BATTERY ENERGY STORAGE SYSTEM- DRAFT GUIDELINES

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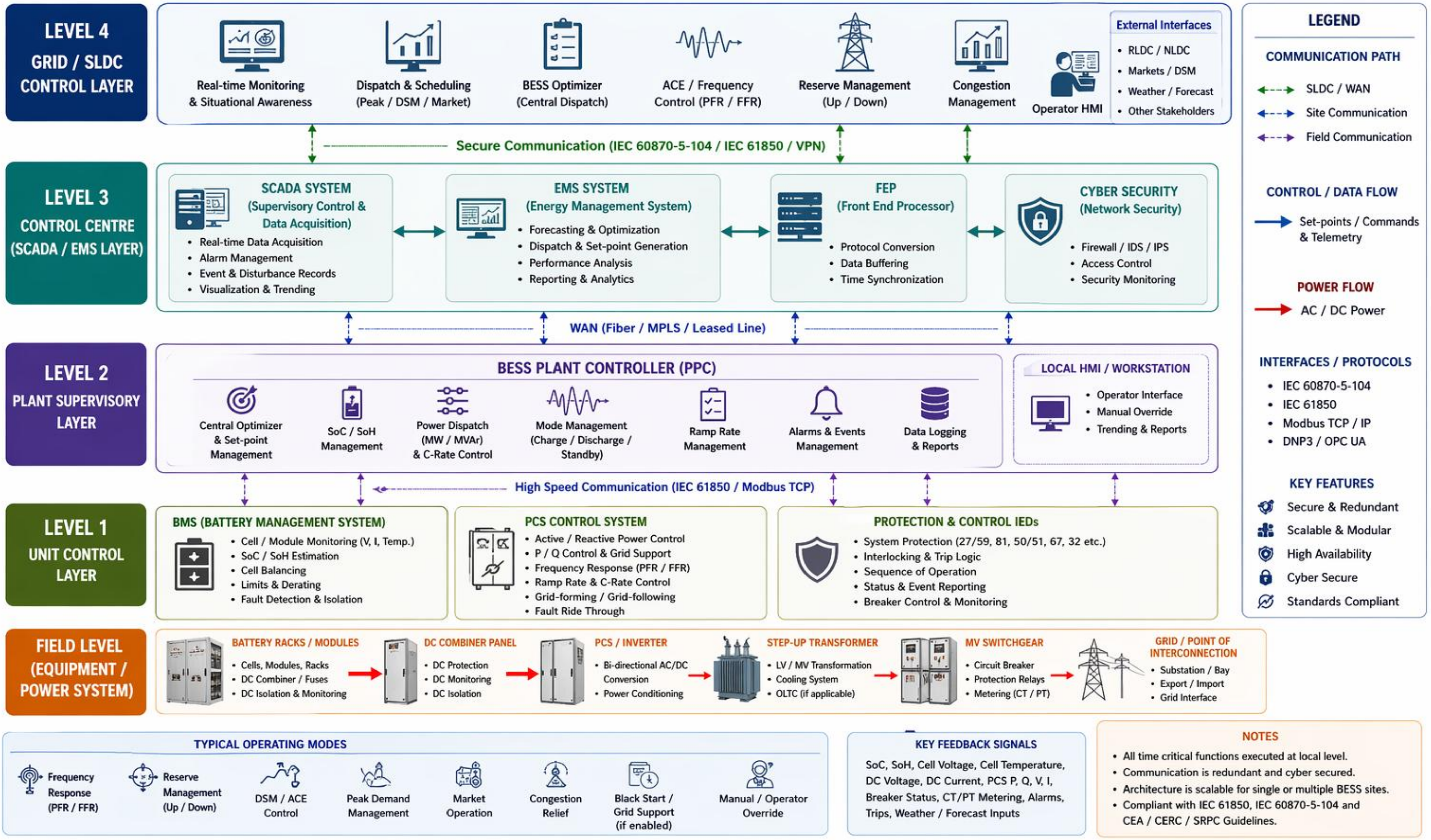
KSEB

BATTERY ENERGY STORAGE SYSTEM (BESS) – CONTROL & COMMUNICATION ARCHITECTURE

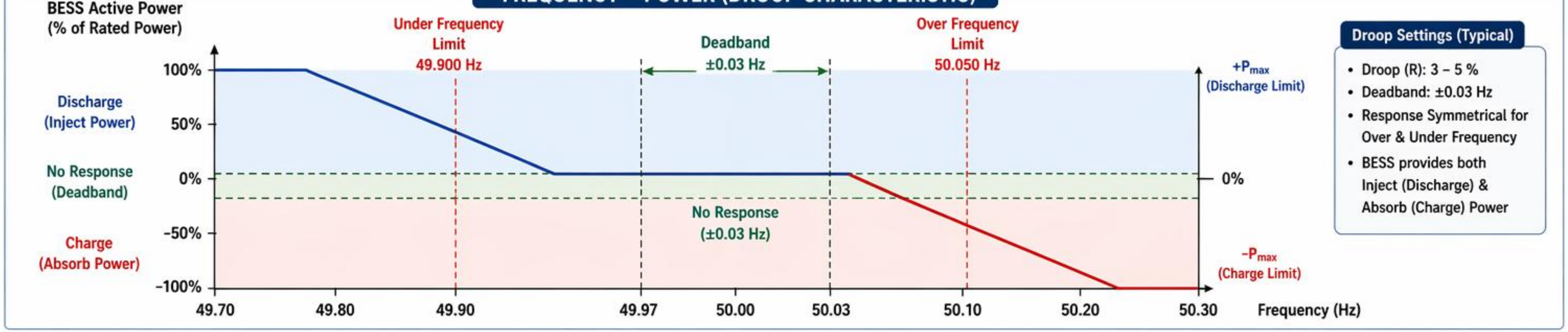
Hierarchical Control Structure from SLDC to Field Level



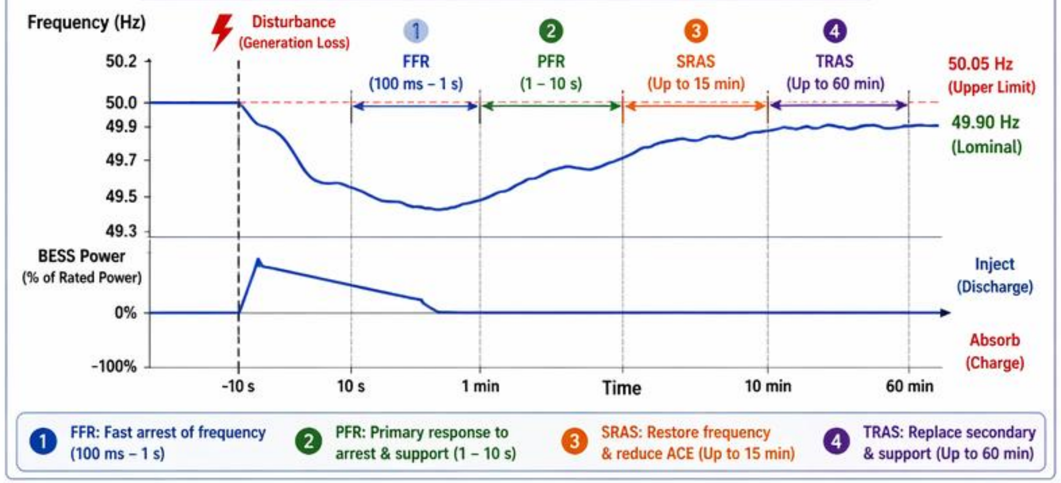
BESS FREQUENCY RESPONSE – PFR & FFR (AS PER INDIAN GRID CODE)

Nominal Frequency: 50.000 Hz | Allowable Operating Band: 49.900 – 50.050 Hz

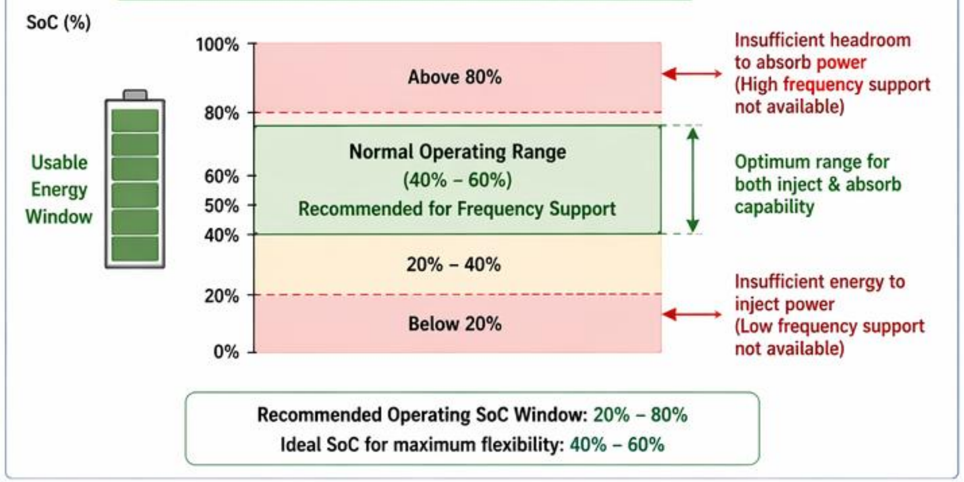
FREQUENCY – POWER (DROOP CHARACTERISTIC)



