Akihiko Tsuchida,
General Manager of
Middle East Office

EV model used in pilot

Building Smart Communities Development of the EV Pilot in Masdar City

Masdar EV Smart Community Project Team

MHI is currently implementing a pilot for an advanced "smart" transportation system using electric vehicles (EVs) in Abu Dhabi, capital of the United Arab Emirates. The pilot is part of the Masdar City project to develop one of the most sustainable communities on the planet — a partnership project with Masdar, a local state-owned enterprise. Let's follow the Masdar EV Smart Community Project Team in their quest to apply the results of this EV transportation system, which is the first of its kind to succeed in a region of intense heat, to the establishment of smart communities around the world.

In an area adjacent to Abu Dhabi International Airport, construction is underway of Masdar City, one of the world's most advanced smart communities. It is a hugely ambitious project to create a city of the future in a desert where daytime temperatures can reach around 50ºC. In this city of the future, EVs are under the control of an EV control center, the product of an EV pilot project launched by Masdar in collaboration with MHI in January 2011. The EVs are used for intra-urban transportation and also for travel to Abu Dhabi International Airport and neighboring areas.

A Pioneer in Intra-Urban Transportation Infrastructure

How did MHI come to be involved in the Masdar City transportation infrastructure project? Akihiko Tsuchida, General Manager of MHI Middle East, reflects on how it began: "MHI and Masdar first came to the table over an EOR [Enhanced Oil Recovery] project that used MHI's CCS [Carbon Dioxide Capture and Storage] technology." However, the UAE — one of the world's leading oil exporter is now rapidly moving toward greater diversification of its economy. As a state-owned enterprise whose goals include becoming a global hub for renewable energy and clean technologies, Masdar's interest did not stop with the EOR project. "After the EOR project, Masdar became interested in MHI's transportation infrastructure technology as well. We proposed our EV control center — an essential feature for creating sustainable cities that aims to achieve a low carbon footprint — and it proved to be a good fit with the orientation of the smart community that Masdar was working toward, and so the EV pilot project was adopted."

Three Months to Start of Service

Excitement at the project's adoption was tempered somewhat by an extraordinarily ambitious goal: the pilot operation was to be completed in time for the World Future Energy Summit (WFES), which would be hosted three months hence. Simply bringing the EVs to the site was not enough to start the EV pilot project. On the software front, MHI needed to create an EV control center that could take into account the traffic flows of all vehicles in the city as well as the electrical supply and demand environment to ensure no vehicles would be held up. In terms of hardware, MHI had to install a charging infrastructure and the communications system necessary to implement the EV control center. Moreover, as this was the UAE's first official EV pilot project, there were numerous problems to overcome, including integration with existing infrastructure, testing to ensure that everything would work in the intensely hot environment, as well as acquiring official registration to run the EVs, which were not available on the market in the Middle East, on public roads.

According to Kyoko Oshima, who oversaw the wireless and electronic technologies, "MHI had already completed development of an in-vehicle device used for communication between the EVs and the EV control center, but then came a change of plan to use smartphones, which were already in widespread use. The aim of this change was to build a user-friendly system that anyone could easily enjoy in the future. However, this meant we had to build a completely new system and that alone made the whole process a series of hurdles to overcome."

Unexpected problems also arose getting the project underway. "One example was the installation of the roadside antennas to allow communication between the EVs and the EV control center. UAE has different environmental factors compared to Japan, such as the uniquely high temperatures and humidity, as well as the sand and dust. System adjustment for the local climate was a constant process of trial and error," explains Masato Kato, who supervised equipment control.

Atsushi Adachi, who coordinated the on-site construction, ran up against an incompatibility in charging outlet types. "We had confirmed beforehand the type officially used in the UAE, but in practice there were multiple plug types in use, and they did not fit the cable outlets we had procured. In principle, it is not a good idea to use adapters for EV outlets due to the high-amperage electrical current, but we could not delay the start of the test runs, so we made it through the period by continuously monitoring the adapters until we could replace them."

