Energy Solution in the Industrial and Commercial Sectors

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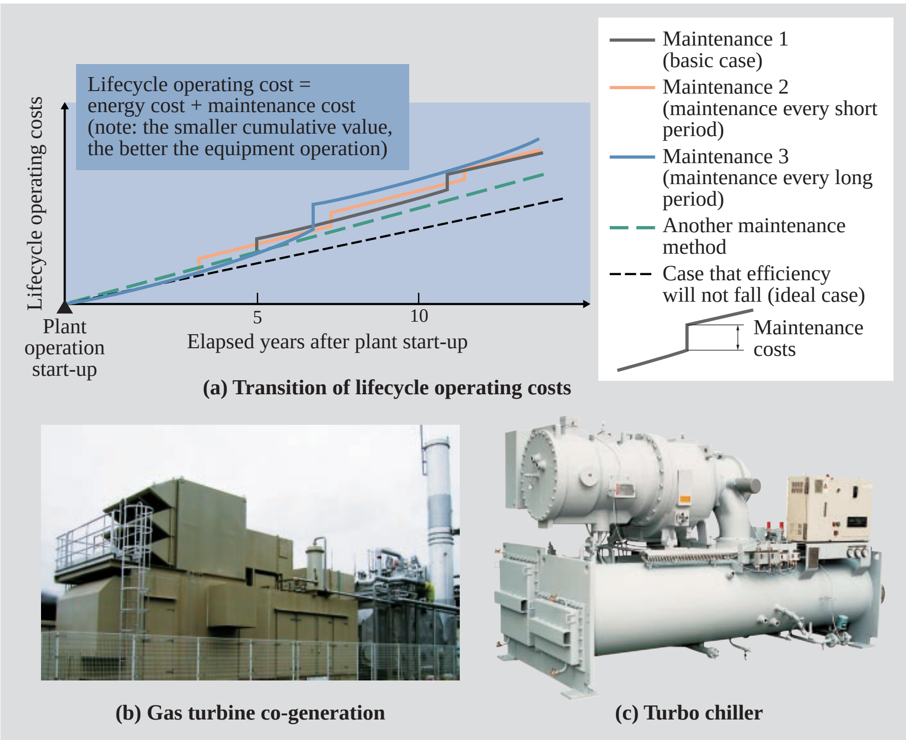
OVERVIEW: As concrete measures for reducing emissions of greenhouse gases (mainly CO_2) pledged under the commitment period of the Kyoto Protocol, ESCOs — targeting customers in the industrial and commercial sectors — are drawing attention. As a service business based on a platform for so-called "monozukuri" (i.e. "making things by the hands of skilled labor" in Japanese), the Hitachi Group is actively engaged in ESCO business, which has built up many successes since starting up in 1999. In regard to ESCO equipment currently in operation, to address issues that come up concerning operation of equipment, new measures (starting with methods for optimizing operation of each of multiple machines and for evaluating performance of constituent devices) make it possible to minimize operation cost over the lifecycle of a machine or facility.

INTRODUCTION

OVER recent years, the energy supply-demand situation has been changing dramatically. In particular, owing to rapid economic growth in the "BRIC" countries (i.e. Brazil, Russia, India, and China) and the current crisis concerning oil supply and demand (which is described by the in-vogue "peak-out theory" of crude-oil deposits), the price of crude oil has risen extraordinarily. On top of that, planning and execution of concrete measures for reducing greenhouse-gas



(a) Transition of lifecycle operating costs

(b) Gas turbine co-generation

(c) Turbo chiller

Fig. 1—The Search for Operation and Maintenance Methods that Minimize Operating Costs Accumulated over a Long-term Lifecycle.
As for energy-saving equipment, performance deteriorates with elapsed operational period. By optimally implementing maintenance method and its frequency in accordance with operational status of equipment, each cost in the lifecycle (i.e. CO_2 emission volume, energy consumption, and accumulated operating costs) can be minimized.

emissions [primarily CO_2 (carbon dioxide)] within the commitment period of the Kyoto Protocol (which started in 2008) is acquiring an urgent status from the viewpoints of the industrial and commercial sectors.

