

PAS 1878:2021

Energy smart appliances – System functionality and architecture – Specification



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Foreword

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Relationship with other publications

PAS 1879:2021, *Energy smart appliances – Demand side response operation – Code of Practice*.

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Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Requirements in this PAS are drafted in accordance with *Rules for the structure and drafting of UK standards:2017*, subclause **G.1.1**, which states, “Requirements should be expressed using wording such as: ‘When tested as described in Annex A, the product shall ...’”. This means that only those products that are capable of passing the specified test will be deemed to conform to this PAS.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

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0 Introduction

0.1 Purpose

The purpose of this PAS is to enable standardized control, subject to an explicit consumer consent, of energy smart appliances (ESAs) on an electricity network in order to:

- match the short-term availability of intermittent renewable energy generation sources such as wind and solar;
- decrease the peak load on the electrical transmission and distribution networks to alleviate the need for network upgrades to handle new domestic appliance types, such as electric vehicle (EV) chargepoints and electric heating, ventilation and air conditioning (HVAC) systems;
- allow control of electricity network characteristics such as line frequency, system inertia and network voltage, and help prevent network and generation outages; and
- to allow the offset of short-term market imbalances by controlling flexible load on the network.

These aims are achieved by shifting (in time) and/or modulating (increasing or decreasing) the collective electricity consumption or production of domestic appliances, in line with consumer preferences and agreement, in response to signals from grid-side actors.

At longer timescales and with sufficient notice, consumer behaviour change can be achieved through electricity suppliers altering the tariff that electricity consumers pay, which encourages the use of appliances at times outside of peak demand or at times when excess generation capacity is expected to be available. This is called the “routine” method and is delivered through electricity suppliers setting time of use (ToU) tariffs. For rapid load responses and for control by other grid-side actors, direct control of load is required, and consumers are rewarded for allowing their appliances to be controlled for the overall benefit to the network. This is known as the “response” method. These methods are collectively called demand side response (DSR).

These methods aim to provide benefits to all electricity consumers. Such benefits might be indirect, as domestic appliances providing DSR services support network operation, which benefits all consumers connected to the network. Such benefits might also be direct, additional benefits may accrue to consumers willing to invest in and adopt appliances containing the ESA functionality and communication capabilities. Consumers with ESAs can reduce their electricity costs by operating domestic appliances using the Routine method, and can earn revenues by allowing domestic appliances to be controlled flexibly using the Response method. Actors providing these revenue opportunities to consumers are encouraged to make these benefits clear to encourage the uptake of domestic appliances able to support network operation.

It is also expected that other energy -related services might be offered in addition to the minimum specification set out in this PAS and PAS 1879:2021, such as optimization of rooftop solar self -consumption with appliances or battery storage, that can provide additional benefits for consumers. The IEC 60364 series of standards provide guidance on the information exchange within prosuming electrical installations, e.g. IEC TS 60364-8-3:2020, Table 1.

This PAS provides a technical specification that allows domestic appliances to operate in such a DSR system and it is intended to be read in conjunction with PAS 1879:2021, which provides recommendations for the provision of DSR services by service providers.

0.2 Demand side response and energy smart appliances

Response mode DSR requires communication between domestic appliances and a controlling entity, which itself communicates with the appropriate regulated electricity market participant. This controlling entity is termed the “DSR service provider” (DSRSP) in this PAS. More than one DSRSP might be associated with a single premises at any one time but an appliance is associated with only one DSRSP at any one time.

The role of the DSRSP and the environment in which it operates is described in PAS 1879.

Functionality in addition to that offered by these ESAs, such as communications gateway functionality depicted as “customer energy manager (CEM)”, Energy Management Gateway and “ESA gateway (ESAG)” in Figure E.1, is also required in an end-to-end DSR system and is treated in this PAS as a necessary component of the entire system.

The diagram illustrates the smart metering system architecture. It shows the following components and their connections:

- Regulated Electricity Market Participant** (grey box) connected to the **Demand Side Response Service Provider (DSRSP)** (orange box) via a bidirectional arrow.
- Supplier/meter Electricity Market Participant** (grey box) connected to the **Smart metering system** (yellow box) via a bidirectional arrow.
- Electricity grid** (grey box) connected to the **Smart metering system** (yellow box) via a bidirectional arrow.
- Demand Side Response Service Provider (DSRSP)** (orange box) connected to the **Customer Energy Manager (CEM)** (orange box) via a bidirectional arrow labeled **Interface A**.
- Customer Energy Manager (CEM)** (orange box) connected to the **Energy Smart Appliance (ESA)** (blue box) via a bidirectional arrow labeled **Interface B**.
- Smart metering system** (yellow box) connected to the **electricity meter** (yellow box) via a bidirectional arrow.
- Electricity grid** (grey box) connected to the **electricity meter** (yellow box) via a solid line.

Key:

- Communications connections in scope of PAS 1878
- Optional communications connections in scope of PAS 1878
- ⇄ Communications connections out of scope of PAS 1878
- Mains low voltage electricity
- Out of scope

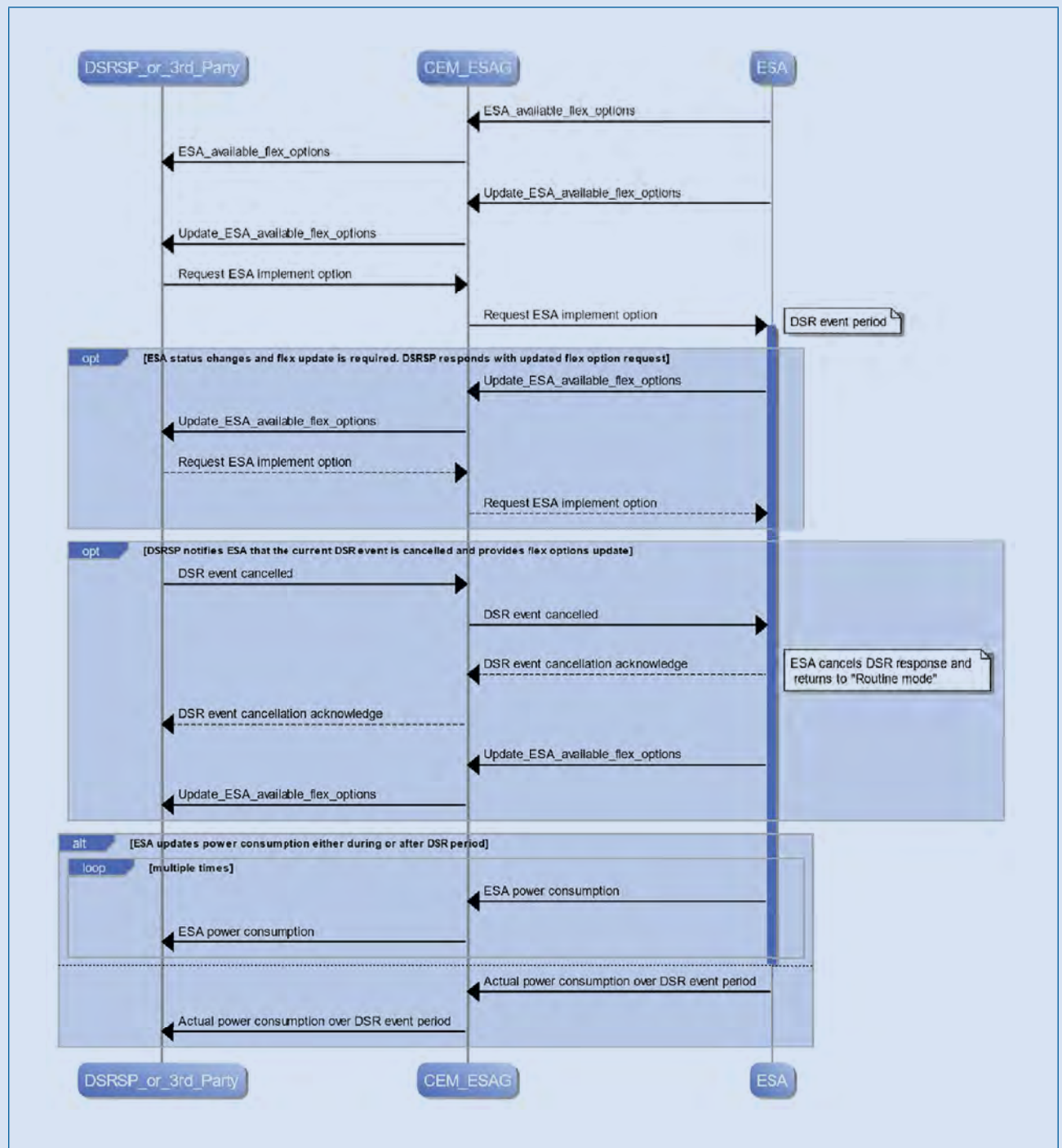
In order to support a minimum level of DSRSP and ESA interoperability for every ESA type, this PAS requires that each ESA is supplied with a CEM and an ESAG. These are logical entities and can be provided with the ESA in a number of ways. For example, they can be built into the ESA, supplied as separate physical units, provided as software operating in the cloud or another device such as a mobile broadband station, or provided as part of the smart metering system. One CEM could connect to multiple ESAs. A combined CEM/ESAG can be offered. In this PAS, “CEM” also indicates a CEM/ESAG combination or an individual CEM as appropriate unless otherwise stated.

0.3 Operational model

The DSR system operates in the following manner, in accordance with Figure 1 and as illustrated in Figure 2 (where the CEM and ESAG have been combined for the sake of clarity).

