369 does not use the term 'defeat devices' but describes the act to be prohibited in recital (35) on test methods and harmonised standards and further sets provision for suppliers in points 4 and 5 of Article 3 'General obligations of suppliers'.

Recital (35):

> *Energy consumption, performance and other information concerning the products covered by product-specific requirements under this Regulation should be measured by using reliable, accurate and reproducible methods that take into account the generally recognised state-of-the-art measurements and calculation methods. In the interests of the proper functioning of the internal market, standards should be harmonised at Union level.*

[3] Cf. http://www.europarl.europa.eu/doceo/document/TA-8-2019-0397_EN.html#title2

[4] https://ec.europa.eu/energy/en/news/commission-publishes-new-energy-efficient-labelling-regulations-empower-consumers

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> ***Such methods and standards should, to the extent possible, take into account the real-life usage of a given product, reflect average consumer behaviour and be robust in order to deter intentional and unintentional circumvention.*** *Energy labels should reflect the comparative performance of the actual use of products, within the constraints due to the need of reliable and reproducible laboratory testing.* ***Suppliers should therefore not be allowed to include SOFTWARE OR HARDWARE THAT AUTOMATICALLY ALTERS THE PERFORMANCE OF THE PRODUCT IN TEST CONDITIONS.*** *In the absence of published standards at the time of application of product-specific requirements, the Commission should publish, in the Official Journal of the European Union, transitional measurement and calculation methods in relation to those product-specific requirements. Once a reference to such a standard has been published, compliance with it should provide a presumption of conformity with measurement methods for those product-specific requirements adopted on the basis of this Regulation.*

Article 3 General obligations of suppliers.

> *4. Once a unit of a model is in service, the supplier shall request explicit consent from the customer regarding any changes intended to be introduced to the unit by means of UPDATES that would be detrimental to the parameters of the energy efficiency label for that unit, as set out in the relevant delegated act. The supplier shall inform the customer of the objective of the update and of the changes in the parameters, including any change in the label class.*
> *For a period proportionate to the average lifespan of the product, the supplier shall give the customer the option of refusing the update without avoidable loss of functionality.*
>
> *5. The supplier shall not place on the market products that have been designed so that a model's performance is automatically altered in test conditions with the objective of reaching a more favourable level for any of the parameters specified in the relevant delegated act or included in any of the documentation provided with the product.*

The only definition of 'defeat device' in the context of the EU Ecodesign or Energy labelling regulation and standards is found in the test standard IEC 62552 for household refrigerators which defines a 'defeat device' as *'any control device, software, component or part that alters the appliance operating characteristics during any test procedure, resulting in measurements that are unrepresentative of the appliance's true characteristics that may occur during intended use under comparable conditions.'*

The term circumvention can be considered analogously to the term 'defeat device'.
In development of the ecodesign and energy labelling regulations, the term 'defeat device' came first – inspired by the discussion on the vehicle emissions – but was later replaced by the more general definition of circumvention; realizing that in appliances it is most likely not possible to point to a certain 'device' that is responsible for the circumvention.

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3.4 Ecodesign regulations

In parallel with the energy labelling framework regulation, some of the new or revised product specific Ecodesign regulations, explicitly address 'circumvention' as well as 'software updates' (Article 6, cf. Figure 3-1). Recently, the initial article was further improved with the addition of the two last sentences (1 and 2 in italics in Figure 3-1).

Article 6

CIRCUMVENTION AND SOFTWARE UPDATES

The manufacturer, importer or authorised representative shall not place on the market products designed to be able to detect they are being tested (e.g. by recognising the test conditions or test cycle), and to react specifically by automatically altering their performance during the test with the aim of reaching a more favourable level for any of the parameters declared by the manufacturer, importer or authorised representative in the technical documentation or included in any of the documentation provided.

The energy consumption of the product and any of the other declared parameters shall not deteriorate after a **SOFTWARE OR FIRMWARE UPDATE** when measured with the same test standard originally used for the declaration of conformity, except with explicit consent of the end-user prior to update.

1) No performance change shall occur as a result of rejecting the update.

2) *A software update shall never have the effect of changing the product's performance in a way that makes it non-compliant with the ecodesign requirements applicable for the declaration of conformity.*

Figure 3-1: (Draft) Article 6 applied in certain revised Ecodesign Regulations

By end of February 2019, the complete text was present in the Regulations voted end January 2019 on motors, welding equipment, and commercial refrigeration. For the revised regulations on household washing machines and washer dryers as well as dishwashers, the above text is present, however without the addition of point 2). The Article is not present in the regulations of transformers and external power supplies because there is no possibility of software update.

This Article shall be also read in conjunction with Annex IV[5] on the 'Verification procedure for market surveillance purposes' of new draft Regulations:

[5] See the text of Annex IV of the draft ecodesign Regulation on commercial refrigerating appliances, http://ec.europa.eu/transparency/regcomitology/index.cfm?do=Search.getPDF&ds_id=59531&version=2&AttLang=en&db_number=2&docType=DRAFT_MEASURE

Where a model has been designed to be able to detect it is being tested (e.g. by recognizing the test conditions or test cycle), and to react specifically by automatically altering its performance during the test with the objective of reaching a more favourable level for any of the parameters specified in this Regulation or included in the technical documentation or included in any of the documentation provided, the model and all equivalent models shall be considered not compliant.

2. The model shall be considered to comply with the applicable requirements if […]

(c) when the Member State authorities check the unit of the model, they check whether the manufacturer, importer or authorised representative has put in place a system that complies with the requirements in the second paragraph of Article 6; and

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4 ANTICSS definition of 'circumvention'

So far, current legislation uses different terms and explanations to describe the acts that shall be prohibited:

- '*Defeat device*', i.e. any element of design which *senses* […] or any other parameter for the purpose of *activating, modulating, delaying or deactivating the operation of any part of the […] system, that reduces the effectiveness of the […] system under conditions which may reasonably be expected to be encountered in normal […] operation and use*.
- […] emerging technologies, taking into account that consumers are increasingly using *connected devices* in their daily lives.
- '*Defeat devices*' which *alter a product's performance under test conditions*.
- Suppliers should therefore not be allowed to include *software or hardware that automatically alters the performance of the product in test conditions*.
- […] *updates* that would be detrimental to the parameters of the energy efficiency label for that unit, as set out in the relevant delegated act.
- […] *products that have been designed so that a model's performance is automatically altered in test conditions* with the objective of reaching a more favourable level for any of the parameters specified in the relevant delegated act or included in any of the documentation provided with the product.
- '*Defeat device*': any *control device, software, component or part that alters the appliance operating characteristics during any test procedure*, resulting in measurements that are unrepresentative of the appliance's true characteristics that may occur during intended use under comparable conditions.
- '*Circumvention*': […] *products designed to be able to detect they are being tested* (e.g. by recognising the test conditions or test cycle), *and to react specifically by automatically altering their performance during the test* with the aim of reaching a more favourable level for any of the parameters declared by the manufacturer, importer or authorised representative in the technical documentation or included in any of the documentation provided.
- The energy consumption of the product and any of the other declared parameters shall not deteriorate after a *software or firmware update* when measured with the same test standard originally used for the declaration of conformity, except with explicit consent of the end-user prior to update.

One of the main tasks of the ANTICSS project was to further elaborate a clear and comprehensive definition to delimitate the act of 'circumvention' under EU Ecodesign and Energy label regulations from other effects that can be considered to be suspicious in terms of reaching a more favourable level for any of the parameters measured in a test and declared by the manufacturer.

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The ANTICSS definition initially starts from the new Article 6 on circumvention included in the ecodesign Regulations for some appliances under preparation by the European Commission within the so called 'Ecodesign package' adopted in July 2019 by the European Commission (cf. 3.4). However, based on a couple of circumvention cases collected by literature research, stakeholder interviews as well as dedicated input of Market Surveillance Authorities, the ANTICSS project team considered Article 6 too restrictive, since it is focusing only on automatic performance alterations (i.e. achieved through the presence of software). Therefore a broader definition of circumvention was prepared, including also manual and/or pre-set alterations of the product or performance.

'Circumvention' *is the act of designing a product or prescribing test instructions, leading to an alteration of the behaviour or the properties of the product, specifically in the test situation, in order to reach more favourable results for any of the parameters specified in the relevant delegated or implemented act, or included in any of the documentations provided for the product. The act of circumvention is relevant only under test conditions and can be executed e.g.*

a) by automatic detection of the test situation and alteration of the product performance and/or resource consumption during test, or

b) by pre-set or manual alteration of the product, affecting performance and/or resource consumption during test or

c) by pre-set alteration of the performance within a short period after putting the product into service.

Figure 4-1: ANTICSS definitions of 'circumvention'

Additionally, within ANTICSS several acts have been detected which might not be found non-compliant, but still do not follow the goal of the EU ecodesign and/or labelling legislation of setting ecodesign requirements and providing reliable information about the resource consumption and/or performance of a product by exploiting loopholes or other weaknesses in standards or regulations. Against this background the category of 'jeopardy effects' has been introduced; for cases falling in this classification, further analysis is needed to assess if the act of circumvention is present or other measures should be taken to close the regulatory loopholes.

'Jeopardy effects' *encompass all aspects of products or test instructions, or interpretation of test results which do not follow the goal of the EU ecodesign and/or energy labelling legislation of setting ecodesign requirements and providing reliable information about the resource consumption and/or performance of a product.*

These effects may not be classified as circumvention, but become possible due to loopholes or other weaknesses in standards or regulations.

Figure 4-2: ANTICSS definitions of 'jeopardy effects'

Both ANTICSS definitions build the basis for further analyses, conclusions and recommendations with regard to the relation of smart products and circumvention in this working paper.

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5 Delimitation of the term 'smart' products

More and more products on the market are promoted as 'smart' (e.g. smart controls, smart TVs, smart washing machines, smart fridges, smart grids, smart homes, etc.). Being equipped with internet connection, which is not only a mean to update the device, they provide the possibility for remote control and offer additional functions to consumers. So called 'smart appliances' have links to computing clouds and app controls and can be upgraded with extra programmes, recipes etc. Sophisticated on-board controls facilitate increasing variety of functions, enable the product to respond to internal or external operating conditions and provide smoother and possibly more efficient processes. However, they might also be misused to alter the appliances' operating characteristics specifically during a test procedure, with the aim of reaching a more favourable level for any of the parameters to be declared by the manufacturer according to EU legislation.

Aim of this and the following section is to develop a better understanding of 'smart appliances', their specific characteristics and those operation principles that might constitute the basis for circumvention.

5.1 Basic definition of 'smart' in relation to devices

The Oxford dictionary provides the following definition of smart (of a device)[6]:

> *Programmed so as to be capable of some independent action.*

The core of being smart in this definition is the word 'independent'. The appliance itself – without interference of the user – is capable of taking action (because it is being programmed). More specifically, the appliance is able to get inputs, process these inputs and take action (based on the – results of the – processing). This technically requires at least:

- inputs and therefore something to provide these inputs, e.g. **sensors**;
- hardware and **software** to process the inputs; and
- putting the results of the processing into action, e.g. through **actuators**.

