CIM models for capabilities of Grid Edge Devices and EV as DERs

Discussion with reference to IEEE 1547, IEC 61850-7-420, IEEE 2030.5, IEC 63584 (OCPP)

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Event: CIM UML Feature Proposals
Date: 08 January 2024
Location: Remote

Document for discussion
Not intended for publication

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Or

GridOptimize

Context

IEC TC 69 JWG 15 : Design the information modelling for information exchange with EV charging management systems

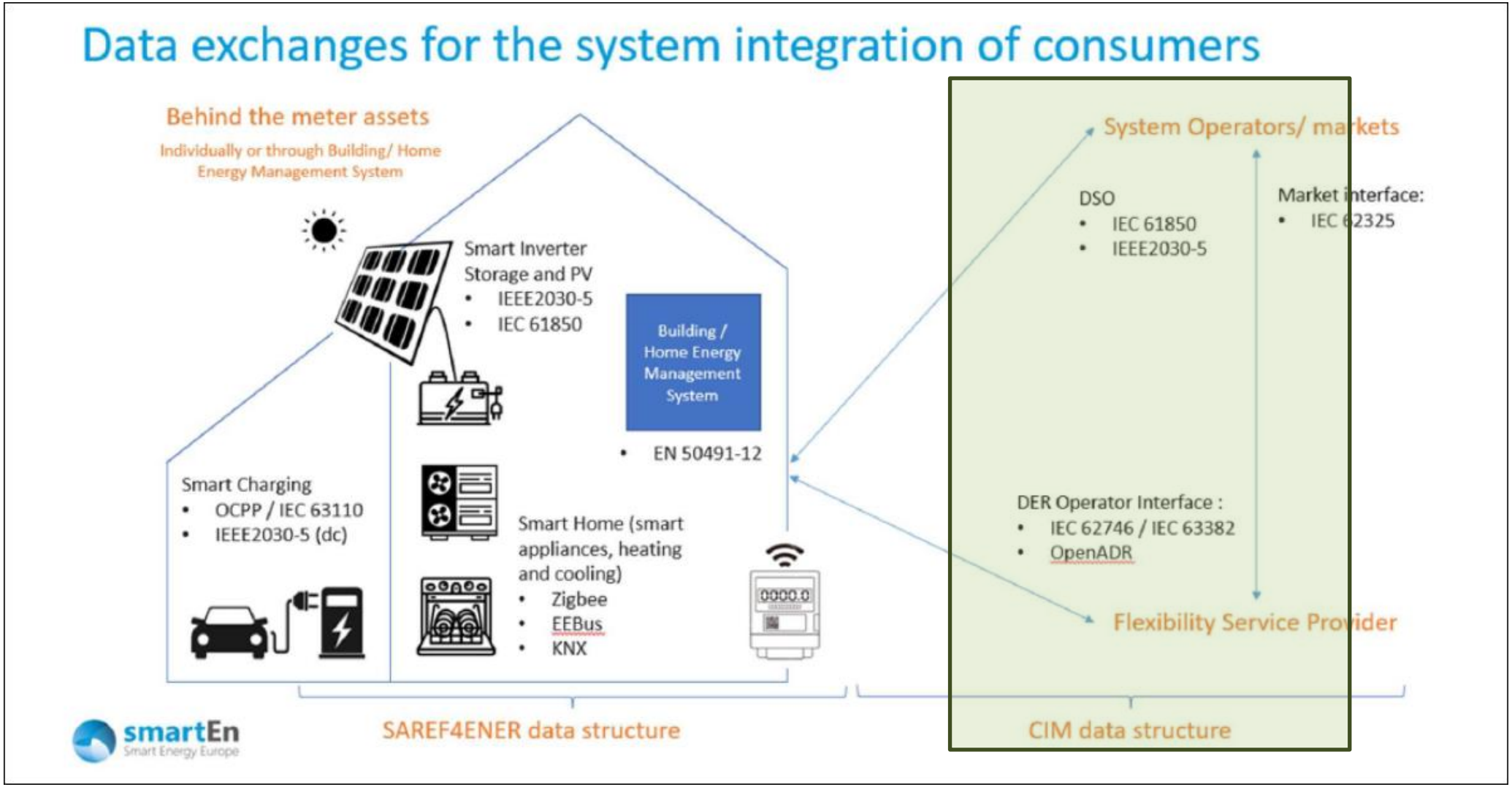
TC 57 WG 21 : resource modelling for generic Grid Edge Devices for flexibility services

Various standards address information exchange with remote devices

- **IEEE 1547**
- **IEEE 2030.5**
- **IEC 61850 models defined in part 7-420**
- **Mappings to IEEE 1815.2, Modbus (Sunspec alliance)**

Context – Example for discussions in Europe

Other protocols may be used in larger sites such as public, fleet, …



Existing CIM Models – (different views)

Historical

- **IEC 61968-5 Metering package** EndDeviceGroup class to manage groups of EndDevices. Smart Inverters in the DER context, are considered types of EndDevices

Specialized

- **IEC 61970-302 IEEE1547Dynamics package** for dynamics analysis of one or a few DER

To harmonize & extend

- **IEC 62746-4 RegisteredDistributedResource**
- **IEC 61970-301 Conducting Equipment – part of wires model for network analysis**

In progress

- **Asset - with reference to an Asset Type based on make, model version**

Requirements for resource capabilities

For operational planning of flexible resources

- **Assets = installed capability per resource**
  - **Per physical energy connection**
  - **Per aggregated resource**

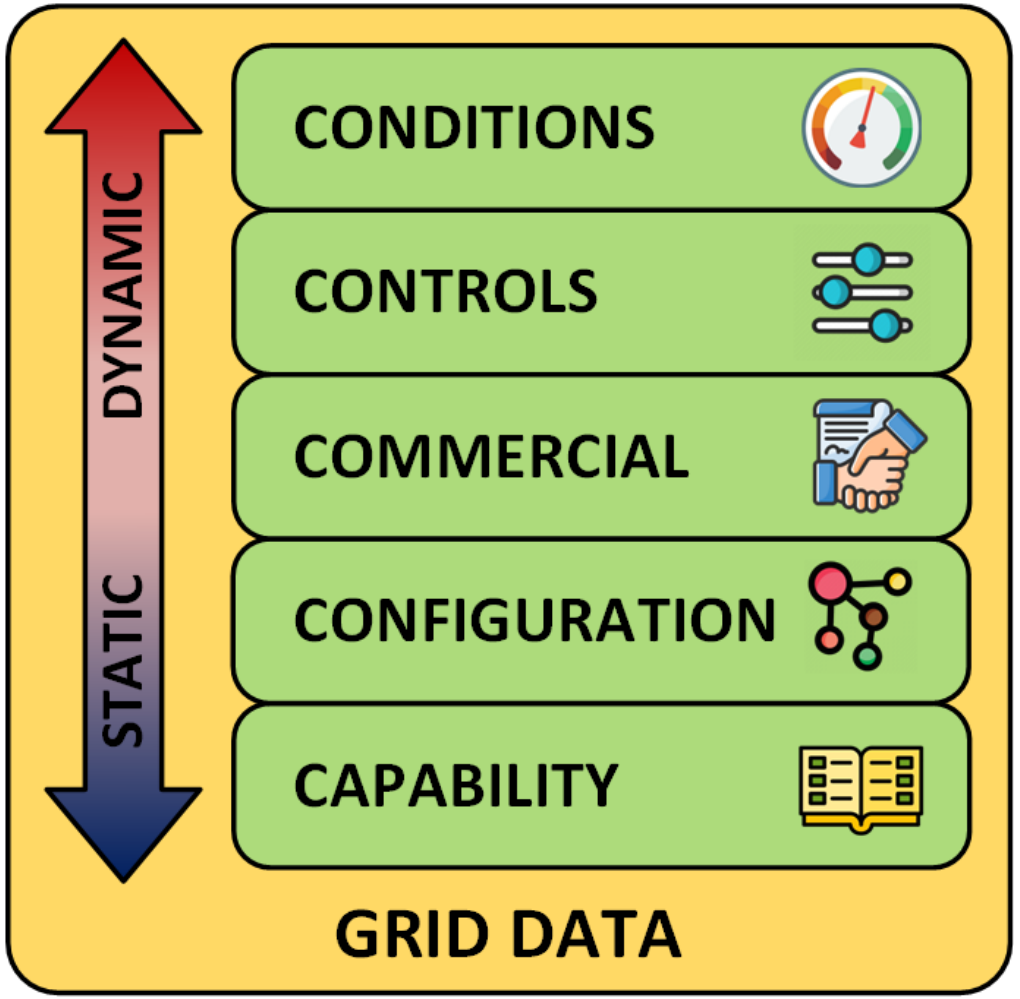
For analysis

- **Real-time & forecast values within ranges supported by devices**
- **Operational functional parameters per device**
  - **More complex rules for aggregation / publication of settings**

Categories of data
(ordered by fast to slow frequency of updates)

IEEE 1547 categories

- Monitoring & measurements
- Operational functions parameters and controls
- Configuration / Operating limits
- Nameplate = design ratings



Source: GridOptimize LLC

Resource capabilities – multiple versions!

