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PSU ESI Review

January 2024

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U.S. DEPARTMENT of ENERGY

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PSU ESI Review

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Abstract

A guide to developing an Energy Service Interface (ESI) was created as part of the Grid Modernization Laboratory Consortium 2.5.2 ESI project. The approach applies device-agnostic and service-oriented ESI principles and leverages documents such as the Interoperability Maturity Model and Common Grid Service Definitions to provide a methodology to review, develop, and update standards and profiles to engage distributed energy resources (DER) to provide grid services. This document evaluates the ESI developed by Portland State University's Power Engineering Group under the Electric Grid of Things project funded by the U.S. Department of Energy. The evaluation explores the compliance of this specific implementation with the GMLC ESI principles to provide an example of an ESI profile and gap analysis.

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Index Terms

Energy Service Interface, Distributed Energy Resources, Energy Grid of Things

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CONTENTS

ACRONYMS

ACE Area Control Error

BA Balancing Authority

CIM Common Information Model
CSIP Common Smart Inverter Profile

DER distributed energy resource

ESI Energy Service Interface
EV electric vehicle

GMLC Grid Modernization Laboratory Consortium
GO Grid Operator
GSP Grid Service Provider

HTTP Hypertext Transfer Protocol

IEC International Electrotechnical Commission
IEEE Institute of Electrical and Electronics Engineers
IMM Interoperability Maturity Model
IP Internet Protocol

JSON JavaScript Object Notation

OSI Open Systems Interconnection

PII personally identifiable information
PKI public key infrastructure
PSU Portland State University

REST Representational State Transfer
RFC Request for Comment

SAE Society of Automotive Engineers
SPC Service Provisioning Customer
SSL Secure Sockets Layer

TCP Transmission Control Protocol
TLS Transport Layer Security

UDP User Datagram Protocol
UML unified modeling language

XML Extensible Markup Language

1 INTRODUCITON

The US Department of Energy has funded several interoperability-related projects that have led to the development of an Energy Service Interface (ESI) specification development guide. The guide applies principles and tools that support interoperable and service-oriented interfaces and system architectures. In earlier work, the ESI is described as a "bi-directional, service-oriented, logical interface that supports the secure communication of information between entities inside and outside of a customer boundary to facilitate various energy interactions between electrical loads, storage, and generation within customer facilities and external entities" [1]. The service-oriented nature of the interface interactions emphasizes what is expected to be delivered, a service, rather than how the objective is to be met, direct control [2], [3].

To aid in the development of a highly interoperable and service-oriented interface, the Grid Modernization Laboratory Consortium (GMLC) team developed a short list of guiding principles and recommendations for evaluating interface specifications. The first principle is the ESI is service-oriented. The second is the ESI maintains privacy and does not expose the identity or other details of individual distributed energy resource (DER) but only the collective capability of all DER in the DER facility for a particular grid-DER service. Finally, the ESI is device agnostic making it universally applicable and eliminating the need for customization based on the device type. These principles, combined with the Interoperability Maturity Model (IMM) criteria, provide a framework to evaluate a standard or implementation and determine if there are improvements needed to support such service-oriented interactions [4].

While the guide provides interoperability requirements for the interface to support such service-oriented agreements, it does not specify which protocols should be used, allowing for innovation and alignment among multiple standards. In some cases, the ESI principles will apply to multiple interface interactions over the service lifecycle to meet the grid service agreement. The five lifecycles discussed in the guide are: register and qualify, schedule, operate, measure and verify, and settle. The information and interfaces necessary to satisfy interoperability requirements for each lifecycle might vary depending on the details included in the service agreement. The specification review needs to ensure that the ESI principles and the IMM criteria are met for each of the lifecycle phases.

The Portland State University (PSU) team has developed an ESI implementation under DOE OE0000922 funded by the Office of Electricity. This paper discusses the specific implementation and evaluates it based on the GMLC Guide to Developing Energy Services Interfaces. The result is two-fold; an ESI specification and a gap analysis that guides improvements to the implementation.

2 Common Grid Service Interactions

The GMLC classified grid services into six categories, termed "grid-DER services" [5], [6], [7]. These are generalized categories of grid services that aggregations of DER can provide. The following subsections presents the six grid-DER service categories and data capture diagrams of the lifecycles for each service.

2.1 Energy Service

A Grid Service Provider (GSP) seeks DERs capable of providing Energy Service to ensure a Balancing Authority (BA) continuously provides adequate energy resource supply. Participating DERs consume or produce a specified amount of energy over a scheduled period of operation.

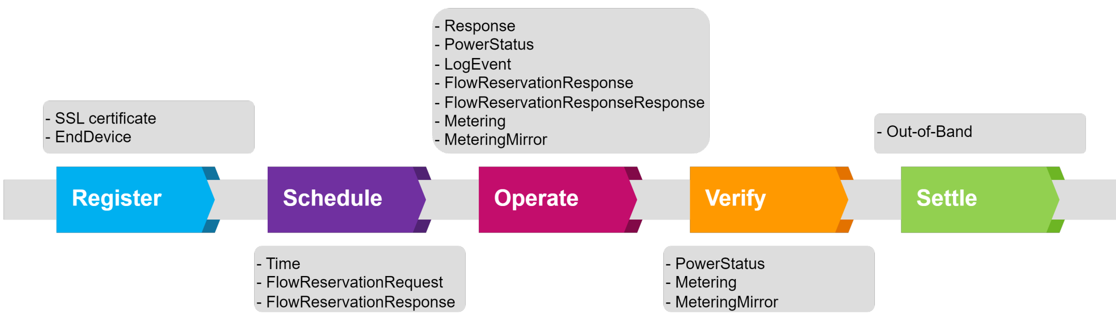

Fig. 1: Data capture for Energy Service lifecycles.

2.2 Reserve Service

DERs capable of providing Reserve Service are either sources or loads that can maintain some real power reserve capacity. This capacity can be dispatched during resource contingency situations. The response time for these resources is intra-hour, within a timeframe of 5-30 minutes, depending on several factors. Contingency situations include unanticipated resource ramping events, loss of committed generation, or erroneous projections of load.

