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SunSpec Plant Information Exchange

SunSpec Alliance Interoperability Specification

SunSpec Alliance Plant Extract Document Workgroup

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ABSTRACT

The SunSpec Specification suite consists of the following documentation:

- SunSpec Technology Overview
- SunSpec Information Model Specifications
- SunSpec Model Data Exchange
- SunSpec Plant Information Exchange

This is the Plant Information Exchange document. A Plant Information Exchange standard enables these functions:

- A common monitoring extract format for asset analysis tools
- A means to extract and send historic plant data between different monitoring systems
- A way to report asset performance to financial partners, for plants managed by different monitoring systems

Change History

D-1: Initial (A) Draft – Brett Francis : 2012-May-23

D-1: B Draft – workgroup 2012-May-31 and 2012-June-7, Brett Francis : 2012-Jun-12

D-1: C Draft – Additional elements and grammar improvements – Brett Francis : 2012-Jun-13

D-1: D Draft – workgroup 2012-June-28 – plant, sunSpecMetadata and strings blocks

D-1: E Draft – workgroup 2012-July-05 – intro update, participant block, enumerated types – Brett Francis : 2012-Jul-18

D-1: F Draft – John Nunneley input 2012-Aug-09

T-1: A – Promoted to TEST level 1.0 – John Nunneley 2012-Aug-09

T-1: B – General formatting, layout and grammar improvements – Brett Francis 2012-Sept-05

T-2:A – Incorporating feedback – 2012-MMM-dd

V2-D1: Flesh out financial oversight use case and NREL requirements. 2013-Feb-14

V2-D2: Incorporate feedback. 2013-Feb-21

V2-D3: Incorporate feedback. 2013-Feb-28

V2-D4: Incorporate feedback. 2013-March-14, SunSpecAggregatedData, MetaData

V2-D6: Formatting, clarification, oSPARC updates

Introduction

The SunSpec Alliance Technical Committee has identified a significant gap hindering growth and innovation in the software analysis tool ecosphere for solar power plants. This SunSpec Alliance Interoperability Specification describes the Plant Extract Document (aka "Plant Extract", or "Extract"). The target audiences for this document are Plant asset owners, operators, and application software developers serving needs across the Plant lifecycle. The Plant Extract's initial purpose is to meet two challenges:

Customers need a common monitoring extract format as input to their own asset analysis tools

Customers need a way to extract and send historic plant data between systems

Beyond these initial challenges it is expected that, through the industry's increased use of a standard Plant Extract, many benefits will be delivered across the power plant lifecycle over the longer term. The extract format is designed to be readily extensible to incorporate new Plant information properties as the use cases are expanded and developed.

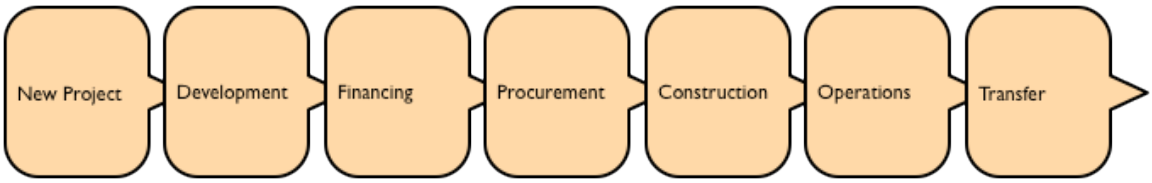

Fig. 1 – Plant Lifecycle

Some expected longer-term benefits of the industry's use of a consistent Plant Extract are:

- Promote information reuse across the lifecycle and create an information feedback loop to improve new projects
- Enable consistent understanding of Plant IDs by all parties from new project through transfer
- Creation of operations backup copies from O&M provider housed data
- Use of tools across lifecycle and data obtained from multiple vendors
- Bring about stand-alone tools for risk identification, third-party certification and general purpose financial analysis
- Associate performance history with a plant in a single document
- Deliver plant history when ownership is transferred

Version 2 Development

A general "pull" application programming interface (API) is defined to request a Plant Extract document.

A spreadsheet (CSV, XML, or other) encoding is defined.

The schema is extended to support the Financial Oversight / Periodic reporting use case. Aggregation of base data into fixed intervals is introduced. Plant level measurements, status, and outage information are added. Additional properties are added to enrich the plant description.

Future Development

XML was chosen for its flexibility and ease of transformation. Other representations in CSV, JSON, and HTML are envisioned.

The primary use case that has driven this version of the Plant Extract Document is to support the, "Standard Data Download" use case. This use case requires the creation of a standard download format for sample data to be retrieved from a monitoring system that covers some period of time – e.g. one day, week, or month's worth of data. An additional use case, termed "Operational Continuity", has also driven current thinking. The operational continuity use case is expected to bring about the ability to perform a bulk data export / import operation between monitoring systems.

Additional use cases as described as longer-term benefits were discussed as well as use cases to support financial and operational oversight is envisioned. To meet the current focus and additional use cases the Plant Extract Document has been designed with extensibility features to allow for rapid support of new use cases.

