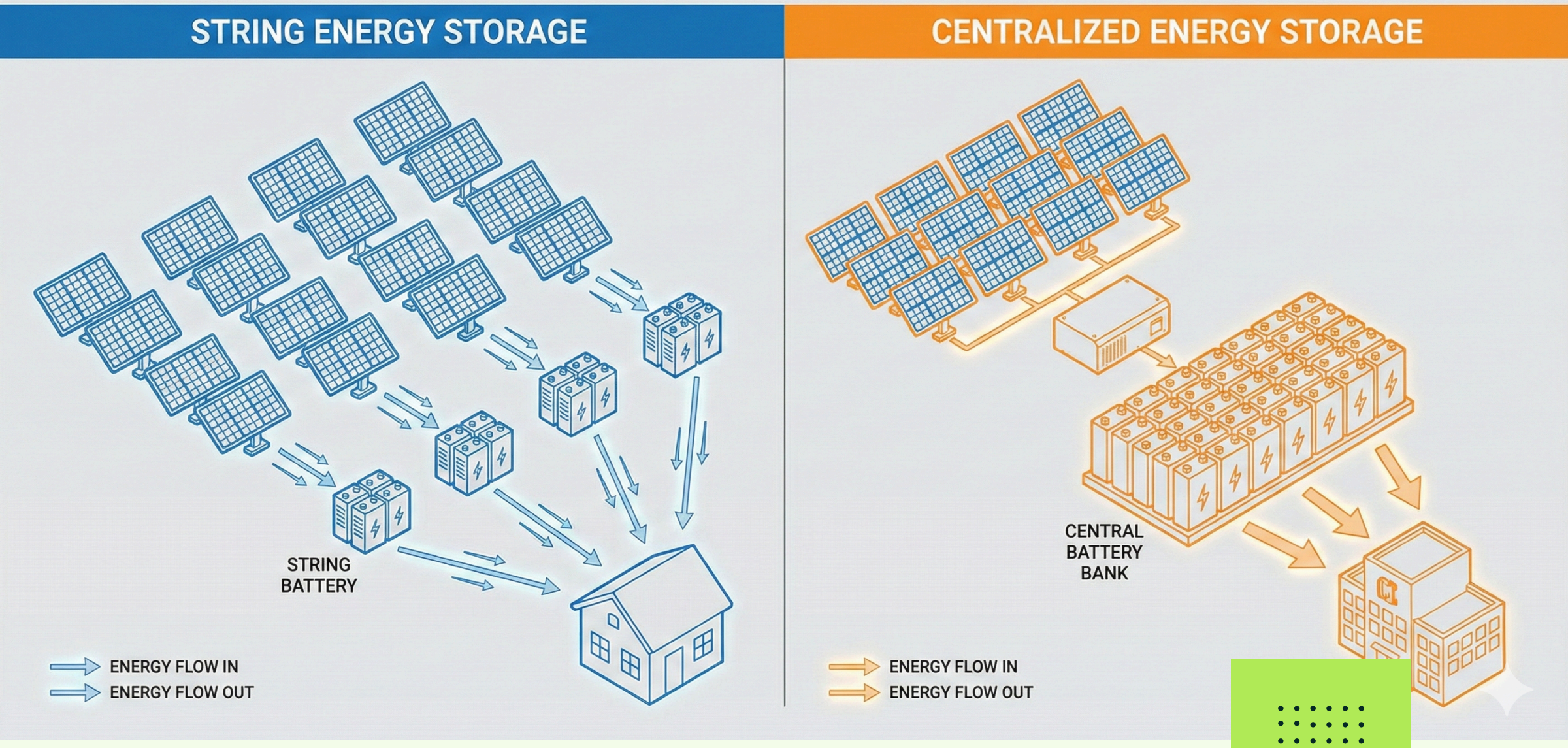
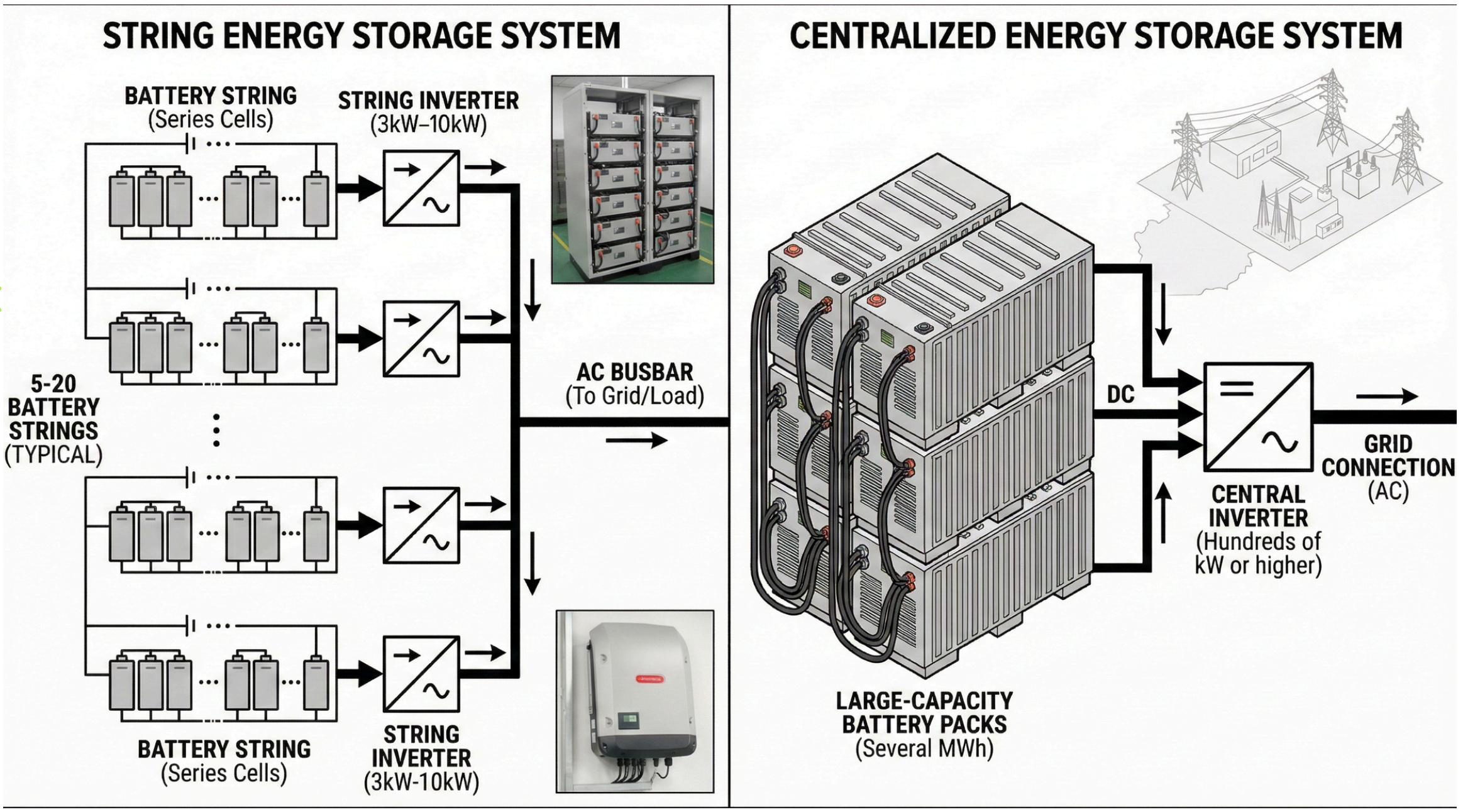
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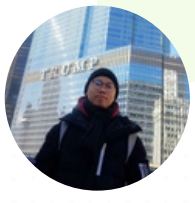
6 In-depth Comparison of String and Centralized Energy Storage Systems



