DEIP Interoperability Steering Committee

Reference Architecture for Consumer Energy Resources

Statement of Purpose

This document is intended to describe current and potential future communication architectures relating to the management of consumer energy resources (CER). The document is broken into a series of diagrams, each of which represents either a current architecture or a potential (future) use-case, as highlighted in the title of each diagram.

The intent of this document is not to dictate or promote specific architectures for future consideration; rather it is intended to provide a visual understanding of architectures that exist (and may be commonly used) currently, or are predicted to emerge over the next 1 to 3 years. The intent is to support the evaluation of technical and cyber security requirements of such architectures, and for emerging use-cases consider their feasibility both technically and from a policy & regulatory perspective.

Explanatory Notes

- Due to the breadth of systems involved in CER management the scope of these architectures go beyond simply the CER, and into areas including market interactions, DNSP operations and cloud based third-party/vendor platforms.
- The scope of this document is systems relating to or engaging with Consumer Energy Resources (as opposed to Distributed Energy Resources); as such some systems relevant for DER are not considered in scope for these architecture diagrams.
- Systems, devices and actors described in the architecture diagrams indicate functional & logical concepts rather than physical ones. A single physical device may constitute numerous functional systems shown in these architectures; similarly a single functional system may be distributed across a number of physical devices.
- Some of these diagrams demonstrate how CER devices may be managed or controlled by external systems or actors. In such programs consumer control over their devices must be paramount; they may relinquish operational control to third-parties of their own volution because they deem it to be in their interest, and this may be rescinded at any time.
- A number of architecture include roles relating to cloud-based systems. It should be noted that such platforms (of all types – including OEM platforms, VPPs and broader aggregators) may be based off-shore, and that this may have ramifications for sovereign oversight of such systems, as well as cyber security.
- In current public key infrastructure implementations (particularly flexible export programs) an individual DNSP / utility server may take on the role of SERCA, however work is currently underway to identify an alternative national approach to managing this.

Definitions

Consumer energy resources (CER): residential-scale energy resources often situated behind the revenue meter. Includes local generation (i.e. rooftop solar PV and battery storage) as well as large and/or flexible loads, such as electric vehicle chargers and typical demand response devices (e.g. pool pumps, electric hot water systems and air conditioners). In some cases CER may be metered separately and potentially operate on a different tariff to the main site tariff (e.g. off-peak hot water).

Gateway: A communications and/or control system typically located on a local network, which is able to manage one or more local CER devices. Additional functionality may include the ability to meter site generation & load, and to receive and interpret communications signals from external agents to manage CER (note that they may also provide further additional functionality to the consumer). Gateway devices may be integral to other local systems (e.g. battery or solar inverter integrated for charge & export control). Common examples include Home Energy Management Systems (HEMS), Building/Energy Management Systems (BMS/EMS) and site controllers.

Abbreviations

AGC	Automated Generator Control
AMI	Advanced Metering Infrastructure
BTM	Behind The Meter
CSIP-AUS	Common Smart Inverter Profile for Australia
DLC	Direct Load Control
DNSP	Distribution Network Service Provider
DOE	Dynamic Operating Envelope(s)
DRED	Demand Response Enabling Device (as per AS/NZS 4755.1)
DRM	Demand Response Mode (as per AS/NZS 4755.1)
DSO	Distribution System Operator
EDGE	(Project) Energy Demand and Generation Exchange
EVSE	Electric Vehicle Supply Equipment
HEMS	Home Energy Management System
HWS	(electric) Hot Water System
ICCP	Inter-Control Centre Communications Protocol
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer
OPC	Open Platform Communications
SERCA	Smart Energy Root Certificate Authority (for public key infrastructure)
VPP	Virtual Power Plant

Legend

Protocols & standards

—————▶ CSIP-AUS / IEEE 2030.5

—————▶ Typically proprietary comms

—————▶ Manual information exchange

—————▶ OCPP v1.6 / 2.0 (/ 3.0)

—————▶ DRM relays as per 4755.1/3

—————▶ ProjectEDGE (e.g. RESTful-JSON)