Kentaro Kawaguchi from the Strategic Business Development Department says "In a new field like smart communities, difficulties arise since product archetypes do not yet exist. You have to start by defining exactly what it is you will be creating. You have to visualize what users will need when they operate the product and nail down the specifications with those assumptions in mind. It is astounding that we managed to make everything happen in less than three months." This was how the first official EV pilot project in the Middle East came into existence.

Secretary-General Ban Ki-moon and Chancellor Merkel Visit

Completed with astonishing speed in time for the opening of the WFES, the EV control center is a pragmatic scheme that contributes to global environmental conservation, and it was received with great interest by the WFES attendees. The electricity in Masdar City is generated by photovoltaics and the goal is to build a smart community for its 40,000 residents and 50,000 commuters. It is a truly groundbreaking project, and the world leaders have lined up to tour the Masdar City, including Secretary-General Ban Ki-moon of the United Nations and Chancellor Angela Merkel from Germany.

Maki Nemoto, in charge of the EV pilot project office in Masdar City says, "For us to meet the requirements, improvement is mandatory and we reflect the ideas and needs regarding the EV control center on a daily basis. As a result the number of users tripled in six months. At present, each vehicle travels around 100km per day, or approximately 2,000km per month. Yet so far we haven't encountered any major problems. MHI's EV control center is proving itself in the extreme climate here in Abu Dhabi."

MHI is exploring various energy management technologies to make better smart communities. Already, in addition to demonstrating different types of energy management technology in Andalusia and Kyoto, discussions are getting underway with local government agencies in China and India. Through the EV pilot project in Masdar City, the world of smart communities has begun to transition from the conceptual stage to the realization stage, and MHI leads the field by a wide margin.

A: Masdar staff and project team. Nemoto (second row, fourth from left), Watanabe, Abu Dhabi Office General Manager (second from right), and Kawaguchi (right of Watanabe)

B: Adachi, Oshima and Kato from left

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Special Feature | **Turbochargers**

THE DYNAMISM OF TURBOCHARGERS

P02-03 : The TD015 (in technician's hands), the smallest-class car turbocharger fitted in light-class car engines, and the MET90MA (behind technician), the largest-class marine turbocharger for container vessel diesel engines. Medium- and large-sized marine turbochargers are produced at the Saiwaimachi Plant of Nagasaki Shipyard & Machinery Works (Power Systems), while small turbochargers for passenger cars and other uses are produced mainly at Sagamihara Machinery Works (General Machinery & Special Vehicles), but also in plants overseas.
Nagasaki Shipyard & Machinery Works, Nagasaki Prefecture

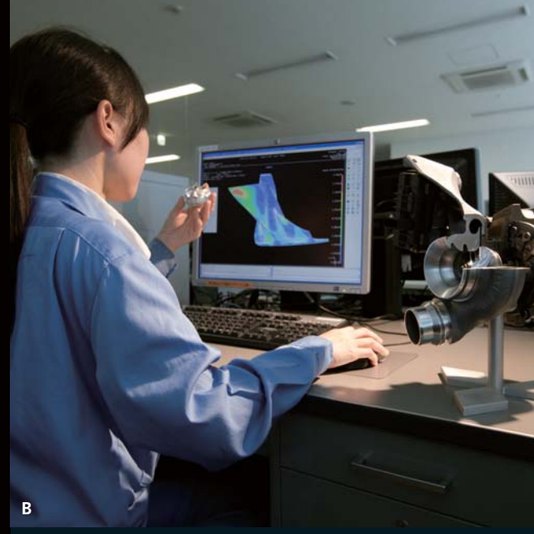
Front cover : Turbocharger for passenger car engine
Sagamihara Machinery Works, Kanagawa Prefecture

The turbocharger — a compelling response to harsh economic times and environmental standards

Most people associate turbo engines with high horsepower sports cars. However, the engines of most trucks, buses, construction machinery, generators and ships are also powered by turbochargers. The future development of car engines depends heavily on turbochargers. Turbochargers are essentially supercharging systems that efficiently burn fuel in a piston chamber by pumping large amounts of compressed air to the engine. As such, they are now attracting keen attention as formidable responses to current economic and environmental issues because of the increased engine power, improved fuel consumption and reduced emissions that they are capable of delivering in downsized engines.

