An EV Managed Charging Framework: Simplifying Managed Charging with Energy Service Contracts

March 2021

Published by the SEPA Energy Services Interface Task Force

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About SEPA

The Smart Electric Power Alliance (SEPA) is dedicated to helping electric power stakeholders address the most pressing issues they encounter as they pursue the transition to a clean and modern electric future and a carbon-free energy system by 2050. We are a trusted partner providing education, research, standards, and collaboration to help utilities, electric customers, and other industry players across four pathways: Regulatory and Business Innovation, Grid Integration and Electrification. Through educational activities, working groups, peer-to-peer engagements and advisory services, SEPA convenes interested parties to facilitate information exchange and knowledge transfer to offer the highest value for our members and partner organizations. For more information, visit www.sepapower.org.

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Scope

This framework describes a business and technical approach to integrate and coordinate electric vehicle (EV) charging within electric power distribution areas and across a balancing area. Integrating behind-the-meter (BTM) resources provides a powerful tool to support enhanced grid stability, reliability and resiliency as the grid undergoes fundamental shifts in generation, distribution, and historical demand profiles.

This framework, based on existing and widely supported standards, proposes energy service contracts as an open, transparent, and enforceable method to support energy information exchanges and transactions. Energy service contracts are realizations of energy services interface (ESI) principles (GMLC 2018, Hardin 2011). This document presents service contract data elements that can accommodate a wide range of uses and market structures, along with the necessary service components and coordination architecture to enable secure and reliable energy information exchanges. This document does not define the contracts themselves, but rather identifies standard semantics that will be used to write contracts.

From the outset, the Energy Services Interface Task Force (ESI TF) has been focused on advancing the state of interoperability to support the full array of BTM distributed energy resources (DER) including solar PV, energy storage, smart thermostats, and fuel cells. At the SEPA 2019 Grid Evolution Summit held in Washington D.C. there was strong support expressed by attendees to apply ESI TF efforts to EV managed charging. This document describes the framework for integrating EV charging into grid planning and daily operations. While EVs are mobile DER, the charging equipment and billing meter are stationary. In fact, the energy service contracts, enabling services, and coordination architecture are agnostic to DER device type.

It is the goal of the SEPA ESI TF to develop energy service contracts as a standardized information exchange mechanism to enable local and area-wide situational awareness of the capacity and availability of resources to provide energy and power services. This framework will be followed by additional work products: a business requirements document for EV managed charging, energy service contract specifications, a proof-of-concept reference implementation (open-source software) along with an implementation guide.

Introduction

Currently, few residential EV chargers (EV supply equipment, EVSE) models are designed to support bi-directional communications. For EVSEs with communications, there is no single standard to support easy on-boarding or standard market mechanisms to encourage participation in demand response (DR) programs or local congestion mitigation. Charging stations, facilities with one or more EVSEs, may have the capability to support more advanced grid interactions, like frequency regulation or voltage support, but the lack of standardization on the part of device manufacturers, software providers, and utilities adds considerable cost and complexity to integrating these behind-the-meter resources. There is also no standard for auto manufacturers to provide grid services via telematics.

As commercial EV fleets emerge, there will be a new set of challenges. EV fleet charging facilities are likely to be concentrated at seaports, airports, and other retail and wholesale transportation distribution centers. Existing substations, transformers and conductors may not be able to accommodate an unplanned increase in energy demand depending on the time of day when charging occurs. For example, charging after normal business hours may lead to higher evening demand peaks. Yet advanced communications and the solid-state power conversion electronics of EV chargers can both mitigate the potential impact of new loads and provide valuable grid services. EV charging facilities may also install solar PV and energy storage systems, further enhancing their capability to support grid operators.

The electric generation portfolio is rapidly changing. There are already 10 states where variable energy (i.e., wind and solar) make up over 20 % of bulk power generation. In four of these states, wind and solar comprise 30 % or more of electric power generation (EIA 2018). More than 200 cities and counties, 11 states, Puerto Rico and the District of Columbia have a commitment to transition to 100 % renewable generation of electricity (UCLA 2019). At the same time, within certain geographic areas the distribution system is evolving at a fast pace, as rooftop solar, EV charging and energy storage significantly alter historical load profiles.

The "increased adoption of DERs – such as rooftop solar, battery storage and EVs – is an emerging challenge for utilities. While the increase in DERs is part of this challenge, *transportation electrification in many ways is the most significant [challenge]."*
SEPA 2019a

"Supporting accelerated EV deployment will likely exceed the capacity of existing electrical infrastructure in the near term, and will require upgrades and new capacity deployment, typically taking many months and sometimes years – due to distribution planning, regulatory approval and project construction cycles. As the industry moves towards higher speed charging, the amount of time required and the costs to deploy charging infrastructure will increase. Consideration of opportunities to mitigate costs and incorporate load management strategies to minimize on-peak charging must start now." SEPA 2019b

One of the most direct means to minimize the challenges of rapid EV adoption while simultaneously enhancing energy reliability and resiliency is to support interactive communication and coordination between grid operators, EVSEs and charging stations, and EV drivers. This interactive capability is known as managed charging, which refers to "central or customer control of EV charging to provide vehicle grid integration (VGI) offerings, including wholesale market services." (SEPA 2019b). An energy service contract promises to provide a standard mechanism to exchange actionable information across the value chain.

The Role of an Energy Service Contract

Why an Energy Service Contract?

Rooftop solar generation, the availability and capacity of energy storage, EV chargers, smart thermostats and other flexible demand response assets are currently operationally invisible to utilities. An energy-service-contract-based communication and coordination implementation can make the invisible capacity of flexible resources visible and available to system operators while preserving the autonomy and privacy of energy consumers. Energy service contracts can also enable next day and near real-time DER capacity forecasts to provide situational awareness of distribution grid conditions, allow more flexibility in matching energy demand and supply, facilitate energy transactions, and improve distribution system resiliency.

