Achieving a Coal Boiler Tailored to Low Carbon Societies

CO_2 capture and storage technology development based on chemical absorption

Energy demand is burgeoning mainly as a result of economic growth in developing countries and other parts of the world. Reducing carbon emission from coal-fired power plants is crucial for preventing global warming while stably supplying power. Toward this end, this article features an initiative aimed at achieving CO_2 sequestration and capture technology based on a chemical absorption method.

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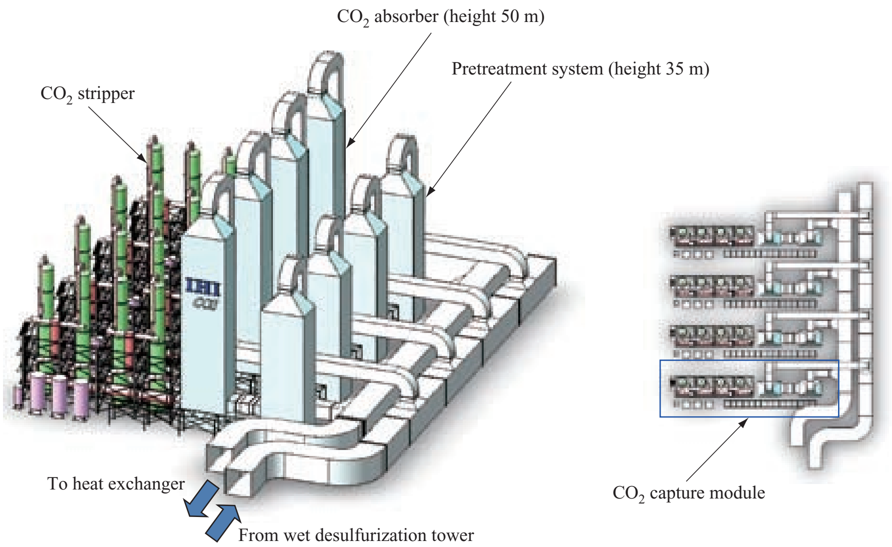
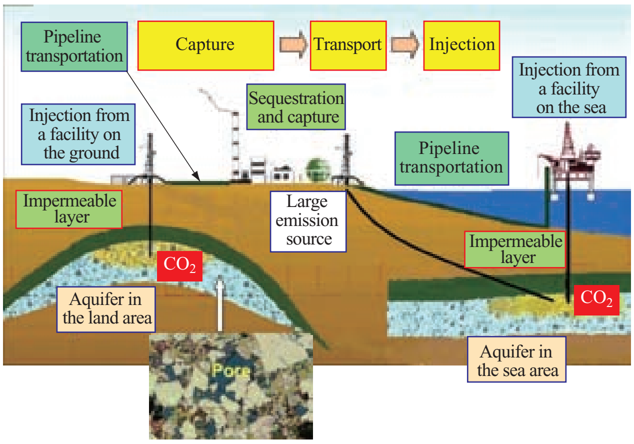


Chemical absorption CO_2 capture plant

What is CCS?

Global warming greatly impacts the environment, ecosystem, and human society at a global scale. Indeed, this problem shakes the foundations of human survival. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) assessed the likelihood of anthropogenic greenhouse gas being the cause of global warming to be "over 90%." The significance of this IPCC report was reaffirmed at the 34th G8 Summit (G8 Hokkaido Toyako Summit) in July 2008, where the leaders agreed on the "need for shared vision for the world to cut



Micrograph of aquifer
CO_2 stored in pore space

Conceptual diagram of CCS
Source: Industrial Science and Technology Policy and Environment Bureau, METI, “CCS 2020”

carbon emissions by at least 50 percent by 2050.” Carbon dioxide (CO_2) is the primary anthropogenic greenhouse gas, almost of which is generated when fossil fuels such as petroleum, natural gas, and coal are used as sources of energy. In addition to curbing the amount of generated CO_2, it is important not to release the generated CO_2 into the atmosphere.

