MESA
Open Standards for Energy Storage

2024 MESA Workshop:
Testing of IEEE 1815.2 beyond UL 1741

Tylor Slay - PNNL

March 6, 2024

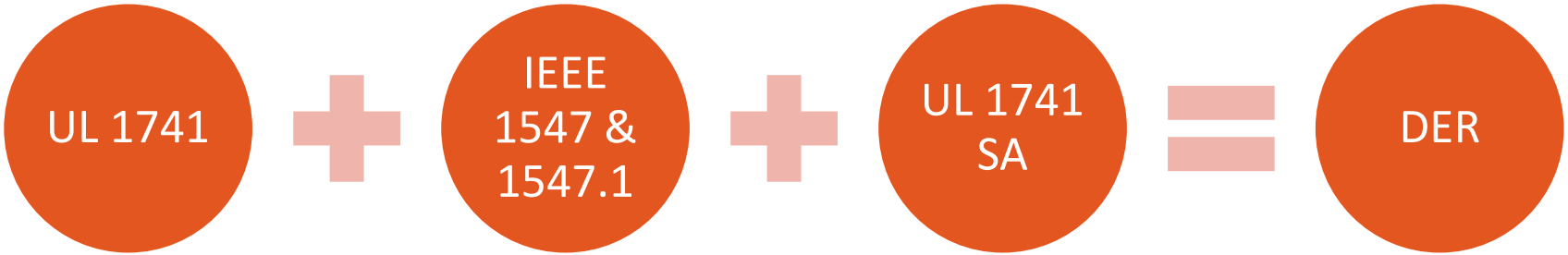
Agenda

- Overview of UL 1741 and IEEE 1547
- IEEE 1815.2 and advanced functionality
- Introduction to scheduling and test coverage
- Combining Controls

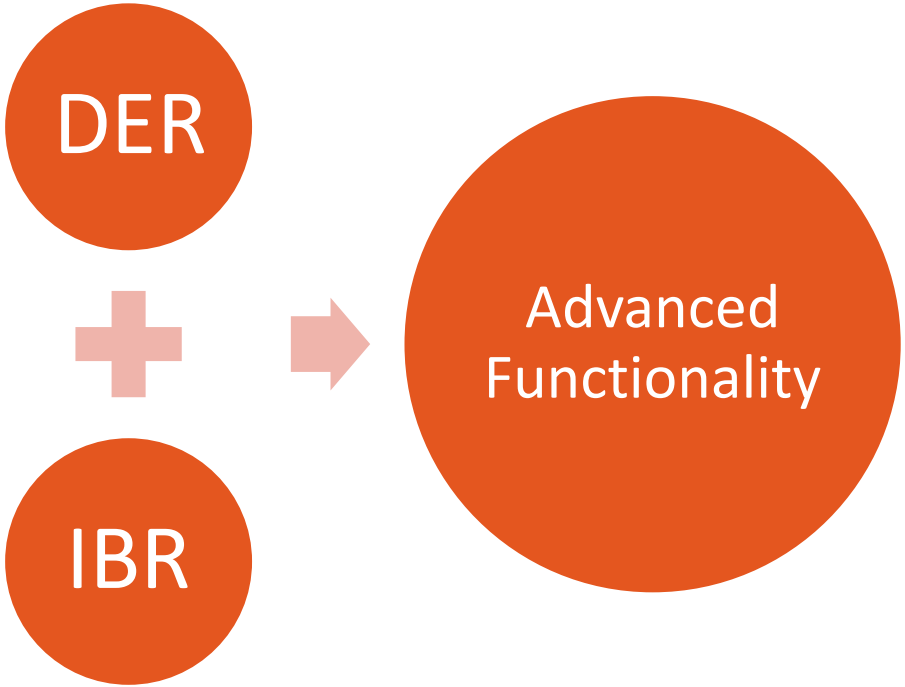
Beyond UL 1741

Where IBR and DER cross paths

Utility Interactive Product



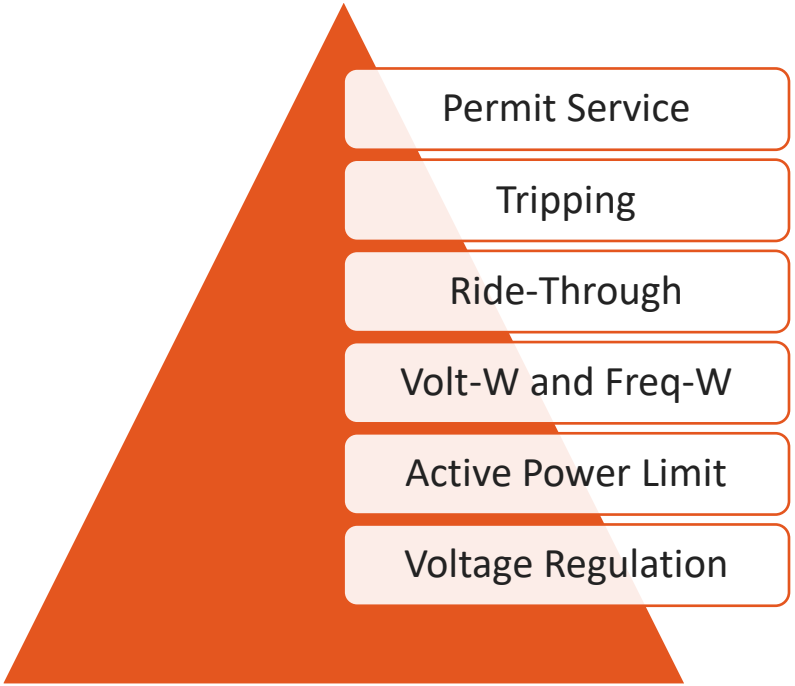
IEEE 1815.2



Control Modes

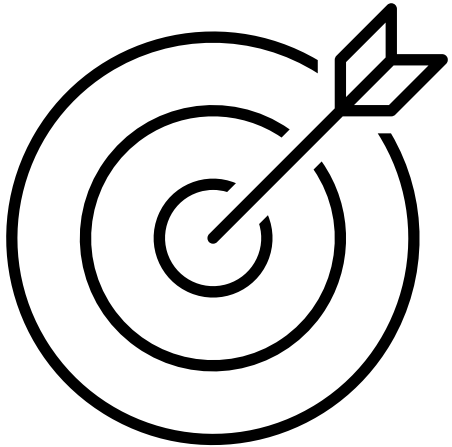
- Prioritization
- Types
- Precedence
- Compatibility