Seamless integration and interoperability across the value chain among customers, device and equipment manufacturers, service providers, and system operators is a multifaceted challenge. The Grid Modernization Lab Consortium *Interoperability Strategic Vision* whitepaper identified an Energy Services Interface (ESI) as a key organizing element for achieving interoperability (GMLC 2018). The SEPA ESI TF defines an energy services interface as a bi-directional, service-oriented, logical interface that supports the secure communication of information between parties to facilitate various energy interactions between electrical loads, storage, and generation.

An energy service contract is a means to implement the ESI information exchange. Contracts can be based on a common, industry standard vocabulary of measurements, event signals, and terms and conditions. The contracts may include a request and corresponding response (commitment) for resource availability for a given service area. The contracts may be for a day-ahead or same day service for a given capacity and duration, an open-ended "as needed" commitment over a longer period, or a real-time service request. The terms and conditions may be based on a preexisting agreement with terms for non-performance communicated in real-time.

> Energy service contracts will include different contract types – resource registration, resource availability, resource schedule and resource commitment.
>
> Each contract type will have a standard format containing mandatory and optional data elements.

Energy service contracts, with concomitant service components, discussed below, can simplify the integration of DER into utility operations across the board – EV drivers, charge station owners, third-party aggregators, and system operators. Services components include onboarding new devices and systems, mapping resource availability and capacity to the grid topology, and communicating event and price signals so that local and system-wide energy and power flow demands can be readily met by behind-the-meter assets.

The contracts will support the autonomous scheduling and dispatch of DER resources based on a common agreement between energy service requestors (buyers) and providers (sellers).

Energy Service Contract Data Elements

A contract between parties may be a one-way "prices to devices" that can represent a real-time tariff or rate. A two-way information exchange may enhance reliability and reduce overall system costs by reducing uncertainty in forward, day-ahead, or real-time markets. Depending on the contract type, energy service contracts may include basic information elements shown in Table 1: *who* - the service requestor and provider; *what* - energy or active and reactive power; *where* - where a service is needed - at a distribution substation, feeder or circuit; *how much* - the quantity and cost of the energy or power delivered; *when* - the start date-time, anticipated response (latency) time, ramp time and duration; and *how* – a standardized format for a Service Level Agreement that may include a specific performance requirement, opt-in/opt out terms and conditions (if event-based), measurement & verification of service delivery, etc. The latter information components may be based on a previously established agreement outside the information exchange payload.

Table 1 Basic information elements carried in energy service contracts.

Core information exchange data elements	
Who	Service requestor and provider
What	Energy or power – kWh, kW, kVAR
Where	Coordination Area. Coordination areas may exist within a nesting of coordination areas that represent the grid topology – transformer, section, feeder, secondary substation, primary substation, service territory, balancing area.
How Much	Quantity, uncertainty, cost/price
When	Start date-time, ramp time, duration
How	Specific performance requirements, opt-in/opt out terms and conditions (if event-based), measurement & verification of service delivery, etc. These terms and conditions may be documented in a service agreement rather than included in operational messages.

Core Service Components

Two-way or multi-party agreements require a suite of core services, commonly referred to as a full technology stack, to ensure reliable and secure message transmission, delivery, and response. As an example, the various email services to send, receive, route and display emails assume and reference services and system components outside the scope of the interface itself. The concept of a full technology stack is illustrated in Figure 1.

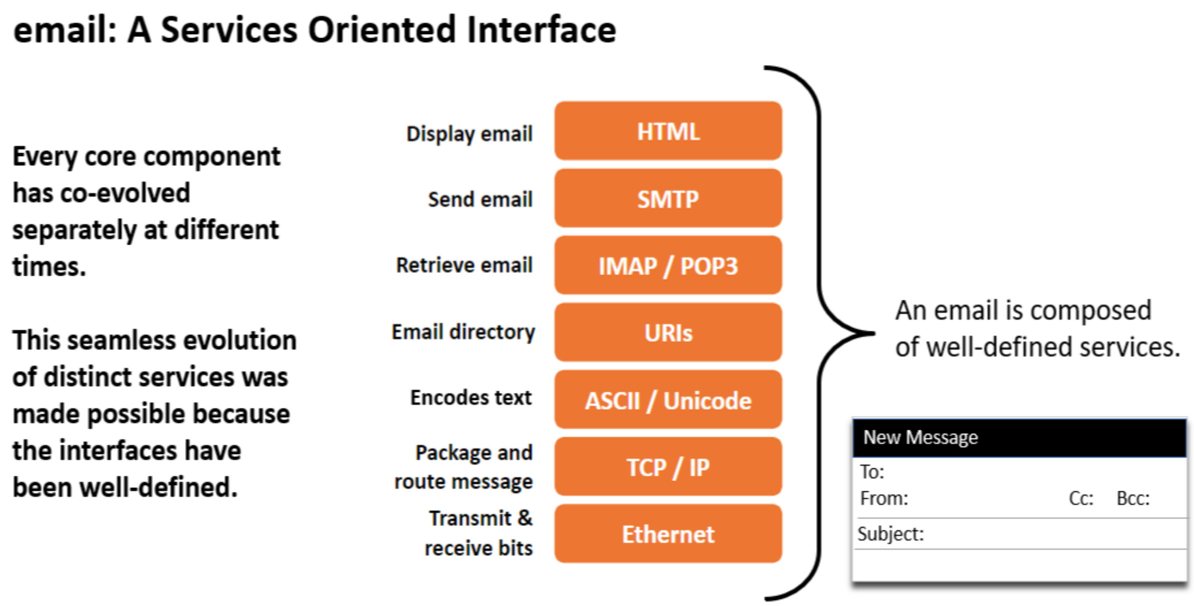

Figure 1 Core services and a full technology stack

The committee that developed the information specification for OpenADR (OpenADR, 2018) recognized the importance of leveraging existing protocols and standards while allowing *substitution* of these components as systems, services and technologies evolve.