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Structural Differences



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String System

- Composed of multiple independent battery strings connected in parallel.
- For example, there are usually 5-20 battery strings.
- Each battery string is connected to an inverter.
- The power of an inverter from a certain brand ranges from 3kW to 10kW. Then these inverters are connected in parallel to the AC busbar.

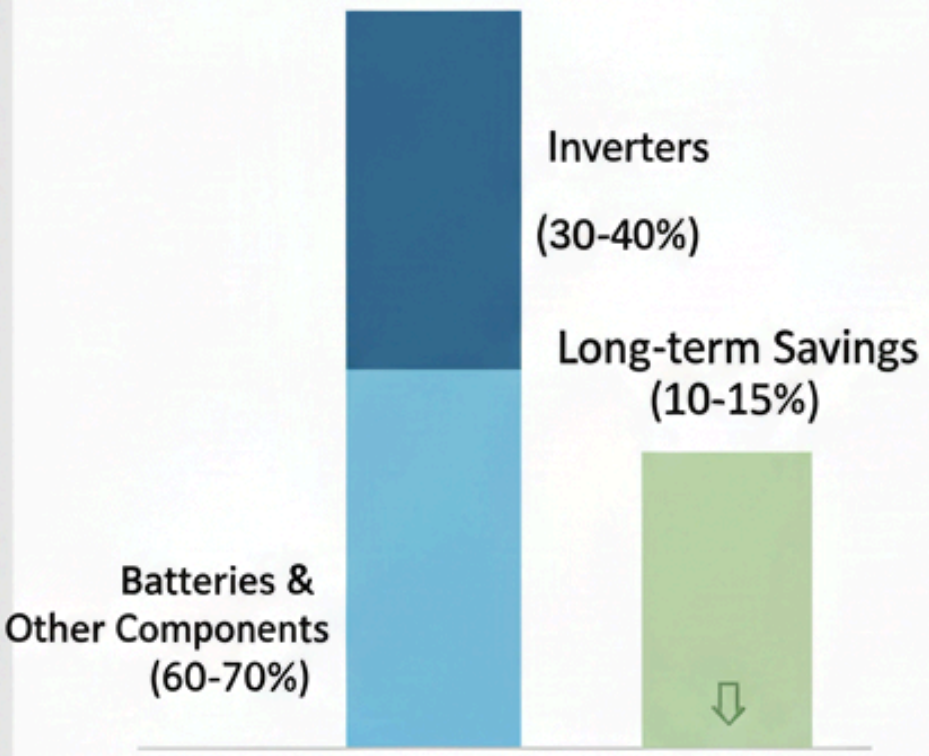
Centralized System

- Adopts large-capacity battery packs placed centrally. The capacity of battery packs in some large-scale energy storage power stations can reach several megawatt-hours.
- It is connected to the grid through a high-power inverter, which can have a power of hundreds of kilowatts or even higher.

