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International perspective on EE in Power Plants

Energy Efficiency in the Power Plant Sector

What is being done now, and what are the emerging technologies?

International perspectives with relevance for Vietnam

Tuesday, April 21th 2026



Challenges in a Vietnamese context

Vietnam's power sector is under simultaneous pressure from rapid demand growth, fuel security concerns, rising emissions, and the need for system flexibility as renewable generation expands.

The power sector has been a major enabler of industrial growth, but it is also a major source of emissions and fuel dependence.

According to the World Bank, electricity demand in Vietnam is expected to keep growing at around 6 to 7% per year, and the power sector accounted for 61% of energy -sector emissions in 2020.

Key message:

In Vietnam, energy efficiency in the power sector is no longer only about reducing losses in individual plants . It is now about improving the efficiency of the entire generation and delivery system while preparing thermal assets for a more flexible role.

What “energy efficiency” means in the power plant sector

In the power plant sector, energy efficiency can be divided into four levels:

1. **Plant - level thermal efficiency**
   How much electricity is produced from each unit of fuel.
2. **Auxiliary power reduction**
   Reducing internal electricity use for pumps, fans, cooling systems, flue gas treatment, and handling systems.
3. **Waste heat recovery and energy integration**
   Capturing energy that would otherwise be lost in flue gas, cooling water, or process streams.
4. **System - level efficiency and flexibility**
   Operating the generation fleet, grid, and storage in a way that minimizes fuel use and curtailment while maintaining reliability.

Key message:

Internationally, the focus has moved from isolated component upgrades to whole-system optimization .

Where the biggest efficiency losses are today

For thermal power plants, the main efficiency losses are still found in:

- Boiler and combustion losses
- Flue gas heat losses
- Steam cycle losses
- Cooling system losses
- Auxiliary electricity consumption
- Part-load operation, especially where plants are used more flexibly to balance wind and solar

In coal-fired power plants, flue gas losses are a major issue, with flue gas carrying a large share of boiler losses. Waste heat recovery can measurably improve plant efficiency and reduce specific CO2 emissions.

Key message:

In mature thermal fleets, the next gains often come from waste heat recovery, controls, and flexible operation, rather than from one large equipment replacement .

What is being done now internationally?

Across Europe, China, Japan, Korea, and increasingly Southeast Asia, current energy -efficiency work in the power plant sector focuses on seven practical areas:

1. **Turbine and boiler retrofits**

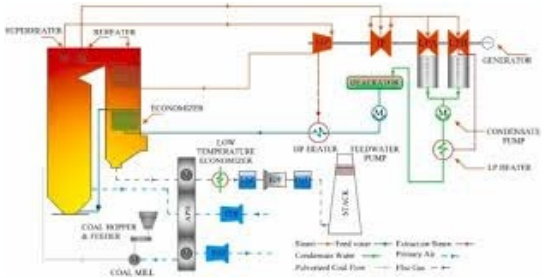
Blade upgrades, seal improvements, better steam path design, burner optimization, sootblowing optimization.

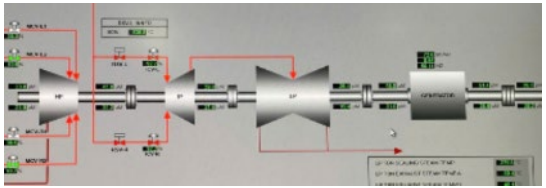
2. **Digital optimization and advanced controls**

Real-time monitoring, digital twins, predictive maintenance, AI -based combustion control, and heat -rate optimization.

3. **Waste heat recovery**

Low-temperature economizers, organic Rankine cycle solutions, absorption heat pumps, and improved feedwater heating.





Where the biggest efficiency losses are today ?

4. **Auxiliary power reduction**

High-efficiency motors, variable speed drives, improved pumps and fans, cooling system optimization.