PRODUCTS THAT DEFY EXPECTATIONS

A



B

A : Turbocharger performance being tested while fitted in an engine. The photo shows a gasoline engine with a rated speed of 6,000rpm being operated at 5,000rpm. The outside of the engine is scorched red due to prolonged exposure to extremely hot exhaust gases, with the turbine inlet temperature reaching 900°C. There are now calls for gasoline engines to be fitted with turbochargers that can withstand exhaust gas temperatures of up to 1,050°C.
Sagamihara Machinery Works, Kanagawa Prefecture

B : After the basic design has been completed at the Nagasaki Research & Development Center, the Turbocharger Engineering Department of Sagamihara Machinery Works uses 3D imaging to analyze the thickness and angles of the blades, the most important components of the turbocharger's compressor wheel. The 3D imaging allows engineers to simulate the optimal balance between the conflicting requirements of strength and lightness (thinness), while also taking the client's requests into consideration.
Sagamihara Machinery Works, Kanagawa Prefecture

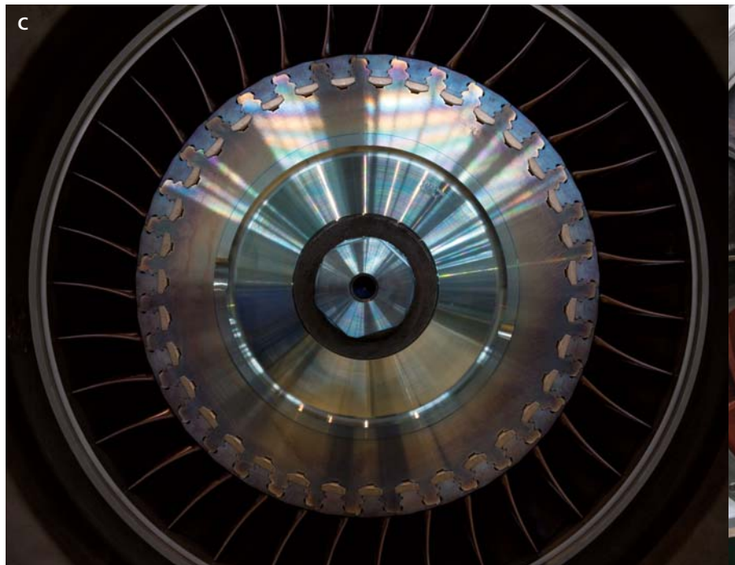
C : The turbine rotor used in the MA90 model is shining proof of MHI's world-class engineering capabilities in the development and production of high-speed rotating machines. The meticulous design of the turbine rotor and compressor wheel for both ships and cars is handled by the Turbomachinery Laboratory of the Nagasaki Research & Development Center.
Nagasaki Shipyard & Machinery Works, Nagasaki Prefecture

D : Reduced-size model of the hybrid MET42MAG turbocharger with built-in generator that produces electricity from the engine's exhaust gas, providing the ship with all the electric power it needs during its voyage. MHI expects the increasing popularity of eco-ships to drive up demand because of reductions in fuel consumption and CO_2 emissions that it delivers.
Nagasaki Shipyard & Machinery Works, Nagasaki Prefecture

Development and production of turbochargers require experience, resources and creativeness

The development of turbochargers faces never-ending challenges due to the vital role they play in defining engine performance. For example, developers of turbochargers for car engines are expected to satisfy strict criteria in terms of performance, quality, cost and delivery dates, while also liaising closely with the automakers during their engine development process.
This also involves providing expert engineering support to enable them to meet their own customers' demanding requirements regarding engine output characteristics and positioning within the vehicle.
They must also have a flair for identifying the needs of their time as is evident in marine turbocharger (MET) development. This development attitude is epitomized by hybrid turbochargers that use engine exhaust gas to generate electricity and by VTI turbochargers* that are fitted with an innovative variable mechanism.

*VTI (Variable Turbine Inlet) turbocharger: A variable turbocharger with an exhaust gas nozzle inlet area that can be adjusted to two different settings. Narrowing the nozzle inlet area increases the boost pressure of the exhaust gas, thereby enabling faster rotation of the turbine when the engine is running at low speeds and delivering improved fuel efficiency.



