WASHINGTON STATE UNIVERSITY

MPOPF Simulation and OpenDSS Validation

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Washington State University

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strLoadShape = 'New Loadshape.LoadShape npts =8 interval = 1 mult = [0.705 0.75 0.777 0.787 0.796 0.782 0.783 0.789]'
strLoadShapePV = 'New Loadshape.LoadShapePV npts =8 interval = 1 mult = [0.3 0.5 0.8 0.9 1 1 0.99 0.9]'
```

MPDOPF Verified for $T = 8, PV = 10\%, Batt = 15\%$

MPDOPF Simulation Results

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------------------------------------------------------------
01. Machine ID: ETRL204-ARYAN
02. Horizon Duration: 8
03. Nature of Simulation: Spatially-Distributed-OPF with 4 Areas.
04. GED Configuration: pv_10_batt_15
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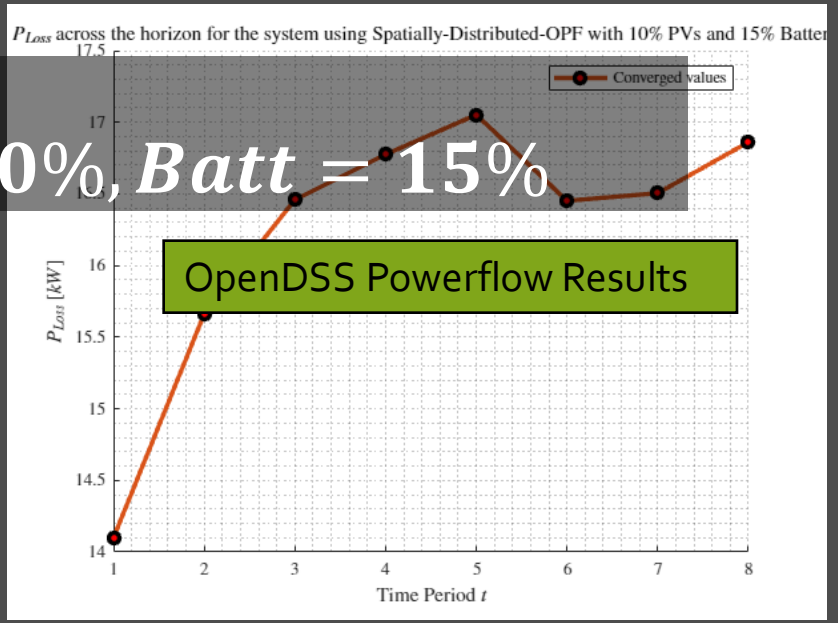


```
Hour: Full 8 Hour Horizon
01. Horizon Line Loss: 129.87 kW
02. Horizon Total Substation Power: 7081.55 kW + 1415.56 kVAr
03. Horizon Total Load: 7175.76 kW + 3948.23 kVAr
04. Horizon Total Generation: 223.61 kW + 2791.98 kVAr
05. Horizon Total PV Generation: 223.61 kW + 45.49 kVAr
06. Horizon Total Battery Generation: -0.00 kW + -53.51 kVAr
07. Horizon Total Static Capacitor Reactive Power Generation: 2800.00 kVAr
08. Horizon Total Substation Power Cost: $239.48
09. Horizon Total SCD Observed: 0.00 kW
10. Horizon-end Battery Energy Deviation from Reference: 0.00 kWh
------------------------------------------------------------
11. Number of Macro-Iterations: 5
12. Simulation Time: 769.62 s
13. Time to solve with sequential (non-parallel) computation: 740.73 s
14. Time to solve if OPF computation parallelized: 468.59 s
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Hour: Full 8 Hour Horizon
Horizon Line Loss: 129.8017 kW
Horizon Total Substation Power: 7081.9146 kW + 1408.5741 kVAr
Horizon Total Load: 7175.7623 kW + 3948.234 kVAr
Horizon Total Generation: 223.6076 kW + 2791.9764 kVAr
Horizon Total PV Generation: 223.6058 kW + 45.487 kVAr
Horizon Total Battery Generation: 0.0017449 kW + -53.5106 kVAr
Horizon Total Static Capacitor Reactive Power Generation: 2800 kVAr
Horizon Substation Power Cost: $ 239.4947
----------------------------
Horizon Period (hourly time-steps): 8 h
GED Penetration: 10% PVs + 15% Batteries
Maximum All Time Voltage Discrepancy: 0.000149 pu
Maximum All Time Line Loss Discrepancy: 0.011397 kW
Maximum All Time Substation Borrowed Real Power Discrepancy: 0.13449 kW
Maximum All Time Substation Borrowed Reactive Power Discrepancy: 0.95273 kVAr
----------------------------
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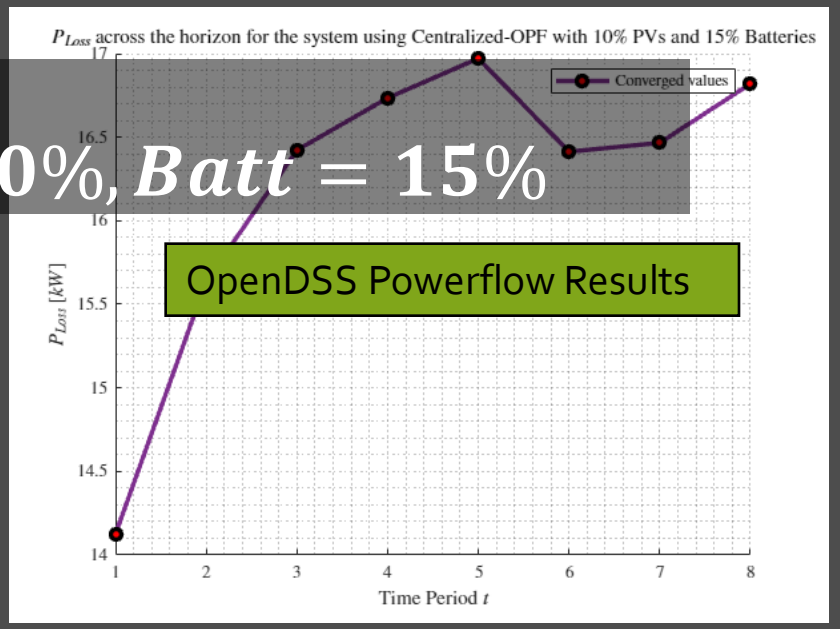
strLoadShape = 'New Loadshape.LoadShape npts =8 interval = 1 mult = [0.705 0.75 0.777 0.787 0.796 0.782 0.783 0.789]'

strLoadShapePV = 'New Loadshape.LoadShapePV npts =8 interval = 1 mult = [0.3 0.5 0.8 0.9 1 1 0.99 0.9]'

