Microgrid and Grid Stabilization Technologies for Renewable Energy and Data Center Applications

BLEnDer RE

1. Data Center Challenges

As data centers grow in scale, the following challenges are becoming increasingly significant:

- ✓ Power supply constraints
- ✓ AI-driven load fluctuations
- ✓ Renewable energy integration

To address these challenges, demand for microgrid and BESS-based solutions is growing. This presentation proposes a data center microgrid solution leveraging:

- ✓ Islanded microgrid technologies
- ✓ Large-scale BESS technologies

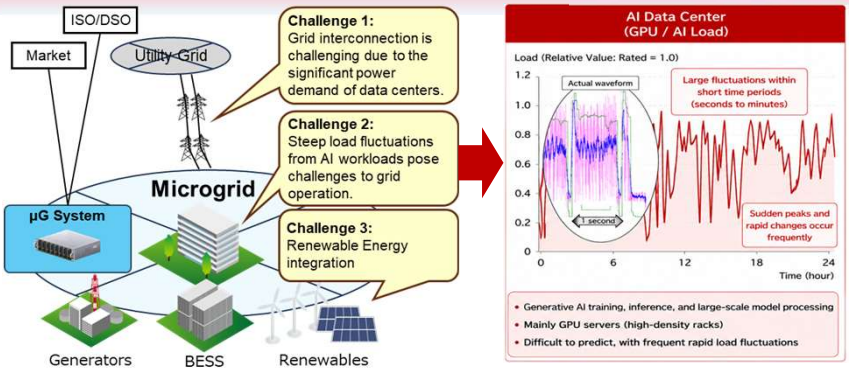


Fig. 1. Data Center Challenges and AI Workload Characteristics

2. Microgrid Applications for Data Centers

Data centers require both Grid Stabilization and Economic Load Dispatch to manage load fluctuations ranging from milliseconds to hours. (Fig. 2)

① Grid Stabilization (Fig. 3)

- ✓ ΔF and ΔP control for rapid supply-demand balancing
- ✓ Timescale: milliseconds to 1 minute

② Economic Load Dispatch (Fig. 4)

- ✓ Optimization of generators, market transactions, and BESS
- ✓ Minimization of operating costs
- ✓ Timescale: min to days

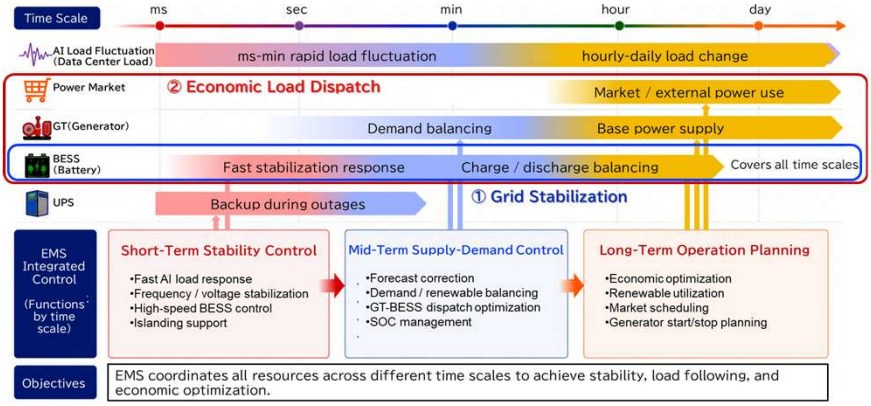


Fig. 2. Coordinated Grid Stabilization and Economic Load Dispatch

⊿F	✓ Detects frequency fluctuations and applies feedback control according to the rate of change. ✓ Operates about 0.5 seconds after the event occurs.
⊿P	✓ Detects the mismatch between mechanical input and electrical output of synchronous generators directory at high speed and applies feedforward control. ✓ Operates about 0.1 seconds after the event occurs.

⊿F+⊿P results in less frequency fluctuation and allows to return to the reference frequency more quickly.

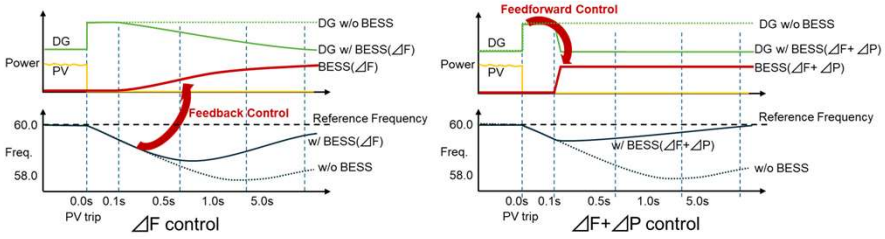
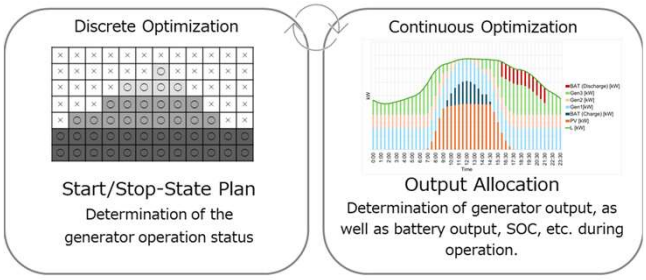


Fig. 3. Grid Stabilization functions



Function Objective : Cost Minimization

Fig. 4. Economic Load Dispatch

By combining Grid Stabilization and Economic Load Dispatch, the proposed solution enables:

- ✓ Mitigation of AI data center load fluctuations from milliseconds to days
- ✓ Stable and reliable power supply
- ✓ Market-aware operation optimization
- ✓ Reduced electricity and operating costs

As a result, the proposed microgrid solution achieves both reliability and economic efficiency. (Fig. 5)

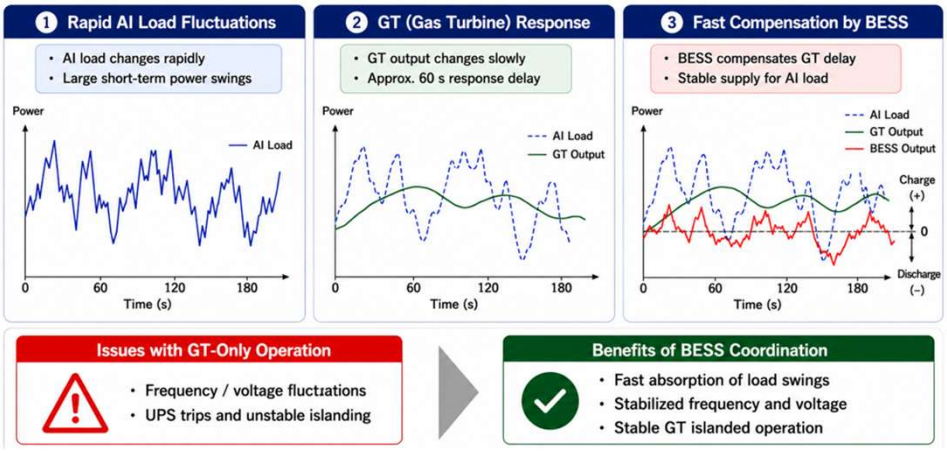


Fig. 5. Enhancing GT Operation through BESS-Assisted Load Balancing

3. Application Examples

- ✓ Islanded Microgrid (Oki Islands, Japan) : Energy management and ΔP/ΔF control
- ✓ Large-Scale Grid-Connected : BESS 240MW / 720MWh control system

➧ Proven technologies for AI data center microgrids