# Interoperability Profile for Electric Vehicle Fleet Managed Charging

## Utilizing IEEE 2030.5-2018

**April 2022**



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# Executive Summary

The development of publicly and widely available electric vehicle charging infrastructure is a pressing need, and is a key milestone in enabling the further transition to renewable energy. Integrating new load centers such as fleet charging stations also brings the potential for that load to participate in distribution and transmission system operator demand management programs and other grid management functions orchestrated by distribution system operators (DSOs).

Recently developed smart grid standards have numerous mandatory and optional configurations and functions sets that provide desirable flexibility and wide ranges of implementation choices, but potentially at the expense of readily interoperable systems. Insufficient specificity on the application of such a standard limits the relevance of certification and conformance testing of solutions across organizations and systems.

The goal of this work is to demonstrate how an application profile can utilize a standard, or combination of standards, to implement a use case describing a business operation or function in a manner that provides the specificity required to achieve two goals: 1) Document the required configuration and implementation options to perform the function, and 2) Develop conformance testing that will validate the correct implementation of the standard to perform the function detailed in the application profile.

This application profile analyzes the capabilities of IEEE 2030.5-2018, an available smart grid standard, to effectuate a use case that defines the communications aspects of the business function of a DSO executing demand management or demand response programs with responsive load inclusive of individual and aggregator mediated residential and fleet EVSE via Charge Station Management Systems interfacing with the electric DSO.

# 1 Introduction

This Interoperability Profile specifies one way to utilize an open industry standard communications protocol[1] to facilitate an interoperable implementation of the Electric Vehicle Fleet Managed Charging Use Case[2] developed by the SEPA Interoperability Profile Task Force, a subgroup of the SEPA Testing and Certification Working Group.

The EV Fleet Managed Charging Use Case (“Use Case”) outlines the information exchanges between Electric Vehicle (EV) Charging Station Management Systems (CSMS), Distribution System Operators (DSOs) and any human in the loop required to ensure appropriate action(s) to fulfill the requirements of the Use Case, which includes EVSE participation in DSO demand management events. This Profile and the Use Case do not address the registration of distributed energy resources with the DSO.[3]

DSOs and EV charging systems managed by charge station operators (CSO) via CSMS and EVSE need to exchange information to enable charging of EV’s and EVSE participation in DSO demand management programs. This Interoperability Profile is intended to serve as a reference for industry, allowing DSOs, vendors, aggregators, and electric vehicle owners to use a common language and understand the types of information exchanges that may be required to manage EVs as grid assets, rather than grid stressors.

Ultimately, the aim is for this Interoperability Profile to facilitate smarter charging of electric vehicle fleets[4] given the variety of constraints, including economic or reliability considerations that may face distribution system operators.

The SEPA Interoperability Profile Task Force notes that much of this profile is built from the good work associated with the Common Smart Inverter Profile (CSIP).[5] Without that Profile, this work would not be nearly as complete, nor useful, and certain language used in this Profile is pulled directly from CSIP in an effort to maintain consistency across the industry.

Note further that the key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this Profile are to be interpreted as described in RFC 2119.[6]

[1] Open industry standard communications protocol: open-document and standardized, not proprietary; industry-for the utility/communications industry; standard-published by a standards development organization; communications-used for machine-to-machine electronic communications; protocol-defined commands, language, etc. to exchange information between two entities
[2] https://sepapower.org/resource/ev-fleet-managed-charging-use-case/
[3] The SEPA Interoperability Profile Task Force note that a DER Registration Profile would be useful for the industry as utilities and vendors navigate methods to communicate DER capabilities given the variety of DER that could potentially be useful in the modern power system.
[4] An EV fleet in the context of this work can range in size from a single EV owned by a homeowner to a large convoy of EVs supporting a given business function (e.g. mail delivery).
[5] See Common Smart Inverter Profile Implementation Guide v2.1
[6] https://datatracker.ietf.org/doc/html/rfc2119

# 2 Guiding Principles

The following principles have been applied in the development of this Electric Vehicle Fleet Managed Charging Interoperability Profile:

1. **Fair and balanced** – The DSO articulates a need that can be met by any EVSE eligible and enrolled in the program. There is no proprietary advantage to any party, nor any inherent preference towards a given EV fleet size.
2. **Leverage existing standards and models** – Significant work has been completed by industry stakeholders to facilitate standardized DER control architectures and data models across stakeholders. This profile aims to demonstrate how those standards can be used to meet the function stated within.
3. **Eliminate optionality and keep to a single base profile –** Many standards, including IEEE 2030.5, have optionality built-in, which affords multiple implementation opportunities. This profile outlines one way of executing the Use Case with IEEE 2030.5; there may be other/better methods appropriate for different circumstances that utilize other standards, or combinations of standards.
4. **Create a specification for practitioners –** The reader of this profile should be familiar with the electric distribution industry generally, and both the standards referenced and the SEPA EV Fleet Managed Charging Use Case specifically. The profile is *not* intended to replace a test script or certification process, but is intended for practitioners to align on a particular approach.
5. **Limit focus to DSO-to-CSMS or DSO-to-aggregator data exchanges –** This profile is silent regarding the communications and physical layers used to exchange the data outlined herein. An implementation of this profile will occur with communication and physical layers that may have ramifications on the execution, security and reliability of the data exchanges profiled here.

# 3 Architectural Overview

This profile addresses the data exchanges between the DSO and an Aggregator, or the DSO and a CSMS directly. The profile relies upon Aggregator and CSMS interactions with individual EVSEs, and potentially human actors to effectuate the desired electrical system impacts; however, the data exchanges between the Aggregator/CSMS/EVSE/EV are out of the scope of this profile.

The information exchanges between the DSO and charging stations have been modeled on two scenarios, the primary difference between the scenarios being the addition of an aggregator in the second scenario:

- Scenario I: Direct DSO and CSMS bidirectional information exchange. (“Direct Exchange”)
- Scenario II: DSO ←→ DER Aggregator ←→ CSMS information exchange. (“Aggregator Mediated”)

In both cases, the information exchanges are governed by regulatory and DSO requirements. IEEE Std 2030.5™-2018 (“IEEE 2030.5”) provides the industry with a standard that “defines the application layer with TCP/IP providing functions in the transport and Internet layers to enable utility management of the end user energy environment, including demand response, load control, time of day pricing, management of distributed generation, electric vehicles, etc. Consistent with the Guiding Principles driving this work, the interoperability profile will use 2030.5 to facilitate information exchanges.