The Plant Extract Document uses the SunSpec Logger Upload XML as the standard encoding for time series data – it is expected there will be additional input to the Logger Upload workgroup as the Plant Extract Document is adopted in the industry.

At this point in time the Plant Extract Document schema is left open to the definition of new properties and the inclusion of other data models though no such extensions are specified at this time. Since the Plant Extract Document is first and foremost a standard enveloping scheme, it is envisioned that rich sources of Plant metadata will be developed and readily transported in a Plant Extract Document.

No online registry of Plant properties and extensions yet exists. To promote the inclusion of new properties, parties who adopt the Plant Extract are encouraged to contribute properties for collection and incorporation by the Plant Extract Document Workgroup into an updated specification.

Supported Use-cases

These are not the entire set of possible use cases that the current Plant Extract Document can or will support but the following use-cases are those that have been most driving discussion for this document's revision.

Orange Button (aka Standardized plant downloads) – The ability for any SunSpec member to request that an Orange Button be added right next to their monitoring provider's "CSV download" option. This Orange Button will allow a data provider to be SunSpec compliant with the Plant Extract document independent of any other certification. More details are in this document's Orange Button Definition section.

Operational continuity – The ability to export/import historic plant data between systems.

Financial oversight – The ability to periodically report on key plant performance indicators to enable true "apples-to-apples" comparison of plants.

Operational status – Snapshot report of plant status and key performance indicators as input to grid operations.

Plant Extract Document Definition

The Plant Extract is a definition for a document-oriented *envelope* with an allowed set of *standard blocks*.

Supporting a use case to transfer a large volume of operational data from one system to another may be quite bulky, therefore, it may be necessary to break the extract into digestible chunks as dictated by data granularity and system limits. To address the entire use case spectrum from a small to a large volume of data, the Plant Extract definition supports the representation of a single extract, or a set of related extracts, drawn from a single plant.

Compliance

A compliant system shall expose an ability to extract information in a format that validates against the Plant Extract Document XML Schema definition.

The `sunSpecPlantExtract` envelope and element

The `sunSpecPlantExtract` element represents an envelope that contains one or many standard blocks of information that describe a power plant.

Specifically, the `sunSpecPlantExtract` element can contain five types of elements considered the *standard blocks*: a required `plant` element, an optional single `sunSpecData` element, an optional `sunSpecMetadata` element, an optional single sunSpecIntervalData element, and optional single sunSpecAggregatedData element, an optional `strings` element, and an optional single `extractExtensions` element.

Attributes

The `t` attribute must be present and must contain an UTC (aka “Universal Time Coordinate” or “Zulu”) timestamp that is compliant with the ISO 8601 extended format representing a combined date and time to the second. The timestamp must represent the moment that the extract document was created with all current contents. A set of multiple extracts may be created to represent a single larger extract action. When creating a set of extracts, the timestamps on all extracts in the set must be exactly the same, as the `t` attribute then represents the moment that the set of extracts was created. Expected timestamp format: `"YYYY-MM-DDThh:mm:ssZ"`

The `v` attribute, if present, must contain the version number describing the Plant Extract specification with which the extract complies. The version value will be increased when incompatible changes are introduced by the workgroup. If this attribute is absent the value is to be interpreted as `“1”`. At this time only `“1”` is a valid value.

The `seqId` attribute, if present, is used to represent the sequence number that the associated extract is within a set of extracts. If this attribute is absent the value is to be interpreted as `“1”`.

The `lastSeqId` attribute, if present, is used to represent the highest sequence ID in a set of extracts created to represent a single larger extract action. If this attribute is absent the value is to be interpreted as `“1”`.

The `periodStart` attribute indicates the starting range of the time period that this document covers. Expected timestamp format: `"YYYY-MM-DDThh:mm:ssZ"`

The `periodEnd` attribute indicates the ending range of the time period that this document covers. Expected timestamp format: `"YYYY-MM-DDThh:mm:ssZ"`

The `plant` standard block and element

The various plant info elements and their attributes together define the *plant standard block*.

The `plant` element represents a standard block describing information related to a power plant. The `plant` element is a required standard block within the Plant Extract. The information contained in this block is expected to meet two goals: disambiguation of a power plant throughout the industry, and delivery of descriptive properties for both customers and tools.

Attributes

The `id` attribute must be present and must contain a value generated in accordance with the UUID Version 4 Random algorithm as described in RFC 4122 section 4.4. The use of delimiting hyphens is optional. The Plant `id` travels with the Plant Extract and serves to uniquely identify this Plant over the complete Plant lifecycle.

The `v` attribute must be present and must contain the version number describing the `plant` element specification with which the entire `plant` block complies. At this time only `"1"` is a valid value.

The `locale` attribute must be present and must contain the locale describing the language in which all values in the plant element and any other elements in the *plant standard block* content model are represented. The value of the attribute must use IETF language tags as defined by BCP 47 - RFC 5646. Although not required, the preferred level of the `locale` value is at least a *language subtag plus script subtag*, examples: `en-US`, `zh-Hans`, `de-DE`, `fr-FR`, etc.

