IMMENSE ADDITIONAL FOSSIL FUEL EXTRACTION AND RISING CLIMATE-RELEVANT EMISSIONS FROM GEOENGINEERING PROJECTS IN ASIA

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INTRODUCTION

In Asia, the number of new and planned carbon capture and storage (CCS) projects has increased rapidly in recent years. The captured CO_2 is mostly used for enhanced oil recovery (EOR) or enhanced gas recovery (EGR). EOR and EGR involve pumping pressurized CO_2 into oil or gas reservoirs to recover remaining reserves from ageing oil and gas fields and to extract otherwise inaccessible fossil fuels, thereby significantly increasing production. This technology was developed by the oil industry half a century ago to tap hard-to-reach deep oil reserves and it is now being marketed under a new name and with a touch of green.

A glance at one example, at the CO_2 emission balances of the Chinese Sinopec CCS projects, makes it clear that CCS is not about reducing CO_2 emissions, as we are supposed to believe, but only about increasing fossil production volumes. The projects claim to store CO_2, but in reality lead to multiple sources of new emissions, e.g., CO_2 emissions at a Shengli power plant have more than quintupled due to a CCS project. Since the CO_2 emissions produced could only be partially calculated, the outcome is likely even more devastating in reality.

Emissions from fossil fuel extraction are likely to continue to increase as oil and gas fields become harder to reach and are located at ever greater depths – this means, for example, longer pumping distances and even greater volumes of water to push the raw materials to the surface from depths of several kilometres.

At some locations in Asia, industries are developing around the use of captured CO_2, e.g., to produce chemicals or fizzy drinks. However, it must be clear on the one hand that these are energy-intensive processing steps that generate emissions, and on the other hand that this is not a long-term storage of CO_2, as the processed CO_2 is released again once the products are consumed.

ENHANCED OIL RECOVERY NOT ONLY ADDS CO_2 EMISSIONS, IT MULTIPLIES THEM

In Asia, captured CO_2 is mainly used for EOR and EGR. This section explains the catastrophic climate effects of this practice with the help of some concrete, quantitative examples. The numbers show: EOR and EGR increases CO_2 emissions, even when compared to the amount of CO_2 captured. Other emissions and costs, such as the energy required for CO_2 capture, methane emissions at the extraction sites, health and environmental costs due to extraction and pollutants, could not be taken into account due to a lack of data.

In its 2021 annual report, Sinopec, China’s second-largest energy company, reports using 0.31 million tonnes of captured CO_2 for EOR in 2021 and notes in an additional release that these EOR activities increased oil production by 0.089 million tonnes. The U.S. Environmental Protection Agency (EPA) gives an average of 0.43 tonnes of CO_2 emissions per barrel of crude oil and the Norwegian Petroleum Directorate (NPD) states that one tonne of crude oil corresponds to 7.49 barrels. Thus, one tonne of crude oil is equivalent to about 3.22 tonnes of CO_2 emissions. With 0.43 tonnes of CO_2 emissions per barrel of crude oil, the increasing oil production by 0.089 million tonnes of crude oil results in an additional 0.29 million tonnes CO_2 emissions. This amount does not include the following additional CO_2 emissions and costs:

- The CO_2 capture process in the power plant requires a high energy

input, which increases the consumption of fossil fuels by up to 30 %, i.e., even more fossil energy resources have to be extracted and burned to generate the same amount of energy with CCS.
- About 30 % of the captured CO_2 used for EOR immediately re-enters the atmosphere. This corresponds to 0.093 million tonnes of CO_2 emissions in the above example.
- The extraction and transport of crude oil generate emissions, on average 95 kg CO_2-equivalent per barrel of crude oil, which corresponds to 0.7 tonnes of CO_2-equivalent per tonne of crude oil. This translates into 0.062 million tonnes of additional CO_2 equivalent emissions for the example calculated above.
- At the extraction sites, climate-relevant methane emissions occur.
- The combustion of fossil raw materials generates high environmental and health costs due to the pollutants they contain.

Even ignoring the significant additional emissions from the energy-intensive CO_2 capture process and the methane emissions caused, the CCS-EOR example described above causes more CO_2 emissions (0.445 million tonnes) than CO_2 is captured (0.31 million tonnes). Moreover, there is no guarantee that the CO_2 compressed underground will not re-enter the atmosphere through one of the numerous boreholes in the underground gas fields that the CO_2 is pumped into or through tectonic movements.