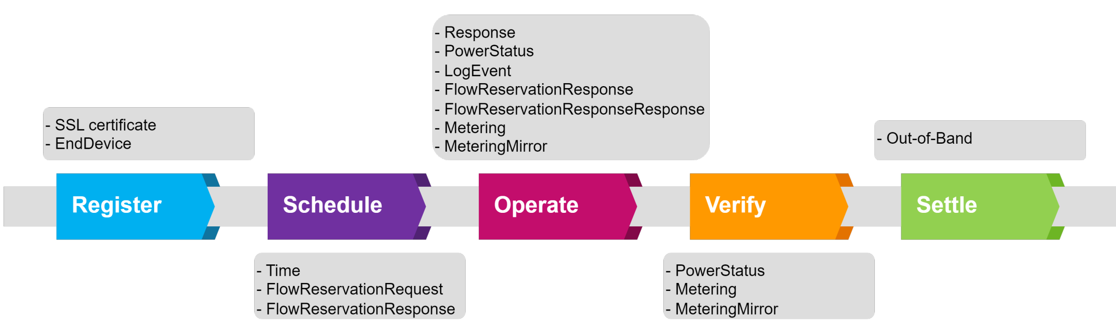

Fig. 2: Data capture for Reserve Service lifecycles.

2.3 Regulation Service

Regulation Service supports control of the Area Control Error (ACE). The GSP follows an automatic control signal based on the ACE and uses asynchronous messaging to dispatch participating DERs. Source and load DERs capable of supporting Regulation Service adjust their real power. When the ACE is high load DERs consume. When the ACE is low, source DERs produce and load DERs defer consumption.

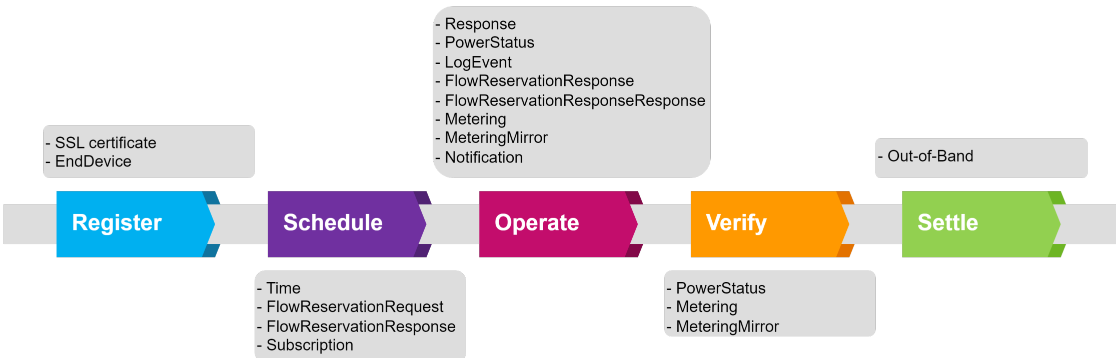

Fig. 3: Data capture for Regulation Service lifecycles.

2.4 Blackstart Service

A GSP seeks DERs capable of providing Blackstart Service to help a Grid Operator (GO) re-energize parts of its balancing area that have experienced a sustained outage. The GSP has two types of DER available for Blackstart Service dispatch: sources capable of independently supplying power and supporting voltage and loads that can defer consumption to a post-recovery period.

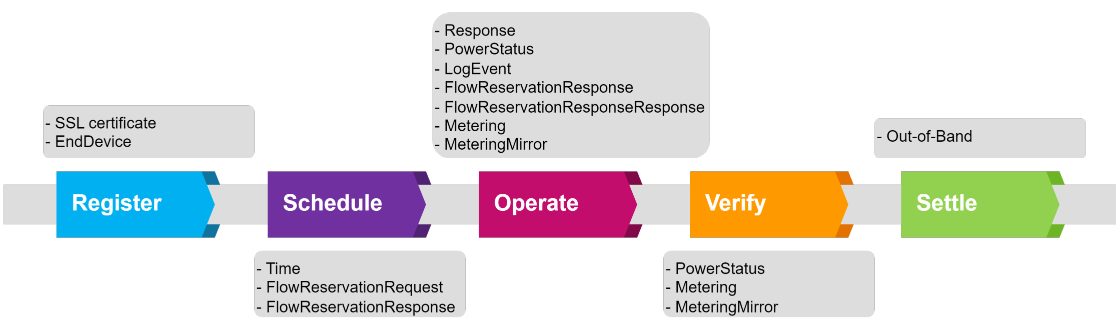

Fig. 4: Data capture for Blackstart Service lifecycles.

2.5 Voltage Managment Service

DERs that provide Voltage Management Service autonomously detect and correct voltage excursions when these excursions exceed defined limits, typically $\pm 5\%$ of nominal. This is typically done by absorbing or injecting reactive power when voltages exceed or drop below these thresholds, though real power may be used too. DERs can participate in Voltage Management Services if they can control reactive and/or real power in response to voltage deviations.

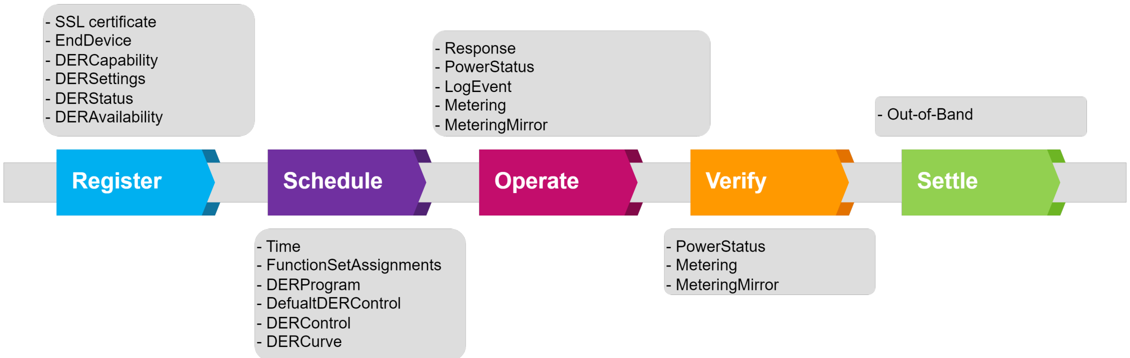

Fig. 5: Data capture for Voltage Management service lifecycles.