For a product (or appliance) to be called smart the above must take place *within* the product.

However, according to the understanding of the ANTICSS consortium, this definition neither sufficiently reflects the broad range of applications and communication principles of products being promoted as smart, nor offers a robust explanation for the possibilities in terms of circumvention in test situations.

[6] Source: https://en.oxforddictionaries.com/definition/smart

In principle, this approach (i.e. sensor, processing software and actuator) and the reaction to (only) one input parameter seems to apply to almost every product with regular control logic within the appliance (e.g. washing machines: sensor measuring the water temperature; software analysing if temperature level is sufficient and activating the heating element if necessary). Thus, in the following, a deeper understanding of the applications and functionalities of smart products will be elaborated.

5.2 Definition according to the European standard for smart appliances

Against the background that home appliances are not only electrical/mechanical machines anymore which accomplish some household functions (stand-alone systems), but nowadays often are highly intelligent ('smart') and networked devices, that form complete energy consuming, producing, and managing systems, the European Commission had performed a study to bring together semantics and data from smart appliances in buildings and households. In that study, ontologies were used to improve the communication among stakeholders, providing a shared understanding that shall reduce ambiguities and confusion in the terminology adopted in the smart appliances domain. Within the project, a so called 'Smart Appliances reference ontology' (SAREF) was developed that can be used to match the data from different organizations (European Commission 2015). In that study, a definition of smart appliances by the Energy@Home Data Model is cited. Version 2.1 of October 2015 includes the following definition of smart appliances (Energy@home Association 2015):

> *A **smart appliance** is an appliance connected in the Home Area Network (HAN) and equipped with some intelligence to cooperate with the other home actors in order to provide new services to the consumer, like for instance energy consumption awareness, demand response, etc.*
> *The Smart Appliance plays an active role in the home system complying with the system policies, satisfying the user wishes and always assuring its best performance. Most of these technologies imply some information transfer from the Smart Grids to the Smart Appliance (thus a communication channel within the HAN and outside the Home Domain) and an additional control and supervision logic (inside and/or outside the appliance).*

Based on the study, the created language (so-called 'reference ontology') for smart appliances became a European standard called SAREF (Smart Appliances REFerence ontology) in 2015. This Technical Specification (TS) has been produced by ETSI Technical Committee Smart Machine-to-Machine communications (SmartM2M). (Technical Specification ETSI TS 103 264 V2.1.1) defines smart appliances as follows:

> ***Smart appliances**: devices, which are used in the household, e.g. for performing domestic work, and which have the ability to communicate with each other and which can be controlled via Internet.*

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5.3 Definition according to DG JRC study on 'Smart home and appliances'

A recent study 'Smart home and appliances' published by DG JRC (Serrenho and Bertoldi 2019) with the aim of providing an overview of the whole smart home ecosystems, inter alia gives an outline of the Smart Appliances and Smart Home Technologies. According to the understanding of that study,

> *Usually, the term smart is used when a service or a product is somehow connected or connectable to other services or products through a network of some kind enabled by ICT services or goods. For the purpose of this report, smart or connected devices are devices with embedded ICT and that can be connected to other devices or systems via a cable or wirelessly.*

Further, the study also refers to the EU Ecodesign Preparatory Study on Smart Appliances (cf. section 5.4), characterizing smart appliances as shown in Figure 5-1:

Smart Appliances	
Main Functionality	Home appliances with the capability to communicate both with the user and other platforms and services
Specific Functionalities	Communication between the smart meter, providing information to the energy utility Ability to change the appliance's consumption pattern Possibility to adapt its consumption to energy produced on-site Ability to support variable pricing based on day-ahead energy market
Interface	Device display, peripheral displays, web applications, energy portals
Communication	Wire and wireless communication
Interaction	bi-directional between the user and energy utilities
Noticeable market players	Major home appliances companies

Figure 5-1: Characteristics of smart appliances (Serrenho and Bertoldi 2019)

5.4 Definitions according to the EU Ecodesign Preparatory Study on Smart Appliances

The Ecodesign Preparatory Study on Smart Appliances[7] defines 'smart' appliances in the broadest sense as appliances that are able to communicate which can be performed on four different **communication levels** (Vanthournout et al. 2017):

- ***'Internal' communication***:
  - Ø **Within the appliance**, e.g. a refrigerator reduces the temperature just before door opening as consequence of a learning process
- ***'External' communication*:**
  - Ø **Between appliances**, e.g. energy management to avoid peaks in power demand
  - Ø **Between appliance and energy provider**, e.g. appliances respond to changes in energy availability,
  - Ø **Between appliance and manufacturer / consumer**, e.g. updates of software, or communicate error codes to the manufacturer to facilitate repair

Further, the preparatory study identified three different 'functionality classes' which are related to the services or **utility** of the features:

- ***Energy saving features***, e.g. heat water shortly before typical hot water demand
- ***Demand side flexibility***, e.g. remotely activated power modulation of water heater
- ***Other smart home features***, e.g. webcam in fridge, security, health monitoring

The study also stated that all functions concerning the utility of technical safety of the appliance, e.g. automatic activation of overvoltage protection, are not considered to be smart functions and that the manufacturer does not need to activate the smart function of a product prior to delivery, it might be activated later by the consumer or by a service provider.

For the purposes of the ANTICSS project, the definitions and conclusions of the Ecodesign Preparatory Study on Smart Appliances are still too narrow as the further focus of the Ecodesign preparatory study on smart appliances is set to *demand side flexibility* only.
Therefore, also the definition of 'smart' in the Ecodesign preparatory study seems to focus mainly on the external communication principle between appliance and energy provider since this is an essential function for a product to adapt its power or energy consumption (the demand) to other conditions in the electricity system, e.g. the availability of renewable energy. However, a product that provides demand side flexibility might not be 'smart' at all – in the sense of being intelligent. In some cases it might be enough to simply follow the external command from the energy provider; for example an electric storage water heater switches on when receiving an external command like it would do with any user command.

[7] http://www.eco-smartappliances.eu/

The external input might also be seen as an input that is being processed, just like an internal input would be, although in case of an external command a communication function – or at least a receiving function – is necessary.

Finally, also other functionalities of smart appliances like remote control (e.g. links to computing clouds and app controls), upgrades (e.g. with extra programmes, recipes, etc.) or software updates are not taken into account in the Ecodesign preparatory study any more.

5.5 Beyond smart: Artificial Intelligence (AI-enabled appliances)

Another term in the context of smart appliances is 'artificial intelligence' (AI enabled appliances). Under this concept apparently different services are discussed such as voice control, intelligent assistant control systems, communication between several appliances or devices that learn the users' behaviour so that they can adjust the settings themselves.
(Press 2017) inter alia lists the following artificial intelligence technologies:

- *Speech Recognition: Transcribe and transform human speech into format useful for computer applications. Currently used in interactive voice response systems and mobile applications.*
- *Virtual Agents: from simple chatbots to advanced systems that can network with humans. Currently used in customer service and support and as a smart home manager.*
- *Machine Learning Platforms: Providing algorithms, application programming interfaces (APIs), development and training toolkits, data, as well as computing power to design, train, and deploy models into applications, processes, and other machines.*
- *Deep Learning Platforms: A special type of machine learning consisting of artificial neural networks with multiple abstraction layers. Currently primarily used in pattern recognition and classification applications supported by very large data sets.*
- *AI-optimized Hardware: Graphics processing units (GPU) and appliances specifically designed and architected to efficiently run AI-oriented computational jobs. Currently primarily making a difference in deep learning applications.*
- *Decision Management: Engines that insert rules and logic into AI systems and used for initial setup/training and ongoing maintenance and tuning. A mature technology, it is used in a wide variety of enterprise applications, assisting in or performing automated decision-making.*

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5.6 ANTICSS understanding of 'smart' appliances in relation to circumvention

ANTICSS specifically aims at analysing the potential of 'smart' appliances in relation to circumvention (CV), which is understood as the alteration of the appliances' operating characteristics specifically during a test procedure, with the aim of reaching a more favourable level for any of the parameters to be declared by the manufacturer according to EU legislation (see section 4). ANTICSS will address this question from two perspectives, cf. Figure 5-1.

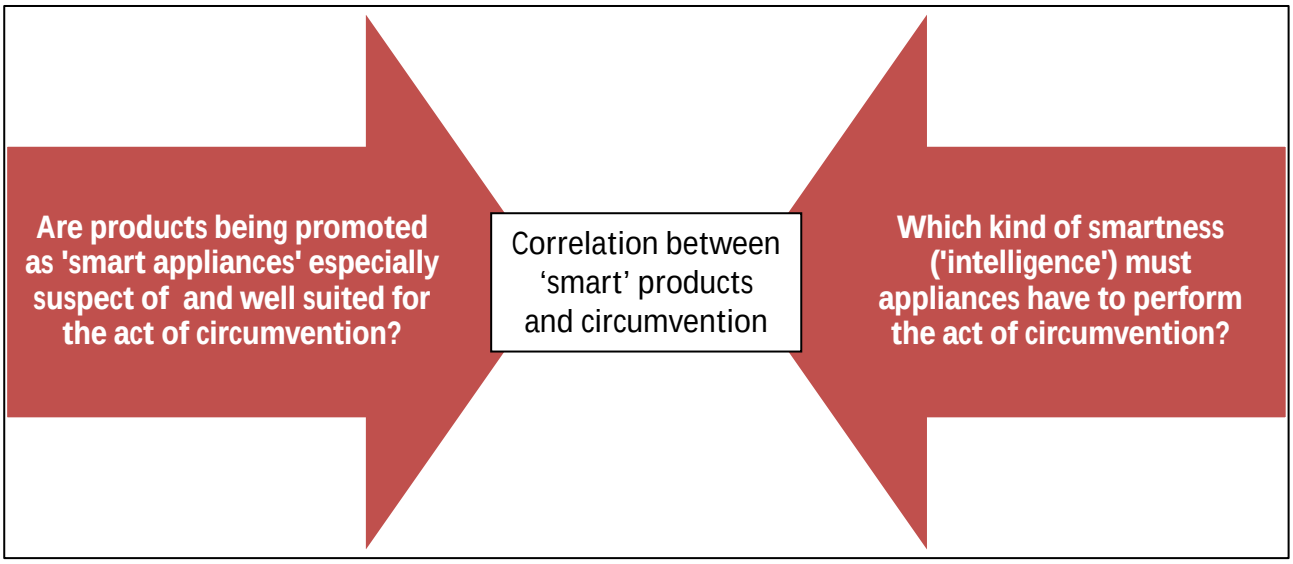

Figure 5-2: ANTICSS approach for the correlation between 'smart' products and circumvention

Appliances marketed as smart seem to be characterized mainly by the offered services (utilities), a connection to internet, as well as the communication level (focus on external communication, i.e. between different appliances and/or the possibility of being controlled via internet).
On the other hand, appliances designed in a way to be able to circumvent, i.e. altering their characteristics specifically during compliance testing, might have to be characterized in a different way for which the aforementioned definitions or classifications of smart appliances might not provide sufficient basis. While generally the ***presence of software*** within the appliance seems to be precondition of smartness, the act of circumvention might go beyond simple control logic which is implemented in nearly all appliances: sensor, processing software and actuator (reacting to (only) one input parameter). In comparison, 'smartness' related to circumvention seems to be a more sophisticated or 'intelligent' processing.

