**Imperfect Market Equilibrium**



**DAs Results in MPEC vs Optimal**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **DA** | **MPEC Profit**  **(Sell – Buy)\*price** | **MPEC Social Welfare** | **Optimal Profit**  **(Sell – Buy)\*price** | **Optimal Social Welfare** |
| **1** | -7117.499356 | -102.630568 | 751.584933 | -20713 |
| **2** | -9620.759900 | -1.573718 | 901.584933 |
| **3** | -9181.249319 | -132.174822 | 751.584933 |
| **4** | -1718.455981 | -293.614721 | 301.584933 |
| **5** | -9124.109317 | -421.874580 | 901.584933 |
| **6** | -4093.673307 | -442.596462 | 751.584933 |
| **7** | 718.208215 | -498.984685 | 451.584933 |
| **8** | -1930.153749 | -639.210378 | 451.584933 |
| **9** | -9446.546394 | -485.113727 | 1051.584933 |
| **SUM** | -51514.2 | -3017.77 | 6314.264 | -20713 |

Icon

Description automatically generated

As shown in the bar plot, DA7 has achieved highest profit among all the Strategic DAs in the MPEC. Interestingly its value is even higher than the Optimal profit for this particular DA. All DAs in optimal, have profits much closer to each other comparing the DAs profit in the MPEC.

Chart, line chart

Description automatically generatedBus 3 Price (LMPs) for DA1 sitting at that node:

|  |  |  |
| --- | --- | --- |
| **Time** | **Bus 3 - DA1 MPEC** | **Bus 3 – Optimal** |
| 1 | 15 | 150 |
| 2 | 15 | 150 |
| 3 | 15 | 90 |
| 4 | 30 | 60 |
| 5 | 63.98778534 | 44.38544 |
| 6 | 30 | 35.45058 |
| 7 | 60 | 30 |
| 8 | 30 | 30 |
| 9 | 53.8317768 | 28.30219 |
| 10 | 30 | 26.81809 |
| 11 | 30 | 25.19692 |
| 12 | 30 | 23.81077 |
| 13 | 50.79273229 | 24.45108 |
| 14 | 66.63382554 | 30 |
| 15 | 68.81510443 | 60 |
| 16 | 30 | 90 |
| 17 | 15 | 150 |
| 18 | 15 | 150 |
| 19 | 15 | 150 |
| 20 | 14 | 150 |
| 21 | 12 | 150 |
| 22 | 12 | 150 |
| 23 | 15 | 150 |
| 24 | 12 | 150 |

Chart, line chart

Description automatically generatedBus 5 Price (LMPs) for DA7 sitting at that node:

|  |  |  |
| --- | --- | --- |
| **Time** | **Bus 5 – DA7 MPEC** | **Bus 5 – Optimal** |
| 1 | 15 | 150 |
| 2 | 15 | 150 |
| 3 | 30 | 90 |
| 4 | 30 | 60 |
| 5 | 74 | 44.38544 |
| 6 | 60 | 35.45058 |
| 7 | 60 | 30 |
| 8 | 60 | 30 |
| 9 | 63.62066 | 28.30219 |
| 10 | 30 | 26.81809 |
| 11 | 30 | 25.19692 |
| 12 | 60 | 23.81077 |
| 13 | 86.89262 | 24.45108 |
| 14 | 85 | 30 |
| 15 | 92.39485 | 60 |
| 16 | 30 | 90 |
| 17 | 15 | 150 |
| 18 | 15 | 150 |
| 19 | 15 | 150 |
| 20 | 12 | 150 |
| 21 | 12 | 150 |
| 22 | 12 | 150 |
| 23 | 15 | 150 |
| 24 | 12 | 150 |

**DAs Results in EPEC vs Optimal**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **DA** | **EPEC Profit**  **(Sell – Buy)\*price** | **EPEC Social Welfare** | **Optimal Profit**  **(Sell – Buy)\*price** | **Optimal Social Welfare** |
| **1** | 29289.049193 | -976.301639470214 | 751.584933 | -20713 |
| **2** | 19968.733300 | -689.2396846259442 | 901.584933 |
| **3** | 21265.890354 | -770.4196477342487 | 751.584933 |
| **4** | 29674.545255 | -917.2555750849252 | 301.584933 |
| **5** | 35921.403161 | -1094.640688782206 | 901.584933 |
| **6** | 37077.299533 | -1126.2077519827928 | 751.584933 |
| **7** | 43937.244704 | -1453.2200180567725 | 451.584933 |
| **8** | 47252.504371 | -1542.98343519458 | 451.584933 |
| **9** | 37150.503193 | -1184.0061853033917 | 1051.584933 |
| **SUM** | 301537.2 | -9754.27 | 6314.264 | -20713 |

Chart, bar chart

Description automatically generated

After running diagonalization algorithm for N=25 iterations, we can see that all the DAs achieved more profit than the optimal model. Sum of all DAs profit increased from (-51514.2) to (301537.2) and their social welfare from (-3017.77) decreased to (-9754.27).

DAs 7,8 and 9 in bus 5 have achieved more profit than other DAs that are located in other Buses in EPEC.