2.6 Frequency Response Service

DERs that provide Frequency Response Service autonomously detects and corrects frequency deviations when these deviations exceed defined limits as defined by frequency-watt or frequency-VAr curves. Frequency deviations occur continuously within a power system, most of which are minor and can be managed by a Regulation Service. Frequency Response Service is responsible for arresting sudden and drastic deviations in frequency, as described by NERC BAL-003-1 Frequency Response Standard [8]. DERs can participate in Frequency Response Services if they are capable of controlling reactive and/or real power in response to frequency deviations.

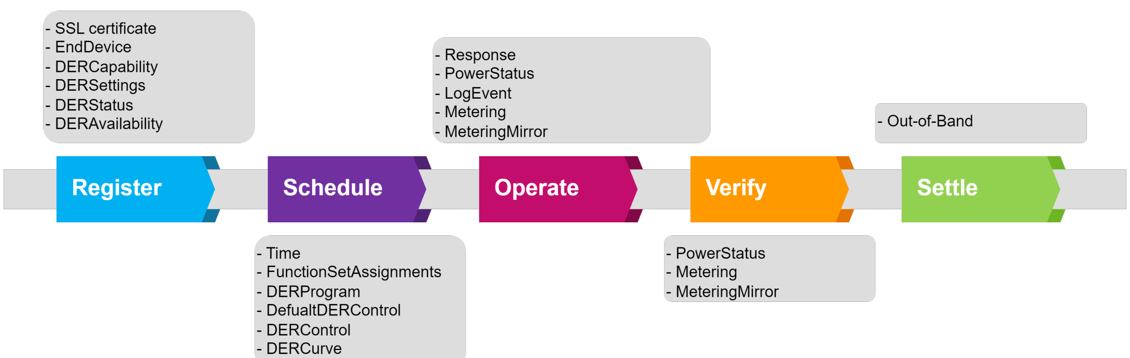

Fig. 6: Data capture for frequency response service lifecycles.

3 Interoperability Maturity Model Criteria

3.1 Criterion 1

The IMM supports the adoption of any interface by formalizing key components identified by actors within the ecosystem for which the interface was designed. The IMM consists of 33 criteria covering configuration & evolution, safety & security, operations & performance, organizational, informational, technical, and community. This evaluation excludes the community criterion as it is dependent on adoption across the ecosystem.

3.1.1 Description

The ability of the interface to accommodate the integration with legacy components and systems is described along with an upgrade migration path.

3.1.2 Applied to the to ESI

The ESI-compliant specification is backward compatible and has an upgrade mechanism.

3.1.3 Assumptions

- The version of the supported specification is identified.

3.1.4 Questions

1) Is there a migration path for the integration of legacy systems and components with new components?
2) Is there documentation showing how new components are accommodated?
3) Does the specification maturity support this functionality?

3.1.5 Notes

There are many issues when it comes to backward compatibility that should be addressed. Sometimes backward compatibility must be broken to improve security or privacy. The process of when it is acceptable to break backward compatibility as well as what upgrades can be made without breaking compatibility.

3.1.6 Location in document

- Schema version negotiation [9, Section 5.7.2]

3.1.7 Gap

- Questions 1 and 2 are not answered within the implementation profile. The primary communication standard used by the profile Institute of Electrical and Electronics Engineers (IEEE) std 2030.5 [9] is not backward compatible but outlines the migration path which should be backward compatible with the current version.
- Request for Comment (RFC) 9110 for Hypertext Transfer Protocol (HTTP) provides an excellent example of accommodating legacy components while providing extension points for modification to the specification.

3.2 Criterion 2

3.2.1 Description

Interface capabilities can be revised over time (versioning) while accommodating connections to previous versions of the interface and without disrupting overall system operation (such as supporting a rolling upgrade process.

3.2.2 Applied to the to ESI

The ESI-compliant specification can be updated without disruption of system operation, which includes backward compatibility.

3.2.3 Assumptions

- Assumes many devices operating in the system so that work on one does not impact the system from functioning.
- The specification includes a means for updating the ESI elements of the communications interface in a coordinated fashion.
- The ESI implementer or a proxy manages rolling upgrades.

3.2.4 Questions

1) Is there a documented process for revising an interface to extend its capabilities over time?
2) Is there a documented process to ensure you can support multiple versions of interfaces, including previous versions?

3.2.5 Notes

The interface chosen is not owned by the implementer, but there should be documentation of how the interface can handle revisions of the standard chosen.

3.2.6 Location in document

- Schema version negotiation [9, Section 5.7.2]

3.2.7 Gap

- Question one is not answered within the implementation profile. The primary communication standard used by the profile IEEE std 2030.5 also does not include discussion on modification of the standard in this way.
- RFC 9110 for HTTP provides an excellent example of accommodating legacy components while providing extension points for modification to the specification.

3.3 Criterion 3

3.3.1 Description

The way regional and jurisdictional differences are supported is described.

3.3.2 Applied to the to ESI

The ESI-compliant specification has configuration flexibility to address policy differences.

3.3.3 Assumptions

- Policies that are defined should be harmonized between actors.

3.3.4 Questions

1) Does the specification describe regional and jurisdictional differences within the ecosystem for the same interface?
2) How is flexibility managed to account for jurisdictional and/or regional differences?

3.3.5 Notes

The first condition that should be addressed for this very broad criterion is which jurisdictions and/or regions do you expect the specification to be used within. This may be too broad of a criterion for an implementation profile.

3.3.6 Location in document

- Coordinated and uncoordinated Pricing and Metering servers [9, Section D.1.7]
- Introduction [10, Section 1]

3.3.7 Gap

- Questions 1 and 2 are not answered within the implementation profile. The primary communication standard used by the profile IEEE std 2030.5 only references jurisdictional differences within pricing and metering servers. The Common Smart Inverter Profile (CSIP) profile defers to utility interconnection tariffs, Utility Handbooks, contracts, and other regulatory processes.

3.4 Criterion 4

3.4.1 Description

Configuration methods to negotiate options or modes of operation including the support for user overrides are described.

3.4.2 Applied to the to ESI

The ESI-compliant specification supports modes of operation and user overrides.

3.4.3 Assumptions

- Modes include grid services or other modes of operation.
- Business process (messaging and their sequencing) need to support selecting options.