Therefore, in addition to the utilities and communication levels as proposed in the EU Ecodesign preparatory study on smart appliances (cf. section 5.3), ANTICSS has identified two further principles being relevant for detecting and assessing the smartness of appliances in relation to their ability to circumvent.

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The **technical operating principle:**

- ***Internal adjustment***, e.g., washing machine adapts the cycle to the detected level of soiling of the clothes to be washed (direct control);
- ***Learning[8] system***, e.g., refrigerator detects the consumer behaviour and adapts the inside temperature according to predicted door openings (adaptive control);
- ***External control***, e.g., reaction of the appliance or adaptation of performance triggered by the energy provider or consumer (e.g., consumer operates an appliance via smartphone).

Finally, the **implementation principle** of 'smartness' is of relevance for the compliance testing:

- ***Software installed*** already in the product as placed on the market
- ***Software update***, after a product has been placed on the market. This requires[9] a communication channel, i.e. the product is connected to a network. A software update might not only come from the manufacturer, but also from third parties or even other users.
- ***Hardware update*** (upgrading), after the product has been placed on the market, e.g. by adding new or more accurate sensors, after the product has been placed on the market.

In summary, for the ANTICSS project, the following parameters as shown in Figure 5-1 are of relevance to characterize the smartness of products.

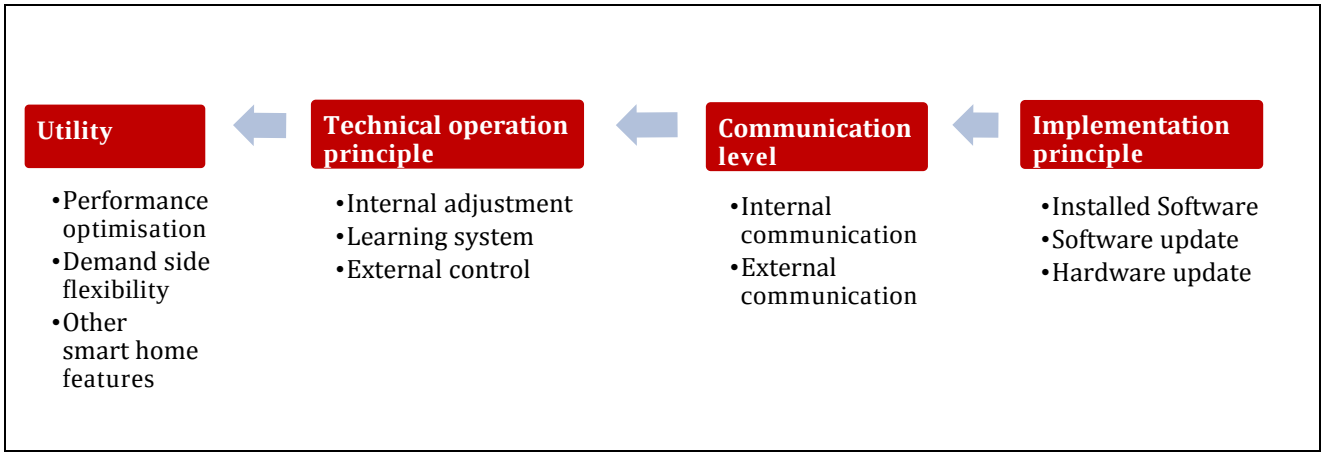

Figure 5-3: ANTICSS understanding of relevant parameters to characterize the smartness of products

[8] Note: According to APPLiA, represented in the ANTICSS Advisory Board, self-learning products that take autonomously decisions and improve processes by themselves without input from the outside are still fiction and won't become reality for household appliances within the next couple of years. The technical operation principle 'Learning system' as applied in this working paper, e.g. water heaters adapting processes to the consumer's water withdrawal pattern, the adaptation processes are still planned and designed by the manufacturer, not through learning of the appliance itself.

[9] Excluding the option that the software update is done by means of e.g. a USB stick brought and connected to the product which e.g. was in the past a way how some premium washing machines could be updated.

Possible interaction of these parameters is shown in Table 5-1, for example, the utility of smart features can be achieved through different technical functionalities and communication levels.

Table 5-1: Interaction of utility, technical operation and communication level of smart functions

Utility (services) Technical operating principle	Performance optimisation[10]	Demand side flexibility	Other smart home features	Relation between smart products and circumvention
Process adaptation through *internal adjustment*	'Internal' communication		'Internal' communication	Which kind of smartness ('intelligence') must appliances have to perform the act of circumvention?
Process adaptation through *learning system*	'Internal' or 'external' communication		'Internal' or 'external' communication	
Process adaption through *external control*		'External' communication	'External' communication	Are products being promoted as 'smart appliances' especially suspect of and well suited for the act of circumvention?

It is assumed that the question of the necessary kind of smartness ('intelligence') of appliances to perform the act of circumvention rather addresses the technical operation principles 'internal adjustment' and 'learning system', i.e. internal communication principles within the appliance. In contrast, the question of products being marketed as 'smart appliances' and their suitability for the act of circumvention rather relates to the technical operation principles 'external control', and to some extent also to 'learning appliances', focusing on external communication principles, i.e. communication between appliances or between the appliance and an external actor.

[10] The work developed by the ANTICCS project for the definition of circumvention and the analysis of different product cases revealed that the adaptation of a process can affect performance and/or resource consumption of a product at the same time. Thus 'performance optimisation' comprises both energy savings as well as changes in the product functional performance.

6 Analysis of the relation between 'smart' products and circumvention

In the following, several examples of (smart) features or 'intelligent' processing in appliances will be presented and used as a starting point to analyse the role of smart products and functions in terms of possible circumvention of legislation and standards under EU Ecodesign and Energy labelling. The cases S1 to S3 have been initially collected by literature research and a survey amongst the ANTICSS project partners within work package 2 (Basic analysis of circumvention) as cases of being suspect of circumvention[11]. Beyond these, the cases S4 to S12 present further examples of smart functionalities of energy related appliances. All cases are described in more detail with regard to their utility, technical operation principle as well as the communication level based on the ANTICSS understanding of smart appliances according to Table 5-1 in section 5.5.

6.1 Analysis of software-related (= smart?) product cases

S1: Holiday mode in refrigerators and freezers[12]

During the energy consumption test according to EN 62552:2013, the refrigerator (or freezer) is maintained in a climate chamber with constant temperature and humidity. The length of the test is longer than a week and during that time, the refrigerator (or freezer) door remains closed. Some appliances are equipped with sensors and software being able to detect that the door remains closed at constant ambient temperature.
As a consequence, the energy consumption is reduced by activating a so called holiday mode. In this mode, the performance of the appliance differs from the usual one e.g. by prolonging the periods between two defrost cycles. The function is also activated in actual operation if the door remains closed for a longer period of time at constant temperature (e.g. in case of holidays), so that the energy consumption is also reduced in real use in certain situations. The measured energy consumption in holiday mode does not correspond to the real use of the appliance under typical (non-holiday) conditions.

[11] See ANTICSS Deliverable D7: Definition of circumvention and differentiation to other effects (Preliminary Report), https://www.anti-circumvention.eu/storage/app/media/uploaded-files/ANTICSS_Definition_circumvention_Preliminary_Long.pdf
[12] Case 4: Refrigerators and freezers' in ANTICSS Deliverable D7

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Function is categorised as follows:

Utility	***Performance optimization***	Reduction of energy consumption
Technical operation principle	***Internal adjustment***	Altering the operating characteristics and performance of the refrigerator or freezer after longer term closure of the door
Communication level	***Internal communication***	Within the appliance, i.e. a sensor detects upon stable temperature that the door is not opened for a longer period and activates the holiday mode
Smartness / circumvention?	*Appliances specifically marketed as 'smart' due to this function?* No. *Smartness (= intelligence) of the technical operation principle of this function?* Not necessarily; the process might be based on a simple control logic (temperature sensor; actuator (reacting to a defined parameter, e.g. stable temperature range over a certain time) *Circumvention according to ANTICSS definition (cf. section 4)?* The holiday mode leads to reduced energy consumption in real-life during longer periods without door openings. However, manufacturers might exploit the circumstance that also standard testing conditions operate without door openings, leading to reduced energy consumption under test as well, thus not reflecting typical real-life conditions. According to the ANTICSS definition, this function might not be classified as circumvention as the act of circumvention is relevant only under test conditions, whereas the holiday mode is expected to be applied also in real-life. In that case, although this act may be not classified as circumvention, it could be classified as jeopardy effect becoming possible due to loopholes or other weaknesses in standards or regulations. It might be classified as circumvention, however, if the function is operating only under test and not being active under real-life conditions.	

S2: Defrost function in refrigerator-freezers[13]

In frost-free refrigerator-freezers, any ice accumulating on the evaporator inside the cabinet is automatically removed from time to time by activating a heater to melt the ice (defrost phase). After opening the door, some appliances show an altered operating cycle for the duration of one or two defrost periods (defrost period is defined by the time between two defrosts, the start of defrost to the start of the next defrost):

- First, an internal fan is continuously running (also during compressor off-cycle), resulting in an additional power of 2 W during the compressor off cycles. Besides the additional electricity consumption, the fan causes a change in the internal compartment temperature.
- Secondly, the defrost heater is active for a longer period. In the reported case, it increased from 3 minutes to approximately 18 minutes.
- Additionally, the defrost period is shortened (from 52 to 26 hours in the reported case).

[13] Case 10: Refrigerator-freezer' in ANTICSS Deliverable D7

The changes mentioned before can be observed for one or two defrost periods. Afterwards, the cabinet control changes back to the operating cycle before the door opening (fan only running during compressor on cycle, defrost phase 3 minutes, defrost period 52 hours) until another door opening is detected. According to standard EN 62552:2013, there are no door openings during the energy consumption test. The appliance must be installed according to the user manual, unless otherwise stated in the standard.
The appliance must run at a certain temperature range measured by the thermocouples positioned inside the cabinet. Before the energy consumption test is started, the appliance has to reach stable operating conditions (energy consumption and storage temperatures values of two measurements agree within 3 % and 0.5 K, respectively). During the altered behaviour of the cabinet, the stability criteria are not met and therefore the energy consumption measurements will not take into consideration this behaviour. In the reported case, one door opening per day increases the energy consumption by about 12 %.
It has to be mentioned that the future standard and regulation has already tackled the difference in defrost intervals. Manufacturers are forced to declare what kind of defrost algorithm they are using together with the timings.