- a) The ESA determines its flexibility offers (taking into account consumer preferences and, optionally, electricity tariffs) and provides them to the DSRSP, using the CEM/ESAG as an intermediary. The CEM communicates with the DSRSP using a common interface specified in this PAS.
- b) This information is updated whenever the flexibility status of the ESA changes (e.g. the consumer turns the ESA on or off) or a flexibility offer is no longer valid (e.g. it has expired or been cancelled by the consumer).
- c) The DSRSP maintains an up-to-date list of the possible flexibility offers provided by the CEM on behalf of the ESAs that it manages.
- d) Whenever the DSRSP is requested to perform a DSR operation, the DSRSP is able to select its chosen flexibility and time parameters from its portfolio of flexibility offers.
- e) The DSRSP then sends a message to a selected number of ESAs, via their CEMs, requesting that they implement one of their provided flexibility offers. The ESA implements this flexibility offer and enters response mode.
- f) During the DSR event period:
 - 1) each ESA continues to provide the DSRSP with updated flexibility offers whenever its flexibility status changes. The DSRSP may respond by sending an updated flexibility offers request;
 - 2) if the DSRSP decides to cancel the participation of a particular ESA in the current DSR event or if the DSR event is cancelled, then the DSRSP informs the ESA, via the CEM. The ESA acknowledges this cancellation, enters routine mode and sends an updated set of flexibility offers to the DSRSP;
 - 3) depending upon the requirements of the DSRSP and subject to prior agreement, the ESA might periodically send power consumption information to the DSRSP;
 - 4) the consumer might change their preferences, which can in turn override the ESA flexibility offer and require the ESA to return to its routine mode.
- g) Once the DSR event period is completed, the ESA provides the DSRSP with information concerning its power consumption throughout the period. This step might be omitted if the ESA has been providing periodic power consumption information.
- h) The DSRSP is then able to provide aggregated flexibility verification information to the grid-side actor which requested the DSR service (including real-time power consumption values).

Figure 2 – DSR system operational flow



0.4 Alignment with DSR and ESA policy principles

There are four principles that are seen as critical for effective DSR through ESAs. This PAS aligns with these principles as described below.

- a) **Interoperability:** The ability of an ESA to work seamlessly across any appropriate DSR service operated by any authorized system actor. In order that DSR signals can be communicated to all ESAs, open standards to support interoperable commands and languages are essential for enabling free consumer choice, and thereby a competitive market. Communications to and from the ESA to the DSRSP are necessary.

The key aspect of interoperability in this PAS is to allow a consumer to switch an ESA to a different DSRSP at any time and maintain DSR functionality without the need to purchase or install any new equipment, or the need for a home visit from an installer or supplier of equipment. This is supported by the definition of the minimum required common data model, information model and communication protocol, performance and security requirements for the interface between the DSRSP and CEM.

- b) **Data privacy:** The secure transmission and storing of data on the device or with any controlling party. Only the minimum amount of data needed to operate a DSR service is shared with DSRSPs. Consumers need to be in control of any data exchanged with third parties arising from the ESAs, with clear consent procedures that allow them to make informed decisions regarding data sharing and to update their consent as appropriate.
- Personal data, if required, is stored in a secured area in an ESA and all communication in the DSR system includes authentication and encryption. Personal data is transferred between components of the DSR system only if absolutely necessary, and is limited as much as possible. Such data is not transferred without the knowledge and permission of the consumer. Data privacy standards and guidelines are referenced as appropriate.

- c) **Grid stability:** The prevention of outages on the grid caused by inappropriate operation of ESAs. Consideration should be given to the security of electricity supply, to ensure that ESAs would not represent a risk to its stability.

NOTE 1 *The ability to shift or modulate the electricity consumption or production of ESAs, as specified in this PAS, contributes to maintaining electricity grid stability. This principle focuses on avoiding any ESA operation which could unintentionally be detrimental to grid stability e.g. large load swings at the exact time when a tariff changes price or ESAs' flexibility information being out of date when called for a response.*

ESAs update their flexibility information to DSRSPs whenever their flexibility status changes, so DSRSPs have an up-to-date knowledge of the flexibility available and can iteratively call responses. CEM operation modes are defined with a control hierarchy so that consumer wishes are respected and electricity network operator needs are met.

The DSRSP is able to determine whether or not each DSR event is subject to a randomized timing offset if it decides that such an offset is necessary for grid stability.

In the case of exception conditions (e.g. power loss), the ESA transitions or resets to a mode that brings it into a safe state (see 5.3.5.2.5). This depends upon the ESA type and the manufacturer. The ESA reports its change in flexibility status to the DSRSP whenever possible.

In the event of a loss of communications between the ESA and the DSRSP, the ESA continues with its currently selected flexibility option and logs its power consumption periodically for transmission to the DSRSP whenever communications are resumed. The DSRSP is able to include a timeout value in the flexibility option request message to a CEM or ESA, upon the expiry of which the ESA reverts to routine mode if it has not already done so.

- d) **Cyber security:** the appropriate protection of ESAs from unauthorized access and the correct use of ESAs by authorized parties only in order to achieve valid DSR events. This includes information security of the ESA itself, messages sent between authorized parties and the ESA, as well as the security of local (i.e. home area network) and/or cloud-based networks through which third parties can communicate with ESAs. ESAs, control systems, including those used by DSRSPs, and communications between these parties are covered by this principle. Both consumers and electricity network operators need confidence that ESAs are cyber secure for safety and privacy.

Cyber security is an important aspect of the DSR system. This PAS specifies minimum requirements for the storage and exchange of information between the DSRSP and ESA, and for the authentication of the DSRSP, the CEM, the ESAG and the ESA.

An ESA is required to meet baseline device authentication and verification, including software and firmware checks and updates, communications authentication/encryption and secure data management criteria. Cyber security standards and guidelines are referenced as appropriate.

NOTE 2 *An informative trust modelling exercise is included in the Annexes to PAS 1879.*

0.5 Integration with smart metering systems

DSR operation of ESAs defined within this PAS does not require the use of a smart metering system but is fully compatible with smart metering systems.

NOTE 1 *The options for combining the DSR system architecture with the GB smart metering system specifically are described in Annex D. The DSR architecture does not exclude combination with other smart metering architectures.*

NOTE 2 *In the UK there is currently no regulatory or legal requirement specifically on metering DSR provision. There are regulatory and legal requirements on metering electricity supply. Attention is drawn to Schedule 7 of the Electricity Act 1989 [1] and the Measuring Instruments Regulations 2016 [2]. In the UK, the Balancing and settlement code [3] defines codes of practice which provide further details on settlement metering requirements for consumer electricity supply.*

NOTE 3 *A regulated electricity market participant requesting DSR services might require the DSRSP to evidence delivery of DSR services. This might require an ESA to provide information regarding its power consumption to the DSRSP.*

0.6 Alignment with standards

Standardization of domestic DSR is currently at an immature stage in some areas and work is ongoing within European and International level standards development organizations. The architecture presented in this PAS is aligned with this work carried out in several CEN/CENELEC and ISO/IEC Technical Committees including, IEC TC57 *Power systems management and associated information exchange*, CENELEC TC205 *Home and building electronic systems*, and CENELEC TC59X *Performance of household and similar electrical appliances*.

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1 Scope

1.1 In scope

This PAS specifies requirements and criteria that an electrical appliance needs to meet in order to perform and be classified as an energy smart appliance (ESA). It defines the attributes, the functionalities and performance criteria for an ESA, and specifies how compliance with these can be verified.

This PAS covers:

- the generic, or specific, functional requirements of ESAs, which enable the performance of DSR-based activities;
- the ESA system architecture for DSR-based activities, including communication links and object functionalities and, in particular, the interfaces between the CEM and the ESA and between the CEM and the DSRSP;
- the ESA operational sequence of DSR-based activities, including communication protocols where necessary; and
- relevant ESA lifecycle considerations.

This PAS also covers compatibility with smart meter technologies, specifically full compatibility with the GB smart metering system.

This PAS applies the following criteria in defining the requirements that are to be met by an ESA performing DSR-based activities.

- **Interoperability:** the ability of an ESA to work seamlessly across any appropriate DSR service operated by any authorized system actor.
- **Data privacy:** the secure transmission and storing of data on the device or with any controlling party.
- **Grid stability:** the prevention of outages on the grid caused by inappropriate operation of ESAs.
- **Cyber security:** the appropriate protection of ESAs from unauthorized access and the correct use of ESAs by authorized parties only in order to achieve valid DSR events.

For requirements relating to compatibility with all forms of DSR-based activity, two types of DSR are covered in detail:

- supplier/utility set electricity tariffs; and
- TSO/DSO requested services with responses called by DSRSPs (transmission and distribution network level, including grid frequency sensitive).

This PAS specifies the minimum requirements to perform these DSR-based activities, in line with the four criteria above.

This PAS covers the following electrical appliances that are used in domestic or small business settings¹⁾:

- cold appliances (see 3.1.6);
- wet appliances (see 3.1.6);
- heating, ventilation and air conditioning (HVAC) appliances (see 3.1.19);
- smart EV chargepoints (see 3.1.28); and
- battery storage.

1.2 Out of scope

This PAS does not cover:

- the deployment and functional configuration of the wider DSR environment;
- standards implied by existing relevant overarching regulation, e.g. the general safety or other aspects of the non-smart functionality of an ESA; and
- contracting, payment services or general consumer protections.

1.3 Intended audience for this PAS

This PAS is intended to be used by manufacturers of ESAs and CEMs. Other actors who might have an interest in this PAS are maintainers of ESAs, manufacturers and maintainers of interfacing products, software developers and service providers.

NOTE The specified characteristics of an ESA are complementary with the DSR environment in which it operates, which will be described in PAS 1879, as the characteristics enable the ESA to perform DSR-based activities.

¹⁾ In the UK, this PAS is most applicable to customers in Profile Class 1 – Domestic Unrestricted Customers and Profile Class 2 – Domestic Economy 7 Customers, as defined by Elexon [4].