IEEE 1547 – Prioritization of DER responses

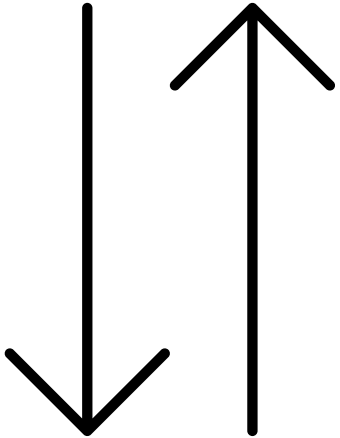


Control Types

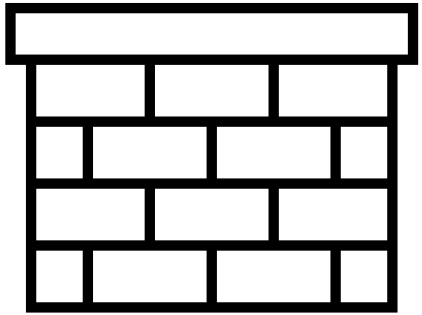
Target
Control seeks a single point



Modify
Control modifies a target

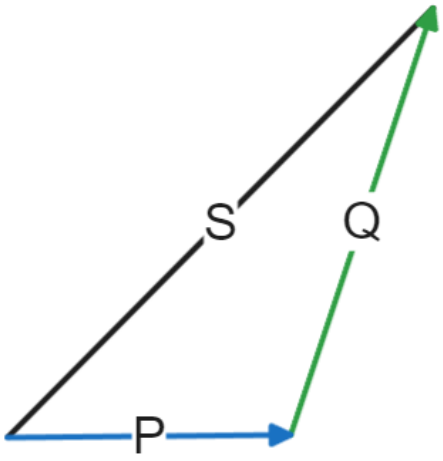


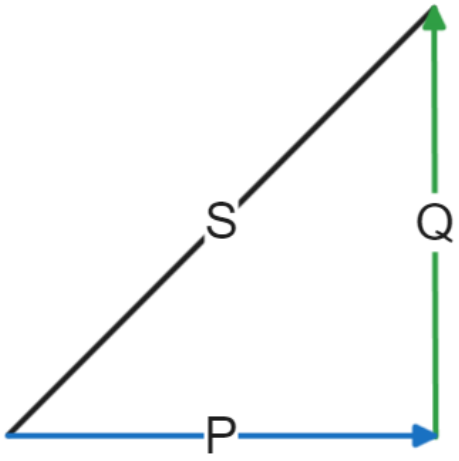
Limit
Bounds control

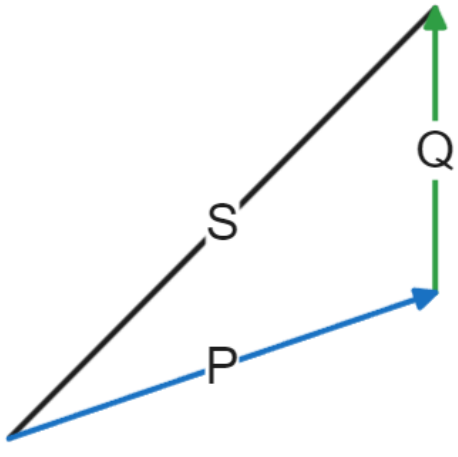


Precedence

VAR before W







W before VAR

Compatibility

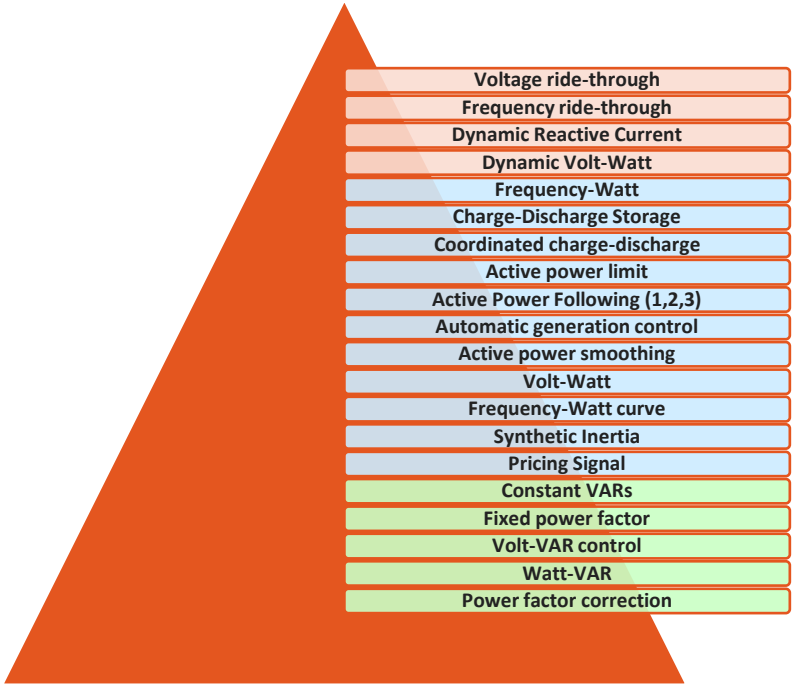
LEGEND C - Compatible **P - Priority** **M - Mutually Exclusive**	Voltage Ride-Through	Frequency Ride-Through	Dynamic Reactive Current	Dynamic Volt-Watt	Frequency-Watt	Charge-Discharge Storage	Coordinated Charge-Discharge	Active Power Limit	Active Power Following (1,2,3)	Automatic Generation Control	Active Power Smoothing	Volt-Watt	Frequency-Watt Curve	Synthetic Inertia	Pricing Signal	Constant VARS Function	Fixed Power Factor	Volt-VAR Control	Watt-VAR	Power Factor Correction
Voltage Ride-Through																				
Frequency Ride-Through	C																			
Dynamic Reactive Current	C	C																		
Dynamic Volt-Watt	C	C	C																	
Frequency-Watt	C	C	C	C																
Charge-Discharge Storage	C	C	C	C	C															
Coordinated Charge-Discharge	C	C	C	C	C	C														
Active Power Limit	C	C	C	C	C	C	C													
Active Power Following (1,2,3)	C	C	C	C	C	C	C	**P**												
Automatic Generation Control	C	C	C	C	**P**	**M**	**P**	**P**	**M**											
Active Power Smoothing	C	C	C	C	C	C	C	**P**	**P**	**M**										
Volt-Watt	C	C	C	C	C	C	C	**P**	**P**	**M**	**P**									
Frequency-Watt Curve	C	C	C	C	**P**	C	C	C	**P**	C	C	C								
Synthetic Inertia	C	C	C	C	**P**	C	C	C	**P**	C	C	C	C							
Pricing Signal	C	C	C	C	C	C	C	C	C	C	C	C	C	C						
Constant VARs Function	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C					
Fixed Power Factor	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	**P**				
Volt-VAR Control	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	**M**	**M**			
Watt-VAR	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	**M**	**M**	**P**		
Power Factor Correction	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	**M**	**M**	**P**	**P**	