- As designed
- Actual
- Forecast [0..N]

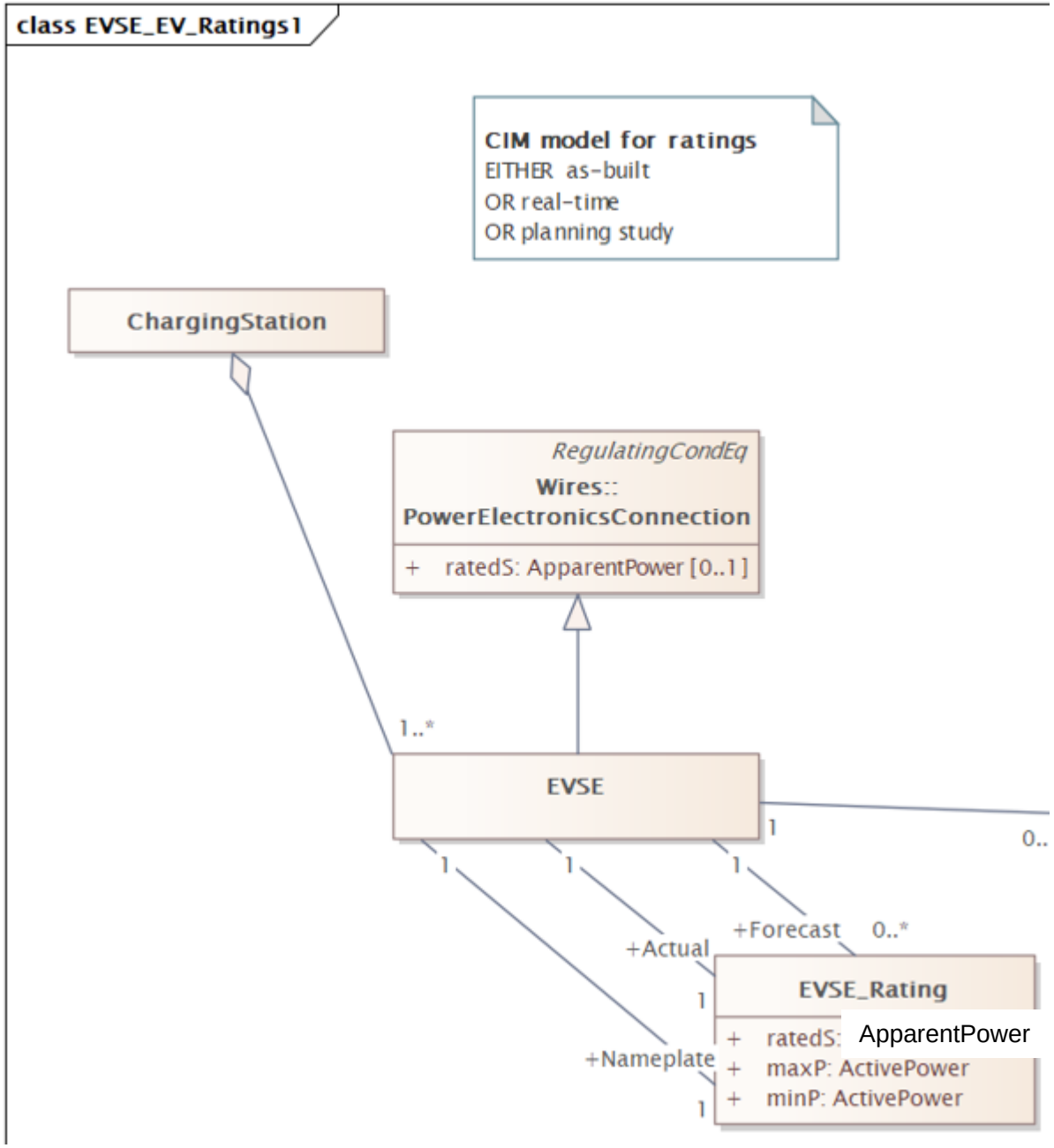
- From grid operator for Point of Connection
  - static (as installed)
  - dynamic = as communicated
- From Charging Park, Charging Zone capabilities
  - dynamic due to maintenance & faults
- From EVSE
  - static = maybe from asset catalog of product types per manufacturer
  - dynamic due to maintenance & faults
- From EV that is currently connected
  - dynamic = communicated by ISO 15118

Proposal

Define rating class to allow multiple instances

- **E.g. used in different contexts**
- **E.g. used by different levels: EVSE, ChargingStation, other aggegrations**

Similar concept can be applied to operational functions



Object Model Challenges

- **Define a set of classes to hold the parameters for each function**
  - **Usable for all use cases**
    - **analysis (WG13)**
    - **operation scheduling (WG21)**
    - **real-time exchanges (WG14 - replace IEC 61968-5)**

- **Define a CIM style naming convention for the attributes**

With mapping to other protocols

Examples of data objects

- …

Reminder: categories

• Nameplate = design ratings	static
• Configuration / Operating limits	infrequent changes (day, hour)
• Operational functions parameters	static or infrequent update
• Monitoring & measurements	dynamic (fast change)

Static (nameplate) design ratings

IEEE 1547 Description	IEC 61850-7-420 Naming	CIM properties
Nameplate Active Generation Power Rating at Unity Power Factor	DGEN.WMaxRtg	maxP
Nameplate Active Charging Power Rating at Unity Power Factor	DSTO.ChaWMaxRtg	minP
Nameplate Reactive Supply (Injection) Power Rating	DGEN.IvarMaxRtg	maxQ
Nameplate Reactive Absorption Power Rating	DGEN.AvarMaxRtg	minQ
Nameplate Apparent Generation Power Rating	DGEN.VAMaxRtg	ratedS
Nameplate Apparent Charging Power Rating	DSTO.ChaVAMaxRtg	

Aggregation of ratings (assuming a common point of connection to the grid)

P,Q,S = addition

V, f = copy

Configuration / Operating limits (could change per day, hour)

For new ratings class

IEEE 1547 Description		IEC 61850-7-420 Naming
Maximum Active Generation Power	W	DGEN.WMax
Maximum Active Charging Power	W	DSTO.ChaWMax
Maximum Reactive Injection Power	VAr	DGEN.IvarMax
Maximum Reactive Absorption Power	VAr	DGEN.AvarMax
Maximum Apparent Generation Power	VA	DGEN.VAMax
Maximum Apparent Charging Power	VA	DSTO.ChaVAMax

Aggregation of ratings (assuming a common point of connection to the grid)

P,Q,S = addition

V, f = copy

Todo: extra classes for real-time information exchanges

Operational functions parameters

Many functions – for example

Supports Active Power Limit Mode	DWMX.	Active Power Limit
Supports Charge/Discharge Mode	DWGC.	Set Active Power
Supports Frequency-Watt Mode	DHFW.	Freq-Watt (droop)
Supports Volt-VAr Control Mode	DVVR.	Volt-Var

Each with their own parameters: e.g. DVVR

Voltage-Reactive Power (Volt-VAr) Function	IEC 61850 Data Object	Clarification and Additional Test Instructions
Voltage-Reactive Power Mode Enable	DVVR.ModEna	
V_{Ref} Reference voltage	DVVR.VRefSet	
Autonomous V_{Ref} adjustment enable	DVVR.VRefAdjEna	
V_{Ref} adjustment time constant	DVVR.VRefTmms	
V/Q Curve Points	DVVR.VVArCrvDel	Curve of volt-var points using delta voltage between nominal and point
Open Loop Response Time	DVVR.OpnLoopMax	Time to ramp up to 90% of the new reactive power target in response to the change in voltage

Monitoring & measurements

IEEE 1547 Description	IEC 61850-7-420 Naming
Active Power	DECP.MMXU.TotW
Reactive Power	DECP.MMXU.TotVAr
Voltage(s)	DECP.MMXU.PhV.phsA.mag, .phsB.mag, .phsC.mag
Frequency	DECP.MMXU.Hz
Operational State	DGEN.DERState
Connection Status	DGEN.DERState.1
Alarm Status	CALH.GrAlm
Operational State of Charge	DSTO.UseSocPct

Reminder: Object Model Challenges

- **Define a set of classes to hold the parameters for each function**
  - **Usable for all use cases**
    - **analysis (WG13)**
    - **operation scheduling (WG21)**
    - **real-time exchanges (WG14 - replace IEC 61968-5)**