The defined information exchanges contemplated within the Use Case supporting this Interoperability Profile allow for multiple opt-outs throughout the process that end the need for continued information exchange. Furthermore, a given DSO's strategy may rely upon both direct exchanged and aggregator mediated EV fleet charging management as part of a larger, multi-pronged DER control architecture. The two scenarios presented here aim to capture the nuances associated with each of the primary prongs.

## 3.1 Scenario I – Direct Exchange

In the direct DSO and CSMS bidirectional information exchange scenario (Scenario I), the CSMS may take multiple forms. As shown in Figure 1, the CSMS may control multiple EVSEs at multiple facilities, or it may be integrated within an EVSE at a residential home. The Use Case establishes the precondition that the CSMS is already "working with DSO input", which for the purposes of this profile will mean that the CSMS:

- Has been discovered within the DSO established communication network
- Has implemented appropriate cybersecurity measures consistent with DSO requirements
- Manages the charging of EVSEs that are interconnected to the DSO grid at known and stationary locations

The information exchanges are displayed in Figure 1. Note that there may be further information exchanges needed to accomplish the use case that are beyond the scope of this profile. For instance, the CSMS may elicit opt-outs from the EV Fleet Operator and the Charge Station Operator. However, the mechanisms and data exchanges required for those opt-outs are considered vendor proprietary. Note that the CSMS MUST then communicate the opt-in/out with the DSO as specified in Section 4.4.

 

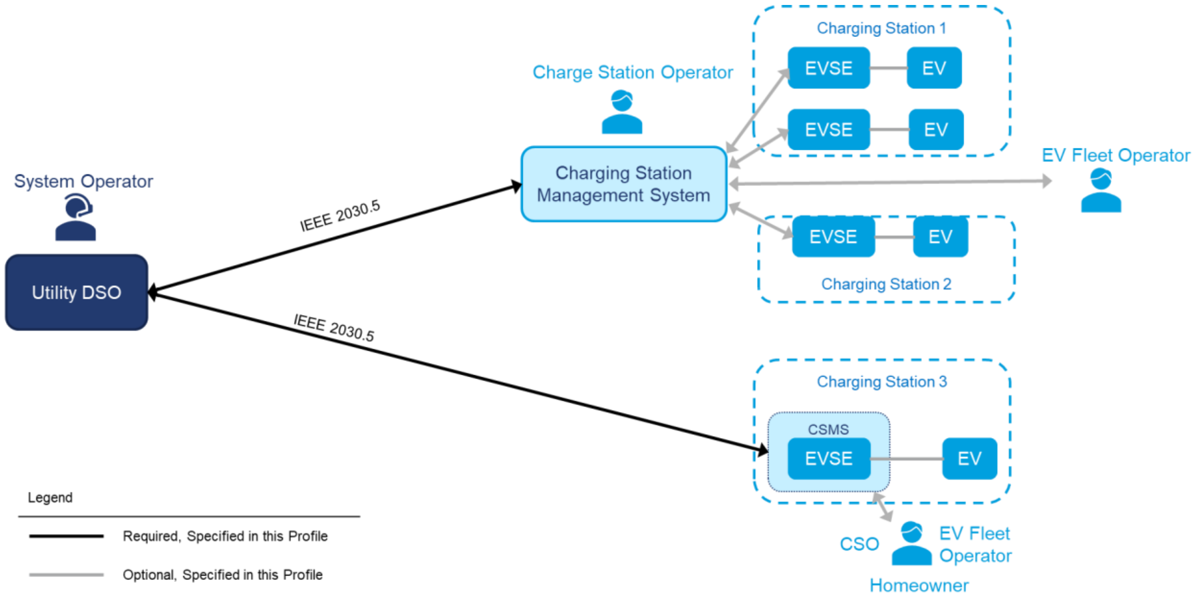


*Figure 1 - Scenario I Direct DSO and CSMS Information Exchange*

Note that in Figure 1, the information exchanges that are specified in this profile are shown by black lines, whereas the grey lines indicate information exchanges required to complete the Use Case, but for which implementation strategies are more flexible.  This profile does include optional specifications that may be adopted for most of the grey line information exchanges.

## 3.2 Scenario II – Aggregator Mediated

Scenario II includes the DSO interacting with a DER Aggregator to meet the needs of the distribution system. Within this profile, the DER Aggregator's EV Fleet is of most interest, but the Aggregator may have additional DER that could be combined to meet the needs of the DSO in the most cost-effective manner. Data exchanges downstream of the Aggregator are not specified in this profile, and they may include proprietary protocols that function as trade secrets for the Aggregator to provide services to the CSO and EV Fleet Operator. This scenario model is represented in Figure 2.

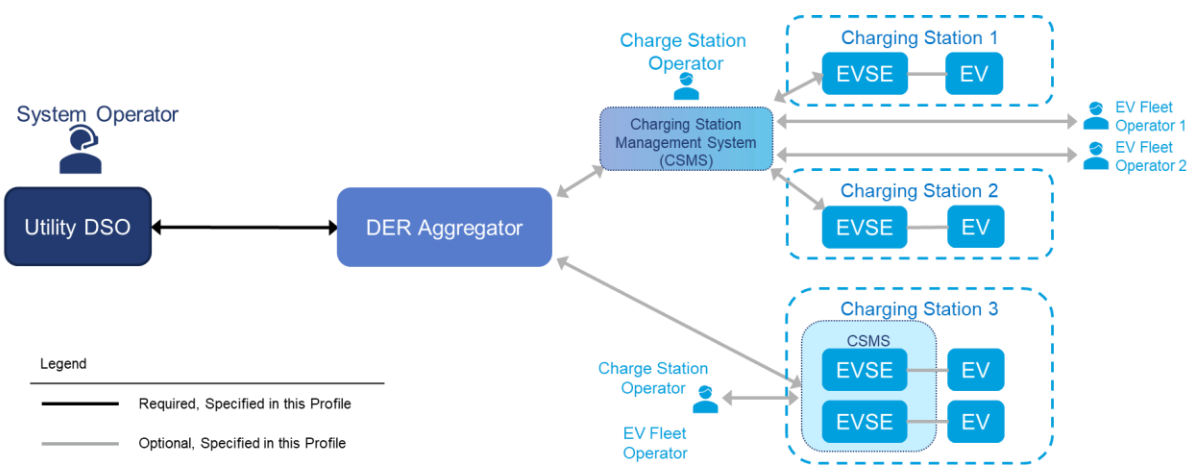


*Figure 2 - Scenario II Aggregator Mediated Information Exchange*

Note that in Figure 2, the information exchanges that are specified in this profile are shown by black lines, and information exchanges required to complete the Use Case but that are unspecified in this profile, are indicated by grey lines.