Compatible: functions can run simultaneously regardless of how priority is set.

Priority: functions priority setting must be different, so it is clear which function has greater priority.

Mutually Exclusive: functions cannot be simultaneously active.

Example – All Control Modes



Mutually Exclusive:

- Frequency-Watt
  - Frequency-Watt Curve
- Active Power Following (1,2,3)
  - Automatic Generation Control
- Automatic Generation Control
  - Charge-Discharge Storage, Active Power Following (1,2,3), Active Power Smoothing, Volt-Watt
- Constant VARs
  - Volt-VAR Control, Watt-VAR, Power Factor Correction
- Fixed Power Factor
  - Volt-VAR Control, Watt-VAR, Power Factor Correction

Priority:

- Active Power Limit
  - Active Power Following (1,2,3), Automatic Generation Control, Active Power Smoothing, Volt-Watt
- Active Power Following (1,2,3)
  - Active Power Limit, Active Power Smoothing, Volt-Watt, Frequency-Watt Curve, Synthetic Inertia
- Automatic Generation Control
  - Active Power Limit, Active Power Following (1,2,3), Volt-Watt
- Constant VARs Function
  - Fixed Power Factor

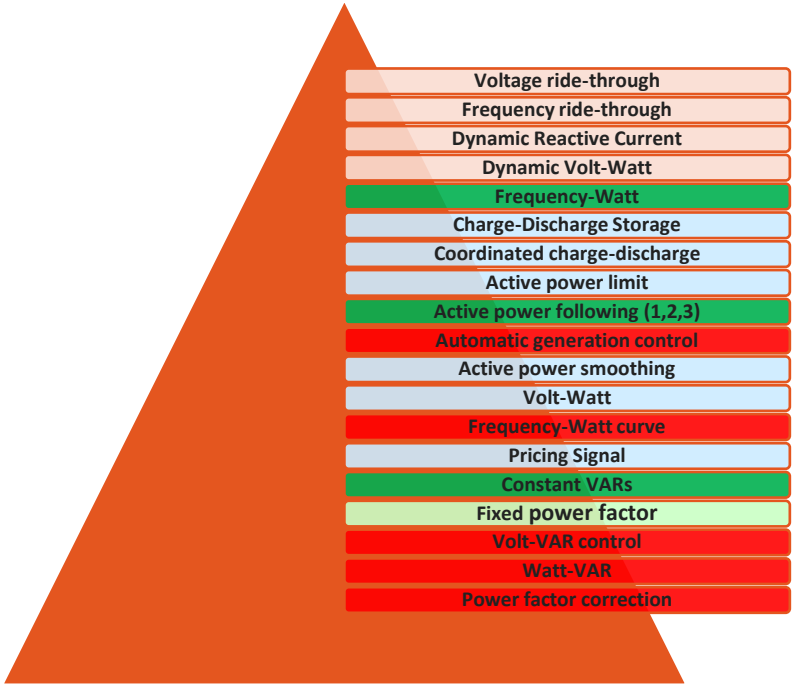
Example – Active Power Response

LEGEND C - Compatible **P - Priority** **M - Mutually Exclusive**	Voltage Ride-Through	Frequency Ride-Through	Dynamic Reactive Current	Dynamic Volt-Watt	Frequency-Watt	Charge-Discharge Storage	Coordinated Charge-Discharge	Active Power Limit	Active Power Following (1,2,3)	Automatic Generation Control	Active Power Smoothing	Volt-Watt	Frequency-Watt Curve	Synthetic Inertia	Pricing Signal	Constant VARS Function	Fixed Power Factor	Volt-VAR Control	Watt-VAR	Power Factor Correction
Voltage Ride-Through																				
Frequency Ride-Through	C																			
Dynamic Reactive Current	C	C																		
Dynamic Volt-Watt	C	C	C																	
Frequency-Watt	C	C	C	C																
Charge-Discharge Storage	C	C	C	C	C															
Coordinated Charge-Discharge	C	C	C	C	C	**P**														
Active Power Limit	C	C	C	C	C	C	C													
Active Power Following (1,2,3)	C	C	C	C	C	C	C	**P**												
Automatic Generation Control	C	C	C	C	**P**	**M**	**P**	**P**	**M**											
Active Power Smoothing	C	C	C	C	C	C	C	**P**	**P**	**M**										
Volt-Watt	C	C	C	C	C	C	C	**P**	**P**	**M**	**P**									
Frequency-Watt Curve	C	C	C	C	**P**	C	C	C	**P**	C	C	C								
Synthetic Inertia	C	C	C	C	**P**	C	C	C	**P**	C	C	C	C							
Pricing Signal	C	C	C	C	C	C	C	C	C	C	C	C	C	C						
Constant VARs	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C					
Fixed Power Factor	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	**P**				
Volt-VAR Control	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	**M**	**M**			
Watt-VAR	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	**M**	**M**	**P**		
Power Factor Correction	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	**M**	**M**	**P**	**P**	