Content Model

The `plant` element can optionally contain these types of elements:

- a single `name` element,
- a single `description` element,
- a single `notes` element,
- a single `activationDate` element,
- a single `location` element,
- a single `nameplate` element,
- a single `capabilities` element,
- a single `designElements` element,
- one or more `participant` elements,
- multiple `property` elements.

The `name` element

The `name` element, if present, represents the common name of the `plant` element that is its parent. The `name` element takes part in the *plant standard block*.

The `description` element

The `description` element, if present, represents a text description of the `plant` element that is its parent. The `description` element takes part in the *plant standard block.*

The `activationDate` element

The `activationDate` element, if present, represents the date the power plant described by the `plant` element that is its parent was actively delivering power to the utility grid or energy off-taker. The activationDate element's value must be compliant with the ISO 8601 date format: `"YYYY-MM-DD"`

The `location` element

The `location` element, if present, represents the location of the `plant` element that is its parent. The `location` element takes part in the *plant standard block*.

`location` Content Model

The `location` element can optionally contain the following types of elements: a single `latitude` element and a single `longitude` element, a single `line1` element, a single `line2` element, a single `city` element, a single `stateProvince` element, a single `country` element, a single `postal` element, a single `elevation` element, and a single `timezone` element. All elements participate in the *plant standard block.*

The `latitude` element, if present, represents the decimal degrees north or south of the equator of the `plant` element that is its ascendant. The `latitude` element is a positive (representing northward) or negative (representing southward) decimal number in the expected format: `±XX.XXXXXX` where the digits after the decimal are only necessary when expressing increasingly accurate values.

The `longitude` element, if present, represents the decimal degrees east or west from the Prime Meridian of the `plant` element that is its ascendant. The `longitude` element's value is a positive (representing eastward) or negative (representing westward) decimal number in the expected format: `±XXX.XXXXXX` where the digits after the decimal are necessary when expressing increasingly accurate values.

The `line1` element, if present, represents the first line of detailed address information of the `plant` element that is its ascendant.

The `line2` element, if present, represents the second line of detailed address information of the `plant` element that is its ascendant.

The `city` element, if present, represents the city in which or most near to the `plant` element that is its ascendant.

The `stateProvince` element, if present, represents the subdivision (e.g., province or state) within the country of the `plant` element that is its ascendant. The state-province element's value must comply with the ISO 3166-2 standard.

The `country` element, if present, represents the country of the `plant` element that is its ascendant. The `country` element's value must be expressed as either a two-character code compliant with ISO 3166-1 alpha-2 or a three-character code compliant with ISO 3166-1 alpha-3.

The `postal` element, if present, represents the geographical area of the `plant` element that is its ascendant, as delineated by the local postal system. The `postal` element's value is expected to be contain some combination of the Arabic numerals "0" through "9" and/or the letters from the ISO basic Latin alphabet.

The `elevation` element, if present, represents the average elevation of the `plant` element that is its ascendant. The `elevation` element's value is to be numeric and expressed in meters.

The `timezone` element, if present, represents the time zone of the `plant` element that is its ascendant. The `timezone` element's value should comply with either:

the ISO 8601 standard for describing an offset from UTC using `±hh:mm` as an acceptable format, or

the ISO 8601 UTC offset **and** a descriptive string from the list of time zone abbreviations as captured in Wikipedia `http://en.wikipedia.org/wiki/List_of_time_zone_abbreviations`. For example, `UTC+04:00 SCT` would be the preferable way of describing Seychelles Time

The `mapURL` element, if present, is an aerial or other image of the plant, or a map application such as google earth that can be used to render and image of the plant. The `mapURL` element's value is a well formed URL string.

The `nameplate` element

The `nameplate` element, if present, represents an unbounded set of `property` elements that describe the physical characteristics of the plant represented by the parent `plant` element. The `nameplate` element takes part in the *plant standard block.*

The set of properties in the `nameplate` element is unbounded and potentially driven by other workgroups; however, as of this writing, valid property `id` attribute values are:

ID	Type	Description
installedDCCapacity	float	The total installed direct current capacity of the power plant expressed in kW
installedACCapacity	float	The total installed alternating current capacity of the power plant expressed in kW
installedPanelArea	integer	The total surface area of panels installed at the power plant expressed in m^2
nominalPowerRating	float	The total nominal power of the power plant expressed in kWp

The array element

The pvArray element, if present, describes the attributes of a PV array. Plants with multiple arrays will have a pvArray element for each array. The pvArray element appears in the *plant standard block.*

The pvArray element may contain 0 or more property elements. Valid property id attribute values are:

ID	Description
description	Description or identifier
numModules	Number of modules, or panels, in the array
m2	The total surface area of panels expressed in $m^{2.}$
orientation	The orientation of the array in degrees from true North.
trackerType	The type of tracker employed. Fixed Array, Single-Axis Tracker, Dual-Axis Tracker
fixedTilt	The fixed tilt value if not tracked.
fixedAzimuth	The fixed azimuth value if not tracked
dcRating	Total DC STC rating of the array in kW
installType	Rooftop, Ground
num	Number of arrays of this type

The designElements element

The designElements element, if present, represents an unbounded set of property elements that describe elements of the plant design represented by the parent plant element. The presence of a property contained by the designElements element represents that the plant uses a particular type of design.. The designElements element takes part in the *plant standard block.*