In January 2022, Sinopec completed the retrofit of its Qilu Petrochemical fertiliser plant in Zibo City in Shandong Province with a CO_2 capture system and announced that the captured CO_2 will be transported by pipeline to the Shengli oilfield for EOR. The CO_2 capture facility at this site is expected to be commissioned in 2022. On its website Sinopec stated: *"The project is also expected to boost crude oil production by nearly 3 million tonnes in the next 15 years."* This is confirmed by press reports: "*Sinopec expects to reinject 10.68 million tonnes of CO_2, into the wells over the next 15 years and to be able to increase oil production by a total 22 million barrels*." This extra production volume of crude oil over the next 15 years corresponds to 9.6 million tonnes of additional CO_2 emissions. Taking into account the emissions generated during extraction and transport (on average 95 kg of CO_2 equivalent per barrel of crude oil, or 0.7 tonnes of CO_2 equivalent per tonne of crude oil), this corresponds to a further 2.1 million tonnes of CO_2 equivalent – in total 11.7 million tonnes of additional CO_2 emissions. Once again, this does not take into account the energy-intensive CO_2 capture technology, the methane emissions caused, the environmental and health costs, and the CO_2 returning to the atmosphere.

Sinopec is also the owner and operator of the Shengli power plant in Dongying in Shandong province. CO_2 has been captured in the power plant's older, coal-fired unit since 2010. The quantity amounts to up to 36,500 tonnes of CO_2 per year. The captured CO_2 is transported by road tanker about 80 kilometres to the Shengli oil field for EOR. How much additional crude oil was produced with this amount of CO_2 is not disclosed, but if the average of Sinopec's EOR activities in 2021 is applied, it is 10,489 tonnes of crude oil emitting 33,773 tonnes of CO_2. This amount of CO_2 does not yet include the following additional CO_2 emissions:

- The CO_2 capture process at the coal-fired power plant requires a high energy input, which increases the consumption of fossil fuels by up to 30 %, i.e., even more coal has to be extracted and burned to generate the same amount of energy with CCS.
- Transport by tanker truck over about 80 kilometers for EOR: With an average reference emission of 52.7 grams of CO_2 per tonne-kilometre, the transport of 36,500 tonnes of CO_2 over 80 kilometres for EOR corresponds to 153,884 tonnes of CO_2 emissions.
- About 30 % of the captured CO_2 used for EOR will be directly emitted back into the atmosphere, this translates into 10,950 tonnes of CO_2 annually.
- Extraction and transport of crude oil: On average 95 kg CO_2-equivalent per barrel of crude oil, which corresponds to 0.7 tonnes of CO_2-equivalent per tonne of crude oil. This translates into 7,342 tonnes of additional CO_2 equivalent emissions.

Setting aside the considerable additional emissions from the energy-intensive CO_2 capture process at the coal-fired power plant, the CCS-EOR project at Shengli still produces over five times more CO_2 emissions (205,949 tonnes) than CO_2 is captured (36,500 tonnes).

In the course of this decade, Sinopec plans to increase the available CO_2 capture capacity at the Shengli power plant to one million tonnes of CO_2 per year. These plans were already supposed to be implemented in 2017, the reason for the postponement was not disclosed.

According to a CCS database and press, EOR activities increased the oil recovery in Shengli oil field, one of the largest and oldest oil fields in China, by 10 % to 15 %. According to the MIT CCS database, the Shengli oil field's annual production was 27 million tonnes of oil in 2012, two years after the CCS-EOR activities were initiated. An increase of 10 % to 15 % with EOR to 27 million tonnes corresponds to 2.45 million tonnes to 3.5 million tonnes of crude oil. This increase was certainly not achieved with the captured 36,500 tonnes of captured CO_2-EOR, but this scenario should nevertheless be calculated in order to illustrate the effects of larger-scale EOR activities. Applying the U.S. EPA and NPD (average) values introduced above, this means that between 7.89 million tonnes (10%) and 11.27 million tonnes (15%) of additional CO_2 emissions are being generated each year.