—————▶ Generic comms
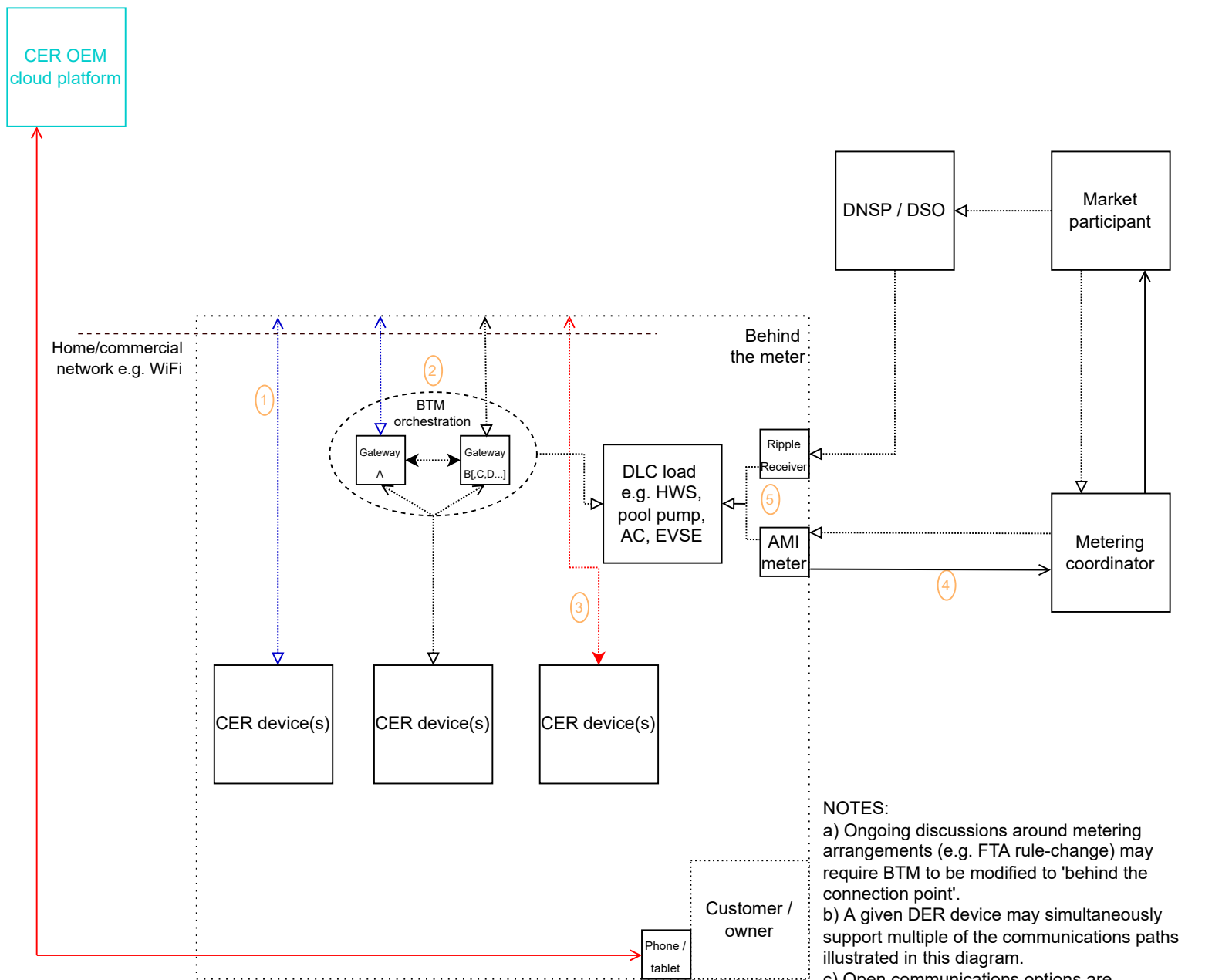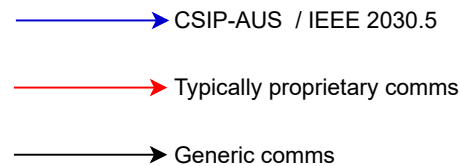
Signal types

—————▷ Control only

—————▸ Data only

—————▶ Control + data

············· Multiple parallel options

Cloud platform   Cloud platform that may be based either on-shore or overseas

NOTES:
a) In the signal types definition, control signals represent information that is intended to be acted upon e.g. a dispatch set-point, de-energise command or price signal. Data signals represent information only, with no explicit request to act on it (although it may trigger control actions there or elsewhere in the respective system).