The set of properties in the designElements element is unbounded and driven by the PED workgroup; however, as of this writing, valid property id attribute values are:

ID	Value
plantType	Residential, Commercial, Industrial, Utility
inverterType	Micro, String, Central
DCOptimized	None, String, Panel
mountingType	Fixed, Horizontal, Tilted, Azimuth, Dual. Mixed
weatherType	Onsite, Satellite, Local, Model, Mixed

The capabilities element

The capabilities element, if present, represents an unbounded set of property elements that describe the control capabilities of the plant represented by the parent plant element. The presence of a property contained by the capabilities element represents that the capability is present at the power plant. The capabilities element takes part in the *plant standard block.*

The set of properties in the capabilities element is unbounded and driven by the SunSpec Inverter workgroup; however, as of this writing, valid property id attribute values are:

ID	Description
fixedWatt	The fixed watt control capability is present at the power plant
fixedPF	The fixed power factor control capability exists at the power plant
fixedVAr	The fixed reactive power control capability is present at the power plant
voltVAr	The volt reactive power control capability is present at the power plant
freqWatt	The frequency watt control capability is present at the power plant
dynamicVAr	The dynamic reactive power control capability is present at the power plant
lowVoltageRideThrough	The low voltage ride through capability is present at the power plant
highVoltageRideThrough	The high voltage ride through capability is present at the power plant
charge	The capability to control storage charging is present at the power plant
discharge	The capability to control storage discharging is present at the power plant

The equipment element

The equipment element, if present, represents an unbounded set of property elements that provides a high level summary of the equipment used in the operation of the plant represented by the parent plant element. The equipment element takes part in the *plant standard block.*

Module metadata for each module type.

ID	Description
Mn	Manufacturer
Md	Model number
stc	Nameplate DC power rating of module at STC
m2	Nameplate surface area of module
tcoef	Nameplate temperature correction coefficient
num	Number of installed modules

Meter metadata for each meter type.

ID	Description
Mn	Manufacturer
Md	Model number
uncertainty	Nameplate uncertainty of meter
num	Number of installed meters

Inverter metadata for each inverter type.

ID	Description
Mn	Manufacturer
Md	Model number
WRtg	Nameplate AC power rating of inverter
uncertainty	Uncertainty of AC energy measurement
num	Number of installed inverters

Combiner metadata for each combiner type.

ID	Description
Mn	Manufacturer
Md	Model number
DCWRtg	Nameplate DC power rating of combiner
num	Number of installed combiners

Sensor metadata for each sensor type.

ID	Description
Mn	Manufacturer
Md	Model number
measurement	The measurement this sensor provides (irradiance, temp, pressure, humidity
uncertainty	Sensor measurement uncertainty
num	Number of installed sensors of this type

Logger metadata for each logger type.

ID	Description
Mn	Manufacturer
Md	Model number
Vr	Version
network	The type of backhaul network used (dedicated, shared, wireless, cellular)
fieldbus	The type of fieldbus network used (serial, ethernet, wifi, zigbee, plc, other)
num	Number of installed sensors of this type

The `participant` element

The `participant` element, if present, represents an unbounded set of `property` elements that describe human organizations participating in the operation of the plant represented by the parent `plant` element. The `participant` element takes part in the *plant standard block.*

A `participant` element must have a `type` attribute, where the `type` attribute describes the type of the participant being described in the element. The case-insensitive valid values for the `type` attribute are:

ID	Description
operator	The operator of the power plant, responsible for the production of power
owner	The owner of the power plant's assets
designer	The designer of the power plant, responsible for the specifications
installer	The installer of the power plant, responsible for the construction.
custodian	The keeper of the monitoring data

financier	The provider of capital for the plant construction
offtaker	The purchaser of the energy produced by the plant
jurisdiction	The utility which the power plant is interconnected.

The set of properties in the participant element is unbounded and likely to grow; however, as of this writing, valid property id attribute values are:

ID	Type	Description
organization	string	The name of the organization participating in the operation of the power plant
contact	string	The name of the person at the organization participating in the operation of the power plant
phone	string	The phone number of the organization participating in the operation of the power plant. All phone numbers should be conveyed without formatting and contain the country code to support international dialing.
email	string	The email address of the person at the organization participating in the operation of the power plant.

The property element

The property element, if present, represents an item in an unbounded set of descriptive properties of the plant element that is its ascendant. The property element may be included in any other plant standard block; however, there are specific blocks where particular property elements are expected.

A property must have an id attribute and may optionally have a type attribute, where the type attribute describes the type of the element's value. A property must be unique within the block that it is present as determined by a case insensitive comparison of a property's id attribute. The property element takes part in the *plant standard block*.

The case-insensitive valid values for the type attribute are:

ID	Description
float	The property element's value must be a lexically valid representation of a floating point number as described in the XML Schema Part 2: Datatypes Second Edition section 3.2.4
integer	The property element's value must be a lexically valid representation of an integer as described in the XML Schema Part 2: Datatypes Second Edition section 3.3.13
string	The property element's value must be a valid representation of a string as described in the XML Schema Part 2: Datatypes Second Edition section 3.2.1

`url`	The property element's value must be a valid URL representation as described by RFC 1738

The `sunSpecData` standard block and element

The various Sun Spec data elements and their attributes together define the *SunSpec data standard block*. This block is used to report raw data samples collected from sensors and devices located at the plant.