Mutually Exclusive:
- automatic generation control

Priority:
- active power limit
- active power following (1,2,3)
- active power smoothing
- volt-watt
- frequency-watt curve
- synthetic inertia

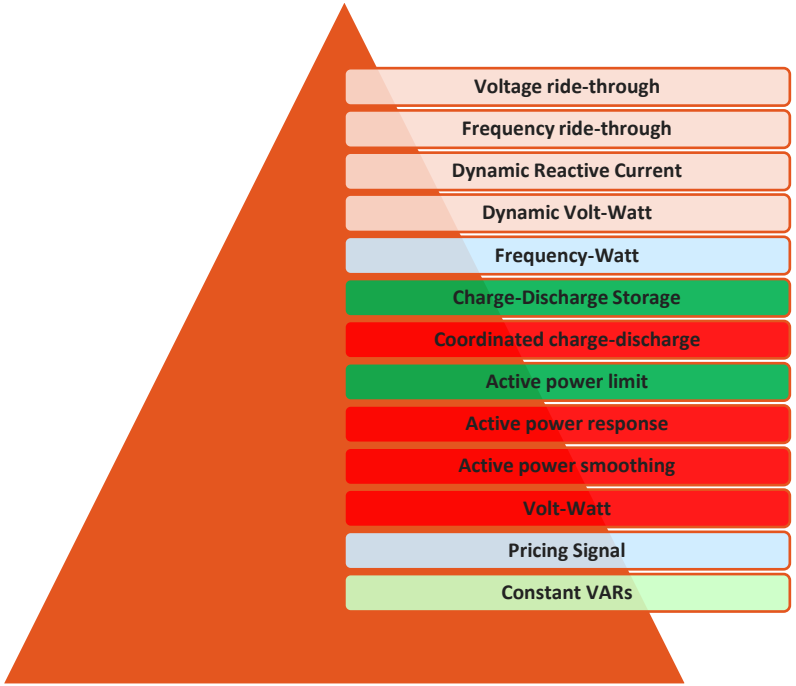
Example – Mutually Exclusive



Mutually Exclusive:

- Frequency-Watt
  - Frequency-Watt Curve
- Active Power Response
  - Automatic Generation Control
- Automatic Generation Control
  - Active Power Smoothing, Volt-Watt
- Constant VARSz
  - Volt-VAR Control, Watt-VAR, Power Factor Correction

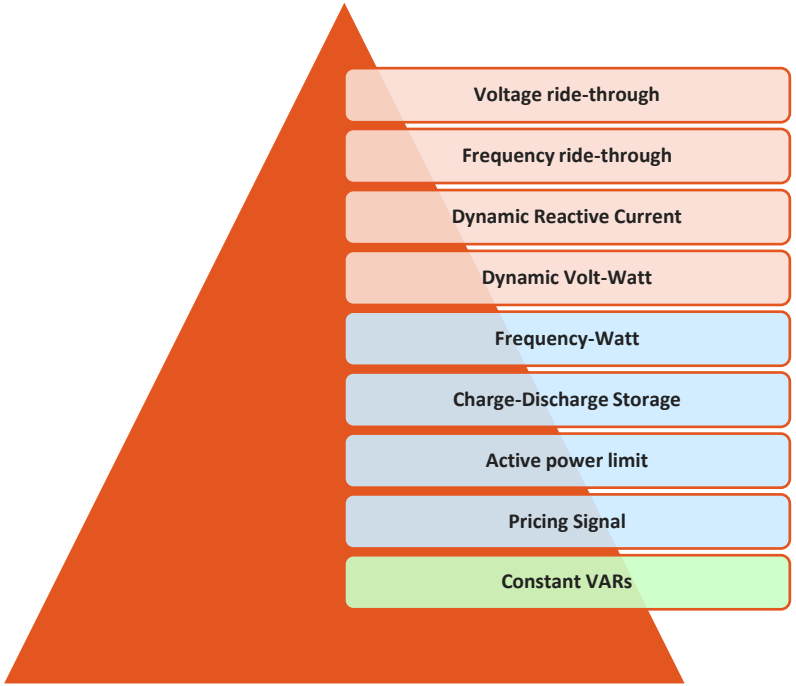
Example – Priority



Priority:

- Charge-Discharge Storage
  - Coordinated Charge-Discharge
- Active Power Limit
  - Active Power Response, Automatic Generation Control, Active Power Following (1,2,3), Active Power Smoothing, Volt-Watt

Example – Active Controls



Priority:

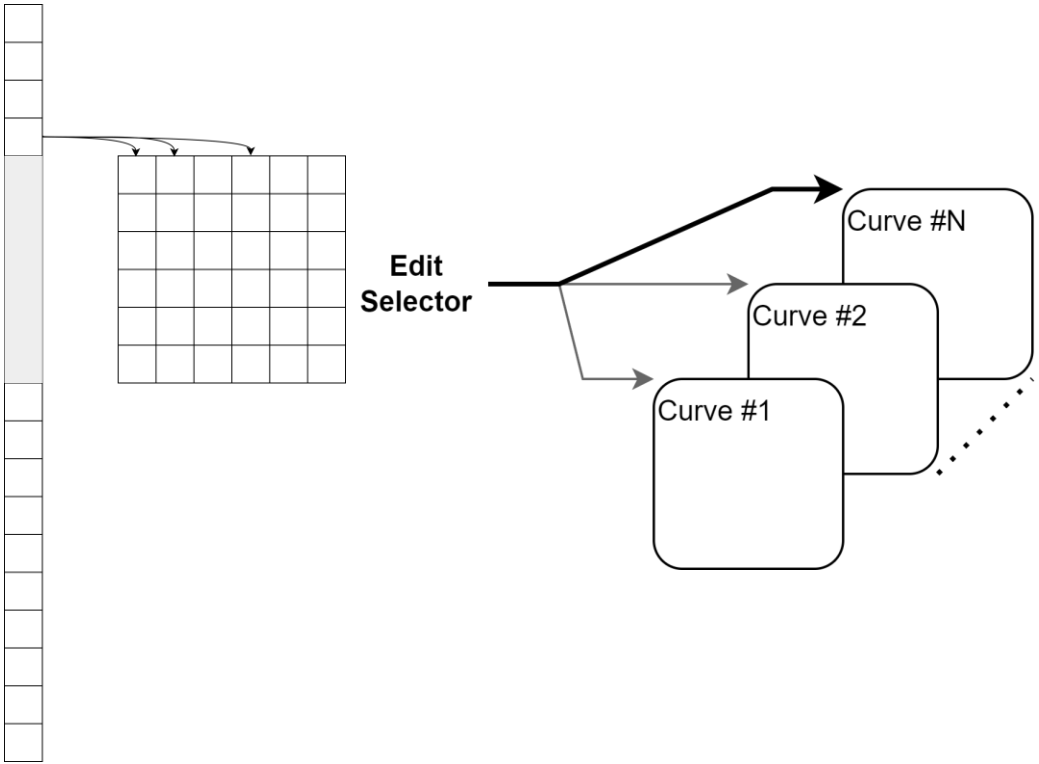
- Charge-Discharge Storage
  - Coordinated charge-discharge
- Active Power Limit
  - Active Power Response, Automatic Generation Control, Active Power Smoothing, Volt-Watt
- Active Power Response
  - Active Power Smoothing, Volt-Watt, Frequency-Watt Curve
- Active Power Smoothing
  - Volt-Watt
- Volt-VAR Control
  - Watt-VAR, Power Factor Correction

