Introduction
The increasing penetration of renewable energy in power grids requires to reallocate an adequate level of controllability to ensure reliable power system operation. An emerging mainstream concept to solve this problem is achieving the controllability of portions of distribution networks to satisfy the assigned trajectory of the active and reactive transits within the framework of deploying battery energy storage system (BESS) and demand response (DR) programs. Achieving dispatchability of a distribution feeder is realistic way to reduce the uncertainty of distributed generation (DG) within the existing power grids in the step-by-step deployment of the concept of smart grids.

Theory/Method/Hypothesis
The proposed method in [1] to realize the dispatchability of the distribution feeder utilize a BESS, receding horizon model predictive control (MPC) and adaptive data-driven consumption forecasting within the framework of day-ahead and intra-day operation. The configuration is shown in the following figure.

Follow the idea of dispatching a distribution feeder in [1], there are three main aspects involved in the performance of dispatchability of the feeder. This thesis mainly focuses on these three aspects to improve the original configuration.

A) In the original configuration, a non-convex MPC problem is set up based on the non-linear battery model which was proposed in [2]. It is obvious that non-convex problem doesn’t work very well in MPC problem because the non-convex problems are hard to solve exactly in a reasonable time and can’t always ensure a global optimum solution. It is necessary to simplify the original battery model to obtain a convex MPC problem, which may sacrifice the non-linear characteristics of the battery model at the same time. So convexification of the original MPC problem involves compromises.

B) The dispatchability of the distribution feeder relies a lot on the size of the BESS. A larger size of the BESS definitely can ensure better dispatchability of the feeder. But at the same time, the operator needs to consider the investment of the BESS because a high cost of the BESS may have not economic benefits in return. So an appropriate size of the BESS needs to be selected if the configuration is implemented in hardware.

C) An accurate day-ahead forecasting method largely decides the performance of dispatchability of the distribution feeder. A simple data-driven consumption forecasting method is applied in the original configuration. Based on the data analysis of power consumption, a method of considering the long-term forecasting bias based on the seasonal variations of power consumption is a possible step to improve the original day-ahead forecasting method.

Results
With respect to the work of [1], three main aspects involving the performance of the dispatchability are investigated in the thesis.

1. Convexification of the non-convex MPC problem: Based on the two time constant (TTC) equivalent circuit of the lithium-ion battery, a convex MPC problem with the extracted power of the battery cell as its control variable is set up based on approximations. The performance of the convex MPC is compared with the original non-linear MPC. The simulation results show that the new convex MPC doesn’t impact the performance of dispatchability, which is shown in the above figure.

2. Determination of the size of the BESS: A data analysis method of determining the size of the BESS based on a concept of day-based confidence level of dispatchability is presented.

3. Improvement of the day-ahead forecasting method: From the data analysis, it shows that there is forecasting bias because of the seasonal changes of power consumption. A method of compensating the original day-ahead forecasting method considering the long-term forecasting bias is demonstrated in this thesis.

Conclusion/Perspectives
The thesis focuses on the three aspects to integrate and improve the work in [1]. A novel convex MPC is proposed to control the BESS for dispatching the distribution feeder. In addition, a simple method to select the size of the BESS is presented based on the day-based confidence level. Finally, a concept of improving the day-ahead forecast method by taking the long-term variation of power consumption into consideration is proposed and verified.

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References