The `sunSpecData` element, if present, must comply with the SunSpec Logger Upload Interoperability Specification. Additionally, the `<d>` records within the `sunSpecData` element must be in time ascending order based upon the `t` attribute in the `<d>` element. The `<d>` records contained in this element are expected to be records related solely to the power plant identified in the extract's `plant` element.

The `sunSpecIntervalData` standard block and element

The various Sun Spec data elements and their attributes together define the *SunSpec interval data standard block*. This block is used to report interval data samples from sensors and devices located at the plant.

Interval data is derived from the base device samples and calculated for a specified time period. The data samples are put into "buckets" called "bins" sized to the requested time interval. E.g. hourly data values are aggregated from base 5 minute samples and reported for a single 24 hour period. Each bin should have 12 base data samples and some method is used to aggregate the values for that interval into a single value.

Supported Time Intervals: 15 minute, Hourly, Daily, Monthly, Annually

Supported Aggregation Methods: Average, Minimum, Maximum, First, Last, Difference, Sum. Note that not all methods are appropriate for all data points.

Quality Indicator: A given time interval is expected to have a specific number of samples for a given sampling frequency. The quality indicator (spct) is the ratio of samples to expected samples and shall be less than or equal to 1. A value of 1 indicates all samples were received while a value of zero indicates that there are no samples in the interval.

|……..|……..|……..|…….

Example with a 5 minute interval, all bin samples present.

1. 14:55:00 q=1
2. 15:00:00 q=1 (last bin of the hour)
3. 15:05:00 q=1 (first bin of the hour)
4. 15:10:00 q=1

5. 15:15:00 q=1
6. 15:30:00 q=1
7. 15:45:00 q=1
8. 16:00:00 q=1 (last bin of the hour)
9. 16:05:00 q=1 (first bin of the hour)

Rules for Interval Sampling and Aggregation methods: Conventions must be established so that interval reporting is done consistently across implementations. Examples are given to illustrate the edge conditions and use of the quality indicator.

1. Intervals shall begin exactly at the start of the interval and end just before the start of the next interval. I.e. 5 minute intervals will begin on 5 minute boundaries, 00:00:00, 00:05:00, … 00:55:00
2. The label (timestamp) for the bin shall be the end of the interval. I.e. the 24 hourly intervals are labeled 01:00:00, 02:00:00, … 23:00:00, 00:00:00 where 00:00:00 is the last hourly bin of the day. NOTE: This may appear confusing when labeling by the beginning of the interval is more natural to a human. Consistency for machine reading is preferred in this specification. See the following example:

```
5 Min bins RIGHT LABEL (from raw samples)
20130607T02:59:56 a'
20130607T02:59:57 b' <- Bin "03:00" (the last of the 02:nn:nn) has a', b' [55, 00)
20130607T03:00:00 a
20130607T03:01:03 b
20130607T03:03:22 c
20130607T03:04:10 d <- Bin "03:05" has a, b, c, d [00, 05)
20130607T03:05:42 e
20130607T03:06:13 f
20130607T03:08:28 g <- Bin "03:10" has e, f, g [05, 10)
20130607T03:10:28 h
20130607T03:11:17 i <- Bin "03:15" has h, i [10, 15)
20130607T03:16:17 j
20130607T03:18:21 k <- Bin "03:20" has j, k [15, 20)
20130607T03:22:03 l
20130607T03:23:10 m <- Bin "03:25" has l, m [20, 25)
```

3. The interval shall contain all samples with timestamps in the range of the interval. I.e. an hourly interval would contain all samples in the range of XX:00:00.000 –XX:59:59.999
4. The quality indicator (spct) shall indicate the ratio of actual number of valid samples to expected # of samples. The default quality value of 1 indicates all samples were present and valid. Samples that are out-of-range should not be used as a sample and should be counted as missing. If no samples are present, then the spct value shall equal zero and the interval value shall be NULL. The distribution of the samples across the interval may also have an effect on quality. The expected number can be plus or minus one.

5. The method indicator (m) shall indicate the method used to perform the aggregation. Note that not all methods will apply to all data points.

    a. AVERAGE. The sample values are summed and divided by the actual number of samples.

    b. MINIMUM: The sample values are compared and the least value is returned.

    c. MAXIMUM: The sample values are compared and the greatest value is returned.

    d. FIRST: The first sample in the interval is returned.

    e. LAST: The last sample in the interval is returned.

    f. DIFFERENCE: Used in energy production (integral) calculations. If there are no samples in the interval, the value is 0. Otherwise, the closing sample, if available, or the last available sample if not, is subtracted from the opening sample, if available, or the previously last available sample if not, to calculate the DIFF. The quality of the DIFF calculation (spct) indicates the gaps from the ideal sample boundaries. See the following example.