Particularly in regard to the industrial field, which has been actively promoting energy saving since the start of the 1970s, further CO_2 reduction is anticipated, and the theme of “CO_2 reduction” is being added to the themes of “energy saving” and “short-term pay-back year of capital investment in energy-saving equipment;” consequently, multi-dimensional business solutions are being urged more than ever before from both the technological and business aspects.

In regard to maintaining environmental conditions for people and suppressing global warming, reduction of CO_2 emission is an important theme that will without doubt challenge humankind from now onwards.

As for CO_2 reduction, the new concept of a “cap and trade” system — which sets an upper limit on greenhouse-gas emission in each company and regulates and trades excesses or deficiencies in relation to that limit as emission credits — was already established, and the first such emissions trading system to start operation was in the UK in 2002. Covering European regions, its market scale has already surpassed 3 trillion yen. Moreover, the USA is also moving towards introducing a European-style emissions trading system. At the G8 Hokkaido Toyako Summit, which took place in July 2008, CO_2 reduction was also vigorously discussed. And momentum to introduce such a system at the earliest possible chance in the next few years has been building.

The Hitachi Group implemented a so-called ESCO (energy service company) — targeting customers in the industrial and commercial sectors — in 1999.

In the rest of this report, from among Hitachi’s energy solutions for CO_2-emission reduction and global environmental preservation, case examples on reducing the “lifecycle operating cost” of energy-saving equipment operating at various locations and customers in Japan are focused on (see Fig. 1).

ESCO BUSINESS PURSUITS BY HITACHI

Hitachi started ESCO business in 1999. First facilities, which started running after initial ESCO contract have already surpassed eight years or so (as of summer 2008). As for maintaining the performance of each facility at the highest possible level over the contract period, the overriding responsibility lies with the ESCO business that handles all customers.

Energy facilities mainly consist of co-generation machinery (like gas turbine and gas engine) as well as chiller equipment and air compressor. It is often the case, particularly in the industrial sector, that these facilities operate under the most severe conditions in regard to machinery — that is, year-round, continuous operation. Consequently, within the contract period with a particular ESCO business, it is also sometimes the case that performance (i.e. power output) and efficiency fall and, in turn, machinery may malfunction or shut down unexpectedly. As for facilities of ESCOs contracted with Hitachi, the energy demand-supply status of each facility is monitored at all times. Since ESCO facilities operate while external and demand conditions change constantly, it is extremely difficult to estimate the degree of degradation in performance from the initial start-up condition.

From actual operational data and mechanical properties of each machine and computer simulation model developed by Hitachi, degree of deterioration of true performance of each machine is evaluated, optimum operation and maintenance methods for particular site conditions can be determined, and, in turn, above model can enable lifecycle operating costs minimum (see Fig. 2).

Minimizing operating costs brings both parties in minimization of lifecycle costs, and CO_2 reduction can actually be implemented; in other words, desirable results from the viewpoints of both the customer and the ESCO can be achieved. The features of measures to reduce operating costs are described below.

(1) Optimization of inspection and maintenance of equipment

As for equipment and facilities, if appropriate maintenance is not executed, performance and efficiency will inevitably decrease with time. The degradation rate in equipment performance varies in accordance with each machine and external factors such as the ambient air condition and location installed. As a result, performance and degree of deterioration are estimated by using monitoring data on atmospheric conditions and so on, and maintenance procedures and timing are reset while being instructed to the operator.

(2) Monitor abrupt equipment performance change

An abrupt equipment performance change is considered to cause sudden fouling of air and cooling water on the equipment side and the demand fluctuation (e.g., increase and decrease in productivity). In case that there is a significant difference between current monitoring data and past