3.4.4 Questions

1) Do your interfaces support user choice options?
2) Do your interfaces support one or more modes of operation?
3) Do you have documentation explaining how user overrides and options are supported?

3.4.5 Notes

The specification outlines FlowReservationRequest as the primary method/data object for user choice in grid service participation. Using the DER function set allows the user to participate in all grid services and opt out at any time.

3.4.6 Location in document

- Response function set [9, Section 8.8]
- Flow Reservation function set [9, Section 10.9]
- Distributed Energy Resource function set [9, Section 10.10]

Service	Lifecycle	From	To	Method/Data Object
Energy	All	client	server	FlowReservationRequest
Energy	All	client	server	FlowReservationResponseResponse
Blackstart	All	client	server	FlowReservationRequest
Blackstart	All	client	server	FlowReservationResponseResponse
Reserve	All	client	server	FlowReservationRequest
Reserve	All	client	server	FlowReservationResponseResponse
Regulation	All	client	server	FlowReservationRequest
Regulation	All	client	server	FlowReservationResponseResponse
Voltage	All	client	server	DERAvailability
Voltage	All	client	server	DERCapability
Frequency	All	client	server	DERAvailability
Frequency	All	client	server	DERCapability
All	All	client	server	Response

TABLE 1: Method/Data Object evaluation for Criterion 4

3.5 Criterion 5

3.5.1 Description

The capability to scale the integration of many components or systems over time without disrupting overall system operation is supported.

3.5.2 Applied to the to ESI

The ESI-compliant specification is scalable without interruption to any interfacing actor.

3.5.3 Assumptions

- Scalability is also a system architecture issue.

3.5.4 Questions

1) What are the limits of your ability to scale component integration?
2) Can large-scale integration be achieved without disruption of service?

3.5.5 Notes

IEEE std 2030.5-2018 and CSIP v2.0 do not discuss system scaling or its effects on system operation. This may be covered within utility interconnection tariffs, Utility Handbooks, contracts, and other regulatory processes.

3.5.6 Location in document

- N/A

3.5.7 Gap

- The specification does not discuss scaling or how it assures system operation while scaling.

3.6 Criterion 6

3.6.1 Description

The ability of overall system operation and quality of service to continue without disruption as interfacing actors (DERs, utilities, aggregators) enter or leave the system is supported.

3.6.2 Applied to the to ESI

The ESI-compliant specification has methods for interfacing actors to enter or leave without disruption to the system.

3.6.3 Assumptions

- Does the grid operator adjust appropriately to maintain the quality of service as actors enter or leave the system?
- Do systems that coordinate the operation of DER facilities support their entering and leaving the system without disruption?

3.6.4 Questions

1) Can your communications system operate without disruption as parties enter or leave the system?

3.6.5 Notes

The communication interface outlined by the specification has no issues with actors entering or leaving as it is HTTP over Transmission Control Protocol (TCP)/Internet Protocol (IP) using a Representational State Transfer (REST) architecture. IEEE std 2030.5-2018 does specify how interfacing actors are supposed to enter or leave the system.

3.6.6 Location in document

- Protocol flexibility [9, Section 4.1]
- Use of TCP [9, Section 5.2]
- Certificate management [9, Section 6.11]
- Discovery [9, Section 7]

3.6.7 Gap

- The specification should quantify what the quality of service is and outline how interfacing actors affect it.

3.7 Criterion 7

3.7.1 Description

Unambiguous resource identification and its management is described.

3.7.2 Applied to the to ESI

The ESI-compliant specification supports unambiguous identification of resources DER facilities referenced across the interface.

3.7.3 Assumptions

- An identity management feature exists for creating and maintaining uniqueness.
- Archives for reconciliation and audit have lasting unique references to reliably process history.

3.7.4 Questions

1) Do all devices have a unique way to identify them?
2) Is there a system in place to manage the allocation of identifiers?
3) Is there documentation describing the identifiers and how they are assigned, managed, and retired?

3.7.5 Notes

Implementation profiles may already specify how unique resource identifiers are created and managed including roles for third party management, such as a consortium or government agency. Information exchange requires unambiguous references to the interacting parties and associated information.

3.7.6 Location in document

- Long-form device identifier [9, Section 6.3.4]
- Manufacturing public key infrastructure (PKI) [9, Section 6.11.3]
- Types package outlines the master resource ID type [9, Appendix B.2.3.4]

3.8 Criterion 8

3.8.1 Description

Resource discovery methods for assisting with identification and integration between actors (such as access to information like owner, DER type, location, etc.) are supported.

3.8.2 Applied to the to ESI

The ESI-compliant specification has resource discovery methods to support the integration of interacting actors.

3.8.3 Questions

1) Does the system support the initial handshake for the discovery of new resources?
2) Do the resource discovery methods support mutual understanding of device capability?
3) Are resource discovery methods supporting configuration documented?

3.8.4 Notes

The discovery of both new actors and the ability of said actors to traverse the servers' resources to find resources to participate in grid services is supported. All resources are defined and their use is documented with IEEE std 2030.5-2018 and CSIP v2.0.

3.8.5 Location in document

- Schema [9, Section 4.4]
- Registration[9, Section 6.9]
- Discovery [9, Section 7]
- Grid-DER Service Dispatch Use Cases [11, Appendix B]

3.9 Criterion 9

3.9.1 Description

The requirements and mechanisms for auditing and logging exchanges of information is described.

3.9.2 Applied to the to ESI

The ESI-compliant specification describes mechanisms for auditing and logging the exchange of information.

3.9.3 Assumptions

- Information that will be audited or logged is defined.
- Each contractual engagement has an energy services agreement in place.
- There may be different versions of the energy services agreement depending on the needs of the contracting parties.
- Specific energy services agreements may implement a subset of the auditing and logging mechanisms described in the ESI implementing communications specification.
- Multiple interfaces might require auditing and logging i.e., metering

3.9.4 Questions

1) Do you have the capability to log information exchanges?
2) Do you have the capability to audit your information exchange logs?
3) Is there documentation describing the auditing and logging processes?

3.9.5 Notes

IEEE std 2030.5-2018 and CSIP v2.0 outline events that should be logged, but there is no description of how those logs are supposed to be stored or audited.