MESA

Point Multiplexing

- Curves
- Schedules
  - Version 1
  - Version 2

Point Multiplexing



Curve Points

Point Description:

- Type
- Number of Points
- Units (X-Value)
- Units (Y-Value)
- [1] X-Value
- [1] Y-Value

Type:

1. Not applicable / Unknown
2. Volt-Var modes
3. Frequency-Watt mode
4. Watt-VAR mode
5. Voltage-Watt modes
6. Remain Connected
7. Temperature mode
8. Pricing signal mode
9. HVRT Must Trip
10. HVRT Momentary Cessation
11. LVRT Must Trip
12. LVRT Momentary Cessation
13. HFRT Must Trip
14. HFRT Momentary Cessation
15. LFRT Must Trip
16. LFRT Momentary Cessation

Curve States:

1. Referenced
    1. (BI107) = TRUE
2. Reserved
    1. (BI107) = FALSE
3. Unused
    1. (AI330) = 0

Scheduling Points

Version 1

- Identity
- Priority
- Type
- Start Date
- Start Time
- Stop Date
- Stop Time
- Repeat Interval
- Repeat Interval Units
- Number of Points
- [1] Value
- [1] Time Offset

Version 2

- ~~Type~~
- [1] Value
- [1] Time Offset
- [1] Action Type (BO/AO)
- [1] Action Index

Scheduling Example

Point Index	Description	Value
AO87	Active Power Limit Max Setpoint	100
AO88	Active Power Limit Min Setpoint	50

Scheduling: Version 1

- High Must Trip Curve Index
- Low Must Trip Curve Index
- High Momentary Cessation Curve Index
- Low Momentary Cessation Curve Index
- High Must Trip Curve Index
- Low Must Trip Curve Index
- High Momentary Cessation Curve Index
- Low Momentary Cessation Curve Index
- 1 = ON, 0 = OFF
- High Frequency Hysteresis Curve Index
- Low Frequency Hysteresis Curve Index
- Constant Vars Reactive Power Target
- Fixed Power Factor Setpoint
- Curve Index
- Pricing Function Setpoint
- Threshold

1. AO23
2. AO24
3. AO25
4. AO26
5. AO28
6. AO29
7. AO30
8. AO31
9. BO14
10. BO15
11. BO16
12. AO87
13. AO88
14. AO93
15. AO106
16. BO20
17. BO21
18. BO22
19. AO146
20. BO24
21. AO173
22. AO186
23. AO187
24. AO188
25. AO203
26. AO210
27. AO217
28. AO226
29. BO31
30. AO241
31. AO476
32. AO476
33. BO18
34. BO19
35. BO17
36. AO120
37. AO129
38. AO138
39. BO23

Schedule:

- Identity = 1
- Type = 12
- [1] Value = 100
- [1] Time Offset = 0

Schedule:

- Identity = 2
- Type = 13
- [1] Value = 50
- [1] Time Offset = 0

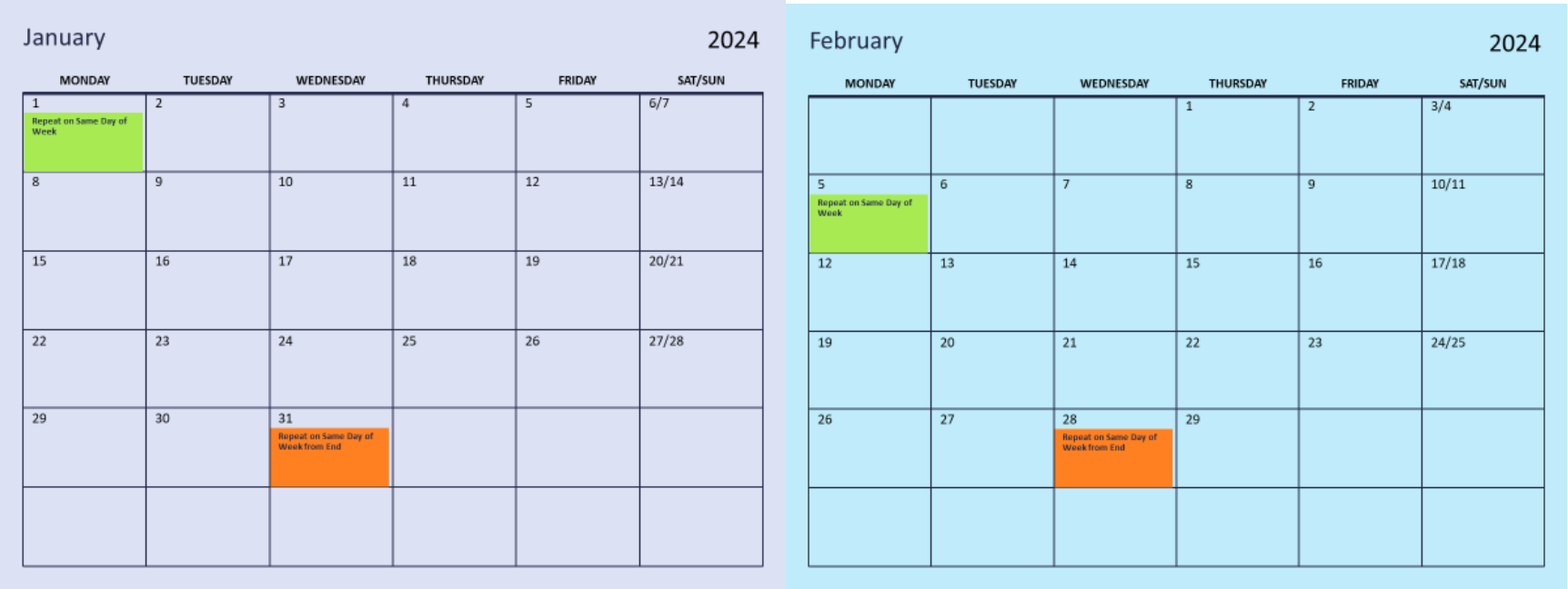
Schedule: Version 2

Schedule:

- Identity = 1
- [1] Value = 100
- [1] Time Offset = 0
- [1] Action Type = AO
- [1] Action Index = 87
- [2] Value = 50
- [2] Time Offset = 0
- [2] Action Type = AO
- [2] Action Index = 88

- The updated version allows a single schedule to hold all control context.
- There is more freedom… and more chance for mistakes
- The schedule points can have the same time offset if sequential

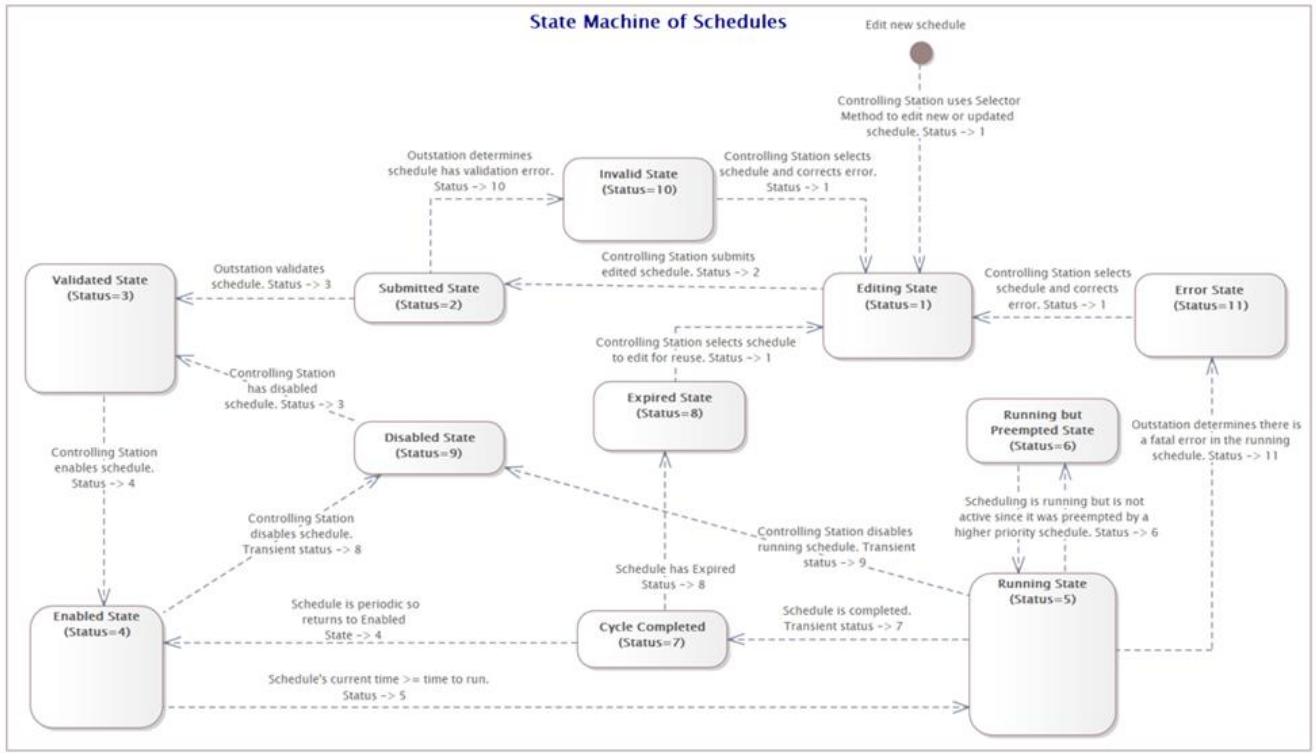
Repeat Schedules: same day/same day from end



Repeat Schedules: monthly

Repeat Schedules: weekly on day

Schedule State



States:

1. Editing
2. Submitted
3. Validated
4. Enabled
5. Running
6. Preempted
7. Completed
8. Expired
9. Disabled
10. Invalid
11. Error

Editing

- Controlling Station sets AO3000 to the desired Schedule Index.
- This schedule may be a new schedule, a schedule being updated, or a schedule that the
- Outstation sets BI3000 = 0 (Not Validated) for the selected schedule.
- Outstation sets BI3001 = 0 (Not Enabled) for the selected schedule.
- Outstation sets Selected Schedule Status (AI3010) = 1 (**Editing state**).

Submitting

- Controlling Station sets Submit Selected Schedule for Validation BO3000 = 1.
- Outstation “stores” the schedule and sets Selected Schedule Status to **Submitted state** (AI3010 = 2) … BI3001 remains = 0.
- Outstation performs validation:
  - If validation was successful, Outstation sets BI3000 = 1 (Validated) and transfers it to **Validated state** = 3.
  - If validation failed, the Outstation sets BI3000 = 0 (Not Validated) and transfers it to the **Invalid state** = 9.

Validated

- Outstation only validates items that may be statically validated.
- “Static” information includes the schedule’s formatting is correct, the Time Offsets contains sequential time values, the Action Type, Index pointers are valid, and the Value is within bounds.
- Outstation sets BI3000 = 1 (Validated) … BI3001 remains = 0.
- Outstation sets Selected Schedule Status to **Validated state** (AI3010 = 3).