Function is categorised as follows:

Utility	***Performance optimization***	Reduction of ice accumulation, Improvement of defrost performance
Technical operation principle	***Internal adjustment***	Activating a fan, increasing the active time of the defrost heater and shortening the period between two defrost cycles after detecting door openings.
Communication level	***Internal communication***	Within the appliance, i.e. a sensor detects the opening of the door and prolongs the active time of fan and heater.
Smartness / circumvention?	*Appliances specifically marketed as 'smart' due to this function?* No. *Smartness (= intelligence) of the technical operation principle of this function?* Not necessarily; the process might be based on a simple control logic (temperature sensor; actuator (reacting to a defined parameter, e.g. increase of temperature after door opening) *Circumvention according to ANTICSS definition (cf. section 4)?* The defrost function leads to increased energy consumption in real-life due to fans and heater running after door openings. Manufacturers might exploit the circumstance that standard testing conditions operate without door openings, leading to reduced energy consumption under test as the defrost cycles are not activated so often, thus not reflecting typical real-life conditions. According to the ANTICSS definition, this function might not be classified as circumvention as the act of circumvention is relevant only under test conditions, whereas the defrost function is expected to be applied also in real-life. In that case, although this act may be not classified as circumvention, it could be classified as jeopardy effect becoming possible due to loopholes or other weaknesses in standards or regulations. However, it might be classified as circumvention, if the energy consuming defrost function would be programmed in a way to be totally switched off specifically under test due to recognizing the test situation.	

S3 Automatic brightness adjustment function in consumer electronics TV[14]

According to standard IEC 62087-2:2015, the energy consumption of TVs is tested with default settings. In the reported case, an automatic brightness adjustment function is activated by default. This function analyses the broadcast program and when fast moving images are detected, the brightness of the television is reduced automatically. As a result, the measured energy consumption of the television is significantly lower compared to a broadcast without fast moving images. The standardised test movie, which is used for measuring the energy consumption, consists of fast moving images only. Prior to the start of the standardised test movie, a countdown clip is shown. This countdown lasts for 10 seconds and does not contain any fast moving images. After the 10 seconds, the movie content is played and the automatic brightness adjustment function is triggered. This results in a reduction of the input power of approximately 35 %.

Function is categorised as follows:

Utility	***Performance optimization***	Reduction of energy consumption
Technical operation principle	***Internal adjustment***	Reduction of the brightness of the television when detecting fast moving images.
Communication level	***Internal communication***	Within the appliance, i.e. a sensor detects fast moving images and adapts the brightness of the television
Smartness / circumvention?	*Appliances specifically marketed as 'smart' due to this function?* No. *Smartness (= intelligence) of the technical operation principle of this function?* Not necessarily; the process might be based on a simple control logic (frame rate sensor; actuator (reacting to a defined parameter, e.g. frame rate over a certain value) *Circumvention according to ANTICSS definition (cf. section 4)?* The automatic brightness adjustment function leads to reduced energy consumption in real-life due to reducing the brightness when fast moving images are detected. However, manufacturers might exploit the circumstance that also standard testing conditions operate with fast moving pictures, leading to reduced energy consumption under test as well, thus not reflecting typical real-life conditions. According to the ANTICSS definition, this function might not be classified as circumvention as the act of circumvention is relevant only under test conditions, whereas the automatic brightness adjustment function is expected to be applied also in real-life. In that case, although this act may be not classified as circumvention, it could be classified as jeopardy effect becoming possible due to loopholes or other weaknesses in standards or regulations. It might be classified as circumvention, however, if the function is operating only under test and not being active under real-life conditions.	

[14] Case 13: Consumer electronics TV' in ANTICSS Deliverable D7

S4 Cool-down function in domestic refrigerator-freezers[15]

In frost-free refrigerator-freezers, any ice accumulating on the evaporator inside the cabinet is automatically removed from time to time by activating a heater to melt the ice (defrost phase). To avoid an increase in temperature of the frozen food, some appliances are programmed to cool-down products inside the cabinet just before a defrost event. This cool-down function consumes extra energy. In some cases, the cool-down starts just after the maximum testing-time of 48 or 72 hours is reached, meaning that the extra energy consumption of this function is not incorporated in the test result. This is in accordance to the current standard EN 62552:2013. The difference in energy consumption is reported to be about 4 %.
It has to be mentioned that the future standard and regulation have already tackled this issue. In future, the aforementioned behaviour is part of the energy consumption value.

Function is categorised as follows:

Utility	***Performance optimization***	Protection of food against increasing temperatures due to defrost heater
Technical operation principle	***Internal adjustment***	Reduction of temperature (cool-down function) before starting the defrost phase with activated heater to melt the ice
Communication level	***Internal communication***	Within the appliance, i.e. a software activates the cool-down function at a defined time ahead of the defrost phase
Smartness / circumvention?	*Appliances specifically marketed as 'smart' due to this function?* No. *Smartness (= intelligence) of the technical operation principle of this function?* Not necessarily; the process might be based on a simple control logic (certain timing programmed; actuator (reacting to a defined parameter, e.g. start of cool-down function after xy hours; after that start of defrost phase after xy+z hours) *Circumvention according to ANTICSS definition (cf. section 4)?* The cool-down function leads to increased energy consumption in real-life. Manufacturers might exploit the circumstance that standard testing conditions operate for a defined time without door openings that might trigger the defrost phase. If the defrost cycles are not activated so often under test, also the cool-down function would not be activated so often, which leads to reduced energy consumption under test, thus not reflecting typical real-life conditions. According to the ANTICSS definition, the function itself might not be classified as circumvention as the act of circumvention is relevant only under test conditions, whereas the cool-down function is expected to be applied also in real-life. However, if the function is programmed in a way to specifically start only after the compliance testing period as described above, it would be classified as circumvention, point c) '*pre-set alteration of the performance within a short period after putting the product into service*'.	

[15] Case 24: Domestic refrigerator-freezers' in ANTICSS Deliverable D7

S5: Domestic electrical storage water heaters with typical water withdrawal pattern

The smart control in domestic electrical storage water heaters adapts the heating phase to the typical usage pattern of hot water. The function is set by the manufacturer and is ready for use right after the device is installed. The smart control mode operates the device based on the typical water withdrawal pattern of the particular device. The intended use of the device, corresponding to the typical withdrawal pattern set by the manufacturer, would lead to an increase in energy efficiency of the storage water heater by 17.1 % compared to a device which keeps the temperature always at a constant level. This is considered in the test standard (DIN EN 50440:2015).

If the consumer usage of the storage water heater does not follow the default setting of the typical water withdrawal pattern, the water would not have the desired temperature. The smart control can be switched off by the consumer in order to fit the consumer needs, which would lead to an increase of energy consumption of the device.

Function is categorised as follows:

Utility	***Performance optimization***	Reduction of energy consumption due to water heating according to a pre-set typical withdrawal pattern
Technical operation principle	***Internal adjustment***	Adaptation of the water heating to the typical water withdrawal pattern of a particular device as programmed by manufacturer
Communication level	***Internal communication***	Within the appliance, i.e. a software activates the water heating according to a typical water withdrawal pattern
Smartness / circumvention?	*Appliances specifically marketed as 'smart' due to this function?* No. *Smartness (= intelligence) of the technical operation principle of this function?* Not necessarily; the process might be based on a simple programme logic (measuring the time; actuator (reacting to a defined parameter, e.g. start of heating the water at certain pre-defined time intervals) *Circumvention according to ANTICSS definition (cf. section 4)?* The programmed withdrawal pattern leads to lower energy consumption compared to non-stop water heating. Standard measurements shall be carried out by using the pre-defined *declared* load profiles. According to the ANTICSS definition, the function itself would not be classified as circumvention as the act of circumvention is relevant only under test conditions, whereas the pre-set water withdrawal pattern is expected to be applied also in real-life. It might become circumvention if the appliance would be programmed in a way that the declared pre-set water withdrawal pattern (assumption: highly energy efficient) is altered automatically within a certain period after putting the product into service towards more consumer convenient, but less energy efficient withdrawal patterns (point c of the ANTICSS definition of circumvention).	

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S6: Domestic electrical storage water heaters with individual water withdrawal pattern

The smart control in domestic electrical storage water heaters adapts the heating phase to the usage of hot water. The smart control mode detects user behaviour, i.e. the time when the consumer usually withdraws hot water, and specifically heats the water just in time before the predicted withdrawal pattern.

The test standard DIN EN 50440:2015 considers the lower energy consumption of a water heater operated with a typical withdrawal pattern (see case S5). If the user related withdrawal pattern differs from the typical pattern, the energy consumption of the device does not correspond to the energy efficiency declared by the test.

Function is categorised as follows:

Utility	***Performance optimization***	Reduction of energy consumption due to water heating according to predicted withdrawal pattern of the consumer
Technical operation principle	***Learning appliance***	Smart control learns from the user behaviour over a period of time and adapts the water heating to the individual withdrawal pattern of the user
Communication level	***Internal communication***	Within the appliance, i.e. software monitoring the typical consumer behaviour in terms of water withdrawal and activating the water heating just before the predicted withdrawal of water.
Smartness / circumvention?	*Appliances specifically marketed as 'smart' due to this function?* Yes. *Smartness (= intelligence) of the technical operation principle of this function?* Yes; the process has to be based on an intelligent programme logic (measuring the real-life usage over a certain time and autonomously adjusting the actuator accordingly (reacting based on complex algorithms, i.e. start of heating the water just before the time of predicted use) *Circumvention according to ANTICSS definition (cf. section 4)?* Standard measurements for water heaters declared as smart appliances shall be carried out by using for the first week a random sequence of load profiles chosen from the declared load profile and the load profile one below the declared load profile with smart control disabled, and for a second week a repetition of the same sequence with smart control enabled. It might become circumvention if the appliance is programmed in a way that it recognizes being under test (as the same load profiles will be used over a period of 5 days) and in consequence alters the product performance and/or resource consumption during test, e.g. reacting specifically during the second week of the test with smart control enabled (point a of the ANTICSS definition of circumvention).	

S7 Refrigerators with cool-down function adapted to predicted door opening patterns

The adapt temperature feature is supposed to maintain the optimum temperature in the refrigerator regardless of how frequently the door is opened. The manufacturer explains that when the door of the refrigerator is opened, the temperature suddenly rises and the food is exposed to a thermal shock which in turn causes it to perish sooner. The refrigerator continuously monitors and analyses the way the consumers uses the refrigerator. Thus, it can predict when the consumer will probably open the fridge door and just before the predicted time arrives, the smart adapt temperature function of the fridge decreases the temperature by 1 or 2 K to make sure that a constant temperature is maintained and that the food stays fresh. Lowering the temperature by 1 or 2 K before door opening leads to an additional operation time of the compressor. Thus, the energy consumption of the refrigerator increases. The additional energy needed, rises with the rising number of predicted door openings. In case the consumer changes his behaviour and the door is not opened as predicted by the adapt temperature function of the fridge, both the lower temperature and the additional energy consumption are needless.