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions of this PAS²⁾. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

BBS EN ISO/IEC 27000:2018 *Information technology – Security techniques – Information security management systems – Overview and vocabulary* FIPS 186-4, Digital Signature Standard

EN 303 645, v2.1.1 (2020-04), Cyber Security for Consumer Internet of Things: Baseline Requirements³⁾

Non-standards publications

[N1] DCUSA LTD, *Distribution and Connection Use of System Agreement Document, v12.8 Pre-Release_Public*. London. 15 December 2020.⁴⁾

[N2] National Cyber Security Centre (NCSC). *Implementing the Cloud Security Principles*, v1.0. 17 November 2018.⁵⁾

[N3] National Institute of Standards and Technology (NIST). Special Publication 800-56A, Revision 2: *Recommendation for Pair-Wise Key Establishment Schemes Using Discrete Logarithm Cryptography*. Barker, E., Chen, L., Roginsky, A., Smid, M., May 2013.

[N4] Internet of Things Security Foundation (IoTSF). *Secure Design Best Practice Guides, Release 1.2.1*. Day, J., Shepherd, R., Kearney, P., Storer, R., December 2018.

[N5] National Institute of Standards and Technology (NIST), FIPS 140-2, Security Requirements for Cryptographic Modules⁶⁾

[N6] Internet Engineering Task Force (IETF), RFC 8915, Network Time Security for the Network Time Protocol. 2020.⁷⁾

²⁾ Documents that are referred to solely in an informative manner are listed in the Bibliography.

³⁾ Available at https://www.etsi.org/deliver/etsi_en/303600_303699/303645/02.01.00_30/en_303645v020100v.pdf

⁴⁾ Available at <https://www.dcusa.co.uk/dcusa-document/>

⁵⁾ Available at <https://www.ncsc.gov.uk/collection/cloud-security/implementing-the-cloud-security-principles>

⁶⁾ Available at <https://csrc.nist.gov/publications/detail/fips/140/2/final>.

⁷⁾ Available at <https://tools.ietf.org/html/rfc8915>

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this PAS, the following terms and definitions apply.

3.1.1 active period

period within a power profile for which the power value is non-zero

3.1.2 appliance

product or system that consumes, stores or generates electrical energy during its functional use

3.1.3 appliance controller

sub-system of an appliance responsible for controlling the operation of the appliance machinery and power sub-system

3.1.4 appliance machinery

part of an appliance that carries out the main functions of the appliance

3.1.5 auxiliary proportional controller (APC)

device controlled by the GB electricity smart metering equipment and capable of selecting one of a range of values

3.1.6 cold and wet appliances

electrical goods used in a domestic or small business environment, for example refrigerators, tumble dryers and washing machines

3.1.7 consumer

domestic (i.e. individual households) or small business user (i.e. small and medium-size enterprise) who:

- a) has the authority to enter into a service contract with a DSRSP; and
- b) has one or more ESAs that can be subscribed to a DSR service

3.1.8 consumer access device (CAD)

physical or logical device that links the GB smart meter HAN and the consumer HAN, which is permitted to extract real-time energy and tariff data from the smart meter system

3.1.9 customer energy manager (CEM)

logical entity providing functionality used to manage one or more ESAs or ESAGs, specific to a supply point, in order to provide DSR services

NOTE 1 A CEM could either be in a box located in the premises or in the cloud with connectivity to the ESA.

NOTE 2 In this PAS, the term "CEM" indicates a CEM/ESAG combination or an individual CEM, as appropriate, unless otherwise stated.

3.1.10 data communications company (DCC)

entity to establish and manage the GB data and communications network required to connect smart meters to the business systems of energy suppliers, network operators and other authorized service users of the network

NOTE Smart DCC Ltd (DCC) operates under the Smart Meter Communication Licence' [5] which was granted by the Department for Business, Energy and Industrial Strategy (BEIS) and is regulated by Ofgem.

3.1.11 demand side response (DSR)

shifting (in time) and/or modulation (increase or decrease) of electricity consumption and/or production through the controlled operation of ESAs, in line with consumer preferences, in response to signals from, and acting in agreement with, regulated electricity market participants

3.1.12 demand side response service provider (DSRSP)

organization using ESAs to provide demand side-related energy management services to regulated electricity market participants

3.1.13 electric vehicle (EV) chargepoint

equipment enabling the recharging, or in the case of vehicle to grid (V2G) discharging, of an EV

3.1.14 energy flexibility event

action of an ESA or a CEM relating to an energy flexibility request

3.1.15 energy flexibility request

request from a DSRSP to a CEM or ESA to modify load, generation or storage

3.1.16 energy gateway

communications bridge between DSR-related devices located inside and outside the premises

3.1.17 energy smart appliance (ESA)

appliance that meets the requirements specified in this PAS; it is communications-enabled and able to respond automatically to price and/or other signals by shifting or modulating its electricity consumption and/or production

3.1.18 ESA gateway (ESAG)

functional entity between one or more ESAs and a CEM

3.1.19 heating, ventilation and air conditioning (HVAC) appliances

electrical goods used in domestic or small business environments for heating, ventilation or air conditioning

3.1.20 home area network (HAN)

communications network typically deployed over short distances and used within a premises

3.1.21 interoperability

ability of an ESA to work seamlessly across any appropriate DSR service operated by any authorized system player, including allowing a consumer to switch an ESA to a different DSRSP at any time and maintain DSR functionality

3.1.22 local physical interface

interface on the ESA or CEM that can only be accessed physically (e.g. USB port, UART, JTAG port)

3.1.23 local user interface

interface on the ESA or CEM used for user interaction that can only be accessed physically (e.g. buttons, keypad, speaker, touchpad, screen)

3.1.24 network logical interface

logical interface or protocol operating over the network physical interface that connects the ESA or CEM to other entities on a communications network

3.1.25 network physical interface

hardware interface that physically connects the ESA or CEM to a communications network (e.g. Ethernet, radio transceiver)

3.1.26 power profile

series of data points representing the value of power at points in time

3.1.27 premises

geospatial extent owned or occupied by a consumer and containing one or more appliances that consume, generate and/or store electrical energy

NOTE 1 A premises can have a mixture of energy smart and non-energy smart appliances.

NOTE 2 The appliances can be located within the buildings of the premises (for example, domestic white goods) or outside the buildings of the premises (for example, a smart EV chargepoint).

3.1.28 smart EV chargepoint

EV chargepoint that is energy smart through meeting the requirements in this PAS

3.1.29 smart meter

device measuring electrical energy transfer that meets the prevailing national smart meter specification(s) for the country in which the meter is located

NOTE The current specification for GB smart meters is SMETS2.

3.1.30 smart meter home area network (SMHAN)

network used to communicate between smart meters and any device in the home that is authorized to communicate with the smart meter

NOTE 1 This might also be known as a smart meter display or home energy monitor and other items, e.g. smart appliances, as and when they become available.

NOTE 2 In the GB smart metering system this is a Zigbee network.

3.1.31 standalone auxiliary proportional controller (SAPC)

functionality in GB smart metering that will connect to the HAN via the Communications Hub and is capable of containing up to 5 APCs

3.1.32 supply point

point at which a premises connects to the electricity supply network operated by the distribution system operator (DSO) or distribution network operator (DNO)

3.2 Abbreviated terms

For the purposes of this PAS, the following abbreviations apply.

APC	auxiliary proportional controller
CA	certification authority
CAD	consumer access device
CEM	customer energy manager
DCC	Data Communications Company
DNO	distribution network operator
DSO	distribution system operator
DSR	demand side response
DSRSP	demand side response service provider
DUIS	DCC User Interface Specification
ESA	energy smart appliance
ESAG	energy smart appliance gateway
ESME	Electricity Smart Metering Equipment
EV	electric vehicle
HAN	home area network
HCALCS	HAN connected auxiliary load control switch
HEMS	home energy management system
HTTPS	secure hypertext transfer protocol
HVAC	heating ventilation and air conditioning
IoT	Internet of Things
mDNS	Multicast Domain Name System
NTS	Network Time Security
OCPP	Open Charge Point Protocol
OpenADR	Open Automated Demand Response
PII	Personal Identifiable Information
PKI	public key infrastructure
SAPC	standalone auxiliary proportional controller
SMHAN	smart meter home area network
TLS	transport layer security
ToU	time of use
TSO	transmission system operator
UART	universal asynchronous receiver-transmitter
USB	universal serial bus
V2G	vehicle to grid
WAN	wide area network

4 ESA architecture

COMMENTARY ON CLAUSE 4

The ESA energy flexibility architecture is made up of functional elements. Some components have a specified physical implementation (e.g. ESAs need to be in the presence of the consumer), whilst others are only logical with no specified physical implementation (e.g. a CEM is a logical entity, which can operate on a device in the premises or on a server for cloud-based models). Therefore, example physical implementations shown in any figures are illustrative only.

A description of each component is provided in 4.1 to 4.3.

The main components associated with the systems level functional architecture are shown in Figure 3 and described in the following subclauses. This architecture is compatible with the functional architecture described in existing CENELEC and IEC documents (see BS EN 50631-1:2017, BS IEC 62746-10-1:2018, PD IEC/TR 61850-90-8:2016 and BS EN 50491-12-1:2018), as described in Annex E.

The ESA is a physical appliance, an edge processing device, making use of energy smart functionality and is sited on the consumer premises. The CEM is a logical entity providing energy management functionality and may be sited either on the consumer premises or externally to the consumer premises and either as standalone equipment or as part of other equipment including the ESA itself. The DSRSP is a business entity logically connected to a number of ESAs via their CEMs and is sited externally to the consumer premises.

