HORIBA's Superior Techniques of Environmental Measurement Contribute to Creating a Low-Carbon Society

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In recent years, we are facing a turning point in energy supply. Historically, the energy-supply structure of the world has been based on fossil fuel from the Middle East and South America. Consumption of alternative energy is expanding to mass consumption regions and is dramatically changing the utilization profile. This report addresses the current situation and issues of the energy-supply structure. HORIBA's measurement technologies are introduced for the energy-producing suppliers.

Introduction: Energy Situation

Global energy trends have been changing drastically after the Fukushima disaster in Japan and the shale gas revolution in North America. The German government is proceeding with phasing out nuclear power, and power from renewable energy and fossil fuels have been increased at the same time. Gas turbine electric power has a shorter startup period than coal-fired power plants. Therefore, the number of newly constructed gas turbine electric power plants increased right after the Fukushima disaster. Then the number of newly constructed coal-fired power plants increased due to the low cost of coal. After that, the volume of renewable energy increased in association with the implementation of the Paris Agreement. However, renewable energy output is not stable. In order to make up for the fluctuations in power from renewable energy, power from fossil-fuel power plants is now required to compensate. If coal-fired power plants are operated constantly, the power generation efficiency is good, but the efficiency gets worse when it needs to be controlled to fill gaps in the supply.

Table 1 shows the GDP of several countries. At the present moment, the US has the top GDP in the world, but China will take the top position in the near future. After these two, the GDP of India is also rising rapidly. Environmental pollution has been a critical issue in China with increasing energy consumption. The Chinese government has been implementing countermeasures for improving the environment. Passenger automobiles are changing to electrical vehicles (EV) in some cities in China due to strong leadership by local governments. For example, in Shenzhen, China, 16,000 public buses have been changed to EV and 1/3 of taxis have been changed to EV. Fluctuations in the electricity generation capacity of renewable energy is one of the issues, and improved battery performance is starting to make it possible to solve this problem with renewable energy.

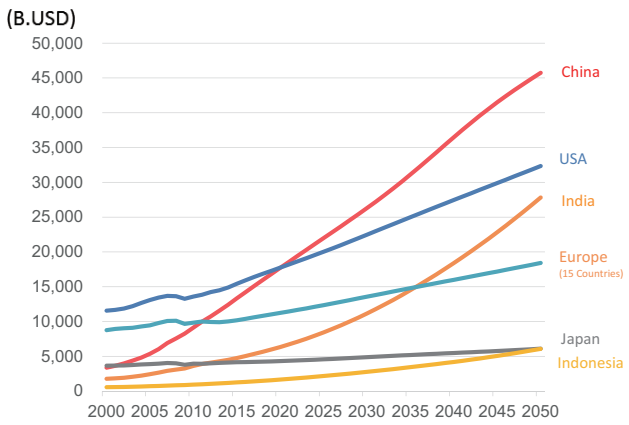

Table 1 Trends in the GDP of major countries
Data: From OECD data, GDP long-term forecasts

Greenhouse Gases

The Paris Agreement will take effect in 2020. The agreement's long-term goal is to limit the increase in average global temperature above pre-industrial levels to

well below 2°C, aiming to limit the increase to 1.5°C. Countries with insufficient natural resources are trying to increase their renewable energy and reduce dependence of fossil fuel producing countries. Each country is taking various measures to meet their obligations under the agreement. One of these is a carbon tax designed to tax fossil fuels based on their carbon content. This has produced rapid results in Northern Europe. In other measures, carbon capture and storage (CCS) technology is being developed for storing carbon dioxide produced when burning fossil fuels in the ground instead of releasing it into the atmosphere. However, in Japan this technology will take time to implement due to difficultly in securing locations to store carbon dioxide. On the other hand, there are cases where the cost of renewable energy is lower than the cost of using fossil fuels for thermal power generation if conditions are good—for example, if raw materials and land are inexpensive and the weather is favorable. In Japan, however, there are limited locations suitable for wind and solar power generation, which makes it difficult for these to be effective. Meanwhile, with biomass there is a difficulty with procuring raw materials. Renewable energy is therefore not expected to increase dramatically in Japan.

Measurement Technologies for Contributing to Improving the Environment and Becoming a Low-Carbon Society

Environmental measurements for thermal power plants include measurements for combustion management, exhaust gas processing control, and exhaust gas regulation, as well as water quality measurements. An important analyzer for these measurements is the Continuous Emission Monitoring System (CEMS), which monitors exhaust gas. If a CEMS is not operating correctly, the thermal power plant may need to stop operation in some cases. It is therefore important to minimize missing time due to breakdowns and maintenance and ensure that measurement data can be used for official records. Furthermore, in the future it is likely that we will need systems to prevent data tampering and functions that leave a history if tampering does occur.