Enabled

- Controlling Station sets AO3000 to the desired Schedule Index.
- Controlling Station sets Selected Schedule Enabled to **Enabled state** (BO3001 =1).
- Outstation checks if Selected Schedule is Validated (BI3000 = 1).
- If not validated, the schedule goes to the transient **Disabled state** = 8, then returns to the **Validated state** = 3.
- Outstation sets Selected Schedule Status (AI3010 = 4).

Running

- Start conditions:
  - *Selected Schedule is Validated* (BI3000 = 1) *AND*
  - *Selected Schedule Is Enabled* (BI3001 = 1) *AND*
  - The current time is later than or equal to the time-to-run *AND*
  - The repeat criteria are met
- Outstation sets the schedule's status to **Running state**, e.g., Schedule Index #1 (AI3500), Schedule Status = 5.

Cycle

- Outstation transfers the schedule to the **Cycle Completed** state = 7
- If the schedule is periodic:
  - The Outstation transfers the schedule to **Enabled state** = 4 to await its next run.
- If the schedule is not periodic, the Outstation transfers the schedule to the **Expired state** = 8.

Expired

- Outstation transfers the schedule to **Expired state** = 8
- The Controlling Station must select the completed schedule for editing to the process starts all over again.

Disabled

- Controlling Station selects the *Schedule Index* via AO3000
- Controlling Station sets *Selected Schedule Not Enabled* (BO3001 = 0) for the selected schedule.
- The schedule is transferred to the **Disabled state** = 9, thus causing an event to be reported.
- The schedule is then transferred to the **Validated state** = 3.

Invalid

- Outstation transfers the schedule to **Invalid state** = 10. The Controlling Station is informed via status events.
- *Selected Schedule Is Enabled* shows Not Enabled (BI3000 = 0) for the selected schedule.
- *Selected Schedule is Validated* shows Not Validated (BI3001 = 0) for the selected schedule.
- Outstation logs the type of invalidity

Error

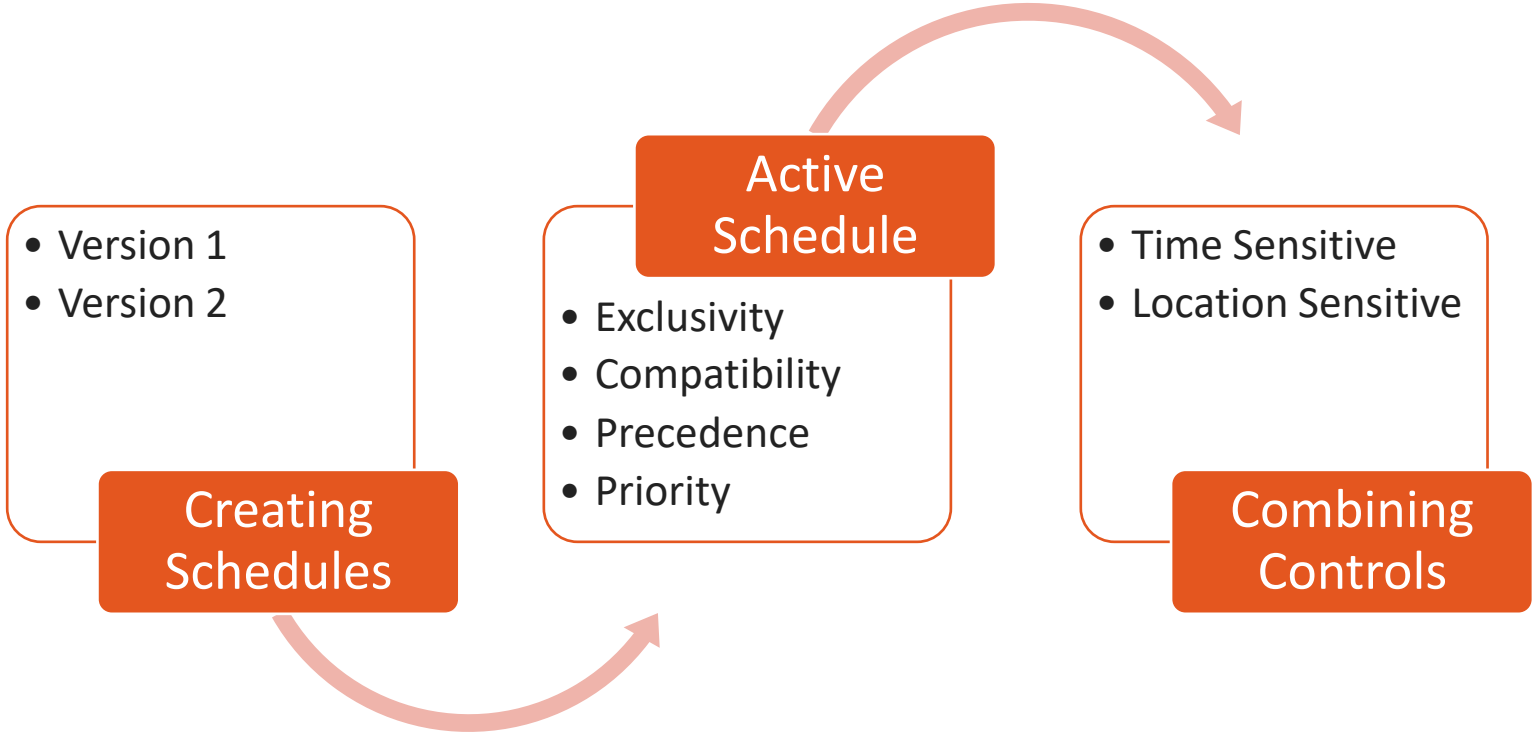
- Outstation transfers the schedule to **Error state** = 11
- *Selected Schedule Is Enabled* shows Not Enabled (BI3000 = 0) for the selected schedule.
- *Selected Schedule is Validated* shows Not Validated (BI3001 = 0) for the selected schedule.
- Outstation logs the type of error