FREQUENCY EXCURSION & BESS RESPONSE (EXAMPLE: GENERATION LOSS)



BESS SOC WINDOW FOR FREQUENCY RESPONSE



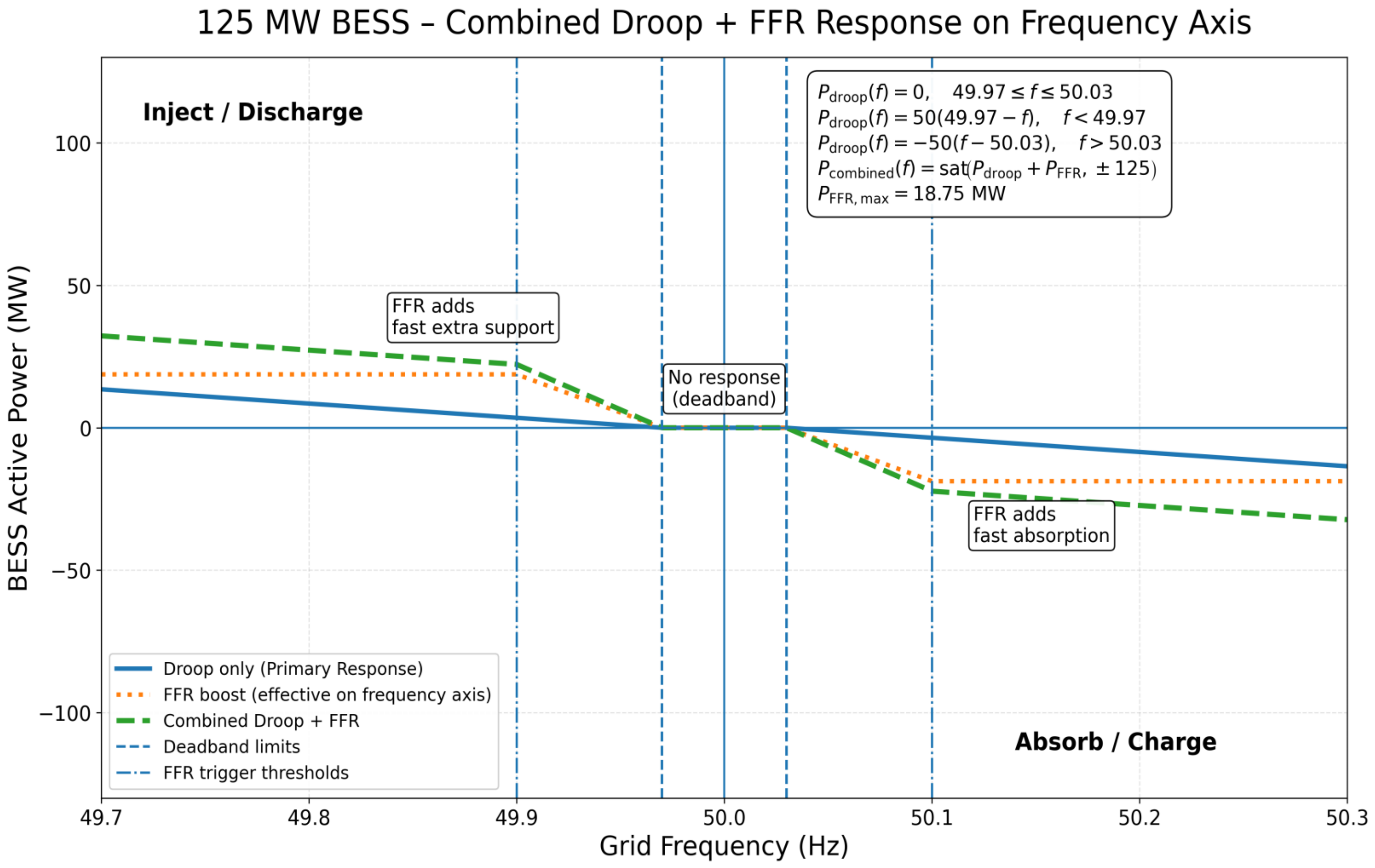
BESS ADVANTAGE FOR FREQUENCY RESPONSE

OPTIMUM RESERVE (TYPICAL GUIDANCE)

Primary Reserve (PRAS)	Secondary Reserve (SRAS)	Tertiary Reserve (TRAS)	SoC Margin
10% – 15% of BESS Rated Power (Immediate – 45 s)	15% – 25% of BESS Rated Power (Upto 15 min)	20% – 30% of BESS Rated Power (Upto 60 min)	20% – 80% (Use mid SoC 40% – 60% for best flexibility)

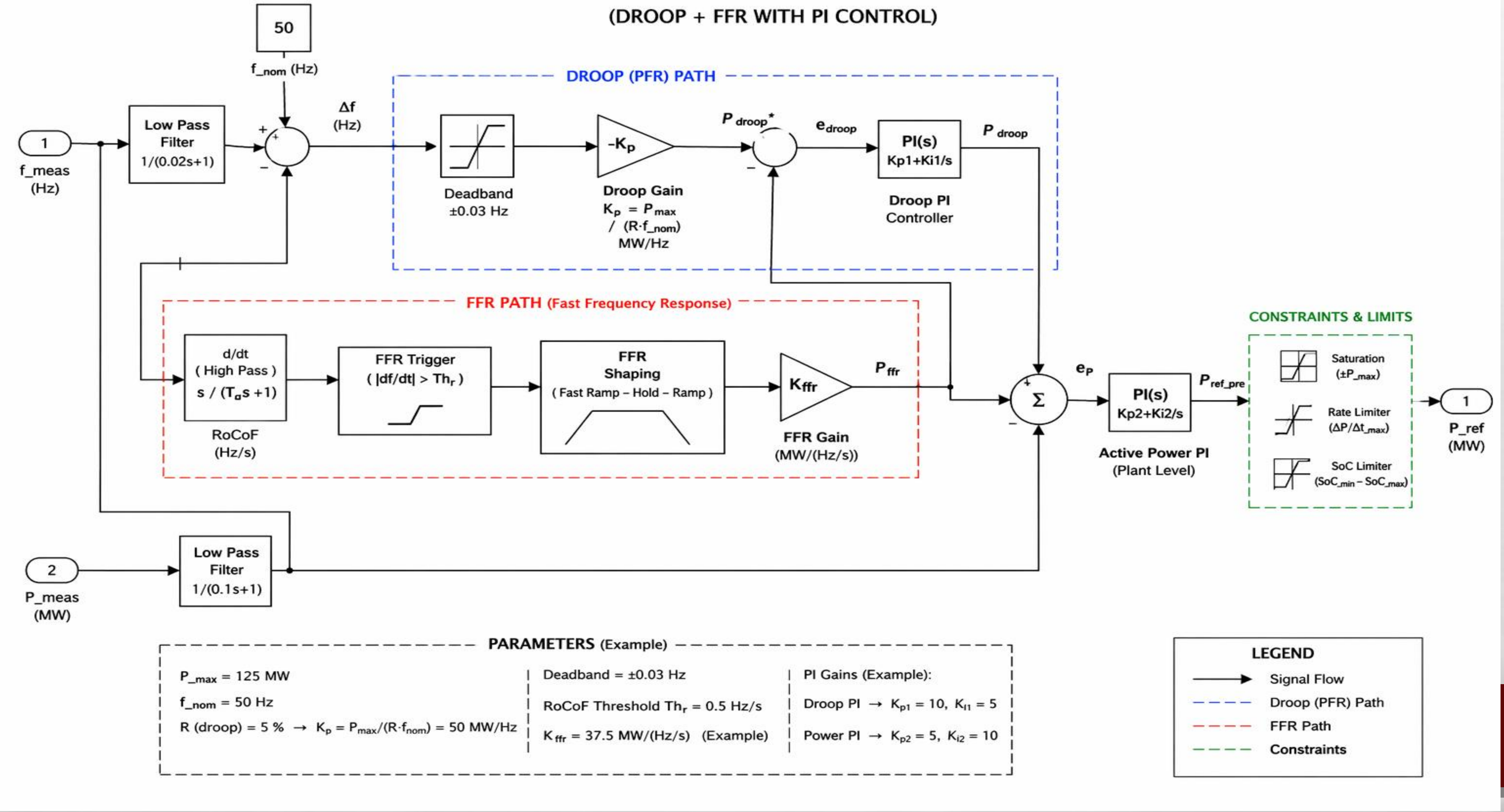
Reference: Indian Electricity Grid Code (IEGC), 2023 – Regulation: 74 (Frequency Control & Reserves) | FFR is mandatory for IBRs as per CEA Connectivity Regulations.