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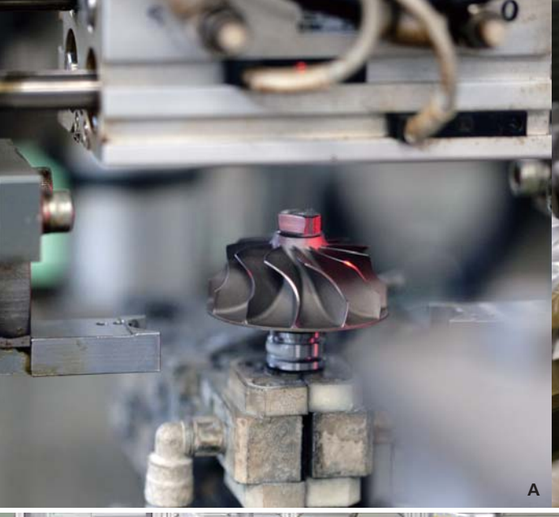


A: Using an MHI-manufactured cleaning device to remove dirt from the previous process.

B: Cartridges that have been manufactured and assembled on an automated production line.

C: VIsual inspection of turbine rotors straight from the automated production line.

D: Part of the automated production line that assembles cartridges, the core components of turbochargers. The various tasks of manufacturing, assembling, measuring and inspecting turbine rotors and compressor wheels are efficiently performed by robots working at their assigned stations around the clock. The relentless accumulation of improvements has brought it to a level of automation that is unmatched anywhere in the world.

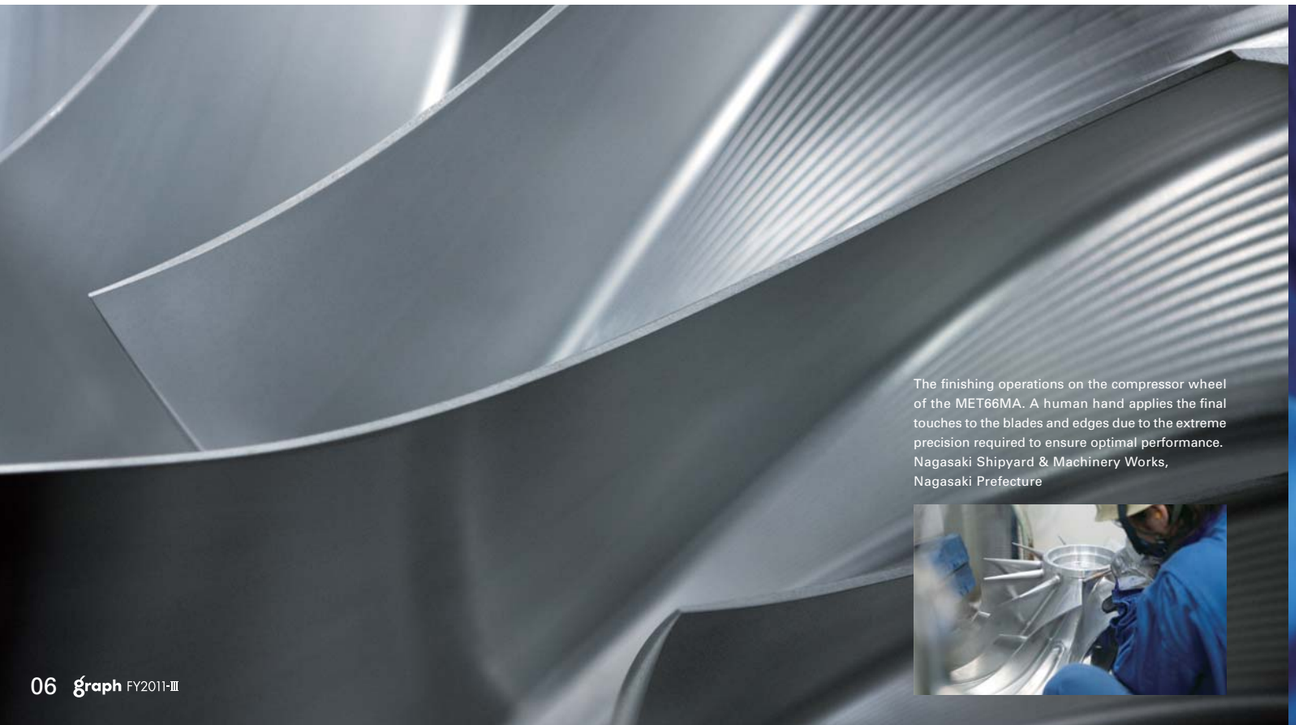
(Photo A~D: Sagamihara Machinery Works, Kanagawa Prefecture)

