



Best Practices in Power System Operation and Grid Management

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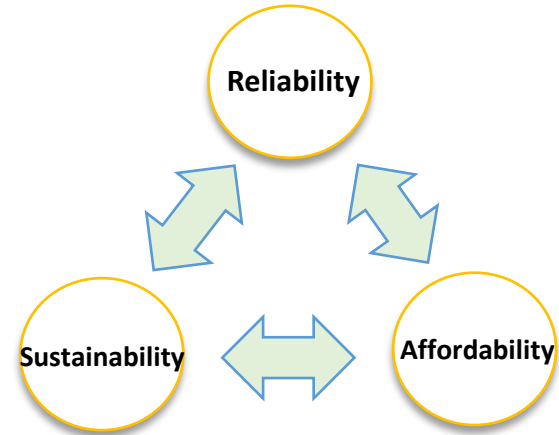
Naypyitaw, Myanmar

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Overview of Modern Grid Management

- **The Trilemma:** Balancing Reliability, Sustainability, and Affordability.
- **The Evolution:** Transitioning from unidirectional grids to dynamic, bidirectional smart grids.
- **Core Principle:** Maintaining instantaneous balance between supply and demand 24/7.



Load Forecasting

PILLAR 1: OPERATIONAL PLANNING

- **Short-Term Load Forecasting (STLF):** next hour to 7 days, Monthly and Yearly
- **Long-Term Load Forecasting:** 5 Years ahead Demand Forecasting.
- **Data Inputs:** Historical load patterns, weather data, and socioeconomic factors.
- **Best Practice:** Utilizing Computer Aid Model to reduce forecast error margins.

Unit Commitment and Economic Dispatch

PILLAR 1: OPERATIONAL PLANNING

- **Unit Commitment (UC):** Determining which generators to start up or shut down over a 24-hour cycle.
- **Economic Dispatch (ED):** Optimizing the output of online generators to meet demand at the lowest cost.
- **Goal:** Maximizing efficiency while respecting generator ramp rates and constraints.

Outage and Maintenance Planning

PILLAR 1: OPERATIONAL PLANNING

- **Scheduled Maintenance:** Coordinating generator and transmission outages (Substations, Line etc), without compromising grid security.
- **Risk Assessment:** Performing grid simulation before approving any major line shutdown.
- **Objective:** Minimizing system congestion and energy price spikes during maintenance.

Grid Situations(SCADA / EMS)

PILLAR 2: REAL-TIME OPERATION

- **Centralized Command:** Utilizing SCADA (Supervisory Control and Data Acquisition) for real-time visibility.
- **EMS Integration:** State Estimation, Power Flow studies, and Alarm processing.
- **Best Practice:** Clean visual dashboards for operators to identify anomalies instantly.

Frequency Control (Active Power Balance)

PILLAR 2: REAL-TIME OPERATION

- **Normal Operation:** 49.5 ~ 50.5 Hz
- **Primary Control (Governor Response):** Immediate, automatic response to arrest frequency drops (seconds).
- **Secondary Control (LFC/AGC):** Centralized automated signal to restore frequency to nominal 50 Hz/60 Hz (minutes).
- **Tertiary Control:** Manual dispatch adjustments to restore operating reserves.

Voltage Control (Reactive Power Balance)

PILLAR 2: REAL-TIME OPERATION

- **Voltage Profile:** Keeping system voltage within strict statutory limits (+/- 5%) for System Normal Condition and (+/- 10%) for System Abnormal Condition.
- **Control Assets:** Adjusting Transformer Taps, Shunt Capacitors, Reactors, and Generator excitation.
- **Dynamic Support:** Utilizing SVCs and STATCOMs for rapid, dynamic voltage regulation.

Grid Congestion Management

PILLAR 2: REAL-TIME OPERATION

- **Thermal Limits:** Ensuring transmission lines do not exceed their physical capacity.
- **Re-Dispatching:** Managing generator outputs to shift power flow away from overloaded lines.
- **Dynamic Line Rating (DLR):** Utilizing real-time weather Condition, CT Rating to unlock hidden transmission capacity.

System Security & N-1 Criterion

PILLAR 3: RELIABILITY AND SECURITY

- **The N-1 Standard:** The grid must survive the sudden loss of any single critical Component (line or generator) without collapsing.
- **Cascading Failure Prevention:** Isolating faults quickly to protect the wider system.
- **Best Practice:** Dynamic contingency lists updated in the control center regularly.

Contingency Analysis

PILLAR 3: RELIABILITY AND SECURITY

- **What-If Simulations:** Offline software running thousands of failure scenarios effectively.
- **Corrective Actions:** If a potential violation is detected, operators shift generation as required.
- **Operational Reserves:** Maintaining spinning and non-spinning reserves for instant deployment. Spinning reserves is now available 2%.

Power System Stability

PILLAR 3: RELIABILITY AND SECURITY

- **Rotor Angle Stability:** Generators must remain in synchronism.
- **Voltage Stability:** Preventing heavy reactive load from triggering a voltage collapse.
- **Small-Signal Stability:** Monitoring and damping low-frequency oscillations across the grid.

Renewable Energy Integration

PILLAR 4: MODERN GRID CHALLENGES

- **Challenge of Intermittency:** Managing sudden drops in Solar outputs.
- **Flexible Generation:** Balancing renewables using fast-ramping gas turbines and hydro plants, BESS.
- **Fault Ride-Through (FRT):** Enforcing grid codes so renewable plants do not trip during minor grid disturbances. But Grid Code is finished as final draft.

Battery Energy Storage Systems (BESS)

PILLAR 4: MODERN GRID CHALLENGES

- **Fast Frequency Response:** BESS can inject or absorb power in milliseconds.
- **Peak Shaving:** Storing excess solar energy during the day and discharging it during peak evening loads.
- **Grid Shifting:** Deferring expensive traditional transmission upgrades.

Demand-Side Management

PILLAR 4: MODERN GRID CHALLENGES

- **Load Shifting:** Incentivizing consumers to shift heavy usage to off-peak hours. Planned Load Shedding is applied during Dry Season.
- **Demand Response:** industrial loads shutting down during peak grid stress.
- **Advanced Metering (AMI):** Two-way communication between utility and consumers for smart usage.

Cyber Security in Power Grids

PILLAR 5: RESILIENCE AND RECOVERY

- **The Threat:** Increasing digitalization creates access points for cyber warfare attack and malware.
- **Defense-in-Depth:** Air-gapped control networks, strict firewalls, and multi-factor authentication. Existing SCADA- EMS system applies these defense.
- **Asset Hardening:** Continuous scanning for substations and smart relays.

Black Start and Disaster Recovery

PILLAR 5: RESILIENCE AND RECOVERY

- **The Black Start Unit:** Hydro or diesel generators capable of starting without external grid power.
- **Restoration Path:** Step-by-step restoration of lines and connecting power to base-load plants.
- **Regular Drills:** Testing communication channels(PLCC, Fiber) and restoration procedures regularly.

Dispatcher Training and Simulation (DTS)

PILLAR 5: RESILIENCE AND RECOVERY

- **The Simulator for Grids:** Simulating blackouts, major faults for operators.
- **Operator Decision:** Reducing human error under high-stress scenarios.
- **Best Practice:** Making DTS certification mandatory for all control room personnel. DTS system is now under implementation stage.

Conclusion and The Way Forward

- **Approach:** Grid management requires a proper link between Planning, Operation, and Resilience.
- **Technology:** AI, Energy Storage, and Automation are no longer optional—they are essential.
- **The Goal:** A secure, zero-carbon, and highly efficient power ecosystem.

Thank You

For your Attention