The Sinopec Eastern China CCS project is located at Sinopec's Nanjing Chemical Industries Co. Ltd. plant in city of Nanjing, Jiangsu Province. The plant emits CO_2 in the production of synthetic ammonia and in the conversion of coal into hydrogen. A demonstration facility to capture 0.05 million tonnes of CO_2 was commissioned at the site in 2015, and the captured CO_2 is used for EOR in nearby oilfields. Already in 2019, Sinopec announced plans for a larger CCS project at the plant. The completion of the project was initially announced for 2021 and has since been postponed to 2025. According to press reports the new capture unit will be designed to capture 0.2 million tonnes of CO_2 per year and is expected to "*scale up production at the field by 1320 barrels per day*". This is equivalent to 64,326 tonnes of crude oil per year and those correspond to 207,129 tonnes of CO_2 emissions – without taking into account the further emissions from CCS-EOR mentioned above.

In autumn 2021, Sinopec announced the discovery of a new oil reserve in its Shengli field comprising 458 million tonnes of shale oil and flow rates of up to 0.062 million tonnes of shale oil annually. A report prepared for the German Renewable Energy Association compares the CO_2 emissions of different fossil fuels and describes around 40 % higher emissions for shale oil compared to crude oil (see fig. 2) due to shale oil composition, longer pumping distances and increased water-to-petroleum ratio. This means that 4.5 tonnes of CO_2 are emitted per tonne of shale oil, which corresponds to 2.061 billion tonnes of CO_2 in relation to the newly discovered shale oil deposit in the Shengli field. This site is just one of many and Shengli is one among several oil and gas fields where Sinopec is extracting fossil fuels. The scale of CO_2 emissions associated with this single site should illustrate how ineffective CCS is, even after decades of development and extensive research funding, even if there were a secure storage site for the captured CO_2. The total amount of CO_2 captured by Sinopec in 2021 (0.31 million tonnes) is equivalent to 0.00015 % in CO_2 content of this single newly discovered oil reserve.

A LARGE NUMBER OF CCS PROJECTS ARE UNDERWAY

This section aims to provide an overview of CCS projects in Asia and the Middle East. Due to the large number of projects, the section focuses on new developments, planned projects and major ongoing projects. The interactive world map on geoengineering, prepared by ETC Group and the Heinrich Boell Foundation, provides an insight into further project locations. The majority of new and ongoing projects plan to deploy CCS for enhanced oil recovery (EOR) or enhanced gas recovery (EGR).

Bahrain

In January 2022, Mitsubishi Heavy Industries EMEA, Ltd., a developer of CO_2 capture technology, and Aluminium Bahrain B.S.C. (Alba), a major aluminium producer in Bahrain, signed a memorandum of understanding to examine the feasibility of capturing CO_2 from the exhaust gases of an aluminium smelter operated by Alba in Bahrain. Information about the time frame of the project, the planned amount of CO_2 captured and the use of the captured CO_2 remain undisclosed.

China

The UK-China Guangdong CCUS Centre (GDCCUSC) was established to test and promote CCS and CCUS in China and is funded by public bodies in the UK and China. The GDCCUSC selected the coal-fired Haifeng power plant to test five different CO_2 capture technologies, including two amine-based, two membrane-based and one physical absorption approach. A larger-scale CCS project at Haifeng, with a planned annual CO_2 capture capacity of one million tonnes, is planned after completion of the CO_2 capture technology tests. A geological offshore CO_2 storage site for the Haifeng project is being investigated in the nearby Pearl River Mouth Basin. According to a preliminary analysis, the basin is suitable for EOR activities, "*but technical and economic feasibility status* requires *further evaluation*". The commissioning of the larger-scale CO_2 capture project was initially announced for the 2020s and was postponed this year to 2030.

China's Huaneng Group intends to develop a new post-combustion CCS-EOR project with an annual capture capacity of 1.5 million tonnes of CO_2 at its coal-fired power plant in Zhuozitou Village, Zhengning county, Gansu Province. The project is scheduled to be operational by 2023 and captured CO_2 will be transported via pipeline for underground discharge or EOR use. Tianjin, near Beijing, is home to the Huaneng Group's GreenGen IGCC demonstration project, which aims to develop an integrated gasification combined cycle (IGCC) with CCS. The construction of the first demonstration phase was completed in 2012. Since 2016, further CO_2 capture capacities have been added and are scheduled to be commissioned in the 2020s. Once completed, the project is expected to capture up to 0.1 million tonnes of CO_2 per year. A third phase is currently under consideration and will involve the construction and operation of a 400-megawatt IGCC power plant with associated CO_2 capture facilities and EOR.

Since 2006, Alstom has been operating a CCS demonstration project at its coal-fired Harbin power plant in Heilongjiang Province. The project captures up to 0.2 million tonnes of CO_2 per year and the captured CO_2 is used for EOR in nearby oil fields, such as the Daqing oil field. Alstom had planned an additional CCS project in Heilongjiang Province, where a 700-megawatt coal-fired power plant was to be commissioned with China Tatang Corporation for EOR activities, but the project was cancelled.