MESA

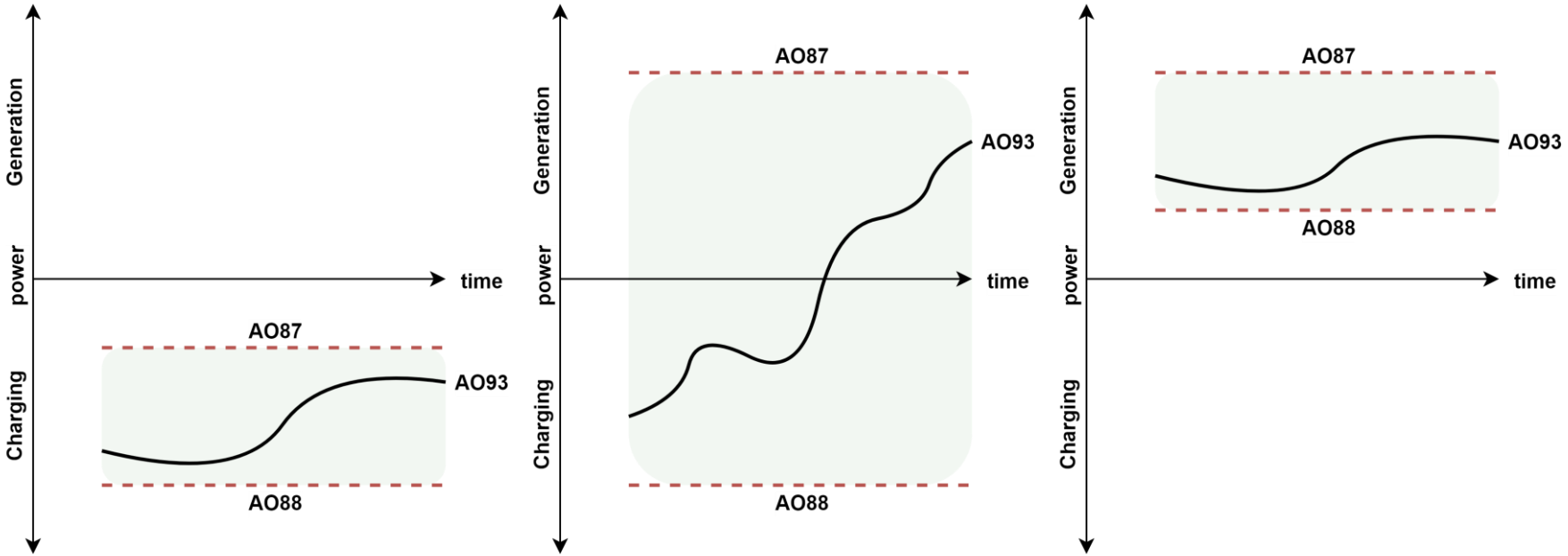
Hands-on

Putting it all together

Scheduling


Creating Schedules
• Version 1
• Version 2
Active Schedule
• Exclusivity
• Compatibility
• Precedence
• Priority
Combining Controls
• Time Sensitive
• Location Sensitive

Active Power Limit



Layer More Controls:

LEGEND C - Compatible **P - Priority** **M - Mutually Exclusive**	Voltage Ride-Through	Frequency Ride-Through	Dynamic Reactive Current	Dynamic Volt-Watt	Frequency-Watt	Charge-Discharge Storage	Coordinated Charge-Discharge	Active Power Limit	Active Power Following (1,2,3)	Automatic Generation Control	Active Power Smoothing	Volt-Watt	Frequency-Watt Curve	Synthetic Inertia	Pricing Signal	Constant VARS Function	Fixed Power Factor	Volt-VAR Control	Watt-VAR	Power Factor Correction
Voltage Ride-Through																				
Frequency Ride-Through	C																			
Dynamic Reactive Current	C	C																		
Dynamic Volt-Watt	C	C	C																	
Frequency-Watt	C	C	C	C																
Charge-Discharge Storage	C	C	C	C	C															
Coordinated Charge-Discharge	C	C	C	C	C	C														
Active Power Limit	C	C	C	C	C	C	C													
Active Power Following (1,2,3)	C	C	C	C	C	C	C	**P**												
Automatic Generation Control	C	C	C	C	**P**	**M**	**P**	**P**	**M**											
Active Power Smoothing	C	C	C	C	C	C	C	**P**	**P**	**M**										
Volt-Watt	C	C	C	C	C	C	C	**P**	**P**	**M**	**P**									
Frequency-Watt Curve	C	C	C	C	**P**	C	C	C	**P**	C	C	C								
Synthetic Inertia	C	C	C	C	**P**	C	C	C	**P**	C	C	C	C							
Pricing Signal	C	C	C	C	C	C	C	C	C	C	C	C	C	C						
Constant VARs Function	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C					
Fixed Power Factor	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	**P**				
Volt-VAR Control	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	**M**	**M**			
Watt-VAR	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	**M**	**M**	**P**		
Power Factor Correction	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	**M**	**M**	**P**	**P**	

Active Power Limit
AGC
Charge-Discharge

Section 6

MESA Membership

MESA Membership

Membership Fee:

- ✓ Offers entry into working groups and committees
- ✓ Members can be elected to the Board of Directors

2024 Membership Options:

Standard (Companies with revenue > $1M): $5,000

Small Business (Companies with revenue ≤ $1M): $3,000

MESA/SunSpec Joint Modbus Membership: $9,000

Individual/Strategic Partner: $1,000

Student: $350

Read more about MESA's membership options at http://mesastandards.org/membership/

Discretionary Allocation to Technical Priorities:

- ✓ Variable depending on organizational technical priorities
- ✓ Fees can be directed toward a specific project

2024 Technical Allocation:

A min $5,000 per company (depends on available funds) focused on MESA-DER certification program development

Questions?

The IEEE 1815.2 ballot pool is open!

- You need to become a member of the IEEE Standards Association. Once you are a member, you can sign up for the ballot pool for IEEE 1815.2.
- You can sign up by going to https://development.standards.ieee.org/ and then selecting “Invitations and Ballots” from the Menu in the upper right.
- You should then select the “Open Invitations” tab and find P1815.2.
- Click on Ballot Invitations to join the Ballot Pool.
- You will be notified when you can start reviewing IEEE 1815.2