    DIFF = (spct > 0 ? : ((BinClose ? (BinClose : this.LAST)) - (BinOpen ? (BinOpen : prev.LAST))) : 0)

    DIFF.spct = 1 – (**ABS(bin opening boundary - first sample available timestamp) + ABS(bin closing boundary - last sample available timestamp)) / (seconds in bin)**

```
15 minute data, 1 hour interval
00:00 0
00:15 1
00:30 2
00:45 3
01:00 4  ** BIN1 (4-0)  4, spct=1
01:15 5
01:30 6
01:45 7
02:00 8  ** BIN2 (8-4) 4, spct=1
02:15 9
02:30 10
02:45 11
            ** BIN3 (11-8) 3, spct=.75
03:05 12
03:15 13
03:30 14
03:45 15
04:00 16  ** BIN4 (16-11) 5, spct=.92
04:15 17
04:30 18
04:45:19
04:55 20
            ** BIN5 (20-16) 4, spct=.92
05:15 21
05:30 22
05:45 23
06:00 24  ** BIN6 (24-20) 4, spct=.75
06:15 25
06:30 26
```

```
06:45 27
06:55 28
                    ** BIN7 (28-24) 4, spct=.92 (1)
07:15 29
07:30 30
07:45 31
                    ** BIN8 (31-28) 3, spct=.50 (.60)
08:05 32
```

The `sunSpecAggregatedData` standard block and element

The Sun Spec plant level data elements and their attributes together define the *SunSpec aggregated data standard block*. This block is used to report aggregated data samples from sensors and devices located at the plant.

Plant level data is aggregated from the base device interval data by combining one or more devices. E.g. The Plant level energy measurement may be derived from summing the energy generation measured by each inverter. Alternatively, this measurement may come from a single meter at the combined output of the plant. The method is not prescribed in the PED although some examples may be given.

Plant level measurements

ID	Description
`WH`	Lifetime AC energy generated by all PV
`W`	AC real power reference at point of interconnect
`V`	AC voltage reference at point of interconnect.
`A`	AC current reference at point of interconnect.
`Hz`	Frequency reference at point of interconnect.
`PF`	Powerfactor reference at point of interconect
`ENVIRONMENTALS`	
`Gghi`	Global horizontal irradiance reference (W/m^2)
`Tmpamb`	Ambient temperature reference (˚C)
`WndSpd`	Wind speed reference (m/s)
`Pres`	Atmospheric pressure reference (hPa)
`RH`	Relative humidity reference (%)
`Rain`	Lifetime rainfall totals (mm)

Array level measurements for each array.

ID	Description
`DCWH`	Lifetime DC energy generated from array
`DCW`	DC power output of array
`DCV`	DC voltage reference at array output.

DCA	DC current reference at array output.
ENVIRONMENTALS	
Gpoai	Irradiance measurement in plane of array
Hpoai	Lifetime irradiation received in plane of array
Tmpbom	Back of module temperature reference for array

Plant Availability States - expressed as a percentage of the interval time in any given state.

Availability State	Description
Operating	Connected and generating power
Islanded	Disconnected and generating power for local loads
Standby	Includes starting up, shutting down, test mode
Env	Environmental conditions are out of spec. I.e. not enough sunlight to generate power
Grid	Grid conditions are out of spec. I.e. voltage or frequency violations caused the plant to trip off.
Shutdown	Operator requested shutdown for maintenance, testing, or other purposes
Forced	Outage due to Plant failure
Emergency	Shutdown due to force majeure. Extraordianry event beyond the control of the operators.

Plant Fault Categories - expressed as the number of faults of a given type and timestamp of oldest fault of that type.

Fault Category	Description
inverter	Number of active inverter faults, timestamp of oldest active
module	Number of active module faults, timestamp of oldest active
meter	Number of active meter faults, timestamp of oldest active
sensor	Number of active sensor faults, timestamp of oldest active
comm	Number of active communication faults, time stamp of oldest active
other	Number of other active faults, time stamp of oldest active

Facility Net Energy Measurements.

ID	Description

WHl	Lifetime ac energy exported to facility loads
WHx	Lifetime ac energy exported to grid
WHi	Lifetime ac energy imported from grid
WHc	Lifetime ac energy charged to storage
WHd	Lifetime ac energy discharged from storage
WHp	Lifetime ac energy imported to PV (parasitic losses)

The sunSpecMetadata standard block and element

The various Sun Spec metadata elements and their attributes together define the *SunSpec metadata standard block*.

The sunSpecMetadata element, if present, represents additional descriptive information about the model, device, or point in a manner that complies with the Logger Upload sunSpecData specification element structure. If a sunSpecData element and the sunSpecMetadata element exist in the current extract, the sunSpecMetadata element should contain additional descriptive information about the model, device, or point(s) in the sunSpecData element.

The strings standard block and element

The various strings elements and their attributes together define the s*trings standard block*.

The strings element, if present, represents additional language localization information for other elements contained in the sunSpecExtract element when information in more than one language is extracted. One strings element may exist per extracted additional language.