5. **Grid loss reduction and dispatch optimization**

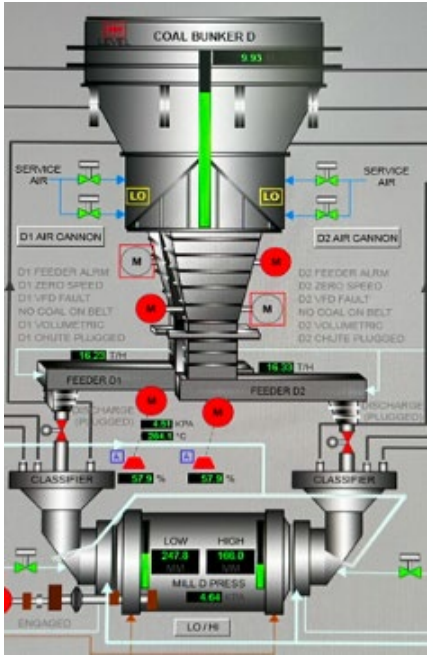
Better dispatch reduces inefficient plant cycling and lowers total system fuel burn.

6. **Fuel switching and co -firing**

Replacing older coal generation with higher -efficiency gas units, biomass co-firing in selected cases, and early pilots for hydrogen blending.

7. **Flexibility retrofits for thermal plants**

Shorter minimum load, faster ramping, lower start -up fuel, and reduced cycling losses, especially important in systems with high wind and solar shares.



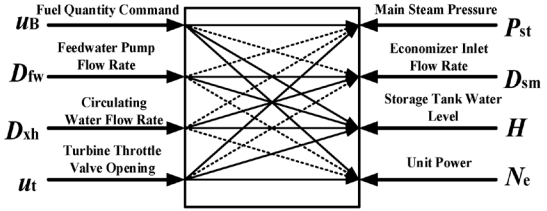
Best available near-term efficiency measures for thermal plants

For existing coal and gas plants, the highest -priority near -term measures are usually:

Heat - rate improvement programs
Routine performance testing, leakage reduction, condenser cleaning, steam trap and valve maintenance, combustion tuning.

Low - temperature waste heat recovery
Recovering heat from flue gas for feedwater heating or other site uses.

Advanced process control
Using model - based controls to optimize combustion, steam conditions, and auxiliary systems.



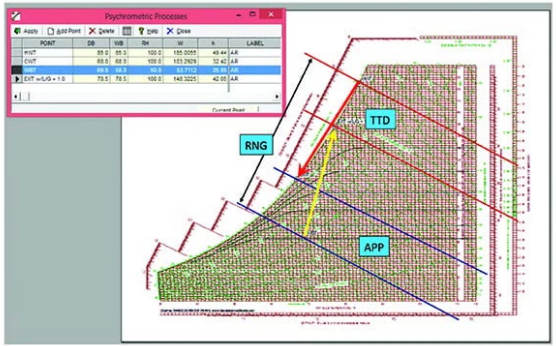
Best available near-term efficiency measures for thermal plants

Variable frequency drives and motor upgrades
Particularly on fans, pumps, and cooling water systems.

Improved outage planning and predictive maintenance
Reducing fouling, forced outages, and hidden degradation.

Flexible operation retrofits
Improving efficiency penalties during ramping and low -load operation.

An internal source describes several waste heat recovery options already practiced or proposed for coal plants, including low -temperature economizers, absorption heat pumps, Brayton -cycle- based recovery, and organic Rankine cycle systems.

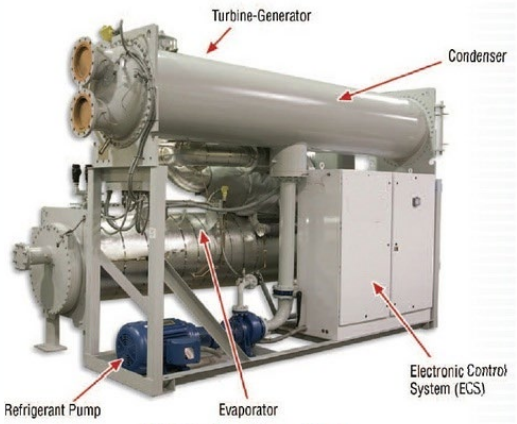


Emerging technologies internationally

The most relevant emerging technologies are not all equally mature and therefore t hey can be separated into commercial now, scaling, and longer-term.

