DECENTRALIZED MICROGRID COORDINATION USING MULTI-AGENT SYSTEMS

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Abstract - Microgrid (MG) networks are expected to help increase grid flexibility and the integration of renewable generation. To improve network cooperation performance, this paper proposes a novel distributed control strategy to manage energy flows using a multi-agent system. Power dispatching is achieved through flexible electricity markets to maximize MG profit. A distributed power flow calculation algorithm is proposed to guarantee that the power flow in the network is within line capacity. Simulation shows that the control strategy manages to ensure MG power balance while maximizing profit. Additionally, the power flow is within line capacity to guarantee system security.

Keywords – micro grid, multi-agent system, power management, distributed system, optimization

1. INTRODUCTİON

For their operators, MGs are expected to help supply loads reliably and facilitate efficient renewable generation integration. However, as in current power systems, coordination among MGs could provide addition stability benefits, that individual MGs could not achieve. In this paper, two aspects of coordination are considered. The first is power dispatching, i.e., how MGs can trade power with each other. Then, results feasibility must be checked for line capacity violations.

2. CONTROL STRATEGY

2.1. POWER DİSPATCHİNG

Events such as failures and faults can cause power imbalance in MGs. To reduce load shedding and generation curtailment, neighboring MGs can assist each other to compensate imbalances, while maximizing participators profit. Here, each agent controls an MG, monitors its facilities and negotiates with neighbor agents. An MG with insufficient generation is called a requester, and establishes an electricity market [1] to obtain the neighbours' power price and volume and divide the demand among them. A priority order is used, e.g., more power is taken from cheaper MGs.

2.2. POWER FLOW CALCULATİON

As power supplied by one MG to others changes, power flows in the network change. However, line flow capacities (lines interconnecting MGs only) limit power transfers, the security of the network should be check during the trading. Here, a distributed algorithm is run to obtain the connecting lines flow, as in equations (1)—(3) [2].

$$\Delta p_{n-1,s} = p_{n-1,s} - v_{n-1} \sum_{j\in(n-1)} v_j (g_{n-1,j}\cos\theta_{n-1,\mathrm{j}} + b_{n-1,j}\sin\theta_{n-1,\mathrm{j}}) = 0 \quad (1)$$

$$\Delta p_{n-1,s} = p_{n-1,s} - \sum_{j\in(n-1)} (g_{n-1,j} + b_{n-1,j}\theta_{n-1,\mathrm{j}}) \quad (2)$$

where θ is the MG voltage angle. (1) is the power flow iteration equation. $p_{n-1,s}$ is the output power of MGs at the $(n-1)th$ iteration step. The second item in (1) is the sum of power flowing on the connecting lines. v is the voltage magnitude. $g_{n-1,j}$ and $b_{n-1,j}$ are the line conductance and susceptance between MGs $(n-1)$ and j. $\Delta p_{n-1,s}$ is the error value for the θth iteration. This paper assumes that the voltage magnitude is 1 as only the active power is discussed. Assuming angles are small, $\cos\theta \approx 1$, $\sin\theta \approx \theta$. Substituting into (1), the power flow calculation becomes (2). Finally, in (3), a is an iteration parameter to correct the voltage angle:

$$\theta_{n,s} = \theta_{n-1,s} + a \times \Delta p_{n-1,s} \quad (3)$$

2.3. RESULTS

The simulated system contains 13 MGs. Results show that during the fault period at 54 min, the average load shedding is 204.79 W without coordination. With coordination, the load shedding is cancelled and the total electricity trading cost is 79.44€. Comparing power flows on the line between MGs 3 and 2, there is a 3.7% average error. Overall, results show that the reliability and efficiency of operation of the system is improved.

CONCLUSİON

This work shows that through coordination, networked MGs can mutually benefit from assisting each other in case of difficulty.

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