> "A typical web browser or email system uses many standards from many sources and has evolved rapidly to accommodate new requirements by being structured to allow *substitution*. The set of standards (information, service, or messaging) is said to be composed to perform the task of delivery of email. Rather than creating a single application that does everything, perhaps in its own specific way, we can use components of code, of standards, and of protocols to achieve our goal. This is much more efficient to produce and evolve than large integrated applications such as older customized email systems." (OASIS 2014)

In the same way, to enable energy service contracts there must be a standard set of end-to-end services and components to ensure secure and reliable information exchange sessions. In addition, the demarcation of services must support ready substitution.

The proposed ESI TF reference implementation services will include auto-registration, auto-discovery, resource forecasting and scheduling, event streaming, anomaly detection, and dynamic remapping of resources to changes in grid topology.

DER Coordination & Control

Scheduling, system control and resource dispatch are essential to ensuring grid reliability. System planners and power engineers rely on supervisory control and data acquisition systems to collect, aggregate, and analyze real-time data to monitor, manage, and control the electrical distribution system. DER coordination contrasts with the traditional direct control by system operators.

Traditional utility coordination and control communications are centralized in a hub-and-spoke layout. These control schemes were appropriate for the time but are poorly suited “to handle large numbers of intelligent interacting edge devices.” (PNNL 2017) A utility may not want the responsibility of controlling hundreds of thousands of devices and a user or owner may not want to extend such control to their electric utility provider.

Direct control has several potential drawbacks.

- Potential mismatch between grid and customer operational objectives.
- Not adaptable to changes in technology or needs of grid and customers.
- Requires greater data exchange about DER characteristics and state.
- Customer privacy, scalability and safety are challenging to address.

Enabling onboarding and real-time information flows can encourage broad market participation by asset owner and system operators and enhance the reliability and resiliency of the power distribution system, while lowering costs. Flexible resources may be dialed up or down based on the availability of renewable resources, local congestion challenges, or system wide disruptions. Energy service contracts can enable operators and third parties to coordinate scheduling, optimization, and dispatch services seamlessly and securely.

In a seminal paper, “Ultra-Large-Scale Power System Control and Coordination Architecture” (PNNL 2014) the authors assert that “current power system controls do not properly address the new grid requirements to achieve existing policy mandates for renewable and distributed resources, and responsive customer demand.” They suggest that a federated architecture that supports both multiple and competing objectives across organizational boundaries and local autonomous operations is needed to support the new dynamics and emerging complexity of the modern grid.

The growth of smart, customer-owned DER, cloud computing, and the app economy creates an opportunity to shift from a central and distributed control paradigm toward decentralized coordination and control across the traditional boundaries of grid operator (GO), third-party DER service provider (DSP), and end-user whether charge station operator (CSO) or EV driver. The federated architecture supports a nested hierarchy of local controls and system wide coordination, Figure 2.

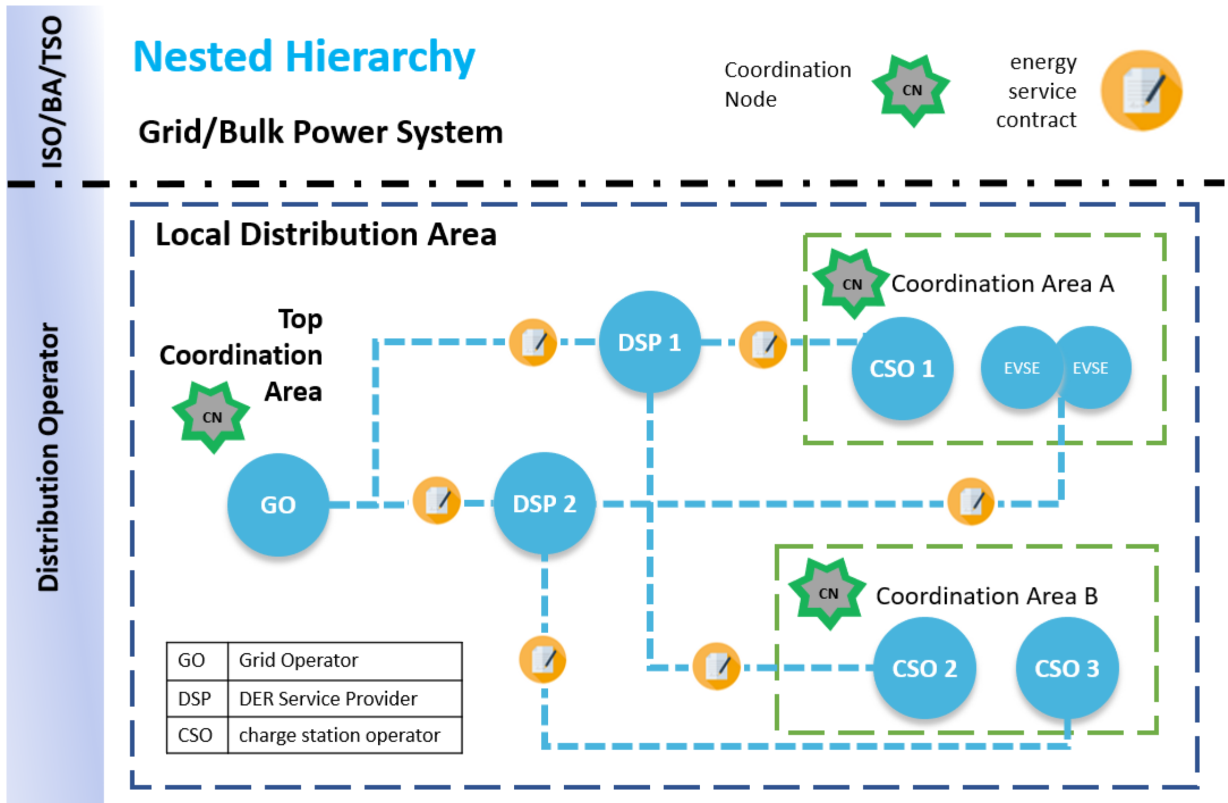

Figure 2 Nested grid coordination architecture

The services (service discovery, service registration, real-time signal streaming, dynamic resource mapping to grid topology) can be designed to enable a plug-and-play capability. This integrated approach enables real-time, fine-grained distribution system coordination and control in a multi-stakeholder environment. Auto-registration and auto-discovery fosters wider participation of flexible resources.