PRIMARY RESPONSE & FAST FREQUENCY RESPONSE

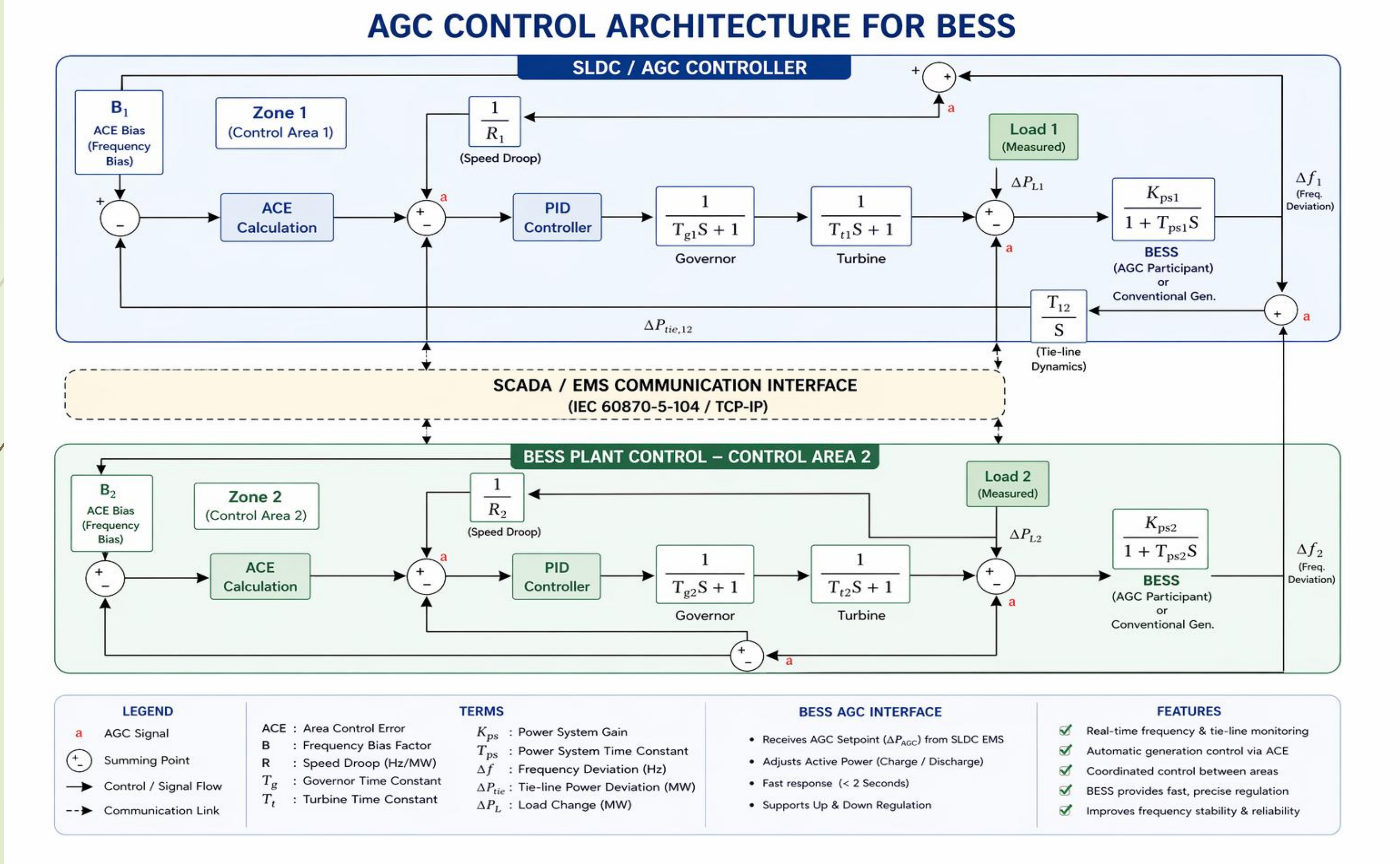


- Around the nominal frequency of 50 Hz, there is a deadband (49.97–50.03 Hz) where the BESS does not respond
- Once the frequency moves outside this band, the droop control (PFR) starts acting first in a proportional manner. Further the frequency deviates, the more power the BESS injects (for low frequency) or absorbs (for high frequency), following a linear slope (50 MW/Hz for 5% droop).
- On top of this, the FFR component adds a fast, additional "boost" when the frequency deviation becomes more severe (for example below ~49.9 Hz or above ~50.1 Hz in the graph). Unlike droop, which increases gradually, FFR acts almost instantaneously and injects a fixed extra power (about 18.75 MW) to quickly arrest the frequency decline or rise.

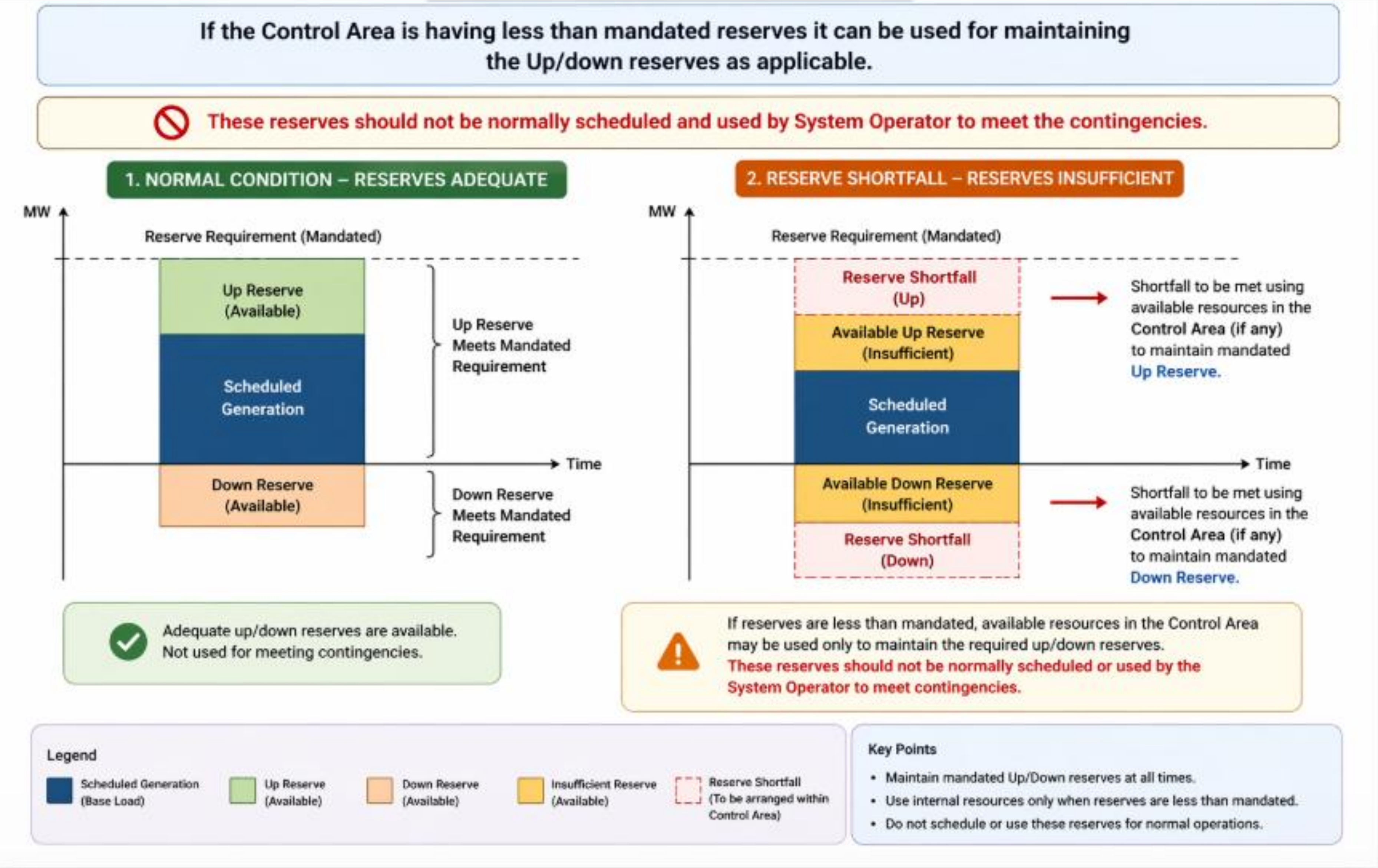
BESS ACTIVE POWER CONTROLLER
(DROOP + FFR WITH PI CONTROL)



Automatic generation control



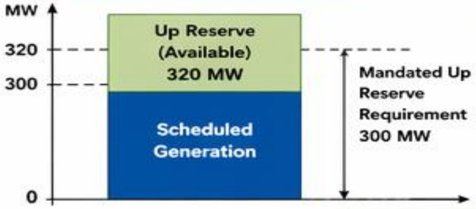
RESERVE MANAGEMENT



RESERVE MANAGEMENT – NORMAL CONDITION, RESERVE SHORTFALL & MYLATTI 125 MW BESS UTILIZATION (UPDATED LOGIC)

1. NORMAL CONDITION – RESERVES ADEQUATE

UP RESERVE (Adequate)

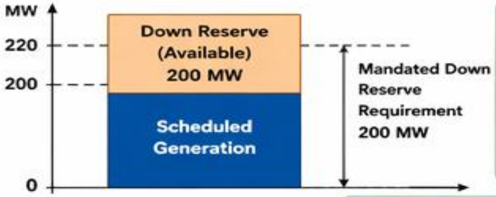


CALCULATION

Mandated Up Reserve Requirement = 300 MW
Available Up Reserve (from Generators) = 320 MW
Surplus Up Reserve
= 320 – 300 = **20 MW**

✓ System secure – Surplus Up Reserve = 20 MW

DOWN RESERVE (Adequate)



CALCULATION

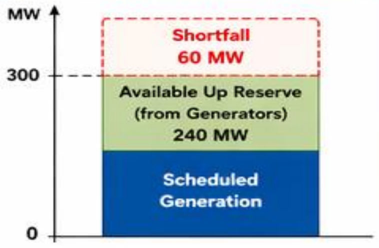
Mandated Down Reserve Requirement = 200 MW
Available Down Reserve (from Generators) = 220 MW
Surplus Down Reserve
= 220 – 200 = **20 MW**

✓ System secure – Surplus Down Reserve = 20 MW

System is secure in both directions. Reserves are adequate. MYLATTI BESS is **NOT** obligated for reserve and can be used for DSM, market operations, peak support, etc., as per SLDC schedule.