Attributes

The locale attribute must be present and must contain the locale describing the language in which all descendant values in the strings element are represented. The value of the attribute must use IETF language tags as defined by BCP 47 - RFC 5646. Although not required the preferred level of the IETF language tag is at least a *language subtag plus script subtag*, examples: `en-US`, `zh-Hans`, `de-DE`, `fr-FR`, etc.

The extractExtensions standard block and element

The various extract extensions elements and their attributes together define the *extract extensions standard block*.

The extractExtensions element, if present, represents the mechanism for including unique, proprietary, or standardized content that has not yet been, nor may never be, codified into the Plant Extract specification. To keep this block from becoming a free-for-all, a lightweight pattern is to be used within this standard block's elements and attributes.

The extension element

The extension element, if present, represents a named extension.

Attributes

The `name` attribute must be present and represents the name of the extension.

In order to reduce potential name collisions the `name` attribute value should be a value based upon the domain name of the entity including the extension. As an example a `name` attribute value of `iepmodel` would be the recommended name of the `extension` element containing information compliant with the IEP Model project, since the IEP Model Project website uses a domain name of **`iepmodel`**`.net`

The `xmlns:location` attribute must be present and describes the location from which the namespace name document describing the content within the `extension` element can be retrieved. The expectation is that the content retrievable from the location is human readable.

The `xmlns:`*`prefix`* attribute must be present and describes the namespace name to be used within the `extension` element.

Orange Button Definition

For any party to become certified with the basic Orange Button Definition and to use the SunSpec Plant Extract Document "Orange Button" logo they must have the following capability in their software package:

- An ability to extract information from the software package in a format that complies with the Plant Extract Document XML Schema definition

Once the payload is verified, the software package can use the following button to display the ability for a user to extract compliant information.

Fig. 1 – SunSpec Orange Button

Orange Button API

Beyond the basic certification requirements for use of the Orange Button, it is understood that many existing systems will offer their own programmatic way of obtaining a Plant Extract. However, when a software package is making the SunSpec Plant Extract available using an application programming interface, the workgroup has some recommendations on functionality based upon feedback from members.

The following functionality, sometimes described as formatted property–value pairs, should be incorporated in an API if at all possible. An API client should be able to:

- know the version of the payload *before* sending a request: only "`1`" or "2" is valid at this time.

- request a Plant Extract by the plant `id` attribute that uniquely identifies the Plant as described above in the *plant standard block. If the plant id is not known then the API will return the default plant.*

- take a common file extension approach to describe the payload format of the resulting Orange Button download. When a single extract is requested, `.xml` or `.zip` are recommended. When a multi-extract download is requested `.zip` is recommended.

- provide an authentication and authorization mechanism to the requestor that supports the data owner's sharing policy preferences

- request `locale=<<xx-XX, ...>>` as one or more language tags that describe languages to include in the resulting Orange Button download. The values should be described at the preferred level of the IETF language tag which is at least a *language subtag plus script subtag*, examples: `en-US`, `zh-Hans`, `de-DE`, `fr-FR`, etc.

- request `periodStart=<<YYYY-MM-DDThh:mm:ssZ>>` as the requested start of the period of `sunSpecData` block to be contained in the Orange Button download

- request `periodEnd=<<YYYY-MM-DDThh:mm:ssZ>>` as the requested end of the period of `sunSpecData` block to be contained in the Orange Button download

- request `block=<<plant, sunSpecData, ...>>` as one or more desired standard blocks to include in the resulting Orange Button download. The full list is: `plant`, `sunSpecData`, `sunSpecMetadata`, sunSpecAggregateData, sunSpecIntervalData, `strings`, `extractExtensions`

- request `cf=<<p[id="TmpBOM"], m[id="303"], ...>>` as a straightforward mechanism to use the attributes of standard block elements to enable source-based "content filtering" (or "cf") of plant extract data to include in the resulting Orange Button download.

Again, all of the example parameters describe functionality that the workgroup recommends is included based upon feedback from members. These parameters are not required to achieve basic Orange Button certification.

Describe POSTing of a skeleton PED document to request an extract that is more finely filtered.