Proposed Business and Regulatory Context

Right Scaling Approaches

In a market-based economy careful consideration must be given not only to technical solutions but also to commercial and regulatory considerations. A one-size-fits-all set of mandates and technical requirements may be impractical politically and culturally. It may also stifle technological innovation through unnecessary constraints. With these considerations in mind, we recommend an approach, based on existing standards and widely deployed technologies, that scales with the capacity of an EV charging installation. This approach integrates EVs into grid operations by differentiating technical requirements based on their impact, or load class, shown in Figure 3.

A small load is represented by a residential cluster of EVSEs that may be on the same transformer with a nameplate capacity of 50 kVA or less. A medium load is represented by a charging station with a minimum nameplate capacity of 50 kVA but less than 500 kVA. A high load represents an EV fleet charging facility with greater than 500 kVA nameplate capacity.

The *Program Templates* section of this document provides three examples of how these small, medium, and large loads can be managed using an "intelligence at the edge" framework

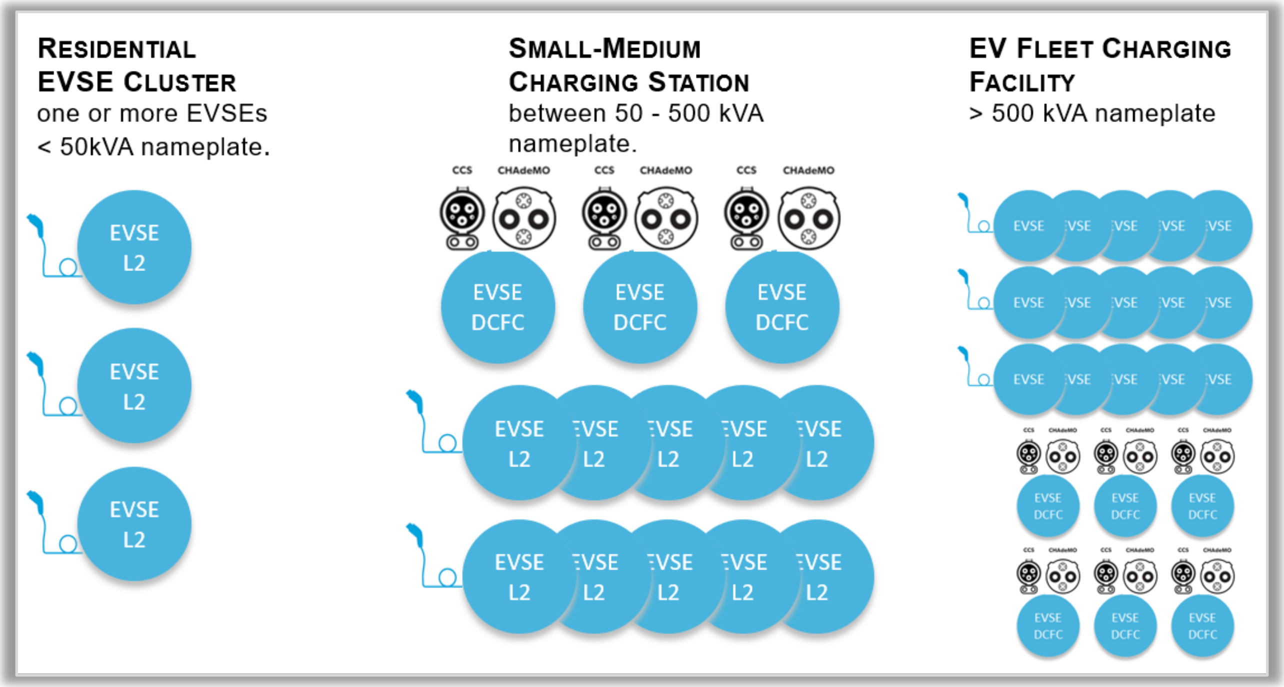

Figure 3 Integrating EVs into grid operations by differentiating technical requirements based on their impact, or load class

Roles and Relationships

For the contracts to enable the coordination of energy supply and use, including power and ancillary services, between any two parties such as energy suppliers and EV owners, markets, and service providers, it is essential to have a framework that balances rigor and flexibility. The definitions, structure, and message meanings must be strict enough to enable two independently developed applications to interoperate. The contracts must also be able to adapt to a wide range of permutations of roles, responsibilities, and market types.

For simplicity, we focus on four fundamental roles (Figure 4): a Grid Operator, a DER Services Provider, a Charge Station Manager and the EV Driver. The Grid Operator might be a distribution system operator, a balancing authority, or an independent system operator. The DER Services Provider may be a charge network operator, a charging station operator, or a third-party aggregator. The DER Services Provider provides energy services to the Grid Operator by transmitting event or price signals to a Charge Station Manager. The DER Services Provider is the market intermediary between the asset owner or driver and the grid. The Charge Station Manager is the supervisory controller that interacts with lower-level primary controllers, the EV chargers. A single entity may serve a dual role. For example, a charge network operator may serve as both a DER Services Provider and a Charge Station Manager. The Charge Station Manager role may be shared by two entities, such as the charge network operator optimizing resources, and the charge station operator setting their own local asset management policies regarding when and how to provide load reduction or ancillary grid services. Depending on service agreements, an EV driver may or may not be able to opt out of providing grid services.