3.9.6 Location in document

- Log Event function set [9, Section 9.6]

Service	Lifecycle	From	To	Method/Data Object
All	All	client	server	LogEvent

TABLE 2: Method/Data Object evaluation for Criterion 9

3.9.7 Gap

- Questions two and three are not answered by the specification. The specification should outline what should be stored, and how long it should be stored if it requires backup. There should be a designated auditor for the logs and they should dictate what the auditing requirements are to be.

3.10 Criterion 10

3.10.1 Description

Privacy policies are defined, maintained, and aligned among the parties of interoperating systems.

3.10.2 Applied to the to ESI

The ESI-compliant specification describes privacy policy support mechanisms and how information is protected.

3.10.3 Assumptions

- There are jurisdictional considerations concerning privacy policies.
- The specification may need to accommodate flexibility to support different policies.
- The security policies are consistent for support of privacy protection policies.

3.10.4 Questions

1) Is there a privacy policy?
2) Is a community privacy policy part of your community governance agreement?
3) Does all information exchanges take place with partners who have a privacy policy?
4) What is the policy if partners do not have a privacy policy?
5) Is there proforma contractual language for your privacy policy?

3.10.5 Notes

The specification does outline personally identifiable information (PII) which applies to all communication between interfacing actors. In addition, the specification outlines the need for trust between interfacing actors to capture the behavior that may be from a compromised actor.

3.10.6 Location in document

- ESI Privacy Policy [12, Section 4.1]

3.10.7 Gap

- Question five is not defined within the specification. This question should also be extended to require proforma contractual language that protects privacy. The terms of service outline privacy for nearly every application used by consumers today and they do nothing to protect the privacy of the user.

3.11 Criterion 11

3.11.1 Description

Security policies are defined, maintained, and aligned among the parties of the interoperating system.

3.11.2 Applied to the to ESI

The ESI-compliant specification has mechanisms to support security policies.

3.11.3 Assumptions

- There are jurisdictional considerations concerning security policies.

3.11.4 Questions

1) Do you have a security policy?
2) Is there a community security policy?
3) Do any of your information exchanges take place with partners who do not have a security policy?
4) Is your security policy aligned with those of interoperating parties?
5) Is there anything detecting security breaches and what happens in such events?

3.11.5 Notes

The specification adopts the security specifications outlined by IEEE std 2030.5-2018 and adds a layer of trust to enhance security.

3.11.6 Location in document

- ESI Security Policy [12, Section 4.2]
- Security [9, Section 6]
- Device credentials [9, Section 6.3]

Service	Lifecycle	From	To	Method/Data Object
All	All	client	server	Secure Sockets Layer (SSL) certificate

TABLE 3: Method/Data Object evaluation for Criterion 11

3.11.7 Gap

- Questions 3-5 would require knowing the actor within the system. The specification outlines the interactions between general GOs, GSPs, and Service Provisioning Customers (SPCs), which makes it impossible to answer the questions.

3.12 Criterion 12

3.12.1 Description

Failure mode policies are described and aligned among the parties of the interoperating systems to support the safety and health of individuals and the overall system.

3.12.2 Applied to the to ESI

ESI-compliant specification describes failure modes.

3.12.3 Assumptions

- As a system architecture issue all participants should not negatively impact the components of the overall system, not just the ESI.
- This could also be defined on either side of the interface.
- Responses to failures are aligned among interoperating systems in the ESI agreement/contract.

3.12.4 Questions

1) Do you have a failure mode policy?
2) Is there a community failure mode policy?
3) Do any of your information exchanges take place with partners who do not have a failure mode policy?
4) Is your failure mode policy aligned with those of interoperating parties?

3.12.5 Notes

The specification is primarily focused on communication between a server and a client.

3.12.6 Location in document

- Log Event function set [9, Section 9.6]
- Distributed Energy Resource function set [9, Section 10.10]

Service	Lifecycle	From	To	Method/Data Object
All	All	client	server	LogEvent
Frequency	All	server	client	DefaultDERControl
Voltage	All	server	client	DefaultDERControl

TABLE 4: Method/Data Object evaluation for criterion 12

3.12.7 Gap

- Question one is partially satisfied. There are communication failures discussed, but there is no discussion of what failures could happen and what should be done when they happen.
- Questions 2-4 would require knowing the actor within the system. The specification outlines the interactions between general GOs, GSPs, and SPCs which makes it impossible to answer the questions.

3.13 Criterion 13

3.13.1 Description

Performance and reliability requirements of the interface are defined.

3.13.2 Applied to the to ESI

Performance and reliability requirements of the ESI-compliant specification are defined.

3.13.3 Assumptions

- There exists a defined set of performance and reliability requirements and metrics.

3.13.4 Questions

1) Are performance and reliability requirements defined for all interfaces?
2) Which reliability requirements are specified by the entity or entities that govern your business processes?
3) Do your interfaces meet the performance requirements for all interfaces?

3.13.5 Notes

The specification nor IEEE std 2030.5-2018 discuss performance and reliability in this manner. This should be covered within utility interconnection tariffs, Utility Handbooks, contracts, and other regulatory processes. The CSIP v2.0 certification process ensures the performance and reliability of most DER function set modes of operation.

3.13.6 Gap

- Question one is not satisfied with the FlowReservation function set which is used by four of the grid services.
- Questions two and three would require knowing the actor within the system. The specification outlines the interactions between general GOs, GSPs, and SPCs which makes it impossible to answer the questions.

3.14 Criterion 14

3.14.1 Description

The interface definition specifies the handling of errors in exchanged data.

3.14.2 Applied to the to ESI

The ESI-compliant specification specifies error handling.

3.14.3 Assumptions

- Things break and interactions do not always work as anticipated.

3.14.4 Questions

1) Do your interfaces have documented error-handling expectations?
2) Does your process for building and revising interfaces include a step for creating or revising the error handling management documentation?

3.14.5 Notes

There are many layers of interactions that require error handling. Error handling should be defined through the Open Systems Interconnection (OSI) stack. IEEE std 2030.5-2018 adopts the error handling from TCP/IP for layers one through five. Layers six and seven are defined with the HTTP headers and Response function set.

3.14.6 Location in document

- HTTP headers [9, Section 5.4]
- Response function set [9, Section 8.8]

3.15 Criterion 15

3.15.1 Description

Time order dependency and sequencing (synchronization) for interactions is specified.