# 4 General Requirements

## 4.1 Security Requirements

Security SHOULD be used in all interactions between the Aggregators, CSMS, EVSE, and EV and other entities receiving or transmitting EV related information. The composition of any CSMS or Aggregator DER access to DSO servers is managed via contractual relationships and is not covered in this Profile. However, the commissioning of technology SHOULD include cybersecurity measures, including certificates, authorization, authentication, and access control consistent with the default security policy found in section 6.8 of the IEEE 2030.5 standard.[7]

## 4.2 Commissioning

The commissioning of the CSMS and associated actors (Charging Stations, EVSE, EVs, Charge Station Operator, and EV Fleet Operator) is DSO specific and is assumed to be outside the scope of this profile. At any point in its useful life, the Charging Station may elect to participate in a demand management program. Both evaluating the suitability of Charging Station infrastructure for potential participation in that demand management program and the process for enrolling in the program are outside of the scope of this profile.

Enrollment and commissioning may include agreement upon a variety of business rules, incentives, technical specifications and charging station performance characteristics. Depending on DSO guidelines, the commissioning process may be retriggered with significant alterations of the charging station power characteristics (e.g., adding more EVSEs). At the end of the commissioning process, each charge station management system (CSMS) SHALL have a globally unique identifier (GUID) such that the CSMS and DSO can be confident in the referenced. As explained in Section 5.4, the GUID described here SHALL be *long-form device identifiers* (LFDI) used in IEEE 2030.5.

## 4.3 Group Management

Effective management of DERs requires that their location be known from both the electrical system and geolocational perspectives. In certain cases, settings or commands may be sent to all CSMS's within a DSO's entire system. In other cases, the settings or commands will be targeted to limited numbers of charging stations due to differences in needs across the distribution system. Although topological grouping is expected to be the primary use case, any type of grouping is allowed. Each DSO will apply the grouping levels as it sees fit to meet its own operational needs.

[7] Note that it is anticipated that different jurisdictions MAY mandate additional security policies.

Group membership MAY change over the life of the Charging Station. These changes CAN be the result of system configuration or changes in segmentation or equipment. Grouping is accomplished in IEEE 2030.5 via *function set assignments (FSA)* managed by the DSO Server. Aggregators and DER Clients SHALL support IEEE 2030.5 subscriptions / notifications to collect group assignments under their *EndDevice* resource (e.g., /edev/{#}/fsa), and the corresponding *Function Set Assignments* resource (e.g., /fsa/{#}).  DER CAN exist in multiple groups to support DSO management at differing levels of the system. The DSO will maintain these groups over time and deliver group changes to the impacted DERs.

*Table 1- Function Set Assignment (FSA) Group Management Roles*

| Actor | Function | |
|---|---|---|
| [redacted] | Establish, Manage and Maintain Function Set Assignments (FSA) | Subscribe to DSO Server Group and Function Set Assignments (FSA) |
| **DSO** | X | |
| **Aggregator** | | X |
| **Charging Station (CSMS)** | | X |

## 4.4 Demand Management Events

Before delving into the specifics of the IEEE 2030.5 profile, some terms and general themes should be defined and explained in plain English.

For the purposes of this profile, the intent is to facilitate the demand management components of EV Fleet Management as defined in the companion Use Case. Other related profiles and use cases may address other possible EVSE power system impacts (i.e., power quality and V2G, to name a few).

The companion Use Case is written such that the DSO identifies the demand management opportunity, solicits opt-ins, and confirms the needs before dispatching the demand management event. To accomplish this precondition using IEEE 2030.5, the DSO will need to issue an event and then cancel the event based on the responses and re-evaluation of system needs. This validation is accomplished following the same process but leads to the outcome of canceling, instead of dispatching, the demand management event.

Note that a given CSMS will opt-in or opt-out the EVSE under its purview via *Responses* for a given *DERControl* event. Therefore, each *DERControl* event must require *Responses* and specify the *replyTo* field of the event. The CSMS SHALL opt-in or opt-out via the two *Response* types specified below. While IEEE 2030.5 supports additional *Responses,* this Profile specifies the following to support opt-in and opt-out of events:

*Table 2 - Response Types Supporting Opt-In and Opt-Out*

| Enumeration Value | Description | Why Sent | When Sent |
|---|---|---|---|
| 4 | User has chosen to opt-out | To notify response server that user has chosen to opt out of the event. Must occur before event begins | When user actively chose to opt out or when device automatically opts out due to user preference |
| 5 | User has chosen to opt-in | To notify response server that user has chosen to opt in to the event. Must occur before event begins | When user actively chose to opt in or when device automatically opts in due to user preference |

This profile describes the use of the IEEE 2030.5 control resource *DERControl* to issue a demand management event.[8] The *DERControl* settings allow for multiple *DERControl* messages to be sent, superseded, and canceled. To change the *DERControl* setting, a new *DERControl* is issued to supersede or cancel the existing *DERControl*.

A DSO may have default DER controls managing a charging station. These controls could provide for grid support functions, such as power factor settings or voltage ride-through set points. However, the default DER controls – the IEEE 2030.5 *DefaultDERControls* control resource – are not specified or adjusted within this profile.

## 4.5 Communication Interactions

In both the Direct Exchange and Aggregator Mediated scenarios, communications, notifications and call backs (subscription/notification) SHALL be used to limit system polling to the greatest extent practical.

In both scenarios, the CSMS MAY function as an aggregating agent, managing multiple charging stations with multiple EVSEs. The CSMS MAY also function to manage one EVSE directly managed by the DSO. Regardless, subscription/notification SHALL be used.