Commercial now or near -commercial :

- AI-supported combustion and performance optimization
- Digital twins for asset management
- Advanced sensors and online performance diagnostics
- ORC for low-grade heat recovery in selected cases
- High-efficiency motors and drives
- Hybridization with battery storage for plant support services



ORC Turbine Generator for Waste heat recovery

Emerging technologies internationally

Scaling internationally

- Thermal energy storage integrated with power and heat systems
- Industrial -scale heat pumps for low -grade heat recovery
- Advanced flexibility retrofits for coal and gas plants
- Carbon capture with partial heat integration improvements
- Hybrid plant configurations combining thermal generation, storage, and renewables

Longer -term / selective use cases

- Hydrogen co -firing
- Supercritical CO2 power cycles
- Advanced long -duration storage supporting thermal fleet retirement
- Full CCUS integration with optimized waste heat use

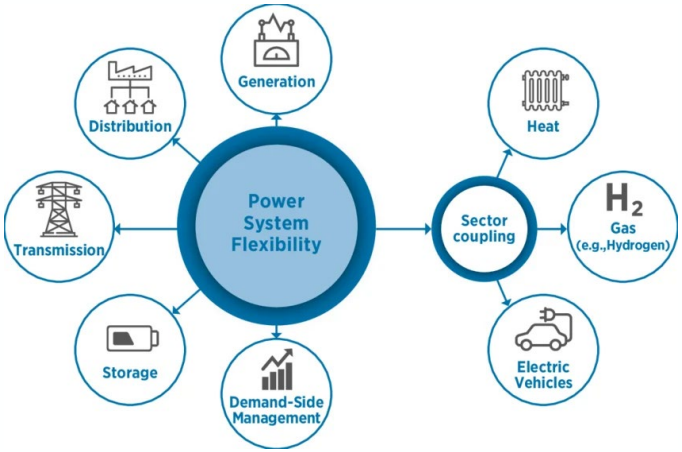
Key message:

The most bankable technologies for the next 3 to 5 years are still digital optimization, waste heat recovery, auxiliary load reduction, and flexibility retrofits . Hydrogen and advanced cycles are strategically important, but not the first efficiency priorities for most Vietnamese assets.

Flexibility is the new efficiency challenge

As solar and wind shares grow, traditional baseload plants are often forced into more cycling and lower -load operation. That creates a new efficiency problem:

- higher heat rate at part load,
- more start -stop losses,
- increased maintenance,
- and lower effective fuel efficiency across the system.



Flexibility is the new efficiency challenge

Large-scale renewable deployment in Vietnam requires much greater grid flexibility, storage, and dispatch capability.

In practice, this means power plant efficiency can no longer be judged only at full load design conditions. It must be judged under real operating conditions.

International response:

- lower minimum stable load,
- faster ramp rates,
- better start-up management,
- integration with storage,
- and digital dispatch optimization.

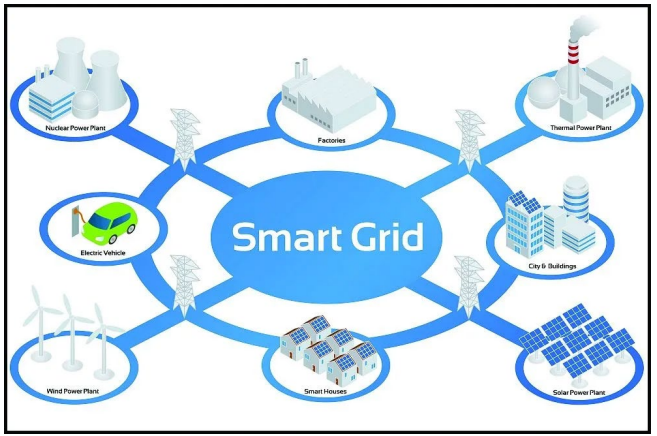
Key message:

In a renewable-heavy system, flexibility and efficiency are linked.