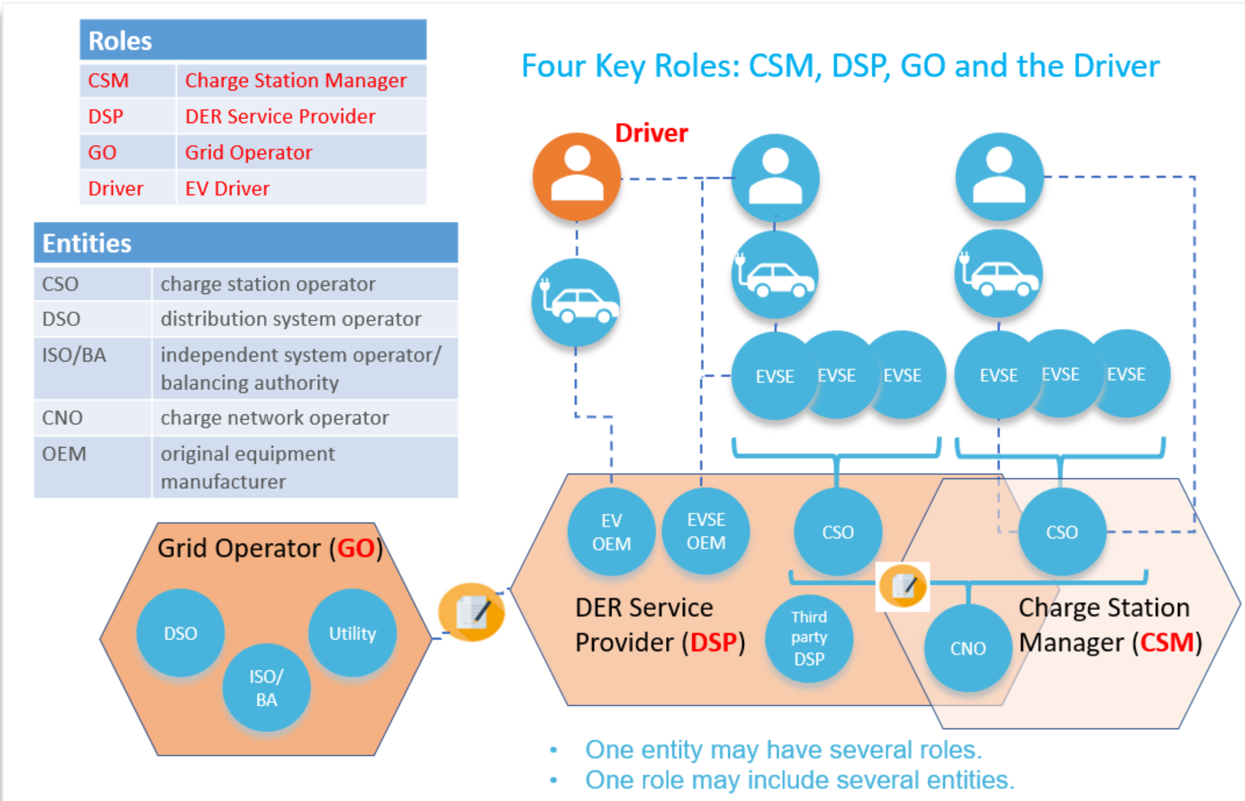

Figure 4 Key roles and relationships

It is important to note that relationships can be nested (Figure 2). A building energy management system may be connected to a charge network operator, a traditional energy services aggregator or a distribution system operator. The DER Service Provider, in turn, may have a contractual relationship with a distribution system operator and participate in a wholesale market at the same time. The contracts must be able to unambiguously represent any permutation of roles and responsibilities and support dynamic rather than fixed role configurations.

Grid Services

Grid services, including energy capacity and ancillary services, support the continuous flow of electricity to ensure that supply meets demand. Traditionally, these services have been provided by generators and distribution field equipment. The proliferation and penetration of distributed solar, energy storage, EV charging and other DER represent new challenges for system operators. Standard energy information exchanges can transform these challenges into opportunities to improve power quality and system reliability.

The term "grid services" is generally used to describe a set of energy products where the amount of energy (kWh) or power (kW or kVAR) is differentiated in terms of response time, duration of energy product provision, dispatch method, locational boundary, application, and other factors.

For example, balancing supply and demand may require:

- an increase or decrease in demand within a balancing area or service territory (peak shaving/load shaping/abundant renewable supply),
- a request to decrease demand or export power for a short or long duration at a wholesale pricing node or secondary substation (congestion management or non-wires alternative), or
- a request to reduce demand or increase supply in less than 10 minutes (standby reserve).

Similarly, power factor correction or frequency regulation may require an increase or decrease in real or reactive power within a coordination area with a precise, low latency response time.

In short, grid services can be defined in terms of a request or agreement to increase or decrease energy or power within a specific geospatial boundary at a specified time and duration.

The Role of Time-of-Use Rates

Several reports have shown that well-designed time-of-use (TOU) and other time-varying rate structures can effectively shift power consumption away from peak demand and drive significant savings for both customers and utilities. Currently, the few implementations of EV-targeted TOU rates are like traditional TOU structures and vary by time of day and day type (weekday or weekend/holiday) across the service territory.

Several utilities have instituted EV-specific tiered TOU rates to encourage charging during off-peak hours. Generally, pricing is adjusted to reflect seasonally higher demand periods.

PG&E EV B TOU summer rates

This tariff structure is a well-established means to shift load. It is a passive, set-and-forget mode that can effectively reduce peak demand periods by providing a relatively fixed market signal to encourage shifting load. However, fixed TOU rates are unresponsive to real-time grid interruptions and indifferent to local distribution conditions. In a residential area with a high penetration of EVs, local transformers and feeders may experience steep ramp times when the clock strikes 11 p.m. Energy contracts with a cooperative intelligence-at-the-edge coordination mechanism can enable staggered charge times and charging rates within a designated coordination area and across a wider time window.