Function is categorised as follows:

Utility	***Performance optimization***	Protection of food against increasing temperatures due to door openings
Technical operation principle	***Learning appliance***	Smart control learns from the user behaviour over a period of time and reduces the temperature (cool-down function) just before door openings as per predicted consumer usage
Communication level	***Internal communication***	Within the appliance, i.e. software monitoring the typical consumer behaviour in terms of door openings and decreasing the temperature inside the refrigerator before the predicted typical time of door openings.
Smartness / circumvention?	*Appliances specifically marketed as 'smart' due to this function?* Rather not; smart fridges rather highlight functions like internet connection, touch-screen interface, connection to other appliances within the household and remote control via smartphone. *Smartness (= intelligence) of the technical operation principle of this function?* Yes; the process has to be based on an intelligent programme logic (measuring real-life usage over a certain time and autonomously adjusting the actuator accordingly (reacting based on complex algorithms, i.e. start of cool-down function just before the time of predicted door openings) *Circumvention according to ANTICSS definition (cf. section 4)?* The standard test is performed without any door openings. In that case, the smart function would recognize that it is not necessary to activate the cool-down function additionally. The appliance might not be found non-compliant, however, would have 'missing representativeness' compared to real-life where the activated cool-down function causes higher energy consumption. It might become circumvention if the smart function is programmed in a way that it recognizes being under test (no door openings at all) and in consequence e.g. even prolongs the regular sequence of cool-down cycles (point a of the ANTICSS definition of circumvention).	

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S8: Automatic programmes adaptation in ovens, steam ovens and microwaves (theoretical)

Ovens, steam ovens and microwaves are equipped with automatic cooking programmes. These programmes assist users with optimised cooking processes for specific food in order to prevent the user from making mistakes that could compromise the quality of the cooked food. The automatic cooking programmes do not always provide the desired or expected quality of the cooked food. Thus, the user might adapt the cooking programme manually, e.g., by prolonging the cooking time of the device, increasing the oven temperature, or increasing the power demand of the microwave. The user specific alteration of the cooking process can be detected and the automatic cooking programme can be altered according to the actually performed cooking process. The alteration of the automatic cooking programme cannot be predicted as it depends on the individual preferences of the user. Higher oven temperatures, higher power demand of microwave operations, or longer cooking times lead to a higher annual energy consumption than declared by the manufacturer.

Function is categorised as follows:

Utility	***Performance optimization***	Improving the cooking performance, convenience to the user
Technical operation principle	***Learning appliance***	Smart control learns from the user behaviour over a period of time and adapts the cooking programmes to the actually performed cooking processes
Communication level	***Internal communication***	Within the appliance, i.e. software monitoring the typical consumer behaviour in terms e.g. temperature settings or timing of cooking processes and adapting the cooking programmes accordingly.
Smartness / circumvention?	*Appliances specifically marketed as 'smart' due to this function?* Yes. *Smartness (= intelligence) of the technical operation principle of this function?* Yes; the process has to be based on an intelligent programme logic (measuring real-life usage over a certain time and autonomously adjusting the actuator accordingly (reacting based on complex algorithms, i.e. autonomously altering the settings of the cooking programmes) *Circumvention according to ANTICSS definition (cf. section 4)?* The standard test is performed with pre-defined heating functions (conventional, forced air circulation, hot steam) as well as temperature settings. In that case, the smart function would recognize that it is not necessary to adapt the programme at all. It might become circumvention if the smart function is programmed in a way that it recognizes being under test due to the specific standard test settings and in consequence adapts certain performance setting leading to more favourable results (point a of the ANTICSS definition of circumvention).	

S9: Software update results in change of water temperature in dishwashing machines (theoretical)

The drying performance of a dishwashing machine depends on the water temperature during the rinsing cycle. The hot water heats up the cutlery and dishes, thus the water evaporates from the surface of the items. High water temperature provides high drying performance. Dishwashing machines are delivered with smart features that are able to connect with the internet, which enables the manufacturers to provide programme updates or services. In case, after delivery, the manufacturer sends an update to improve the drying performance, which leads to a higher water temperature during the rinsing cycle of the dishwashing machine, the energy consumption of the dishwashing machine increases.

Function is categorised as follows:

Utility	***Performance optimization***	Improving the drying performance of the dishwasher
Technical operation principle	***Internal adjustment***	The water temperature of the rinsing cycle is increased (based on newly programmed control logics) to improve the drying performance
Implementation principle	***Software update***	The internal operation principle of the appliance is only changed through an update provided by the manufacturer after the product has been placed on the market
Communication level	***External communication***	Between appliance and manufacturer, i.e. the update is automatically installed via internet connection.
Smartness / circumvention?	*Appliances specifically marketed as 'smart' due to this function?* Possibly (wifi-connection). *Smartness (= intelligence) of the technical operation principle of this function?* Not necessarily; a software update is rather an implementation principle. The appliance offers the technical conditions to receive and process software updates via internet connection. However, the new technical function itself, implemented via software update, is rather not 'intelligent' as only the temperature, i.e. a defined parameter is adapted. *Circumvention according to ANTICSS definition (cf. section 4)?* According to the ANTICSS definition, the function itself would not be classified as circumvention as the act of circumvention is relevant only under test conditions, whereas software updates only apply after the product has been placed on the market. Nevertheless, if a software update leads to improved performance (drying performance) for the consumer on the one hand, but at the expense of the energy consumption of the product or any other of the declared parameters, then according to ANTICSS understanding this would fall under the category of 'Jeopardy effects' which encompasses design aspects of products or test instructions, or interpretation of test results which do not follow the goal of the EU ecodesign and/or labelling legislation of setting ecodesign requirements and providing reliable information about the resource consumption and/or performance of a product. See also section 3.4 about how software updates will be addressed in future regulations to avoid undermining EU Ecodesign and Energy labelling aiming at reducing energy consumption.	

S10: Automatic programmes in ovens, steam ovens and microwaves

Ovens, steam ovens and microwaves are equipped with automatic cooking programmes. These programmes assist users with optimised cooking processes for specific food in order to prevent the user from making mistakes that could compromise the quality of the cooked food. Manufacturers provide Apps for mobile phones and updates for automatic programmes via internet connection. Thus, the database for automatic cooking programmes of the device can be enriched with latest recipes. The updates might cause higher annual energy consumption of the device, particularly if high oven temperatures, high power demand of microwaves or long cooking processes in steam ovens are implemented.

Function is categorised as follows:

Utility	***Other smart home features***	Providing sophisticated comfort for the user
Technical operation principle	***Internal adjustment***	The internal database for automatic cooking programmes of the device is complemented with further recipes
Implementation principle	***Software update***	The internal database of the appliance is only changed through an update provided by the manufacturer after the product has been placed on the market
Communication level	***External communication***	Between appliance and manufacturer, i.e. the update is automatically installed via internet connection.
Smartness / circumvention?	*Appliances specifically marketed as 'smart' due to this function?* Yes. *Smartness (= intelligence) of the technical operation principle of this function?* Not necessarily; a software update is rather an implementation principle. The appliance offers the technical conditions to receive and process software updates via internet connection. However, the new technical function itself, implemented via software update, seems to be 'intelligent' if not only recipes are provided but also the settings of automatic cooking programmes are adjusted according to the new recipes. *Circumvention according to ANTICSS definition (cf. section 4)?* According to the ANTICSS definition, the function itself would not be classified as circumvention as the act of circumvention is relevant only under test conditions, whereas software updates only apply after the product has been placed on the market. Nevertheless, if a software update leads to improved performance (more recipes) for the consumer on the one hand, but at the expense of the **energy consumption of the product or any other of the declared parameters, then according to ANTICSS understanding this would fall under the category of** 'Jeopardy effects' which encompasses design aspects of products or test instructions, or interpretation of test results which do not follow the goal of the EU ecodesign and/or labelling legislation of setting ecodesign requirements and providing reliable information about the resource consumption and/or performance of a product. See also section 3.4 about how software updates will be addressed in future regulations to avoid undermining EU Ecodesign and Energy labelling aiming at reducing energy consumption.	

S11: Appliances adapting power demand to the electricity availability on the grid

Appliances like washing machines, dishwashers, tumble dryers or electric storage water heaters can in principle be designed in a way to be able to communicate with the electricity grid or the electricity supplier. Aim is to contribute to avoiding peaks in the power demand and to increase the use of electricity generated by renewable energy sources. Signals via e.g. power line may be used to communicate about the availability of surplus or about the shortage of power on the grid. This can be detected by the appliance through an internal or external energy managing device. Alternatively, other means like frequency sensing might be used as the frequency is changing with total load on the grid, and high availability of energy will increase the load and thus the frequency. Action may be an immediate start as far as the appliance is in a start time delay or in a special 'ready for operation' mode. For example electric storage water heaters in private dwellings show high demand side flexibility, as the water can be heated when a surplus of electricity is available on the grid, without compromising the comfort for the consumer. Only when the water is heated up a long time before it is withdrawn by the consumer, it loses heat and has to be heated up to the pre-set desired temperature again, leading to a higher energy demand of the device.
In case of electricity shortage, the energy managing device will delay the start of the appliance, which leads to additional standby power demand. If electricity shortage is detected during the operation of the appliance, the energy managing device stops the operation of the appliance. If this happens e.g. during the main wash phase of the washing machine or the dishwashing machine, when the water has already been heated up, the process water cools down and has to be heated up, when the operation of the device is continued, after a signal about the end of electricity shortage has been received. This leads to extra energy demand of the appliance as the water has to be reheated.

Function is categorised as follows:

Utility	***Demand side flexibility***	The power demand of the appliance is adapted to the availability of electricity on the grid
Technical operation principle	***External control***	An external or internal energy managing device receives an external signal and operates the appliance
Communication level	***External communication***	Between the appliance (or an energy managing device) and the external electricity grid or electricity supplier.
Smartness / circumvention?	*Appliances specifically marketed as 'smart' due to this function?* Yes. *Smartness (= intelligence) of the technical operation principle of this function?* Probably. On the one hand, it could be seen as simple control logic if e.g. the frequency sensing is performed by a separate energy managing device and the appliance just gets an external control signal to start or stop instead of using an on/off switch by the user. However, the process probably will be based on an intelligent programme logic (reacting based on complex algorithms, i.e. autonomously altering the settings of the programmes, e.g. heating up again after interim stop of the machine).	

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	Circumvention according to ANTICSS definition (cf. section 4)? According to the ANTICSS definition, this function might not be classified as circumvention as the act of circumvention is relevant only under test conditions, whereas the demand side flexibility function is expected to be applied also in real-life. So far, appliances are tested out of the box, without testing external control functions like remote control based on demand side flexibility. The appliance tested might not be found non-compliant, however, would have 'missing representativeness' compared to real-life where standby due to delay start or necessary reheating of the water causes higher energy consumption. It might only become circumvention if the embedded smart function of the appliance is programmed and misused in a way that it recognizes being under test (due to specific standard test programmes) and in consequence changes certain performance parameters specifically under test in order to reach more favourable results (point a of the ANTICSS definition of circumvention).