A - Behind the Meter Communications
(existing system)

→ CSIP-AUS / IEEE 2030.5

→ Typically proprietary comms

→ Generic comms

CER OEM
cloud platform

DNSP / DSO ⟵⋯⋯ Market participant

Home/commercial
network e.g. WiFi

Behind
the meter

① BTM orchestration ②

Gateway A ⟷ Gateway B[,C,D…]

DLC load
e.g. HWS,
pool pump,
AC, EVSE

Ripple
Receiver

⑤

AMI
meter

Metering
coordinator

④

③

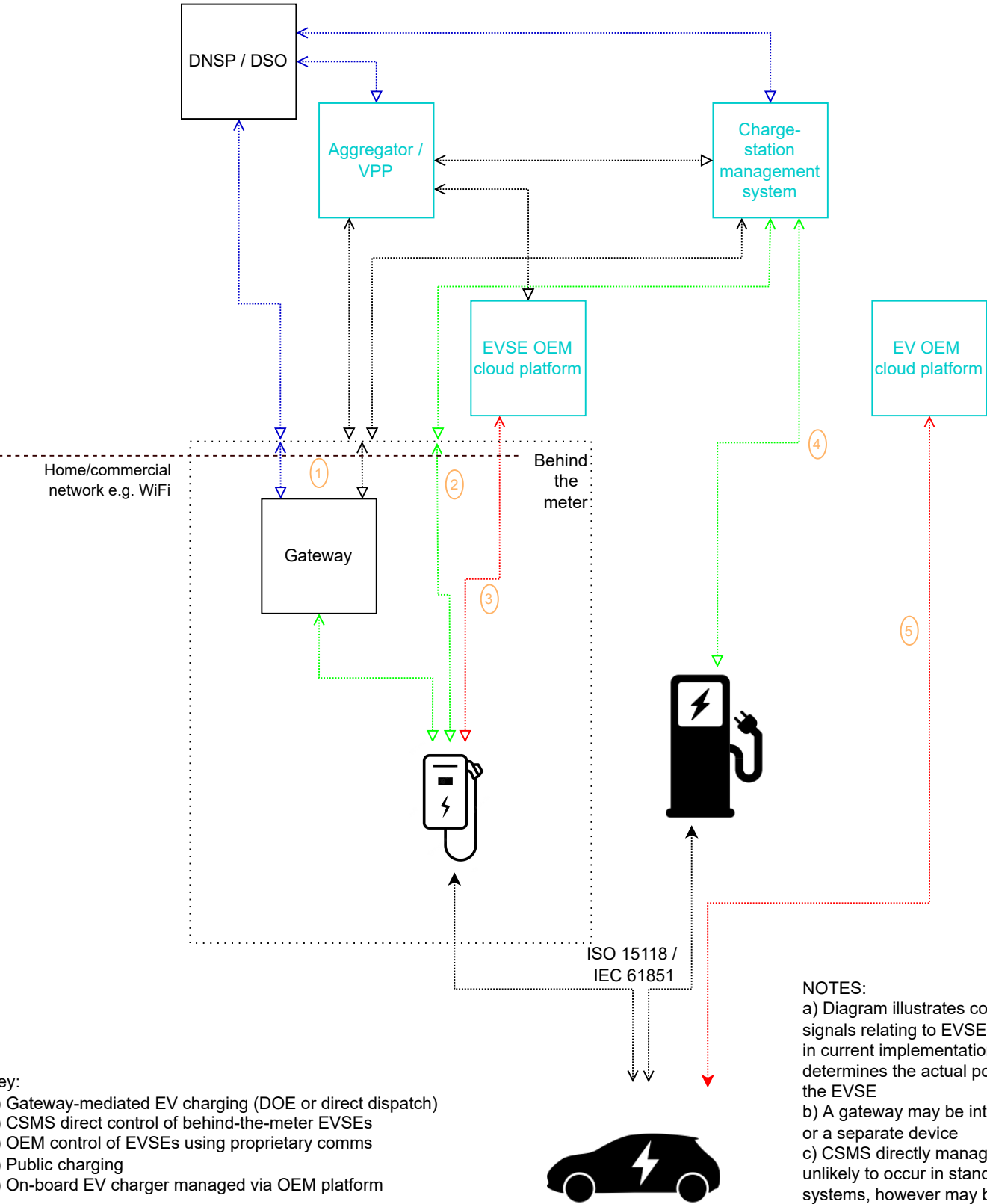CER device(s) CER device(s) CER device(s)

