A Case Study for the Emissions Reduction for Coal Power Plants in Viet Nam

Savin VEN JOHNSON
Master Student
Lyndon B. Johnson School of Public Affairs, University of Texas at Austin
PO Box Y, Austin, Texas 78713-8925, USA
E-mail: savin.venjohnson@gmail.com

HENDRI
Researcher
Graduate School for International Development and Cooperation, Hiroshima University,
1-5-1 Kagamiyama, Higashi-Hiroshima 739-8529, Japan
Faculty of Forestry, State University of Papua, Manokwari 98314, Indonesia
E-mail: hendri888@gmail.com

Kabunga NACHIYUNDE
Doctoral Student
Graduate School for International Development and Cooperation, Hiroshima University,
1-5-1 Kagamiyama, Higashi-Hiroshima 739-8529, Japan
E-mail: kabunga2003@yahoo.com

Johannes BREIT
Master Student
Graduate School for International Development and Cooperation, Hiroshima University,
1-5-1 Kagamiyama, Higashi-Hiroshima 739-8529, Japan
E-mail: Johannes.breit@hotmail.de

Hui Xuan LI
Doctoral Student
Beijing Jiaotong University
School of Traffic and Transportation
Traffic and Transportation Planning and Management
Beijing, 100044, P.R.China
E-mail: lihuixuan27@163.com

Abstract

Energy demand in Vietnam rapidly increased during the last decades (1998-2008), with the industrial sector consuming up to 48 per cent of the total 32.0 Mtoe energy used. To enlarge the energy generation, Viet Nam government plans to install additional coal powered plants, effectively contributing further to greenhouse gas emissions. Clean Coal Technology (CCT) could be one solution to minimize these emissions. However, several barriers for the implementation of this technology exist. The analysis of CCT and the identification of barriers hindering the implementation in Viet Nam are an important initial step towards the diffusion of CCT. To enhance CCT adoption in Vietnam, five recommendations are proposed in this study including a supporting framework of regional and international partnerships.
Keywords; Coal, CCT, IGCC, GHG emissions.

1. Introduction

In 2011 the Vietnamese government announced plans to construct 90 new coal-generated electricity plants by 2025 (Marusiak, 2011). These energy generation plants are a necessary part of Viet Nam's economic growth strategy based on industrialization. Industry has powered phenomenal economic growth (GDP), as shown in figure 1, over the recent decades (1990-2008). However, the country's shift from agriculture towards more industry (industrialization) and services since1990 (Figure 2) has led to greater stress on finite energy resources.

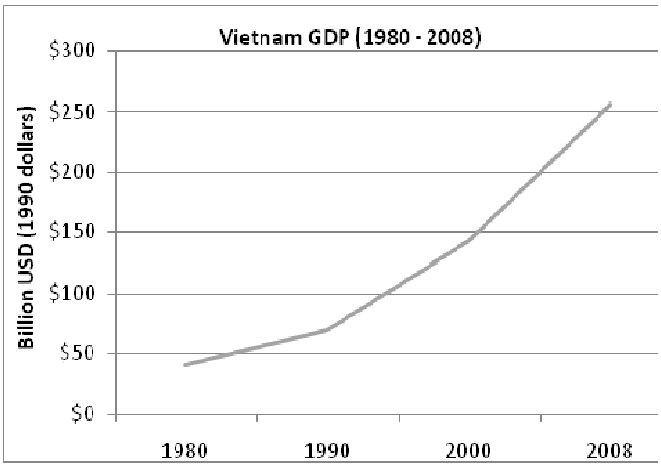

Figure 1. Vietnam GDP (World Bank, 2011a)