# 5 IEEE 2030.5 Implementation Requirements

This section defines IEEE 2030.5 implementation requirements for facilitating information exchanges identified in the companion EV Fleet Managed Charging Use Case.

The IEEE 2030.5 protocol utilizes a client/server model based on a REpresentational State Transfer (REST) architecture utilizing the core HTTP methods of GET, HEAD, PUT, POST, and DELETE.[9] In the REST model, the server hosts resources, and the client uses the HTTP methods to act on those resources. In this profile, the server is implemented at the DSO, and

[8] Throughout this profile, we use a combination of plain language and terminology from the IEEE 2030.5 specification, related to specific 2030.5 objects or methods. Those 2030.5 objects and methods are *italicized* to denote the 2030.5 specific implementation.

[9] https://www.ics.uci.edu/~fielding/pubs/dissertation/rest_arch_style.htm

the client is then implemented at the Aggregator or on a single CSMS. The IEEE 2030.5 protocol provides a subscription mechanism for the server to push resources to the client. As noted in Section 4.5, this profile will use that mechanism.

In IEEE 2030.5, a resource is a piece of information that is exposed by a server. These resources are used to represent aspects of a physical asset such as a smart inverter, attributes relating to the control of those assets (e.g., Volt-VAr curve), and general constructs for organizing those assets. IEEE 2030.5 resources are defined in the IEEE 2030.5 extensible markup language (XML) schema and access methods are defined in the web application description language (WADL). The schema is generally organized by Function Sets, a logical grouping of resources that cooperate to implement IEEE 2030.5 features. IEEE 2030.5 provides a rich set of Function Sets (e.g., Demand Response Load Control, Pricing, Messaging, Distributed Energy Resource, etc.) to support a variety of use cases. This profile addresses only the subset of IEEE 2030.5 Function Sets required to effectuate the requirements defined in the companion EV Fleet Managed Charging Use Case.

## 5.1 Simplified Components

### 5.1.1 Commissioning, Metering, Device Capability, and End Devices

Consistent with the companion Use Case, this profile assumes that the suite of technologies required to achieve the Use Case has been commissioned and provisioned consistently across actor agreements, which may be governed by DSO guidelines.

To practically implement this profile, the DSO will need to have solutions in place for metering. Those solutions MAY rely upon customer/aggregator equipment, but the metering needs for measuring and validating EV managed charging performance are assumed to be completed by DSO-controlled solutions and are outside of the scope of this profile.

Similarly, the capabilities of the DER client – the CSMS and downstream end devices - shall be capable of meeting the parameters of the managed charging DSO program. For the purposes of this profile, it is assumed that the DSO/Aggregator verifies system capabilities in the commissioning of a DER client and corollary enrollment in the DSO program.

### 5.1.2 Randomization

IEEE 2030.5 provides a randomized start time and duration function set, which offsets potential impacts of simultaneous mass-DER adjustments. This functionality may be useful for some DSO programs, but is not used in this profile. When *Start Time* and *Duration* are discussed herein, the intent is a specific and coordinated *Start Time* and *Duration* consistent with Section 5.1.3.

### 5.1.3 Coordinated Time Sync

Within 2030.5, the DSO server can use the *Time* function set to distribute the current time to clients. However, practical limitations on the network traffic capabilities have led major utilities to consider alternate time architectures. For the purposes of this profile, we assume that each

 

DER client uses some global positioning system (GPS) server for timekeeping and aligns with all IEEE 2030.5 time drift requirements, particularly those in Section 9.2.3 of that standard.

## 5.2 Registration of new End Devices

This Profile adopts the out-of-band registration model, wherein the DSO server creates EndDevice instances corresponding to authorized devices (Charging Stations) at start-up, prior to any client device connecting to the server. The DSO server receives a list of authorized devices via an out-of-band process. Once the DSO establishes the lists and resources in Figure 3, the Charging Station is effectively registered. In order for the CSMS to know group assignments and receive *DERControl* events, the CSMS MUST work through the resources in Figure 3.

When an authorized CSMS queries the DSO server's *EndDeviceList (*the address for which is provided by the DSO in an out-of-band process), the DSO server SHOULD return an *EndDeviceList* containing a single entry – the *EndDevice* corresponding to the Charging Station agent making the query. From there, the CSMS works through various DSO server-hosted lists to effectively gather the details needed to receive and respond to demand management opportunities.

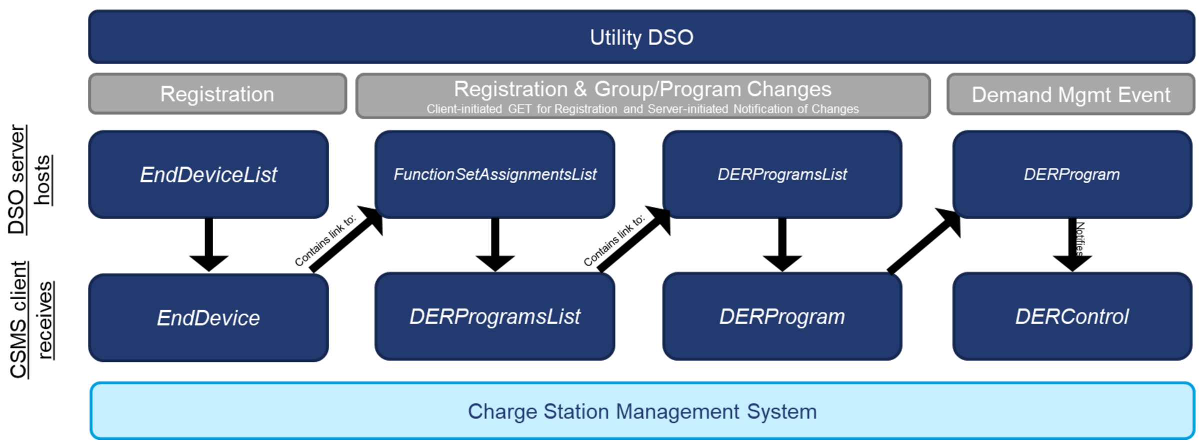


*Figure 3 - Overview of resources used in this Profile*

## 5.3 DER Function Set

Used as defined in IEEE 2030.5, the top-level resource for organizing DER controls is the *DERProgram*. In this profile, the *DERProgram* is the resource used to convey controls to a group (i.e., each controllable group has an associated *DERProgram* for issuing controls to that group). Servers host one or more *DERProgram*s, which in turn expose *DERControl* events to DER clients. In our profile, the DSO functions as the server, while the CSMS and/or Aggregator function as the DER clients. *DERControl* events contain attributes that allow DER clients to respond to events, such as start time and duration.

