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Two scenarios for carbon capture and storage in Vietnam

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ABSTRACT

Vietnam plans to develop dozens of new coal-fired power generation units over the next 20 years. If they are indeed build, in order to avoid a dangerous level of global warming, it may appear necessary to dispose of these plants' CO2 by burying it in deep underground geological formations instead of releasing it into the atmosphere, using carbon capture and storage (CCS) technology. We show that CCS has a technical potential in Vietnam, according to the geology and the industrial geography. To discuss under which economics conditions this potential could actualize, we examine two scenarios for 2050. In the first scenario, CO2 is used in Enhanced Oil Recovery (EOR) only. EOR technology makes CCS cheaper by injecting CO2 in partially depleted oil field, aiming to recover more oil. The second scenario considers CCS deployment in coal-based power plants, on top of using it for EOR. In both scenarios, a few gas-fired CCS power plants are build, reaching 1 GW in 2030, supported by Enhanced Oil Recovery and international carbon finance. The decision point where the two scenarios diverge is in 2030. A scenario to switch all currently existing or planned power plants to low-carbon by 2050 is to retrofit 3.2 GW of coal-fired capacity and install 1.2 GW of gas-fired capacity with CCS every year, starting in 2035 for 15 years. Capture readiness would lower the costs of using CCS in Vietnam, but is not mandatory today.

1. Introduction

Boden et al. (2013) measured that fossil fuel CO_2 emissions to the atmosphere in 2014 were 9.8 GtC, and coal burning was responsible for 42% of those. This is not sustainable, and all the more worrying that countries like China, Vietnam, Indonesia, and India are adding coal-based power generation units faster than countries like Germany or USA are retiring them. To make coal-power generation compatible with a low-carbon economy, the industry has been demonstrating the technology of CO_2 capture and storage (CCS), to dispose of the CO_2 underground instead of releasing it in the atmosphere (Metz et al., 2005).

CCS technology seems a priori relevant for Vietnam, a lower middle income country with billion tons of coal reserves, who as of 2016 officially plans to open one new 500 MW goal-fired electricity generation unit every three months in the years to come (The Government of Vietnam, 2016). Yet CCS is not in the energy policy agenda in the country, according to our survey of local stakeholders (Nguyen-Trinh and Ha-Duong, 2015) who furthermore anticipated that CCS would remain a low priority question in Vietnam for the next twenty years.

We argue that the prospective availability of CCS at some point in the future do raise questions about the power plants being built today, in 2016. These plants will probably still be operating in 2050, should they be built with a CCS retrofit in mind? This is of course only interesting to do if there is a plausible perspective that the plant will have to be retrofit with CCS in the future. In order to help the reader assess the plausibility of such perspective, this manuscript exposes two long-term narrative scenarios about the prospect of CCS in Vietnam.

This manuscript is organized as follows. Section 2 describes what CCS is and what is capture-ready, focusing on the relevance of these technologies for Asian countries. Section 3 reviews the literature on CCS in Vietnam. We show that the industrial and geological conditions are favourable for carbon dioxide storage, even if neither capture readiness nor CCS RD & D is on the political agenda. Section 4 exposes two visions of CCS technology penetration in Vietnam up to 2050. The first scenario limits it to Enhanced Oil Recovery (EOR) – a technology which could help the country extract more oil from existing fields and defray the cost of CCS. The second scenario describes a future where, in addition to EOR, CCS comes to be used at coal-based power plants, justifying capture readiness. In Section 5, we compare quantitatively the High CCS scenario to a baseline without CCS based on a national energy mix simulation model with twelve technologies: three fossil fuels, big hydro, four renewable energy technologies, coal CCS, gas CCS, bio CCS, and imports. This model computes the system Levelized Cost of Electricity Generation (LCOE) and the system greenhouse gases emissions. Section 6 discusses policy implications and concludes.

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2. Literature review

2.1. Carbon capture and storage exists at the industrial scale

This section illustrates how it is technologically feasible to capture CO_2 emitted from burning fossil fuels, compress it and then bury it underground in geologic formations for a very long time (Metz et al., 2005).

According to GCCSI (2016), fifteen large scale CCS demonstrations projects were operating in 2015. The majority was deployed in the United States and Canada, with 2 in the EU and 3 in the rest of the world. None was in Asia. But when it comes to development, the focus of moves from projects in North America (three in advanced planning) will be towards projects in Europe and China (a combined eight in advanced planning). These examples show that CCS can be used to reduce emissions from fossil fuel burning installations and from fuel processing facilities. They substantiate the claim that CCS has the potential to allow deep cuts in greenhouse gases emissions. Although CCS is expensive compared to the value of avoided CO_2 in most carbon finance markets today, some affluent countries like Norway have at times imposed CO_2 taxes higher than the cost of CCS. There are not many alternatives to control emissions for large industrial installations, besides shutting them down.

The BLUE Map scenario described in IEA (2008) quantified the role that CCS could have in a portfolio of actions to mitigate CO_2 emissions, particularly those coming from coal power plants. The BLUE road-map proposed an ambitious CCS growth path with 100 projects globally by 2020 and over 3400 projects by 2050. In Asia, China and India are together were to implement 21 CCS projects by 2020 and 1260 CCS projects by 2050, and to account for 37% of total global CCS projects by the same year.