2. RESERVE SHORTFALL CONDITION – DEFICIENCY AND CORRECTION USING MYLATTI 125 MW BESS

A. UP RESERVE SHORTFALL



CALCULATION

Mandated Up Reserve Requirement = 300 MW
Available Up Reserve (from Generators) = 240 MW
Up Reserve Shortfall
= 300 – 240 = **60 MW**

CORRECTION USING MYLATTI BESS

SLDC instruction: Keep 60 MW of MYLATTI BESS capacity available as Up Reserve.
Effective Up Reserve
= 240 + 60 = **300 MW**
(Requirement Restored)

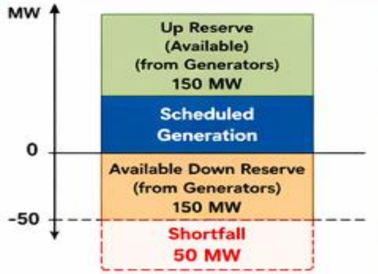
MYLATTI BESS – UP RESERVE USAGE

BESS Capacity (AC) = 125 MW
Up Reserve Earmarked = 60 MW
Remaining Available Capacity
= 125 – 60 = **65 MW**

IMPORTANT NOTES

- Only 65 MW can be used for other controlled uses such as DSM, market operation, peak support, etc.
- 60 MW is reserved for contingency and must be instantly available.

B. DOWN RESERVE SHORTFALL



CALCULATION

Mandated Down Reserve Requirement = 200 MW
Available Down Reserve (from Generators) = 150 MW
Down Reserve Shortfall
= 200 – 150 = **50 MW**

CORRECTION USING MYLATTI BESS

SLDC instruction: Keep 50 MW charging headroom of MYLATTI BESS available as Down Reserve (absorption capability).
Effective Down Reserve
= 150 + 50 = **200 MW**
(Requirement Restored)

MYLATTI BESS – DOWN RESERVE USAGE

Down Reserve Earmarked (charging headroom) = 50 MW

- BESS should not be kept near full charge.
- Maintain SoC in mid-range (40% – 60%) so that 50 MW charging power is available when required.
- This 50 MW headroom is reserved for contingency absorption.

3. PRACTICAL COMBINED EXAMPLE FOR MYLATTI 125 MW BESS

SLDC REQUIRES MYLATTI BESS TO MAINTAIN:

- Up Reserve = 50 MW
- Down Reserve = 30 MW

Total Reserve Margin to be kept aside
= 50 + 30 = **80 MW**

→

BESS CAPACITY ALLOCATION

BESS Total Capacity (AC) = 125 MW
Total Reserve Margin (Up + Down) = 80 MW
Remaining Capacity for Other Uses
= 125 – 80 = **45 MW**

→

MEANING

Only **45 MW** can be used for normal energy-related functions (DSM, market operation, peak support, etc.), subject to SoC and SLDC instructions.
80 MW remains reserved for grid security.

KEY TAKEAWAY

Reserved capacity is **NOT** for normal energy operations. It is a safety margin for contingency support, ensuring reliability, frequency stability, and grid security.

4. WHEN CONTINGENCY OCCURS

Example: Generator trip of 60 MW → MYLATTI BESS responds instantly using reserved capacity → Restores balance, maintains frequency & supports grid security

Reserved capacity is released ONLY when required for real-time events (FFR / Droop / Contingency).

5. IMPORTANT OPERATING PRINCIPLES

1. Reserves are dynamic and based on real-time grid conditions.
2. BESS response is activated only when reserve shortfall exists or during real-time events.
3. Reserves are not used for routine scheduling, market arbitrage, or peak shaving when shortfall exists.
4. SoC must be maintained in mid-range (40% – 60%) for bi-directional readiness.
5. SLDC instructions and CEA / SRPC guidelines to be strictly followed.

6. MYLATTI 125 MW BESS SUMMARY

BESS Rating (AC)	125 MW / 500 MWh
PCS Capacity (AC)	137.5 MVA (24 × 5 MVA + 7 × 2.5 MVA)
Usable for Grid Support	Up to 125 MW (subject to reserve obligation & SoC)
Role in Grid	Reserve Provider | Frequency Support | Peak Support | Market Operations

MYLATTI 125 MW BESS

CORE MESSAGE: MYLATTI 125 MW BESS acts as a flexible and reliable reserve resource, ensuring grid security while also enabling optimal utilization for energy operations based on SLDC instructions.

DSM (Deviation Settlement Mechanism) / ACE (Area Control Error

DSM / ACE MANAGEMENT USING MYLATTI 125 MW BESS – OPERATING PHILOSOPHY, CALCULATIONS & EXAMPLES

1. WHAT DSM / ACE MEANS (OPERATIONALLY)

- DSM (Deviation Settlement Mechanism)
  → financial penalty for deviating from schedule
- ACE (Area Control Error) → real-time control signal

$$ACE = (P_{actual} - P_{schedule}) + B \cdot (f - 50)$$

Where:

- $P_{actual} - P_{schedule}$ → tie-line / power imbalance
- B → frequency bias (MW/Hz)
- f → system frequency (Hz)

ACE > 0 → excess generation → need to absorb power (BESS charges)

ACE < 0 → deficit → need to inject power (BESS discharges)

2. ROLE OF MYLATTI 125 MW BESS

BESS is used to:

- ✓ Reduce DSM penalties
- ✓ Maintain ACE close to zero
- ✓ Improve frequency stability

MYLATTI 125 MW BESS

Acts as fast balancing resource

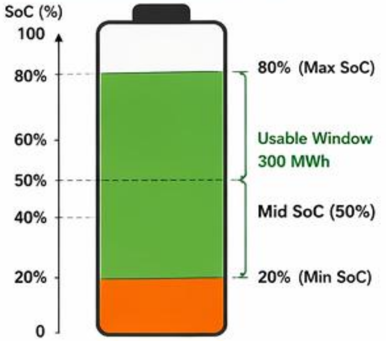
3. KEY CONCEPT: SOC OPERATING WINDOW

Assume MYLATTI:

- Energy capacity = 500 MWh
- SoC limits: SOC_{min} = 20%, SOC_{max} = 80%

Usable energy window:

$$E_{usable} = (80 - 20)\% \times 500 = 60\% \times 500 = 300 \text{ MWh}$$



Maintain SoC in mid-range (40% – 60%) to enable both charge & discharge capability

4. BESS RESPONSE BASED ON ACE / DSM VOLUME LIMITS

A. FIRST VOLUME LIMIT (Mild ACE / DSM)

Rule: BESS moves SoC toward mid-point (50%)

▶ Mid SoC Calculation:

$$SOC_{mid} = \frac{SOC_{max} + SOC_{min}}{2} = \frac{80 + 20}{2} = 50\%$$

▶ Example:

- Current SoC = 70%
- Target = 50%
- Energy to discharge:

$$(70 - 50)\% \times 500 = 20\% \times 500 = 100 \text{ MWh}$$

▶ Operation:

Use low C-rate (say 0.25C)

$$P = 0.25 \times 125 = 31.25 \text{ MW}$$

▶ Time required:

$$t = \frac{100}{31.25} \approx 3.2 \text{ hours}$$

✓ Meaning:

- Smooth correction
- No aggressive action
- Maintain flexibility

B. SECOND VOLUME LIMIT (Moderate ACE / DSM)

Rule: BESS counters ACE with moderate power (medium C-rate)

▶ Example:

ACE = −80 MW (deficit)

▶ Use:

$$P_{BESS} \approx 0.5C = 0.5 \times 125 = 62.5 \text{ MW}$$

▶ Effect:

Remaining imbalance:

$$80 - 62.5 = 17.5 \text{ MW}$$

→ Remaining handled by:

- generators
- AGC

▶ Energy usage:

For 15 minutes (0.25 hr):

$$E = 62.5 \times 0.25 = 15.6 \text{ MWh}$$

✓ Meaning:

- Faster correction
- Still controlled
- Avoids full discharge

C. BEYOND SECOND LIMIT (Severe ACE / Contingency)

Rule: Use maximum C-rate (full power)

▶ Example:

ACE = −150 MW

▶ BESS output:

P = 125 MW (full)

▶ Remaining:

150 − 125 = 25 MW

▶ Energy usage:

For 10 minutes ($\frac{10}{60}$ hr):

$$E = 125 \times \frac{10}{60} = 20.8 \text{ MWh}$$

✓ Meaning:

- Emergency action
- Frequency support critical
- Prevents:
  - grid collapse
  - load shedding

7. COMBINED CONTROL PHILOSOPHY

Condition	ACE Level	BESS Action	C-rate
Mild	Small ACE (|ACE| < 30 MW)	Move SoC to 50% (SoC balancing)	Low (0.2 – 0.3C)
Moderate	Medium ACE (30 – 100 MW)	Counter partially (Moderate response)	Medium (0.4 – 0.6C)
Severe	High ACE (|ACE| > 100 MW)	Full response (Max power)	High (1C)

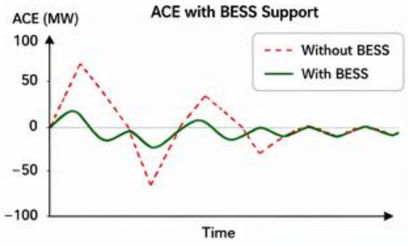
8. PRACTICAL MYLATTI STRATEGY

1. Maintain SoC: $40\% \le SOC \le 60\%$
2. Monitor ACE
   - ACE < 30 MW → Mild
   - 30 – 100 MW → Moderate
   - |ACE| > 100 MW → Severe
3. Dispatch BESS: $P_{BESS} = f(ACE, SOC, limits)$

Subject to: Power limits, SoC limits, ramp rate, SLDC instructions

9. WHY THIS APPROACH WORKS

- Avoids unnecessary battery cycling
- Preserves energy for contingencies
- Minimizes DSM penalty
- Improves frequency control



KEY TAKEAWAY

MYLATTI 125 MW BESS operates in a staged ACE control mode:
Mild deviations are managed through SoC balancing, moderate deviations through partial response, and severe deviations through full power injection, ensuring optimal DSM performance while preserving battery availability for contingencies.

- BESS Capacity: 125 MW / 500 MWh
- Usable Energy Window: 300 MWh (20% – 80% SoC)
- Mid SoC Target: 50%
- SoC Operating Window: 40% – 60% (Recommended)

PEAK DEMAND MANAGEMENT USING MYLATTI 125 MW / 500 MWh BESS

SLDC may finalise the input energy and output energy schedules for BESS block wise to meet the peak demand period considering the Aux Consumption, RTe, C rate etc.

1. CONCEPT

MYLATTI
125 MW / 500 MWh BESS

Charge (Store Energy) during Off-Peak / Low Demand Period

Discharge (Supply Energy) during Peak / High Demand Period

OBJECTIVES

- Reduce peak demand on the grid
- Avoid grid overloading and DSM penalty
- Flatten load curve
- Optimize energy usage and operating cost

2. KEY FACTORS CONSIDERED BY SLDC

- Auxiliary Consumption (Aux) ≈ 2% of input energy
- Round Trip Efficiency (RTE) ≈ 90%
- C-rate Limits (Charge / Discharge Power Limits)
- State of Charge (SoC) Limits (Operational Range)

3. MYLATTI BESS – TECHNICAL DETAILS

BESS Rating (AC)	125 MW / 500 MWh
PCS Capacity (AC)	137.5 MVA (24 × 5 MVA + 7 × 2.5 MVA)
Usable Energy	500 MWh (Full Usable)
Round Trip Efficiency (RTE)	90%
Aux Consumption	≈ 2% of input energy
SoC Operating Range	0% – 100% (Full Usable)
Max Charge / Discharge Power	125 MW
Duration at Full Power	4 Hours (500 MWh / 125 MW)

4. USABLE ENERGY CALCULATION

BESS Rating = 125 MW / 500 MWh (Full Usable)

At Full Power Discharge:

Energy Supplied = Power × Time = 125 MW × 4 h = 500 MWh

5. CHARGING ENERGY REQUIREMENT (WITH LOSSES)

Energy required to be delivered during peak (E_{out}) = 500 MWh

Considering RTE = 90%

Energy to be charged (E_{in}, w/o Aux) = 500 / 0.90 = 555.6 MWh

Including Aux Consumption (2%)

Total Input Energy (E_{total}) = 555.6 × 1.02 ≈ **567 MWh**

≈ 567 MWh input energy is required to deliver 500 MWh during peak.

6. CHARGING SCHEDULE (OFF-PEAK EXAMPLE)

Assume Off-peak charging window = 6 hours (e.g., 00:00 – 06:00)

Required Charging Power

$$P_{charge} = \frac{E_{total}}{\text{Charging Duration}} = \frac{567\ \text{MWh}}{6\ \text{h}} \approx \mathbf{94.5\ MW}$$

Check C-rate (Assume 500 MWh capacity)

$$\text{Charge C-rate} = \frac{94.5}{500} = 0.19C$$

Within typical operational limit (≤ 0.5C to 1C)

7. DISCHARGE SCHEDULE (PEAK EXAMPLE)

Assume Peak period = 4 hours (e.g., 18:00 – 22:00)

Discharge Power

$$P_{discharge} = \frac{E_{out}}{\text{Peak Duration}} = \frac{500\ \text{MWh}}{4\ \text{h}} = 125\ \text{MW}$$

Check C-rate

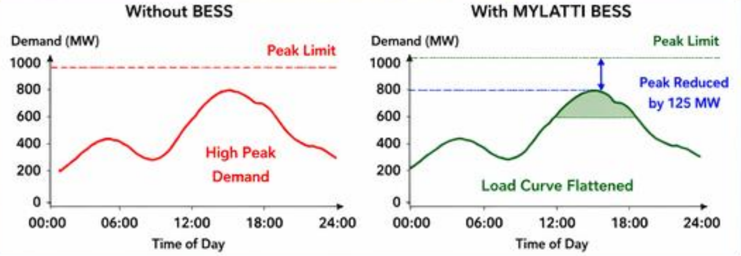
$$\text{Discharge C-rate} = \frac{125}{0.25C}$$

Within typical operational limit (≤ 0.5C to 1C)

8. BLOCK-WISE SCHEDULE EXAMPLE (15-MIN INTERVALS)

Time Block	Period	Operation	Power (MW)	Energy in Block (MWh)	Cumulative SoC (MWh)
00:00 – 06:00	Off-Peak	Charging	≈ 95	≈ 23.8	0 → 500
06:00 – 18:00	Day Time	Idle / Reserve / Market	0 to variable	–	Maintain 100%
18:00 – 22:00	Peak	Discharging	125	31.25	500 → 0
22:00 – 24:00	Night	Idle / Reserve	0 to variable	–	At minimum
Total		500 MWh discharged during peak			

9. IMPACT ON LOAD CURVE



10. IMPORTANT NOTES

- BESS will always maintain SoC limits as per SLDC instructions. (Typically 0% – 100% for full usable projects).
- Schedule may change based on grid conditions, reserve requirements, and market signals.
- In the event of reserve shortfall or frequency issues, BESS may be diverted from peak shaving to grid support.
- SLDC / CEA / SRPC guidelines and real-time directions will be strictly followed.