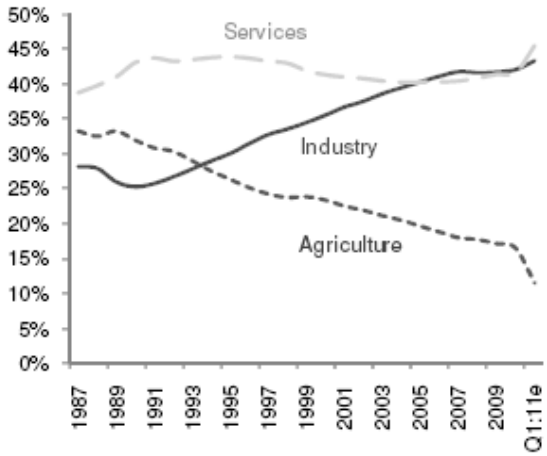

Figure 2. Sectoral Share of Viet Nam (World Bank, 2011b)

The development of these coal-generated power plants has regional and global implications. The Business as Usual (BAU) scenario that neglects emissions reduction strategies will increase greenhouse gas (GHG) emissions in Viet Nam; higher emissions will in turn further degrade the environment, increase pollution, and have detrimental long term impacts on peoples' health. The second Viet Nam National Communication Report, under the aegis of the United Nation Framework Convention on Climate Change (UNFCCC), concluded that GHG emissions from energy sector increased 35.0 per cent to 150.9 Mt CO_2 equivalent in 2000 (UNFCCC, 2010). Viet Nam's energy sector was the second largest contributor of GHG after agriculture. Therefore, construction of coal-fired power plants needs to incorporate emissions reduction and mitigation of negative impacts in order to provide for environmental and social sustainability.

Clean Coal Technology (CCT) can be a mitigation tool for reducing GHG emissions within the energy sector. However, information and implementation of CCT in Viet Nam is still limited and faces several barriers. The purpose of this study is to identify the barriers and challenges for implementing CCT, apply lessons learned from China's experiences in CCT, and provide recommendations for next steps to address these constraints.

2. Energy Supply and Demand in Viet Nam

Viet Nam has an abundance of fossil fuel resources, including coal, oil and gas. As the government promoted greater industrial development, consumption of fossil fuels dramatically increased to support the industry sector. In 2008, the industry sector became the largest energy consumer in Viet Nam, accounting for about 48 per cent of country's energy use (Figure 3).

As it continued to industrialize, Viet Nam began producing more energy intensive goods. For example, the World Bank (2011a) reported that $1000 of product required 129 kilograms of oil equivalent (kgoe) in 1998 but in 2008, 278 kgoe was required to

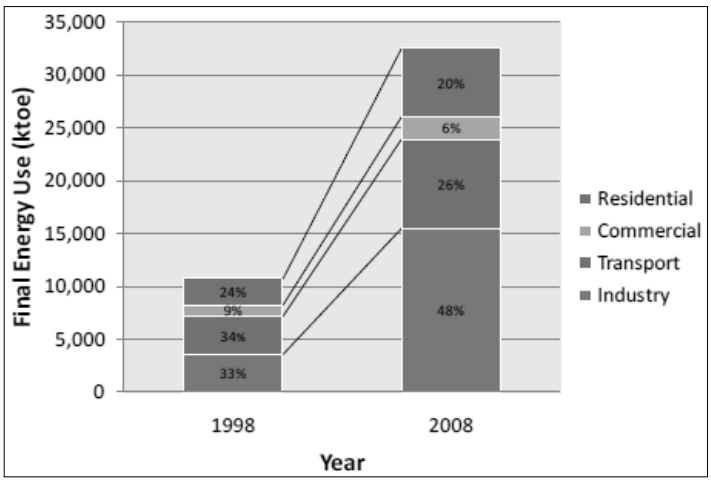

Figure 3. Viet Nam's Commercial Energy Use 1998 and 2008 (World Bank, 2011a)

produce the same value of products. Total energy consumption tripled between 1998 and 2008, going from 10.8 million tons of oil equivalent (Mtoe) to 32.5 Mtoe. Despite current ample fossil fuel resources, the World Bank (2011a) estimates that Viet Nam will be a net importer of energy within the next five to ten years. By 2020, consumption of coal and oil is expected to double in order to support Viet Nam's industry and electricity needs (USAID, 2007). Hand in hand with this, Viet Nam's economic growth strategy will also increase GHG emissions as a result of more fossil fuel consumption, specifically projections are that CO_2 emissions will rise by about 80 per cent from 2010 to 2020 (USAID, 2007).