Customer /
owner

Phone /
tablet

NOTES:
a) Ongoing discussions around metering
arrangements (e.g. FTA rule-change) may
require BTM to be modified to 'behind the
connection point'.
b) A given DER device may simultaneously
support multiple of the communications paths
illustrated in this diagram.
c) Open communications options are
encouraged where practical to avoid consumer
lock-in and enable churn.
d) A given site may include one or more gateway
devices (e.g. HEMS, site controllers etc.) that
may intercommunicate, and manage disparate
CER (ideally in a coordinated fashion for the
consumer's benefit).
e) Several of the following diagrams refer to a
"BTM System"; this diagram describes the
detailed comms flows that can occur within a
BTM system on those architectures, including
e.g. the presence or absence of gateways etc.

Key:
1) CSIP-AUS native device comms
2) Gateway BTM comms (many options, including SunSpec Modbus, IEEE 2030.5 /
CSIP-AUS, DNP3, MQTT, OpenADR, OPC, etc.)
3) Proprietary device comms (e.g. vendor/cloud control) which may also include
firmware upgrades.
4) Metering data
5) DNSP- or market-driven direct load control e.g. off-peak hot water.

B - Electric Vehicle Smart Charging
(existing system)

Legend:
- → CSIP-AUS / IEEE 2030.5 (blue)
- → OCPP v1.6/2.0(/3.0) (most likely industry path) (green)
- → Typically proprietary comms (red)
- → Generic comms (black)

DNSP / DSO

Aggregator / VPP

Charge-station management system

EVSE OEM cloud platform

EV OEM cloud platform

Home/commercial network e.g. WiFi

Behind the meter

Gateway

① ② ③ ④ ⑤

ISO 15118 / IEC 61851

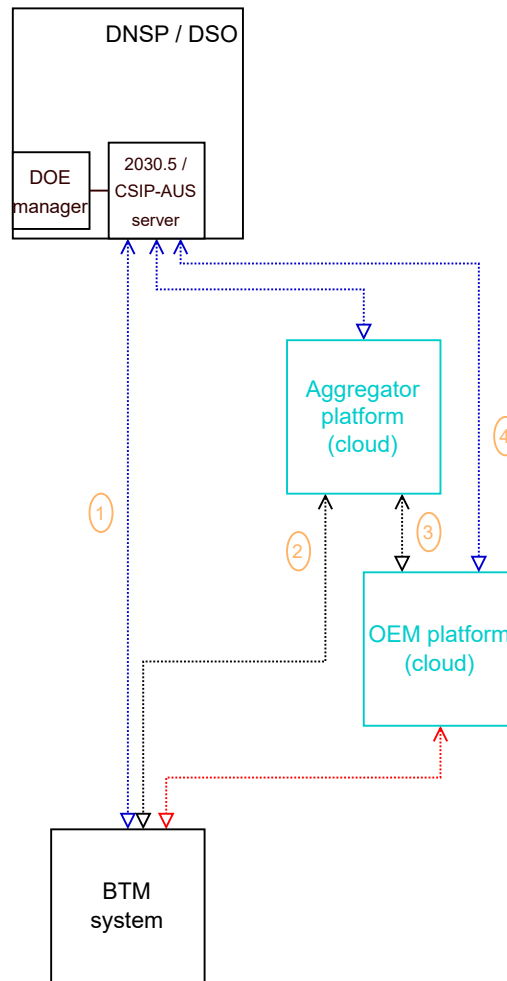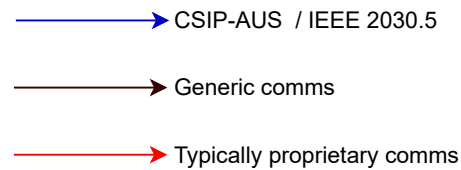**Key:**
1) Gateway-mediated EV charging (DOE or direct dispatch)
2) CSMS direct control of behind-the-meter EVSEs
3) OEM control of EVSEs using proprietary comms
4) Public charging
5) On-board EV charger managed via OEM platform

