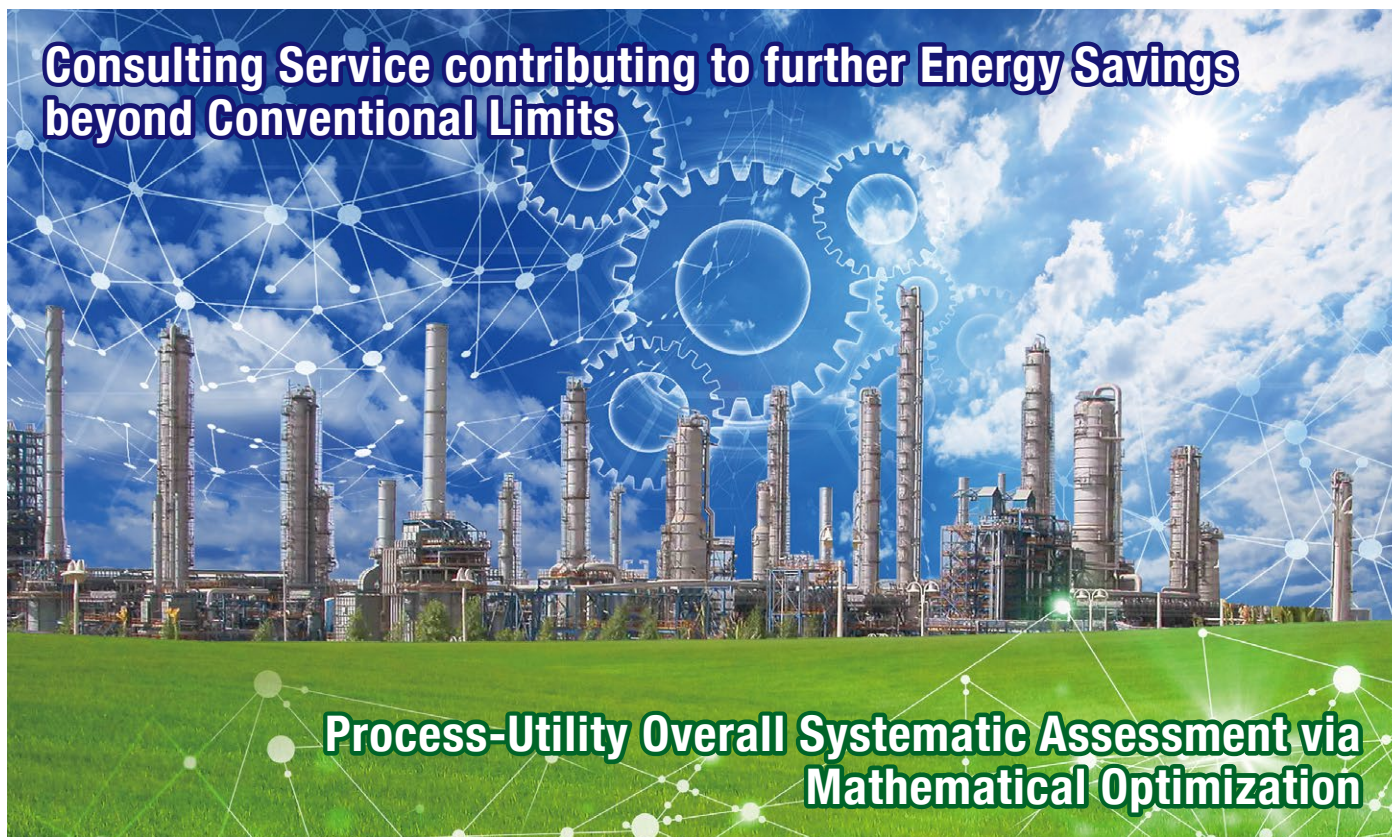


HERO

Hybrid Energy system Re-Optimization



Remarkable energy savings of **39.7%** against existing plants

HERO's mathematical optimizer is able to process and examine a much greater number of alternative configurations compared to conventional approaches which results in unexpected and promising energy-saving options. HERO has been demonstrated through application to several Japanese petrochemical plants, which have already been highly process-intensified after the oil crises in a national project. As illustrated in the summary below, HERO provided remarkable solutions for further energy-savings. For example, an aromatics plant reduced total energy consumption by 39.7%.