MPCOPF Verified for $T = 8, PV = 10\%, Batt = 15\%$

MPCOPF Simulation Results

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------------------------------------------
01. Machine ID: ETRL204-ARYAN
02. Horizon Duration: 8
03. Nature of Simulation: Centralized-OPF
04. GED Configuration: pv_10_batt_15
----------------------------
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```
Hour: Full 8 Hour Horizon
01. Horizon Line Loss: 129.59 kW
02. Horizon Total Substation Power: 7081.84 kW + 1285.80 kVAr
03. Horizon Total Load: 7175.76 kW + 3948.23 kVAr
04. Horizon Total Generation: 223.51 kW + 2922.02 kVAr
05. Horizon Total PV Generation: 223.61 kW + 128.23 kVAr
06. Horizon Total Battery Generation: -0.10 kW + -6.22 kVAr
07. Horizon Total Static Capacitor Reactive Power Generation: 2800.00 kVAr
08. Horizon Total Substation Power Cost: $239.51
09. Horizon Total SCD Observed: -0.00 kW
10. Horizon-end Battery Energy Deviation from Reference: 0.00 kWh
------------------------------------------------------------
11. Number of Macro-Iterations: 1
12. Simulation Time: 1872.15 s
13. Time to solve with sequential (non-parallel) computation: 1191.35 s
14. Time to solve if OPF computation parallelized: 1191.35 s
------------------------------------------------------------
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```
----------------------------
Hour: Full 8 Hour Horizon
Horizon Line Loss: 129.5051 kW
Horizon Total Substation Power: 7081.7363 kW + 1277.9781 kVAr
Horizon Total Load: 7175.7623 kW + 3948.234 kVAr
Horizon Total Generation: 223.5079 kW + 2922.011 kVAr
Horizon Total PV Generation: 223.6058 kW + 128.2327 kVAr
Horizon Total Battery Generation: -0.097902 kW + -6.2217 kVAr
Horizon Total Static Capacitor Reactive Power Generation: 2800 kVAr
Horizon Substation Power Cost: $ 239.5056
----------------------------
Horizon Period (hourly time-steps): 8 h
GED Penetration: 10% PVs + 15% Batteries
Maximum All Time Voltage Discrepancy: 8.8485e-05 pu
Maximum All Time Line Loss Discrepancy: 0.013391 kW
Maximum All Time Substation Borrowed Real Power Discrepancy: 0.072875 kW
Maximum All Time Substation Borrowed Reactive Power Discrepancy: 1.0043 kVAr
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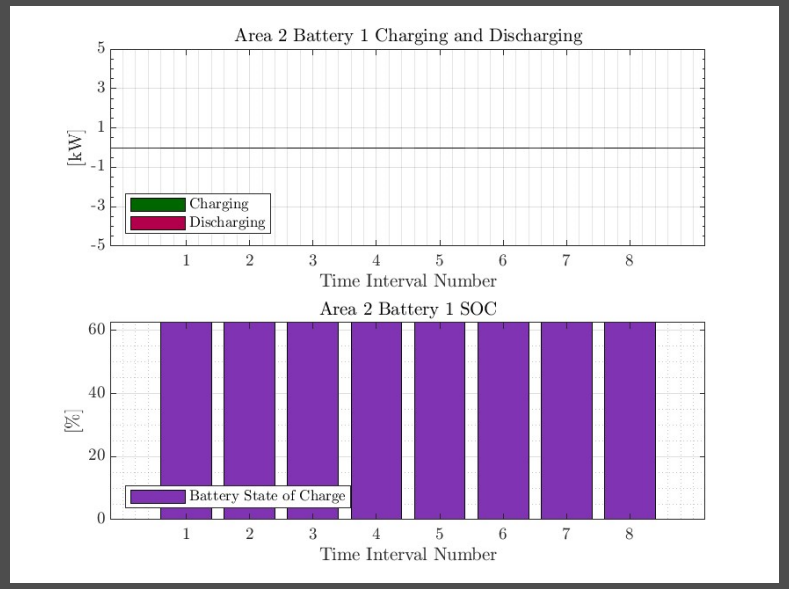
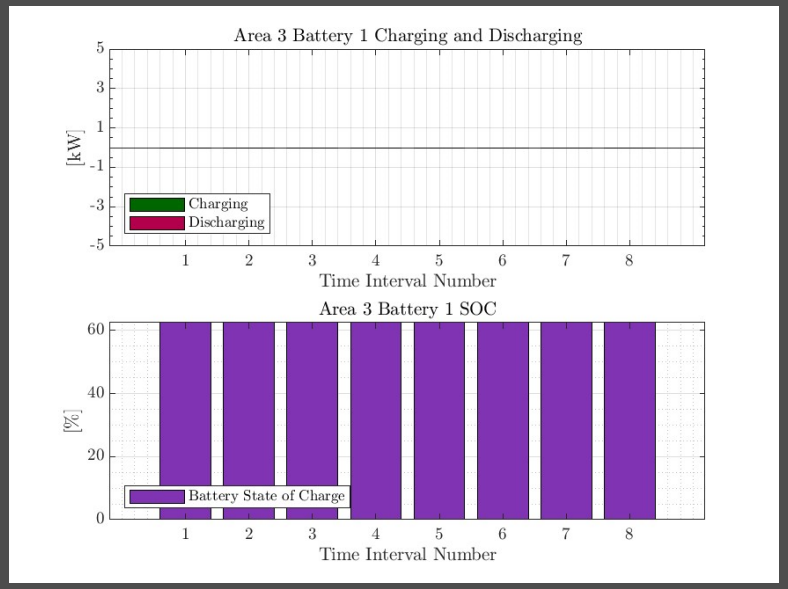
strLoadShape = 'New Loadshape.LoadShape npts =8 interval = 1 mult = [0.705 0.75 0.777 0.787 0.796 0.782 0.783 0.789]'

strLoadShapePV = 'New Loadshape.LoadShapePV npts =8 interval = 1 mult = [0.3 0.5 0.8 0.9 1 1 0.99 0.9]'