NOTES:
a) Diagram illustrates communication signals relating to EVSE control, however in current implementations the vehicle determines the actual power drawn from the EVSE
b) A gateway may be integral to the EVSE or a separate device
c) CSMS directly managing BTM EVSEs are unlikely to occur in standalone residential systems, however may be prominent in apartment carpark and related applications

C - DOE Dispatch using CSIP-AUS
(existing system)

CSIP-AUS / IEEE 2030.5

Generic comms

Typically proprietary comms

DNSP / DSO

DOE manager

2030.5 / CSIP-AUS server

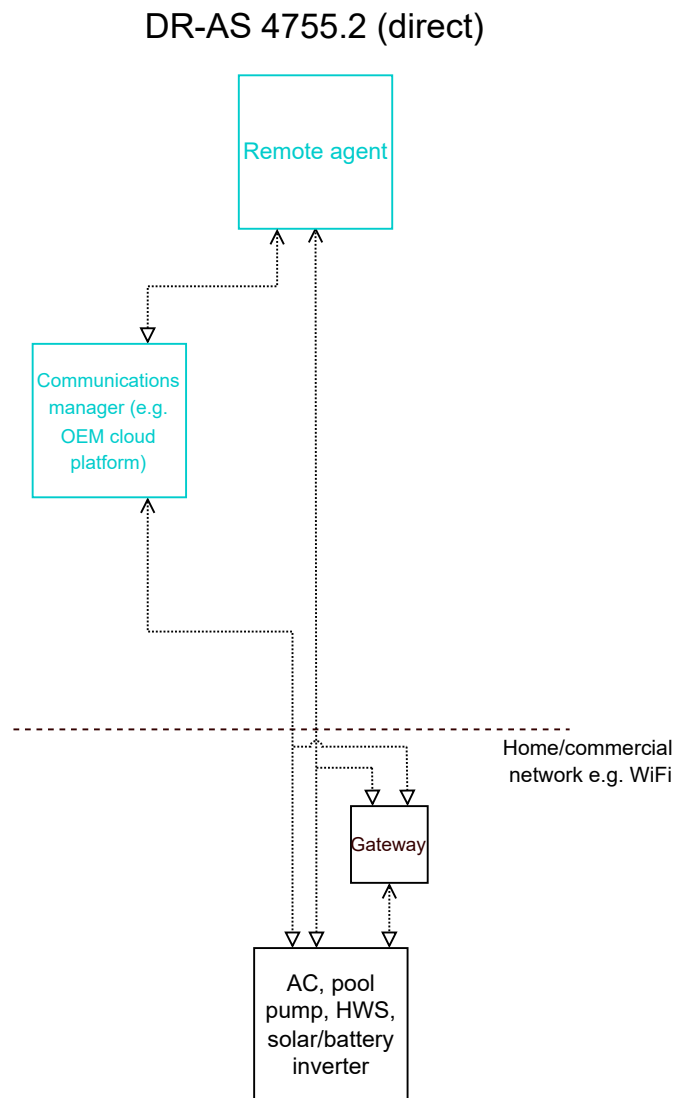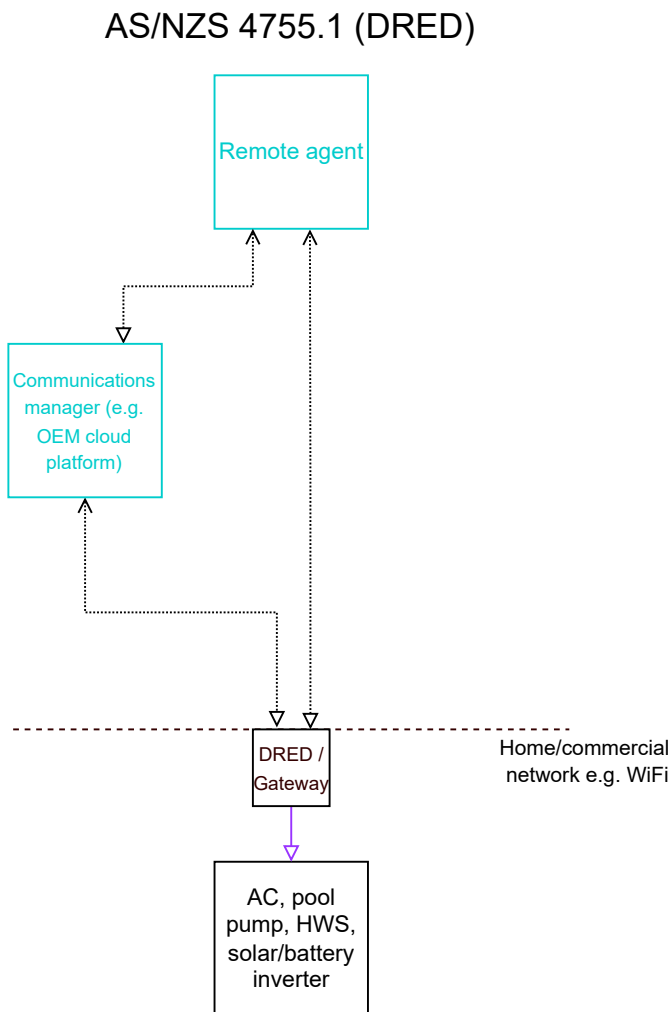Aggregator platform (cloud)