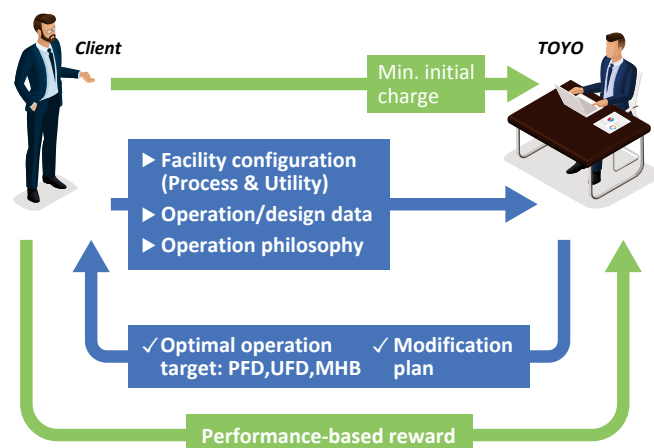
HERO can meet various demands: reduction of steam boiler duty, increase of steam exportation, and/or increase of electric power selling, etc. Based on each client's business environment, HERO provides economically attractive solutions.

Case 1	Case 2	Case 3
Boiler Duty	MPS Export	Hot oil Duty
31.3 MW	2.7 MW	12.3 MW
-39.7%	+473%	-22.8%
18.9 MW	15.5 MW	9.5 MW

HERO benefits clients both Technically and Financially

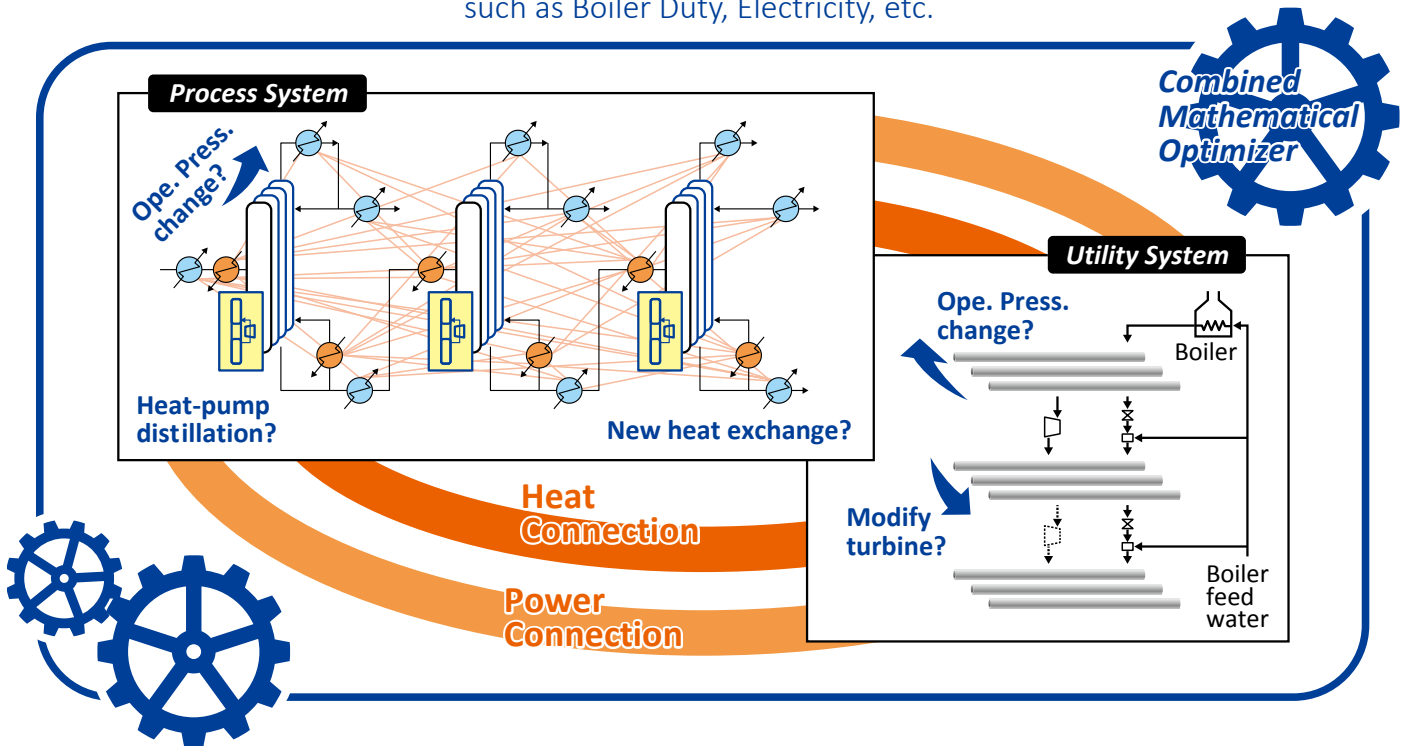
Through the dedicated diagnosis of the client's plant using tailor-made optimization models, HERO benefits the client TECHNICALY. Not only are the characteristics of the facilities analyzed but also operation philosophy, equipment modification constraints, and investment policy are fully embedded into the optimization model, so that the resulting solutions perfectly fit the client's preference.