2.1. Coal in Viet Nam's Development Strategy

Coal has played a key role in Viet Nam's development, powering social and economic development in the past and supporting power needs and industrial growth in the future. Viet Nam has been fortunate in that its production of coal has far exceeded its consumption (Figure 4).

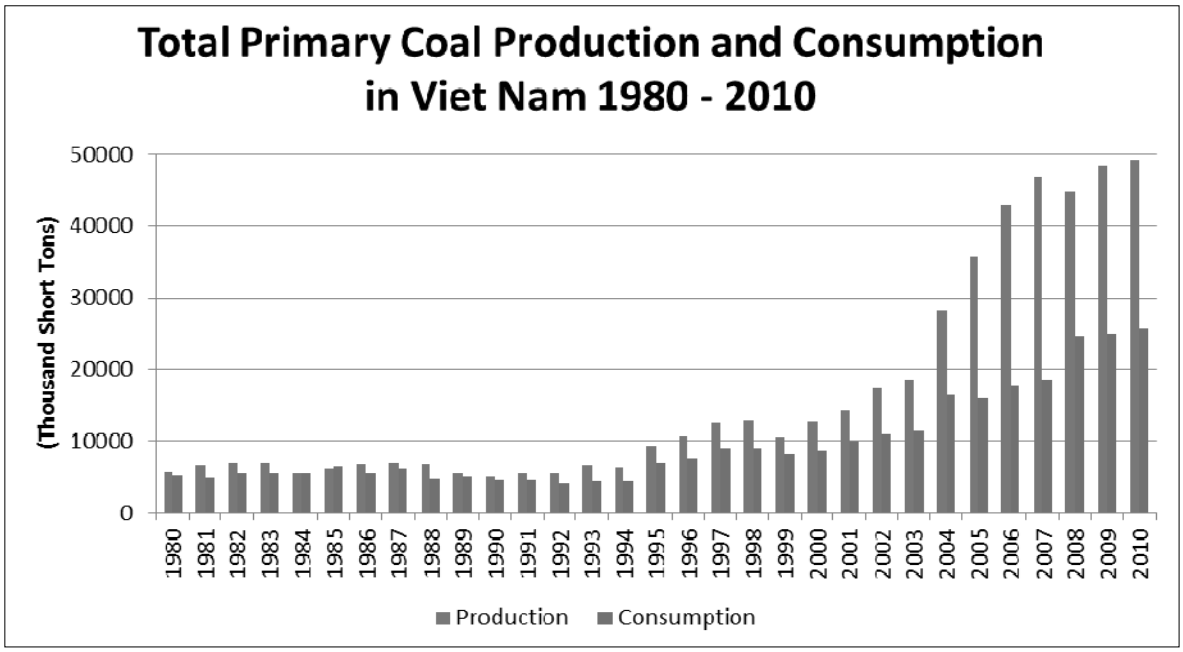

Figure 4. Coal Production and Consumption
(Data from U.S. Energy Information Administration, 2011.)

However, Viet Nam's Ministry of Industry and Trade (Table 1) projects that demand for coal is expected to nearly double over five years, from 29 million to 47 million tons by 2015 (Nguyen, 2008).

Table 1. Coal demand projections 2010 and 2015, in million tons. (Adapted from Nguyen, 2008)

Demands	2010	2015
Electricity Generation	11.7-12.3	22.6-23.8
Cement Production	5.3	6.4
Construction Material Production	4.9-5.1	5.6-5.9
Fertilize Production	1.1	1.8
Paper Production	0.3	0.4
Textile industry, dye	0.3	0.4
Metallurgy	1.6-3.3	4.4-6.3
Others	3.8-4.3	5.4-6.0
Total	29-32	47-51