DER client devices SHALL be capable of internally storing and supporting at least two unique *DERProgram* instances. The intent is that a given *DERProgram* will have associated business rule implications related to the DSO's preferred charge behavior. Each *DERProgram* will issue a set point. One program will have rules/incentives associated with hitting or exceeding that set point (charge more). Another program will have rules associated with hitting or falling short of the set point (charge less).

When a *DERControl Event* is active, it overrides any existing *DefaultDERControl* for that specific control. A DSO implementation of the *DefaultDERControl* may include specific *DERCurves*, and local jurisdiction guidelines should be consulted for parameters of *DefaultDERControl.* This profile does not specify a *DefaultDERControl.*

The relationship described above is captured in Table 3.

*Table 3 - IEEE 2030.5* DERControl *Commands Used in this Profile*

| Grid Support Function | IEEE 2030.5 Resource | IEEE 2030.5 Control Command |
|---|---|---|
| Load Increase | DERProgram | *DERControl = opModFixedW* |
| Load Decrease | DERProgram | *DERControl = opModFixedW* |

The business implications for these Function Sets are captured in the examples provided below. The actual implementation of this profile may vary from the examples provided.

**Load Increase Program:**

- Charging Station is enrolled in DSO Load Increase program and the data exchange is facilitated via this profile, a CSMS, and DSO Server
- On Monday, the DSO Server issues an *opModFixedW DERControl* event for one hour, beginning at 12:00 on Tuesday.
- The *opModFixedW* value is 0.3.[10]
- Because the *DERControl* event is issued under the Load Increase program, the CSMS controls the Charging Station demand such that it is always above 0.3 during the Event time (12:00-13:00).
- The DSO verifies that demand was above the set point throughout the event time.

**Load Decrease Program:**

- Charging Station is enrolled in a DSO Load Decrease program and the data exchange is facilitated via this profile, a CSMS, and DSO Server
- On Tuesday morning, the DSO Server issues an *opModFixedW DERControl* event for one hour, beginning at 5:00 PM on Tuesday.
- The *opModFixedW* value is 0.3.
- Because the *DERControl* event is issued under the Load Decrease program, the CSMS controls the Charging Station demand such that it is always below 0.3 during the Event time (17:00-18:00).
- The DSO verifies that demand was below the set point throughout the event time.

[10] Per 2030.5, the *opModFixedW* value may be between -1 and 1. For the purposes of this profile, the *opModFixedW* must be a value between 0 and 1.

## 5.4 Identification and Group Management

Depending on the program, the DSO may know the Charging Station participating in a demand management event, in order to ensure the operation of the grid and to verify participation in the event. The DSO MAY have programs where neither the location (topological or geolocational) nor the performance of the DER matter. However, the DSO SHOULD still provide unique identifiers for each DER. In IEEE 2030.5, those unique identifiers are referred to as a *long-form device identifier (LFDI)*. Depending on the desired level of controllability required by a given DSO, multiple layers of *LFDI* may be provided. As described in Section 4.2, the use of a *LFDI* functioning as a globally consistent identification method allows all actors, across organizational boundaries, to reference the same asset consistently.

Figure 4 and Figure 5 identify the resources that are required to receive an *LFDI* under this profile. It also shows the optional level of granularity with which the DSO may opt to assign unique identifiers. Specifying unique identifiers to different granularities has different levels of merit, but it is ultimately up to the DSO implementation. This profile merely requires:

- In the direct-managed scenario, only the CSMS SHALL have an *LFDI*
- In the aggregator facilitated scenario, only the aggregator SHALL have an *LFDI*

In practice, the DSO will likely find it optimal to provide an *LFDI* to each charging station to capture the location (topographical and geolocational) of the charging station. As defined in the use case, the charging station provides the point of common coupling (or point of interconnection) with the grid and is thus of most interest to the DSO. If the DSO aims to manage charging at a more granular level than the point of interconnection, each EVSE should be assigned an *LFDI*.