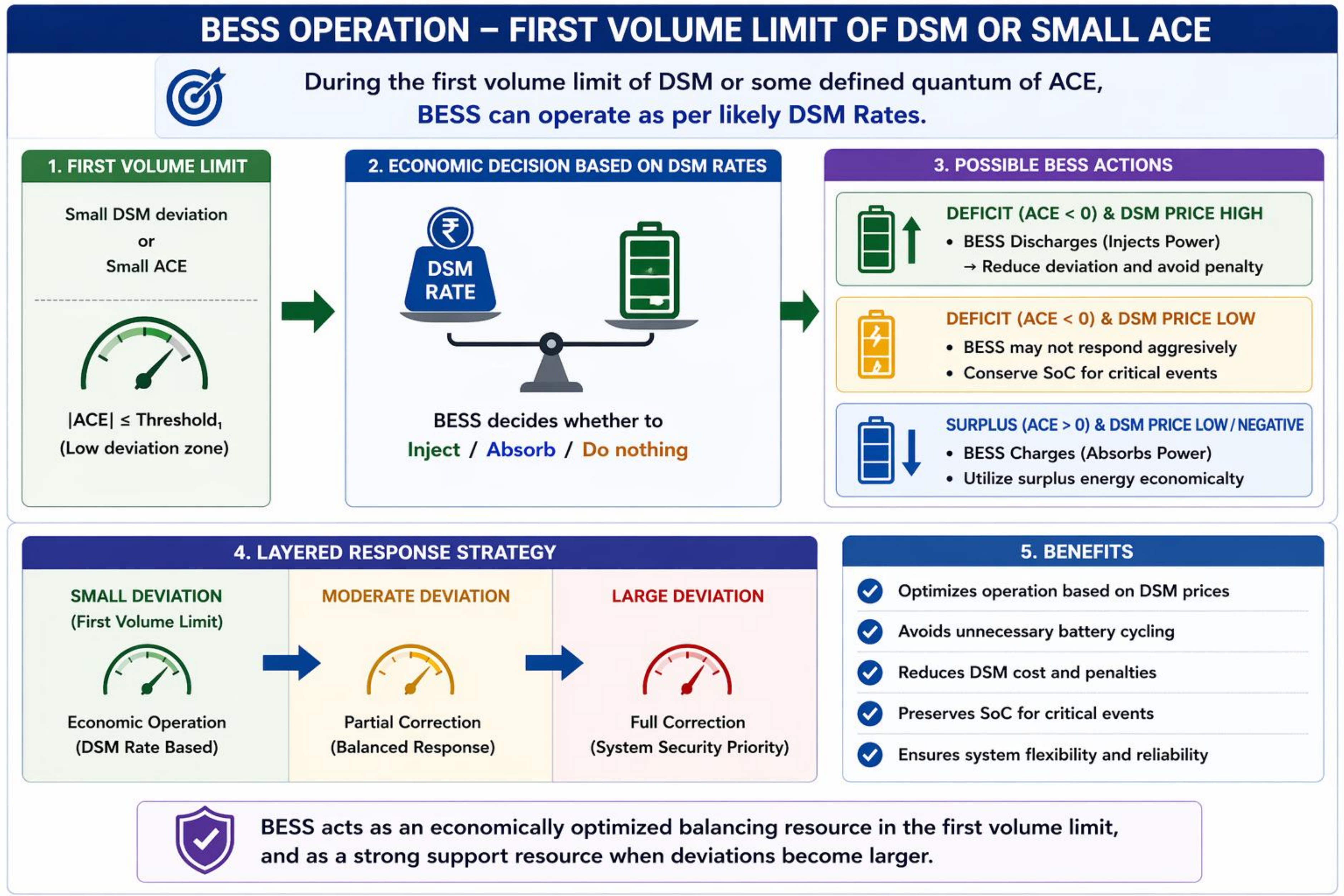
11. SUMMARY

- Deliver 125 MW for 4 hours during peak
- 500 MWh usable energy supplied
- Peak demand reduced by up to 125 MW
- Helps in DSM, reduces penalty and grid stress
- Efficient, reliable and grid supportive operation

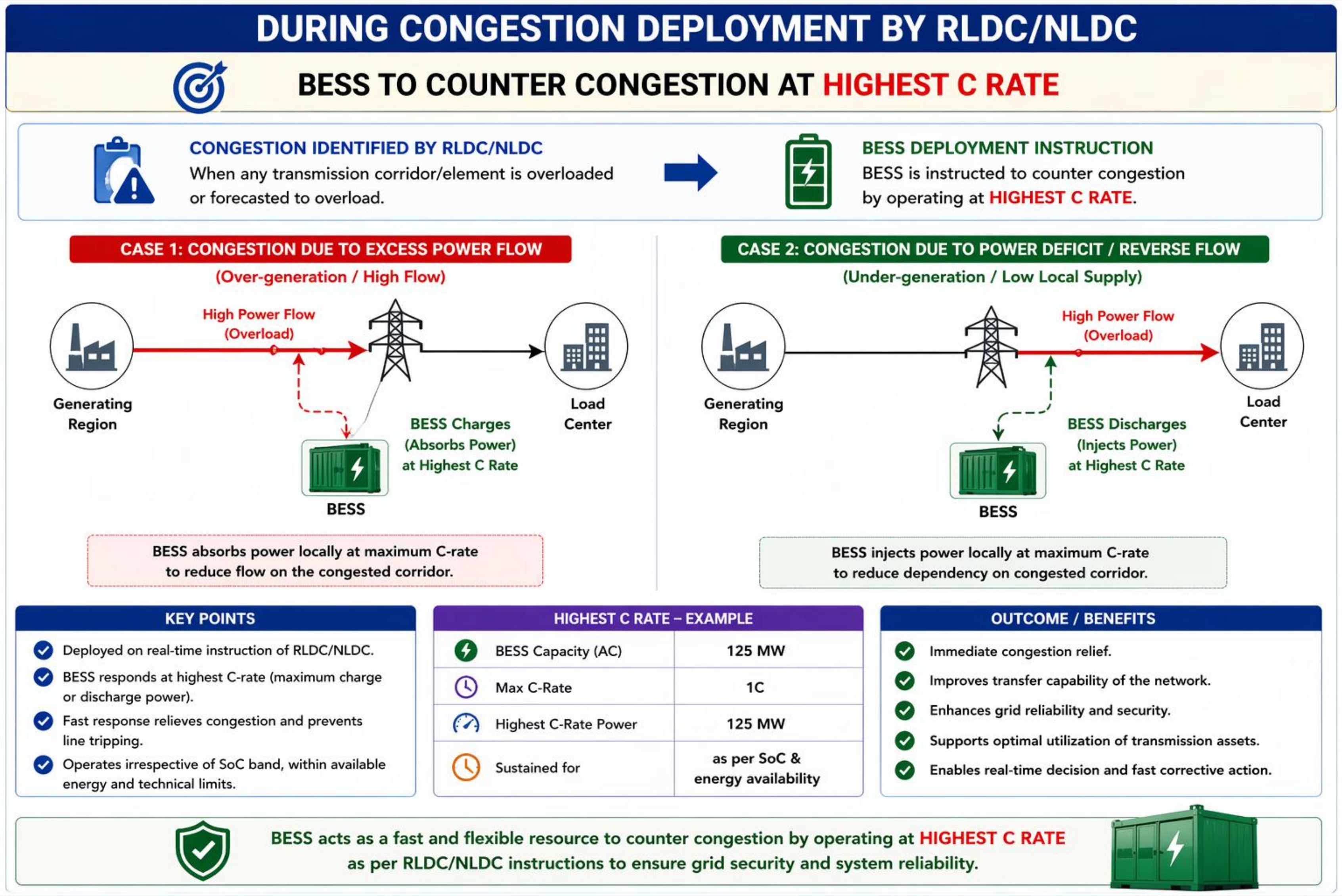
12. KEY TAKEAWAY

MYLATTI 125 MW / 500 MWh BESS can deliver full 125 MW for 4 hours during peak period, subject to SoC availability, RTE, Aux consumption, C-rate limits and SLDC instructions.