S12: Energy management in private households

In so called smart home environments an energy management system is able to avoid power peaks inside a dwelling. In the current case it is assumed that the allowed power demand of the household is pre-set to a maximum of 25 kW. Assumed that in the household a washing machine and a dishwasher are operating in their main wash programmes, the power demand of both devices could add up to about 5.5 kW. In case more devices are switched on, e.g. the cooking range (max. 10 kW) and an instantaneous water heater (max. 18 kW), the maximum power demand of 25 kW is exceeded. Thus, the energy management system would interrupt the operation of the washing machine, the dishwasher or even both in order to avoid a peak in the power demand of the household. The water in the washing machine or the dishwashing machine cools down and has to be heated up again after one or more other devices are switched off.

Function is categorised as follows:

Utility	***Demand side flexibility***	The operation of the devices is adapted to the free power capacity of the dwelling
Technical operation principle	***External control***	An external or internal energy managing device receives an external signal and organises the simultaneous operation of different appliances
Communication level	***External communication***	Between different appliance (or an energy managing device) and the external electricity grid or electricity supplier.
Smartness / circumvention?	*Appliances specifically marketed as 'smart' due to this function?* Yes. *Smartness (= intelligence) of the technical operation principle of this function?* Probably. On the one hand, it could be seen as simple control logic if e.g. the power sensing is performed by a separate energy managing device and the appliance just gets an external control signal to start or stop instead of using an on/off switch by the user.	

	However, the process probably will be based on an intelligent programme logic (reacting based on complex algorithms, i.e. autonomously altering the settings of the programmes, e.g. heating up again after interim stop of the machine). *Circumvention according to ANTICSS definition (cf. section 4)?* According to the ANTICSS definition, this function might not be classified as circumvention as the act of circumvention is relevant only under test conditions, whereas the energy management function is expected to be applied also in real-life. So far, appliances are tested out of the box, without testing external control functions like remote control based on energy management. The appliance tested might not be found non-compliant, however, would have 'missing representativeness' compared to real-life where necessary reheating of the water causes higher energy consumption. It might only become circumvention if the embedded smart function of the appliance is programmed and misused in a way that it recognizes being under test (due to specific standard test programmes) and in consequence changes certain performance parameters specifically under test in order to reach more favourable results (point a of the ANTICSS definition of circumvention).

6.2 Summary

The following table provides an overview of the analysed exemplary product cases and shows their allocation to utilities and technical operation principles.

Table 6-1: Allocation of analysed product cases to the utilities and technical operation principles

Utility (aim) Technical operation principle	Performance optimisation	Demand side flexibility	Other smart home features
Internal adjustment	S1: Holiday mode in refrigerators and freezers S2: Defrost function in refrigerator-freezers S3: Automatic brightness adjustment when detecting fast moving pictures in TVs S4: Automatic cool-down function before each defrost phase in refrigerators / freezers S5: Automatic water heating in accordance to pre-set water withdrawal pattern in electrical storage water heaters		

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Utility (aim) / Technical operation principle	Performance optimisation	Demand side flexibility	Other smart home features
Learning system	S6: Adapting water heating to predicted consumer's water withdrawal pattern in electrical storage water heaters S7: Adapting cool-down function to predicted consumer's door opening pattern in refrigerators S8: Adapting cooking programmes to actually performed cooking patterns in ovens, steam ovens and microwaves		
External control		S11: Adapting power demand to electricity availability of the grid in washing & dishwashing machines, tumble dryers or electric storage water heaters S12: Adapting the operation between different devices to free power capacity of the dwelling	
Implementation principle: Software update	S9: Software update to improve drying performance in dishwashing machines		S10: Software update to add further cooking programmes to ovens, steam ovens and microwaves

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7 Conclusions and recommendations

7.1 'Smartness' of products and their relation to circumvention

The ANTICSS analysis of smart appliances specifically related to the issue of circumvention shows that there is a difference between products marketed as smart and products acting smart, see following scheme.

Table 7-1: Different approach: Products marketed as 'smart' and products acting 'smart'

Products marketed as 'smart' ⟷	Products acting 'smart' (= intelligent)
For products marketed as 'smart appliances', there seems to be no clear definition. Often, either the ***utility*** or the possibilities for ***external communication*** via internet connection are highlighted under this term. Products are marketed as smart when for example providing ***automatic software updates***, remote control function via smartphone app or for the purpose of demand side flexibility, as well as communication between appliances or to a smart home network. Also computer functions for appliances other than computers (e.g. smart TVs), additional functions like a webcam for controlling and communicating the status (e.g. smart fridge), as well as learning or AI-enabled appliances are promoted as smartness. These functionalities, however, do not necessarily provide the technical configuration to circumvent compliance testing.	Products with the ***technical operation principle*** and configuration to circumvent compliance testing, i.e. with the ability to detect being in a test situation and altering the product performance and/or resource consumption specifically during test in order to reach more favourable test results, are not necessarily marketed as smart products, for example the function 'internal adjustment'. Further, if a standard test situation is clearly differing from real-life conditions, e.g. through dedicated parameters such as stable ambient conditions over a certain time (apparent for refrigerators with no door openings under test), or a certain sequence of cycles, a more sophisticated or smart (= 'intelligent') processing might even not be necessary for the product to detect being under test; simple control logic programmed explicitly towards recognizing these test conditions and adjusting might be sufficient.

In general, the analysis of smart product cases in section 6.1 revealed that

- Ø Appliances with functions marketed as smart do not provide per se an indicator for circumvention.
- Ø Products being able to act smart (= intelligent) in a way of circumventing under compliance testing are not necessarily marketed as smart.
- Ø Software is a precondition for being smart.
- Ø The act of software-related circumvention relevant only under test conditions can be executed either by automatic detection of the test situation and alteration of the product performance and/or resource consumption during test, or by pre-set alteration of the performance within a short period after putting the product into service, see points a) and c) of the ANTICSS definition of circumvention in section 4.

However, circumvention not only takes place based on software but can also be applied by pre-settings or manual alteration of the product, affecting performance and/or resource consumption during test according to point b) of the ANTICSS definition in section 4.

- Ø If some kind of 'intelligent' software is already implemented at the moment the product is placed on the market, those appliances might be more prone to use this software also for circumvention. On the other hand, if standard test conditions clearly differ from real-life conditions, also simple control logic might be sufficient to programme appliances in a way to recognize these test conditions and adjust certain parameters accordingly.
- Ø Finally, not all 'smart appliances' are circumventing under EU Ecodesign and Energy label compliance testing:
  => On the one hand, some of the products' smartness is not at all related to the energy labelling or ecodesign regulated parameters, and/or the smart function even results in higher instead of lower energy consumption.
  => On the other hand, manufacturers explicitly have to use the smartness and programme appliances in a way that they detect being in a test situation as well as alter the product performance and/or resource consumption specifically during test in order to reach more favourable test results.

The question if products being promoted as 'smart appliances' are especially suspect of and well suited for the act of circumvention is assessed in more detail in the following sections: utility (section 7.2), communication level (section 7.3) and implementation principle (section 7.5).
On the other hand, the question which kind or level of smartness ('intelligence') appliances must have to perform the act of circumvention rather depends on the technical operation principle which is analysed in more detail in section 7.4.

7.2 Utility of the smart feature

The potential for circumvention, i.e. gaining more favourable results specifically in the test situation, cannot be derived just from the utility or advertised service of smart functionalities, such as performance optimization, demand side flexibility or smart home capability.

Smart features targeted towards ***performance optimisation*** might be more suspect of leading to circumvention since these features might have the ability of altering the product's performance and/or resource consumption also specifically during compliance testing. However, marketed optimisation of performance does not always mean an optimisation in the sense of reducing energy consumption. If for example the comfort for the consumer is improved, the performance adjustment could even lead to increased energy consumption; see for example case 'S2 Defrost function in refrigerators and freezers' (cf. section 6.1): The performance optimisation is targeted to the reduction of ice accumulation and improvement of the defrost performance, achieved by activating a fan, increasing the active time of the defrost heater and shortening the period between two defrost cycles, which results in increased energy consumption.

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Also the claimed service of ***demand side flexibility*** probably leads to increased energy consumption, as appliances have to stay in 'ready for operation' mode to be able to start at any time useful for the electricity grid, thus causing standby consumption, or processes have to be repeated (e.g. reheating after cooling down) due to interruption of the cycles; cf. case 'S11: Appliances adapting power demand to the electricity availability on the grid'.

Finally, through more sophisticated software, internet connection etc., 'smart appliances' probably consume per se more energy than non-smart ones. They might get a bonus on the energy efficiency requirements in EU Ecodesign and Energy label regulations under the assumption of overall improved utility for example for the electricity grid or through adapting processes specifically towards consumer behaviour (e.g. learning appliances). However, it is often not clear whether the additional consumption of the appliances really outweighs the claimed benefits of the smart functions in terms of overall energy consumption during use[16].
On the other hand, if a bonus for smart functions is given, products declared as smart in order to gain this bonus should be tested to check the actual presence and operation of the smart functionality, i.e. whether the bonus on energy efficiency for the smart control is justified. However, claiming but not providing the utility of a smart functionality in real-life in order to obtain competitive advantage is rather an issue of non-compliance as of circumvention as it can easily be detected under compliance testing.

7.3 Communication level of the smart feature

The potential for circumvention, i.e. gaining more favourable results specifically in the test situation, cannot be derived just from the communication level (internal or external) of smart functionalities. More relevant with regard to circumvention are the underlying technical operation principles: for internal communication the internal adjustment or learning appliances, for external communication possibly also learning appliances, as well as external control.

EXTERNAL COMMUNICATION

Products marketed as 'smart appliances' often highlight possibilities for external communication via internet connection under this term, i.e. automatic software updates, remote control function via smartphone app or for the purpose of demand side flexibility, as well as communication between appliances or to a smart home network.

Possibilities for circumvention through external communication are rather linked to the underlying technical operation principles (external control, or partly learning appliances), further analysed in section 7.4.

[16] This should be taken already into consideration when drafting the regulations and deciding on the overall provision and range of potential bonuses for smart functionalities.

INTERNAL COMMUNICATION

Internal communication principles, i.e. taking place within the appliance, are not always marketed as smart functions, meaning that not always all control strategies are described as functionalities disclosed to the user, or MSAs and test laboratories for compliance testing.

Possibilities for circumvention through internal communication are rather linked to the underlying technical operation principle (internal adjustment, learning appliances), further analysed in section 7.4.

7.4 Technical operation principle of the smart feature

7.4.1 Internal adjustment (direct control)

The technical operation principle 'internal adjustment (direct control)' is prone to circumvention, although these functions are often not marketed as 'smart'. Smartness, i.e. 'intelligent' control logic might not necessarily be a precondition for circumvention based on internal adjustment.

Many processes are automatically adapted to current ambient conditions through internal adjustment, i.e. within the appliance. These functions, based on regular control logic (i.e. sensor, processing software and actuator reacting to input parameters), apply to almost every product and are often not explicitly marketed as 'smart'. Also the ability of a product to detect through embedded software the specific conditions of a test situation and autonomously adjust the product's performance and/or resource consumption in order to achieve more favourable test results takes is based on the principle of internal adjustment.