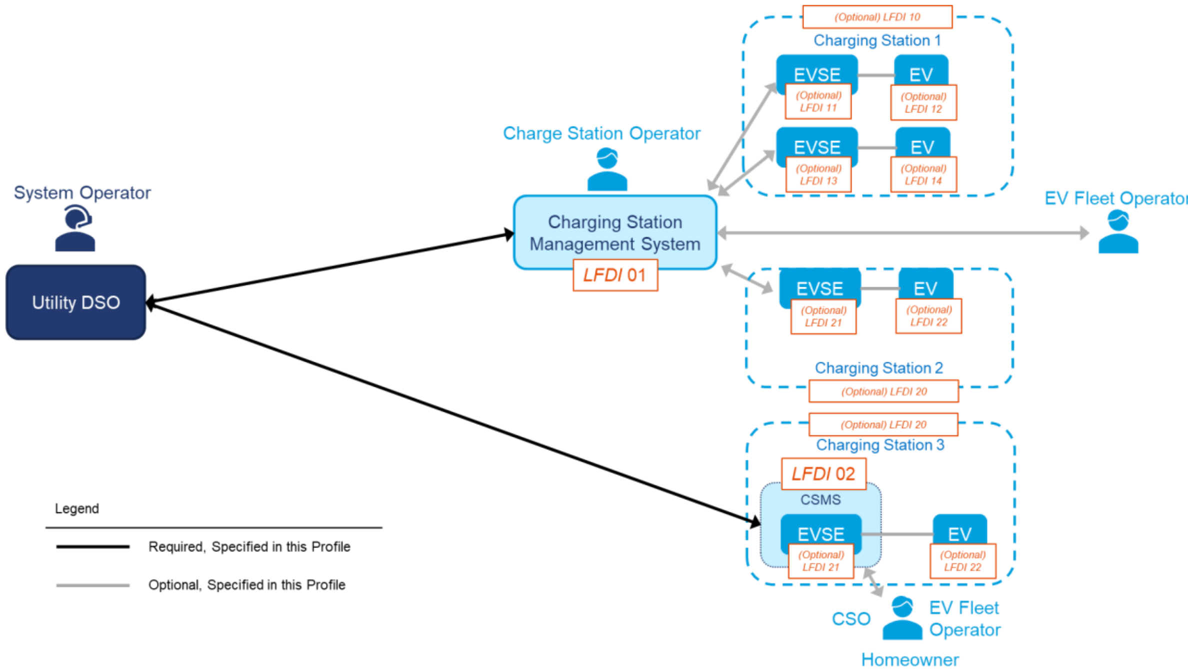


*Figure 4 - Utilization of LFDIs in the Direct Exchange scenario*

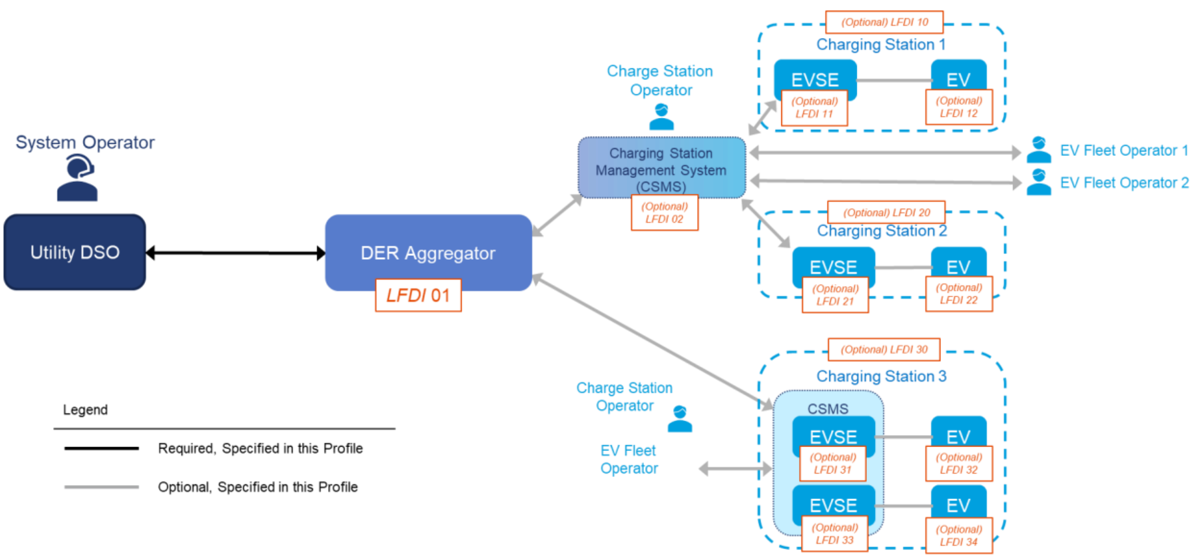


*Figure 5 - Utilization of LFDIs in the Aggregator Mediated scenario*

The *EndDevice* function set provides interfaces to exchange information related to specific client or EndDevice. In the Direct DER Communications scenario, the CSMS and the Charging Station are *EndDevices*. In the Aggregator scenario, the Aggregator itself and all the Charging Stations it manages are all *EndDevices*. The *EndDevice* resource can contain the *EndDevice:DER* resource. This resource contains links for DERs to report their status.

The primary function of groups is the ability to target DER controls to members of those groups. In IEEE 2030.5, DER controls exist within *DERPrograms*, so effectively each controllable group has one associated *DERProgram* to receive the group's DER controls. An Aggregator acting for its DERs and DER Clients SHALL track the *DERProgram* and the group(s) in which they belong. This profile allows DERs to be a member of multiple groups simultaneously.

Note that the DSO server does not need to associate a *DERProgram* for each group; rather, it only needs to associate a *DERProgram* to those groups to which it intends to send controls. For example, if the DSO does not intend to send controls at the Substation level, it does not need to create a *DERProgram* for the Substation groups. To minimize resource requirements for the DSO server, Aggregators, and DERs, the DSO server SHOULD only create *DERPrograms* for groups that are intended to receive controls.

Identification of these groups and programs for this profile follows the same architecture as is used in the Common Smart Inverter Profile (CSIP):

> In IEEE 2030.5, group membership is conveyed to an Aggregator or directly communicated to a DER using the *FunctionSetAssignmentsListLink* in the DER's *EndDevice* instance. This link points to a FunctionSetAssignmentsList (FSAList) that is usually unique to each DER. This list contains one or more *FunctionSetAssignments* (FSA). Each FSA can contain a link to a *DERProgramList,* which contain links to a *DERProgram* the DER is required to track. Aggregators acting for its DERs and DER Clients SHALL traverse all these links and lists to discover all *DERPrograms* the DER is required to track.

The DSO server can structure the FSAs to achieve its grouping objectives in many ways. CSIP has chosen the model shown in Figure 6 to promote efficiency and interoperability.

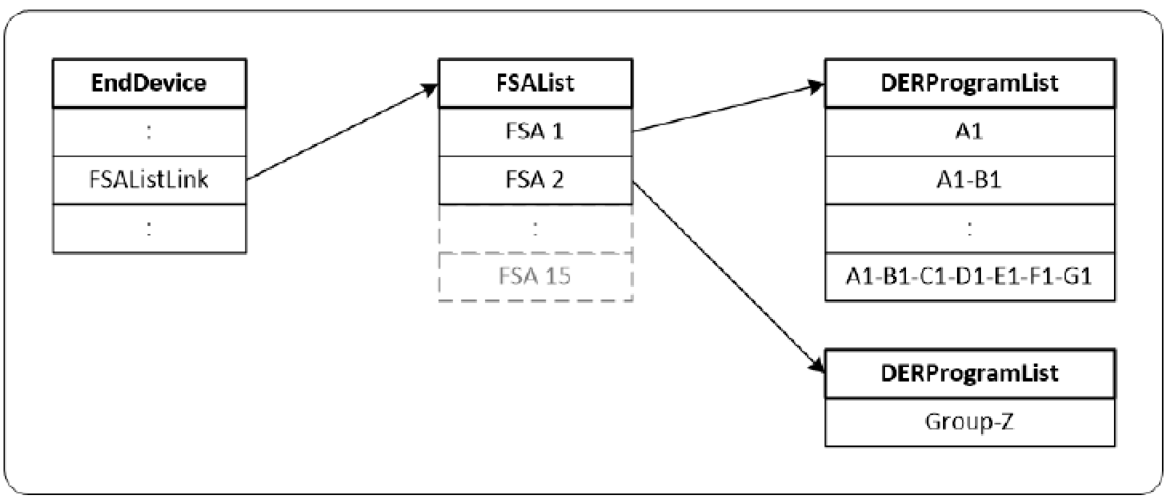


*Figure 6 - CSIP FSA Model Adopted for this Profile*

> In the above model, the *FSA 1* points to a *DERProgramList* that contains all *DERPrograms* for topology groups (those related by circuit topology). *FSA 2* points to a *DERProgramList* containing a *DERProgram* for a non-topology group.

