**6.1 Preliminary Experiment**

A micro-grid consisting of 500 households is virtually established in the preliminary experiment. Three schemes are constructed as is shown in **Table 6.1** and are simulated based on the virtual micro-grid to evaluate their performances. The purpose of the preliminary experiment is to validate the effectiveness of alternative plans and find out what can be further involved in our optimization. The the total power consumptions with different schemes as the results are illustrated inFigure 6.1.

Table 6.1 Schemes for Preliminary Experiment

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Experiment short name | Number of Total EV | Number of EV with alternative plans | Scheme for Alternative plans | Car | State | Optimization goal |
| Scheme-1 | 500 | 500 | [0,1,1,1] | Tesla | Texas | robustness |
| Scheme-2 | 500 | 500 | [0,2,2,2] | Tesla | Texas | robustness |
| Scheme-3 | 500 | 500 | [0,4,4,4] | Tesla | Texas | robustness |



Figure 1 Power consumption using different schemes with alternative plan 1, 2, 4

**Robustness of the grid**

As is shown in Figure 6.1, for the original power consumption where no alternative plans are included, there is a significant peak between *ca.* 16h00 to *ca.* 22h00 with a power load higher than 300KW and the top reaches 662KW while a valley where the power consumption is negligible occurs between *ca.* 1h00 to *ca.* 8h00. Such a drastic fluctuation has adverse effects on the robustness of the power gird.

Therefore, we evaluated the optimization of robustness using ‘MIN-DAVIATIONS’ as the selection function in this experiment. As the Figure 6.1 shows, schemes that provide the agents with alternative plans can significantly restrain the violent fluctuation of power load. Particularly with scheme 1, the peak load during 16:00 to 22:00 is perfectly shaved and these part of power consumption is redistributed to fill the power valley during 1:00 to 8:00. Throughout the day, the power consumption with scheme 1 is fluctuated mildly within the range of 100KW to 300KW. With scheme 2 and 3 respectively, there is still a peak starting around *ca.* 16:00, though the amplitude and duration have decreased. The cause of the peak can be explained as that EVs with alternative plan 2 and 4 will start charging the batteries to a certain amount of capacity immediately when arrive home.

**Cost and diurnal driving**

When off/peak electricity pricing is applied, the power price during peak hours which is usually between 12h00 to 20h00 would be higher while it is showed in the simulation result that the peak of consuming electricity to charge EVs is exactly located in the peak price range. As a result, the cost for the customers would also increase, so minimizing the cost for the customers should also be included as another optimization goal in our further study.

Meanwhile, power consumption without any optimization is shown to be very stable during day time, implying that the optimization is only needed for the peak and valley hours. Moreover, the trips in day time are less predictable so people would tend to charge as soon as it is available for charging. Therefore, we also expect that our alternative plans would not have much effect on the charging behavior in day time. This is validated in this experiment, as all of the three schemes is shown to have very similar curve during day time.

As a periodical conclusion, we have verified in the preliminary experiment that our alternative plans are effective to redistribute the energy consumption with little effect on people’s driving behavior during day time. But the alternative plan 2 and 4 should be modified to further shave the peak by introducing randomness to the starting point of charging.