PURSUIT OF QUALITY

Exploiting craftsmanship of man and machine

With an annual production level of passenger car engine turbochargers in excess of 4.5 million units, accounting for more than 22% of the global market, MHI is aiming to capture the world's top share. This growth has been supported by complete automation in the production of cartridges*, the core heart-like component of a turbocharger. By deploying automated production lines at overseas plants and standardizing production techniques, MHI has created a global mass production structure that consistently delivers extremely high quality. At the other end of the spectrum, the production of huge marine turbochargers that can stretch beyond 3.5m requires elaborate craftsmanship that draws on the techniques and experience of experts. MHI's unique harnessing of the creative capabilities of man and machine allows it to produce turbochargers of all sizes and for all purposes.

* The core portion of the turbocharger that houses the turbine rotor — with rotation powered by the engine's waste heat, and the compressor wheel, which pressurizes the inflow air.



The finishing operations on the compressor wheel of the MET66MA. A human hand applies the final touches to the blades and edges due to the extreme precision required to ensure optimal performance.
Nagasaki Shipyard & Machinery Works, Nagasaki Prefecture

The labyrinth seal fins prevent gas from entering the turbine rotor. The fins, rotating at high speeds and temperatures, engage within the slightest clearance of less than 1mm. Experienced workers manage the assembly precision to 0.01mm levels, using special measuring tools and clearance gauges that they themselves have refined.
Nagasaki Shipyard & Machinery Works, Nagasaki Prefecture

The compressor wheel of the brand new MET53MA that rotates at high speeds. During sailing, it operates at 17,800 rpm. In other words, the leading edge of its blades maintains a speed of 480 meters/sec, surpassing the speed of sound. Nagasaki Shipyard & Machinery Works, Nagasaki Prefecture

CARVING OUT A BRIGHT FUTURE

High Hopes for Heightened Turbocharger Technology around the World

Turbochargers are assuming increasing significance at a time of mounting concern over environmental protection and energy conservation. The amplified power of turbo-fitted engines allows them to become more compact without diminishing basic engine performance. The current downsizing of turbochargers, particularly for engines of European cars, has been driven by reduced fuel consumption and the environmental benefits derived from the reduction in the amount of toxic exhaust gas. Although turbochargers have always been indispensable for marine diesel engines, the increased demand for fuel efficiency is also shining the spotlight on next-generation marine turbochargers that can deliver longer sailing distances.

Furthermore, both the automotive and shipping industries are facing stricter environmental regulations. In the automotive industry, for example, it is generally believed that passenger cars not fitted with a turbocharger will fail to meet the next European emissions standard (Euro VI) for diesel vehicles that will be implemented in 2015. Turbochargers can only benefit from this backdrop of tightening regulations.

Turbochargers Continue MHI's Vibrant Tradition of Reliability in Rotating Mechanisms

MHI boasts a lineup of turbochargers covering a wide variety of engines for passenger cars and commercial vehicles to ships and aircraft, with each one carrying its own history. However, the basic structure of turbochargers shares many similarities with the gas turbine and the jet engine, two products that belong to MHI's realm of expertise. You only have to look at MHI's aerodynamically designed turbine rotors and compressor wheels to realize that MHI has condensed its wealth of experience and knowledge of high-speed rotating machines into its turbochargers. The low incident rate of its turbochargers after they have been fitted in cars and ships provides further evidence of their quality. This quality is also validated by users' high praise of the turbochargers. MHI's tradition of reliability lives on.