This grouping methodology allows the DSO to specify the EV demand management opportunity at the level most appropriate for their program. Some utilities may elect to have all *EndDevice* DER assigned to the same *DERProgramList* containing one assignment, representing a demand management program aimed at system-wide events. Other utilities may implement sophisticated demand management programs that require variable *DERProgramList* endpoints that adjust based on circuit topology.

Prioritization of events is achieved using the *DERProgram:primacy* resource. Priority is assigned at the group (i.e., *DERProgram*) level. There may be occasions where a single *EndDevice* gets conflicting (or differing) directives as part of more than one *DERProgram.* In such occasions, the *DERProgram* with lower primacy takes precedence subject to the normal IEEE 2030.5 event rules. Each *DERProgram* has a primacy value, which is controlled and may be updated by the DSO server.

## 5.5 Subscription / Notification

The DSO server provides resources to support subscriptions that allow rapid notification of a change in the resource. For example, the DSO might issue an emergency “charge less” event based on the level of solar generation on a feeder. In both the aggregator mediated and direct exchanged scenarios, a CSMS implements a notification resource to receive the notifications sent by the DSO server.

Successful implementation and operational performance of this profile depends heavily on the proper operation of the Subscription/Notification function set. Maintenance of subscriptions is described in IEEE 2030.5. In particular:

- The CSMS Client SHOULD renew its subscriptions periodically (e.g., every 24 hours) with the DSO server.
- The CSMS Client SHOULD fall back to polling on perceived communications errors.

The CSMS Client instance contains the *SubscriptionListLink*. The direct exchanged CSMS and the Aggregator CSMS posts to this link to create subscriptions to resources for which it wants to receive notifications. For the needs of this profile, the CSMS subscribes to the following resources:

- *EndDeviceList* – to detect additions/deletions and enabling/disabling of DERs
- *DERProgramList* – to detect changes to the group assignments of each DER and to detect changes in the priority of each DERProgram
- *DERControlList* – to detect the creation of a *DERControl* and changes to its status
- *DefaultDERControl* – to detect changes in the default controls of each *DERProgram*

When a subscribed resource changes, the DSO server posts a *Notification* to the CSMS. For list resources, the *Notification* payload may contain entries from the list, depending on the *limit* setting of the request by the CSMS Client and the policy of the server. The CSMS may need to perform additional list queries to get all changes to the list. Business users may be familiar with Microsoft Outlook’s preview email message feature. The *Notification* is similar in that the user may be able to get all pertinent information from the preview alone. However, the user may need to go directly to the source and open the full email to get the full context. Refer to IEEE 2030.5 Section 8.7 for details about Subscription/Notification behavior.

## 5.6 Scheduling

*DERControls* are IEEE 2030.5 events and SHALL conform to all the event rules in Section 12.1.3 of IEEE 2030.5 as it relates to issuing new events:

- Aggregators and Direct-Controlled DER (via the CSMS) SHALL subscribe to each *DERProgramList* assigned to its DERs to discover changes in *DERProgram*:*primacy*.
- Aggregators and Direct-Controlled DER (via the CSMS) SHALL subscribe to the *DERControlList* of each *DERProgram* assigned to its DERs to discover new controls or changes to existing controls.
- Aggregators and Direct-Controlled DER (via the CSMS) SHALL subscribe to the *DefaultDERControl* of each *DERProgram* assigned to its DERs to discover changes to the default controls.

There are multiple ways to express the start time and end time of an event. Each *DERControl* is an event and therefore explicitly contains a *startTime* (TimeType object) and duration (in seconds) within the *interval* attribute. With these two pieces of information from the *interval* attribute, actors can derive a *Specified End Time,* which is the time when an *Event* completes.

## 5.7 Acting on *DERControls*

Once the CSMS has retrieved and/or received via subscription the necessary DER resources, it waits for *Notifications* of new *DERControl* events. The new *DERControl* may be sent with the *Notification*. Otherwise, the CSMS uses the *Notification* to trigger a GET of the *DERControlList* containing the new *DERControl*. At the start time of the event, the CSMS activates the control for all the targeted DERs, and at the end of the event, the Aggregator de-activates the control returning the control to its default value, if a default was specified. How the CSMS activates/de-activates the control for all the targeted DERs is outside the scope of this profile.

*Responses* are required for each *DERControl*. The CSMS shall post the appropriate *Responses* on behalf of each targeted DER. *Responses* would include information such as confirmation of receipt of the command, and confirmation of dispatch of the DER resource from the CSMS perspective. Note that measuring performance via measurement and verification rules ultimately resides on the DSO, but the CSMS shall confirm intended dispatch to avoid confusion and potential errors.

The messages that would be exchanged to ensure subscription, notify, retrieve the details of the event, and ultimately implement a DER Control event are captured in Figure 7.