COST CONSIDERATIONS

STRING SYSTEM

10kW System Total Cost

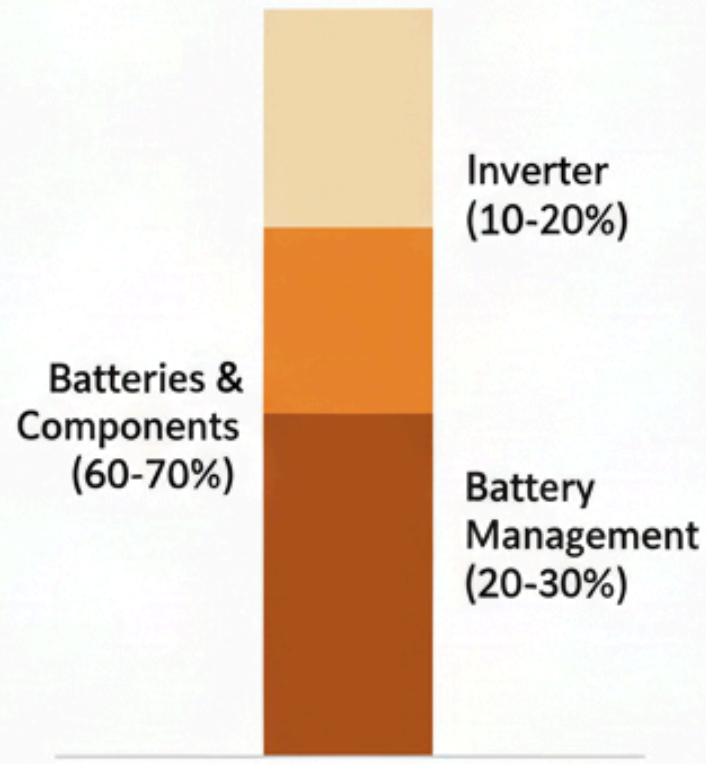


High hardware cost due due multiple inverters

Long-term savings on battery replacement

CENTRALIZED SYSTEM

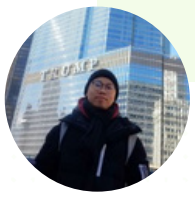
MWH System Total Cost



Low inverter cost

High battery management expenses

Cost Considerations



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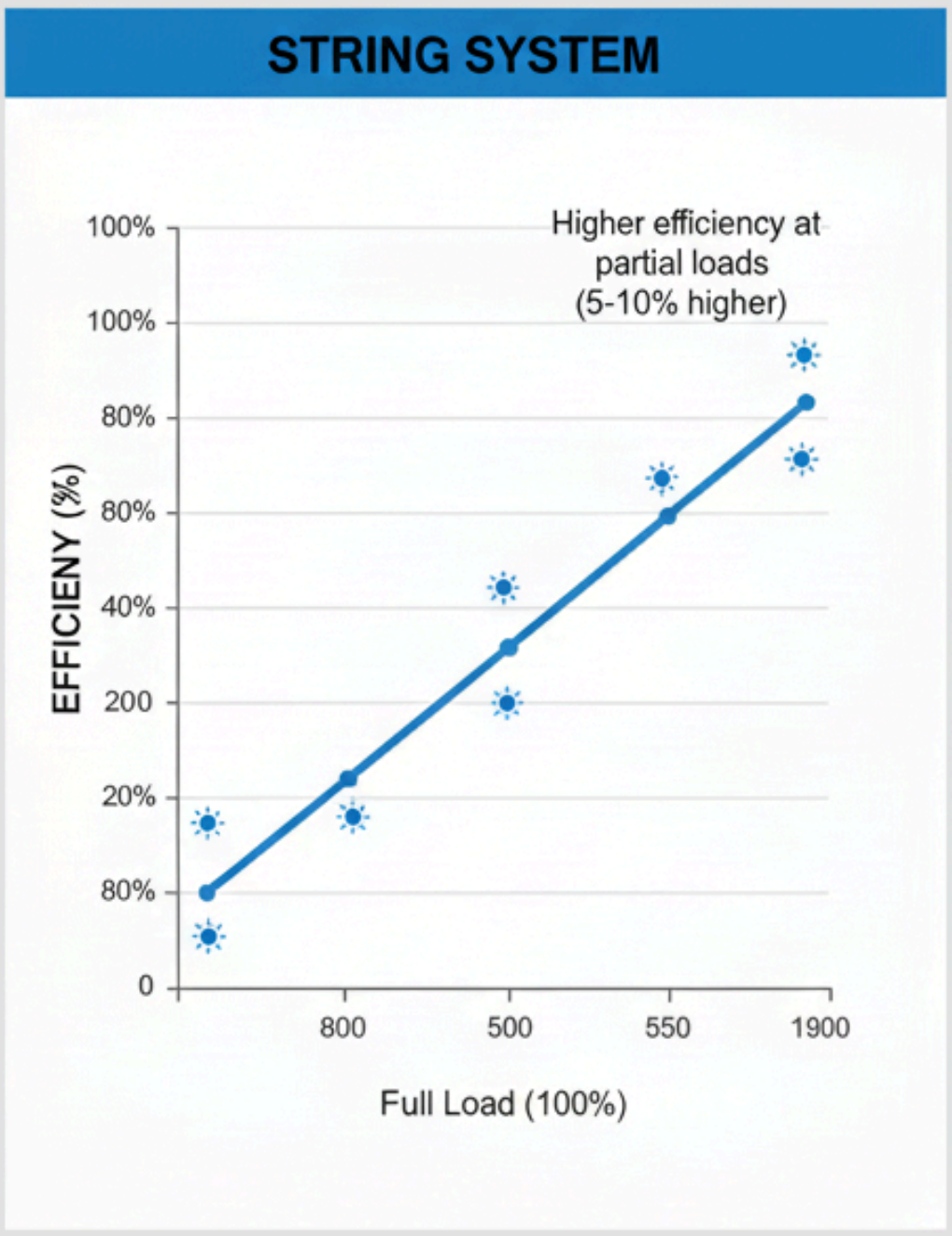
String System