Role of storage and smart grids

Internationally, power sector efficiency is increasingly improved outside the plant fence.

- battery energy storage
- pumped hydropower
- smart grid technologies
- digital dispatch management
- SCADA and automation
- and stronger transmission capacity to integrate variable renewables.



Role of storage and smart grids

These investments improve system efficiency by:

- reducing renewable curtailment,
- lowering reserve requirements,
- reducing inefficient thermal cycling,
- and allowing better dispatch of the most efficient units.

These measures improve system efficiency by using more renewable power, reducing the need for backup reserves, avoiding unnecessary cycling of thermal plants, and enabling more efficient plant dispatch.

Key message:

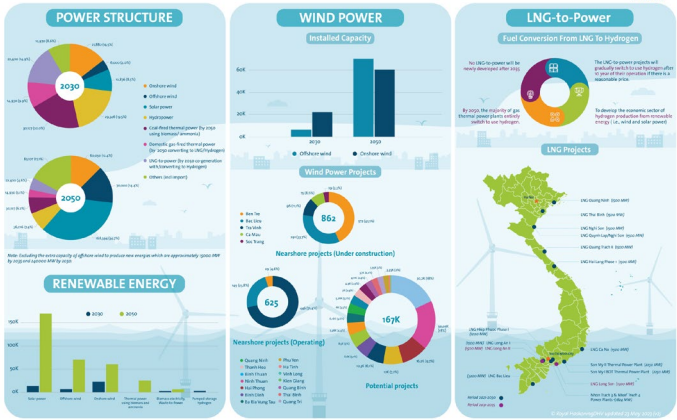
A less efficient plant can still be part of an efficient system if it is used correctly, and a highly efficient plant can be system-inefficient if grid integration is poor.

International technology watchlist for Vietnam

For Vietnam, the following technology watchlist is the most relevant:

High priority now

- digital plant optimization,
- advanced analytics and predictive maintenance,
- condenser and cooling optimization,
- waste heat recovery,
- auxiliary load reduction,
- grid digitalization,
- battery storage for balancing and ancillary services.



International technology watchlist for Vietnam

Medium -term strategic options

- LNG combined -cycle plants with high operational flexibility
- biomass co -firing in selected plants where feedstock logistics are robust
- thermal storage
- industrial heat recovery connected to power -heat integration
- early CCUS readiness studies for major point sources

Longer -term options

- hydrogen co -firing
- CO2 capture at scale
- supercritical CO2 cycles
- repurposing old thermal sites for storage, synchronous condensers, or hybrid energy hubs

Key message:

Reusing retired coal and gas plant sites for batteries, grid support equipment, or combined energy hubs, instead of closing the sites completely .

Key recommendations for the Vietnamese power plant sector

1. Start with operational efficiency, not headline technologies

- The first priority should be heat -rate improvement, auxiliary load reduction, and digital optimization on the existing fleet.

2. Treat flexibility retrofits as efficiency projects

- In Vietnam, flexibility upgrades should be evaluated as part of efficiency strategy, not only as grid support.

3. Systematically screen waste heat recovery

- Especially for larger coal and gas units with high running hours.



Key recommendations for the Vietnamese power plant sector

4. Invest in grid and storage together with generation

- Otherwise plant -level efficiency gains will be offset by curtailment and inefficient dispatch.

5. Prioritize technologies with short payback and low implementation risk

- That means digital controls, drives, heat recovery, maintenance optimization, and dispatch improvements.

6. Build a technology roadmap by plant type

- Vietnam should not use one generic roadmap. Coal, gas, hydro, and renewable -integrated assets need different efficiency pathways.



Closing message

Vietnam does not need to choose between energy security, efficiency, and decarbonization. International examples show that these goals increasingly support each other, if investments are focused on:

- better operation of existing assets
- stronger grid flexibility
- digitalization
- storage
- selective deployment of emerging technologies

The next wave of power sector efficiency in Vietnam will come less from one breakthrough technology, and more from combining plant optimization, flexibility, storage, and smarter system operation.

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THANKS!

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