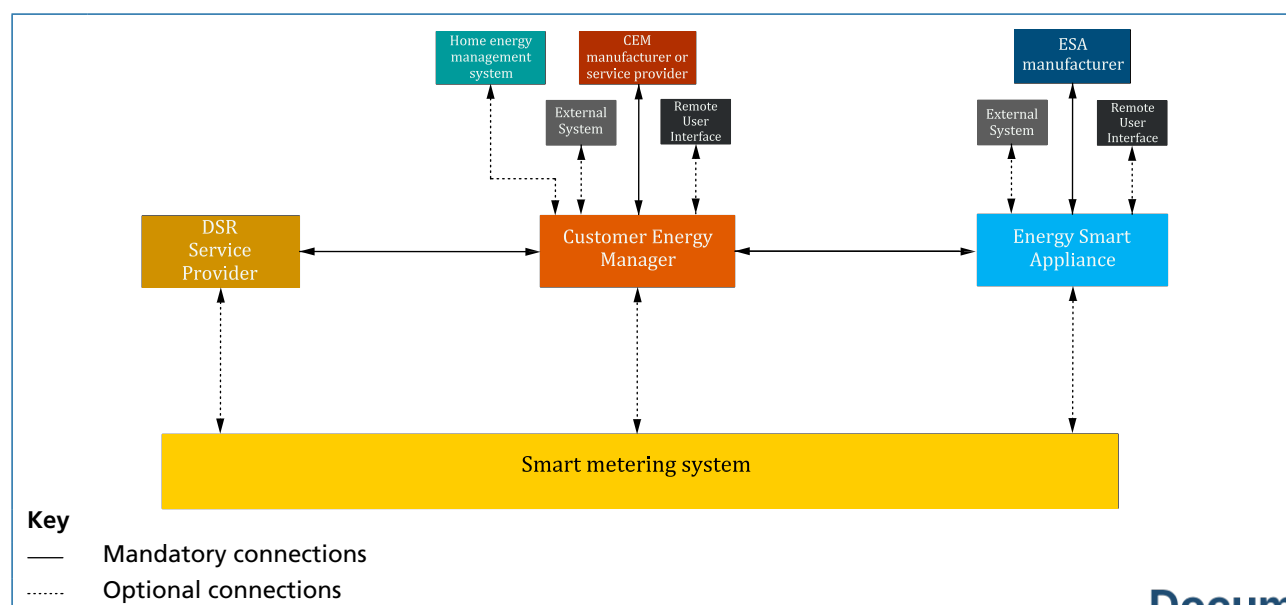
The ESA and CEM provide user interfaces for their energy smart functionality and status which allow the consumer (owner or user of an ESA) to interact with the ESA, CEM and the DSR services provided by the DSRSP.

A CEM is connected to only one DSRSP at any one time. An ESA is connected to only one CEM at any one time. A CEM is connected to at least one ESA.

The CEM and/or the ESA might include an interface to other, non-DSR, services such as remote control applications, service and maintenance, or weather forecasts. The existence, capabilities and connection with DSR services of such interfaces is determined by the manufacturer and is beyond the scope of this PAS.

ESAs can optionally communicate with a smart metering system. Smart metering systems are used to meter electricity at the grid supply point to the premises and to provide associated services. Various different implementations, with different functionalities, exist and are often country-specific. The figures show a generic representation of a smart metering system and the possible interfaces to the DSR system. Details specific to the interfacing of the GB smart metering system are described in Annex D.

Figure 3 – Representation of system level CEM–ESA energy flexibility architecture with separate CEM/ESAG



4.1 Energy smart appliance (ESA)

The operation of the ESA shall be determined by its internal control logic, denoted as the appliance controller in Figure 4. The appliance controller shall send and receive information, and receive requests, across Interface B and the Manufacturer Interface via its Physical Network Interface. The appliance controller shall determine the overall operation of the ESA and shall reject any request that is not applicable (i.e. a request that would result in unsafe, detrimental or otherwise abnormal behaviour).

The ESA shall support at least one network physical interface. The network physical interface shall be used to support the network logical interfaces described in 5.1.2 (Interfaces A and B, the Manufacturer Interface and the User Interface) and might be used to support the network logical interfaces described in 5.1.3. All network logical interfaces shall be logically separate from each other. The ESA shall connect to its manufacturer (or service provider) portal. This connection shall be used to securely download firmware and software updates.

NOTE 1 This connection might also be used for other services.

An ESA shall send registration, de-registration, authentication, flexibility offer, flexibility offer cancellation and status messages to its associated CEM for subsequent communication to the DSRSP. The content and availability of these messages shall be such that the CEM shall be able to apply them to Interface A without loss of information or corruption, in accordance with Clauses 5 and 6.

An ESA shall receive registration, de-registration, authentication, flexibility offer request, flexibility offer cancellation and status messages from the DSRSP via its associated CEM.

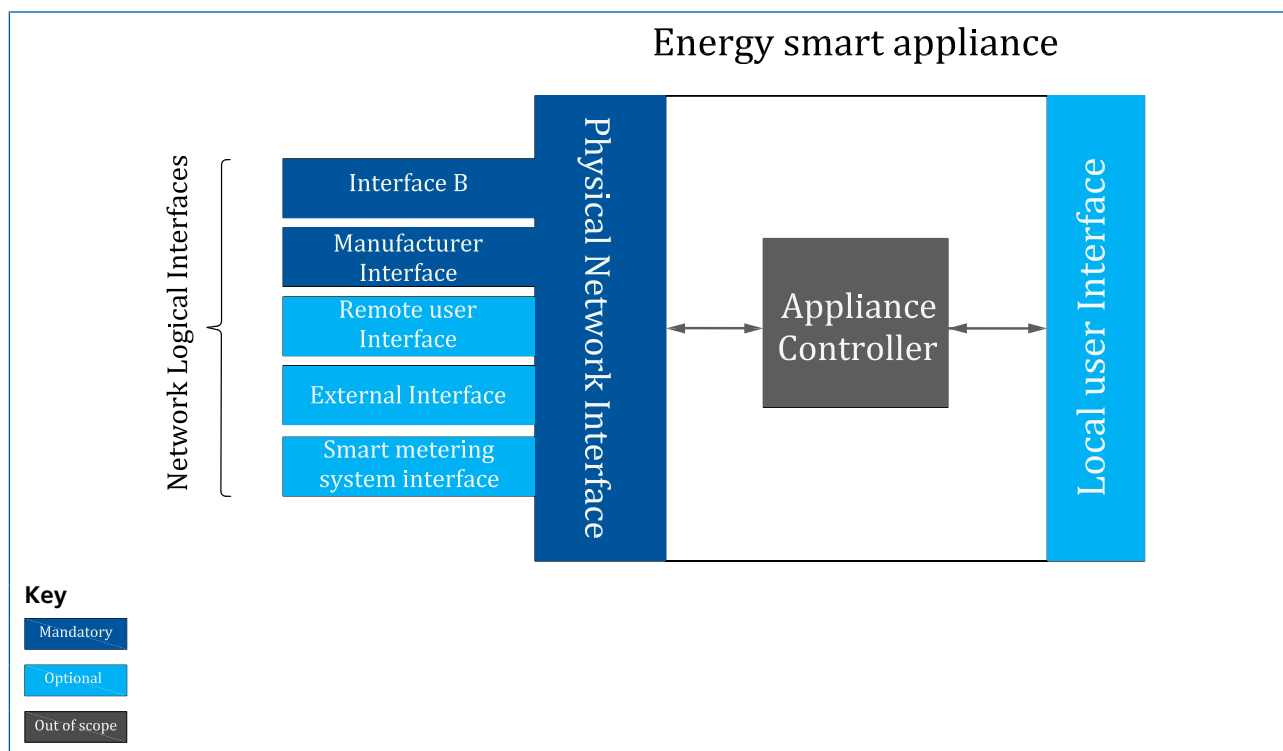
An ESA shall connect to no more than one CEM at any given time.

The ESA shall support a local (built-in) and/or remote user interface for the input of user preferences, ESA DSR operation control and the display of DSR status. The ESA may additionally support a remote user interface for the same purpose.

NOTE 2 The ESA might support other interfaces or functionality related to, for example, general configuration or maintenance. Such interfaces and functionality are beyond the scope of this PAS.

NOTE 3 The specification of the appliance controller is beyond the scope of this PAS.

Figure 4 – Conceptual architecture of an energy smart appliance



4.2 Customer energy manager (CEM)

The CEM shall act as a logical intermediary between a DSRSP and ESAs, interpreting the status of the ESA within the context of the flexibility requirements of the DSRSP, sending flexibility status information to the DSRSP and initiating ESA flexibility actions.

The CEM shall be instantiated either as part of an ESA or in another device in the home or in the cloud.

The CEM shall connect to its manufacturer (or service provider) portal. This connection shall be used to securely download firmware and software updates and might be used for other services.

The CEM shall perform cyber-security operations in accordance with Clause 6 on messages that it receives from, and sends to, an ESA and DSRSP.

The CEM shall perform any reformatting or protocol transcoding on DSRSP-bound messages that it receives from the ESA in order to meet the communications and message format requirements of Interface A in accordance with Clause 5.

The CEM shall perform any reformatting or protocol transcoding on ESA-bound messages that it receives from the DSRSP in order to meet the communications and message format requirements in accordance with 5.3.