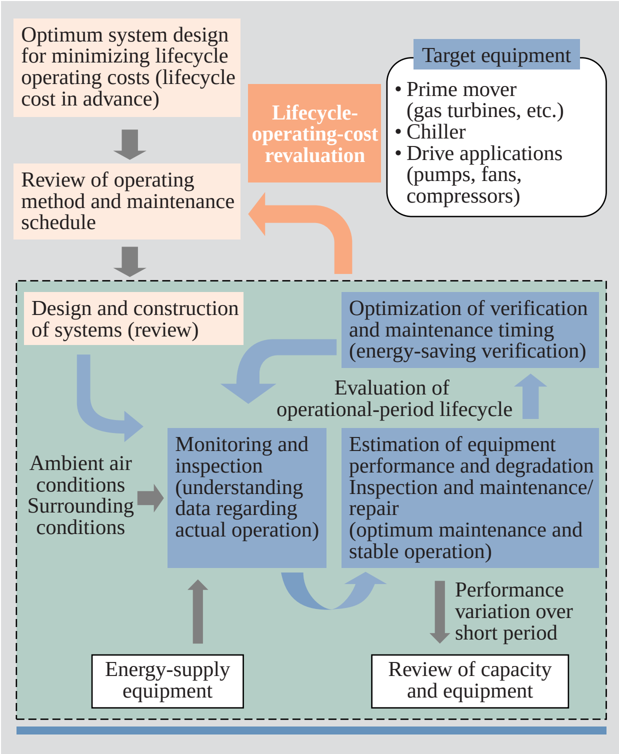


Fig. 2—Execution of Measures for Reducing Lifecycle Running Costs of ESCO Equipment and Facilities.
The lifecycle of energy-service operations varies dependent on equipment installation site condition and operational status. It is important to find out the optimum operating condition for each machine and reflect it in the actual operation.

one, the operator is advised to perform prompt inspection of the equipment and/or demand fluctuation check.

The following three mutual merits, that is, in regard to both the customer and the ESCO, are attained by executing the above-mentioned measures.

(1) Reduction of lifecycle operating costs

Deterioration of performance of energy-supply facilities varies in accordance with location installed and operational status. If appropriate maintenance items and inspection period can be determined (by grasping the actual operational status of each equipment), execution of wasteful or excessive maintenance could be eliminated and lifecycle cost could be minimized.

(2) Curbing production loss due to preventive maintenance on machine faults

By predicting machine malfunctions and implementing preventative maintenance, it is possible to keep up stable production and curb production loss to the customer side.

(3) Optimizing operation of equipment

In accordance with the level of performance deterioration of each equipment, the operational method for minimizing lifecycle operating cost will change. By specifying the operational method for minimizing operating costs in response to operational status of a machine at any time, it is possible to minimize the cost accordingly.

Some specific results of the above performance evaluation are described in the following section.

EVALUATION OF PERFORMANCE OF MAJOR MACHINE EQUIPMENT

Performance Evaluation of Gas Turbine

Gas turbines are important machinery for energy saving, that is, by supplying electrical power and heat simultaneously. Performance of a gas turbine varies significantly with atmospheric conditions: from 5% to 10% during the day or up to 20% seasonably. As a result, in the conventional manner, it is normal to formulate a calculation model for recreating internal phenomena of a gas turbine (based on lots of detailed design information), feed actual operating conditions into the model, and calculate performance. This calculated performance result is then compared with performance measured on an actual machine and performance diagnosis is carried out. A drawback of this performance-evaluation method is that it involves a tremendous amount of work.

As for gas turbines used in energy services, their performance characteristics change considerably in accordance with aging deterioration and major overhauls every several years or so. What's more, it is often the case that targeted machines may not only be in-house products but may also be products bought in from other companies. In such cases, design data is not easily attainable, so accurate performance evaluation is not easy.

Given the above-described issues, we have developed technology for automatically formulating a performance calculation model of a gas turbine from data during actual operation (i.e. without the need for design data). By using a loading-state identification algorithm with multi-dimensional indices developed originally, this method can discern the effects of factors fluctuated (such as atmospheric condition) and evaluate precise variations in machine performance. The predictive accuracy of the performance model is within an error of 1%.

An evaluation example is shown in Fig. 3. With this technology, it has become possible to

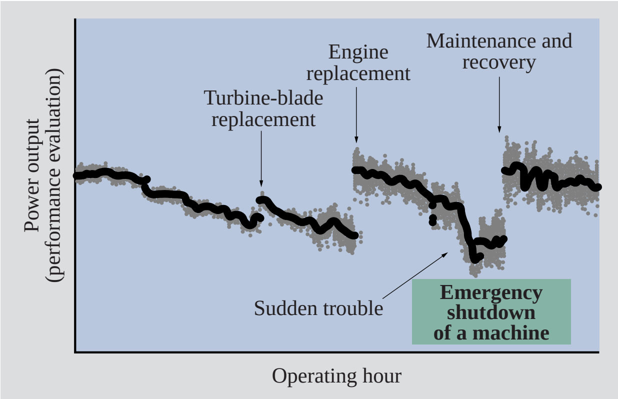


Fig. 3—Evaluation of a Gas Turbine Performance Degradation.
Since aging deterioration of power output as well as performance restoration by maintenance and conditions for abrupt performance degradation can be quantified by use of developed software, appropriate maintenance can be carried out. And trouble due to sudden performance degradation can be forecasted.