3.15.2 Applied to the to ESI

Time order dependency and sequencing for interactions is specified in the ESI-compliant specification.

3.15.3 Questions

1) Do community members have business objectives that require common time order dependency and sequencing definitions?
2) Do business processes and procedures specify time order dependency and sequencing mechanisms to be supported by the interface(s)?
3) Do the interface(s) between community members support these time order dependency and sequencing mechanisms?
4) Does the communication architecture separate network protocols from time order and sequencing information?

3.15.4 Notes

Questions one through three give examples of why time order dependency and sequencing may be needed but are not necessary to establish if the capability needs to exist. For example the User Datagram Protocol (UDP) protocol specifically does not support sequencing or time order dependency, but TCP does. Just using TCP would not satisfy question four, as it does not separate the information from the protocol so the profile must provide a designated information model.

3.15.5 Location in document

- Time function set [9, Section 9.2]

Service	Lifecycle	From	To	Method/Data Object
All	All	server	client	Time

TABLE 5: Method/Data Object evaluation for criterion 15

3.16 Criterion 16

3.16.1 Description

The interface definition specifies the mechanism for message transaction and state management.

3.16.2 Applied to the to ESI

The mechanism for message transaction and state management is specified in the ESI-compliant specification.

3.16.3 Questions

1) Are the transactions and state management specified?

3.16.4 Notes

The specification adopts the REST architecture from IEEE 2030.5-2018.

3.16.5 Location in document

- Design principles [9, Section 1.6]

3.17 Criterion 17

3.17.1 Description

Compatible business processes and procedures shall exist across interface boundaries.

3.17.2 Applied to the to ESI

The ESI-compliant specification supports the business interactions required throughout the life-cycle phases.

3.17.3 Assumptions

- Business processes and procedures relevant to the energy service agreement should be harmonized between actors.

3.17.4 Questions

1) Does your interface use an information model that includes the context of the transaction?
2) Are the business context information model and processes fully supported by the interfaces?

3.17.5 Notes

The context of the transaction only applies to the standard adopted by the specification.

3.17.6 Gap

- The specifics of the grid service and settlement requirements are not included in the information model.
- The specification does not define specific actors nor the business processes that they may employ.

3.18 Criterion 18

3.18.1 Description

Where an interface is used to conduct business within a jurisdiction or across different jurisdictions, it complies with all required technical, economic, and regulatory policies.

3.18.2 Applied to the to ESI

The ESI recognizes technical, economic, and regulatory policies exist in different jurisdictions and has methods or configurable features to support them.

3.18.3 Assumptions

- Policies for integration of DER Facilities with the electric system are defined by local (jurisdictional) policies.

3.18.4 Questions

1) Does your interface comply with all technical, economic, and regulatory policies?

3.18.5 Notes

For example, California Rule 21 sets policy for inverter interconnection in California and must be complied with and supported by the ESI. The specification adopts CSIP v2.0 which satisfies California Rule 21.

3.18.6 Location in document

- IEEE 2030.5 Implementation Profile [11, Sectin 4]

3.18.7 Gap

- Question one would require knowing the actor within the system. The specification outlines the interactions between general GOs, GSPs, and SPCs which makes it impossible to answer the questions.

3.19 Criterion 19

3.19.1 Description

Information models relevant for data exchanged across the interface are formally defined using standard information modeling languages.

3.19.2 Applied to the to ESI

Information model for the ESI-compliant specification is formally defined using standard modeling languages.

3.19.3 Assumptions

- Specification supports the necessary points within its information model using tools such as unified modeling language (UML), Extensible Markup Language (XML), JavaScript Object Notation (JSON)...

3.19.4 Questions

1) Do you have exchanged data elements that are represented in information model(s)?
2) Are the data model(s) for these elements formally defined using standard information languages?

3.19.5 Notes

IEEE std 2030.5-2018 defines all information models within an XML schema as supplementary material for the standard.

3.19.6 Location in document

- Schema [9, Section 4.4]

3.19.7 Gap

- The specification documents all other communication that is outside the standard as XML as well, without a formal schema as it cannot be generalized for all interfacing actors. This process should be formalized through an extension of the interface outlined in Criterion 2.

3.20 Criterion 20

3.20.1 Description

Data exchange relevant to the business context is derived from the information model.

3.20.2 Applied to the to ESI

The information model of the ESI-compliant specification supports the business interactions required throughout the lifecycle phases. (Related to Criterion 17)

3.20.3 Assumptions

- Criterion 19 addresses transactional requirements like prices and metrics.

3.20.4 Questions

1) Is the information exchange relevant to the business context for which it is used?
2) Is the business context derived from information models?

3.20.5 Notes

The specification adapts the business context to the adopted information model rather than deriving it from it. Logically the business context should drive the information model, however, it can be very abstract. It is more convenient to apply business context to existing information models that are more concrete elements and behaviors.

3.20.6 Gap

- Question two would require knowing the actor within the system. The specification outlines the interactions between general GOs, GSPs, and SPCs which makes it impossible to answer the questions.

3.21 Criterion 21

3.21.1 Description

Where the data exchanged derives from multiple information models, the capability to link data from different information models is supported.

3.21.2 Applied to the to ESI

If multiple information models exist, there is a mapping between the information models used by the ESI-compliant specification.

3.21.3 Assumptions

- The ESI may use an information model derived from two or more sources. For example, it may use parts IEC 61968 Common Information Model (CIM) that refer to DER and perhaps an SAE information model for electric vehicle (EV) charging.
- The mapping to these source models should be preserved so that changes in information model standards can be assessed and revised as necessary.

3.21.4 Questions

1) Are there multiple information models across the interface?
2) Is there a capability to support linking different information models?

3.21.5 Notes

The current implementation of the specification does reference multiple information models, but only applies to IEEE std 2030.5-2018. CSIP v2.0 also specifies three information models for the designated operating modes for DER.

3.21.6 Gap

- Multiple information models could exist across the interface for grid service participation, but there is no mapping between them.
- The specification does not discuss the capability to link between different information models. CSIP v2.0 doesn't specify a mapping between DNP3, SunSpec Modbus, and IEEE std 2030.5-2018.