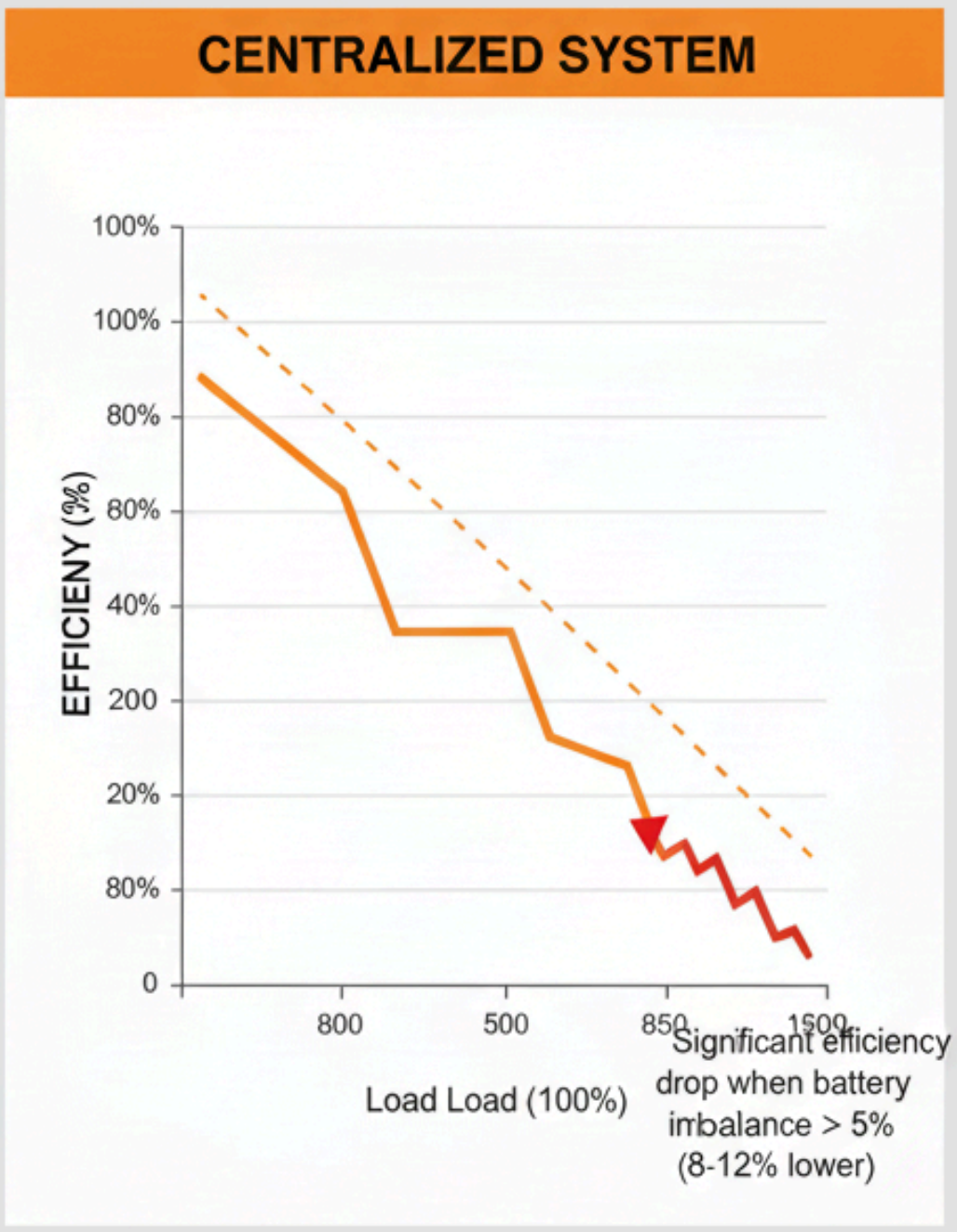
- The hardware cost is relatively high due to the need for multiple inverters.
- Taking a 10kW string energy storage system as an example, the cost of inverters accounts for about 30%-40% of the total cost.
- However, in the long run, it may save on battery replacement costs by reducing battery circulating currents, with an estimated reduction of 10%-15% in battery maintenance costs.

Centralized System

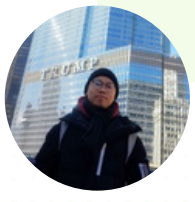
- The cost of inverters is low, accounting for only about 10%-20% of the total cost.
- However, battery management is more difficult. To ensure battery consistency, more costs need to be invested in battery monitoring and maintenance, which may account for 20%-30% of the total cost.

EFFICIENCY COMPETITION





Efficiency Competition



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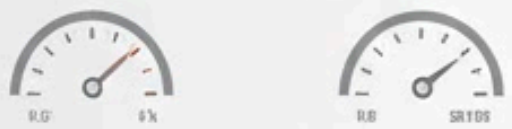
String System

- Each battery string has independent MPPT. Under partial load conditions, such as when the light intensity is 60%-80% of the rated value, its efficiency is 5%-10% higher than that of the centralized system.

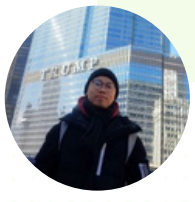
Centralized System

- With centralized control, when the difference between individual batteries exceeds 5%, the efficiency will decrease significantly, possibly being 8%-12% lower than that of the string system.

PROS AND CONS OF BATTERY MANAGEMENT

ASPECT	ASPECT
STRING SYSTEM (DISTRIBUTED BMS)	**CENTRALIZED SYSTEM (SINGLE BMS)**
1 Voltage error within ±0.1V, Current error within ±20.05A 	1 Less precise (System-level averaging)
Battery Balancing Effect Excellent balancing. Extends battery life by 20-30%  STRING SYSTEM	2 Poorer balancing. Shorter battery life  Risk of single point of failure  CENTERLIZED SYSTEM
Fault Detection Rate Over 90% (High)	About 70-80% (Lower)

Pros and Cons of Battery Management



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String System

- Each battery string can be monitored and controlled separately, with a precision of voltage error within ±0.1V and current error within ±0.05A.
- It can effectively balance battery differences and extend battery life by about 20%-30%.
-

Centralized System

- It is difficult to accurately control and monitor each individual battery. The battery fault detection rate is about 70%-80%, while for the string system, it can reach over 90%.
- Once a battery fails, the probability of affecting the entire battery pack is as high as 60%-70%.