The International Energy Agency (IEA) proposed the 450 policy scenario envisioning a “stabilization of the equivalent CO_2 concentration of greenhouse gases to 450 ppm in the Earth’s atmosphere.” This greenhouse gas reduction scenario positions CCS as an important technology along with measures such as energy conservation and renewable energy for power generation.

CCS stands for Carbon dioxide Capture and Storage. In CCS, CO_2 is separated and captured from a major CO_2 source such as factories and power plants, transported and stably stored in a place isolated from the atmosphere. CCS is under the global spotlight as a realistic and economically sustainable technology to prevent global warming.

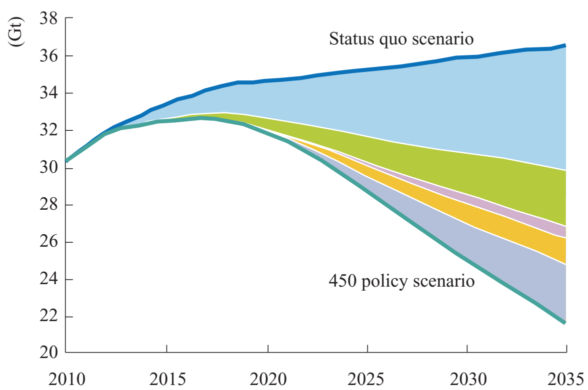
In Europe there is an increasing trend to require “CCS-ready” design for newly installed thermal power plants, which ensures that it is possible to add CCS facilities later when the technology is established. Moreover, the Carbon Sequestration Leadership Forum (CSLF) is advocating for recognition of emission cuts by CCS as a Clean Development Mechanism (CDM) stipulated by the Kyoto Protocol. There are many other attempts to bring CCS projects to the forefront.

CO_2 capture method and post-combustion capture system

Highly developed CO_2 capture technologies include the pre-combustion capture system, oxyfuel system, and post-combustion capture system. In the pre-combustion capture system, the fuel undergoes pretreatment such as gasification before combustion to convert it into CO_2 and H_2, after which the CO_2 is removed. In the oxyfuel system, oxygen is employed instead of air for fuel combustion to provide very high CO_2 concentration in the flue gas for easy CO_2 capture. The post-combustion capture system captures CO_2 from flue gas generated by conventional combustion processes, for instance, by porous solid absorbents and chemical absorption.

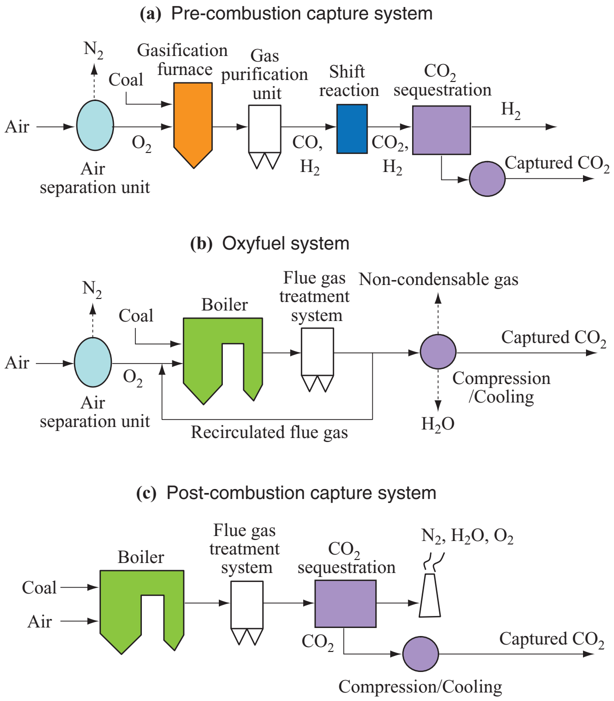
IHI has been developing oxyfuel technology and making progress toward practical use by positioning it as a key CO_2 capture technology that constitutes IHI’s CCS portfolio. The post-combustion capture system is also being developed in order to further reinforce and widen the applications of IHI’s CO_2 capture technology. Please refer to page 6 to learn IHI’s oxyfuel initiative.