- **Define a CIM style naming convention for the attributes**

With mapping to other protocols

IOT based protocols have various naming conventions

from OCPP 2.1

references

SAE J3072-2021 Interconnection Requirements for Onboard, Grid Support Inverter Systems

Table 280. Comparing terminology across standards (based on Table C6 of [RefJ3072])

IEEE 1547-2018	IEC 61850	IEEE 2030.5-2018	OCPP
Mode/Function	**LN**	**DERControl**	**controlType**
Constant Power Factor	DFPF	opModFixedPFInject: Excit	FixedPFInject
Voltage - Reactive Power	DVVR	opModVoltVar: Curve	VoltVar
Active Power - Reactive Power	DWVR	opModWattVar: Curve	WattVar
Constant Reactive Power	DVAR	opModFixedVar: FixedVar	FixedVar
Voltage - Active Power	DVWC	opModVoltWatt: Curve	VoltWatt
High Voltage Trip Curve	DHVT	opModHVRTMustTrip: Curve	HVMustTrip
Low Voltage Trip Curve	DLVT	opModLVRTMustTrip: Curve	LVMustTrip
High Frequency Trip Curve	DHFT	opModHFRTMustTrip: Curve	HFMustTrip
Low Frequency Trip Curve	DLFT	opModLFRTMustTrip: Curve	LFMustTrip
Frequency-Droop (HF)	DHFW	opModFreqDroop	FreqDroop
Frequency-Droop (LF)	DLFW	opModFreqDroop	FreqDroop
Enter Service	DCTE	DefaultDERControl: setES…	EnterService
Cease to Energize and Trip	DCTE	opModEnergize	ChargingProfile
Limit Active Power	DWMX	opModMaxLimW: PerCent	LimitMaxDischarge
NA	DTCD	opModFixedW: SignedPerCent	ChargingProfile
NA	DWGC	opModFixedW: SignedPerCent	ChargingProfile

2.80. ReactivePowerParamsType

Class

ReactivePowerParamsType is used by: Common:DERCurveType

Field Name	Field Type	Card.	Description
vRef	decimal	0..1	Optional. Only for VoltVar curve: The nominal ac voltage (rms) adjustment to the voltage curve points for Volt-Var curves (percentage).
autonomousVRefEnable	boolean	0..1	Optional. Only for VoltVar: Enable/disable autonomous VRef adjustment
autonomousVRefTimeConstant	decimal	0..1	Optional. Only for VoltVar: Adjustment range for VRef time constant

EV + EVSE Settings

working proposal within CIM group discussing DER

To be mapped to IEC 61850

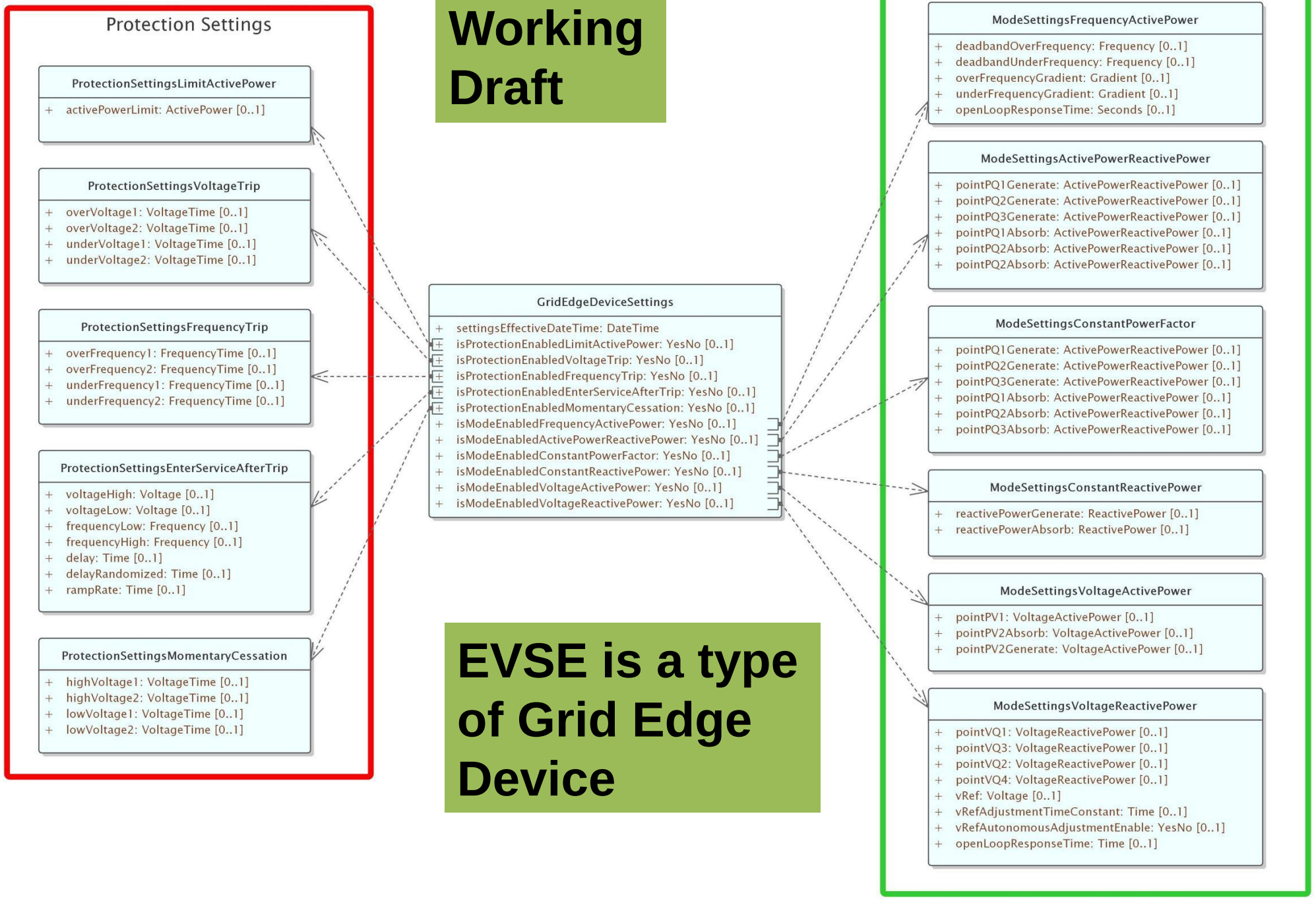
Power limits should be upper and lower limits