With only a minimum initial charge, the client benefits FINANCIALLY from low consulting fees that result in a reduction of operation costs and greater profit. Only when the benefits are realized the performance-based reward system is initialized.



Combined Mathematical Optimizer Minimizes Energy Input

such as Boiler Duty, Electricity, etc.



Process-utility systems simultaneous optimization via plant-wide model

— For effective and practical conservation of net energy consumption —

HERO discovers hidden energy-saving solutions as a result of simultaneous optimization of the process system and utility system. Since simultaneous optimization involves numerous and complicated trade-off relationships, conventional methodologies usually only cover partial optimization on either the process or the utility system resulting in minimal local optimization. In contrast, when Mixed Integer Linear Programming is applied with the HERO optimizer, plant-wide optimizations can be achieved.

HERO suggests the steady-state target and the corresponding modifications, which enable effective and practical energy savings. For effectiveness, the net energy input to the plant is selectively minimized: e.g. energy obtained from off-gas is kept the same. For practicality, operability is comprehensively examined with TOYO's engineering knowledge.

In addition, HERO does not interfere with previously installed advanced control systems or monitoring systems – while such software contributes to the real-time operation through managing dynamic behavior, HERO finds a new steady-state target.

Superior process-system optimization

— Beyond Pinch Analysis —

For process-system optimization, HERO outperforms conventional methodologies such as pinch analysis. HERO of course, considers all possible combinations of heat exchanges as the pinch analysis does. In addition, HERO also considers:

- ▶ Drastic change of operating pressures, temperatures, and heat duties
- ▶ Implementation of new heat exchanges

Further energy-savings can be realized with SUPERHIDIC™, TOYO's own heat-pump distillation system. Since applied to a column in a commercial petrochemical plant in 2016, energy savings of 50% has been achieved.



Flexible utility system optimization

HERO can handle various utility system configurations such as steam systems, hot oil systems, etc. For each type of utility system, adequate options are prepared; e.g. setting new operating pressures for steam headers. In addition, HERO can examine equipment modification such as mechanical modifications of steam turbines which conventional tools cannot analyze but may lead to significant energy savings.



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