2.2. CCS in Southeast Asia and China

CO_2 emission of the East Asia Pacific region have increased more than threefold over the past twenty years. In a report by the Asian Development Bank, Tharakan (2011) estimated that the primary energy demand in the Southeast Asian countries (ASEAN) will increase by about 76% during the period 2007–2030. Of all energy sources used in the region, coal would increase the most. As a consequence, energy-related emissions are set to double by 2030 compared to 2007. World Bank (2010) warned in another study that under the continuation of current policy, emissions of CO2 would double from about 7.2 Gt in 2009 to 14.3 Gt by 2030 in China and EAP5 countries.

Based on a regional study of climate change economics including Indonesia, Philippines, Thailand and Vietnam, Asian Development Bank (ADB) (2009) argued that in Southeast Asia, mitigation through CCS could become feasible as the carbon price rises toward 2050, with reduction potential of up to 22% of emissions under the BAU scenario in addition to consumption changes and fuel switching. See APEC (2005) about the prospects of O_2 storage in the region.

In spite of these perspectives, CCS is not a technology priority for South East Asian countries. Energy policies are understandably more focused on contributing to sustained economic growth, addressing poverty and security. Even in climate change policies, CCS takes a backseat at best. In Vietnam for example, the overall climate policy strategy is to orient the domestic resources towards adaptation, and leave mitigation leadership to international resources.

The regional interest is mostly oriented towards Enhanced Oil Recovery (EOR). For example, Indonesia began examining the EOR potential since 2003 (Indonesia CCS Study Working Group, 2009). Overall, the existing CCS action in South East Asia is one-off and project oriented, it has not progressed towards locationally appropriate CCS regulatory frameworks.

China is the major emitter of greenhouse gases in the region, and about 90% of its emissions come from burning of fossil fuels. Liu (2010) argues that the deployment of the full range of low-carbon technologies, including CCS, is essential for the PRC to decarbonise its power sector and achieve long-term climate change mitigation goals. For many years, approximately 1 GW of new coal-fired power plants began construction in China every week. Using CCS could reduce of CO_2 emissions from the Chinese energy sector by 100 and 380 million tons in 2030 and 2050 respectively (CCICED, 2009). The government promotes CCS research, development and demonstration since 2005 and continuously increases the program's funding (ADB, 2012). Zhu and Fan (2013) focused on the investment decision to retrofit an existing supercritical pulverized coal (SCPC) unit with CCS technology and four uncertainty factors: electricity price, carbon price, CCS investment cost and CO_2 additional O & M cost. The study found that the CCS retrofit investment decision is most sensitive to additional O & M costs for CO_2 capture, and the existing level of CCS technology, but the existing policy framework do support the plant owner to retrofit the existing SCPC unit with CCS.

2.3. Capture-ready concept in plant design and regional planning

In 2010, the three main organisations working on CCS defined that CCS Ready facility is a large-scale industrial or power source of CO_2 which could and is intended to be retrofitted with CCS technology when the necessary regulatory and economic drivers are in place. The aim of building new facilities or modifying existing facilities to be CCS Ready is to reduce the risk of carbon emission lock-in or of being unable to fully utilize the facilities in the future without CCS (stranded assets). CCS Ready is not a CO_2 mitigation option, but a way to facilitate CO_2 mitigation in the future".

The plant is designed to be technically capable of retrofit and built in an appropriate location where it deals with potential roadblocks such as conflicting land use, environmental and other permits, public awareness, and identification of service providers, see Bohm (2007), IEA (2007) for more details on the engineering requirements.

Building a capture ready plant costs more, because additional constraints bear on the project. For example, it may lead to choose a more sophisticated combustion technology than classical boilers. To examine the political feasibility and techno-economic aspects of capture readiness, Sekar (2007) showed that an Integrated Gasification Combined Cycle (IGCC) plant is more expensive to build and operate than a Pulverize Coal (PC) plant, but less expensive to retrofit for CO_2 capture. Bohm (2007) expanded upon this analysis to include the option of building a capture-ready IGCC plant in addition to a baseline plant, pointing out the lower carbon tax level at which a retrofit is economically justified.

Building capture ready is crucial to prevent a 'carbon emission lock in' in countries building up a coal-based power generation capacity. Li et al. (2011b) examined 74 coal-fired power plant sites in China found that only 19% of sites appear to have a high retrofitting potential. Paying for the capture-ready real option cost as insurance does not make business sense. The bottom line would only be impacted if there were under credible treats of CO_2 emissions mitigation measures.

Regional planification can facilitate the adoption of capture ready in new coal plants. Zhou et al. (2013) investigated CCS options for Guangdong, the most economically developed province in China. The project "Guangdong, China's First CCS Ready Province" (GDCCSR) provides a comprehensive review to decision makers on the necessity, feasibility, and roadmap for the CCS development in the province. Li et al. (2011a) evaluated the benefits of a 'CCS Ready Hub' approach and a regional 'CCS Ready' strategy, in the case study of Shenzhen city in southern China. It found that financing 'CCS Ready' at regional planning level can reduce the overall cost of building integrated CCS systems. It recommended that the location of existing large emissions sources should be taken into account when planning new CCS ready plants or a CCS ready hub.

3. The conditions for CCS in Vietnam

This section reviews the drivers influencing CCS in Vietnam at the