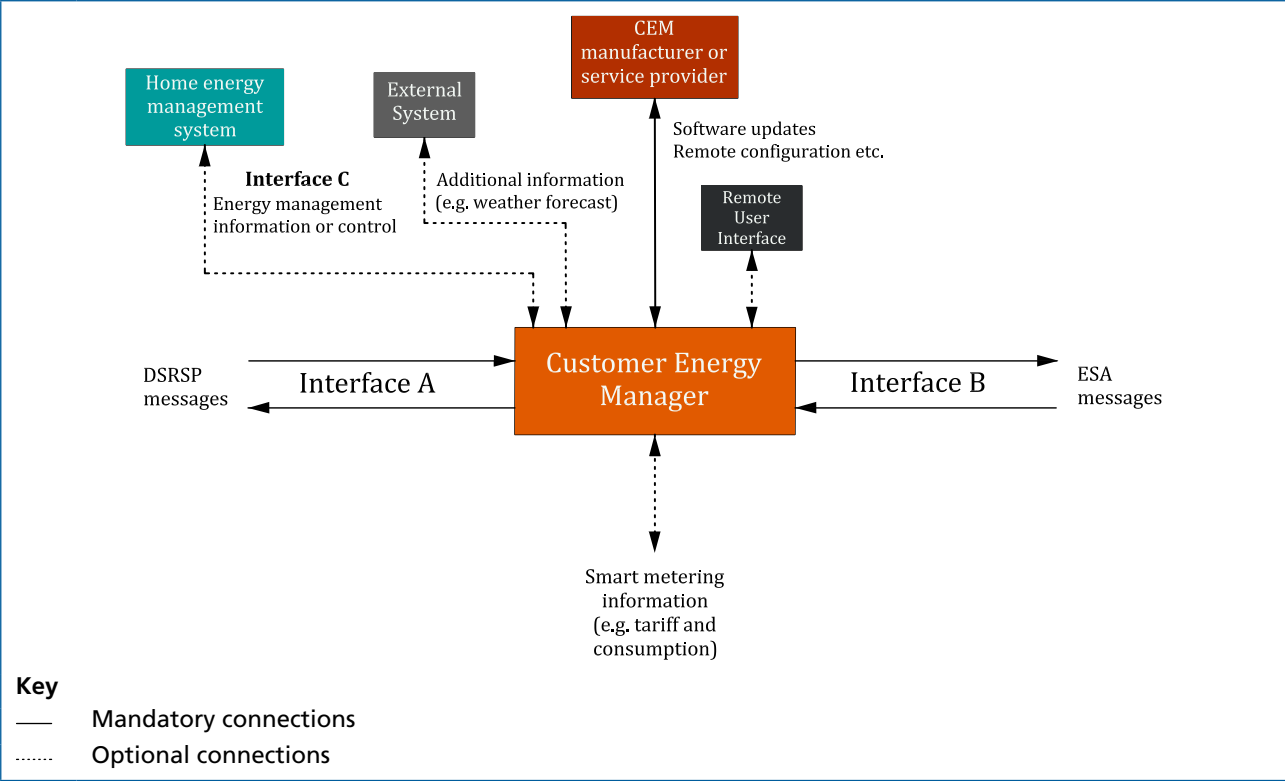
The CEM shall connect to no more than one DSRSP but shall be able to connect to at least one ESA at any given time.

NOTE 1 The CEM might allow the direct transfer of application level message payloads between the energy gateway and ESA, provided that sufficient authentication and integrity checks are performed. The CEM might be implemented on dedicated hardware, within the premises, or as a software entity, either within the premises, outside the premises or distributed across multiple platforms.

NOTE 2 The functionality of the CEM control logic is expected to satisfy a minimum set of requirements to deliver DSR services as set out in this PAS. Defining only a minimum set of requirements for DSR allows manufacturers or operators to provide value-added functionality as they see fit.

The CEM shall present one interface to the DSRSP and another to an ESA as shown in Figure 5.

Figure 5 – CEM interfaces



The CEM may support either a built-in or a remote user interface for the input of user preferences and the display of DSR status.

The CEM shall operate in one of four modes, as described in 5.3.5.2.

The CEM might form part of a Home Energy Management System (HEMS) in order to provide enhanced energy management services including those related to DSR and, if so, shall ensure that it is able to provide services as described in this PAS in addition to these enhanced energy management services.

NOTE 3 *The CEM might receive information from the smart metering system (e.g. tariff and consumption information).*

NOTE 4 *The CEM might optionally support an additional interface to external systems that is used to obtain ancillary DSR-related information such as weather forecasts, to be configured and implemented such that it is at least as secure as Interface A (see Clause 5).*

4.3 Demand side response service provider (DSRSP)

The DSRSP shall be responsible for managing DSR energy flexibility amongst its subscribed ESA portfolio.

The DSRSP receives sets of flexibility offers from each of the active ESAs in its cohort. When implementing a DSR event, the DSRSP shall select one offer from a range of sets of options and send the selection to the appropriate ESA via the associated CEM.

The DSRSP can include the configuration of more than one organization working together, for example an aggregator working in conjunction with a third-party asset manager.

The DSRSP shall present a single interface (Interface A) to each of its registered CEMs in accordance with 5.2.

NOTE *The DSRSP receives requests from Regulated Electricity Market Participants to provide DSR services. These participants include transmission system operators, distribution system operators and, optionally, electricity supply organizations. The DSRSP then contacts its subscribed CEM and ESA portfolio in order to request a flexibility response as appropriate. The Regulated Electricity Market Participants and DSRSPs, and their relationship with ESAs, is described in more detail in PAS 1879.*

4.4 Manufacturer or service provider

Both the CEM and the ESA shall connect to their respective manufacturer or service provider portals. These portals shall provide secure software/firmware updates and device certificate management functionality as a minimum over a secure connection, as described in Clause 6.

4.5 Remote user interface

The optional CEM or ESA remote user interface shall, as a minimum, provide access to information and controls required for the Consumer to engage in DSR services and allow the Consumer to provide their preferences for CEM or ESA operation and DSR service provision. The remote user interface shall give the consumer the ability to manually override, in real-time, current and planned DSR operations. The CEM or ESA and their respective remote user interfaces shall connect securely as described in Clause 6.

4.6 Home energy management system (HEMS)

A HEMS and its associated CEMs shall connect securely as described in Clause 6.

NOTE 1 *Figure B.5 shows an architecture for Interface C and HEMS integration.*

NOTE 2 *The optional home energy management system might provide energy management functionality additional to that provided by the CEM, provide additional information or requests for use by the CEM, or coordinate the operation of two or more CEMs associated with a premises.*

NOTE 3 *Connection of multiple CEMs with a single HEMS over a standardized interface might allow the energy management (including DSR) coordination of multiple ESAs within a single premises.*

5 Communications and messaging

COMMENTARY ON CLAUSE 5

This Clause specifies minimum data model, message sequencing and underlying communications protocols, for Interface A in order to support interoperability between the DSRSP and CEM. Furthermore, this interoperable Interface A definition meets the cyber-security requirements described in Clause 6.

5.1 Interface architecture

5.1.1 General

Unless otherwise stated, references to interfaces, information and messaging shall apply to the application layer or above.

NOTE The mandatory and optional communications interfaces of the ESA DSR systems architecture are depicted in Figure 6.

5.1.2 Mandatory interfaces

5.1.2.1 Interface A

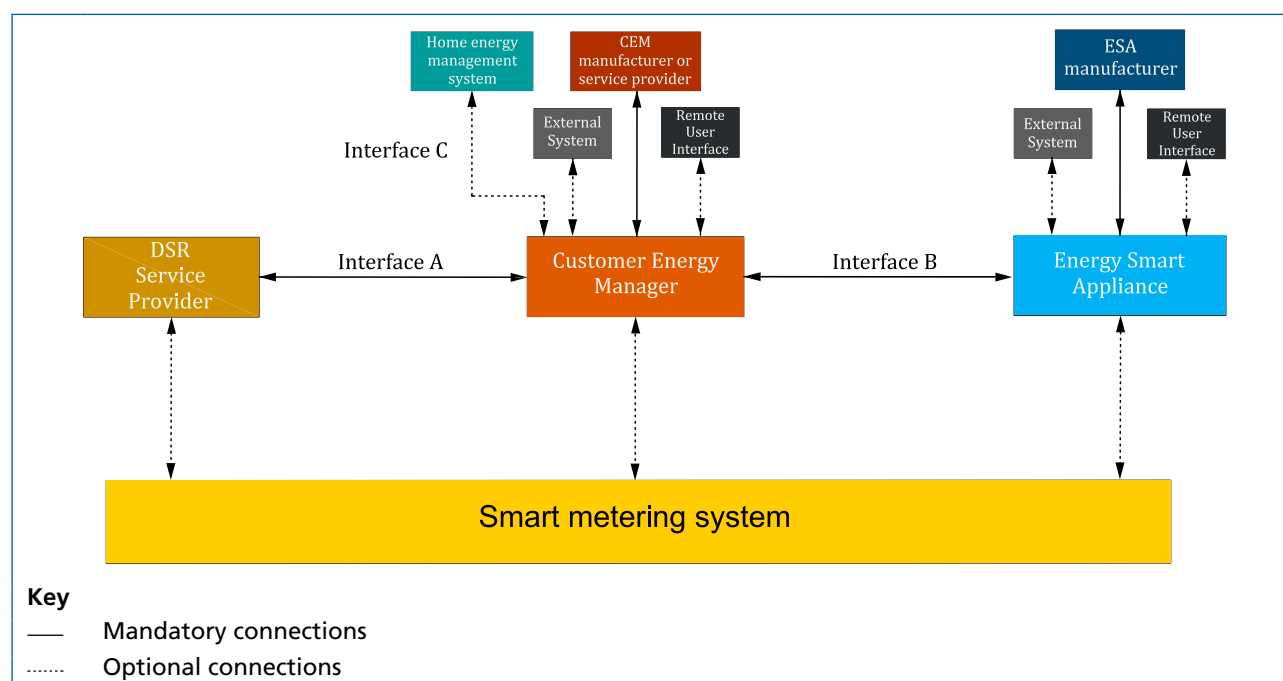
The DSRSP and the CEM shall exchange information relating to device registration, de-registration, flexibility offers, DSR events, status and cyber-security breaches across Interface A. Any DSRSP shall be able to communicate with any registered CEM, and vice versa, using Interface A.

NOTE Interface A is defined by this PAS in order to support interoperability between the DSRSP and the CEM, such that any DSRSP shall be able to operate with any CEM and vice versa. See 3.1.21 for a definition of interoperability.

This interface shall conform to the requirements described in this clause and in Clause 6.

Interface A shall be implemented as specified in Annex F.

Figure 6 – Communications interfaces



5.1.2.2 Interface B

The CEM and the ESA shall exchange information relating to device registration, de-registration, flexibility offers, DSR events, status and cyber-security breaches across Interface B. Interface B shall be defined by the CEM/ESA manufacturer such that there is a clear correspondence between the information model and message sequencing used by Interface A and Interface B.

The CEM shall be able to translate between the data models used on both interfaces with no loss or corruption of information.

NOTE *It is recommended that Interface B uses comparable data and message models as Interface A.*

This interface shall conform to the requirements described in Clause 6.

5.1.2.3 Manufacturer interfaces

Both the CEM and the ESA shall communicate with a remote manufacturer, or service provider portal, using a logical interface defined by the manufacturer/service provider.

