

Study Committee C6

Active distribution systems and distributed energy resources

10281

A Study on the Self-sufficient and Flexible Operation Strategies of Distribution System with High Levels of Renewable Energy

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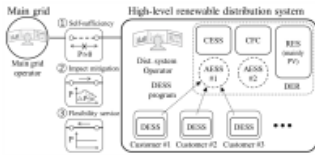
Korea Electrotechnology Research Institute

Introduction

RE : Global Energy Transition

- Keys for high renewable penetration
 - Interconnection & interoperability
 - Accurate forecast
 - Operation strategy & technique
- Operational requirements
 - Energy self-sufficient
 - Variability mitigation
 - Flexibility

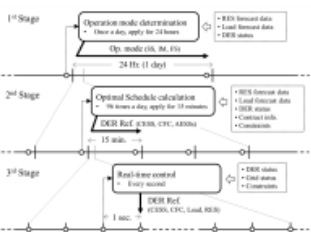
High-Level RE Distribution System



High-Level RE Dist. System

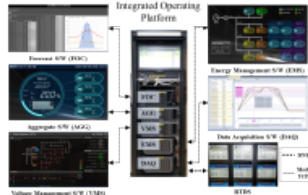
- Definition
 - Dist. system with RESs, DERs and loads
 - 1MW ~ 10MW
- Main components
 - DSO owned central ESS, FC (CESS, CFC)
 - RES (mainly PV)
 - Customer owned decentralized ESS (DESS)
 - Integrated operating platform
- Assumptions
 - Supply power using CFC and PVs
 - Flexible service contracts with the main grid
 - Bilateral contract and utilizes DESSs

Operation Strategy



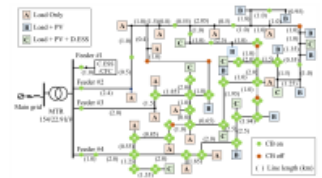
- Hierarchical structure
 - Op. mode determination (once per day)
 - Optimal schedule (once per 15 min.)
 - Real-time control (every sec.)

HILS Verification Environment



- Dist. system-integrated operating platform
 - Energy & voltage management
 - RES forecast
 - DESS aggregator
 - Date acquisition & monitoring

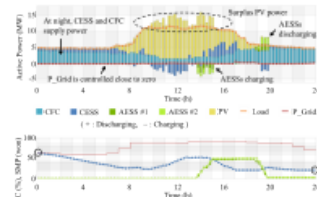
- HILS environment
 - RTDS based dist. system modeling
 - Long-term real-time simulation



| Components | Parameters |
|------------|--|
| MTR | 0.65 A, 60 MVA, 154/22.9 kV |
| Feeder 1 | 1.20 km |
| Feeder 2 | Max. 34.19 km |
| Feeder 3 | Max. 16.62 km |
| Feeder 4 | Max. 30.94 km |
| | Total 43.55 km |
| Loads | Total 23 MW (34 places) |
| PV | Total 17.5 MW (19 places) |
| CESS | 5 MW / 25 MWh (1ea) |
| CFC | 5 MW (1ea) |
| AESS | AESS1 2 MW / 4 MWh (Aggregated, DESS 4ea) AESS2 2 MW / 4 MWh (Aggregated, DESS 4ea) |
| CB | 39 ea (Avg. 1.16 km/ea) |

Numerical Tests

- Self-sufficient (SS)
 - Pgrid is controlled close to zero
 - Supplied power with PVs, the CFC, and ESSs
 - Accurate forecast

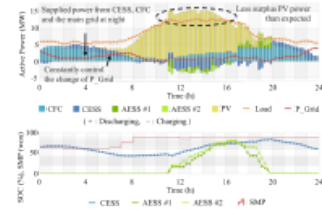


| Type | Scheduled Output Power [kW/h] | Actual Output Power [kW/h] |
|--------------|-------------------------------|----------------------------|
| PV | 84,586 (51.1%) | 90,347 (50.0%) |
| CFC | 72,890 (43.9%) | 79,100 (44.3%) |
| | (Avg. 3,037 kW) | (Avg. 3,295 kW) |
| CESS | 8,337 (5.0%) | 7,910 (4.4%) |
| | (SOC: 60%~>20%) | (SOC: 60%~>20%) |
| Total Output | 346,212 (100.0%) | 378,521 (100.0%) |
| Load | 165,860 | 174,352 |

- Flexibility service (FS)
 - excessive PV power
 - Send power to the main grid (FS time)
 - Accurate forecast

| Type | Scheduled Output Power [kW/h] | Actual Output Power [kW/h] |
|--------------|-------------------------------|----------------------------|
| PV | 113,060 (109.8%) | 111,798 (107.7%) |
| CFC | 59,523 (57.8%) | 54,385 (52.4%) |
| | (Avg. 2,480 kW) | (Avg. 2,266 kW) |
| CESS | -2,053 (-2.0%) | 1,766 (1.7%) |
| | (SOC: 20%~>20%) | (SOC: 20%~>20%) |
| Grid | -67,582 (-65.6%) | -60,634 (-58.4%) |
| Total Output | 302,949 (100.0%) | 303,793 (100.0%) |
| Load | 102,127 | 103,087 |

- Impact mitigation (IM)
 - SS is not possible (less PV power)
 - Change of the Pgrid is controlled



| Type | Scheduled Output Power [kW/h] | Actual Output Power [kW/h] |
|--------------|-------------------------------|----------------------------|
| PV | 123,050 (100.7%) | 109,383 (94.6%) |
| CFC | 68,940 (54.0%) | 62,880 (51.4%) |
| | (Avg. 2,873 kW) | (Avg. 2,620 kW) |
| CESS | 7,416 (5.7%) | -70 (0.0%) |
| | (SOC: 60%~>20%) | (SOC: 60%~>60%) |
| Grid | 3,125 (1.6%) | 29,933 (15.0%) |
| Total Output | 202,533 (100.0%) | 200,084 (100.0%) |
| Load | 201,720 | 199,350 |

