## 6.2 Discussion and Result of Main Experiment

Based on the preliminary experiment, we have already observed the advantages of including randomness in the charging pattern. Therefore, we run the second experiment mainly based on the scheme where all the alternative plans are with randomness, i.e. charging plan 1, 3 and 5.

And the main goal of this part is to look deeper into how the charging plans, flexibility of households, and optimization goal, affect the grid robustness and cost. The detailed discussion of each factor are discussed in the following section.

### 6.2.1 Effect of charging plans on robustness

To compare the effectiveness of random charging plan 1, 3, and 5 on improving the grid robustness, we run the experiments in different schemes while keep other variables unchanged. And the neighborhood are set to have highest flexibility, i.e. all EV’s have alternative plans.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Experiment Reference Name | Number of Total EV | Number of EV with alternative plans | **Scheme for Alternative plans** | Car | State | Optimization goal |
| Benchmark | 1000 | 0 | [0] | Tesla | TEXAS | N/A |
| 151207\_1k\_1k\_0111 | 1000 | 1000 | [0,1,1,1] | Tesla | TEXAS | robustness |
| 151207\_1k\_1k\_0333 | 1000 | 1000 | [0,3,3,3] | Tesla | TEXAS | robustness |
| 151207\_1k\_1k\_0555 | 1000 | 1000 | [0,5,5,5] | Tesla | TEXAS | robustness |
| 151207\_1k\_1k\_0135 | 1000 | 1000 | [0,1,3,5] | Tesla | TEXAS | robustness |

As the robustness is defined as the total electricity consumption. Therefore, the lower the volatility of the curve, the higher the robustness.

1. All four schemes with alternative plans can significantly reach a more stable electricity consumption along the whole day.

And the best scheme ([0,1,1,1]) with standard deviation 160.95 can improve the benchmark situation 450.02 by 64.2%. It can be inferred that, by adopting random charging plans (plan 1, 3 or 5), the households can flexibly coordinate with other candidate by shifting individual load demand to non-busy hours, which contributes to the robustness of the grid.

1. The charging steps in random charging plans do not make significance differences on the robustness of the grid.

The standard deviation of schemes with alternative plans are in the range of 160 to 188, where scheme [0,1,1,1] has the best performance. Because [0,1,1,1] uses alternative plans with 1 step charging, it will be easier to locally optimized by separating the initial starting points.

Please insert picture and graph here

### 6.2.2 Effect of flexible households on the robustness

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Experiment Reference Name | Number of Total EV | **Number of EV with alternative plans** | Scheme for Alternative plans | Car | State | Optimization goal |
| Benchmark | 1000 | 0 | [0] | Tesla | TEXAS | N/A |
| 151207\_1k\_200\_0135 | 1000 | 200 | [0,1,3,5] | Tesla | TEXAS | robustness |
| 151207\_1k\_400\_0135 | 1000 | 400 | [0,1,3,5] | Tesla | TEXAS | robustness |
| 151207\_1k\_600\_0135 | 1000 | 600 | [0,1,3,5] | Tesla | TEXAS | robustness |
| 151207\_1k\_800\_0135 | 1000 | 800 | [0,1,3,5] | Tesla | TEXAS | robustness |
| 151207\_1k\_1k\_0135 | 1000 | 1000 | [0,1,3,5] | Tesla | TEXAS | robustness |

By changing the flexible household percentage, i.e. number of EV’s with alternative plans in a fixed community, we try to discover how and how much the number of flexible households can improve the robustness of the grid. By using the same household data as 6.2.1, with fixed alternative plan scheme [0,1,3,5], we linearly increase the number of flexible household to investigate the improvement of robustness (standard deviation).

1. Increase of the flexible household percentage can improve the robustness of grid.

As percentage of flexible households increase from 0% (benchmark) to 100% (full collaboration), the positive effect on load shifting are always observed. Especially, it is obvious in the graph that the peak load value around 18:00 decreases, and the average midnight consumption increases, when increasing the flexible household percentage.

1. The grid robustness, measure in standard deviation, has negative near-linear relationship with the percentage of flexible households.

The graph X.XX, shows good linearity between these two variables. It can be inferred that, people can have a linear expectation of grid robustness improvement when increase the cooperation level of micro grid. Every marginal individual who joins the micro grid, can have a similar contribution to the robustness.

Please insert picture and table here (1 grid + 1 linear图)

### 6.2.3 Effect of household flexibility on the cost

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Experiment Reference Name | Number of Total EV | **Number of EV with alternative plans** | Scheme for Alternative plans | Car | State | **Optimization goal** |
| 151207\_1k\_200\_0135 | 1000 | 200 | [0,1,3,5] | Tesla | TEXAS | cost minimization |
| 151207\_1k\_400\_0135 | 1000 | 400 | [0,1,3,5] | Tesla | TEXAS | cost minimization |
| 151207\_1k\_600\_0135 | 1000 | 600 | [0,1,3,5] | Tesla | TEXAS | cost minimization |
| 151207\_1k\_800\_0135 | 1000 | 800 | [0,1,3,5] | Tesla | TEXAS | cost minimization |
| 151207\_1k\_1k\_0135 | 1000 | 1000 | [0,1,3,5] | Tesla | TEXAS | cost minimization |

Please insert picture here

(b)

(c)