1, 5, 6, 8 in COPF values

MPDOPF Verified for $T = 8, PV = 10\%, Batt = 15\%$





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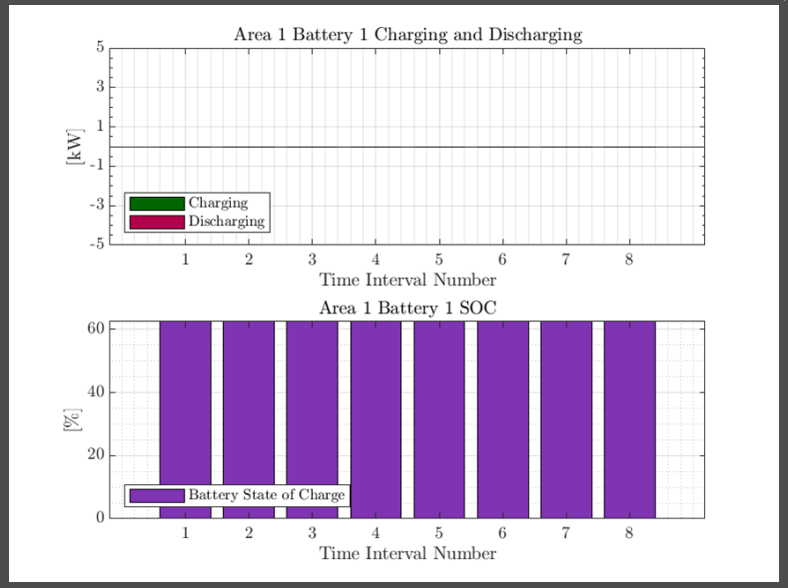
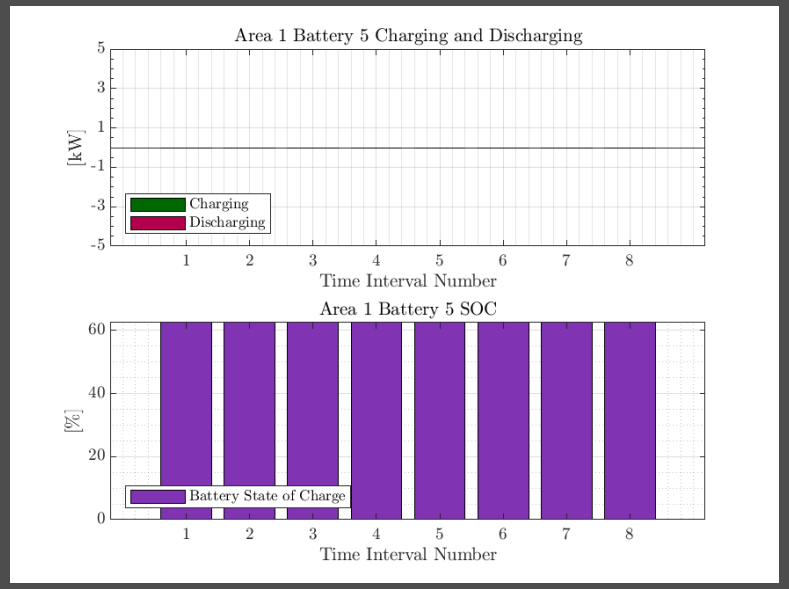
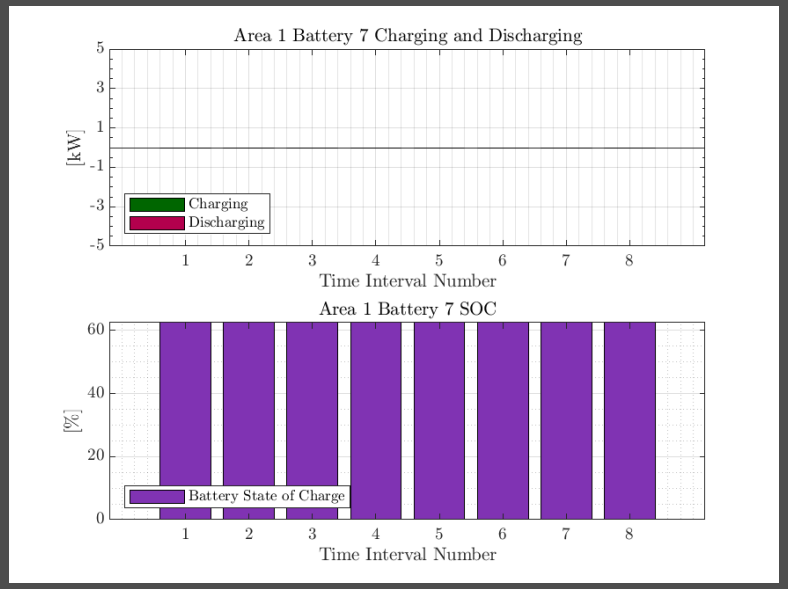
MPCOPF Verified for $T = 8, PV = 10\%, Batt = 15\%$





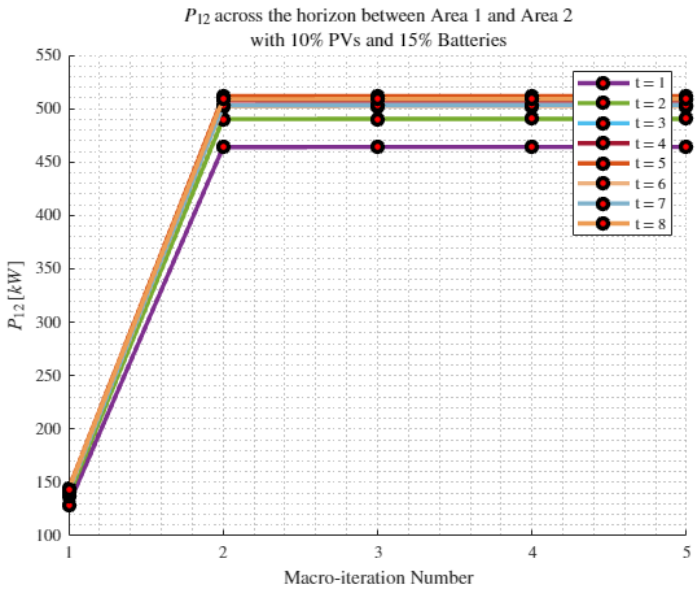


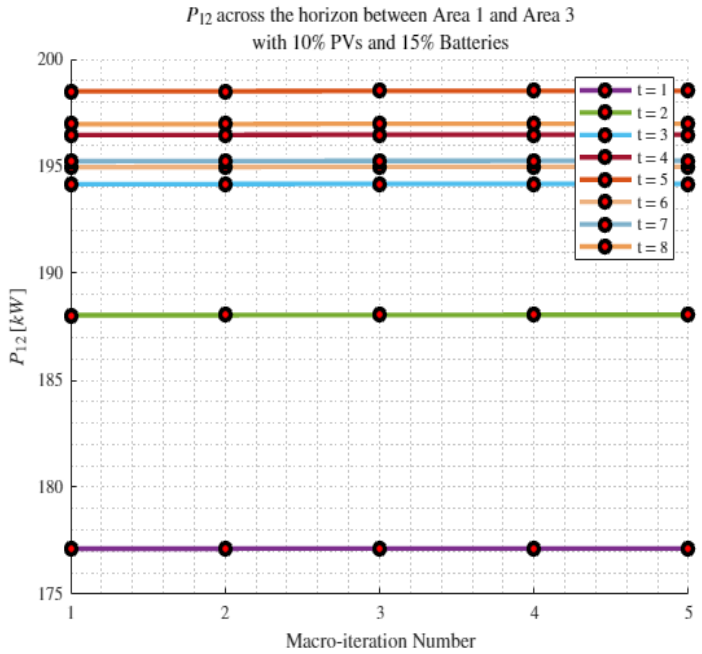
strLoadShape = 'New Loadshape.LoadShape npts =8 interval = 1 mult = [0.705 0.75 0.777 0.787 0.796 0.782 0.783 0.789]'