Since 2017, Ningxia Coal Industry Group Co. Ltd. has been evaluating a CCS project at its Shenhua Ningxia Coal-to-Liquid (CTL) Project in Ningxia province. The development of the CCS concept is still in the initial phase. The use of CO_2 for EOR is being considered.

Sinopec operates a pilot and demonstration CO_2 capture plant at the Zhongyuan Petrochemical Co. Ltd., a large Chinese petrochemical business located in Puyang, Henan Province. The company is a joint venture between Sinopec and Henan province and operates a coal-based petrochemical production line, e.g., for the production of ammonia. The captured CO_2, up to 0.12 million tonnes per year, is transported to the Zhongyuan oil fields for EOR. The oil production in the fields is declining and EOR is used to compensate for the drop in production.

In 2014, Shanxi Coal International Energy Group proposed a 700-megawatt coal-fired power plant with CCS in the city of Xinzhou in Hequ county, Shanxi province. The project was originally scheduled to go into operation in 2017, but it is still at an early stage of development, e.g., proponents are investigating possible CO_2 transport routes and dumping sites.

Huazhong University in Yingcheng City, in cooperation with industry partners, planned to build a CCS demonstration plant in Hubei Province. The CO_2 was to be captured at a 35-megawatt oxy-fuel combustion boiler unit at Jiuda Salt’s power plant in Yingcheng and used for EOR. The power plant was commissioned in 2015. According to the Global CCS Institute, commissioning of the CCS component was planned for the 2020s. In March 2022, it was reported that work on the CCS project had stopped. The reason for this decision has not yet been made public.

The Guodian Taizhou coal-fired power plant is owned and operated by Guodian Taizhou Power Generation and is located in Gaogang County, Taizhou Prefecture, Jiangsu Province. The operator is planning a CO_2 capture project which is expected to come on stream in 2023. The planned capture capacity is 0.5 million tonnes of CO_2, of which 0.3 million tonnes per year will be transported to Sinopec East China Petroleum for EOR.

In 2021, the China National Offshore Oil Corporation (CNOOC) launched an offshore CCS project in the South China Sea, injecting 0.3 million tonnes of CO_2 per year into seabed reservoirs at a depth of 80 meters. The project is located at the Enping 15-1 oil field in the Pearl River Mouth basin, about 190 kilometres southeast of Hong Kong.

India

Since 2019, India's Oil and Natural Gas Corporation Ltd (ONGC) and Indian Oil Corporation Ltd (IOCL) have been exploring a CO_2 capture project at IOCL's Koyali refinery in the Indian state of Gujarat. The project partners intend to use the captured CO_2 for EOR in the nearby Gandhar oil field. In 2021, US-based Dastur International was contracted to conduct design and feasibility studies for the project. In April 2022, ONGC signed a memorandum of understanding with the Norwegian company Equinor ASA to collaborate on the implementation of the project.

Malaysia

The Malaysian state-owned company Petronas intends to develop a CCS project at the Kasawari gas field off the coast of Sarawak, Malaysia. This will involve processing gas from the Kasawari gas field at the Petronas LNG complex in Bintulu, Malaysia. The LNG processing plant will capture CO_2 and inject it into a depleted gas field. The gas is sour gas, a fossil gas with significant amounts of hydrogen sulphide and large amounts of CO_2. Petronas plans to start gas production in 2023 and capturing and injecting CO_2 in 2025. To finance the project, Petronas intends to offer CCS to other industries such as energy, cement, steel and chemicals. In late 2021, Petronas signed memoranda of understanding with oil company ExxonMobil and steel producer POSCO.

Malaysian oil and gas company Petronas and Japanese shipping company Mitsui O.S.K. Lines have signed an agreement to jointly explore the transportation of liquefied CO_2 in Asia Pacific and Oceania regions.

Qatar

Qatar Energy intends to build a liquefied natural gas (LNG) plant with CO_2 capture in Ras Laffan and plans to capture up to 30% of the LNG project's CO_2 emissions and discharge them into a saline aquifer. Total Energies has held a 25% stake in the project since June 2022.