**Chart, line chart

Description automatically generatedBus 3 Price (LMPs) for DA1 sitting at that node after 25 iterations in EPEC:**

|  |  |  |
| --- | --- | --- |
| **Time** | **Bus 3 - DA1 EPEC** | **Bus 3 – Optimal** |
| 1 | 15 | 150 |
| 2 | 14 | 150 |
| 3 | 56.74575 | 90 |
| 4 | 13 | 60 |
| 5 | 88.47457 | 44.38544 |
| 6 | 12 | 35.45058 |
| 7 | 75 | 30 |
| 8 | 12 | 30 |
| 9 | 88.47457 | 28.30219 |
| 10 | 73 | 26.81809 |
| 11 | 12 | 25.19692 |
| 12 | 12 | 23.81077 |
| 13 | 87.42856 | 24.45108 |
| 14 | 89.8983 | 30 |
| 15 | 91 | 60 |
| 16 | 12 | 90 |
| 17 | 30 | 150 |
| 18 | 37.77953 | 150 |
| 19 | 15 | 150 |
| 20 | 15 | 150 |
| 21 | 12 | 150 |
| 22 | 15 | 150 |
| 23 | 15 | 150 |
| 24 | 12 | 150 |

Chart, line chart

Description automatically generated**Bus 5 Price (LMPs) for DA7 sitting at that node:**

|  |  |  |
| --- | --- | --- |
| **Time** | **Bus 5 – DA7 EPEC** | **Bus 3 – Optimal** |
| 1 | 15 | 150 |
| 2 | 13 | 150 |
| 3 | 85 | 90 |
| 4 | 13 | 60 |
| 5 | 98 | 44.38544 |
| 6 | 12 | 35.45058 |
| 7 | 103 | 30 |
| 8 | 12 | 30 |
| 9 | 100.8615 | 28.30219 |
| 10 | 82 | 26.81809 |
| 11 | 12 | 25.19692 |
| 12 | 12 | 23.81077 |
| 13 | 109 | 24.45108 |
| 14 | 89.67179 | 30 |
| 15 | 99.91281 | 60 |
| 16 | 12 | 90 |
| 17 | 30 | 150 |
| 18 | 30 | 150 |
| 19 | 15 | 150 |
| 20 | 15 | 150 |
| 21 | 12 | 150 |
| 22 | 15 | 150 |
| 23 | 15 | 150 |
| 24 | 12 | 150 |

**Comparing LMPS results: EPEC, MPEC, Optimal**

Chart, line chart

Description automatically generatedFor Bus 3 and DA1:

|  |  |  |  |
| --- | --- | --- | --- |
| **Time** | **Bus 3 - DA1 EPEC** | **Bus 3 Optimal** | **BUS 3 – DA1 EPEC** |
| 1 | 15 | 150 | 15 |
| 2 | 14 | 150 | 14 |
| 3 | 56.74575 | 90 | 56.74575 |
| 4 | 13 | 60 | 13 |
| 5 | 88.47457 | 44.38544 | 88.47457 |
| 6 | 12 | 35.45058 | 12 |
| 7 | 75 | 30 | 75 |
| 8 | 12 | 30 | 12 |
| 9 | 88.47457 | 28.30219 | 88.47457 |
| 10 | 73 | 26.81809 | 73 |
| 11 | 12 | 25.19692 | 12 |
| 12 | 12 | 23.81077 | 12 |
| 13 | 87.42856 | 24.45108 | 87.42856 |
| 14 | 89.8983 | 30 | 89.8983 |
| 15 | 91 | 60 | 91 |
| 16 | 12 | 90 | 12 |
| 17 | 30 | 150 | 30 |
| 18 | 37.77953 | 150 | 37.77953 |
| 19 | 15 | 150 | 15 |
| 20 | 15 | 150 | 15 |
| 21 | 12 | 150 | 12 |
| 22 | 15 | 150 | 15 |
| 23 | 15 | 150 | 15 |
| 24 | 12 | 150 | 12 |

Chart, line chart

Description automatically generatedFor Bus 5 and DA:

|  |  |  |  |
| --- | --- | --- | --- |
| **Time** | **Bus 5 – DA7 EPEC** | **Bus 3 Optimal** | **BUS 5 – DA7 EPEC** |
| 1 | 15 | 150 |  |
| 2 | 13 | 150 |  |
| 3 | 85 | 90 |  |
| 4 | 13 | 60 |  |
| 5 | 98 | 44.38544 |  |
| 6 | 12 | 35.45058 |  |
| 7 | 103 | 30 |  |
| 8 | 12 | 30 |  |
| 9 | 100.8615 | 28.30219 |  |
| 10 | 82 | 26.81809 |  |
| 11 | 12 | 25.19692 |  |
| 12 | 12 | 23.81077 |  |
| 13 | 109 | 24.45108 |  |
| 14 | 89.67179 | 30 |  |
| 15 | 99.91281 | 60 |  |
| 16 | 12 | 90 |  |
| 17 | 30 | 150 |  |
| 18 | 30 | 150 |  |
| 19 | 15 | 150 |  |
| 20 | 15 | 150 |  |
| 21 | 12 | 150 |  |
| 22 | 15 | 150 |  |
| 23 | 15 | 150 |  |
| 24 | 12 | 150 |  |

**Checking Loads**

DAs in EPEC will use more energy, more than required, to charge EVs and use it in discharging mode, and increase their profit. DAs compete with each other, and this causes to decrease social welfare in wafer to DAs increase their profit.

Timeline

Description automatically generated

**Total loads in 24 hours in different models:**

Chart, bar chart

Description automatically generated

**Checking Injection Loads Into power network**

These plots show that why there is more load in EPEC. All DAs compete with each other in buying power and then sell it in later time.

A picture containing timeline

Description automatically generated

Total Injection load into grid:

Chart, bar chart

Description automatically generated