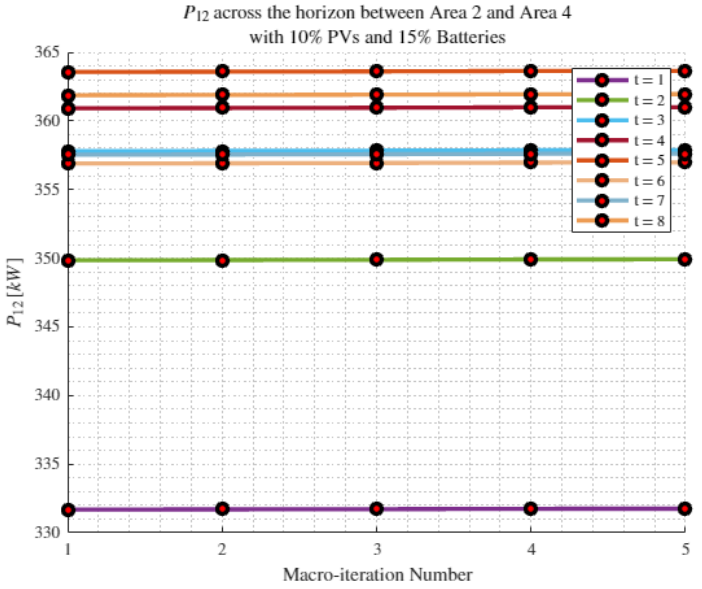
strLoadShapePV = 'New Loadshape.LoadShapePV npts =8 interval = 1 mult = [0.3 0.5 0.8 0.9 1 1 0.99 0.9]'

MPDOPF Verified for $T = 8, PV = 10\%, Batt = 15\%$

Boundary Complex Powers





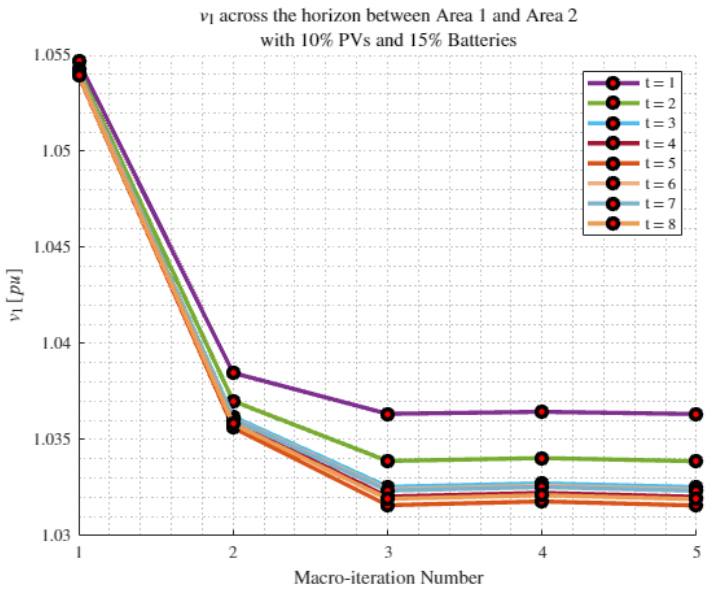


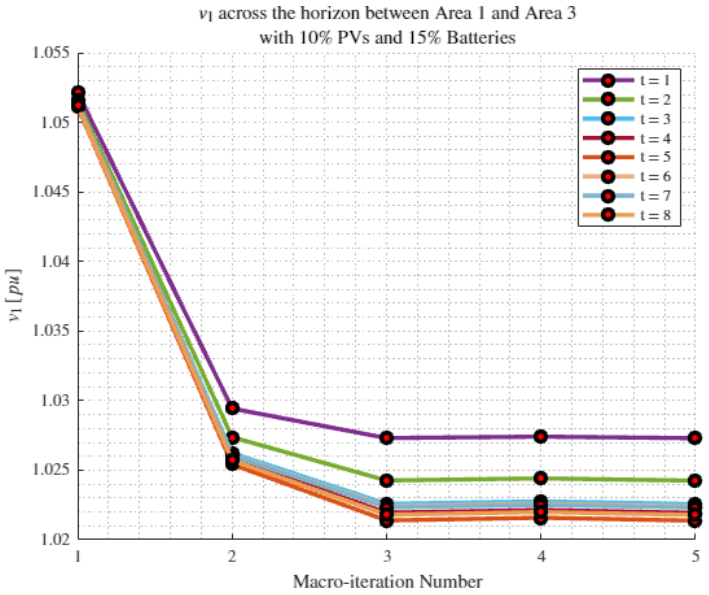
strLoadShape = 'New Loadshape.LoadShape npts =8 interval = 1 mult = [0.705 0.75 0.777 0.787 0.796 0.782 0.783 0.789]'

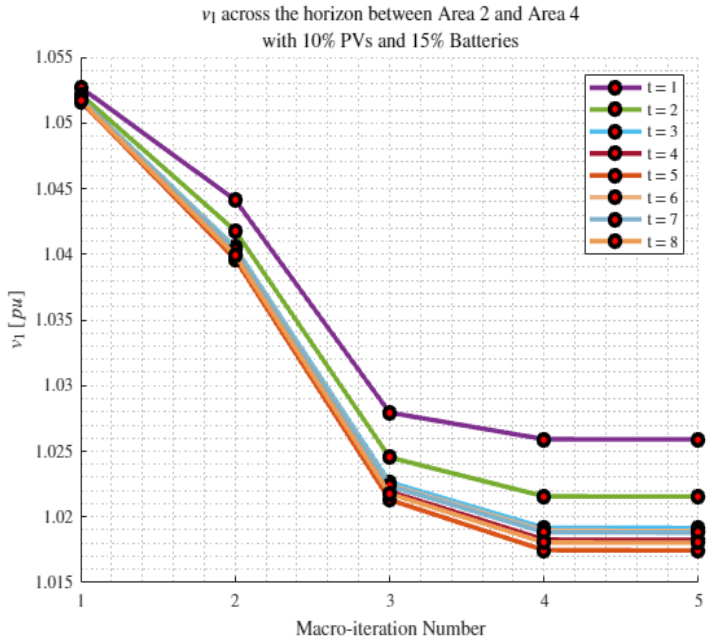
strLoadShapePV = 'New Loadshape.LoadShapePV npts =8 interval = 1 mult = [0.3 0.5 0.8 0.9 1 1 0.99 0.9]'

