Study Committee C6

Active Distribution Systems and Distributed Energy Resources

Paper C6_10825_2022

# Enhancing grid resilience and flexibility with sustainable data centers

S. Trolle, A. Oudalov, K. Lainez Amaya, M. Giese, M. Larsson, S. Porras Aparicio

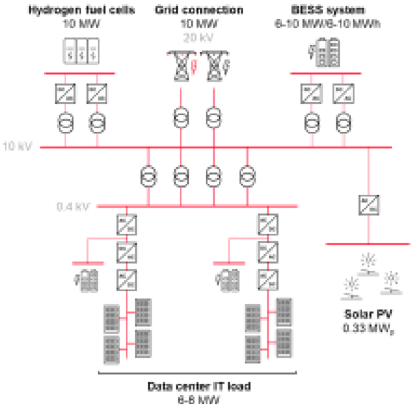
Hitachi Energy

## Motivation

- Data centers are becoming an increasingly **large part of the global energy usage**, potentially exacerbating power grid congestion in urban areas.
- As data centers move toward sustainable on-site power sources, they could possibly play a role as **large, distributed assets for grid flexibility and stability**, providing grid support services.
- The aim of this study is to assess technical feasibility and economic viability of a **data center sustainable microgrid** providing ancillary services such as frequency and voltage support, and flexible demand.

## Approach

- Two systems A and B were defined for a medium-sized data center with **10 MW nominal power** demand, assumed to be connected to a 20 kV medium voltage grid in Europe.
- System A was defined as a conventional data center with on-site diesel generators.
- System B was defined as a data center microgrid with battery energy storage (BESS), hydrogen fuel cells and solar photovoltaic (PV) power.
- The capability of providing frequency and voltage support as well as other ancillary services, such as flexible demand, was evaluated through different simulation models.

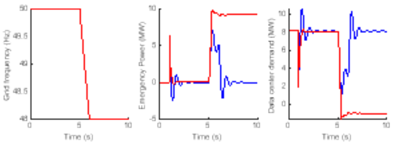



## Objects of investigation

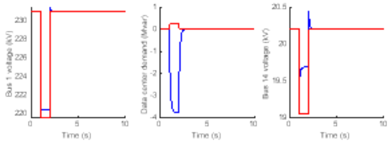
- BESS response to **grid phase step and frequency ramp** in inertia mode and frequency sensitive mode.
- BESS response to **voltage dip in surrounding grid** and impact on downstream grid.
- Operation of a data center microgrid providing **flexible power demand**, including total cost of ownership (TCO) and levelized cost of energy (LCOE).
- Impact on **TCO, LCOE and emissions in operation** with varying utilization of data center on-site sources.

## System modelling and results

- An electromagnetic transient simulation model was used for simulations of a data center BESS with grid forming control.
- The results showed that the **BESS can provide adequate response to frequency deviations** through power injections proportional to the frequency rate-of-change for a shorter or longer time period.



- The BESS was also shown to be able to **improve the voltage profile of the surrounding grid** in case of moderate voltage dips and could thus contribute to voltage management in the local grid.



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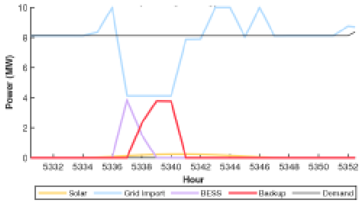
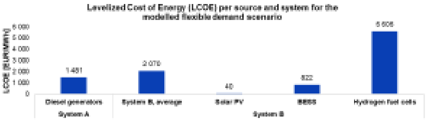
## System modelling and results

- For evaluation of flexible demand provisions, a simulation model was utilized that optimized use of the on-site sources based on technical and economical constraints.
- As a result, a slightly larger share of energy was supplied from the hydrogen fuel cells during these events due to the energy limitations of the BESS.




| System | Source | Base scenario | Flexible demand |
|---|---|---|---|
| A | Grid to data center | 70 182 | 69 582 |
| | Data center on-site sources | 0 | 600 |
| | Diesel generator | 0 | 600 |
| B | Grid to data center | 69 763 | 69 465 |
| | Data center on-site sources | 419 | 1 002 |
| | Solar PV | 419 | 419 |
| | BESS | 0 | 253 |
| | Fuel cells | 0 | 330 |




| Source | CAPEX | OPEX Annual, fixed | OPEX Annual, variable | Fuel/energy 2021 level | Fuel/energy 2041 level |
|---|---|---|---|---|---|
| Diesel generators | 600 €/kW | 34.5 €/kW | 0.02 €/kWh | 1.6 €/l | 2.4 €/l |
| Fuel cell system | 2 500 €/kW | 34.5 €/kW | 0.0006 €/kWh | 5 €/kg | 3.3 €/kg |
| Fuel cell system refurbishment | 750 €/kW | - | - | - | - |
| BESS | 400 €/kW | 9 €/kW | 0.0003 €/kWh | 0.13 €/kWh | 0.19 €/kWh |
| BESS refurbishment | 240 €/kW | - | - | - | - |
| Solar PV | 750 €/kW | 17 €/kW | - | - | - |

## Discussion

- In the modelled scenario, total LCOE for System B was higher than for system A but would **decrease faster with increased use** due to lower OPEX.
- Cost parity for the modelled systems would occur at between **2 200-4 000 MWh energy** supplied per year, depending on assumed CAPEX.
- This points to a rationale for **increasing the use beyond only back-up power** for data centers which have such sources on site, for example through providing ancillary services.
- **Market models for ancillary services** are needed that can accommodate a wide range of services and that reflects the increased deployment of converter-based sources and renewables.
- Ancillary service markets could provide an offset to the high CAPEX of these technologies, increase their adoption rate, and in addition to enhancing the grid resilience and flexibility also **reduce the $CO_2$-intensity of the overall energy mix**.

## Conclusions

- The transition toward sustainable data centers can yield benefits for both data center- and grid operators.
- A large data center **BESS can provide frequency and voltage support to the surrounding grid**, and a sustainable **data center microgrid can provide ancillary services** which would generate revenues to accelerate adoption of these solutions.
- Increased use of sustainable on-site power sources could also **reduce the need for marginal power generation** and lower the overall $CO_2$-intensity of power supplied from the grid.