Risky Dreams: Carbon Capture, Utilization, and Storage (CCUS)

To achieve the Paris Agreement's target of limiting the global temperature rise to 1.5ºC, we must make the earliest possible transition to a decarbonized society. In June 2019, the Government of Japan released its "Long-term Strategy under the Paris Agreement (LTS)" with an emphasis on carbon capture, utilization and storage (CCUS) as a means of addressing climate change.[1] As the term implies, CCUS is a set of technologies to "capture," "utilize" and "store" or "use" carbon dioxide (CO_2) in exhaust emissions arising from fossil fuel consumption at power plants and facilities. This position paper takes a look at CCUS, assesses technical issues, obstacles to practical use and questions about its effectiveness, and challenges Japan's position on CCUS.

History and evaluation of CCS overseas and in Japan

(1) The role of CCS in Japanese policy

Japanese governments and industries are putting significant effort into carbon capture and storage (CCS) and carbon capture and utilization (CCU) as measures to mitigate climate change.

Japan's Strategic Energy Plan (July 2018)[2] and the LTS (June 11, 2019) highlight CCS and CCU heavily along with high-efficiency coal-fired power generation. The LTS stipulates the aim of "full social adoption in 2030 and thereafter" and "introduction of the CCS by 2030 in the coal-fired power generation with a view to commercialization" and "consideration will be given to the export of the CCS and CCU applied in society."[3] In January 2019 at the World Economic Forum in Davos, Prime Minister Shinzo Abe said, "It's time now to think about CCU, Carbon Capture AND Utilization." This is a sign of Japan's intentions to seek the global expansion of this technology.[4]

In February 2019, a Carbon Recycling Promotion Office was established within the Agency for Natural Resources and Energy. It defines the concept of carbon recycling as "a series of processes for limiting CO_2 emissions through its effective capturing, recycling as carbon compounds for fuels or raw materials, or utilizing even in plant factories," and it is trying to effectively promote the innovations needed to realize the concept.[5]

A report released on June 10, 2019 by the Study Group to Evaluate the Potential and Practical Application of Energy and Environmental Technologies[6] established by the Ministry of Economy, Trade and Industry (METI) and the Ministry of Education, Culture, Sports, Science and Technology (MEXT)[7] looks at the current state of R&D and practical use of CCUS, as well as bottlenecks for its social adoption (mainstreaming). It estimates a cost of 12,400 yen per ton of CO2 (t-CO_2) (124US$/t-$CO_2$) to upgrade an existing coal-fired power plant and store CO_2 in an aquifer. It also exposes the reality that the technologies are still far from being practical as a result of numerous challenges, including the enormous amount of energy required in CO_2 capture, transport, and injection processes. Despite this, it concludes that the government will continue long-term R&D to overcome the challenges for realization of the technologies.

(2) Previous targets still not achieved

Looking back to July 2008, the "Action Plan to Create a Low-Carbon Society"[8] said that Japan will develop innovative technologies to achieve the target of "reducing global greenhouse gas emissions by 50% compared to present by 2050, and reducing CO_2 emissions by 60% to 80%." It also declares the aim to reduce the cost of carbon capture to the 2,000 yen /t-CO_2 (20 US$/t-$CO_2$) range in about 2015 and to the 1,000 yen (10 US$) range in the 2020s," and to start large-scale demonstration trials in FY 2009 to develop practical CCS applications by 2020.[9] An April 2015 agreement by director-level ministry officials relating to thermal power plant bids for Tokyo Electric Power Co. includes plans "to consider the introduction of CCS to coal thermal power generation by 2030 assuming the relevant technologies will be commercialized."[10] But now in 2019, despite proponents have completely failed to attain cost targets, the above-mentioned study group report still declares that the long-term target of 2,000 yen will be attained.

There is still no prospect of private-sector uptake, but the government is attempting to pour even more public money into this technology, without having evaluated the complete failure to achieve past targets for cost reduction and commercialization.

(3) A look at CCS demonstration trials

In terms of demonstration trials in Japan, the Research Institute of Innovative Technology for the Earth (RITE) started a 1.5-year trial in 2003 and injected 10,000 t-CO_2 underground.[11] In 2008, large private companies with specialized CCS technologies in electricity, oil refining, oil development, and plant engineering, established Japan CCS Co. and began conducting large scale CCS demonstration trials in the form of government-subsidized or commissioned projects. The trials planned to inject 100,000 t-CO_2 at selected sites – offshore from Iwaki in Fukushima Prefecture, plus Tomakomai City in Hokkaido, and Hibikinada in Kitakyushu City. The Iwaki project was halted after Great East Japan Earthquake in 2011, but the other projects are reportedly "proceeding smoothly."[12] It must be noted that there has been no objective cost-benefit evaluation, and no verification of the projects.