MPDOPF Verified for $T = 8, PV = 10\%, Batt = 15\%$

Boundary Voltages





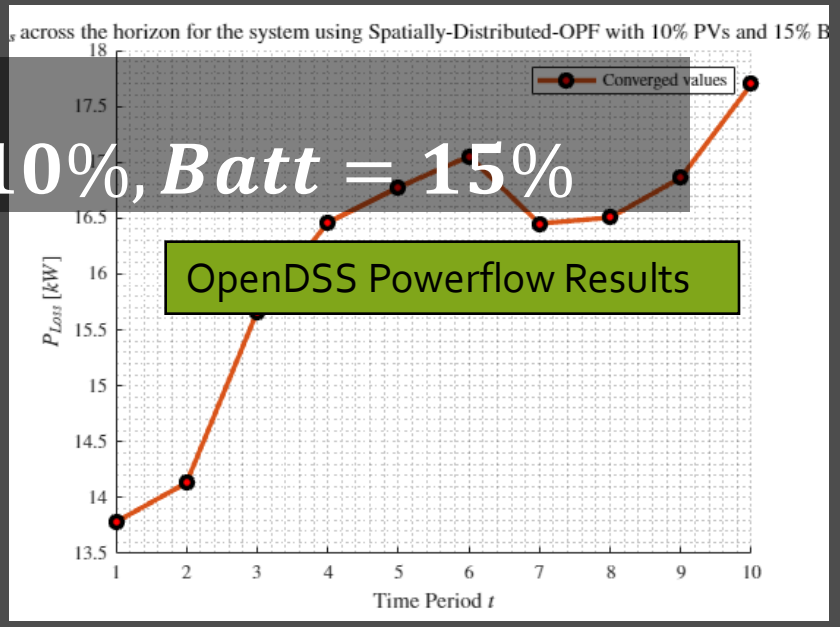


strLoadShape = 'New Loadshape.LoadShape npts =10 interval = 1 mult = [0.668 0.705 0.75 0.777 0.787 0.796 0.782 0.783 0.789 0.826]'

strLoadShapePV = 'New Loadshape.LoadShapePV npts =10 interval = 1 mult = [0.2 0.3 0.5 0.8 0.9 1 1 0.99 0.9 0.7]'

MPDOPF Verified for $T = 10, PV = 10\%, Batt = 15\%$

MPDOPF Simulation Results




```
------------------------------------------------------------
01. Machine ID: ETRL204-ARYAN
02. Horizon Duration: 10
03. Nature of Simulation: Spatially-Distributed-OPF with 4 Areas.
04. GED Configuration: pv_10_batt_15
----------------------------
```

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------------------------------
Hour: Full 10 Hour Horizon
01. Horizon Line Loss: 161.38 kW
02. Horizon Total Substation Power: 8822.85 kW + 1739.65 kVAr
03. Horizon Total Load: 8913.58 kW + 4904.41 kVAr
04. Horizon Total Generation: 251.37 kW + 3487.00 kVAr
05. Horizon Total PV Generation: 255.10 kW + 55.46 kVAr
06. Horizon Total Battery Generation: -3.73 kW + -68.46 kVAr
07. Horizon Total Static Capacitor Reactive Power Generation: 3500.00 kVAr
08. Horizon Total Substation Power Cost: $284.48
09. Horizon Total SCD Observed: -0.00 kW
10. Horizon-end Battery Energy Deviation from Reference: 0.00 kWh
------------------------------------------------------------
11. Number of Macro-Iterations: 5
12. Simulation Time: 3942.82 s
13. Time to solve with sequential (non-parallel) computation: 3903.53 s
14. Time to solve if OPF computation parallelized: 3485.18 s
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----------------------------
Hour: Full 10 Hour Horizon
Horizon Line Loss: 161.5011 kW
Horizon Total Substation Power: 8830.6928 kW + 1731.3489 kVAr
Horizon Total Load: 8913.5786 kW + 4904.412 kVAr
Horizon Total Generation: 244.3731 kW + 3486.9955 kVAr
Horizon Total PV Generation: 248.1008 kW + 55.4602 kVAr
Horizon Total Battery Generation: -3.7278 kW + -68.4647 kVAr
Horizon Total Static Capacitor Reactive Power Generation: 3500 kVAr
Horizon Substation Power Cost: $ 284.716
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Horizon Period (hourly time-steps): 10 h
GED Penetration: 10% PVs + 15% Batteries
Maximum All Time Voltage Discrepancy: 0.00030211 pu
Maximum All Time Line Loss Discrepancy: 0.23144 kW
Maximum All Time Substation Borrowed Real Power Discrepancy: 8.7069 kW
Maximum All Time Substation Borrowed Reactive Power Discrepancy: 0.973 kVAr
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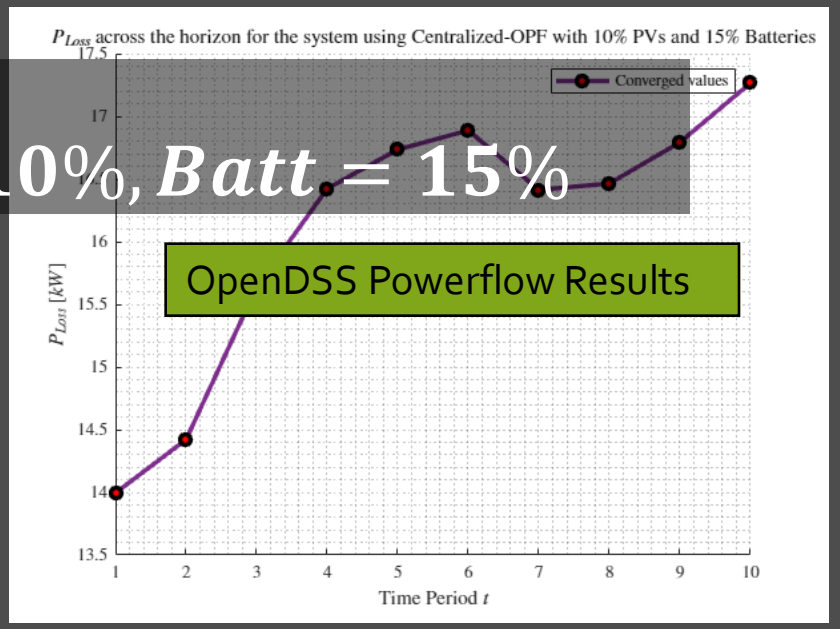
```
strLoadShape = 'New Loadshape.LoadShape npts =10 interval = 1 mult = [0.668 0.705 0.75 0.777 0.787 0.796 0.782 0.783 0.789 0.826]'
strLoadShapePV = 'New Loadshape.LoadShapePV npts =10 interval = 1 mult = [0.2 0.3 0.5 0.8 0.9 1 1 0.99 0.9 0.7]'
```