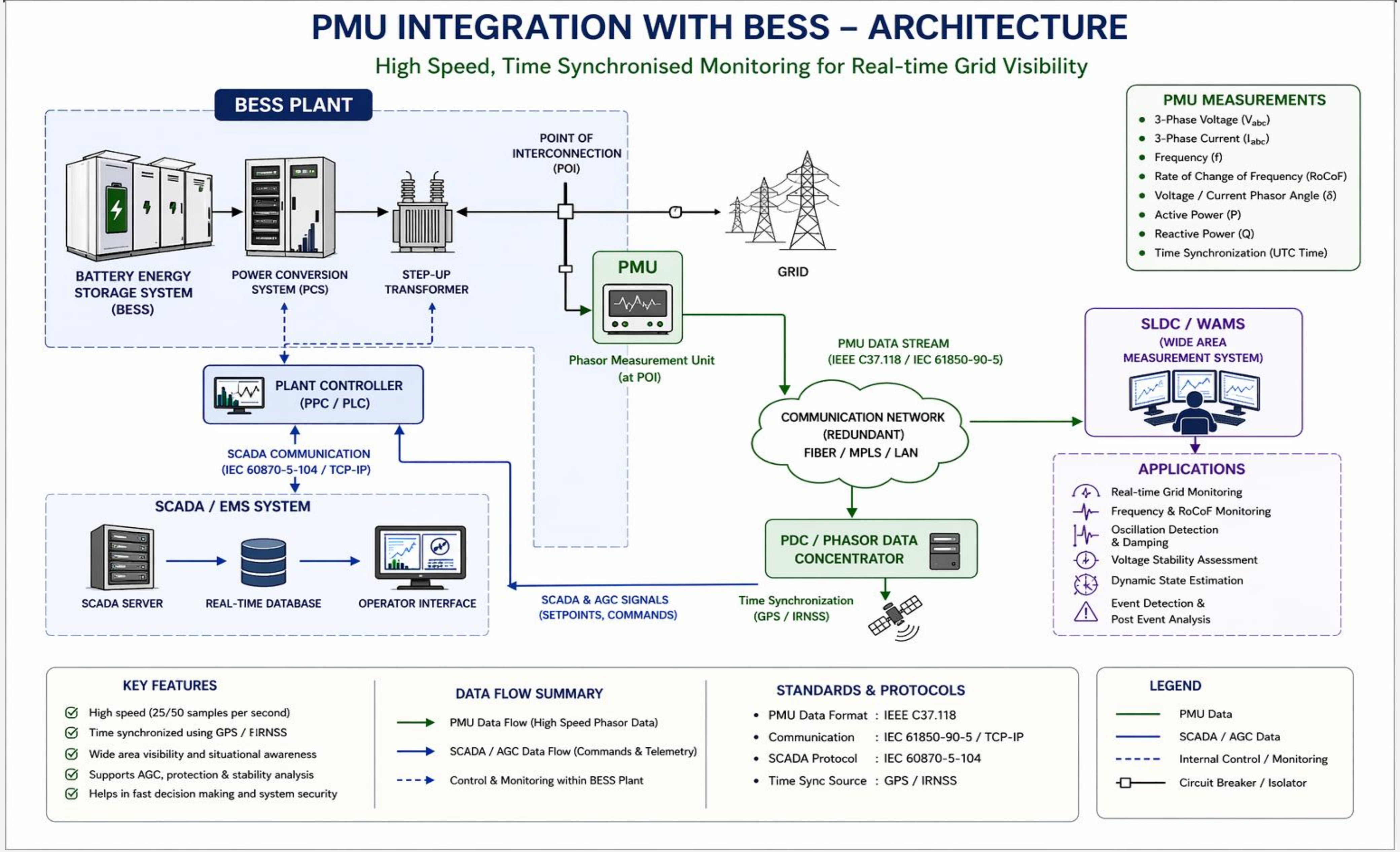
MARKET OPERATION



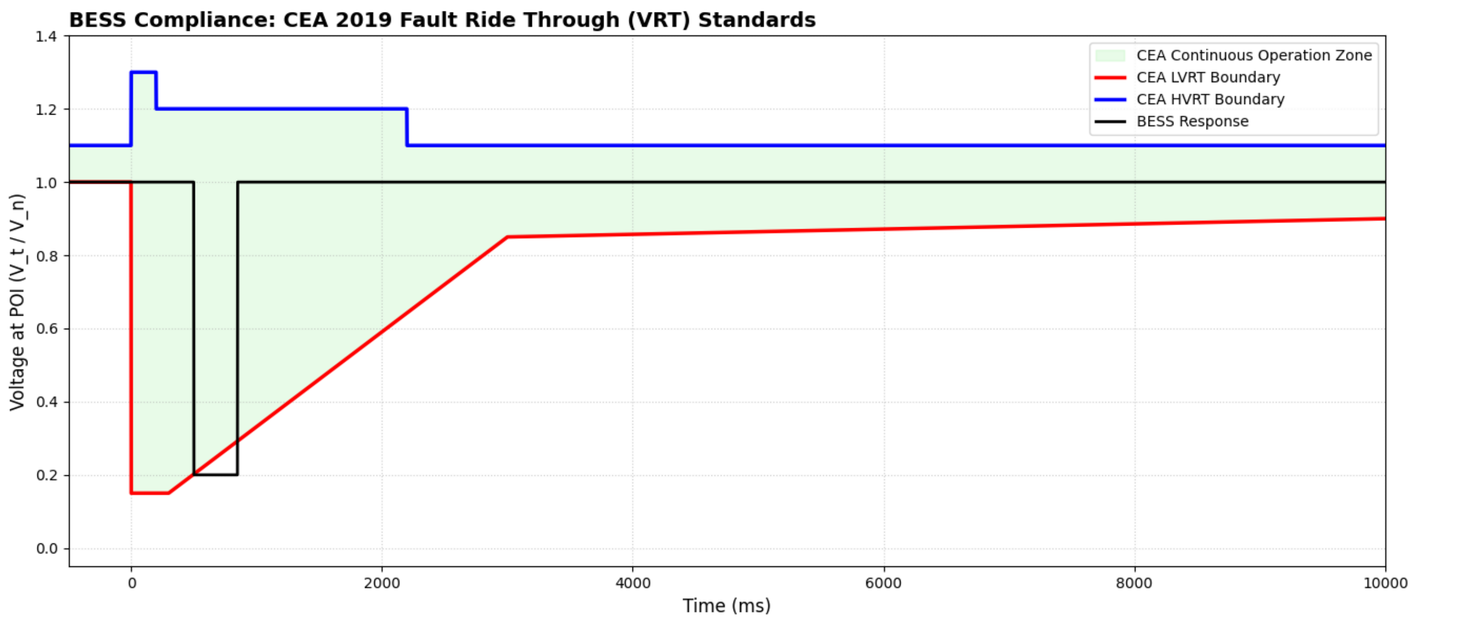
CONGESTION DEPLOYMENT BY RLDC/NLDC

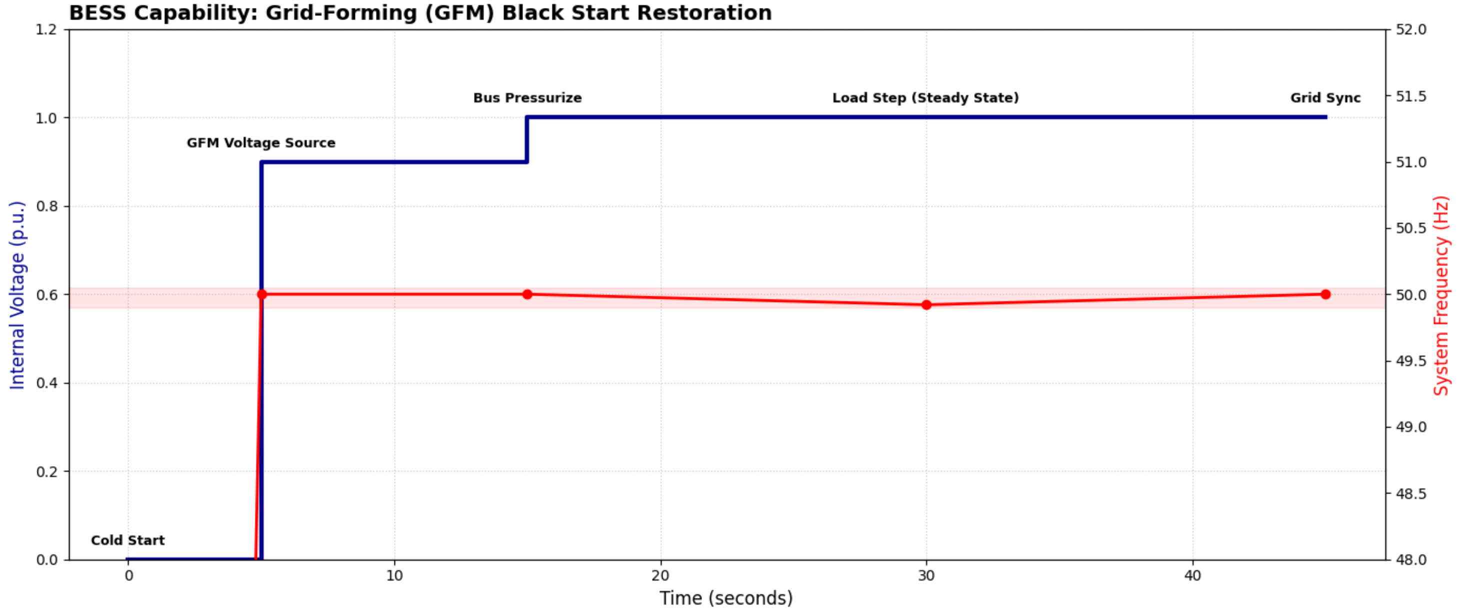


PHASOR MEASUREMENT UNIT