OEM platform (cloud)

BTM system

① ② ③ ④

Key:
1) Direct to site; includes both gateway-mediated and direct-to-device control. Curremtly supports polling only although in principle 4G-type comms could support subscription/notification.
2) Aggregator-mediated to BTM system; supports both subcription/notification and polling.
3) Aggregator-mediated via OEM cloud platform; supports both subcription/notification and polling.
4) OEM-platform-mediated control; supports both subcription/notification and polling.

NOTES:
a) CSIP-AUS communicates a site-level control signal that may need to be managed behind-the-meter - see Diagram A for more details on how this can be performed.
b) DNSP DOEs may incorporate system limitations derived from TNSPs and/or AEMO, which are not typically provided via active online protocols
c) CSIP-AUS supports a limited capability to program settings (e.g. frequency and voltage limts, ramp-rates) into CER. Alternative mechanisms for programming settings such as power quality mode parameters exist and may see further adoption in the future.
d) A BTM gateway is optional in this workflow (i.e. signals may be sent via a gateway or directly to the CER).

D - Demand Response via AS[/NZS] 4755.1/2 *(existing system)*

→ Generic comms

→ DRM relays as per 4755.1/3

AS/NZS 4755.1 (DRED)

Remote agent

Communications manager (e.g. OEM cloud platform)

Home/commercial network e.g. WiFi

DRED / Gateway

AC, pool pump, HWS, solar/battery inverter

DR-AS 4755.2 (direct)

Remote agent

Communications manager (e.g. OEM cloud platform)