Enabling Grid Services with Energy Service Contracts

The capability of contracts to provide a standard request for the forecast availability of flexible resources during the next day or in near-real time and to express precisely where and when they are needed can substantially augment the capabilities of grid operators to respond to dynamic changes in power flow and unplanned conditions such as natural events or equipment failures. The transformation of grid services to contract elements is shown in Figure 5.

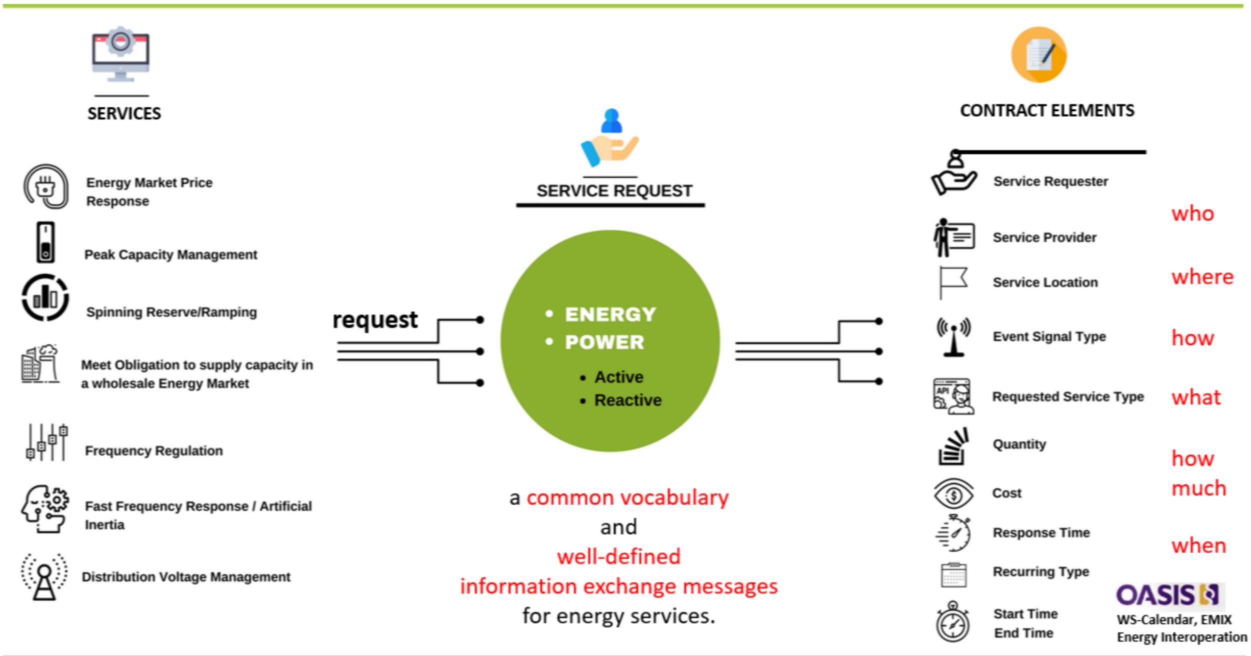

Figure 5 Mapping grid services to energy and power requests

Grid services are reduced to the basic elements of energy or power (the "what") over a given time interval (the "when"), quantity, location, and of course who are the service requestor and provider. Additional elements would include Party IDs, Message IDs, time stamps, Coordination Node ID, and Contract ID. A top-level program agreement would define the expected message types, responses, and terms.

Use Cases

The business case for energy service contracts is best understood by providing concrete examples for their application. Based on SEPA's research, we have identified three use cases for highlighting the challenge and opportunity of vehicle to grid interaction – local congestion management, absorbing abundant renewable supply, and virtual genset. These use cases provide a means to do a cost-benefit evaluation to estimate the value to electric power customers, system operators, and to society at large.

Local Congestion Management

Figure 6 Multiple EVSEs on a local service transformer.

The distribution system has dynamic needs that can occur within a day, month, or season. Currently, the output of most BTM DER (PV, batteries, EVs, smart thermostats, etc.) is not coordinated with dynamic grid conditions. Significant distribution needs are local. There may be an undersized transformer (e.g., a residential service transformer-sized for 6 homes, each of which subsequently adds one or more EV chargers, Figure 6) or a deficiency on a certain section of a distribution feeder. These needs are dynamic in location and time. One distribution feeder may be overloaded for a few hours in the evening during hot summer months, while another feeder may exhibit a high load in early afternoon. Within a local distribution area there may be significant penetration of potentially dispatchable EVSE resources that can provide valuable services to distribution operators - relieving temporarily congested feeders, supporting non-wires alternatives, correcting phase imbalances, volt-var optimization, etc. Currently, there are no standardized mechanisms for system operators to leverage the capabilities, capacities, and availability of DER resources in concert with local challenges that may be occurring at a specific substation, feeder, or circuit.

Since the emergence of electric vehicles over the last 10 years, researchers have noted the clustering of EVs within local distribution areas (EV Project 2013). The local impact of clustered EVs on transformers or feeders is quite dependent on the distribution design, equipment age and capacity, coincidence with other loads, and the charging overlap. These impacts can be mitigated with managed charging (SEPA 2017).

As electric vehicle adoption rates accelerate, congestion management may apply at multiple scales – a local transformer, a feeder, or at a low or medium voltage substation. The same mechanism that can mitigate local congestion can be used to manage system-wide peak demand across a service territory or balancing area.

Depending on the EV charging environment, the “offer” to charge now or to allow for modulated charging may be communicated directly to drivers via a mobile app or to an automated system designed to accommodate variable pricing and event signals. The automated system may be a home or building energy management system, a site controller, or a network managed service.

Absorb Abundant Renewable Supply

As the total share of wind and solar generation continues to grow, curtailment of renewable energy sources is expected to increase. Charging when these renewable resources are abundant relative to demand can provide tangible economic and environmental value to EV owners, plant and system operators, and the whole system. The renewable generation and load profiles of Figure 7 illustrate the benefits of smoothing out resulting load by moving EV charging off the evening peak into the night wind resource and likewise shifting morning-work charging closer to peak sun.