Large earthquakes such as the Niigata Chuetsu Earthquake (October 2004), Niigata Chuetsu Offshore Earthquake (July 2007), Great East Japan Earthquake (March 2011), and the Hokkaido Eastern Iburi Earthquake (September 2018) have occurred with epicenters near the CCS trial sites after CO_2 injection, and a possible causal relationship with CO_2 injection has been pointed out. In the case of the Hokkaido quake, the implementation body quickly announced that there was no causal connection. However, there has been no objective scientific verification by experts, so local residents and the general public are still concerned by the fact that a series of large earthquakes has occurred near CCS demonstration sites. Public acceptance of full-scale CCS will be a significant issue.

(4) Contribution to climate mitigation scenarios

An International Energy Agency (IEA) report acknowledges that there may be a certain role for CCUS along with energy efficiency and renewable energy as measures to reduce CO_2 emissions. However, projections for 2040 in the IEA's Sustainable Development Scenario (SDS), which outlines a major transformation of the global energy system to contribute to the three main energy-related Sustainable Development Goals simultaneously, shows large contributions by energy efficiency (42%) and renewable energy (34%), both of which are becoming larger than in previous scenarios. In contrast, the contribution of CCUS remains low at just 7%.[13]

The "Global Warming of 1.5ºC" special report released by the Intergovernmental Panel on Climate Change (IPCC) in October 2018 includes "bioenergy with carbon capture and storage" (BECCS) as one option in its scenarios for reducing emissions. However, BECCS spawns concerns about massive forest destruction that would have to occur in order to obtain fuel, so it is more difficult for BECCS to attain commercial viability in the future than for CCS.

Problems with CCS: [1] Technical issues

(1) No suitable sites for safe storage in Japan

Implementing CCS requires a base rock layer that can store sufficient amounts of CO_2, but Japan is a land of frequent earthquakes and has many active faults. There are few stable sites that would be suitable for storage over long periods of time, ranging from hundreds to thousands of years. Also, because Japan has almost no petroleum development areas, it also has no major prospect of using so-called "enhanced oil recovery" (EOR), which is one method of CO_2 storage currently being implemented elsewhere. It is also difficult to find aquifers suitable for CO_2 storage in Japan.

(2) Risks in transport, operation, monitoring

Whether qualitatively or quantitatively, it is difficult to predict the risks associated with CCS, such as the risk of leakage during transport, operations, and storage; the level of safety during CO_2 injection and storage; the possible negative impacts on health and the environment in the event of leakage; and the lack of certainty regarding the feasibility of long-term storage. On top of that, no established monitoring methodology exists to detect leakage.

Problems with CCS: [2] Barriers for practical use and deployment

(1) Renewables become cheaper, but CCS remains expensive

Coal-fired thermal power generation emits huge amounts of air pollutants and CO_2, incurring expensive initial costs to limit air pollution, and constantly incurring the cost of fuel to operate. If CCS is then introduced, additional costs will be incurred that are equal to or even greater than the cost of generating electricity. In an estimate in 2018 by a METI study group, coal-fired electricity generation with CCS would cost between 15.2 and 18.9 yen/kWh.[14] Meanwhile, the cost of commercial photovoltaic power generation was at 17.7 yen/kWh and onshore wind power was at 15.8 yen/kWh in 2017. Their costs are basically already competitive with coal power combined with CCS. On top of that, photovoltaics and wind power are projected to drop to 5.1 and 7.9 yen/kWh, respectively, by 2030.[15] In other words, in 2030, when the government hopes that coal power with CCS will be practical, the technology is projected to have dramatically higher costs than renewable energy, which will have achieved considerable further cost reductions by then. Hence, there is virtually no chance for CCS to be competitive economically.

(2) Problems gaining public acceptance

The situation relating to electricity has been changing at a dizzying speed in recent years. Local opposition movements and lawsuits by local communities have sprung up to fight the construction of new power plants in Japan. Banks and insurance companies are increasingly aware of the problems with coal-fired power generation, and have gradually started cutting back on financing and investment for it. Meanwhile, more and more companies around the world are committing to procure all the electricity they need from renewable energy. The transition toward a decarbonized society is unstoppable. Coal power emits massive amounts of CO_2, and adding CCS technology at considerable cost has no economical rationality. In that context, it is increasingly difficult to find any justification to build new coal power plants or extend the operation of existing ones by adding CCS technologies. It is highly questionable whether CCUS, which comes with so many risks, could ever be publicly accepted.