To add settings to show

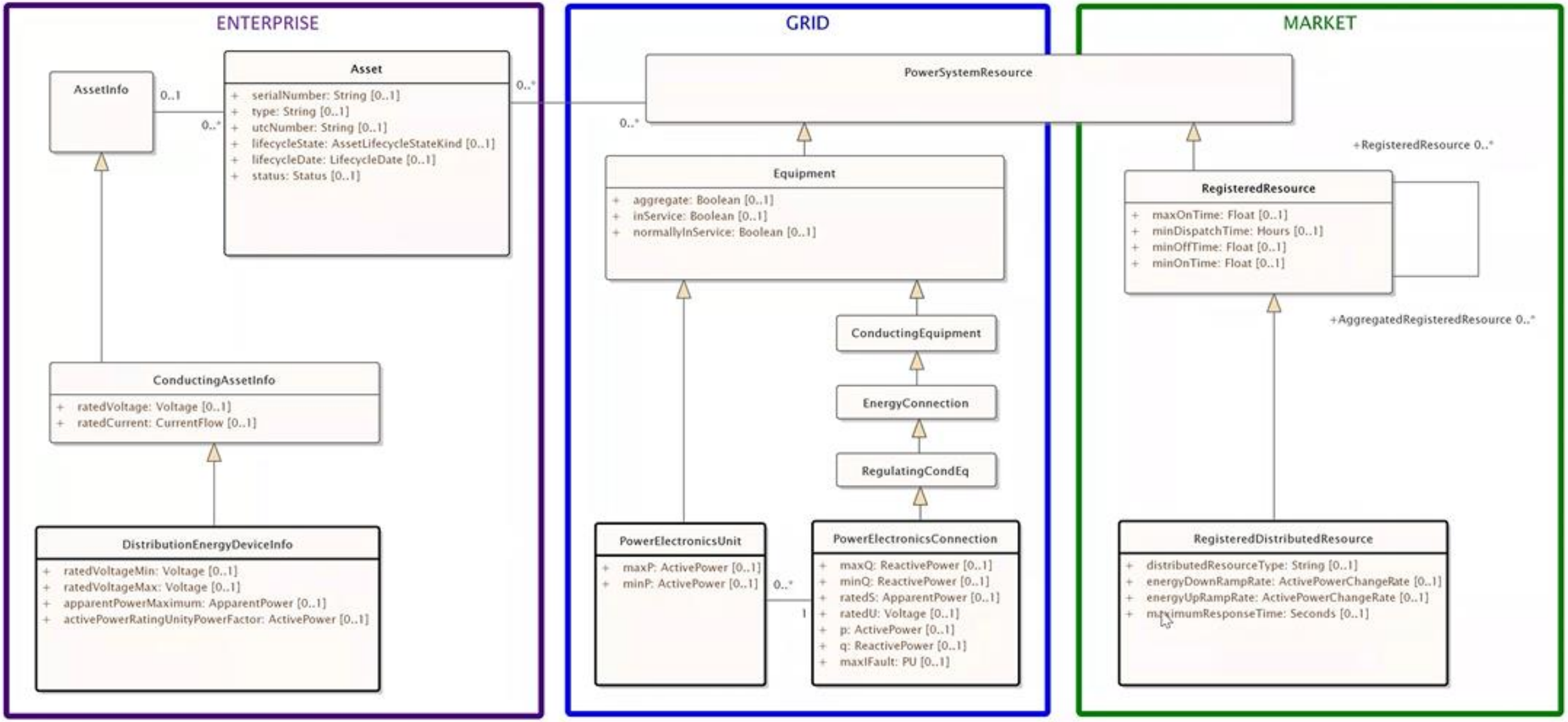
gridFormingCapability / Mode

How to handle regional specific rules for grid forming ?

Maybe different settings for blackStartCapability / Mode



Grid-Market-Enterprise Harmonization

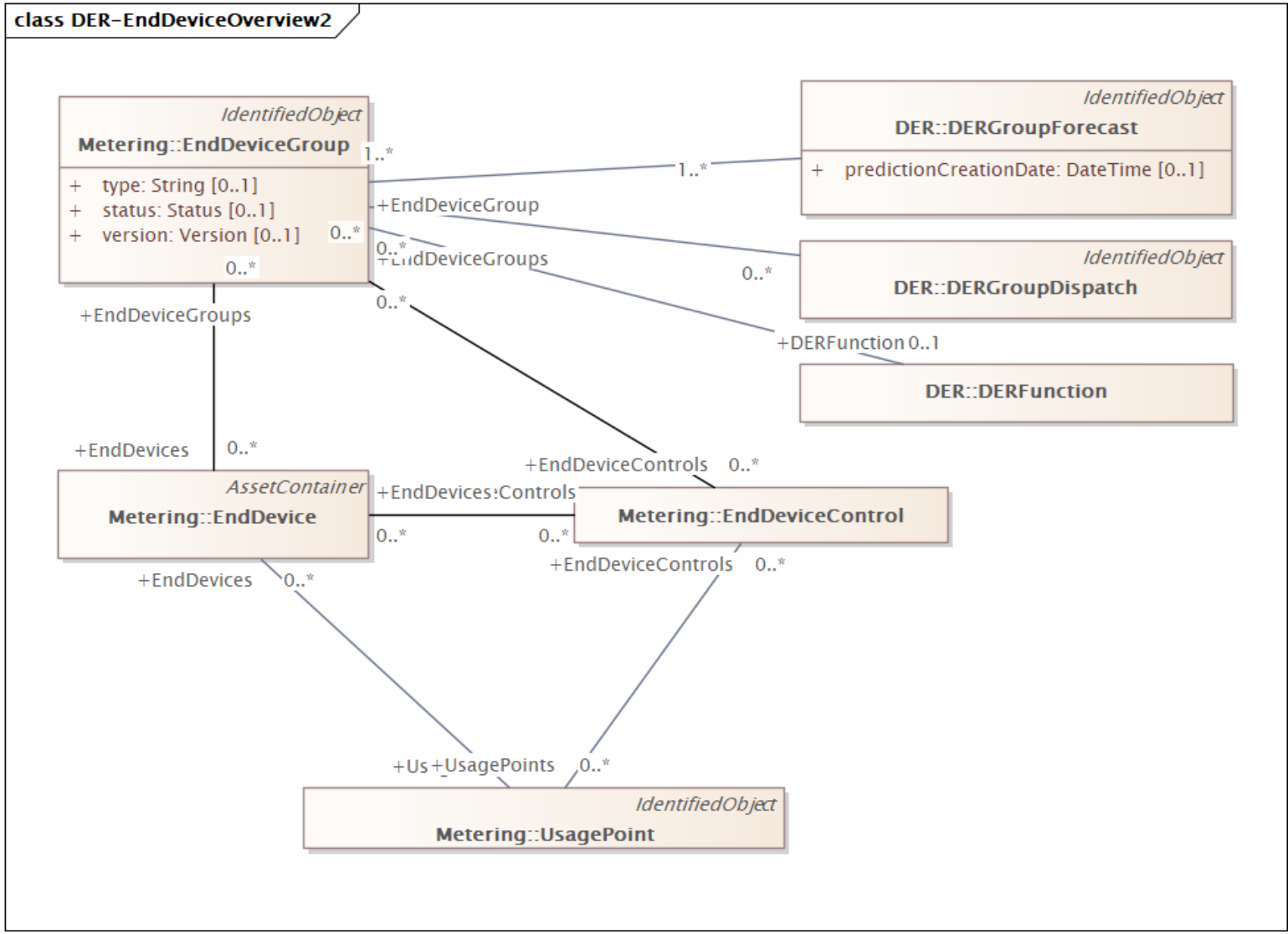


History

IEC 61968-5 Metering package

EndDeviceGroup class to manage groups of EndDevices. Smart Inverters in the DER context, are considered types of EndDevices

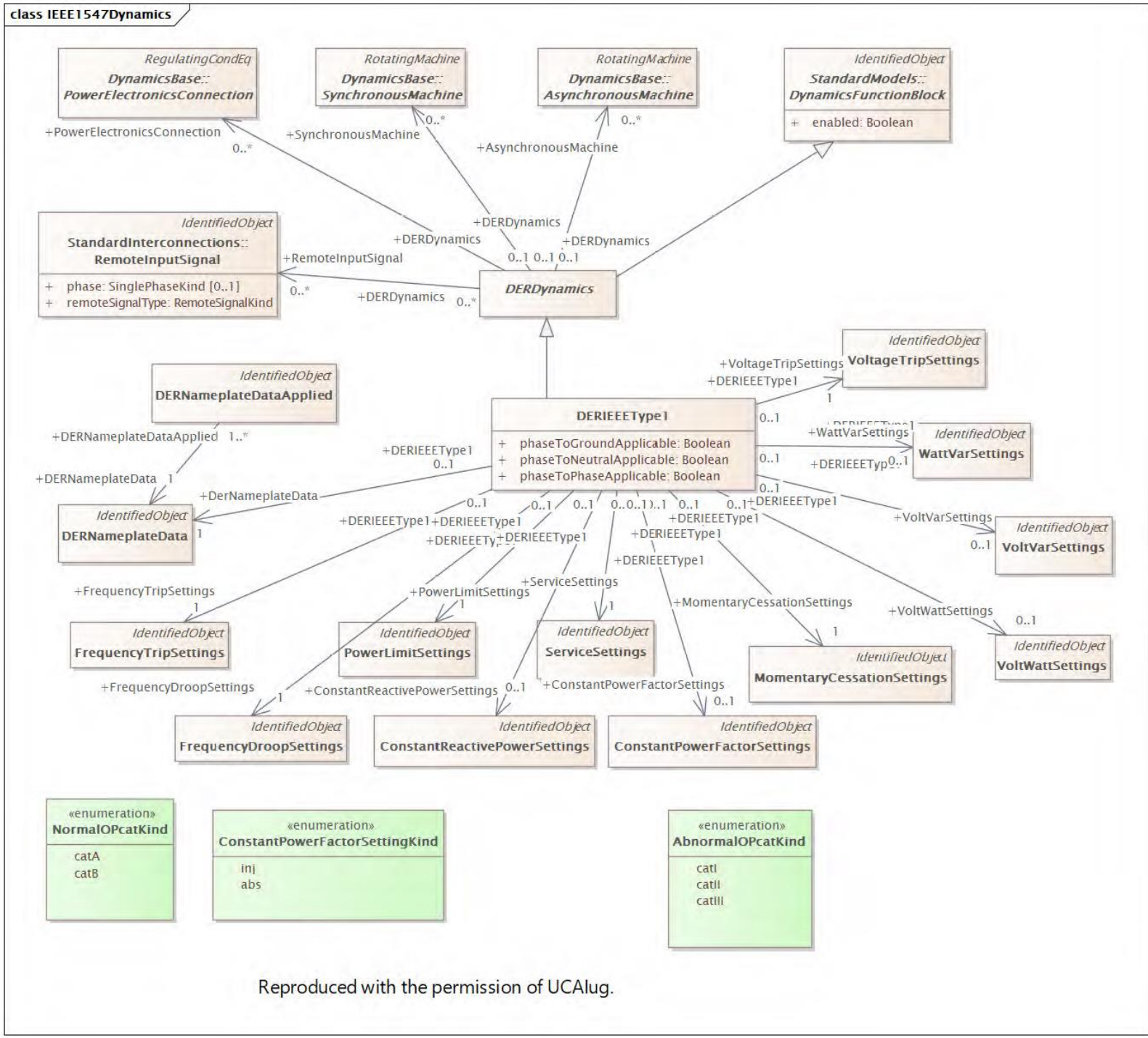
To be deprecated – replaced by newer models from IEC 62746-4



