## 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.

Firstly, all four schemes with alternative plans can significantly reach a more stable electricity consumption along the whole day, compared to benchmark. 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.

Secondly, 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 charging plans with 1 step and random starting point, it will be easier to locally separate the demand load by separate starting point. can all significantly increase the robustness of the grid consumption, by reaching a more stable energy consumption along the time.

Please insert picture and graph here

### 6.2.2 Effect of household flexibility on the robustness

Then,

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 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 | 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 |

Please insert picture here

### 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)