As stationary source exhaust gas measurement regulations for thermal power plants, waste incineration facilities, and so forth, the EU uses EU guidelines, the US uses EPA (Environmental Protection Agency) guidelines, and Japan, South Korea, and China each have their own regulations. Other countries are mainly divided between countries that reference EU regulations and countries that reference the US EPA regulations. Few countries reference the Japanese system, possibly because most of the documents are in Japanese.

CEMS certification standards for facilities that are in operation differ by country. In China, meter certifications are based on the Metrology Law of the People's Republic of China, and site certifications (after transfer) are done using MEP certifications.[*1] Portable gas analyzers are one kind of instrument that is brought onsite to take measurement. The HORIBA PG-300-Series portable gas analyzer is certified under Japanese, South Korean, and Chinese laws and the European EN Standard, and is widely used in Europe as a certification unit for verifying that a CEMS measurement value on a usage process is correct.

***1**: Ministry of Environmental Protection of the People's Republic of China

Increased demands for measuring mercury (Minamata Convention)

On Oct. 17, 2013, the United Nations Environment Programme (UNEP) adopted the Minamata Convention on Mercury for preventing mercury damage to health and the environment. The convention prohibits primary mercury mining and trade. It also regulates products that include mercury, manufacturing processes that involve the addition of mercury, atmospheric mercury emissions, and mercury waste. **Table 1** shows the measurement techniques stipulated in each country's measurement standards.

Table 1 The measurement techniques stipulated in each country's measurement standards

	Regulation	Measurement method
Japan	JIS K 0222	Wet absorption,Atomic absorption spectrometry with reducing vaporization
		Gold-amalgam trap, Atomic absorption spectrometry with heating vaporization
		Continuous monitoring method
U.S.A.	EPA Method 29	Solution absorption procedure
	EPA Method 30A	Continuous monitoring method (Instrumental Analyzer Procedure)
	EPA Method 30B	Sorbent Trap Procedure
	Ps12A	Total Vapor Phase Mercury Continuous Emission Monitoring Systems
	Ps12B	Short term monitoring with 30B Traps
	ASTM Method D6784 (Ontario Hydro method)	Solution absorption procedure (Measurement of each mercury form)
EU	CEN EN 13211	Solution absorption procedure
	CEN EN 14884	Continuous monitoring method (Automated measuring systems)

Table 2 Laser gas measurement technologies

Laser types	Wavelength region (μm)	Measurement Component
LD (Laser Diode)	0.8-3	NH_3, HCL, O_2
DFG (Differential Frequency Generation)	3-5	HC (Hydro Carbon)
QCL (Quantum Cascade Laser)	4-20	NO, SO_2, CO, CO_2

Spectroscopic methods	Advantages
DAS (Direct Absorption spectroscopy)	Easy to compensate for fluctuations of the measurement gas changing
WMS (Wavelength Modulation Spectroscopy)	High sensitivity measurement using differential method
CRDS (Cavity Ring-Down Spectroscopy)	High sensitivity measurement using resonant cell

Measurement Method	Advantages
In situ measurement (Cross stack method, Probe method)	Non-sampling measurement
Extractive measurement (Multi pass cell including resonance cell)	Multi-component measurement, High sensitivity

Figure 2 HORIBA TX-100 Direct laser-based gas analyzer

Measurements using lasers

To Plants that use fossil fuels, such as thermal power plants, are now required to achieve higher efficiency to reduce the environmental burden and move toward a low-carbon society. Up until now, the sampling method has been mainly used to measure target gases. Recently, however, the use of non-sampling (in-situ) measurement is increasing. As such, laser-based methods are starting to be used. In joint research by Tokushima University and the Central Research Institute of Electric Power Industry, real-time 2D temperature and concentration measurements are taken using computer tomography-tunable diode laser absorption spectroscopy (CT-TDALS). This technique is starting to be used to control the efficiency of combustion furnaces. HORIBA has also launched the TX-100 direct laser-based gas analyzer (**Figure 2**). **Table 2** shows the laser light source types used for laser-based gas measurement, spectroscopic methods, and gas measurement methods. Gas analyzers that use quantum cascade lasers (QCL) are often employed for high-sensitivity measurements as the QCLs oscillation wavelength is in the mid-infrared light region, in which many types of gas have strong light absorption properties. These measuring devices are used on stationary sources.

On the other hand, there is the AQMS[*2], a constant air pollution monitoring station that measures the air environment. In Japan, AQMSs have been installed in approximately 1,600 locations where they constantly monitor the air status. Moreover, AQMS have also been installed in many other regions around the world. Some countries install small, inexpensive air monitoring devices that have lower performance than AQMSs but monitor the air status in greater detail. At its Biwako plant in Shiga Prefecture, HORIBA has installed an AQMS onsite that includes a particulate matter 2.5 (PM2.5) meter, a suspended particulate matter (SPM) meter, a trace gas analyzer for monitoring air pollution and measuring carbon monoxide and nitrogen oxide, and a PX-375 PM2.5 automatic component analyzer. Through daily measurements and analysis, HORIBA is not only researching new measurement technology, but is also conducting research to clarify the causes of air pollution.