Specialized

IEC 61970-302
IEEE1547Dynamics
package for dynamics analysis of one or a few DER

Not considered today



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IEC 62746-4

Objective: energy scheduling with demand response programs

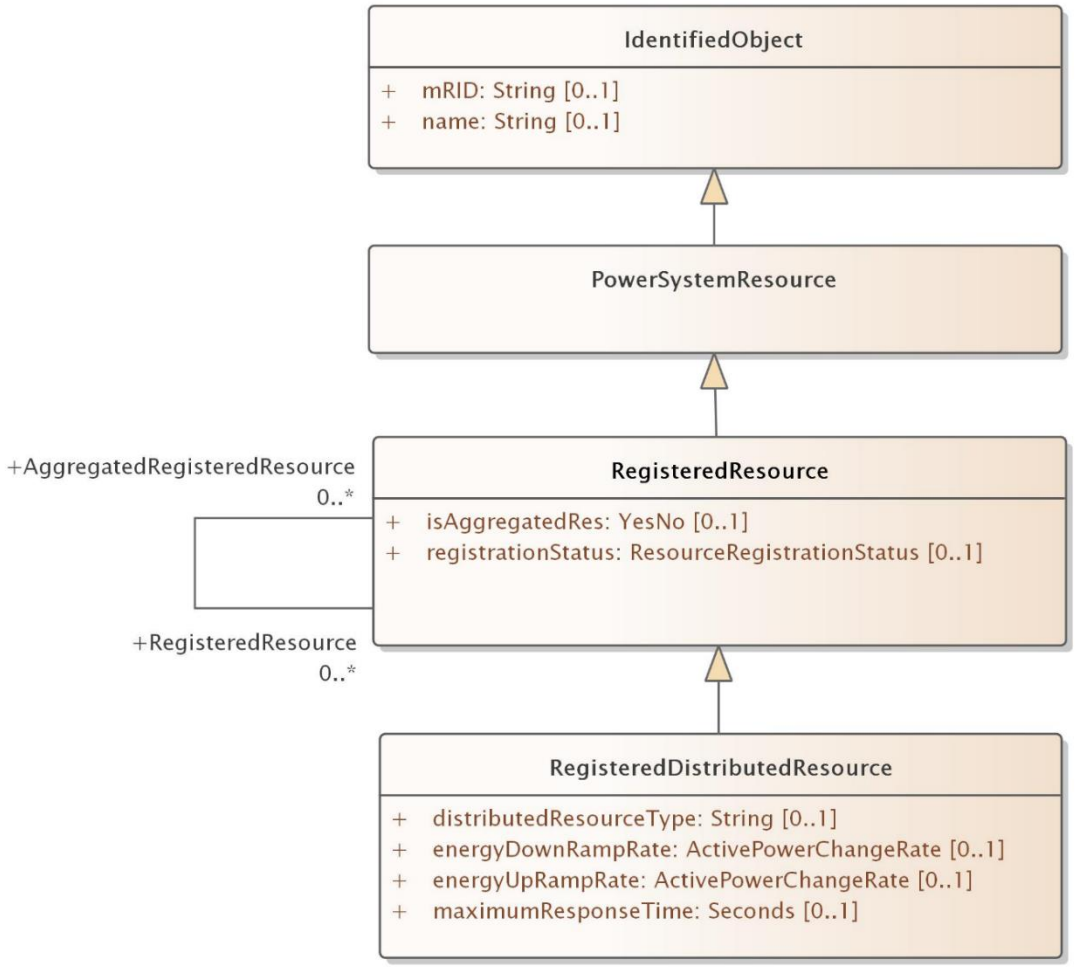
Generic model for aggregation

Limited description of capabilities

Linked to Location

Linked to PNode

May be better to link to UsagePoint



Conducting Equipment

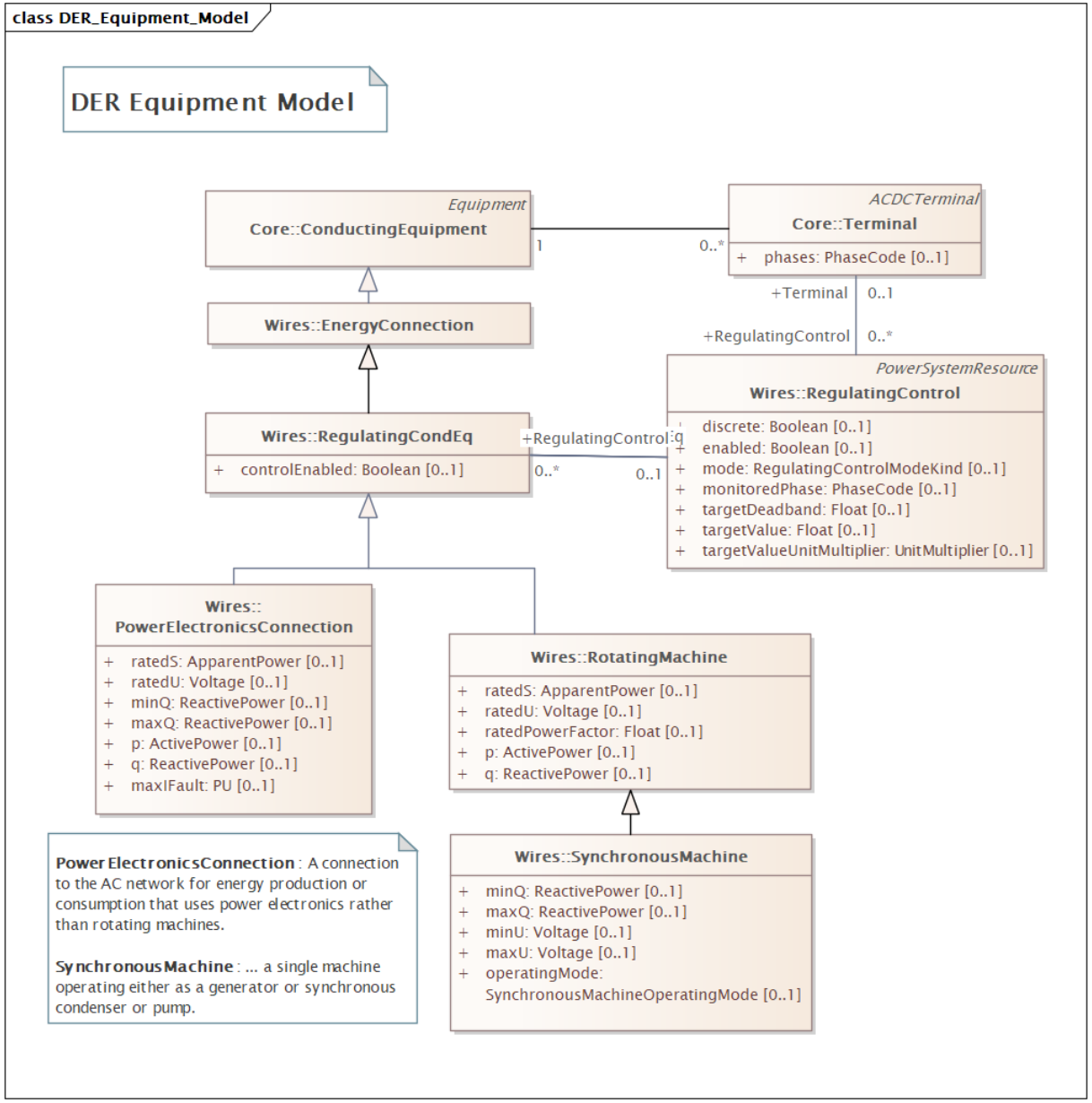
Existing model – CIM 17

PowerElectronicsConnection

- ratings

RegulatingControl

- control parameters
- restricted set of control modes



Conducting Equipment

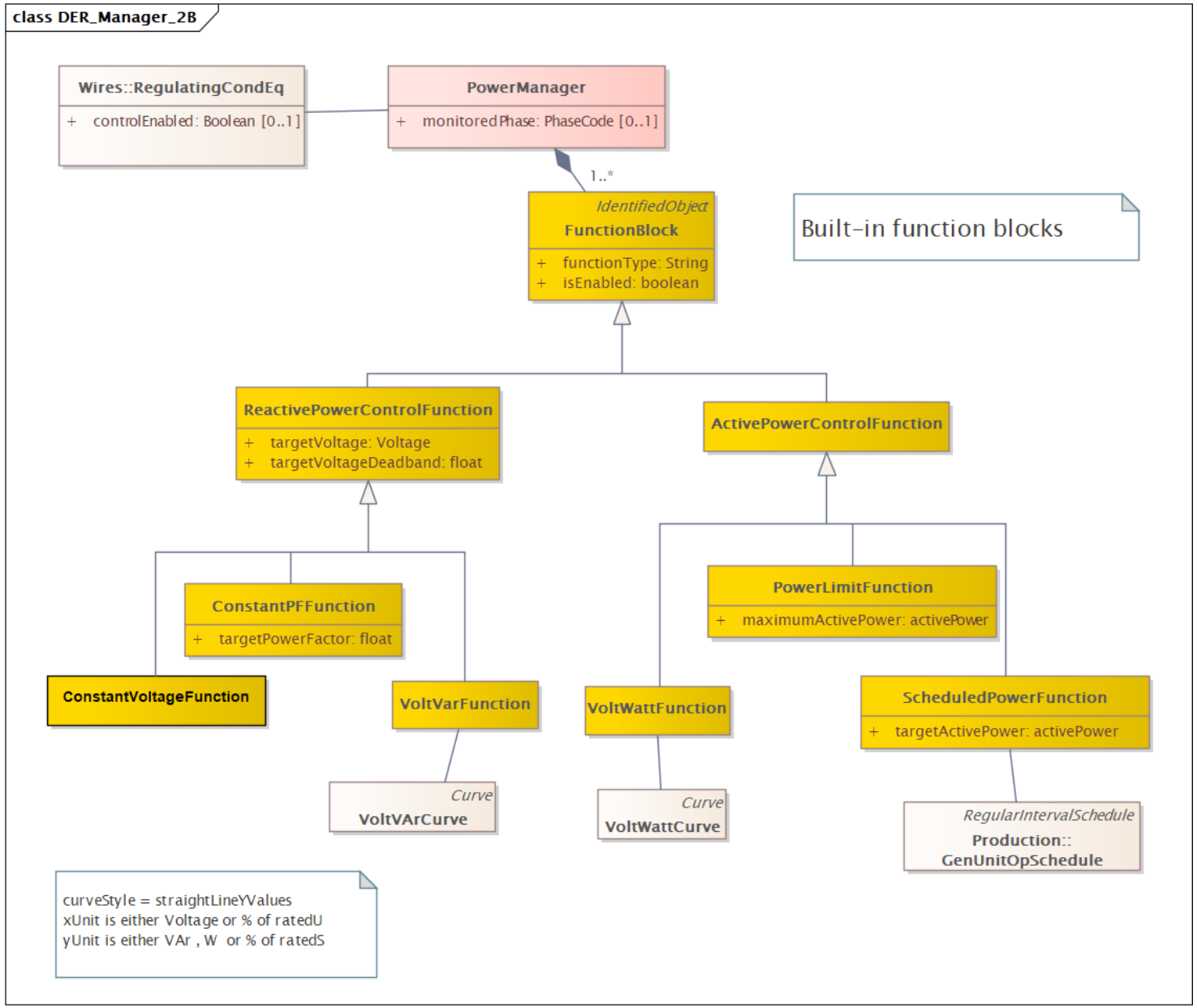
Proposal from draft IEC 62361-xx

Proposal – CIM 18

RegulatingControl replaced by generic **PowerManager** class