Russia

The Russian gas producer Novatek intends to develop a CCS project at the Yamal liquefied natural gas (LNG) plant in Sabetta in the north-east of the Yamal Peninsula. In addition to the LNG plant, the project also includes production at the Yushno-Tambeyskoye gas field. Novatek has already earmarked two sites for injection of captured CO_2, Obsky on the Yamal Peninsula and Tadebyayakhsky on the Gydan Peninsula, into each of which it says it will inject at least 600 million tonnes of CO_2. A third disposal site is currently being considered. A pre-front-end engineering and design (FEED) study was completed in February 2022. Novatek also expressed plans to supply blue hydrogen that meets European standards for CO_2 emissions. Novatek is working on several LNG projects in Western Siberia and aims to increase its annual LNG exports to 70 million tonnes by 2030 and eventually to over 120 million tonnes. Yamal LNG currently produces 2.6 tonnes of CO_2 per tonne of LNG.

Saudi Arabia

The Uthmaniyah CO_2-EOR demonstration project is operated by Saudi Aramco, a state-owned oil company in the Kingdom of Saudi Arabia. The project has been capturing 0.8 million tonnes of CO_2 annually since 2015 at the Hawiyah power plant, a natural gas processing facility in the Eastern Province of Saudi Arabia. The captured CO_2 is transported via an 85 kilometre long pipeline to an onshore injection point at the Uthmaniyah production unit in the Ghawar oil field for EOR or used to produce chemicals.

South Korea

In addition to the CO_2 capture projects in South Korea already announced since 2013 and 2017, the Korean Electric Power Corporation (KEPCO) has announced further plans in 2021. CO_2 is to be captured at industrial plants in the southeastern city of Ulsan and injected into the Donghae-1 gas reservoir as of 2025. The reservoir is located in the Sea of Japan, off the South Korean coast. Eight Korean companies are already involved in the project, including the Korea National Oil Company as project leader, SK Energy for capturing CO_2 from industrial plants, SK for processing the CO_2, Korea Shipbuilding for transport and storage, and the Korea Petroleum Corporation, which has operated the Donghae gas field for 20 years, for the CO_2 injections.

Timor-Leste

In June 2021, Santos and Eni announced joint plans to develop a

CCS storage hub in the Bayu-Undan field in the Timor Sea, off the coast of Timor-Leste. The Bayu-Undan field supplies gas to the Darwin power plant and is located about 500 kilometres northwest of Darwin. The fossil fuel companies intend to transport captured CO_2 through their LNG terminal in Darwin, Wickham Point, Northern Territory, Australia. CO_2 from their own operations and possibly from other emitters is to be captured, compressed, transported and dumped into the Bayu-Undan field. The project entered in the front-end engineering and design phase in March 2022, a stage between feasibility studies and the engineering, procurement and construction phase.

United Arab Emirates

The Abu Dhabi CCS project is a joint venture between Abu Dhabi Future Energy Company (Masdar), Emirates Steel Industries (ESI) and Abu Dhabi National Oil Company (ADNOC). Since 2016, ESI's iron and steel plant in Mussafah has captured up to 0.8 million tonnes of CO_2 as a by-product of iron production. The captured CO_2 is then transported via a 50-kilometre pipeline to ADNOC's Rumaitha oil field where it is used for EOR. In 2020, ADNOC announced plans to expand its current CO_2 capture capacity by 500 % to reach five million tonnes of CO_2 per year by 2030. To this end, another CO_2 plant is to be build, the location of which has not yet been announced. However, in December 2021, ADNOC awarded a FEED contract to the engineering & technology company Technip Energies to develop the untapped oil and gas reserves from the Ghasha Concession fields, including CCS into the development.

CCS PROJECTS AND DEVELOPMENTS – INFLUENCES OF FOREIGN DONORS

In many locations in Asia, the first CCS projects were launched by foreign donors. Not all of these projects have survived, but they have certainly had an impact on the development of CCS in Asia. Indonesia is currently an example of the CCS industry getting off the ground through external donors. In other countries, especially China, this phase is long over and momentum has been created by the industry on the ground. Most of the funders, public and private, come from Australia, the European Union and the UK.

China

In 2010, the governments of China and Australia agreed on a feasibility study for the commercial deployment of CCS in China. Amine-based CO_2 capture technology was to be tested at two power plants of the Huaneng-Group. The plans were supported by the Australian government with AUD 11.5 million. Huaneng's coal-fired Gaobeidian power plant near Beijing was considered as a site for a while, but ultimately the planned capture projects were not implemented.