Coal-generated Power Plants in Viet Nam's Future

Taking advantage of its vast coal supplies, the government of Viet Nam announced plans to build 90 new coal-generated plants by 2025 (Marusiak, 2011). Construction on five of these plants has already begun in 2011. According to Viet Nam's Environmental Protection Agency, the addition of 90 coal power plants is expected to have numerous issues, including environmental problems from rising GHG emissions, increased solid waste and degradation of surrounding air, soil and water quality; socio-economic impacts from disease and ill health from the neighboring communities; and eco-system impacts from terrestrial and aquatic damages cause coal plant operations (Hoang, 2008). In acknowledgement of the negative externalities and the country's vulnerability to the impacts of climate change, the government of Viet Nam is soliciting international assistance to develop emissions reductions programs and CCTs that at same time support national economic growth strategy.

3. Clean Coal Technology in Viet Nam

In 2007, Viet Nam began implementing CCT using gravity concentration and cleaning device under a technology transfer agreement with Japan Coal Energy Center (Viet Nam-Japan Energy Cooperation, 2007). However, the implementation of CCT had been limited to only three coal power plants: Van Danh, Hon Gai, and Cua Ong. The planned 1,000-MW Mong Duong I coal-fired plant, operated by Electricity Viet Nam (EVN), the sole electricity provider in the socialist country, is scheduled to begin operation in 2012 and will be the first Vietnamese CCT power plant to use circulating fluidized bed combustion (CFB) technology. Construction of a few of the 90 coal plants will be CCT-based, higher efficiency and lower emissions plan, aimed at minimizing pollution to nearby neighborhoods (Hoang, 2008). To expand CCT to other power plants, evaluation of more CCTs are needed, along with proposals for addressing the barriers, namely institutional, legal and regulatory, socio-economic challenges.

3.1. Analysis for CCT Innovation in Viet Nam

Coal is considered a dirty fuel because of the emissions and other harmful pollutants given off in its consumption. With Viet Nam's increasing dependence on fossil fuels for its energy needs and economic growth, it is important that there are technology options that would allow continued use of fossil fuels while minimizing emissions of CO_2.

Integrated Gasification Combined Cycle (IGCC) stations must compete with all power plant configurations. In particular, this includes supercritical pulverized-coal fired steam power plants and the numerous others referred to as CCTs, such as pressurized fluidized bed combustion (PFBC). Based on table 2, it can be realized that there is no single technology which has

Table 2. Options of Generating Units (1200W, operating for 20years)

Item	Investment (10^8 Yuan)	Fuel consumption (Mt)	Total fuel cost in 20 years (10^8 Yuan)	SO_2 emission (kt)	NO_x emission (kt)	Investment and fuel cost (10^8 Yuan)
Subcritical 600 MW	44.08	43.164	129.49	531.8	172.7	173.57
Subcritical 600 MW + FGD	49.18	43.824	131.47	54	175.3	180.65
Supercritical 600 MW + FGD	65.92	42.768	128.3	52.7	171.1	194.22
Ultra-supercritical 600 MW + FGD	66.58	41.184	123.55	50.7	164.7	190.13
CFB 300 MW	64.96	45.012	135.04	55.5	90	200
IGCC 485 MW	87.9	39.336	118.01	3.1	15.7	205.91
PFBC 206 MW	81.25	43.56	130.68	53.7	74.2	211.93
GTCC 350 MW	46.25	31.02	326.04	2.4	12.4	372.59

Source: Lu et.al. (2008)

all the advantages; tradeoffs will always exist when choosing an appropriate technology.

For instance, a subcritical 600MW unit has the lowest investment cost at $44.08x10^8$ Yuan. But when it comes to fuel consumption, the most desirable unit is Gas Turbine Combined Cycle power plant (GTCC) followed by an IGCC unit. Operated for a period of 20 years, IGCC has demonstrated to be the best scenario with regards to total fuel consumption. The environmental degradation as a result of SO_2 emission is least with a GTCC unit followed by an IGCC unit. As for the NO_x emissions, the IGCC unit is by far the most superior at only 15.7kt compared to the worst case scenario of a subcritical unit at 175.3kt. When it comes to the investment cost, a subcritical 600MW unit has the lowest costs.