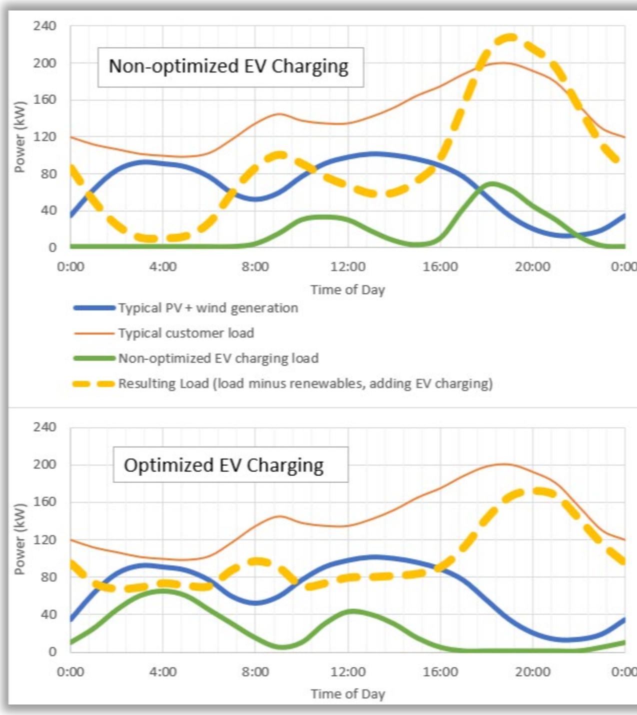

Figure 7 EV charging optimized to use available renewable power.

Time-of-use rates lack the flexibility to accommodate the dynamism of real-world conditions, like changes in cloud cover or wind conditions. During the spring, when demand is low, solar irradiance is at peak, and some conventional dispatchable plants are off-line for maintenance, a generator may have an unplanned outage. A portfolio of real-time, responsive resources can provide the necessary cushion to enhance reliability and resilience.

Offers will be made via the same mechanism described in the Local Congestion Management Use Case.

Virtual Genset

EV fleet charging facilities (Figure 8) are likely to be concentrated at seaports, airports, and other retail and wholesale transportation distribution centers. Existing substations, transformers and conductors may or may not be able to accommodate an unplanned increase in demand particularly depending on the time of day that charging occurs. Charging may occur after normal business hours as the sun sets, resulting in a new demand peak. Yet advanced communications and the solid-state power conversion electronics of EV chargers can not only mitigate the potential impact of new loads but also provide valuable grid services. Larger facilities may install solar PV, energy storage systems, and on-site generators. At the point of common coupling, these facilities, with the ability to increase, decrease, shift, or modulate load and inject or absorb real and reactive power, can readily simulate a virtual generator to provide a full suite of energy and ancillary services including volt/VAR optimization, frequency regulation, spinning and standby reserves.

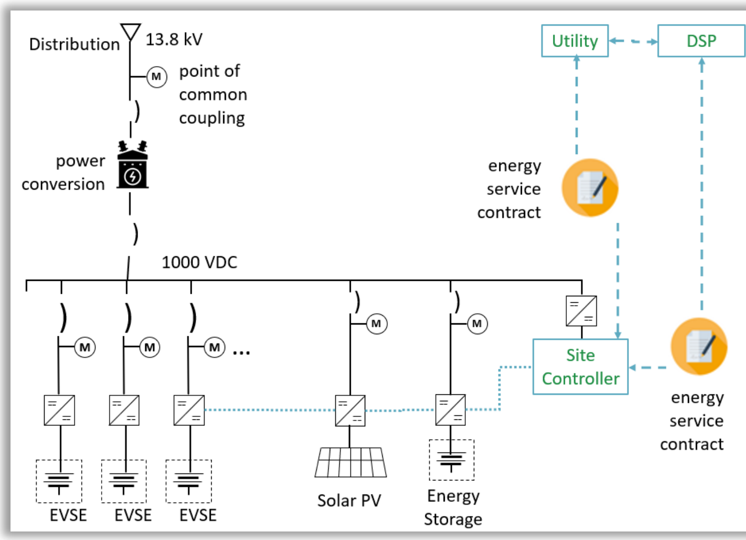

Figure 8 Virtual Genset

Program Templates

The templates in this section provide guidance on program design to meet the requirements outlined in the use cases. The program templates are contextual. Residential, workplace, public and fleet charging stations are contexts that may share similarities and may have distinct opportunities and constraints.

The first section below addresses the Local Congestion Management use case with three tables providing guidance for program objective, customer incentive, rate design and other details for the residential, workplace and public station charging contexts. One will note that there are many similarities in these tables. The proposed rate design in each case is dynamic prices to incentivize shifting load or provision of ancillary services by a CSO. How the prices are defined, whether they are a fixed TOU rate or real-time or day-ahead and how they are presented to the driver may change with context as well as implementation and regulations. The goal is to have common semantics and standardized contracts that simplify what is communicated. The follow-on sections discuss the Absorb Abundant Renewables Supply and Virtual Genset use cases, noting differences from the Local Congestion Management use case.

This framework document provides high level guidance regarding the program elements appropriate for each use case. The forthcoming reference implementation will provide sufficient detail to develop, deploy and implement end-to-end energy service contracts.

Local Congestion Management Program

The US distribution grid is made up of millions of miles of low-voltage power lines and distribution transformers connecting hundreds of millions of customers across the country. In many communities there are sections of the system where the carrying capacity is constrained at certain times of day or times of year. Adding new demands, like EV charging, may exacerbate these constraint conditions.

Mapping EV charging resources to local congestion areas and managing charging sessions can mitigate the impact of the added loads and defer expensive distribution upgrades. At the same time, area-wide managed charging can reduce the cost and reliability risks of system wide peak demands.