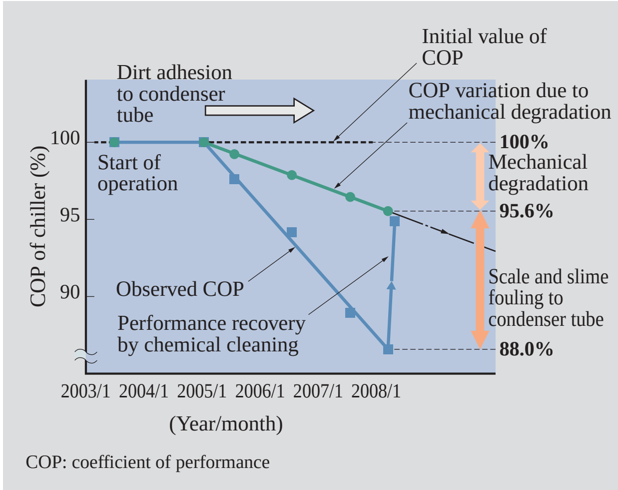


Fig. 4—Aging Degradation of Turbo Chiller (Diagnosing Result by Observation System).
Degree of performance degradation of turbo chiller is estimated by measuring fouling adhesion to condenser tubes. This result is then reflected in the maintenance strategy of the chiller. In this example, the portion of performance degradation due to tube fouling can be almost recovered by chemical cleaning of the condenser tubes.

quantitatively evaluate yearly deterioration in performance (which could not be discerned by conventional means) and recovery status following maintenance (such as replacement of parts) and unexpected changes due to abnormal events. Moreover, since performance deterioration can be evaluated from actual operational data, it is possible to efficiently arrange parts exchange and worker schedules and preserve performance and efficiency of equipment at low cost. In addition, predictive diagnosis enabling prompt detection of short-term deterioration of performance variation is being developed, and from now onwards it is planned to sequentially expand the various sites where the performance evaluation is being executed.

Performance Evaluation of Refrigeration Equipment

In industrial sectors like producing semiconductors, electronic parts, and food, chilled heat is required all year round. Of the energy consumption of them, the portion taken up by chilled heat is extremely big, namely a quarter to a third of total energy consumption.

Consequently, evaluating the level of performance deterioration of cooling equipment and carrying out appropriate maintenance at the appropriate time in response to the deterioration condition of a machine are directly related to minimizing operating cost over the lifecycle of a chiller facility. Both customers and ESCOs wanting to reduce operating costs and cut CO_2 emissions will benefit.

Hitachi has developed a simulator — which uses data on the actual operating behavior of a chiller facility in a similar fashion to the gas-turbine example described above — for estimating deterioration in chiller performance.

This simulator can evaluate performance deterioration by considering a combination of time degradation of heat transfer performance (due to contamination in cooling water) and aging deterioration of a chiller (related to operating hours). The extents of the contributions of each degradation factor in COP are plotted against operating time of a chiller (see Fig. 4).

Optimizing Operation of Complex Equipment (Switchover to Optimization of CO_2 and/or Cost)

Appropriate plan and operation of equipment are devised for a business operation to meet energy demand. Demand (for steam, electricity, etc.), however, varies with the passage of time; therefore, it is sometimes the case that equipment load factor changes in comparison with that at initial stage. Moreover, in the case that electricity or fossil fuel is used in the plant for the energy source, the issues arise such as increasing in operational energy costs and fluctuating influence on global warming (such as increased CO_2