***2**: AQMS (Air quality monitoring station):
A facility with automatic measuring equipment able to take measurements of meteorological data throughout the year, including wind direction and speed, as well as air concentrations of sulfur dioxide, particulate matter, nitrogen oxide, carbon monoxide, and ozone in the air.

Estimating sources

The PX-375 PM2.5 automatic component analyzer uses a combination of the beta-ray absorption method and the fluorescent X-ray method to measure the mass and inorganic components in PM2.5. This enables the analyzer to estimate the sources of the PM2.5. **Figure 3** shows a case where PM10[*3] had temporarily increased. With the component analysis, it was determined that the increase was due to a fire at a recycling plant about 20 km away.

***3**: In addition to PM2.5, the PX-375 can also measure total suspended particles TSP, PM10, and PM1.

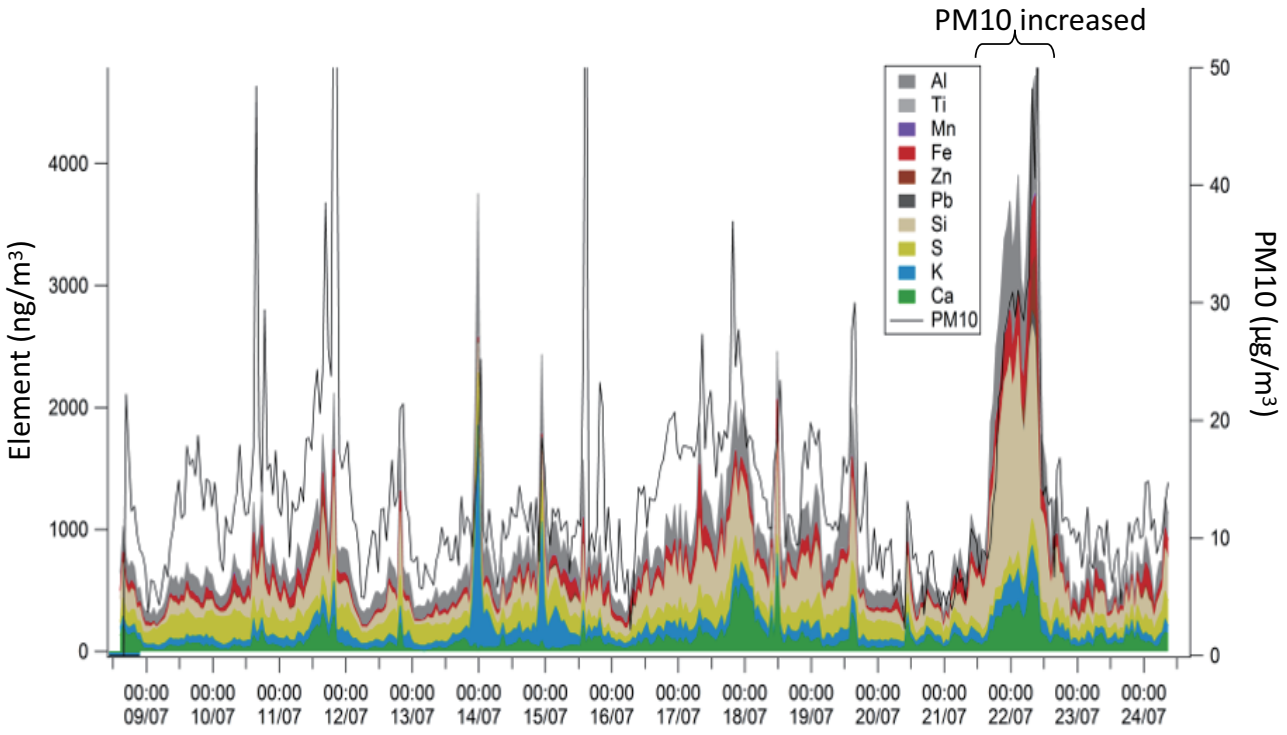

Figure 3 Example of PM10 mass and component measurement data, measured using the PX-375 in Europe

Conclusion

Measurements need to meet the following requirements:

1) Compliance with metrology laws in accordance with the official methods in the regulations of each country or region
2) Long-term stability
3) Short downtime due to breakdowns and maintenance
4) In the future, data tampering must be prevented, and if data tampering does occur, it must be shown in a log.

Finally, HORIBA has the following goals for measurement technology that will contribute to improving the environment and assist the transition to a low-carbon society.

- The technology must be usable in various locations, regardless of the installation environment.
- The technology must be usable by anyone, regardless of their skill level.
- The technology must produce highly reliable measurements.
- The response speed for the measurement values must be fast, and the status of the measured item must be correctly conveyed.

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