As a minimum, this interface shall be used to supply the CEM and ESA with firmware updates, certificate management information (new certificates, certificate revocation etc.), during the CEM and ESA mutual authentication phase described in 5.3.2 and to indicate that the CEM or ESA is to de-register.

This interface shall conform to the requirements described in Clause 6.

5.1.2.4 User interface

A local (built in) or remote user interface shall be provided for the ESA (for example on a smart phone app) and may be provided for the CEM; the remote interface shall conform to the requirements described in Clause 6.

NOTE *Other aspects of this interface are beyond the scope of this PAS.*

5.1.3 Optional interfaces

5.1.3.1 External interfaces

Either the CEM or the ESA can connect to one or more external service providers (e.g. weather service, grid carbon intensity monitoring service) in order to provide additional functionality. When this functionality is related to DSR and energy management functionality (directly or indirectly), this interface shall conform to the requirements described in Clause 6.

5.1.3.2 Smart metering system interface

COMMENTARY ON 5.1.3.2

The DSR system may provide for an interface or interfaces with a smart metering system. The nature and end points of the interfaces are dependent upon the DSR and smart metering systems architectures and are beyond the scope of this PAS. A description of how the DSR system could interface to the GB smart metering system is provided in Annex D.

This interface shall conform to the requirements described in Clause 6 as appropriate for the combination of DSR and smart metering systems.

5.1.3.3 Interface C

This interface shall conform to the requirements described in Clause 6.

NOTE 1 *A CEM can connect to a home energy management system (HEMS) over Interface C. As described in 4.2 and 4.6, the interaction of a CEM and HEMS might provide additional energy management functionality.*

NOTE 2 *This interface might be standardized in the future.*

5.2 Communications architecture

COMMENTARY ON 5.2

The logical functional architecture described in this PAS consists of an ESA within the consumer premises connected through a CEM to a DSRSP in the "cloud". The CEM is a logical functional entity and so can be located within the premises or in the cloud.

Interface A shall connect the CEM and the DSRSP whether the CEM is on the premises or in the cloud.

The ESA and CEM shall communicate over Interface B using a manufacturer defined protocol. Whatever data and messaging models are used over Interface B, the CEM shall be able to translate between them and those used over Interface A with no loss or corruption of information.

NOTE 1 *It is recommended that Interface B uses comparable data and message models to Interface A.*

NOTE 2 *Regardless of the underlying communications bearer protocol (e.g. fixed broadband or mobile), it is assumed that an external CEM will use the industry standard set of Internet Protocol (IP) set of protocols for connection, cybersecurity and data transport.*

In the case of an internal CEM, it is highly likely that IP (likely over ethernet) will be used over one or more bearers such as WiFi, power line or twisted pair (a cable). It is assumed that the CEM will not use a non-IP protocol set such as Zigbee 1.x [6] for Interface A.

Interface A shall use industry standard secure internet protocols and shall support PKI.

Interface B shall support PKI and shall use a data model that is compatible with that used over Interface A.

5.3 Operation model

COMMENTARY ON 5.3

This section describes the flow of information across the interfaces in general terms. More detail on the information model for each phase is provided in 5.4.

The flow of information across the interfaces is divided into the following phases:

1. *Consumer registration with DSRSP*
2. *CEM and ESA mutual authentication*
3. *Device registration of the CEM and the ESA with the DSRSP*
4. *Initialization*
5. *Normal operation (four CEM operating modes)*
6. *Exception conditions*
7. *De-registration*

5.3.1 Consumer registration with DSRSP

COMMENTARY ON 5.3.1

In this phase, the Consumer sets up an account with a DSRSP (possibly via a registration agent acting on behalf of the DSRSP) and is provided with information used to authenticate the ESA and CEM with the DSRSP.

The Consumer shall be able to begin the registration process for the DSR service using a medium other than the CEM or ESA (e.g. internet portal, phone, mail or in person).

The DSRSP or registration agent shall be able to provide the Consumer with information that is to be used during the CEM and ESA to DSRSP service authentication and registration processes.

This information shall include:

- a) DSRSP authorization code;
- b) CEM service provision authorization code (if a remote CEM is used); and
- c) CEM identification token.

NOTE *The details of the DSR service registration process are determined by the DSRSP and are beyond the scope of this PAS.*

5.3.2 CEM and ESA mutual authentication

COMMENTARY ON 5.3.2

The necessary pre-conditions for this phase are listed in 6.14.2.2. The methods used to attain these pre-conditions are manufacture/service provider dependent and are beyond the scope of this PAS.

The detailed requirements for mutual CEM and ESA authentication are provided in 6.14.2.2.2 (CEM and ESA mutual authentication), but are summarized below.

The CEM and ESA shall mutually authenticate using PKI.

Once an authenticated connection is made between the two:

- a) the CEM shall provide an identification token to the Consumer (in the case of a remote CEM); or
- b) the CEM shall provide an identification token to the ESA via Interface B (in the case of a local CEM).

The ESA shall send information including its manufacturer name, serial number, EUI-64, firmware version and firmware installation date to the CEM over Interface B.

5.3.3 Registration of the CEM and the ESA with the DSRSP

COMMENTARY ON 5.3.3

The detailed process requirements for the registration of the CEM and ESA with the DSRSP are provided in 6.14.2.3 (DSRSP and CEM), but are summarized below.

- a) A CEM and ESA shall be registered to only one DSRSP at any given time. A CEM or ESA shall de-register with its existing DSRSP before registering with a new DSRSP.
- b) A CEM or ESA shall communicate only with the registered DSRSP and shall not be capable of communicating with any other (e.g. previously registered) DSRSP.
- c) Prior to registering with a DSRSP, the ESA shall delete any existing information relating to any previous DSRSP registration (DSRSP URL, DSRSP certificate etc.)
- d) The CEM and DSRSP shall mutually authenticate using PKI over Interface A.
- e) The CEM shall send its manufacturer name and serial number to the DSRSP over Interface A for validation.
- f) The CEM shall send its manufacturer name, serial number, EUI-64, firmware version and firmware installation date to the DSRSP over Interface A.

- g) The CEM shall send the ESA manufacturer name, serial number, EUI-64, firmware version and firmware installation date to the DSRSP over Interface A for each ESA connected to the CEM.

Once this registration phase has been successfully completed the ESA, CEM and DSRSP are said to be registered and shall enter the initialization phase.

5.3.4 Initialization

Once the DSRSP, CEM and ESA have successfully authenticated then they shall become associated by exchanging a set of initialization information. This information shall be exchanged during this initialization phase only.

The ESA initialization information shall be passed from the ESA to the CEM over Interface B and from the CEM to the DSRSP over Interface A.

This information shall include the flexibility offer types and the power consumption reporting types supported by the ESA.

***NOTE** This information might include the ESA type and classification.*

The DSRSP initialization information should be passed from the DSRSP to the CEM over Interface A and, on receipt, the CEM shall pass it to the ESA over Interface B.

This information shall include the preferred power consumption reporting type.

Once the initialization phase has been successfully completed the DSRSP, CEM and ESA shall enter the normal operation phase.

5.3.5 Normal operation

5.3.5.1 General

During normal operation, the ESA shall:

- a) inform the DSRSP, via the CEM, of its current flexibility offers;
- b) inform the DSRSP, via the CEM, of any current flexibility offer updates;
- c) act upon a request to implement a flexibility offer from the DSRSP, via the CEM, providing the CEM with updated profiles in response;
- d) for any accepted flexibility offer requests, indicate that it is operating in a DSR event period using its user interface;
- e) either periodically report its instantaneous power consumption to the DSRSP via the CEM during a DSR event, or log its power consumption during a DSR event and report this to the DSRSP via the CEM as an actual power profile at the end of the DSR event;

- f) send an acknowledgement for each accepted flexibility offer request to the DSRSP; and
- g) indicate to the DSRSP that it has cancelled the previously selected flexibility offer.

The CEM shall pass information between the DSRSP and ESA, unencrypting and encrypting between Interface A and Interface B.

***NOTE** As part of normal operation, the DSRSP should:*

- a) *send flexibility offer (DSR event) start requests to the ESA via the CEM;*
- b) *send DSR event cancel requests to the ESA via the CEM;*
- c) *request status updates from the ESA, via the CEM.*

A flexibility offer (DSR event) request shall consist of an ESA flexibility offer identifier and an execution duration value .

5.3.5.2 CEM and ESA operating modes

5.3.5.2.1 General

During Normal Operation phase the CEM and ESA shall be capable of operating in any of the modes described in 5.3.5.2.2 to 5.3.5.2.5.

5.3.5.2.2 Mode 1: Routine mode

The CEM shall be able to perform energy management functions and manage the consumption/production/storage of its connected ESA(s) according to consumer preferences and other parameters (e.g. electricity tariffs, pre-programmed schedules, weather forecast, grid carbon intensity).

***NOTE 1** The energy management functions supported by the CEM and ESA, and the non-DSR related Interface B functionality required are beyond the scope of this PAS.*

***NOTE 2** The CEM might connect with a Home Energy Management System (HEMS) over Interface C (see 4.6 and 5.1.3.3) in which case the HEMS might be able to optimize energy usage across a coordinated set of CEMs and ESAs.*

5.3.5.2.3 Mode 2: Response mode

The ESA shall immediately enter Mode 2 (Response mode) once it has acknowledged to its registered DSRSP that it will be accepting and performing a valid flexibility offer, by sending a valid "flexibility offer request acknowledgement".

The ESA shall continue to send flexibility offer update messages to its registered DSRSP via its registered CEM.

The ESA shall prioritize its Mode 2 operation above its Mode 1 operation in that during the flexibility offer period the ESA shall not accept any requests from the CEM if the requests result in the ESA power consumption forecast contradicting that of the currently active flexibility offer.

The CEM shall immediately enter Mode 2 (Response mode) whenever it receives an authenticated and validated "flexibility offer request acknowledge" message from one of its ESAs to the registered DSRSP.

The CEM shall not include in its related HEMS functionality any of its registered ESAs that are currently in Mode 2.