Linked to one or more control functions with various parameters

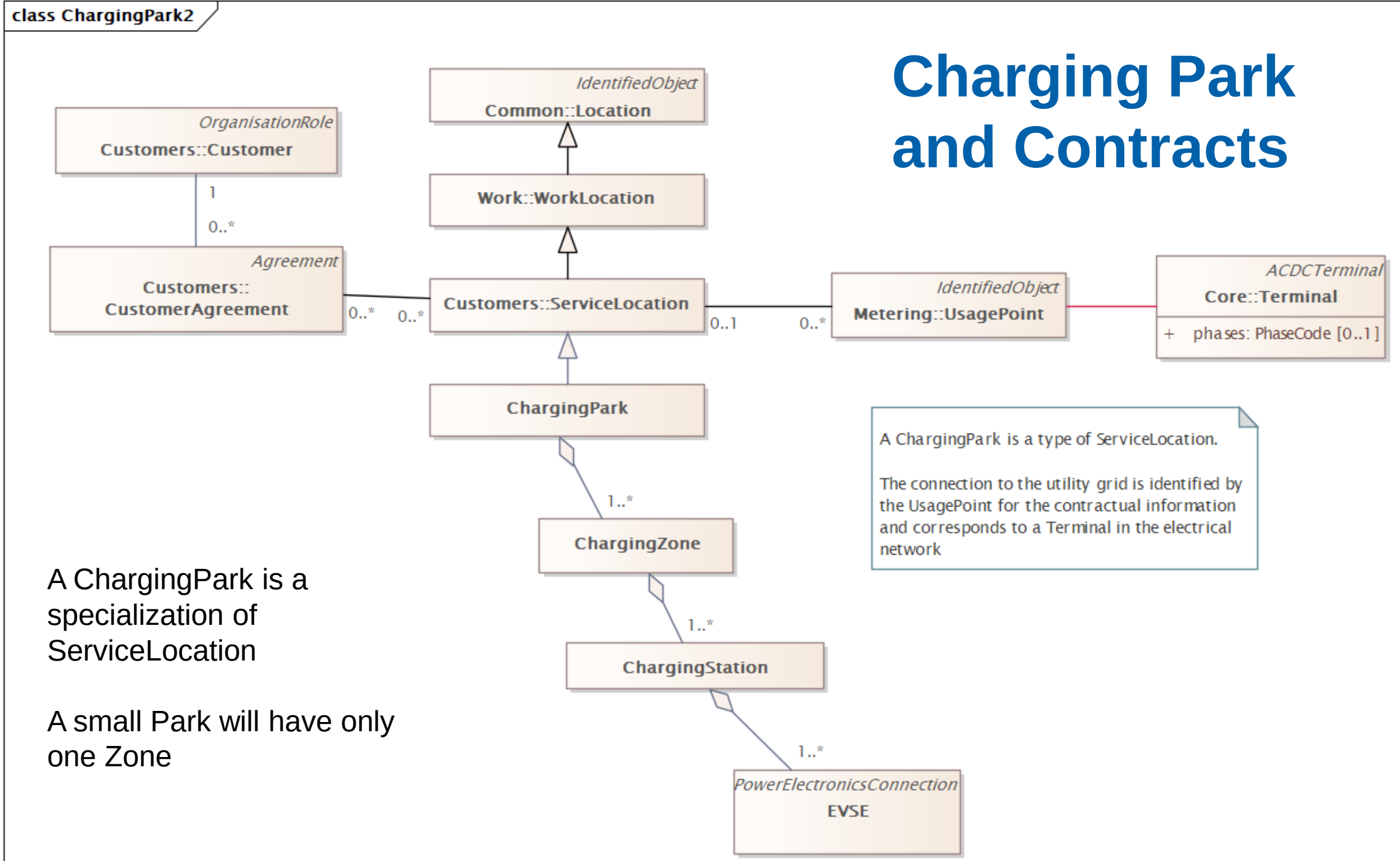
(similar concept as IEEE1457Dynamics)



CIM extensions for electric vehicle charging

- **As presented in June 2024**

Charging Park and Contracts



A ChargingPark is a specialization of ServiceLocation

A small Park will have only one Zone

Definitions

Charging Station

physical equipment consisting of one or more EV supply equipment managing the energy transfer to and from EVs. [IEC 63382-1]

Charging Park

geographical area that encloses one or more charging stations with one operator

[From : IEC 63110-1 and ISO]

Charging Zone

Power management concept representing a group of one or more charging stations within a particular charging park (typically with a relationship with the electrical arrangement)