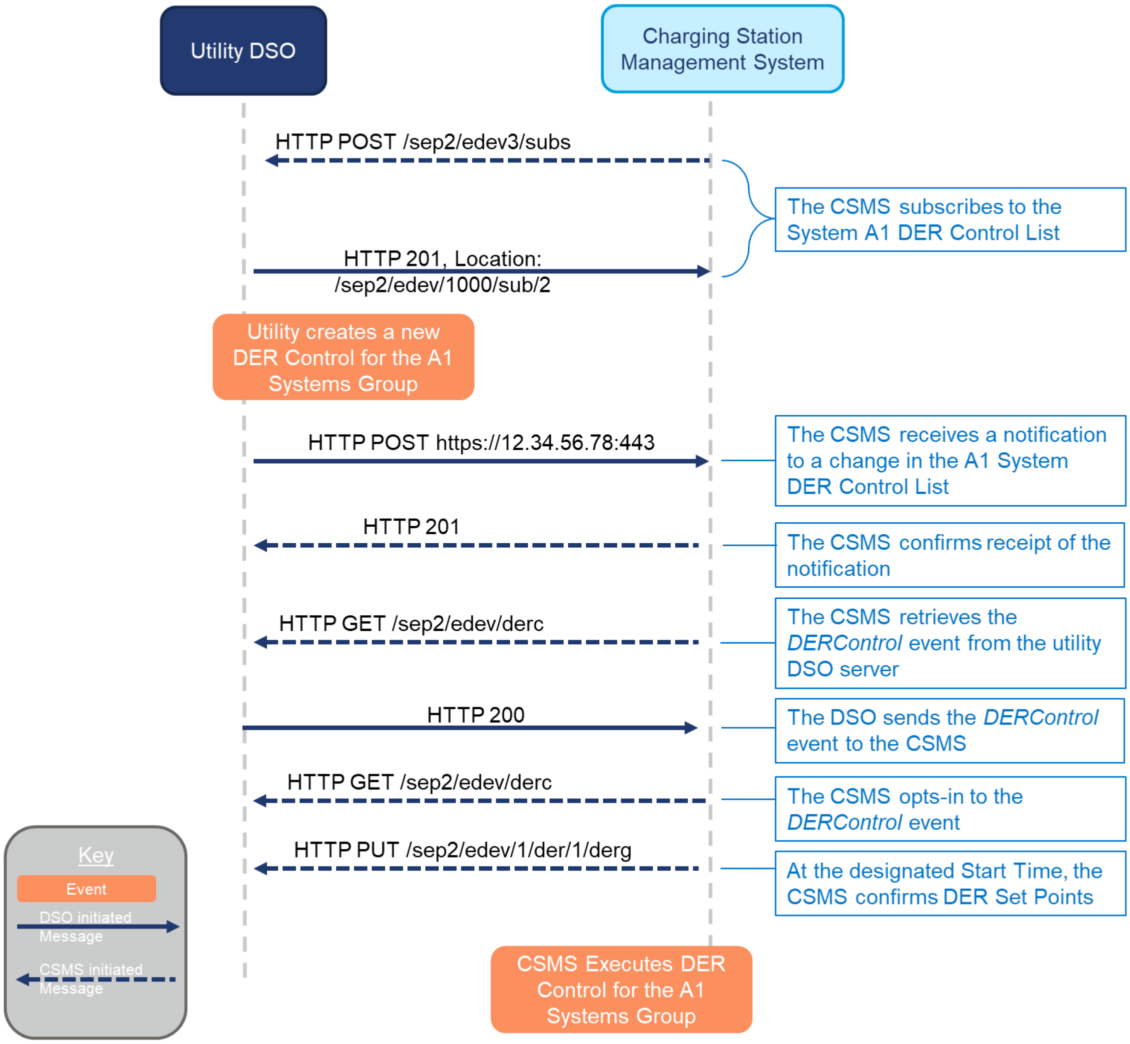


*Figure 7 - Successful DER Control Dispatch Flow*

# 6 Conclusion

To facilitate the interoperable implementation of the Electric Vehicle Fleet Managed Charging Use Case, this Interoperability Profile employed the open industry standard IEEE 2030.5. Considering the various constraints that a DSO may face, the main goal of this Profile is to advance the smart charging of EV fleets. Two scenarios, governed by regulatory and DSO requirements, were identified to illustrate the information exchange between the DSO and the charging stations. The authors hope that this document provides industry with a reference that allows DSOs, vendors, aggregators, and electric vehicle owners to speak a common language and understand the types of information exchanges that may be required. Ultimately, this profile may help to guide the development of new software systems and facilitate the collaboration required to manage EVs as grid assets, rather than grid stressors.

# 7 Common Terms and Definitions

| Common Terms and Definitions | |
|---|---|
| ***Term*** | ***Definition*** |
| Charging Station | The physical location and electrical system where an EV can be charged. A Charging Station has one or more EVSEs. |
| Charge Station Operator (CSO) | The person or organization charged with operating the charging station, which includes maintenance, and coordinating with the DSO and EV Fleet Operator to meet the charging needs of the EVs while optionally participating in DSO programs. The Charge Station Operator may be a homeowner with a single EV. |
| Charging Station Management System (CSMS) | Manages EVSEs. Generally, transforms EVSEs from electrical supply equipment to smart grid actors. The CSMS has the information for authorizing users for using Charging Stations, and monitors charging processes, gives charging commands (smart charging), and integrates information from other sources (e.g., CSO, DSO, Aggregator, EV Fleet Operator). The CSMS may be operated by the CSO directly or by Aggregators and may be separate from or integrated with EVSE. |
| DER Aggregator | An organization that facilitates the integration of EVs into DSO operation. The Aggregator may enroll multiple CSOs across multiple charging stations to meet the requirements as defined by the DSO. The DER Aggregator may also have an expanded portfolio of services and resource types (e.g., standalone storage, water heaters). |
| Electric Vehicle (EV) | An EV is an electric powered vehicle that uses one or more electric motors for propulsion. For the purposes of this use case, EV's are considered plug-in electric vehicles that are primarily charged through electrical sources external to the EV, such as grid power. |
| EV Charging | Electric Vehicles charging their on-board batteries. Can include charging from the EVSE. EVSE may use grid power or stationary energy storage to facilitate charging of the electric vehicle. |
| EV Fleet Operator | Person or organization that is responsible for a vehicle fleet. Responsibilities include operations and maintenance, scheduling, and generally utilizing the EV for its driving capabilities. The EV Fleet Operator may be a homeowner with a single EV. |

| | |
|---|---|
| EV Supply Equipment (EVSE) | An EVSE is considered as an independently operated and managed part of the Charging Station that can deliver energy to or receive energy from one or more EVs. |
| System Operator | The person at the DSO who manages and operates the distribution system. This person may use a variety of software and hardware tools to accomplish the function. |
| Distribution System Operator (DSO) | DSO is the legal entity responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the ability of the system to meet demands for the distribution of electricity. The DSO has many subsystems and further actors that could be spelled out, such as meters and management systems, but has remains at a high level for the purposes of this use case. |