FLEXIBILITY AND EXTENSIBILITY

STRING SYSTEM

MODULAR DESIGN: EASY TO ADD/REMOVE STRINGS



5KW-50KW INSTALLATION

EXPANSION: +100KW (EASY ADDITION)

5KW-50KW | 3-6 MONTHS | 5 YEAR | 2 YEARS

START OF PROJECT | 3 YEAR | 2 YEARS

EXPANSION: (INSTALLATION)



ADAPTABLE TO VARIOUS SCALES

ADAPABLE TO VARIOUS 55MW TOTAL

SUITABLE FOR SMALL TO LARGE COMMERCIAL/INDUSTRIAL

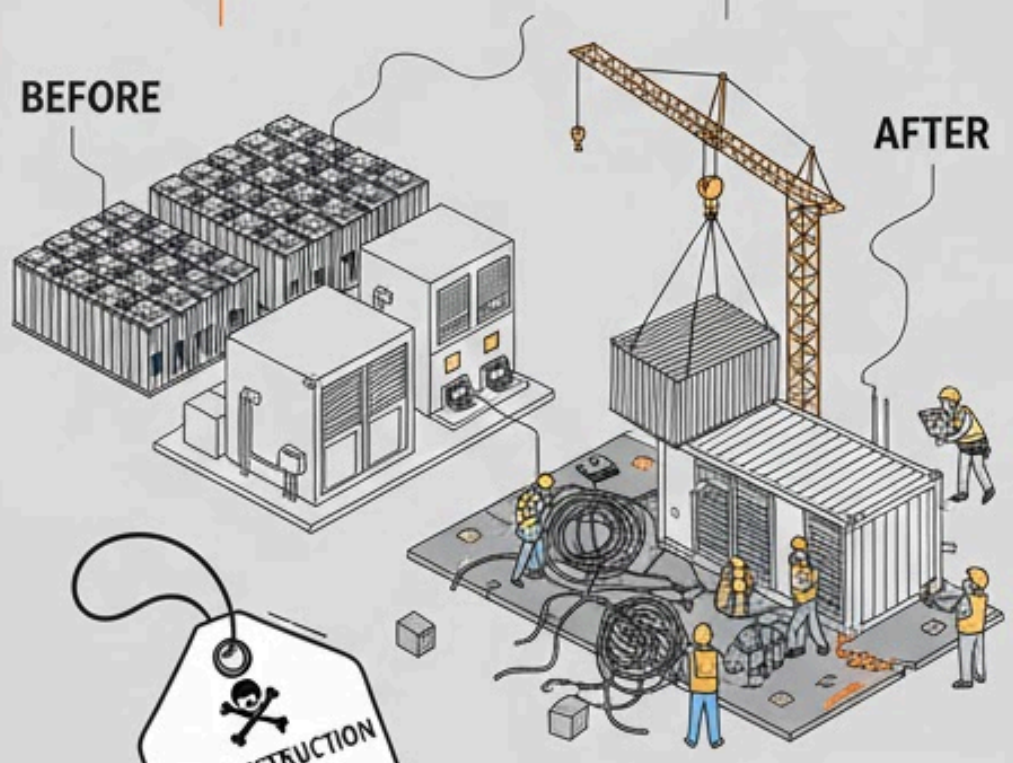
CENTRALIZED SYSTEM

FIXED SCALE: HARD TO ADD CAPACITY

FIXED SCALE: HARD TO ADD FRIBATION & CABLING

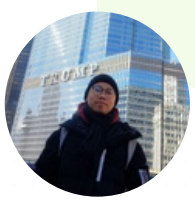
BEFORE

AFTER



BEST FOR LARGE-SCALE: ONE-TIME PROJECTS >5MW

Flexibility and Extensibility



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String System

- With a modular design, battery strings can be added or removed according to needs.
- The interval for expansion can be as short as 3-6 months. It is suitable for various scales of projects, ranging from small-scale commercial energy
- storage (5kW-50kW) to large-scale industrial energy storage (500kW-2MW).
-

Centralized System

- The scale is fixed, and expansion is difficult. If expansion is needed, the cost of re-construction may be 1.5-2 times that of the original system.
- It is suitable for large-scale one-time construction projects, such as large-scale grid-side energy storage (above 5MW).