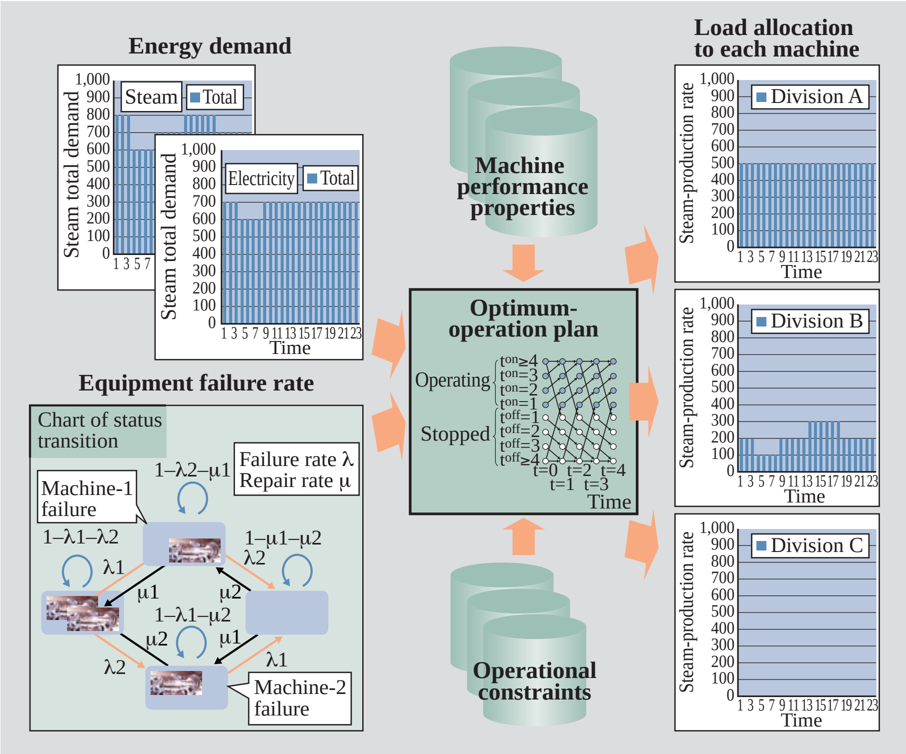


Fig. 5—Planning System for Optimum Design.
Energy demand is forecasted, and the optimal operation plan is devised in consideration of operational constraints and allocates each machine to energy demand. The lower left figure shows an example of status transition of equipment failure in the case of two machines. According to the cumulative operational hours, failure rate and repair rate become different, so the optimum operation plan will be changed.

emission).

One of the solutions to these issues is to utilize various energy sources and accommodate other division's plants with both electricity and steam. With this solution, to efficiently utilize various energy resources and meet various time period demands, the optimal scheduling to minimize total costs is planned and executed for the complex equipment (such as generators and boilers). An optimization method such as dynamic programming can be applied, and equipment operation with multiple energy sources like electricity and steam can be optimized.

In this regard, to accomplish this utilization of a variety of energy sources, as well as reducing total energy costs, it is necessary to keep the risk of effects on productivity from failure of individual machines at or below existing levels. To do that, it is necessary to consider failure rate and repair rate of each machine and forecast the transition probability of operational status (see Fig. 5). In accordance with this probability and equipment-operation plan, the risk of reducing productivity is comparatively evaluated by using energy-supply deficiency in the case of an equipment failure, and standby equipment is selected.

By means of the above method, it is possible to use energy efficiently in response to variation in demand and to save energy costs incurred by each business operation. At the same time, CO_2 emission can be minimized — thereby contributing to global environmental preservation.

CONCLUSIONS

From among Hitachi's energy solutions for reducing CO_2 emission — and thereby contributing to global environmental preservation — several examples of reducing operating cost over the lifecycle of energy-saving equipment operating at various locations in Japan were described in this report. At present, ESCO projects implemented by Hitachi are addressing the two major issues summarized below.

(1) Adaptation to energy cost fluctuation

Over the last few years, energy costs (particularly the price of fossil fuels) have risen steeply (i.e. double to threefold). The rate of this price rise is much bigger than that for electricity, so it is crucial to appropriately select the energy source to adopt.

(2) From energy saving to CO_2 emission reduction

The key issue focused on by the Kyoto Protocol is suppression of global warming, and reducing CO_2 emission is crux of that issue.

The measures to address these two issues are achieving energy conversion and improving equipment efficiency as well as minimizing "lifecycle" operating cost of equipment during actual operation. As a service business providing a platform for so-called "monozukuri," the Hitachi Group will continue promoting energy solutions that contribute to conservation of our global environment.

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