As earlier stated, Viet Nam plans to construct 90 new coal plants by 2025. Because new coal power plants built today have a long life cycle and are not easy to upgrade the technologies involved, decisions made now will have a major impact on the coal utilization mode in the coming years. For this reason, the future 20 years is the strategic opportunity period for the transition from conventional coal utilization.

Advocating for the use of IGCC in China, Liu, Ni, Li, and Ma (2008) argue thus:

> Because the Integrated Gasification Combined Cycle (IGCC) can supply electricity, liquid fuels, hydrogen and other chemicals if needed at low pollution level, and has the potential to make carbon capture and sequestration much easier and cheaper than traditional pulverized coal boiler power plants, it should be the strategic direction for China to meet the requirements of the energy and environmental challenges.

Karg, Haupt, & Zimmermann (n.d.) argue, in support of the position taken by Liu et al. (2008) that IGCC is the best technology suited for producing affordable and clean power. In the same vein, Ordorica-Garcia et al. (2006) further conclude that IGCC plants with CO_2 and H_2S co-capture have substantial technoeconomic advantages over IGCC plants that capture CO_2 and H_2S separately. Liu et al. (2008) argues that the overriding feature of IGCC relates to the optimal coupling of coal-gasification and multiple production processes to achieve high economic benefits, ultra-low pollutant emission, and the ease of carbon dioxide capture. It is the only coal technology hitherto known that can control carbon dioxide emission in an economical manner. Furthermore, Karg et al. (n.d.) argues that IGCC has an outstanding performance and that the position it occupies in the future depend on the extent to which the requirements of power producer in terms of capital investment, generations costs, availability, relevant environmental regulations, site-specific conditions, field of application and disposal consideration can be met. There is an added advantage to IGCC units, with a slight modification, in that it can use coal and natural gas to co-produce electric power and high-quality liquid transportation fuels in one integrated facility (Neathery, Gray, Challman, & Derbyshire, 1999).

In principle, these advantages discussed should push IGCC technology on its way to commercialization in Viet Nam, despite the dominant short-term challenge it faces of finding approaches to reduce plant capital costs. Furthermore, Ordorica-Garcia et al. (2006) argue that IGCC is still an emerging technology and hence, cost reductions are anticipated as IGCC techno-commercial developments progress. The reduction in investment cost is further supported by Stambler (2004) who explains that utility companies in America, anticipate building IGCC plants at costs nearing 1579 US$/MWe (installed) within the next decade. For these reasons discussed above, IGCC is recommendable as a strategic technology for Viet Nam.

3.2. CCT Barriers in Viet Nam

Viet Nam's emerging economy status combined with the complexity and high cost of IGCC and other cleaner technologies presents several barriers to CCT implementation, chief among these are institutional and legal and regulatory, in addition to common socioeconomic barriers that many developing countries face.

3.2.1. Institutional

Viet Nam lacks an enforceable and binding institutional framework for energy production and environmental protection. Despite more than 10 years of effort, the Vietnamese government has yet to develop a rigorous policy for environmental protection and sustainable energy development. Official state documents on national energy strategy and policy have recently been released (UNESCAP, 2005). From 1996 to 2000, Viet Nam carried out the National Science Technology program on Strategy and Policy for Sustainable Energy Development for Period of 2001- 2020. The main target of this program was to create scientific bases for National Energy Policy for the general sector. The results of this program led to the draft of the National Energy Policy, which was prepared and submitted to Government but did not become formally adopted.

Nevertheless, some content from the draft policy became embodied in the Resolutions of the Communist Party of Viet Nam, the Decisions of the Government and in related laws such as Law on Mineral, Law on Oil and Gas, Law on Electricity as

well as master plans for the clean technology of oil and gas, coal, and electricity sector development (Nguyen & Vu, 2008). Key recommendations under the national energy development strategies, which support strategic objectives for achieving socio-economic development and clean technology (UNESCAP, 2005, 14), are to:

> Rationally and efficiently exploit and use national energy resources; ensure sufficient energy supply with continuously increasing quality, rational price for the socio-economic development, diversify the investment and business types in the energy sector, gradually form energy market in Viet Nam; promptly, efficiently and stably develop the energy sector, development goes together with the improvement in social equity and environmental protection.