3.22 Criterion 22

3.22.1 Description

The structure, format, and management of the communication protocol for all information exchanged shall be specified.

3.22.2 Applied to the to ESI

The ESI-compliant specification defines the structure, format, and management of all information exchanged.

3.22.3 Assumptions

- Layered communication protocols (which apply supporting standards) are referenced as part of the standards under review.

3.22.4 Questions

1) Do you have a policy for managing the selection and use of protocols for all exchanged information that ensures consistency of implementation?

3.22.5 Notes

The specification adopts the design principles outlined within IEEE std 2030.5-2018. This includes the use of Transport Layer Security (TLS) TCP/IP and HTTP. The structure of the HTTP messages is defined within the XML schema.

3.22.6 Location in document

- Design pattern [9, Section 4]
- Schema [9, Section 4.4]

3.23 Criterion 23

3.23.1 Description

The information exchanged and business process interactions at the interface are cleanly layered (described separately) from the technical (communication networking) layers in the interface specification.

3.23.2 Applied to the to ESI

The ESI-compliant specification separates the information model used in message exchange from the communications protocol that defines the format for packaging the messaging and handling the network connectivity.

3.23.3 Assumptions

- These are defined internally to the specifications under review.

3.23.4 Questions

1) Is the information transported on the communication network independent of the communication method?
2) Is there agreement within the ecosystem about how semantic (governance) for interfaces is assigned?

3.23.5 Notes

The specification adopts the design principles outlined within IEEE std 2030.5-2018. This includes the use of TLS TCP/IP and HTTP. The structure of the HTTP messages is defined within the XML schema.

3.23.6 Location in document

- Design pattern [9, Section 4]
- Schema [9, Section 4.4]

4 SUMMARY

The primary purpose of an implementation profile is to guide the implementation of an existing standard. The ESI provides additional guidance to ensure grid service lifecycles are accomplished while ensuring privacy and device agnosticity. The reviewed profile is an implementation profile that builds from the established CSIP v2.0, which itself guides the implementation of the IEEE 2030.5-2018 standard. The interoperability maturity roadmap [13] for IEEE 2030.5-2018 does recommend an assessment of CSIP v2.0, but one has not yet been conducted at this time.

The gaps that were identified during this ESI review process are summarized in Table 6. Several gaps are primarily implementation-specific. Other gaps are not relevant because the profile is a general implementation rather than one applied to a specific business or system. Several gaps depend on utility interconnection handbooks, contracts, or regulatory processes such as interconnection agreements. Other identified gaps lead to recommendations to use processes outlined by the HTTP standard, while many other existing standards used in this work are long-standing and highly interoperable, including Linux[1], C[2], and C++[3].

Criterion	Description
1	The primary communication standard used by the profile IEEE std 2030.5 is not backward compatible but outlines the migration path which should be backward compatible with the current version.
2	The primary communication standard used by the profile IEEE std 2030.5 also does not include discussion on modification of the standard.
3	The CSIP profile deffers to utility interconnection agreements, utility handbooks, contracts, and regulatory processes.
5	The specification does not discuss scaling or how it assures system operation while scaling.
6	The specification should quantify what the quality of service is and outline how interfacing actors affect it.
9	The specification should outline what should be stored, and how long it should be stored if it requires backup. There should be a designated auditor for the logs who should dictate auditing requirements.
10	There should be proforma contractual language that “protects” privacy. Terms of service outline privacy for nearly every application used by consumers today and yet they do nothing to protect the privacy of the user.
11	The specification outlines the interactions between *general* GOs, GSPs, and SPCs actors. Without knowing the privacy policies of *specific* actors, it is not possible to specify the security interactions between these actors.
12	Communication failures are discussed, but there are no discussions of what failures could happen and what should be done when they happen.
13	Performance and reliability requirements are not defined for all interfaces.
17	The specifics of the grid service and settlement requirements are not included in the information model. The specification does not define specific actors or the business processes that they may employ.
18	The specification cannot comply with all technical, economic, and regulatory policies because it is a general implementation.
19	The specification documents all other communication that is outside the standard as XML without a formal schema as it cannot be generalized for all interfacing actors.
20	The business context cannot be derived from information models because it is a general implementation.
21	The specification does not discuss the capability to link between different information models.

TABLE 6: Gap summary

Future ESI implementation profiles should not build upon this profile but rather on the root standard itself. Profiles should seek to reduce the number of abstractions from the base material to ensure interoperability. Instead, this profile should either influence the existing CSIP profile to

1. https://www.linuxfoundation.org/resources/open-source-guides
2. https://www.iso.org/standard/74528.html
3. https://isocpp.org/std/the-standard

satisfy the identified gaps, influence the development of new ESI implementations, or the IEEE 2030.5-2018 standard itself should adopt the guidance in an updated version.

APPENDIX A
METHOD/DATA OBJECT CAPTURE

Method/Data Object	Document Location
hostname	Discovery [9, Section 7]
SSL certificate	Device credentials [9, Section 6.3]
CustomerAccount	Billing function set [9, Section 10.7]
CustomerAgreement	Billing function set [9, Section 10.7]
EndDevice	End Device function set [9, Section 8.5]
FunctionSetAssignments	Function Set Assignments function set [9, Section 8.6]
Subscription	Subscription/Notification function set [9, Section 8.7]
Notification	Subscription/Notification function set [9, Section 8.7]
Response	Response function set [9, Section 8.8]
Time	Time function set [9, Section 9.2]
PowerStatus	Power Status function set [9, Section 9.4]
LogEvent	Log Event function set [9, Section 9.6]
Metering	Metering function set [9, Section 10.4]
MeteringMirror	Metering function set [9, Section 10.4]
FlowReservationRequest	Flow Reservation function set [9, Section 10.9]
FlowReservationResponse	Flow Reservation function set [9, Section 10.9]
FlowReservationResponseResponse	Flow Reservation function set [9, Section 10.9]
DERCapability	Distributed Energy Resource function set [9, Section 10.10]
DERSettings	Distributed Energy Resource function set [9, Section 10.10]
DERStatus	Distributed Energy Resource function set [9, Section 10.10]
DERAvailability	Distributed Energy Resource function set [9, Section 10.10]
DERProgram	Distributed Energy Resource function set [9, Section 10.10]
DefaultDERControl	Distributed Energy Resource function set [9, Section 10.10]
DERControl	Distributed Energy Resource function set [9, Section 10.10]
DERCurve	Distributed Energy Resource function set [9, Section 10.10]

TABLE 7: Method/Data Objects for all grid service and their respective lifecycles

APPENDIX B
PRIVACY ASSESSMENT

Each resource transferred between an ESI boundary should be assessed for privacy. The following sections identify if a resource element is private in addition to if it is considered optional. If the resource element is private it should either be stated that it is not implemented to ensure privacy if it is optional or how the breach of privacy is avoided.