Definitions

Electric Vehicle Supply Equipment

EVSE

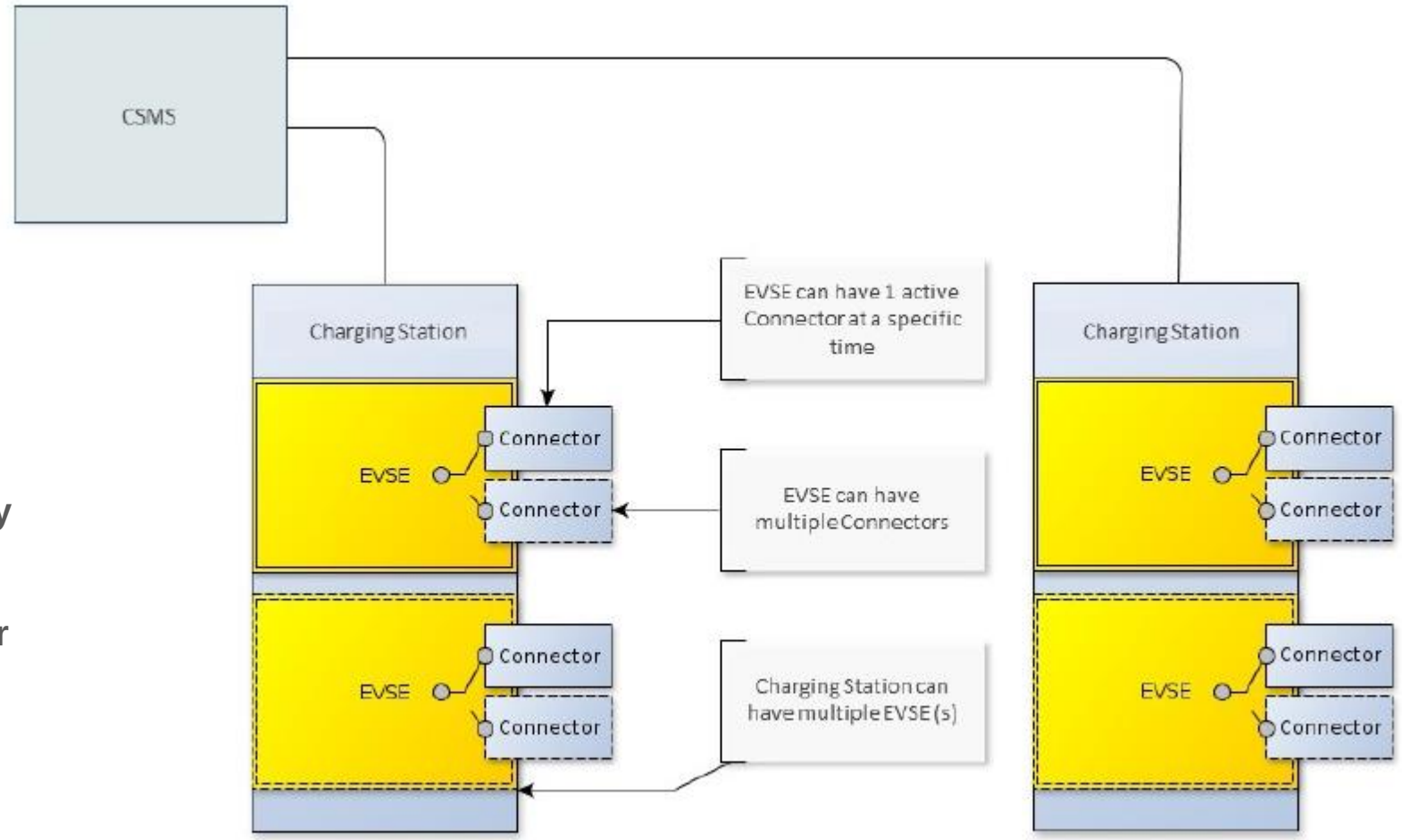
equipment or a combination of equipment, providing dedicated functions to supply electric energy from a fixed electrical installation or supply network to an EV for the purpose of charging and discharging

[SOURCE: IEC 61851-1:2017, 3.1.1, modified – The words "and discharging" have been added to the definition, and the examples have been removed.]

[IEC 63110-1] = to be used by IEC 63382

Background: definitions from OCPP

OCPP-2.0.1_part1_architecture_topology.pdf



Charging Station is the physical system where EVs can be charged.

A Charging Station can have one or more EVSEs (Electric Vehicle Supply Equipment).

An EVSE is considered as a part of the Charging Station that can deliver energy to one EV at a time

EVSE as DER

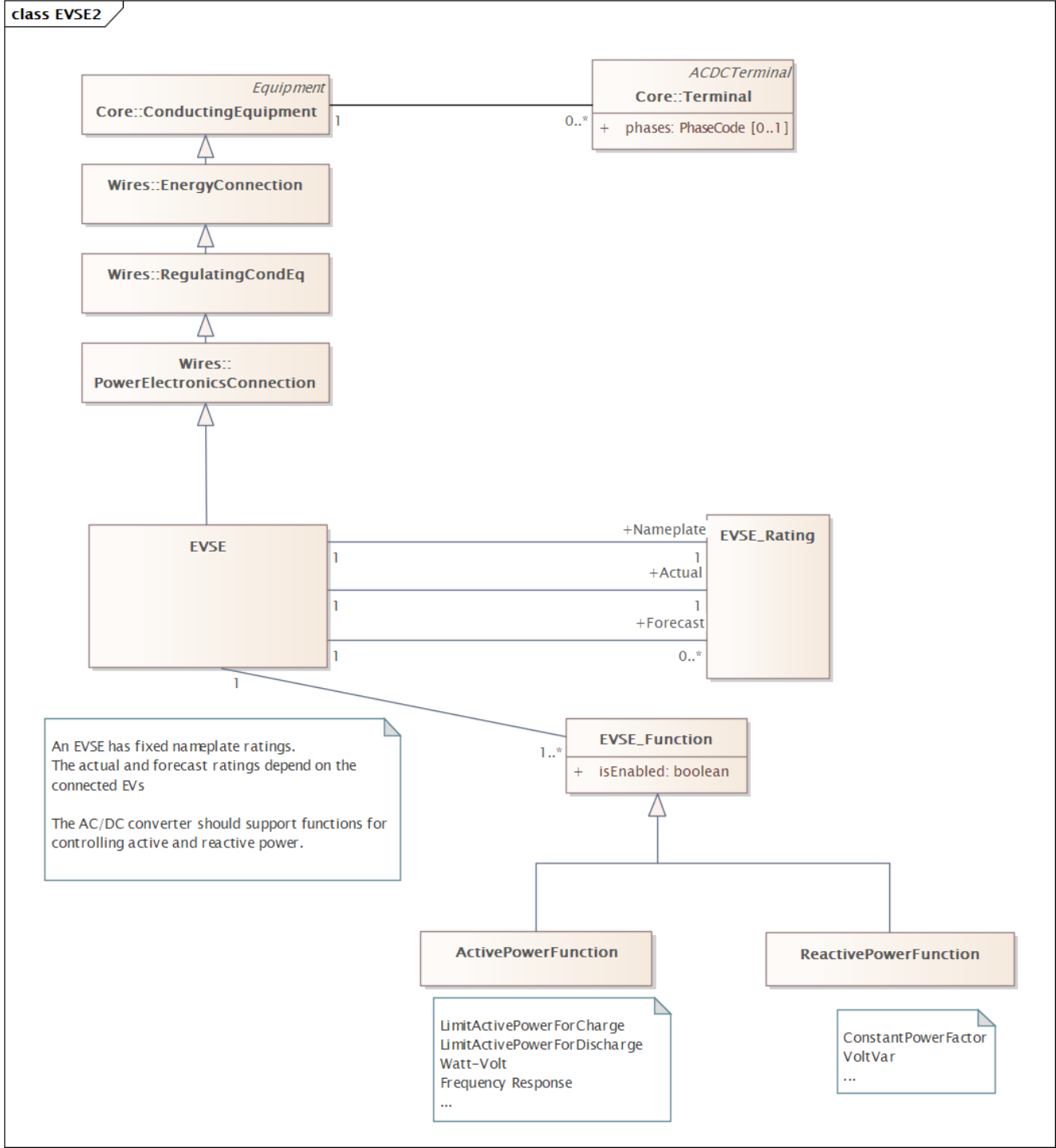
An EVSE is a special type of PowerElectronicsConnection

It will have ratings that depend on the connected EV

The control functions may have settings

- Fixed by grid codes
- Communicated from the DSO via the CSMS

To do : add EVSE type information



Ratings for EVSE + EV – based on CIM 17 (2024)