Notable here is the reference to environmental protection, which signals in a broader sense the reduction of environmentally harmful GHG emissions.

At present, Viet Nam is not legally bound by any national or international agreement to reduce GHG emissions, but the country has taken initiatives to develop its own environmentally-focused policies and programs to monitor and mitigate emissions. However, the major weakness shared among all these national policies is lack of clear definitions, rigorous target-setting and insufficient capacity to implement, monitor and evaluate programs.

3.2.2. Legal and Regulatory Barriers

Viet Nam has few legal requirements directly regulating GHG emissions; however, the Law on Environmental Protection (LEP) created in 2003 but adopted in 2005 contains provisions on emissions management and ozone layer depletion. Specifically, the LEP encourages the reduction of GHG emissions and stipulates implementation of "a strategy on development of renewable energy...and minimization of GHG emissions". Furthermore, the law (LEP, Article 83) includes indirect regulations on GHG emissions, specifically stating:

> Organizations and individuals engaged in production, business and service activities that emit dust and gaseous wastes shall have the responsibility to control and treat dusts and air emissions to comply with environmental standards; Means of transport, machinery, equipment and construction works that release dust and gaseous wastes must be provided with filters and devices that reduce gaseous wastes to comply with environmental standards, and with coverings or other measures to minimize dust to comply with environmental standards.

Viet Nam lacks a specific legal document addressing clean air policies that could serve as the basis for controlling GHG emissions, protection of ozone layer, and climate change mitigation, although, at present, some regulation of air pollution is done through applying provisions of air environment technical standards and environmental impact assessments (Nguyen & Vu, 2008. However, more effort is needed to develop and implement more effective measures such as air emission permits or control of total volume of specific air pollutants as other countries have done.

To further incentivize development of programs, the LEP provides for tax exemptions and subsidies for activities related to clean and renewable energy production (Article 36, Clause 2, Law on Investment, 2005). Furthermore, clause 3, Article 117 identifies "funds support" for the development of clean energy. But the definitions and targets for clean energy are unclear. For example, the funds support allows for organizations and individuals that invest in environmental protection to be given priority access to loans from the environmental protection funds, but does not clarify the types of activities that could receive support (Nguyen & Vu, 2008, 18). The LEP also does not provide recommendations for specific strategies for clean energy. For example, CCTs are not mentioned in the law.

3.2.3. Socio-economic Barriers

Despite rapid economic growth, Viet Nam is still considered a poor developing country and lacks skilled human resources, particularly in technology and scientific sectors, and financial resources. In 2011, the human resources consulting firm Man Power Group conducted a survey of Viet Nam's workforce capacity and found that the country had significant shortages of skilled workers (VietNamNet, 2011). Specifically, the survey found that labor quality was among the lowest 10 per cent among the region, with severe deficiencies in technical knowledge, communications, and management. CCT-based coal plants are sophisticated and complex operations. The shortage of trained and experienced human resources presents a barrier for adopting more modern and efficient technologies.

CCT has high costs in both the before- and after-implementation stages. CCT plants are substantially more expensive than conventional coal plants because of added capital costs from physical and technical equipment, additional processing steps and

time, and enhanced requirements for monitoring and regulating carbon emissions. In the after-implementation stage, the cost of electricity from a CCT plant is much higher, rendering electricity from CCT less price competitive than electricity from conventional coal plants. In fact, costs of CCT-based electricity may be higher than the financial capacities of consumers in poor countries. Even in the United States, a country with the highest per capita income in the world, clean coal is cost-prohibitive for many consumers, presenting a barrier for widespread adoption (Hamilton, 2004).

The much lower income Vietnamese government appears unable and unlikely to invest in CCT on their own. Additionally, there is still uncertainty about the costs and benefits of CCT, especially IGCC and carbon capture and storage (CCS), since they are relatively new technologies and concrete data on processes, technology, costs, and effectiveness are still unknown. This uncertainty is further compounded by the lack of public transparency in Viet Nam's socialist government system, which serves as further disincentive for investment in CCT.