MPCOPF Verified for $T = 10, PV = 10\%, Batt = 15\%$

MPCOPF Simulation Results

```
------------------------------------------
01. Machine ID: ETRL204-ARYAN
02. Horizon Duration: 10
03. Nature of Simulation: Centralized-OPF
04. GED Configuration: pv_10_batt_15
----------------------------
```




```
------------------------------
Hour: Full 10 Hour Horizon
01. Horizon Line Loss: 161.03 kW
02. Horizon Total Substation Power: 8824.15 kW + 1586.67 kVAr
03. Horizon Total Load: 8913.58 kW + 4904.41 kVAr
04. Horizon Total Generation: 250.46 kW + 3640.31 kVAr
05. Horizon Total PV Generation: 255.10 kW + 151.88 kVAr
06. Horizon Total Battery Generation: -4.64 kW + -11.57 kVAr
07. Horizon Total Static Capacitor Reactive Power Generation: 3500.00 kVAr
08. Horizon Total Substation Power Cost: $284.71
09. Horizon Total SCD Observed: -0.10 kW
10. Horizon-end Battery Energy Deviation from Reference: 0.00 kWh
------------------------------------------------------------
11. Number of Macro-Iterations: 1
12. Simulation Time: 10125.58 s
13. Time to solve with sequential (non-parallel) computation: 10100.61 s