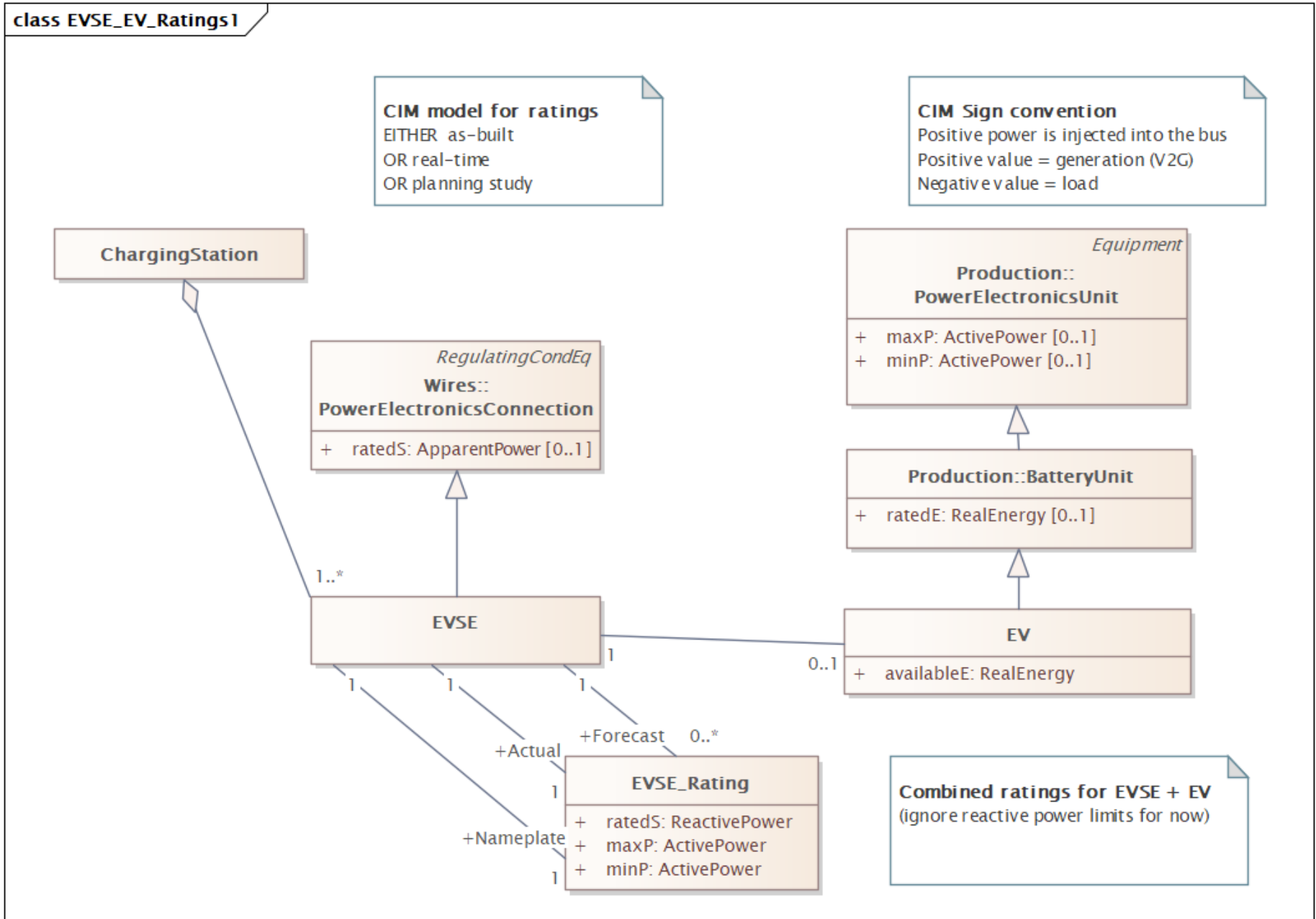
Notes:

Modelling concepts that extend the utility control center Common Information Model (CIM)

As used for utility planning and markets.

Many of properties have equivalents in IEC 61850 models.

Mapping them to IEC 61850 models will be done later.



Power Limiting

Notes:

Diagram shows how power limits = an operating envelope could be associated with the EVSE

These diagrams show the basic framework considering active power.

For EV as DER in some places like California, there could be 30-40 parameters (as per IEEE 1547)

For model inspiration

See 15118-20

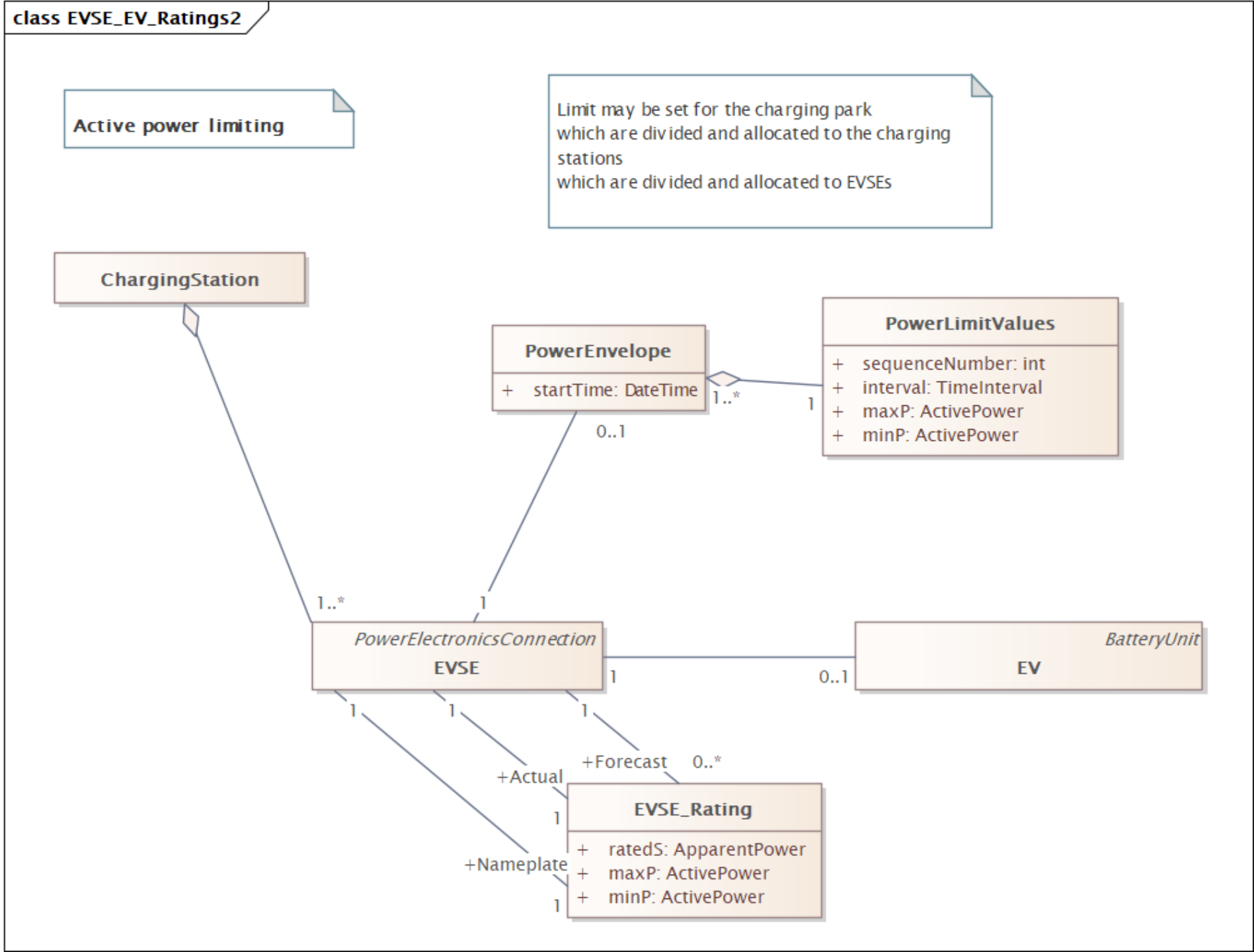
SAE J3072

IEC 63110 UML model

…

Need to add a property to indicate the capability

GridForming vs GridFollowing



Annex

Information exchanges for fleet recharge with incentives

using phases with terms from IEC 62746

1. Inform / Incentivise:

FO provides to CSMS

Import = charging price / energy schedule (no constraints = conventional tariffs)
Import = charging price / energy schedule (optional, soft power limit, encouraged by lower price)
Export = discharging price / energy schedule (feed-in tariff)

DSO may provide mandatory

Import limit power schedule (hard limit)
Export limit power schedule (hard limit)

Schedules = regular by hour, 15 min
Limits could have irregular time periods

EV -> CS -> CSMS supplies aggregated constraints

EV constraints

Required charge state at end of session

2. Plan / Schedule (e.g. price driven self-schedule)

CSMS plans / executes [dis]charging sessions per EVSE + EV

CSMS reports aggregated plan for all EVSE+EV to FO

3. Monitoring / Reporting phase:

Actual power and energy schedule

Import / export transition event times