Widening the Global Expansion of High-Quality Turbochargers

Turbochargers are global products with worldwide demand, and MHI's turbochargers have seen remarkable growth in recent years. The client base for its turbochargers for car engines now extends to automakers in Europe, America and Asia, with foreign companies accounting for more than 80% of the demand. A global network of offices and production centers is essential for maintaining close cooperation with clients during the development process and for the fulfillment of just-in-time delivery and cost requirements. MHI has therefore set up production centers in the Netherlands (MEE), Thailand and China and also built a network of parts suppliers in peripheral regions. This amounts to a global production and distribution structure capable of consistently delivering products of the same high quality as Japanese plants. With its marine turbochargers now being supplied to the top three manufacturers of marine diesel engines (including MHI's UE engine), MHI has concluded licensed production agreements with major Korean companies in order to supply to the world high-performance turbochargers created using Japanese technology.

MHI is also dedicating itself to the development and production of ground-breaking higher value-added turbochargers, such as variable two-stage turbochargers for diesel engine cars that provide all-speed performance, and hybrid turbochargers that meet the growing demand for eco-ships in the shipping industry. These innovative products are expected to make significant contributions towards the creation of a more environmentally conscious and energy-saving society. MHI even hopes that the turbocharger itself accelerates the advent of a sustainable society.

MHI IN THE WORLD

From Singapore DIRECT

Singapore Shares a Story with the World

GTCC Contributes to Stable Power Supply in Singapore

High Uptime Operating Ratios Supported by LTSA

As economies develop and standards of living improve, demand for electricity inevitably increases. This phenomenon is now causing major problems around the world, problems related to both energy resources and the environment. And while some power is generated from renewable energy sources, such as hydro, nuclear, wind, solar and geothermal, most is still generated using fossil fuels — coal, oil, and natural gas — all of which emit CO_2 and thus contribute to global warming. Moreover, the supply of fossil fuels is limited: as the BRICS countries and other developing nations rise to prominence, competition for these resources is intensifying.

Improving Efficiency through Deregulation

Electricity is fundamental to both industry and people's everyday lives, and as such, a stable supply is vital. Customers demand cheaper and more stable supplies of electricity. Thus, suppliers must meet those needs. Toward the end of the twentieth century, a trend emerged, mainly in the U.S. and Europe, of energy market deregulation with the aim of improving efficiency. Furthermore, development of renewable energy sources and the high-efficiency use of fossil fuels were accelerated to bring about a low-carbon society.

Singapore has been quick to respond to this global trend of electric utility deregulation. The country took the plunge into privatization in October 1995 and trading on the National Electricity Market of Singapore (NEMS) began in January 2003. One distinguishing feature of Singapore's electricity is that currently 80% of the energy comes from natural gas, and that figure is expected to rise to 90% by 2014. Beside the fact that many neighboring countries produce natural gas — clean energy in comparison to coal or oil — tourism is a key industry in Singapore, and policies tend to prioritize the environment. For these reasons, natural gas plays a central role in the country's energy.

Among the power generation systems in operation at Singapore's electrical power companies are natural gas-fired gas turbine combined cycle (GTCC) power generation plants made by MHI. These plants produce electricity primarily by gas turbine, but also use the exhaust heat to drive a steam turbine, which generates additional power. The system optimizes the energy source, a kind of "two for the price of one." Since 2001, MHI has supplied four GTCC power plants to Tuas Power, one of Singapore's three largest power companies. Each turbine has a rated output of 360,000kW.

Remote Monitoring of Turbine Conditions

While MHI has supplied a total of four gas turbines to Tuas Power, it has done more than just deliver the power generation system. It has concluded a Long Term Service Agreement (LTSA), a long-term contract under which MHI provides high uptime operating ratios for the facility by undertaking regular inspections. In effect, MHI operates a business model whereby it provides hardware (equipment) and software (operational management) as a package. Two factors underpin the initiative: One was that maintaining a stable electricity supply was a top priority — and MHI could contribute to the creation of that stability; the other was the development of a remote monitoring system (RMS).