Local Congestion Management – residential charging program

Load Profile Objective	Incentivize electric vehicle owners to shift charging patterns to mitigate congestion.
Primary Drivers	Local congestion during evening peaks.
Program Description	Electric vehicle owners may sign up for an EV time-varying rate and reduce their electricity cost by charging during lower priced time intervals.
Customer Incentive	Less expensive charging for EVs.
Rate Design	Dynamic price signals – may be preset levels, day ahead, same-day, or real-time prices.
Target Customer	Residential EV owner that charges in the evening.
Target Loads	EV chargers.
Prerequisite	Customer has EVSE with communication capabilities, or EV manufacturer provides service to the GO or DSP via telematics.
Program Days	Every day, or weekdays only.
Notification	Program signals may be provided day-ahead or real-time.
Opt in/out Behavior	If a program/tariff includes some special notifications or events, the driver may opt out at any time for a given day or duration.

Measurement & Verification (M&V)	Customer pays for energy consumed. EVSE may include a metering device or billing info may be provided by OEM via telematics.
Registration Services	Auto-registration with DSP or CNO.

Local Congestion Management – workplace charging program

Load Profile Objective	Incentivize charge station operators (CSO) to dynamically shift or modulate load based on real-time grid conditions.
Primary Drivers	Workplace charging is a predictable load that can be shifted based on a CSO level-of-service guarantee, driver requirements (battery state-of-charge and anticipated departure), and real-time grid conditions. Coincident peak charging can be mitigated with local coordination.
Program Description	CSO can enroll in a program to reduce or eliminate demand charges and provide valuable grid services.
Customer Incentive	Lower demand and energy charges.
Rate Design	Dynamic price signals – may be preset levels, next day, or real-time prices.
Target Customer	CSO that provides at-work charging.
Target Loads	EV chargers.
Prerequisite	Charge station management system.
Customer Options	The prices that a CSO pays its suppliers may be different than prices offered to the EV driver. A CSO may potentially provide options to a customer to receive a lower price if the charging time is extended or delayed.
M&V	EVSE meter data.
Registration Services	Auto-registration of CSO with DSP or CNO.

Local Congestion Management – public charging station program

Load Profile Objective	Incentivize the EV driver to allow for reduction in power flow based on real-time grid conditions
Primary Drivers	There are destination public charging stations (airports, parking garages, shopping) where charging is secondary. There are also fast charging station locations designed to minimize wait times. In both cases, some intermittency in power flow may be acceptable or invisible to the driver.
Program Description	CSO can enroll in a program to reduce or eliminate demand charges, save drivers money, and provide valuable grid services.
Customer Incentive	Lower demand and energy charges.
Rate Design	Price signals with real-time or dynamic price tiers.
Target Customer	CSO and EV driver.
Target Loads	EV Chargers.
Prerequisite	Charge station management system.
Program Days	Every day, or weekdays only.
Customer Offers	The CSO may pass on price savings to drivers based on offers to delay or modulate power flow.
Program Signals	Price signals with tiers or dynamic prices.
M&V	EVSE meter data.
Registration Services	Auto-registration of CSO with DSP or CNO, and of the driver with the CSO.

Absorb Abundant Renewable Supply Programs

The key differences between the Absorb Abundant Renewables Supply and the Local Congestion Management programs are:

1. Typically, the service request would apply to an entire service territory or balancing area, and
2. Service requests may be more fine-grained time intervals (5 minutes) to accommodate ramping challenges or abrupt supply variability.

Otherwise, the template tables for this use case look like those provided above for the congestion management use case and are not repeated here.

The Absorb Abundant Renewable Supply residential program can accommodate significant changes in wind resources. Workplace charging, a relatively predictable template, can incentivize delayed charging until solar resources are generating sufficient supply, modulate power flow throughout the day, and ramp down charging as supply decreases and demand increases in the late afternoon.

Public charging may be represented by long-term destination public charging stations (airports, parking garages, shopping) where charging is secondary, and fast charging stations designed to minimize wait times. In both cases, some intermittency in power flow may be acceptable or invisible to a driver. The CSO can enroll in a program to mitigate demand charges, save drivers money, and provide valuable grid services.

Virtual Genset Program

The Virtual Genset use case applies to commercial fleet charging facilities, fleet depots and public medium-duty and heavy-duty charging facilities. A large facility may have on-site generation and storage. The facility operator has the flexibility to provide additional services to the grid, including power factor correction and voltage and frequency regulation. Energy supply requests (increase or decrease demand) would use the same information exchange as given for the previous use cases. In addition, large facilities may provide low latency responses as well as much more accurate short-term forecasts, and thus represent a dependable augment for spinning and standby reserves.

Conclusion

Energy service contracts provide a mechanism to exchange key information elements and actionable information across the value chain. The use cases – Local Congestion Management, Absorb Abundant Renewable Supply and Virtual Genset – provide tangible examples of how EV managed charging can provide valuable energy and ancillary grid services. Although the focus has been on EV charging, the coordination and control services allow grid operators to dispatch any flexible DER resources into utility planning and operations across a service territory or within a specific section of a local distribution area.

Work continues in the SEPA ESI Task Force to simultaneously advance on delineating business requirements, developing and deploying a reference implementation, and incorporating this work into revisions of existing standards.

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Acronyms

BA	balancing authority
BTM	behind-the-meter
CNO	charge network operator
CSM	Charge Station Manager
CSO	charge station operator
DCFS	DC fast charger
DER	distributed energy resource
DSP	DER Service Provider
ESI	energy services interface
EV	electric vehicle
EVSE	electric vehicle supply equipment
GO	Grid Operator
ISO	independent system operator
kVAR	kilovolt amp reactive
kW	kilowatt
kWh	kilowatt hour
L2	level 2 charger
M&V	measurement & verification
OEM	original equipment manufacturer
OpenADR	Open Automated Demand Response
SEPA	Smart Electric Power Alliance
TOU	time-of-use
TSO	transmission system operator