In 2013, the Global Carbon Capture and Storage Institute supported the Yanchang Petroleum CCS project with AUD 2.5 million. The project is operated by the state-owned company Yanchang Petroleum and located in the city of Yulin in Shaanxi province. Since 2012, the project has been operating a small-scale CO_2 capture plant, announced a larger-scale project in 2014 and started to construct it in 2017. Commissioning of the larger plant was announced for 2018 and has since been delayed. Yanchang Petroleum plans to use the captured CO_2 for EOR in the Ordos Basin in central China.

Since 2017, the EU has been funding the project "Chinese-European Emission-Reducing Solutions" (CHEERS) with € 9.7 million. The project is led by the Norwegian SINTEF Energy AS and carried out in cooperation with partners from Belgium, China, France, Norway and Poland. CHEERS aims to test, demonstrate and further develop new CO_2 capture technologies in oil refining and other energy-intensive industries. Among the project partners are research institutions and fossil industry partners such as TOTAL and the DONGFANG Boiler Group.

The Net Zero Emission Coal project proposed a coal-fired power plant with CO_2 capture near the oil fields of Daqing, Jilin or Jiangsu. The project was a joint project between China, the EU, the UK and Norway, and was supported by more than US$ 16 million of public funding from Norway and the UK. A feasibility study began in 2007 and the coal-fired power plant with CO_2 capture was scheduled to go into operation in 2014, but the plans did not materialise under the project.

The UK-China Guangdong CCUS Centre (GDCCUSC), publicly funded by the UK and China, was established in 2013 to test and promote CCS and CCUS in China. The members of the centre include research institutions and fossil fuel companies, including the China National Offshore Oil Corporation, Alstom and Shell Cansolv. The centre is undertaking CCS/CCUS projects at the Haifeng power plant and the Huizhou refinery. In April 2022, GDCCUSC staff conducted a preliminary geological study for a planned mineralisation demonstration of CO_2 in basalt rocks on the Zhanjiang Leizhou Peninsula. The centre is growing – in June 2022, the GDCCUSC published several job advertisements, including for researchers and engineers in the field of geological storage and the use of CO_2.

The Oil and Gas Climate Initiative (OGCI) aimed to support the development of five CCS hubs in China, including the Xinjiang Jungger hub. The Xinjiang Jungger hub was to capture CO_2 from cement, chemical and power plants. China National Petroleum Corporation (CNPC) planned to invest in the project's CO_2 infrastructure, and OGCI planned to support CO_2 injections and EOR activities. The project partners also planned to work with the relevant Chinese ministries to establish a legal framework for the CCS hubs. The exact location of the Xinjiang Jungger hub was not disclosed. The entire project was abandoned in ~2022, the reason has not yet been disclosed.

India

The UK Department of Energy and Climate Change funded a CO_2 capture technology trial at Solvay Chemicals India's Solvay Vishnu chemical plant near Tirupati with around € 3.9 million. The technology used was the chemical solvent technology from Carbon Clean, a UK developer of CO_2 capture technology. The trials started in 2012, but the CO_2 capture plant now appears to no longer be part of Solvay Chemicals' portfolio.

Indonesia

The Gundih CCS project is funded by the Norwegian embassy, Kyoto University and other public institutions. During the course of this decade, the project aims to conduct CO_2 injections in the Gundih area in Central Java province to study CCS.

In 2020, Spanish oil and gas company Repsol SA intended to conduct a study for a large-scale CCS/CCUS project in its Sakakemang Block natural gas reserve in South Sumatra. The project plans to inject the captured CO_2 into the adjacent Dayung and Gelam fields.

In 2021, Japan Oil, Gas and Metals National Corporation, Mitsubishi Corporation and other institutions signed a memorandum of understanding and agreed to conduct a joint study on CCS and CCUS at PAU's ammonia plant in Luwuk, Central Sulawesi.

In June 2021, Indonesian state-owned Pertamina signed a memorandum of understanding (MoU) with Japan Petroleum Exploration Co. and the Jakarta-based Lemigas Research and Development Centre to develop CCS/CCUS in the Sukowati and Gundih oil and gas fields. Pertamina signed further MoUs with ExxonMobil in November 2021 and with Air Liquide in January 2022.

In 2021, BP announced it would study the feasibility of CCS/CCUS at its Tangguh LNG plant in Teluk Bintuni Regency, Papua Barat province. The project includes CO_2 capture at Tangguh LNG, CO_2 transport and enhanced gas recovery (EGR) at the Ubadari and Vorwata gas fields. Starting in 2022 the project will begin the front-end engineering and design phase (FEED).