The CEM shall continue to include in its related HEMS functionality any of its registered ESAs that are currently in Mode 1.

The ESA shall remain in Mode 2 until:

- the period stated by the DSRSP request ends;
- the DSRSP requests the period to end; or
- the consumer overrides the DSR operation; or
- the failsafe protections occur.

5.3.5.2.4 Mode 3: Consumer override

The ESA shall enter Mode 3 whenever it receives a manual override (i.e. modify, decline or cancel) from the Consumer.

In Mode 3, the ESA shall allow the Consumer to override any Mode 1 (routine) or Mode 2 (response) operation at any time. This shall be in addition to any existing preferences set by the Consumer which are used in the construction of flexibility offering options for routine and response mode. The override shall be one of:

- a) modification of a planned flexibility offering or current flexibility option; or
- b) rejection of a requested operation; or
- c) cancellation of all routine and/or response mode operations for a specific interval; or
- d) cancellation of an ongoing routine or response mode operation.

If the Consumer override involves a request rejection or event cancellation of a Mode 2 operation, the ESA shall send a "flexibility offer request rejected" or "cancel flexibility offer" (5.4.5.1.6) message to the DSRSP, via the CEM, and immediately revert to Mode 1 (Routine mode). The CEM shall authenticate and decrypt the "flexibility offer cancel" message received from the ESA over Interface B and, if authenticated and validated, shall both re-package the message, send to the DSRSP over Interface A and note that the ESA has transitioned to Mode 1. The CEM shall now include the ESA in any non-DSR HEMS operations as it sees fit.

If the Consumer override involves a request rejection or event cancellation of a Mode 1 operation, the ESA shall send a "Mode 1 request rejected" or "Mode 1 operation cancelled" message to the CEM, (the format of these messages is beyond the scope of this PAS) and immediately revert to Mode 1 (Routine mode). The CEM shall authenticate and decrypt the "flexibility offer cancel" message received from the ESA over Interface B and, if authenticated and validated, shall note that the ESA has transitioned to Mode 1. The CEM shall now include the ESA in any non-DSR HEMS operations as it sees fit.

5.3.5.2.5 Mode 4: Failsafe

The CEM and ESA control logic shall ensure that the CEM and ESA do not perform in a manner that can lead to an unsafe, harmful or otherwise hazardous situation. Whenever such a condition is imminent, the CEM and ESA shall transition into a failsafe state (Mode 4).

Although the DSRSP and CEM should not request an ESA to perform an operation that would result in unsafe, hazardous or otherwise harmful operation, ultimately the ESA's control logic shall ensure that the ESA operates in a safe manner at all times, by putting the ESA into a failsafe state.

The details of the behaviour of the ESA in Mode 4 shall be determined by the manufacturer but shall always ensure that the ESA enters a safe state. The ESA shall always attempt to inform the CEM that it is entering Mode 4 (under some conditions, there might not be time to do so) by sending an encrypted and signed "entering failsafe" message and an encrypted and signed "Cancel flexibility offer" message. The ESA shall indicate that it has entered Mode 4 on its User Interface.

Upon receiving an authenticated and valid “Cancel flexibility offer” message over Interface B from a registered ESA, a CEM shall re-package the message, send to the DSRSP over Interface A and note that the ESA has transitioned to Mode 4.

Upon receiving an authenticated and valid “entering failsafe” message over Interface B from a registered ESA, a CEM shall note that the ESA has transitioned to Mode 4 and exclude the ESA from any DSR or non-DSR HEMS operations.

The ESA shall exit Mode 4 only when safe to do so by sending a valid (encrypted and signed) flexibility offer update message (the ESA shall transition to Mode 2) or appropriate Interface B specific notification (beyond the scope of this PAS, the ESA shall transition to Mode 1).

The details of the behaviour of the CEM in Mode 4 shall be determined by the manufacturer or service provider but shall always ensure that the CEM enters a safe state. The CEM might attempt to inform the DSRSP that it is entering Mode 4 (under some conditions, there might not be time to do so) by sending an encrypted and signed “entering failsafe” message. The CEM shall indicate that it has entered Mode 4 on its User Interface.

5.3.5.3 Operating mode priority

The operating modes of the CEM and ESA shall be prioritized as specified in Table 1, where the highest priority is Priority 1.

5.3.6 Exception conditions

The ESA shall:

- a) detect any attempt by unauthorized parties to compromise its operation or to access sensitive information according to 6.13.1 and;
- b) determine if a failsafe condition has occurred and, if so, transition to Mode 4 (as described in 5.3.5.2.5).
- c) Attempt to resolve any issue arising from a) and b) above, issuing a flexibility offer update message if appropriate. If a safe resolution is not possible, then the ESA shall transition to (or remain in) Mode 4 (as described in 5.3.5.2.5). The ESA shall exit Mode 4, only when safe to do so and when instructed by the Consumer, according to 5.3.5.2.5.

The CEM shall:

- a) detect any attempt by unauthorized parties to compromise its operation or to access sensitive information according to 6.13.1;
- b) determine if a failsafe condition has occurred and, if so, transition to Mode 4 (Failsafe mode); and
- c) attempt to resolve any issue arising from a) and b) above. If a safe resolution is not possible, then the CEM shall transition to (or remain in) Mode 4 (as described in 5.3.5.2.5). The CEM shall exit Mode 4, only when safe to do so and when instructed by the Consumer, according to 5.3.5.2.5.

Table 1 – Operating modes

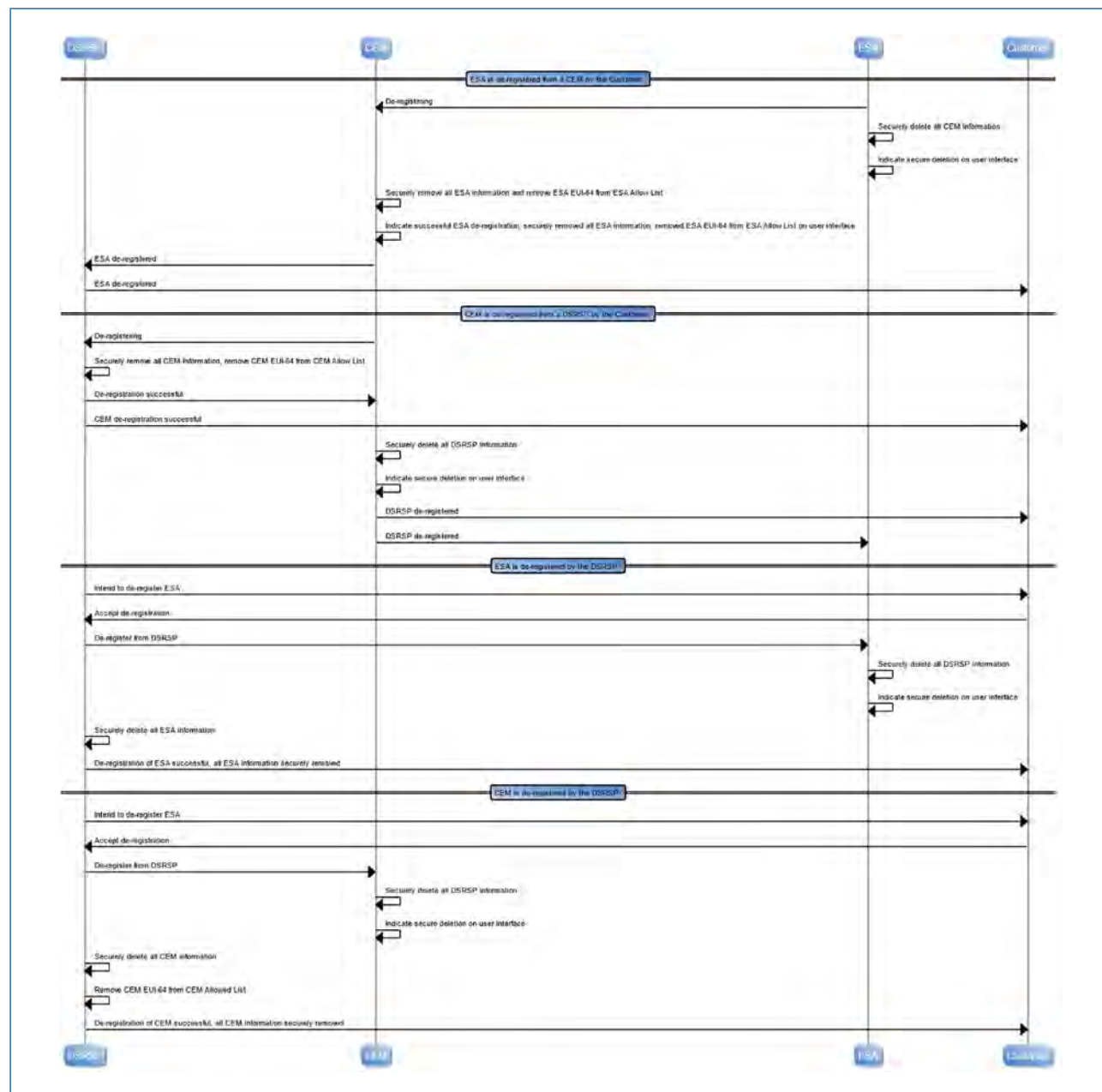
Priority	Operating mode
1	ESA failsafe
2	Consumer override ^{A)}
3	Response mode
4	Routine mode
^{A)} The consumer sets their preferences, which will be automatically considered in Routine and Response Modes. This case specifies a subsequent manual intervention to override planned operation.	

5.3.7 De-registration

COMMENTARY ON 5.3.7

The de-registration processes described below are illustrated in Figure 7.

Figure 7 – De-registration processes for the ESA and CEM



5.3.7.1 De-registration by consumer

When an ESA is instructed to perform the “de-registration mode” and “de-register from CEM” operation, the ESA shall send a “de-register request” message to the CEM. The CEM shall await confirmation from the Consumer before sending a “de-registration confirmation” message to the ESA. The ESA shall securely remove all information related to the CEM and DSRSP, logging all actions, before informing the Consumer that its information removal process is complete.