As the software is installed prior to putting the product into service, it is rather probable that it is active also during the compliance test. Thus, the technical operation principle 'internal adjustment' is potentially prone to circumvention.

The act of circumvention might go beyond simple control logic: circumvention seems to be a more sophisticated or 'intelligent' processing. However, smartness might not necessarily be a precondition for circumvention based on internal adjustment: if a standard test situation is clearly differing from real-life conditions, e.g. through dedicated parameters such as stable ambient conditions over a certain time (apparent for refrigerators with no door openings under test), or a certain sequence of cycles, a more sophisticated or smart (= 'intelligent') processing might even not be necessary for the product to detect being under test; simple control logic programmed explicitly towards recognizing these test conditions and adjusting might be sufficient.

'Internal adjustment' as underlying principle for circumvention is already covered by the EU Energy label legislation, but so far not by all EU Ecodesign regulations (cf. sections 3.3 and 3.4).

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7.4.2 Learning appliances (adaptive control)

The technical operation principle 'learning appliances (adaptive control)' is marketed as smart. So far, the learning principle itself is often not adequately applied in standard measurements (which often require stable conditions and might be too short for a learning period), but rather included to test the claimed smartness of the product and check whether the provided bonus (on energy efficiency) for the smart control is justified. Appliances, tested without using the adaptive control, might not be found non-compliant, although the test result not sufficiently reflects the use of resources as perceived later in consumers' daily life. With regard to circumvention, the embedded intelligent processing software might also be misused to circumvent (which relates to the technical operation principle 'internal adjustment'). Theoretically, the embedded software might also be pre-set in a way to gain advantageous results under test (only), but using the 'intelligent' control to apply alterations of the performance (e.g. increased consumer convenience at the expense of energy efficiency) within a short period after putting the product into service.

In learning appliances, often explicitly marketed as 'smart', processes are adapted to sensory collected information, and then future predicted (real-life) usage patterns of the appliance. In case of this kind of adaptive control, the inputs not only lead to actions, but at the same time, they are also used to shape the parameters of the control algorithm. The process has to be based on 'intelligent' programme logic (measuring real-life usage over a certain time; reacting to several input parameters and autonomously adjusting the actuator based on complex algorithms).

In contrast to software updates which are uploaded to the appliance through external communication only at a certain time after delivery, the software of learning appliances is assumed to be integrated and activated already at the time of delivery, i.e. being available at the time of performing the test standards for the declaration of conformity. Nevertheless, these adaptive control systems become mainly effective during real-life, i.e. after the product has been placed on the market, when learning throughout the application in households. Even if the learning system would be active under test, the duration of a test is in most cases too short for the learning system to be effective as the learning process requires some time, very likely longer than the test period. Also adaptive control requires different conditions and inputs to learn from, whereas the aim of many test procedures is to prescribe stable conditions. In principle, however, if the adaptive control is relevant for a certain function, it could be taken into account in the measurement procedure[17] by specifying a certain 'learning condition or phase' under test as well.

So far, only few learning appliances are already addressed by ecodesign and energy labelling legislation. For example, Regulation (EU) No 814/2013 with regard to ecodesign requirements for water heaters and hot water storage tanks already has integrated such measurement approach[18].

[17] If not yet in the standard, then at least in the verification procedure in the regulation
[18] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32013R0814&from=EN

According to Annex III (general conditions for testing water heaters) of the regulation, measurements shall be carried out using pre-defined load profiles with specific conditions for testing the smart control compliance of (smart) water heaters:

> *Where the manufacturer deems it appropriate to declare the value of smart as being '1', measurements of the weekly electricity and/or fuel consumption with or without smart controls shall be carried out using a two-week measurement cycle as follows:*
>
> - *days 1 to 5: random sequence of load profiles chosen from the declared load profile and the load profile one below the declared load profile, and smart control* disabled,
> - *days 6 and 7: no water draw-offs, and smart control* disabled,
> - *days 8 to 12: repetition of the same sequence applied for days 1 to 5, and smart control* enabled,
> - *days 13 and 14: no water draw-offs, and smart control* enabled.
>
> *The difference between the useful energy content measured during days 1 to 7 (smart control disabled) and the useful energy content measured during days 8 to 14 (smart control enabled) shall not exceed 2 % of the reference energy of the declared load profile.*

The inclusion of the smart control in the water heater regulation and the test of the effect were only done to test the claimed smartness of the product and check whether the provided bonus on energy efficiency for the smart control is justified. However, as the same load profile as predefined in the measurement method is used both for the smart control being disabled and enabled, the real-life learning process seems to be only limitedly represented. Thus, process changes initiated through learning and adaptive control in real life will probably still result in different – better or worse – performance parameters or use of resources compared to those measured and declared according to the relevant delegated or implementing act at the time the product was placed on the market. The test result will not sufficiently reflect the use of resources as perceived later in consumers' daily life (might not be found non-compliant, but 'missing representativeness'). This would also be the case for test situations performed without the learning function activated at all.

With regard to circumvention, the embedded 'intelligent' processing software related to the adaptive control function might be programmed in a way to circumvent by automatic detection of the test situation and alteration of the product performance and/or resource consumption *during* test (though this would then relate to the technical operation principle of 'internal adjustment'). Theoretically, the embedded software of the smart appliance might also be pre-set in a way to gain advantageous results under compliance testing (only), but then applying alterations of the performance (e.g. increasing consumer convenience at the expense of energy efficiency) within a short period after putting the product into service through applying the adaptive control principle – this act would fall under point c of the ANTICSS definition of circumvention, cf. section 4).

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Therefore, it is recommended that:

- learning appliances should be consistently addressed by ecodesign and energy labelling legislation and standards, by including certain variable conditions to test the effect of smart controls being enabled;
- for product groups, where the learning function does not represent the main functionality but rather added value (such as water heaters functioning also without adaptive load profiles, based on a predefined water withdrawal pattern), legislation should specify requirements for smart controls being both disabled and enabled;
  for those products, it should be able to set a safeguard clause for the consumer having the right to have the smart function(s) disabled by the manufacturer before the delivery of the purchase products – or being later deactivatable by the consumer itself with no adverse consequences for the functioning of the product as intended; and
- for product groups where the learning function represents the basic functionality and cannot be disabled under test[19], appropriate test standards have to be developed including representative user patterns that sufficiently represent the learning process to test their compliance to mandatory ecodesign requirements.

7.4.3 External control

The technical operation principle 'external control' is often marketed as 'smart'. Appliances, tested without using the external control, might not be found non-compliant, although the test result not sufficiently reflects the use of resources as perceived later in consumers' daily life. With regard to circumvention, the embedded processing software might also be misused to circumvent (which relates to the technical operation principle 'internal adjustment'). Theoretically, the embedded software might also be pre-set in a way to gain advantageous results under test (only), but using the external control to apply alterations of the performance (e.g. increased consumer convenience at the expense of energy efficiency) within a short period after putting the product into service.

Many products marketed as 'smart appliances' often highlight possibilities for external control via internet connection, such as remote control function via smartphone app, within a smart home network or for the purpose of demand side flexibility. Process adaptation is triggered through external impulses by the consumer, via energy management network, or by the energy provider.

These external control systems become mainly active during real-life, i.e. after the product has been placed on the market. In principle, however, if external control is relevant for a certain function such as demand side flexibility of a product, it could be taken into account in the measurement procedure[20] by specifying a certain 'condition', e.g. connecting the product to a

[19] For example, if the smart navigation software of vacuum cleaner robots is disabled, the robot cannot provide its basic cleaning function.
[20] If not yet in the standard, then at least in the verification procedure in the regulation

network and applying an external trigger under test as well. Nevertheless, process changes initiated through external controls in real life will probably result in different – better or worse – performance parameters or use of resources compared to those measured and declared according to the relevant delegated or implementing act at the time the product was placed on the market. Thus, the test result might not sufficiently reflect the use of resources as perceived later in consumers' daily life (might not be found non-compliant, but 'missing representativeness').

With regard to circumvention, not the fact that the control is external is relevant; however, the embedded processing software related to the control function might also be used to circumvent (though this would then relate to the technical operation principle of 'internal adjustment'). Theoretically, the embedded software of the smart appliance might also be pre-set in a way to gain advantageous results under compliance testing (only), but then applying alterations of the performance (e.g. increasing consumer convenience at the expense of energy efficiency) within a short period after putting the product into service through applying the external control principle – this act would fall under point c of the ANTICSS definition of circumvention, cf. section 4).

Currently, external control features in energy related products are not addressed by ecodesign or energy labelling legislation and in the relevant standards. However, the Ecodesign Preparatory Study on Smart Appliances has set an explicit focus on 'energy smart appliances', which are defined as appliances that are able to automatically respond to external stimuli e.g. price information, direct control signals, and/or local measurements (mainly voltage and frequency)[21]. It is recommended that further standardisation and regulations should take into account this aspect horizontally, as several product groups would be affected; thus, they should consider and systematically take into account external control principles and their possible effects.

[21] Cf. http://www.eco-smartappliances.eu/Documents/Task_7(2)SEC2_22102018_FINAL.pdf

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7.5 Software updates as implementation principle

The implementation principle 'software updates' via network connection is partly marketed as 'smart'. Appliances, tested without installed software updates, might not be found non-compliant, although the test result might not sufficiently reflect the use of resources as perceived later in consumers' daily life after an update.
If not included into compliance testing, i.e. before its placing on the market, software updates cannot be misused for 'circumvention' in the sense of automatic detection of the test situation and alteration of the product performance and/or resource consumption *during* test.
However, depending on the design act, software updates might fall into the categories of 'circumvention' (part c of the ANTICSS definition), or 'jeopardy effects' if the product is specifically designed in a way to reach favourable results in the compliance test, but changes performance parameters either through automatic pre-set of a software update or offering the update sometime after the compliance test which makes it more performant to the consumer but at the expense of e.g. energy efficiency.

Product functioning can be modified through a software update provided sometime after delivery through external communication between the appliance and the manufacturer, third parties or even other users. This requires a communication channel, i.e. the product is connected to a network. Software updates have multiple purposes, e.g. security updates, fault elimination or software enhancement, improving the operation of hardware, peripherals, the performance or overall lifetime, as well as adding new programmes, functions and features. The potential benefits of installing or drawbacks when rejecting them might be different depending on consumers' needs. For example, ensuring that the device remains cyber-secure after newly discovered cyber security vulnerabilities is rather important and might have severe consequences, if the update is not installed, whereas the availability of new convenience features might not be so relevant for some consumers.

Software updates are mainly executed in real life after the product has been placed on the market; if not included into compliance testing, i.e. before its placing on the market, software updates cannot be misused for 'circumvention' in the sense of automatic detection of the test situation and alteration of the product performance and/or resource consumption during test (point a of the ANTICSS definition of circumvention, see section 4). Nevertheless, process changes due to software updates might not sufficiently reflect performance or use of resources as measured and declared for the product at the time of its placing on the market when tested according to the standard for the relevant delegated or implementing act any more. This would fall into the ANTICSS category 'compliant to legislation' but not sufficiently reflecting performance or use of resources as perceived by consumers in daily life ('missing representativeness')[22].