APPLICATION CHOICES

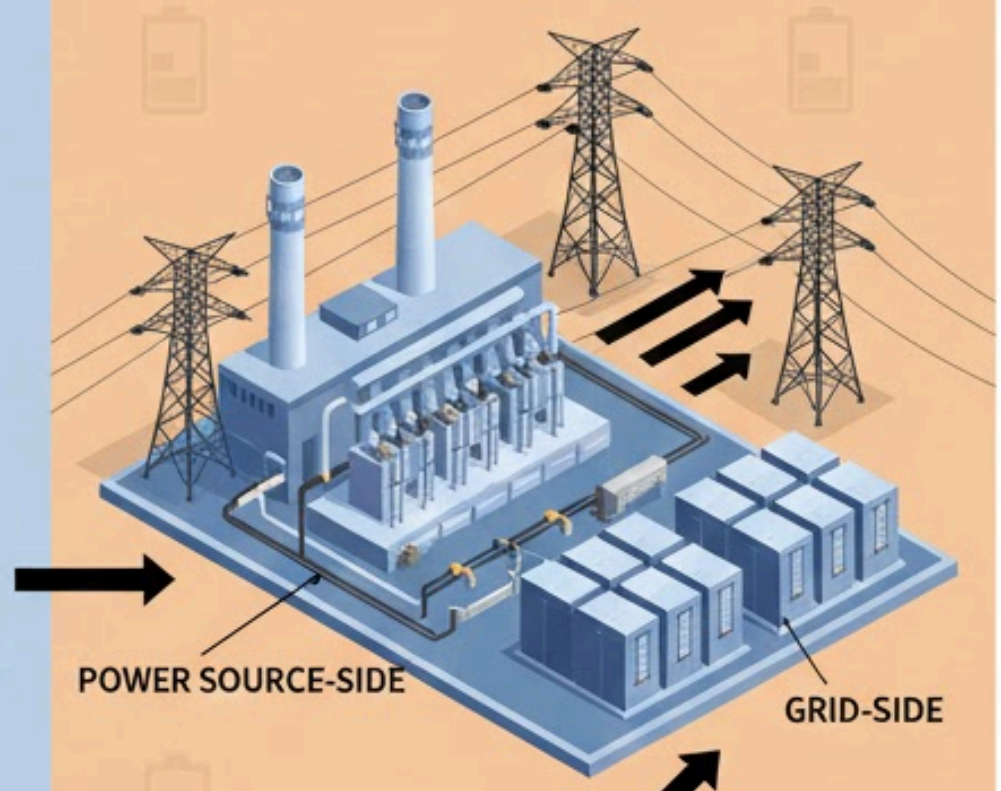
STRING SYSTEM

SMALL-MEDIUM
COMMERCIAL: 10kw-500kw



CENTRALIZED SYSTEM

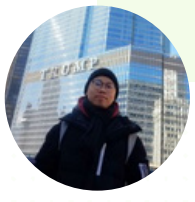
LARGE-SCALE GRID-SIDE:
Peak shaving & frequency regulation, above 5MAW



POWER SOURCE-SIDE:
Stabilize output, work with gen. stations

HANDLES 500+ GWh
ANNUALLY IN US GRID

Applicable Scenarios



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String System

- Small and medium-sized commercial energy storage, such as factories, shopping malls, etc., with a power range of 10kW-500kW.
- Residential energy storage, generally 3kW-10kW. And some scenarios of grid-side energy storage.

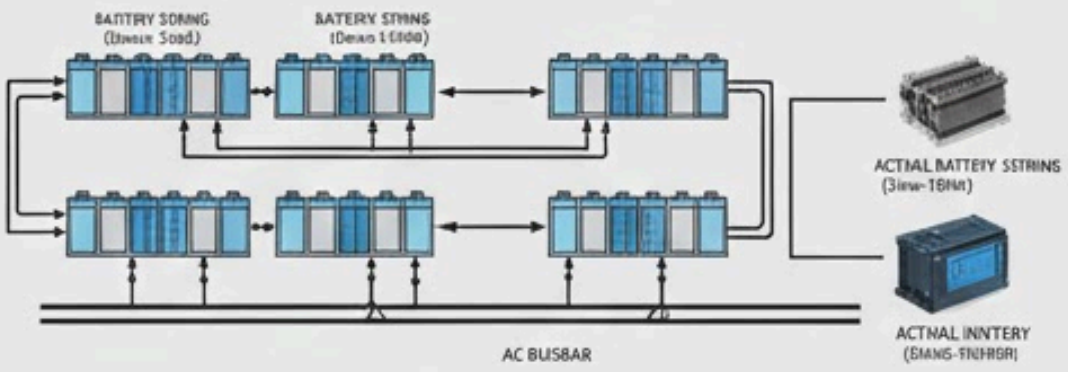
Centralized System

- Large-scale grid-side energy storage, used for peak shaving and frequency regulation, usually with a power of above 5MW.
- Power source-side energy storage, used in conjunction with power generation stations to stabilize power output.

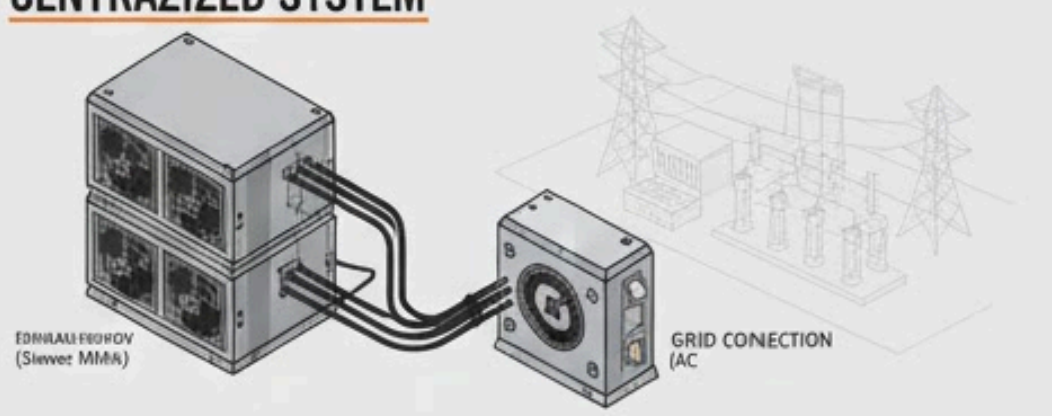
IN-NDETH COMPARISON: STRING VS. CENTRALIZED ENERGY STORAGE SYSTEMS

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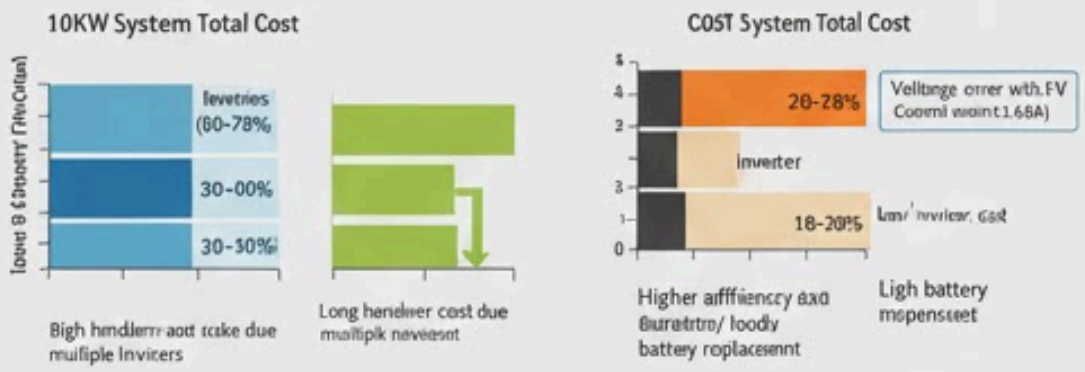
STRING ENERGY SYFERTEM