Israel

The EU funded a field experiment as part of the research project "MUSTANG – A multiple space and time scale approach for the quantification of deep saline formations for CO_2 storage" from 2009 to 2014. The project was led by the Swedish University of Uppsala and conducted in cooperation with 19 research partners from Europe and Israel. The experimental site in Heletz, Israel, was used for CO_2 injections and to test new monitoring and measurement technologies. The tests were conducted at the edges of a depleted oil reservoir in the Heletz oil field in Israel. The amount of CO_2 injected is not available.

Russia

In 2021, the Russian oil company Rosneft signed several strategic cooperation agreements to develop joint CCS/CCUS projects, e.g., with BP, Shell and Equinor. In 2022, due to the political situation, the international companies withdrew from the Russian joint ventures.

Thailand

In April 2022, Japan's INPEX Corporation and Japan's JGC Holdings Corporation signed a memorandum of understanding with Thailand's state-owned Petroleum Exploration and Production Public Company Ltd (PTTEP). The joint project aims to explore the potential development of CCS solutions for the oil and gas sector and other industries with high fossil fuel consumption.

CCUS – CURRENT DEVELOPMENTS IN THE ASIAN CONTEXT

The number of carbon capture use and storage (CCUS) projects in Asia is slowly but steadily increasing. There is increasing in-house development of CCUS technology, but at most sites technology is imported from other continents, for example CO_2 capture technology from the British company Carbon Clean. CCUS projects are implemented in the chemical industry, in the food industry and at steel and cement plants.

China

The Chinese-Canadian company C4X (China Canada CO_2 Conversion X)

Technologies Inc. participated in the COSIA Carbon XPRIZE competition and has reached the final phase in 2019. C4X converts CO_2 captured at power plants, mining, cement, steel production, winery, etc. into chemicals and plastics such as ethylene carbonate, ethylene glycol, methanol, etc.

In 2021, the Icelandic company Carbon Recycling International began installing its CO_2-to-methanol production system, an emissions-to-liquids (ETL) reactor system, adjacent to a coke oven gas production facility in the city of Anyang in Henan province. The plant will be operated by the project company Shunli and is scheduled to be operational in the third quarter of 2022. Another ETL-reactor system is planned for the petrochemical complex in Lianyungang in Jiangsu province on the east coast of China. The CO_2 will be captured at a plant for the production of ethylene oxide. The CO_2-to-methanol plant will be owned and operated by Jiangsu Sailboat and is scheduled to come on stream in 2023.

India

In 2019, Indian Oil commissioned a pilot R&D plant at its Panipat refinery to convert ethanol into fuel and omega-3 fatty acids in collaboration with US-based LanzaTech. A commercial-scale plant was planned, but there is no indication that this plan is still being pursued.

In 2019, the Indian cement producer Dalmia Cement Ltd announced a memorandum of understanding with UK's Carbon Clean. Dalmia Cement and Carbon Clean intend to set up a CO_2 capture plant at Dalmia Cement's plant in Tamil Nadu. The captured CO_2 will be used for CCUS applications or sold. The proposal was reviewed by the Asian Development Bank in 2021 and Dalmia Cement recently announced plans to seek financial assistance from the US government.

Breathe, a company founded in 2016 and based in Bangalore, converts captured CO_2 into high-purity methanol and carbon monoxide. Breathe participated in the COSIA Carbon XPRIZE competition and reached the final phase of the competition in 2019.

In 2021, India's state-owned National Thermal Power Corporation (NTPC) announced plans for a CO_2 capture project at the coal-fired Vindhyachal power station, India's largest thermal power plant. The CO_2 capture technology will be provided by British Carbon Clean and Green Power International has been contracted to design and build the CO_2 capture plant. NETRA, the research and development division of NTPC, plans to set up a demonstration plant to convert CO_2 into methanol at the same site.

Tata Steel commissioned a small-scale CO_2 capture project at its steel plant in Jamshedpur in 2021. The CO_2 capture technology was provided by Carbon Clean. Tata Steel plans to re-use the captured CO_2 onsite.