B.1 ESI DER-GSP

Element	**Optional**	**Private**
base IdentifiedObject (see Table 12)		
ActiveBillingPeriodListLink	yes	no
ActiveTargetReadingListLink	yes	no
BillingPeriodListLink	yes	no
HistoricalReadingListLink	yes	no
PrepaymentLink	yes	no
ProjectionReadingListLink	yes	no
serviceAccount	yes	no
serviceLocation	yes	no
TargetReadingListLink	yes	no
TariffProfileLink	yes	no
UsagePointLink	yes	no

TABLE 8: CustomerAgreement

Element	**Optional**	**Private**
base IdentifiedObject (see Table 10)		
currency	no	no
customerAccount	yes	no
CustomerAgreementListLink	yes	no
customerName	yes	yes
pricePowerOfTenMultiplier	no	no
ServiceSupplierLink	yes	no

TABLE 9: CustomerAccount

Element	**Optional**	**Private**
base Resource (see Table 14)		
mRID	no	no
description	yes	no
version	yes	no

TABLE 10: IdentifiedObject

Element	Optional	Private
base AbstractDevice (see Table 12)		
changedTime	yes	no
enabled	no	no
FlowReservationRequestListLink	no	no
FlowReservationResponseListLink	no	no
FunctionSetAssignmentsListLink	no	no
postRate	no	no
RegistrationLink	no	no
SubscriptionListLink	no	no

TABLE 11: EndDevice

deviceCategory Specifies the bitmap indicating the categories of devices that SHOULD respond. This attempts to directly control a DER by its type.

Element	Optional	Private
base SubscribableResource (see Table 13)		
ConfigurationLink	no	no
DERListLink	no	no
deviceCategory	no	yes
DeviceInformationLink	no	no
DeviceStatusLink	no	no
FileStatusLink	no	no
IPInterfaceListLink	no	no
lFDI	no	no
LoadShedAvailabilityListLink	no	no
LogEventListLink	no	no
PowerStatusLink	no	no
sFDI	yes	no

TABLE 12: AbstractDevice

Element	Optional	Private
base Resource (see Table 14)		
subscribable	no	no

TABLE 13: SubscribableResource

Element	Optional	Private
href	yes	no

TABLE 14: Resource

Element	Optional	Private
base Resource (see Table 14)		
dateTimeRegisterd	yes	no
pIN	yes	no
pollRate	no	no

TABLE 15: Registration

type directly identifies the DER by its type.

Element	Optional	Private
base Resource (see Table 14)		
modesSupported	yes	no
rtgAbnormalCategory	no	no
rtgMaxA	no	no
rtgMaxAh	no	no
rtgMaxChargeRateVA	no	no
rtgMaxChargeRateW	no	no
rtgMaxDischargeRateVA	no	no
rtgMaxDischargeRateW	no	no
rtgMaxV	no	no
rtgMaxVA	no	no
rtgMaxVarNeg	no	no
rtgMaxW	yes	no
rtgMaxWh	no	no
rtgMinPFOverExcited	no	no
rtgMinPFUnderExcited	no	no
rtgMinV	no	no
rtgNormalCategory	no	no
rtgOverExcitedPF	no	no
rtgOverExcitedW	no	no
rtgReactiveSusceptance	no	no
rtgUnderExcitedPF	no	no
rtgUnderExcitedW	no	no
rtgVNom	no	no
type	yes	yes

TABLE 16: DERCapability

Element	Optional	Private
base SubscribableResource (see Table 13)		
modesEnabled	no	no
setESDelay	no	no
setESHighFreq	no	no
setESHighVolt	no	no
setESLowFreq	no	no
setESLowVolt	no	no
setESRampTms	no	no
setESRandomDelay	no	no
setGradW	yes	no
setMaxA	no	no
setMaxAh	no	no
setMaxChargeRateVA	no	no
setMaxChargeRateW	no	no
setMaxDischargeRateVA	no	no
setMaxDischargeRateW	no	no
setMaxV	no	no
setMaxVA	no	no
setMaxVar	no	no
setMaxVarNeg	no	no
setMaxW	yes	no
setMaxWh	no	no
setMinPFOverExcited	no	no
setMinPFUnderExcited	no	no
setMinV	no	no
setSoftGradW	no	no
setVNom	no	no
setVRef	no	no
setVRefOfs	no	no
updateTime	yes	no

TABLE 17: DERSettings

inverterStatus directly indicates the current state of the DER.

Element	Optional	Private
base SubscribableResource (see Table 13)		
alarmStatus	no	no
genConnectStatus	no	no
inverterStatus	no	yes
localControlModeStatus	no	no
manufacturerStatus	no	no
operationalModeStatus	no	no
readingTime	yes	no
stateOfChargeStatus	no	no
storageModeStatus	no	no
storConnectStatus	no	no

TABLE 18: DERStatus

Element	Optional	Private
base SubscribableResource (see Table 13)		
availabilityDuration	no	no
maxChargeDuration	no	no
readingTime	yes	no
reserveChargePercent	no	no
reservePercent	no	no
statVarAvail	no	no
statWAvail	no	no

TABLE 19: DERAvailability

B.2 ESI GSP-GO

Element	Optional	Private
locations	no	no
group id	no	no

TABLE 20: Group

Element	Optional	Private
location	no	no
power (+)	no	no
power (-)	no	no
reactive power (±)	no	no

TABLE 21: Aggregate

Element	Optional	Private
group id	no	no
service type	no	no
interval	no	no
power	no	no
ramp	no	no
price	no	no

TABLE 22: Service

Element	Optional	Private
group id	no	no
service type	no	no
interval	no	no
power	no	no
ramp	no	no
price	no	no

TABLE 23: Settlement

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