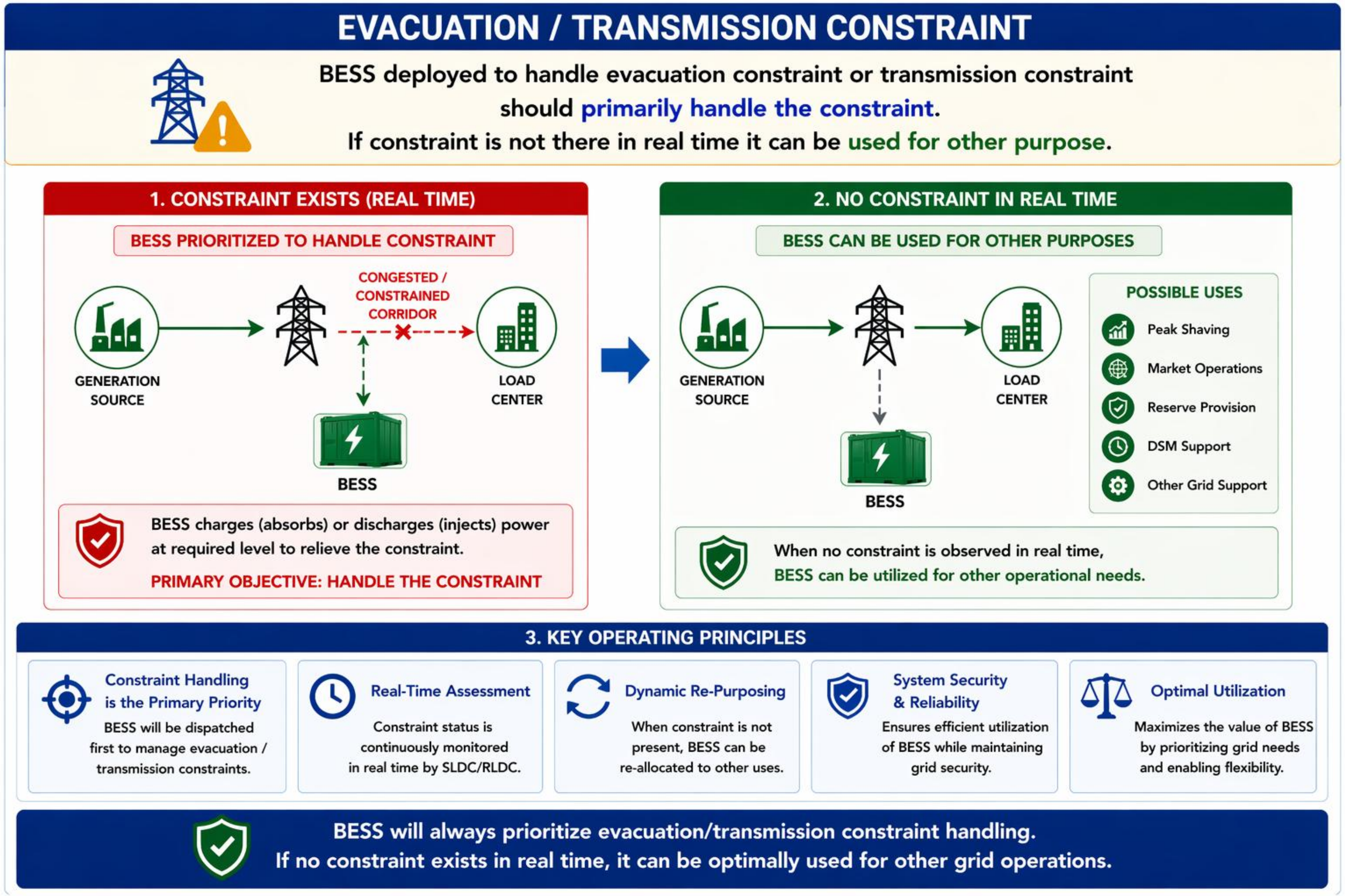


FAULT RIDE THROUGH

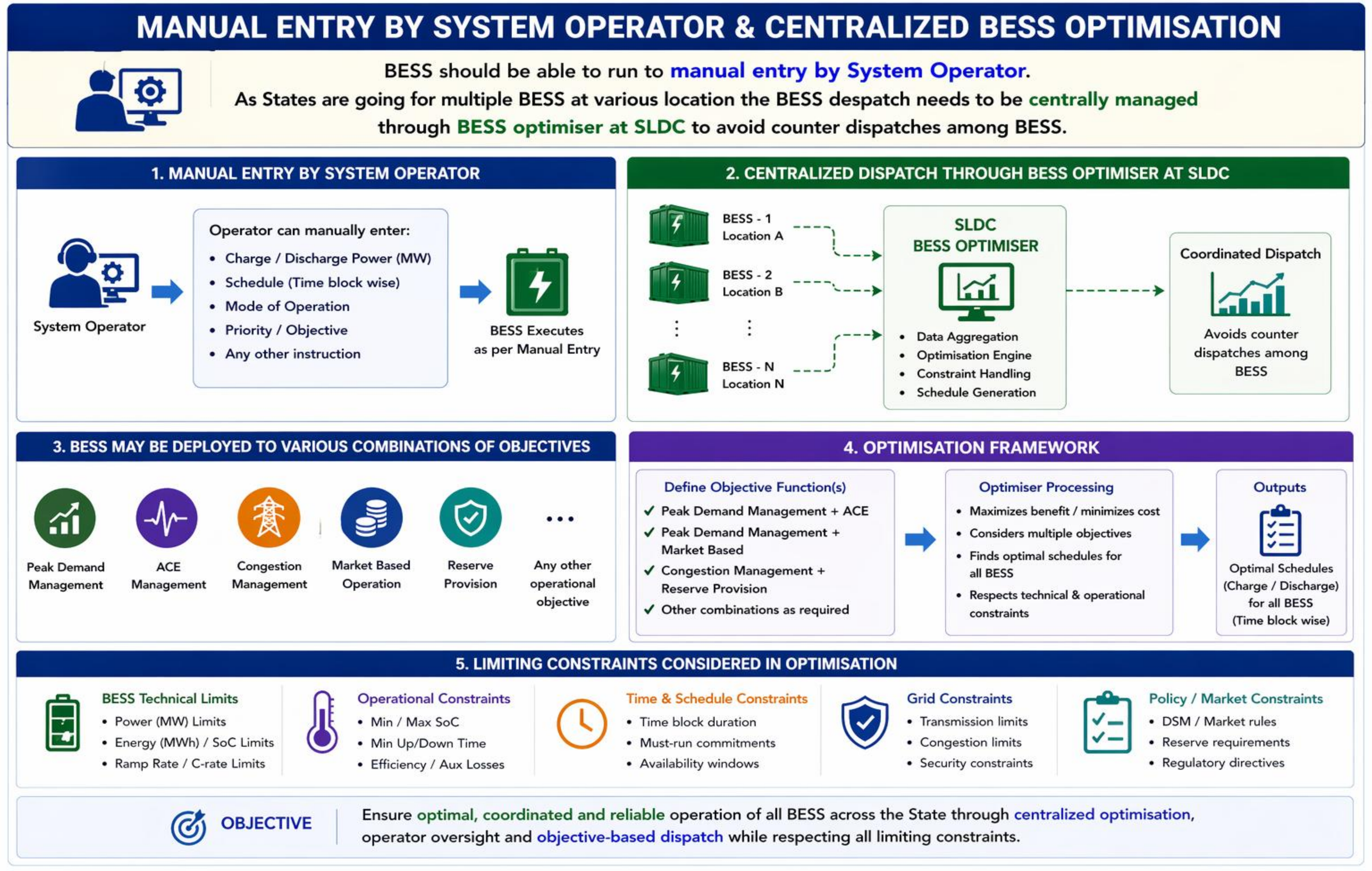




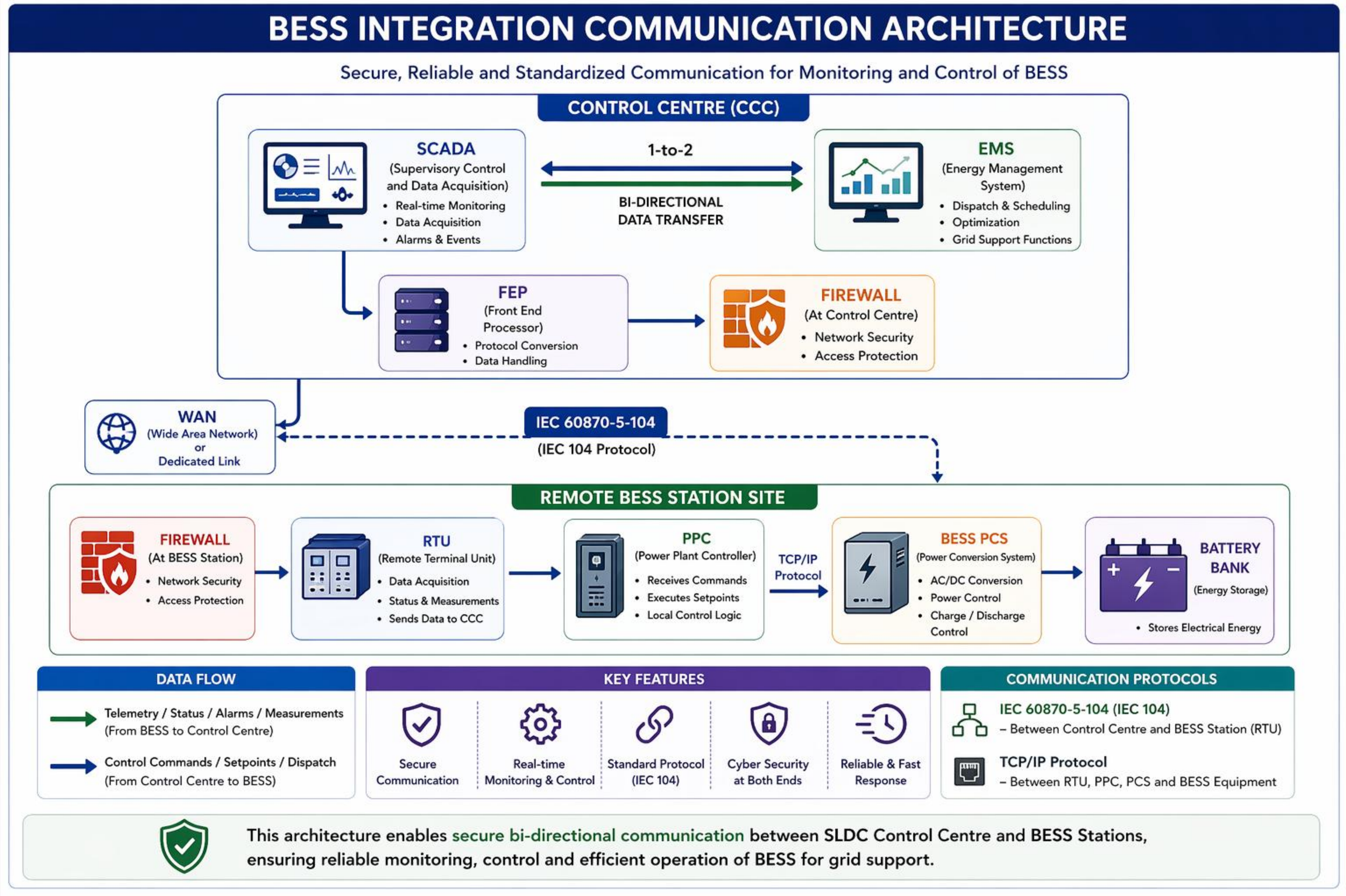
CONGESTION DEPLOYMENT BY RLDC/NLDC



SYSTEM OPERATION



COMMUNICATION ARCHITECTURE



Thank you!