Japan

Since 2019, the Japanese Ministry of the Environment has been funding a CO_2 capture demonstration project at Taiheiyo Cement's Kumagaya plant in the city of Kumagaya, Saitama prefecture. The demonstration-scale amine-based CO_2 capture trials started in autumn 2021. For CO_2 capture Taiheiyo Cement has chosen a capture technology developed by Carbon Clean. In 2021, Taiheiyo Cement was the recipient of a grant under the "Development of Carbon Circulation Technology for the Cement Industry" project, which is funded by the Japan's New Energy and Industrial Technology Development Organization (NEDO).

The Japanese company Mitsui Chemicals has built a demonstration plant for the production of methanol from industrial CO_2 effluent. The plant is located at the company's Osaka facilities where ~150 tonnes of CO_2 can be captured per year. Mitsui launched this project in collaboration with the Research Institute of Innovative Technology for the Earth in Kyoto. In 2021, Mitsui Chemicals and Kyushu University jointly established the Carbon Neutral Research Center, with the aim of researching green hydrogen, CO_2 capture, and CO_2 use technologies.

In April 2022, Sekisui Chemical and LanzaTech Inc. completed the construction of a CO_2 capture demonstration plant at Sekisui Chemical's ethanol plant in Kuji City, Iwate prefecture. LanzaTech has developed the CCUS technology that captures CO_2 from exhaust gases and converts it into ethanol. The conversion is done by microbes that feed on the CO_2 and produce ethanol. Sekisui Chemical aims to test the technical and economic feasibility of the technology. The demonstration plant is only about one-tenth the size of the eventual commercial plant. Since 2021, Sekisui Chemical has also been working with ArcelorMittal on a project to capture and reuse CO_2 from steel production.

Saudi Arabia

In 2021, Gulf Cryo and the Italian Tecno Project Industriale signed a memorandum of understanding to build and operate a CO_2 capture plant, aiming to double Gulf Cryo's existing CO_2 production capacity in Saudi Arabia. The plant is expected to capture ~ 0.25 million tonnes of CO_2 per year to produce high-purity, food-grade CO_2. Gulf Cryo is a United Arab Emirates-based producer of industrial gases, including compressed CO_2 in gaseous or liquid form and in varying concentrations and purities. The CO_2 will likely be captured at Gulf Cryo's Riyadh plant. There is no information yet about the CO_2 capture technology used or the exact schedule. Gulf Cryo has further CO_2 capture projects in Kuweit and Saudi Arabia.

Sustainable Energy Solutions (USA) and King Abdullah University of Science and Technology (KAUST)'s Clean Combustion Research Centre (Saudi Arabia) have developed and demonstrated Cryogenic Carbon Capture technology (CCC). CCC captures CO_2 from exhaust gases in a post-combustion process. In this process, the exhaust gases are cooled to below -130°C. In this way, the CO_2 is frozen, solidified and separated from the exhaust gases. The CO_2 is then liquefied and prepared for transport. In 2021, a pre-FEED study was completed for the deployment of a CCC system at KAUST's Clean Combustion Research Centre in Dubai, Saudi Arabia. The planned plant is expected to capture up to 0.011 million tonnes of CO_2 annually. According to KAUST, the Saudi Arabian Circular Carbon Economy-National Program, an initiative of the Ministry of Energy, is actively pursuing the commercialization of CCC technology in Saudi Arabia.

Taiwan

In 2014, LanzaTech, in collaboration with White BioTech (WBT), opened an industrial demonstration plant for converting steel exhaust gases into ethanol in Kaohsiung, Taiwan. The demonstration plant produced about 100 kilograms of ethanol per day. Plans for a commercial plant were finalized in April 2015, but there is no indication that these have been implemented.

United Arab Emirates

In March 2022, the German government signed cooperation agreements with the United Arab Emirates for the production of blue hydrogen, which is to be delivered to Germany as early as 2022.

State-owned oil company Mubadala Petroleum and Italy's Eni announced an agreement to jointly look at CCUS in September 2021.

In December 2021, the Abu Dhabi National Oil company signed an agreement with France's TotalEnergies to jointly explore CCS/CCUS.

Many of the CCUS projects are still in development or in the early stages. The few ongoing projects show that some industries have interests in CO_2 as a raw material in a limited quantity. However, this does not imply that the products in which CO_2 is used are suitable as CO_2 storage. Capture, transport and purification of the captured CO_2 are very energy-intensive and the captured CO_2 is released back into the atmosphere as soon as the CO_2 -containing products such as chemicals or sparkling water are consumed. Moreover, it should not be forgotten that the CO_2 is produced beforehand – from fossil fuels which, in addition to climate-damaging gases, have many other negative effects on the environment and health.