Microgrid operation port louis

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Conventionally, seaports only provide logistic services to berthing ships, including berth allocation [5,6,7] and quay crane (QC) assignment for handling cargos on ships [8,9,10], which are the emphasis of most existing literatures in maritime community. However, these studies only focus on transportation efficiency while completely ignoring energy management associated with these industrial processes. As a results, seaports consume a large amount of fossil energy, leading to noise and air pollutions on the harbor territory.

Based on the above discussion, it can be found that there may lack a coordination between berth allocation and power dispatch in seaport microgrids considering the multiple uncertainties of AES arrival and renewable generation. To fill the existing research gaps, this chapter proposes an optimal joint scheduling strategy to coordinate power dispatch and berth allocation in a uniform framework under the mentioned multiple uncertainties.

This study aims to jointly schedule berth allocation process of AES and the power dispatch of green port microgrids to improve energy efficiency and economic benefits. Figure 11.1 illustrates a typical structure of port microgrids. On the shore-side, a renewable energy-based microgrid combining onsite photovoltaic (PV), battery energy storage system (BESS), dispatchable distributed generator (DG) and substation connecting to the main grid provides electricity for power loads on both shore-side and ship-side. On the ship-side, AESs anchor to wait firstly when arrive the seaport. Then the seaport allocates berths to the anchoring AESs. At the same time, certain number of QCs are assigned for berthing AESs for cargo handling tasks.

Schematic diagram of port microgrids

The coordination between berth allocation and power dispatch is executed by seaport control center shown in Fig. 11.1. The microgrid determines unit commitment of DGs, charging and discharging power of BESS, power output of PV array and power flow in electrical networks. The decisions of ship-side includes the berthing position and duration of each AES, and the number of QCs assigned for each AES at each time slot. By jointly optimizing the decisions of microgrids and ship-side under the uniform management of seaport control center, an optimal joint scheduling scheme that can achieve the balance between electricity supply costs and AESs service efficiency can be obtained.

The objective of ship-side is to minimize the total service time of AES, which is measured differently from the electricity supply costs of microgrids. To compare the benefits between power dispatch and berth allocation, berthing related cost coefficients are introduced to convert service time of AES into economic costs. Then, the objective function of deterministic joint optimization model can be formulated to minimize the total costs of microgrid operations and AES berth allocation services as follows:

The first and second terms are electricity supply costs of microgrids, which includes the start-up and shut-down cost of dispatchable DGs, electricity purchase cost from the main grid, and generation cost of dispatchable DGs. The third term is the equivalent economic costs of AES berth allocation services, which includes the waiting and berthing costs of AES.

Berth Allocation of AES

To establish the bridge between berth allocation and power dispatch, we improve the traditional AES service order-based berth allocation model by replacing the binary variable fbsk with a new time-indexed binary variable fbst. The binary variable fbst represents ship s is served at berth b at time slot t if fbsk = 1. In this way, the power demands of AES can be expressed mathematically. Meanwhile, the time-indexed model can still formulate the process of berth allocation. Therefore, the time-index model mathematically couples berth allocation and power dispatch. The time-indexed berth allocation model is formulated as follows:

Equation (11.2) can be linearized by big-M method as follows:

where B is the set of berths.

Constraints (11.3) and (11.4) ensure that the AES cannot change its berthing position once it starts berthing. Constraints (11.5) and (11.6) ensure that the binary variable fbst is equal to 1 only when the AES s is served at berth.

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