Problems with CCS: [3] Dubious effectiveness

(1) Too late as a climate solution

In Japan, CCS research began in the 1980s under MITI, METI's predecessor, with the aim of achieving practical feasibility by 2020. Today, however, only two power plants combined with CCS are currently in operation anywhere in the world. In Japan, CCS still has not graduated from the small-scale demonstration stage, so the original grand projections lie in ruins. The hope for practical feasibility in 2020 has withered, and the new target has been delayed by ten years to 2030. However, based on the path so far, the likelihood of practical feasibility for CCS in 2030 is exceedingly low.

In order to limit global warming to the 1.5ºC under the Paris Agreement, the world must promote strategies that can be applied immediately. In other words, it is absolutely crucial to achieve significant emission reductions by 2030. In this context, any strategy that places its hope in a technology that "might" be feasible after 2030 is lacking a basis in reality as a measure to mitigate climate change, and it amounts to nothing more than an excuse to postpone other actions that need to be taken.

(2) CCS will not result in zero emissions

Even with CCS, we cannot achieve zero CO_2 emissions. Energy is consumed in every process involved with CCS: capture of CO_2 in the exhaust gases emitted from power plants or other facilities, compression, transportation, and storage. If, for example, carbon capture equipment using chemical sequestration is attached to a newly-constructed coal-fired power plant, it will reportedly require 3 GJ/t-CO_2 of energy for the capture and pressurization process. In addition, equipping vehicles or other mobile sources with CCS equipment will be difficult, and costs are a major hurdle for small emission sources. Even if such technology could ever be broadly adopted, it would still be impossible for society to achieve decarbonization.

(3) The "U" (utilization) is just a "castle in the air"

Japan has very few sites that would be suitable for CO_2 storage, so it has begun to pour resources into the "utilization" part, CCU to utilize CO_2. One approach that has been floated is to utilize large quantities of CO_2 to replace fossil-fuel-derived chemical products and fuels, and manufacture concrete products using carbonation.[16] Indeed, it is technically possible to use catalytic conversion with hydrogen on CO_2 generated from fossil fuel combustion, and perform "carbon recycling" to create synthetic fuel. However, hydrogen catalytic conversion for inert substances like CO_2 requires enormous amounts of energy. This would be akin to pouring boiling water onto ice to produce warm water, and then consuming a large amount of energy to recreate ice and boiling water from the warm water.

Nowhere in the world has anyone yet considered launching a life-cycle assessment (LCA) analysis of CCU technologies. Under the title of "Creating new societal systems through innovation" the Japanese government says that it is important for Japan to advance R&D with the LCA perspective in mind. But it should not waste time and money on things that simply don't make sense.

Conclusion: CCUS offers no climate solution

As described above, CCUS technologies have many shortcomings in terms of effectiveness, economic viability and environmental impacts, as well as technological risks, and they have no prospect of becoming practically feasible. They also make no economic sense. These technologies cannot help with efforts to achieve CO_2 emission reduction targets or raise the current level of ambition by 2030. Not only are they inadequate as a part of actions to address climate change, they are also inappropriate to be relied upon on or emphasized in government policy.

The Government of Japan has continued to use nuclear power generation by justifying it with promises of creating a complete nuclear fuel cycle, which remains absolutely useless despite having consumed vast amounts of public funds. With CCUS, Japan risks repeating exactly the same story. Continuing to pour public funds into CCUS and prolonging the fantasy of achieving practical feasibility only serves to provide more subsidies to coal-related industries and prolong their life, while cynically delaying what we really need—an exit from coal power. All of this makes it increasingly difficult to achieve the targets of the Paris Agreement.

Japan needs to stop promoting coal power and plodding along its own path with CCS, which makes coal power generation even more costly. It would be vastly more sensible to modernize Japan's electricity grid and promote regulatory reforms in the power sector in order to more effectively utilize renewable energy. What is needed now is a rapid transition away from the use of coal and other fossil fuels. In regard to the priorities of government policy, we need to fundamentally steer Japan toward promotion of energy efficiency, which results in guaranteed reductions in energy consumption and CO_2 emissions, as well as renewable energy, which has seen rapidly cost declines in recent years and is growing rapidly in installed capacity.

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[2] See https://www.enecho.meti.go.jp/en/category/others/basic_plan/5th/pdf/strategic_energy_plan.pdf
[3] See footnote 1, p25-26.
[4] World Economic Forum annual meeting, speech by Prime Minister Shinzo Abe (January 23, 2019), https://www.weforum.org/agenda/2019/01/abe-speech-transcript/
[5] Press release by Agency for Natural Resources and Energy (February 1, 2019), https://www.meti.go.jp/press/2018/02/20190201003/20190201003.html
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