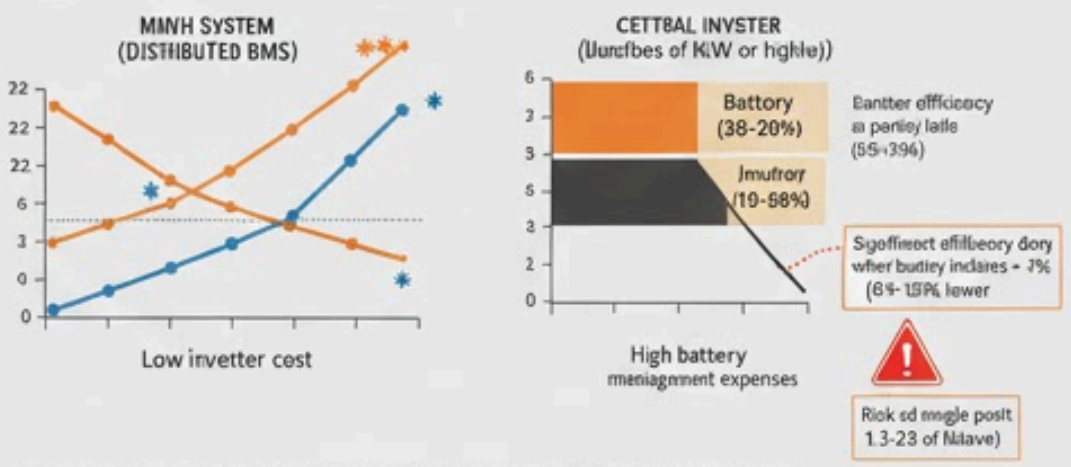
CENTRAZIZED SYSTEM



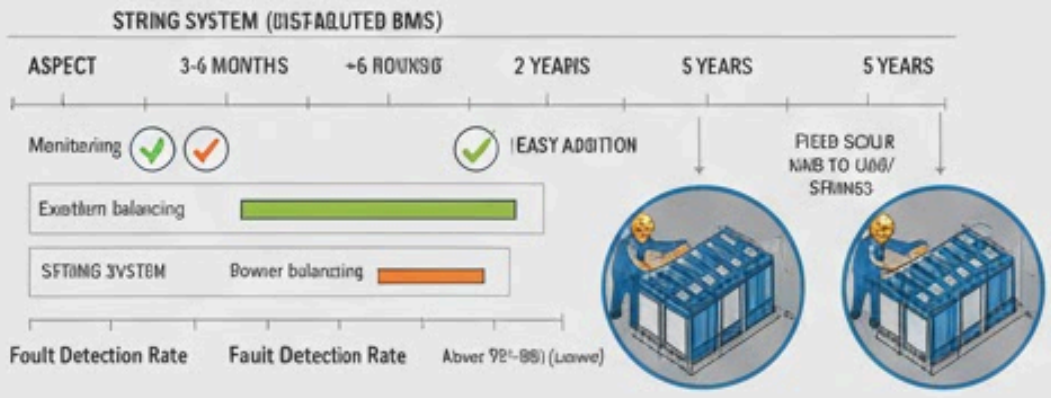
STRUCTURAL DIFFERENCES



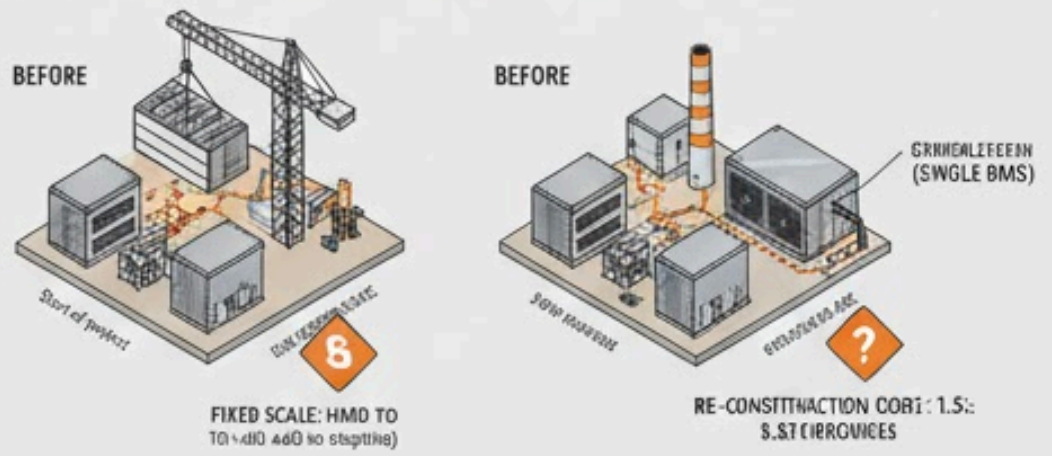
EFFICIENCY COMPETTION



PROS AND CONS OF BATTERY MANAGEMENT



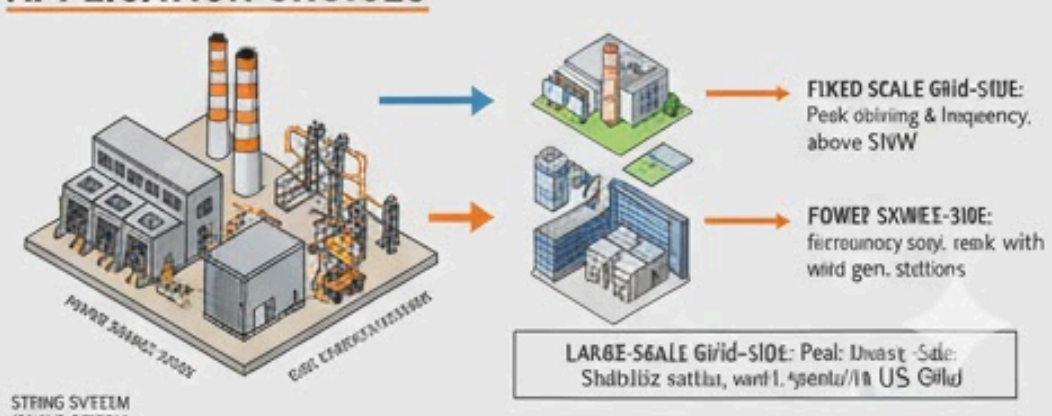