[22] Software updates might lead to better, but also worse energy efficiency and/or resource consumption of the product in consumers' in daily life.

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To address this issue, software updates are explicitly addressed in the second part of Article 6 on circumvention[23] as included in new product specific Ecodesign regulations (cf. chapter 3.4). According to Article 6 of Ecodesign Regulations, the energy consumption and any of the other declared parameters shall not deteriorate after a software or firmware update except with the explicit consent of the end-user prior to update. The form the consent has to be applied is not described, but the verification of its presence is foreseen and also the magnitude of increasing energy consumption cannot make the product non-compliant with the applicable ecodesign efficiency requirements. In addition, no consequences shall arise if the update is not confirmed by the end-user (for example, the end-user cannot be forced to agree to higher energy consumption if he is said that otherwise the appliance would not function any more). Verification by market surveillance in the specific Annex of the new regulations will check all manufacturers' obligations.

The requirements on software updates including confirmation by the end-user as stated in the regulation apply to products placed on the market. However, verification is even possible when the product is already for some or even a long time on the market (the same applies to lifetime requirements): in that case, current software update has to be downloaded during verification; energy consumption and performance will be measured and checked if any of the parameters deteriorate after the update. It is also assessed whether the user is asked for confirmation. If at the moment of verification no software update is available, then these requirements do not apply.

According to ANTICSS understanding, depending on the design act, software updates might also fall into the categories of 'circumvention' (part c of the ANTICSS definition), or 'jeopardy effects' if the product is specifically designed in a way to reach favourable results in the compliance test, but changes performance parameters either through automatic pre-set of a software update or offering the update sometime after the compliance test which makes it more performant to the consumer but at the expense of e.g. energy efficiency, see also Table 7-2.

Table 7-2: Allocation of software updates to the categories 'circumvention', 'jeopardy effects', 'compliant' and 'non-compliant'

Circumvention	As software updates are usually applied only sometime after putting the product into service, i.e. mainly not being included into the test standards so far, they cannot fulfil the act of 'circumvention' in the sense of automatic detection of the test situation and alteration of the product performance and/or resource consumption *during* compliance testing (point a of ANTICSS definition). Software updates might fall under point c of the ANTICSS definition of 'circumvention' if the product is specifically designed for the compliance test in a way to reach favourable results for any of the parameters specified in the relevant delegated or implemented act or included in any of the documentations provided for the product, but at the same time *pre-set* to alter the performance within a short period after putting the product into service through automatic download and installation of a software update and with the effect that the product would get a lower energy efficiency class on the label.

[23] The title of the circumvention article in the ecodesign regulations that were agreed upon most recently was changed into 'Circumvention and software updates'.

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Jeopardy effect	If a software update offered to the consumer leads to improved performance of the product on the one hand, but at the expense of the energy efficiency or any other of the declared parameters, then this would fall under the ANTICSS category of 'Jeopardy effects' which encompasses design aspects of products or test instructions, or interpretation of test results which do not follow the goal of the EU ecodesign and/or labelling legislation of setting ecodesign requirements and providing reliable information about the resource consumption and/or performance of a product.
Compliant	According to Article 6 of some latest Ecodesign regulations (cf. section 3.4), the deterioration of the energy consumption and any of the other declared parameters after a software or firmware update is compliant to legislation provided that the explicit consent of the end-user prior to update is obtained and the magnitude of increasing energy consumption does not exceed the applicable ecodesign minimum requirements.
Non-compliant	Software updates would be non-compliant if the obligation to obtain explicit consent of the end-user prior to an update is not fulfilled. Software updates would be non-compliant if the magnitude of increasing energy consumption would exceed the applicable ecodesign minimum requirements.

With regard to ecodesign and energy label legislation and standards, it is at least recommended to

- Ideally include a 'typical' software update into standard measurements to check how the appliance reacts and performance alters;
- Specify better in which form the consent of the end-user has to be applied, and if the magnitude of the increasing energy consumption should also be communicated;
- Specify how to verify (for energy labelling) the resulting changes with regard to the energy labelling class since the updated product is already placed on the market and therefore not covered by the framework legislation nor by any product specific delegated act. To explain: Article 6 only relates to Ecodesign, i.e. the product will only become non-compliant if the ecodesign minimum requirements are not fulfilled anymore. However, not covered by non-compliance is, if the product still complies with the Ecodesign minimum requirements, but the software update would lead to a lower energy efficiency class (loophole in regulation).
- Specify in which form the verification has to be done that no consequences shall arise if the update is not confirmed by the end-user, since again the updated product is already placed on the market and therefore not covered by the framework legislation.

Further, beyond ecodesign and energy labelling legislation, the consumer rights in case of software updates leading to deteriorating energy and/or performance parameters higher than what the manufacturer claims when asking for the consent to the software update should be clarified (e.g. right of return of the appliance).

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7.6 General recommendations

Horizontal regulatory approach with regard to 'circumvention' under EU Ecodesign and Energy label

Current EU Ecodesign and Energy labelling legislation still use different terms and explanations to describe the acts related to circumvention that shall be prohibited (cf. sections 3 and 4 of this working paper). Parallel to the energy labelling framework regulation, some of the new or revised product specific Ecodesign regulations explicitly address 'circumvention' as well as 'software updates' (Article 6), with the initial article on software updates recently further improved. However, so far this Article is not applied to all, i.e. also existing Ecodesign regulations; further, the new provisions for software updates only relate to Ecodesign minimum requirements, not to possible deterioration of Energy Efficiency classes of the Energy label. Finally, according to ANTICSS understanding, 'circumvention' covers more than just the automatic detection of the test situation and alteration of the product performance and/or resource consumption during test. Collected suspect behaviour cases within ANTICSS show that also by pre-set or manual alteration of the product, affecting performance and/or resource consumption during test or pre-set alteration of the performance within a short period after putting the product into service should fall under the definition of circumvention.

Against this background, it is highly recommended that in future at least the specific Article 6 on 'circumvention and software updates' should be included in all new as well as revised product specific ecodesign regulations. However, to avoid a patchwork, different or not comprehensive enough definitions or even loopholes, a horizontal measure, i.e. in the EU Ecodesign Directive would be preferred.

Provision of 'Extended documentation package' to MSAs with regard to software specifications

Similar to the provisions and recommendations included in the Commission Notice on 'Guidelines for specifying the conditions for the application of these defeat devices or auxiliary emission control strategies' with regard to Regulation 715/2007 on type approval of motor vehicles (cf. section 3.1), a so called 'extended documentation package' is recommended to introduce also for EU Ecodesign and Energy label legislation.

For example, the manufacturer should be obliged to provide an extended documentation package to Market Surveillance Authorities with information on the software specification of their products and the operation of all 'smart' strategies including a description of the parameters that are likely to be active under the conditions of the test procedures set out in the Regulation. The extended documentation package could be a separate technical file to back up conformity and might include the following information:

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(a) A declaration of the manufacturer that the appliance does not contain any (smart) control strategies being used for circumvention;

(b) a description of the smart control strategies and devices employed, whether software or hardware, and any condition(s) under which the strategies and devices will not operate as they do during compliance testing;

(c) a declaration of the software versions used to control smart functions, including the appropriate checksums of these software versions and instructions to the authority on how to read the checksums; the declaration shall be updated and sent to the Market Surveillance Authority that holds this extended documentation package each time there is a new software version that has an impact to the performance of the appliance.

For conformity assessment, Market Surveillance Authorities are required to assess, on the basis of the technical information contained in the extended documentation package, whether the (smart) control strategy might be used for circumvention, and, if so, whether the smart control is still justified pursuant to the Regulation, or whether the compliance approval must be refused due to the application of prohibited circumvention.

Even if such information might be difficult to interpret by MSAs so far, with the right level of technical expertise it should be possible to spot programming intended to circumvent a test situation. Probably, this would require further capacity building and/or assistance by dedicated experts for MSAs or test laboratories to enhance their expertise.

Alternative testing protocols for circumvention recognition

For Market Surveillance Authorities the unambiguous identification of circumvention through testing products with current standards is challenging. It is possible to detect 'suspect' behaviour indicating possible circumvention when the product e.g. automatically switches off (sub)functions, or when the performance of the product decreases unexpectedly during the test (compared to what can be expected according to the product information or recognised state of the art for that product category). Circumvention might also be detected when comparing the product's behaviour under test with product behaviour in real life conditions.

For example, to test possible misuse of software updates, verification should be repeated when the product is already for some or even a longer time on the market. For re-verification, current software update(s) should be downloaded and tested if any of the energy consumption or performance parameters deteriorate after the update.

Further, similar to the provisions and recommendations included in the Commission Notice on 'Guidelines for specifying the conditions for the application of these defeat devices or auxiliary emission control strategies' with regard to Regulation 715/2007 on type approval of motor vehicles (cf. section 3.1), it is recommended that appliances should be tested under variations of the standard testing conditions ('modified testing conditions').

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These are not fixed but kept open due to the need to detect specific technology behaviours in response to a complex set of parameters and the need to keep a non-predictable character.

Usually, the relation between most ambient and use variables on one hand and energy consumption on the other hand is continuous (and even linear): a small change in ambient temperature results normally only in a small change in the energy consumption of the refrigerator; a small change in water inlet temperature results in a proportionate change of the energy consumption of the wash cycle. Moreover, in these cases a physical explanation of the relation exists. An indication for circumvention is when a small change in a variable results in a disproportionate change in energy consumption, e.g. when one door opening during a refrigerator test would increase energy consumption with 10 %. It could be even the case that a small change in a variable that should have no relation with the energy consumption would result in an increase in energy consumption.

Thus, to facilitate the evaluation of the modified tests conditions, it is recommended to develop testing thresholds corresponding to acceptable performance parameter increases per combinations of different ambient conditions. Any appliance test that falls above those testing thresholds should be classified at least as a 'suspicious' case or even as circumvention.

However this approach requires not only alternative test procedures to be defined[24], but also extended resources for MSAs to run such tests.

[24] It has to be noted that alternative testing protocols might not be possible for all product categories under EU ecodesign and energy labelling regulations. For some product categories with compressor included, for example the compressor has to be fixed to reach stable conditions as otherwise the results would not be reliable and representative. Thus, it should be carefully checked for which product groups such an approach would be practicable.

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Austria: BMDW - Bundesministerium für Digitalisierung und Wirtschaftsstandort

Belgium: ECOS - European Environmental Citizens Organisation for Standardisation

Belgium: BHTC - Service public federal sante publique, securite de la chaine alimentaire et environnement

Czech Republic: SEVEn - SEVEn, the Energy Efficiency Center, z.u.

Czech Republic: SEIA - Státní energetická inspekce

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Netherlands: NVWA - Nederlandse voedsel en warenautoriteit

Portugal: ADENE - Adene-agencia para a energia

Portugal: ASAE - Autoridade seguranca alimentar e economica

Spain: FFII – LCOE - Fundacion para el fomento de la innovacion industrial

Spain: CM - Comunidad de Madrid

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