Home/commercial network e.g. WiFi

Gateway

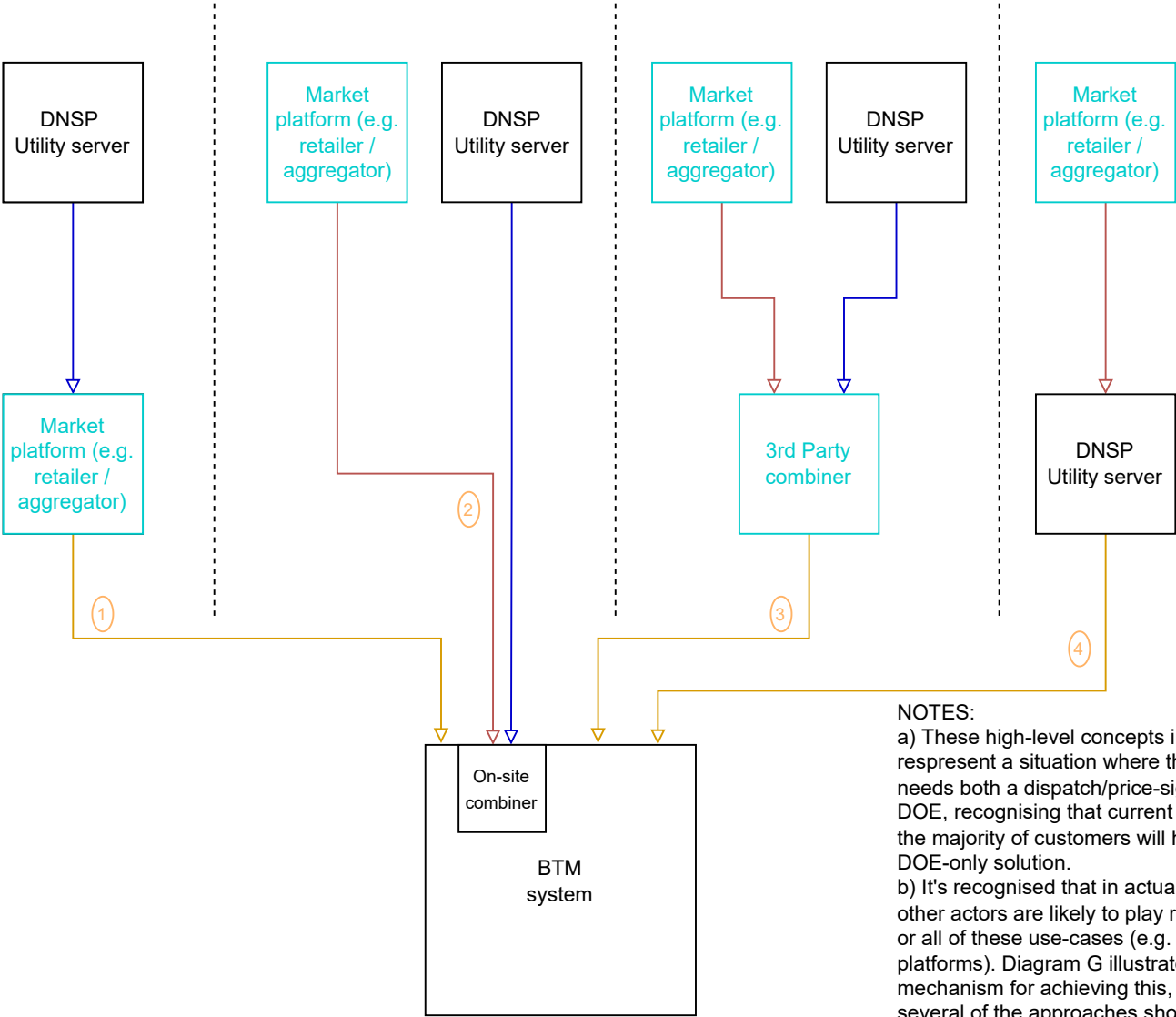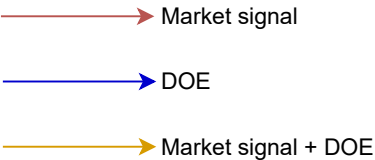AC, pool pump, HWS, solar/battery inverter

NOTES:
a) The DR-AS 4755.2 system describes communication protocols that already exist (e.g. IEEE 2030.5, OpenADR), noting that the relevant standard is still in draft.
b) While the paths described here support a variety of open and proprietary comms standards, in all cases it would be typical that at least one stage of the comms path would operate on a 4755-compliant protocol (e.g. OpenADR, CSIP-AUS Annex C etc.)
c) In the majority of existing programs the DNSP / DSO takes on the role of remote agent, however future expansions of these approaches may introduce alternative uses including market applications and HEMS.
d) Both AS/NZS4755.1 and DR-AS4755.2 support but do not mandate return communications to the remote agent.