PROS AND CONS OF BATTERY MANAGEMENT



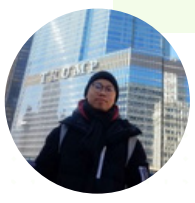
FLEXIBILITY AND EXTENDIBILIY



APPLICATION CHOICES

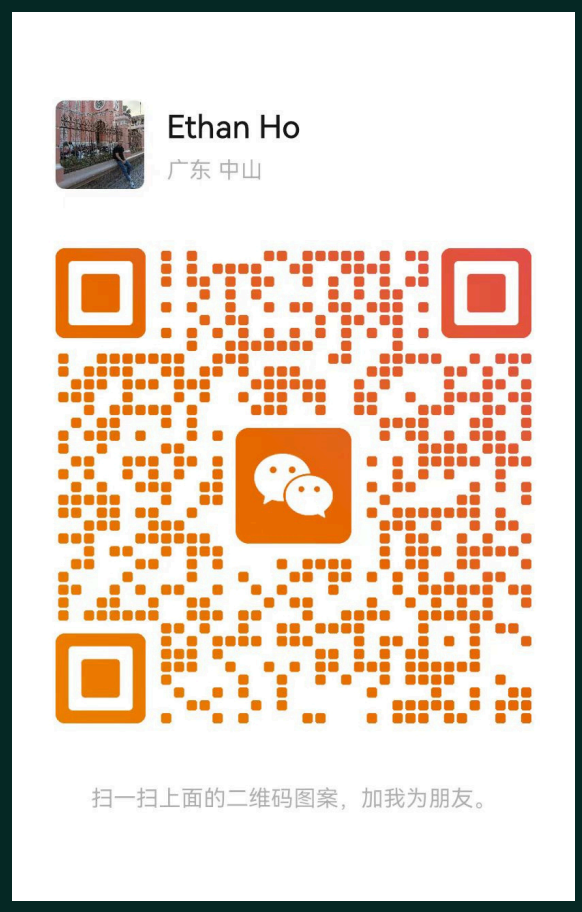


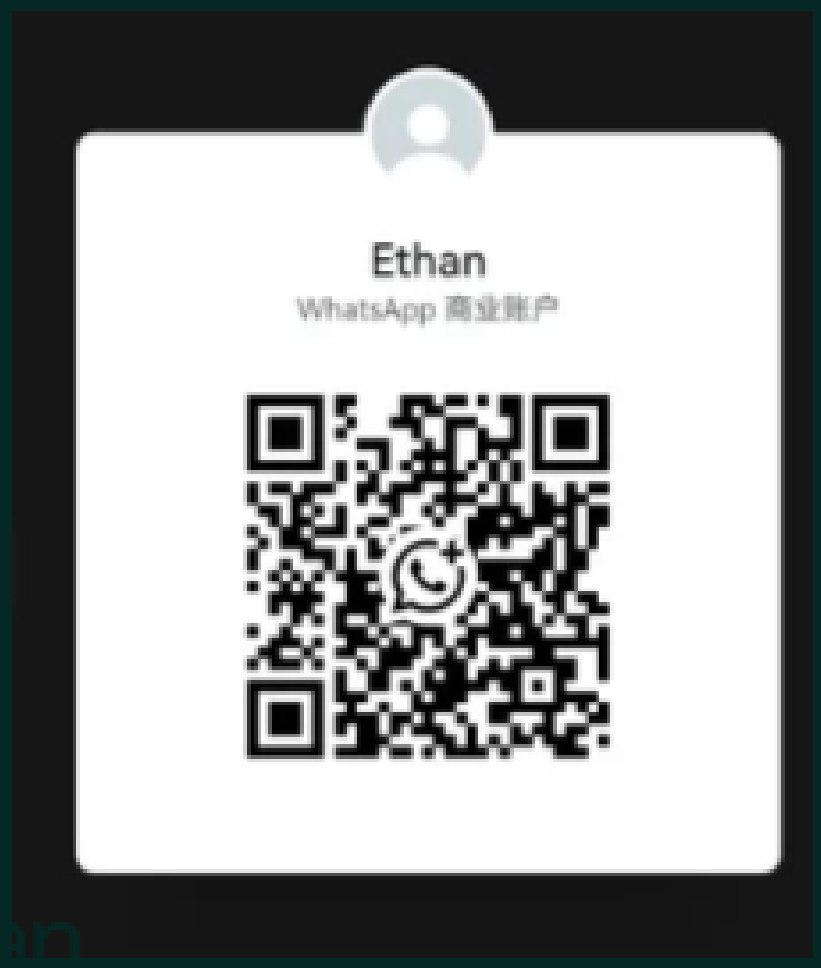
Overall Conclusion



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