The RMS uses information and communications technology (ICT) to collect roughly 2,000 data points and to automatically analyze data every five minutes on more than 150 major components within each gas turbine with the aim of diagnosing potential problems. At present, MHI remotely monitors gas turbines in operation around the world under the LTSA, 24 hours a day, 365 days a year, from remote monitoring centers (RMCs) in Japan. Although there are gas turbine manufacturers in Europe and the U.S. and they work hard to improve their levels of customer satisfaction, none of them have developed such a thorough service or gone so far as to optimize uptime operating ratios.

In fact, according to Tuas Power, the operating ratios of MHI's GTCC have proved extremely high with an annual average of over 99%. This is partly due to the RMS, which prevents shutdowns due to malfunctions. At the same time, Tuas praises the energy efficiency of the GTCC, which is about 20% better than that of conventional oil-fired units. For an electric power company to thrive in a deregulated market, it is important to increase energy utilization efficiency, as well as cut equipment and fuel costs. In both areas, GTCC and LTSA are contributing to the success of Tuas Power.

Balancing Environmental Protection and Operational Efficiency

In order to provide society with a stable electricity supply, power generation systems must be operated efficiently. But it is also vital to secure fuel and accurately transmit power to areas where there is demand. Through the RMS, MHI can monitor peripheral areas, including fuel and transmission, as well as actual turbine operating conditions. If anomalous activity is detected, it is immediately reported and countermeasures are taken. At the heart of this system is a "spirit of good service," which could be described as the Japanese virtue of heartful hospitality. European and American electric companies think highly of it, regarding such complete service as leading to more efficient operation and better reliability.

The gas turbines supplied to Tuas Power have a combustion temperature of 1,350℃ class. MHI has already developed 1,500℃ class turbines and is about to launch 1,600℃ class turbines onto the market. Since there is a direct connection between increased combustion temperature and improved energy utilization efficiency, these advanced GTCC will help power companies operate even more efficiently, as well as promote the effective use of natural resources globally. Moreover, reduced CO_2 and other emissions will prove useful in resolving global environmental issues. For these reasons too, MHI looks forward to further global adoption of the GTCC/LTSA business model.

Lau Tai Hwee, Message to MHI

Tuas Power has had a long and positive relationship with MHI in power generation, beginning with the decision to invest in an MHI gas turbine combined cycle (GTCC) power plant in Singapore.

MHI was selected based on the proven reliability of its generation equipment. When we first considered a GTCC system, MHI took a very hands-on approach, providing us technical information through every step of our evaluation process in selecting the supplier for the GTCC turnkey project. During the execution of the project, MHI's team of experienced managers and engineers achieved on-schedule completion with high quality of work. After the plants commenced commercial operation, MHI has continued its strong support to us with an on-site resident engineer, and providing 24/7 remote monitoring service.

The GTCC system supplied by MHI has been in operation now for a decade and we have been very pleased with its performance – both in terms of its high energy utilization efficiency and actual operating conditions — and with MHI's outstanding support. Reliability has proved to be above 99%, with very few accidental shutdowns. This is especially important for us because Singapore is an actively traded market where the price of electricity is set every 30 minutes, so any downtime costs money.

In the area of support, our needs have been comprehensively met by MHI's Long Term Service Agreement (LTSA). Central to our operations is a remote monitoring system (RMS) that functions 24/7 and eliminates any confusion surrounding who to contact should an issue arise. Moreover, annual inspections and maintenance of gas turbines are handled by a team of MHI's specialist engineers coordinated by an on-site MHI engineer, and working closely with engineers of Tuas Power. We are confident that this combination of RMS and on-site engineer ensures problems are quickly identified and resolved.

Measures to curtail global warming need to be considered even in the face of rising demand for power in Singapore, and for this reason Tuas Power is planning to increase its use of GTCC power plants. We are also looking forward to the emergence of new generation of GTCC that is able to operate with wider variations in gas composition and higher plant efficiency during both full load and part-load operation.

Lau Tai Hwee
Senior Vice President
Generation Business
Tuas Power Generation Pte., Ltd.