E - CSIP-AUS DOE + Market-Signal Merging
(potential use-case)

Legend:
→ Market signal
→ DOE
→ Market signal + DOE

DNSP Utility server

Market platform (e.g. retailer / aggregator)

DNSP Utility server

Market platform (e.g. retailer / aggregator)

DNSP Utility server

Market platform (e.g. retailer / aggregator)

Market platform (e.g. retailer / aggregator)

3rd Party combiner

DNSP Utility server

① ② ③ ④

On-site combiner

BTM system

Key:
1) Market platform DOE pass-through
2) On-site signal combining
3) Third-party signal combining
4) DNSP DOE pass-through

NOTES:
a) These high-level concepts intend to respresent a situation where the end user needs both a dispatch/price-signal and a DOE, recognising that current applications the majority of customers will have a DOE-only solution.
b) It's recognised that in actual solutions other actors are likely to play roles in some or all of these use-cases (e.g. OEM cloud platforms). Diagram G illustrates one mechanism for achieving this, blending several of the approaches shown here.
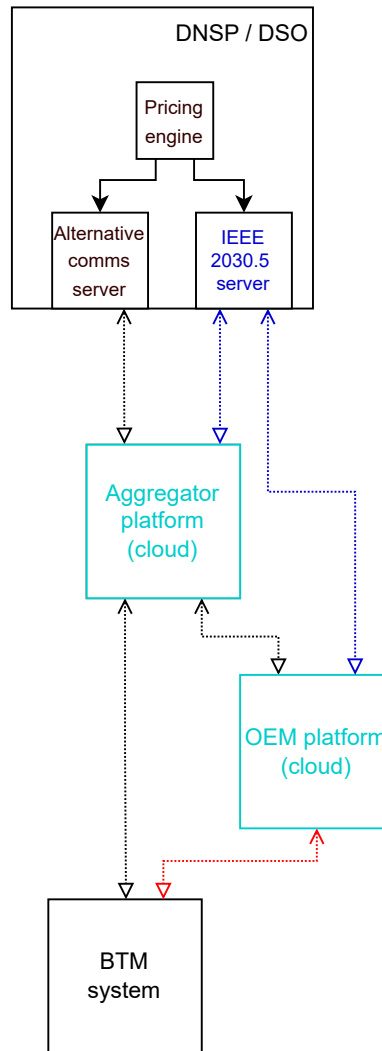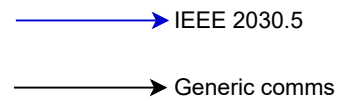c) The use-cases described here have been deemed technically feasible under IEEE 2030.5 & CSIP-AUS, however they may not all be suited to the Australian market & regulatory environment.
d) DOE signals are supplied by a utility server; these do not have to be operated by a DNSP/DSO, however the values are likely to be sourced from a DERMS or similar system operated by the relevant DNSP.
e) While these use-cases describe DOE limits alongside market-signals intended to influence the dispatch of CER, operation of devices will be influenced by other exogenous factors including consumer behaviour and third-party signals.

F - Dynamic Network Pricing
(potential use-case)

IEEE 2030.5

Generic comms

DNSP / DSO

Pricing engine

Alternative comms server

IEEE 2030.5 server

Aggregator platform (cloud)

OEM platform (cloud)

BTM system

NOTES:
a) This use-case is primarily based on the communications architecture used in Project Edith. In the current design this is used to communicate dynamic pricing signals for network support, which operate in parallel to traditional tariffs (which will typically also include a fixed network charge component). Future developments of this approach may enhance dynamic network pricing to incorporate conventional tariff network charges.
b) In Project Edith price signals are likely to be sent alongside DOEs via the mechanism described in Diagram C.
c) A BTM gateway is optional in this workflow (i.e. signals may be sent via a gateway or directly to the CER).

Roadmap

Version 1.0 of the ISC Reference Architecture for CER includes the following:

Existing systems

- Diagram A – Behind the Meter Communications
- Diagram B – Electric Vehicle Smart Charging
- Diagram C – Dynamic Operating Envelope Dispatch using CSIP-AUS
- Diagram D – Demand Response via AS[/NZS] 4755.1/2

Potential use-cases

- Diagram F – CSIP-AUS DOE + Market Signal Merging
- Diagram G – Dynamic Network Pricing

Version 1.1 is slated for release at the end of April 2023, with the following additions planned:

Existing systems

- Market Dispatch
- Network Services

Potential use-cases

- Energy Marketplace / Data Hub (as per ProjectEDGE)
- Data Exchange as per Project Symphony

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