The post-combustion capture system is explained here in a little more detail. Although the system employs several methods, the chemical absorption method demonstrates an advantage in CO_2 capture from flue gas containing little CO_2 with no more than 15% concentration and close to atmospheric pressure. IHI is working on the development of this chemical absorption method. Once the process

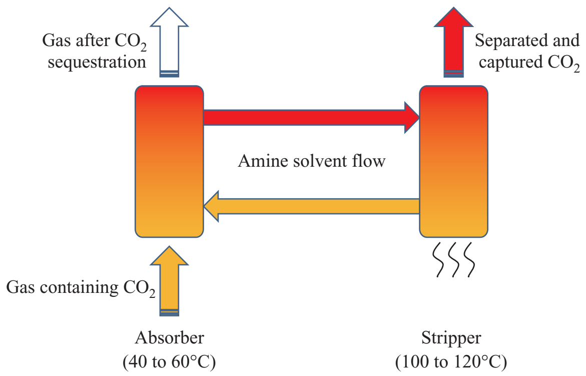


	Emission cut 2020	Emission cut 2035
Energy conservation	72%	44%
Renewable energy	17%	21%
Bio-fuel	2%	4%
Nuclear	5%	9%
CCS	3%	22%
Total (Gt-CO_2)	2.5	14.8

CCS’s role in IEA’s 450 policy scenario
Source: IEA World Energy Outlook 2011



Major CO_2 capture methods



Principle of CO_2 capture by means of chemical absorption

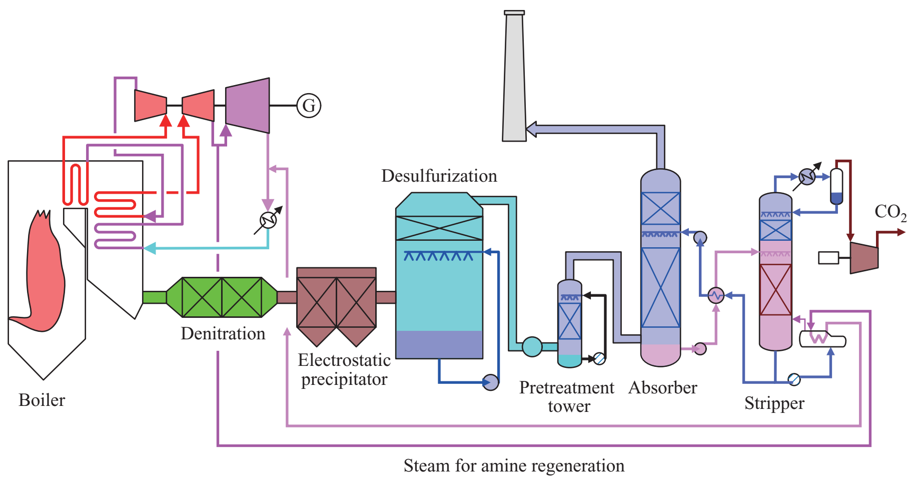
technology based on this method is established, CO_2 capture can be achieved at coal-fired power plants by attaching a post-combustion capture plant to an existing flue gas system even if it has a low concentration of CO_2. This technology is thus applicable not only to newly installed plants, but also to existing plants. Moreover, "partial capture" of flue gas instead of "full capture," which processes all flue gas, brings the advantage of flexibly responding to the need for CCS including the option to minimize initial investment and later increase the amount of collected CO_2 corresponding to later regulations.

Principle and development of the chemical absorption method

The method of chemical absorption CO_2 capture uses the absorption/release reaction of CO_2 with an absorbent. The absorbent is an alkaline aqueous solution e.g. amine.