The CEM shall securely remove all information related to the ESA, logging all actions, before sending an “ESA de-registration notification” message to the DSRSP over Interface A.

The CEM shall receive an encrypted and signed “ESA de-registration acknowledged” message over Interface A to indicate that the DSRSP has securely removed all information related to the ESA and logged all actions.

If the CEM does not receive an “ESA de-registration acknowledged” message within five minutes of sending the “ESA de-registration notification” message then the CEM shall re-send the “ESA de-registration notification” message. If necessary, this process shall be repeated two more times. If no “ESA de-registration acknowledged” message is received within five minutes of the final re-try, then the CEM shall assume that de-registration has been successful and proceed accordingly.

The CEM shall inform the Consumer that the ESA de-registration process is complete and that ESA information has been removed from the DSRSP.

When a CEM is being de-registered from a DSRSP by the Consumer, the CEM shall send a “de-registering” message to the DSRSP over Interface A. On receipt of an encrypted and signed “de-registration successful” message over Interface A, the CEM shall then securely delete all information associated with the DSRSP and shall indicate on its user interface that all information associated with the DSRSP has been securely deleted. The CEM shall indicate to the Consumer and to the ESA that it has been de-registered from the DSRSP.

NOTE 1 *When a CEM or an ESA is being de-registered by the DSRSP, the DSRSP should inform the consumer that it has received the de-registration request and await confirmation before the de-registration process is initiated.*

The ESA shall securely remove all DSRSP information and indicate successful removal on its user interface.

NOTE 2 *The DSRSP should securely remove all ESA information and inform the Consumer of successful de-registration).*

5.3.7.2 De-registration by the DSRSP

When a CEM is being de-registered by the DSRSP, the CEM shall securely remove all DSRSP information and indicate successful removal on its user interface.

NOTE *The DSRSP should inform the Consumer that the CEM is being de-registered and await confirmation before the de-registration process is initiated. When the CEM has removed all DSRSP information, the DSRSP should securely remove all corresponding CEM information and remove the CEM EUI-64 from its CEM Allowed List. The Consumer should be informed of successful information removal and de-registration.*

5.4 Information model

COMMENTARY ON 5.4

This section describes the flow of information across the interfaces in detail. The detailed information elements facilitate the operation model in 5.3.

The flow of information across the interfaces is divided into the following phases:

- a) *Consumer registration with DSRSP (excluded from information model);*
- b) *CEM and ESA mutual authentication;*
- c) *Registration of the CEM and the ESA with the DSRSP;*
- d) *Initialization;*
- e) *Normal operation (four CEM operating modes);*
- f) *Exception conditions;*
- g) *De-registration.*

5.4.1 General

A DSRSP and CEM shall act upon and generate all the information listed below in 5.4.2 and 5.4.3 in order to be compliant with Interface A. The information listed below shall form the basis of a data model.

An ESA shall act upon all information listed below in 5.4.3 generated by the DSRSP and shall generate the information listed below that corresponds to the capabilities of the ESA.

The ESA shall exchange information with the CEM over Interface B. The CEM shall exchange information with the DSRSP over Interface A. The CEM shall perform any translation between the data format used over Interface A and Interface B. This translation shall use the Interface A data model as a reference.

The Interface B data model shall be designed such that the translation performed by the CEM results in no loss or corruption of information.

5.4.2 CEM and ESA mutual authentication

5.4.2.1 Information passed from ESA to the CEM

The information in Table 2 shall be passed from the ESA to the CEM in addition to that used for the PKI authentication process.

Table 2 – Information passed from the ESA to the CEM during the mutual authentication process

Information element	Mandatory/Optional	Note
Interface B version	M	
ESA manufacturer name	M	
ESA unique serial number	M	
ESA EUI-64	M	
ESA firmware version	M	
ESA firmware installation date	M	

5.4.2.2 Interface A version

This information shall indicate the version of the Interface A specification supported by the CEM.

5.4.2.3 ESA manufacturer name

This information element shall provide the name of the ESA manufacturer.

5.4.2.4 ESA unique serial number

This information element shall provide the unique serial number of the ESA.

5.4.2.5 ESA EUI-64

This information element shall provide the Extended Unique Identifier of the ESA [this is an eight byte (64-bit) value].

5.4.2.6 ESA firmware version

This information element shall provide the version of the most recently installed firmware (this is used to check for known functional or security issues and as an input into identity validation).

5.4.3 Registration of the CEM and the ESA with the DSRSP

5.4.3.1 Information passed from the CEM to the DSRSP

The information in Table 3 shall be passed from the CEM to the DSRSP, in addition to that used for the PKI authentication process (as described in 6.14.2.3), in order to allow the CEM and ESA to be registered with the DSRSP.

Table 3 – Information passed from the CEM to the DSRSP during the CEM/ESA registration process

Information element	Mandatory/Optional	Note
Interface A version	M	
CEM manufacturer name	M	
CEM unique serial number	M	
CEM EUI-64	M	
CEM firmware version	M	
ESA manufacturer name	M	
ESA unique serial number	M	
ESA EUI-64	M	
ESA firmware version	M	

5.4.3.2 Interface A version

This information shall indicate the version of the Interface A specification supported by the CEM.

5.4.3.3 CEM Manufacturer

This information element shall provide the name of the CEM manufacturer.

NOTE *The manufacturer's Operator User Interface could be used rather than the name.*

5.4.3.4 CEM unique serial number

This information element shall provide the unique serial number of the CEM.

5.4.3.5 CEM EUI-64

This information element shall provide the Extended Unique Identifier of the CEM. This shall be an eight byte (64-bit) value.

5.4.3.6 CEM firmware version

This information element shall provide the version of the most recently installed firmware (this is used to check for known functional or security issues and as an input into identity validation).

5.4.4 Initialization

5.4.4.1 Information passed from the ESA to the DSRSP via the CEM

5.4.4.1.1 General

The information in Table 4 shall be passed from the ESA to the DSRSP, via the CEM, in order to inform the DSRSP of ESA properties relating to the Normal operation phase. This information shall be exchanged during this initialization phase only and shall be subject to the cyber security conditions described in 6.14.1.

Table 4 – Information passed from the ESA to the DSRSP via the CEM during initialization

Information element	Mandatory/Optional	Note
Flexibility offer types	M	
Power reporting type	M	Periodic power update (with min. update periodicity), actual power profile
ESA type	O	(HVAC, EV charger, etc.)
ESA classification	O	Max/min consumption and/or production

5.4.4.1.2 Flexibility offer type

This information element shall be used to inform the DSRSP which flexibility offer types the ESA is capable of providing during Normal operation. This shall be an enumerated value as defined in Table 5.

NOTE *Subsequent versions of this PAS might include additional enumerations.*

Table 5 – Flexibility offer type enumeration values

Flexibility offer type	Enumeration value	Note
Forecast power profile	1	

5.4.4.1.3 Power reporting type

This information element shall be used to inform the DSRSP of which type of power consumption/production reporting the ESA is capable of providing, and shall consist of one or both of the following types:

- instantaneous power consumption or production, sent to the DSRSP as a minimum periodicity value in seconds; and
- power consumption or production profile (a set of arrays of power consumption values), sent to the DSRSP following the end of a DSR event, denoted by a periodicity value of 0.

5.4.4.1.4 ESA type

The ESA type information element is optionally used to indicate the type of ESA, which shall consist of one of the following:

- cold appliance;
- wet appliance;
- electric HVAC;
- smart EV chargepoint; or
- battery storage.

This information element shall use the enumerated values described in Table C.1.

5.4.4.1.5 ESA classification

The ESA classification information element shall indicate the maximum and minimum consumption and/or production power of the ESA according to Tables C.3 and C.4; this information within the element is optional.

5.4.4.2 Information passed from the DSRSP to the ESA via the CEM

The ESA shall be able to receive and process the information shown in Table 6 from the DSRSP, via the CEM, in order to inform it of DSRSP preferences relating to the Normal operation phase. This information shall be exchanged during this initialization phase only.

Table 6 – Information passed from the DSRSP to the ESA via the CEM during initialization

Information element	Mandatory/ Optional	Note
Preferred power reporting type	M	Provided only if the ESA presents a choice to the DSRSP

5.4.4.3 Preferred power reporting type

The preferred power reporting type information element shall be provided to the ESA by the DSRSP only if the ESA is capable of supporting more than one power reporting type.

This information element shall consist of either:

- instantaneous power consumption or production, provided as a periodicity value in seconds (not to exceed the minimum limit provided by the ESA); or
- power consumption or production profile, denoted by a periodicity value of 0.

5.4.5 Normal operation

5.4.5.1 Information passed from the ESA to the DSRSP via the CEM

5.4.5.1.1 General

The information in Table 7 shall be passed from the ESA to the DSRSP, via the CEM, as necessary during Normal operation phase.

Table 7 – Information passed from the ESA to the DSRSP via the CEM during normal operation

Information element	Mandatory/ Optional	Note
Flexibility offers	M	
Actual power profile	M	M only if type supported or selected by DSRSP
Actual instantaneous power value	M	M only if type supported or selected by DSRSP
Flexibility offer request acknowledgement	M	Contains the flexibility offer identifier
Cancel flexibility offer	M	Interface B only (see 5.3.5.2.5)
Entering failsafe	M	
Free text	O	DSRSP specific

5.4.5.1.2 Flexibility offers

The ESA shall inform the DSRSP about its current flexibility offerings using this information. This information shall include the following:

- forecast power profiles – at least the minimum required set of “least delayed” (LD), “intended operation” (IO) and “most delayed” (MD) forecast power profiles; and
- frequency response capability indicator – indicating the ESA is able to move into a frequency response mode for a specified period. The state of this element shall indicate the frequency response capability of the ESA and is associated with a forecast power profile. Separate Frequency Response Capability indicators shall be provided for each of the LD and MD forecast power profiles.

The Frequency Response Capability indicator shall be defined as in Table 8.