14. Time to solve if OPF computation parallelized: 10100.61 s
------------------------------------------------------------
```

```
------------------------------
Hour: Full 10 Hour Horizon
Horizon Line Loss: 161.0605 kW
Horizon Total Substation Power: 8829.266 kW + 1577.1768 kVAr
Horizon Total Load: 8913.5786 kW + 4904.412 kVAr
Horizon Total Generation: 245.3898 kW + 3640.299 kVAr
Horizon Total PV Generation: 248.0943 kW + 151.8789 kVAr
Horizon Total Battery Generation: -2.7045 kW + -11.5799 kVAr
Horizon Total Static Capacitor Reactive Power Generation: 3500 kVAr
Horizon Substation Power Cost: $ 284.8622
------------------------------
Horizon Period (hourly time-steps): 10 h
GED Penetration: 10% PVs + 15% Batteries
Maximum All Time Voltage Discrepancy: 0.00015989 pu
Maximum All Time Line Loss Discrepancy: 0.19634 kW
Maximum All Time Substation Borrowed Real Power Discrepancy: 7.2355 kW
Maximum All Time Substation Borrowed Reactive Power Discrepancy: 1.0955 kVAr
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```
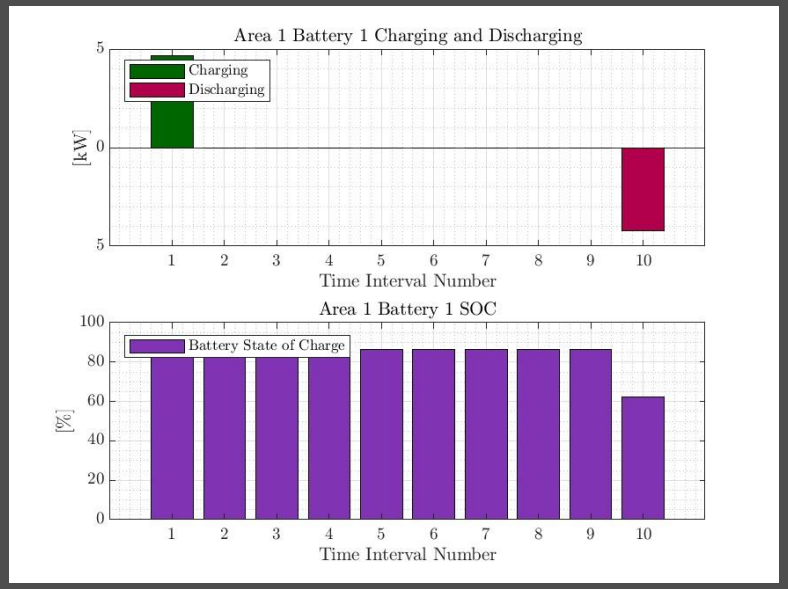
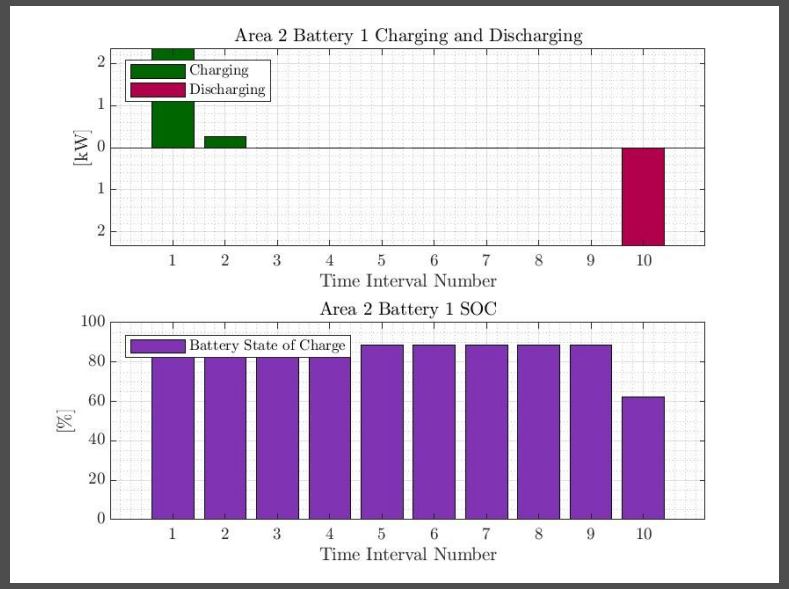
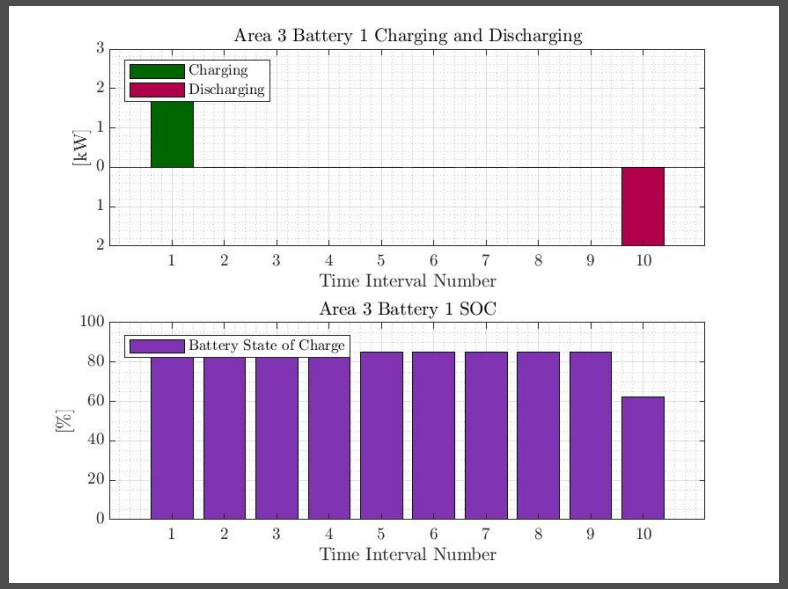

strLoadShape = 'New Loadshape.LoadShape npts =10 interval = 1 mult = [0.668 0.705 0.75 0.777 0.787 0.796 0.782 0.783 0.789 0.826]'

strLoadShapePV = 'New Loadshape.LoadShapePV npts =10 interval = 1 mult = [0.2 0.3 0.5 0.8 0.9 1 1 0.99 0.9 0.7]'

MPDOPF Verified for $T = 10, PV = 10\%, Batt = 15\%$







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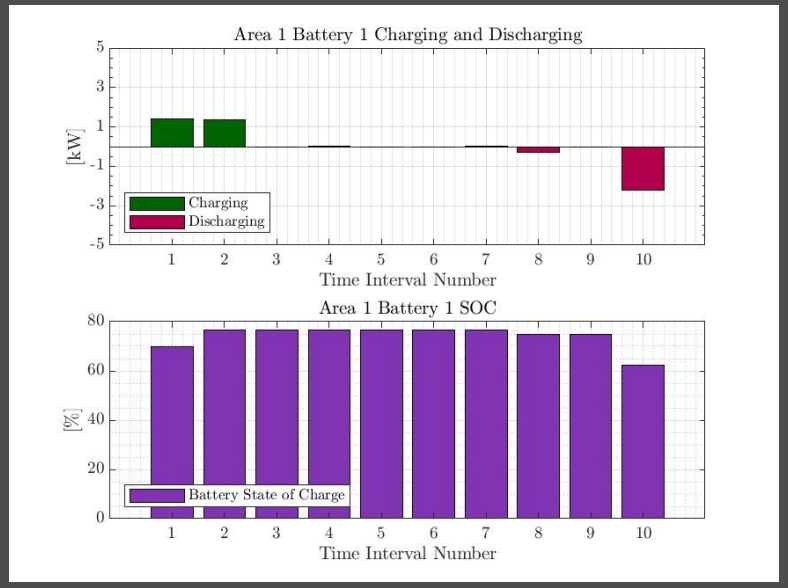
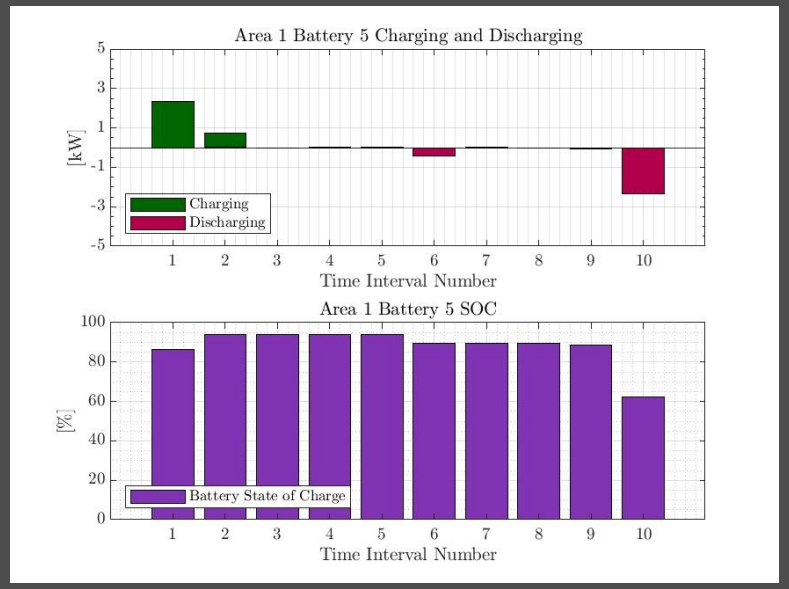
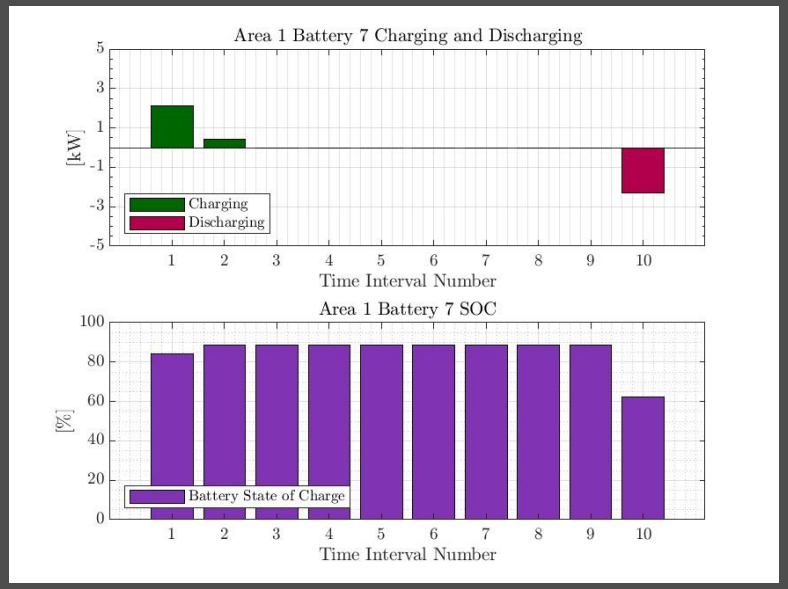
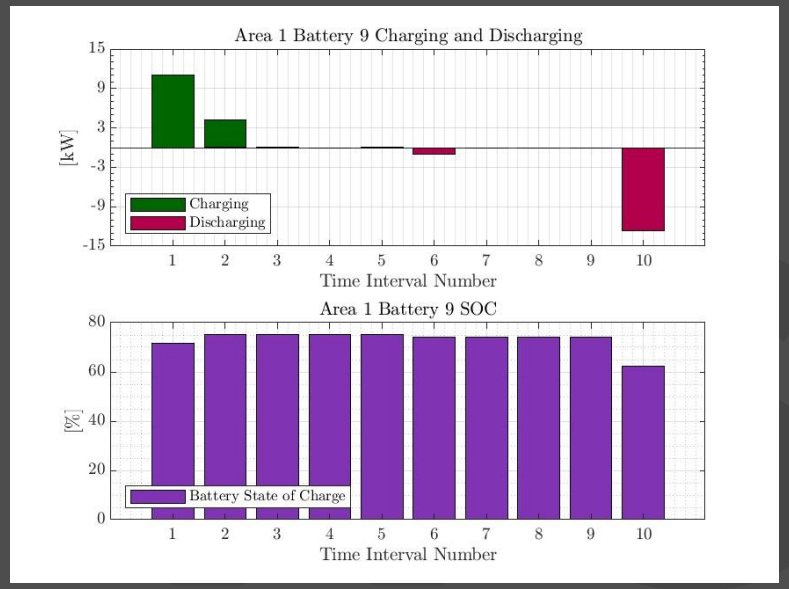
strLoadShapePV = 'New Loadshape.LoadShapePV npts =10 interval = 1 mult = [0.2 0.3 0.5 0.8 0.9 1 1 0.99 0.9 0.7]'

MPCOPF Verified for $T = 10, PV = 10\%, Batt = 15\%$



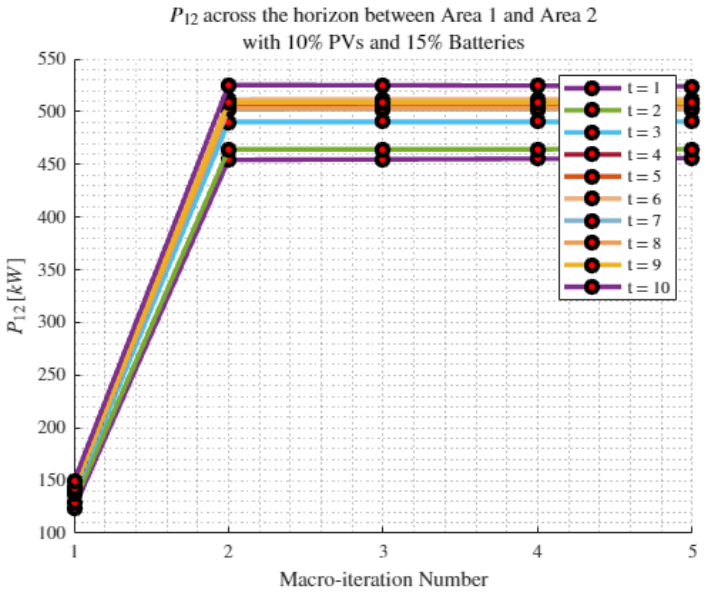


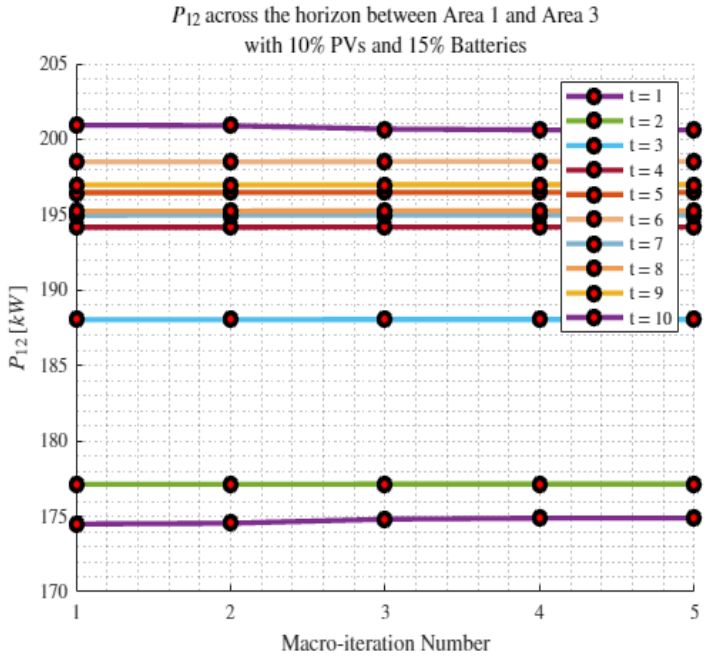


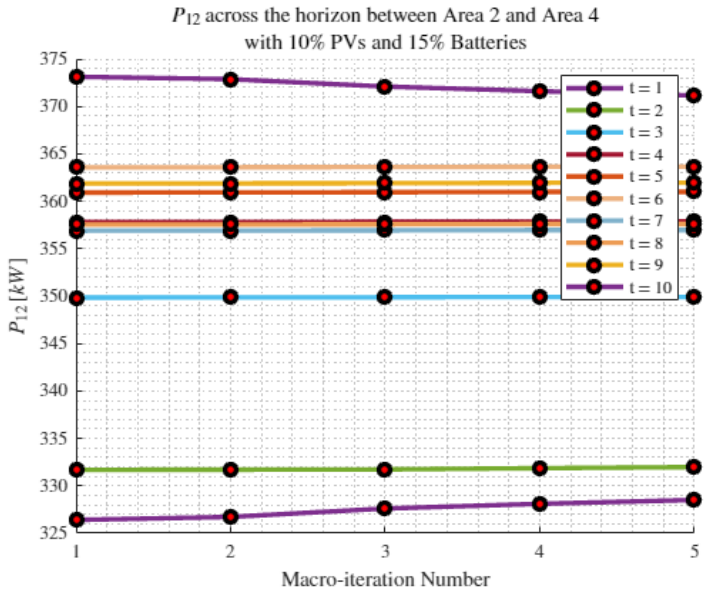


MPDOPF Verified for $T = 10, PV = 10\%, Batt = 15\%$

Boundary Complex Powers







MPDOPF Verified for $T = 10, PV = 10\%, Batt = 15\%$

Boundary Voltages