First, flue gas and a "lean" absorbent containing little CO_2 are brought into contact in an absorber. CO_2 in the flue gas is selectively taken into the absorbent by the subsequent chemical reaction to produce a "rich" absorbent. Then, the absorbent is carried to the stripper, where heat is applied to separate CO_2 in the form of gas from the absorbent. The absorbent then reverts to a lean state. CO_2 separation is achieved by capturing the resultant high concentration of CO_2. Continuous CO_2 capture from flue gas is possible by repeating this cycle with almost no loss of chemical absorbent.

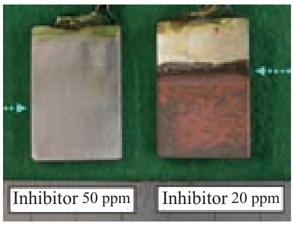
However, the system consumes a considerable amount of heat energy when CO_2 is stripped from loaded rich absorbent (regeneration step). The CO_2 capture from flue gas in power plants involves extraction and consumption of part of the low-pressure steam as a source of heat. This inevitably causes reduced power output and efficiency of the power plants. Therefore, both high-performance absorbent and heat management technology are necessary for achieving the process with less heat.



CO_2 capture power generation system

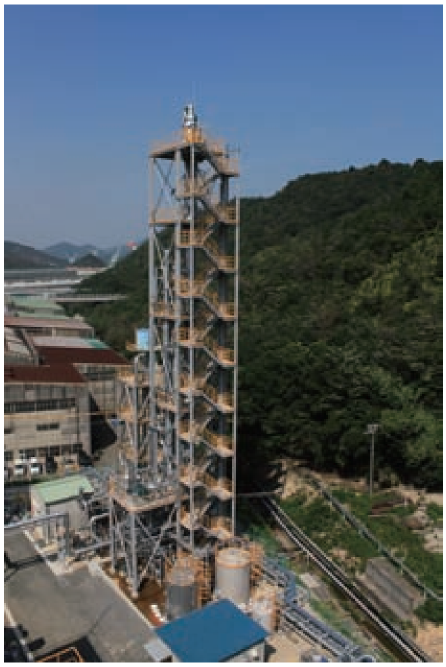
Filling material evaluation and development

Material corrosion evaluation



Absorbent development

Small scale system evaluation (50 kg-CO_2/day)



Chemical absorption pilot plant (20 ton-CO_2/day)

Commercial-scale power plants require treatment of flue gas in the range of tens of thousands to several million m^3N/h. Therefore, a technology to provide efficient large-scale flue gas treatment with low pressure loss is necessary. Additionally, the impacts of oxygen, sulfur, nitrogen oxides, other trace elements, and dust on the absorbent performance and its degradation rates, as well as material corrosion must be assessed in order to devise a necessary process technology to manage them.

IHI is engaged in comprehensive technological development including element technologies that constitute chemical absorption technology encompassing chemical absorbent, towers, tanks, filling materials and other materials, as well as evaluation and plant technologies.

Toward commercialization

The chemical absorption pilot plant (20 ton-CO_2/day, capture rate 90%, CO_2 purity 98% and over) is based on the design knowledge acquired from element technology research related to operational evaluation, material evaluation, and plant simulator technology. The plant is being built in IHI's Aioi Works and evaluation tests are being performed in order.

Operational evaluation can be performed with coal combustion flue gas at this pilot plant as it operates in tandem with the coal combustion test facility attached to it.

Consideration and evaluation will be made through the operation test at this plant regarding the optimal air quality control system including denitration, desulfurization, and dust collection units, as well as the impact of changing the type of coal used.

The acquired knowledge and experience will be applied for a study envisaging scale-up. At the same time, feedback will be given regarding the design of demonstration/commercial modules in pursuit of expansion into a commercially viable facility.

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