Example Plant Extract Document – All elements

```
<sunSpecPlantExtract t="2011-07-23T08:40:50Z" seqId="1" lastSeqId="1" v="1">
  <plant id="c0c18885d5f54cc28792e67d235e0db6" v="1" locale="en-US">
    <name>Lorem ipsum Power</name>
    <description>Lorem ipsum description</description>
    <notes>Lorem ipsum and more lorem ipsum</notes>
    <activationDate>2011-03-22</activationDate>
    <location>
      <latitude>-4.651711</latitude>
      <longitude>55.454865</longitude>
      <line1>12333 Sesame Street</line1>
      <line2>apt #12</line2>
      <city>Beach City</city>
      <stateProvince>SC-05</stateProvince>
      <country>SYC</country>
      <postal>MLLQL G6TX5</postal>
      <elevation>1028</elevation>
      <timezone>+04:00</timezone>
      <property id="parcelNumber">455</property>
      <property id="mapURL" type="url">http://blah.com/map?1667</property>
    </location>
    <namePlate>
      <property id="installedDCCapacity" type="float">250</property>
      <property id="installedACCapacity" type="float">240</property>
      <property id="installedPanelArea"  type="integer">4000</property>
      <property id="nominalPowerRating"  type="float">255.4</property>
    </namePlate>
    <capabilities>
      <property id="fixedWatt" />
      <property id="fixedPF" />
      <property id="fixedVAr" />
      <property id="voltVAr" />
      <property id="freqWatt" />
      <property id="dynamicVAr" />
      <property id="lowVoltageRideThrough" />
      <property id="highVoltageRideThrough" />
      <property id="charge" />
```

```
    <property id="discharge" />
  </capabilities>
  <participant type="operator">
    <property id="name" type="string">Seychelles Power</property>
    <property id="contact" type="string">Sally Sey</property>
    <property id="phone" type="string">14085557899</property>
    <property id="email" type="string">sally@sey-power.com</property>
  </participant>
</plant>
<sunSpecData v="1">
  <d lid="11:22:33:44:55:66" id="GSC400-e101001" t="2011-05-12T09:20:50Z"
     cid="AR45">
    <m id="1">
      <p id="Mn">Amalgamated Industries</p>
      <p id="Md">Composite SuperDevice</p>
      <p id="Opt">Mark 2 &lt;&amp;&apos;&gt;</p>
      <p id="Vr">3.14.159</p>
      <p id="SN">9876543210</p>
      <p id="DA">99</p>
    </m>
    <m id="303">
      <p id="TmpBOM" x="1">20</p>
      <p id="TmpBOM" x="2">18</p>
    </m>
  </d>
</sunSpecData>
<sunSpecMetadata>
  <d lid="11:22:33:44:55:66" man="gsc" mod="r800">
    <m id="303">
      <description>The environmental in the top corner</description>
      <notes>Under a tree</notes>
      <p id="TmpBOM" x="1">
        <description>The panel cell</description>
        <notes>Some notes about the cell</notes>
        <property id="unmas">temp-1-45</property>
      </p>
      <p id="TmpBOM" x="2">
        <label>The module</label>
      </p>
    </m>
  </d>
</sunSpecMetadata>
<strings locale="fr-FR">
  <plant>
    <name>Puissance de Lorem ipsum</name>
    <description>Description d'ipsum de Lorem</description>
    <notes> Ipsum de Lorem et plus d'ipsum de lorem</notes>
    <participant type="operator">
      <property id="operator"
                type="string">Puissance des Seychelles</property>
    </participant>
  </plant>
  <sunSpecMetadata>
```

```
      <d lid="11:22:33:44:55:66" man="gsc" mod="r800">
        <m id="303">
          <description>L'ambiant dans le coin supérieur</description>
          <notes>Sous un arbre</notes>
          <p id="TmpBOM" x="1">
            <description>La cellule de panneau</description>
            <notes>Quelques notes au sujet de la cellule </notes>
            <property id="unmas">temp-1-45</property>
          </p>
          <p id="TmpBOM" x="2">
            <label>Le module</label>
          </p>
        </m>
      </d>
    </sunSpecMetadata>
  </strings>
  <extractExtensions>
    <extension name="iepmodel.net"
               xmlns:location="http://www.iepmodel.net/iep"
               xmlns:iep="http://iepmodel.net/iep">
      <iep:project id="" >
        <!-- ...IEP compliant incorporated information... -->
      </iep:project>
    </extension>
  </extractExtensions>
</sunSpecPlantExtract>
```

Example Plant Extract Document – Small without Additional Languages

```
<sunSpecPlantExtract t="2011-07-23T08:40:50Z" seqId="1" lastSeqId="1"
  <plant id="c0c18885d5f54cc28792e67d235e0db6" v="1" locale="en-US">
    <name>Lorem Ipsum Power</name>
    <description>Lorem ipsum description</description>
    <notes>Lorem ipsum and more lorem ipsum</notes>
    <activationDate>2011-03-22</activationDate>
    <location>
      <latitude>-4.651711</latitude>
      <longitude>55.454865</longitude>
      <line1>12333 Sesame Street</line1>
      <line2>apt #12</line2>
      <city>Beach City</city>
      <stateProvince>SC-05</stateProvince>
      <country>SYC</country>
      <postal>MLLQL G6TX5</postal>
      <elevation>1028</elevation>
      <timezone>+04:00</timezone>
      <property id="parcelNumber">455</property>
      <property id="mapURL"
                type="url">http://blah.com/map?1667</property>
    </location>
  </plant>
  <sunSpecData v="1">
    <d lid="11:22:33:44:55:66" id="GSC400-e101001"
       t="2011-05-12T09:20:50Z" cid="AR45">
      <m id="1">
        <p id="Mn">Amalgamated Industries</p>
        <p id="Md">Composite SuperDevice</p>
        <p id="Opt">Mark 2 &lt;&amp;&apos;&gt;</p>
        <p id="Vr">3.14.159</p>
        <p id="SN">9876543210</p>
        <p id="DA">99</p>
      </m>
      <m id="303">
        <p id="TmpBOM" x="1">20</p>
        <p id="TmpBOM" x="2">18</p>
      </m>
    </d>
  </sunSpecData>
</sunSpecPlantExtract>
```