4. Lessons in CCT from China?

As a socialist emerging economy with strong plans for industrialization, Viet Nam holds many similarities to China. It is worth investigating China's CCT strategies to see if there are lessons that can be applied to Viet Nam.

4.1. Energy Consumption in China

China is one of the largest coal consumers in the world. Coal consumption in China was 1,678 Mega Tonnes of Coal Equivalent (MtCE) in 2003, which accounted for about 67 per cent of the country's primary energy consumption (Crompton & Wu, 2004). Similar to Viet Nam, China prefers coal as an energy source because of the relative ample domestic supply and low cost. The dominance of coal in China for energy production will not diminish in a foreseeable future. Despite being the preferred fuel source, coal has many issues in China.

4.2. Issues with Coal in China

China faces major issues with coal consumption. First, the proportion of coal in end energy consumption is still high, but the proportion of electricity consumption is opposite. Another major problem is that a high proportion of coal is for direct and low-efficiency combustion. Thirdly, coal is of relative low quality in China, which means less energy efficiency and more pollution. Next, coal technology and coal-fired power plants in China are outdated, reducing efficiency. Thus, the energy consumption per unit of GDP in China is more than triple the rest of the world (Figure 5). Finally, coal consumption has brought and left environmental impacts, including severe air pollution, land degradation, and people migration. Faced with these issues, China has, relatively recently, turned to CCT and emissions mitigation programs to improve energy efficiency and sustain environmentally and economically sustainable growth.

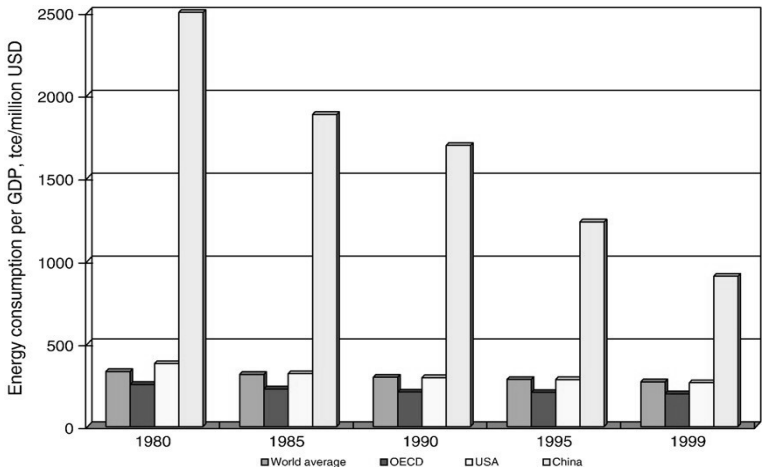

Figure 5. Energy consumption per GDP in China and the world(Lu et al., 2008)

4.3. CCT Development in China

There are 18 CCT programs in China. They can be classed in five fields: coal processing, high-efficiency coal combustion and advanced power generation, clean and efficient comprehensive utilization of coal, coal conversion, and pollution control

and reutilization. Among these 18 technologies, coal washing, blending, coal water mixture (CWM) and CFB technologies have been the most diffused and put into commercial application. Supercritical units, flue gas desulfurization (FGD) units and large-sized coal gasification technology with independent intellectual property are still under development. Coal liquefaction, IGCC, coal bed methane (CBM) development, which are mainly imported from abroad, have entered into commercial demonstration. Briquette, retrofit of small and medium-sized industrial boilers, comprehensive use of coal refuse and fly ash, and reuse of mine water are being improved and perfected (Lu et al, 2008).

4.4. Energy and Environmental Regulations in China

In recent years, China promulgated many laws, regulations and policies related to clean energy sources/technologies and environmental protection. Unlike other countries where CCT development is driven by environmental policies, the development of CCT in China is, instead, significantly driven by the promotion of technical policies. The specifications included in technical and industrial policies are more effective because they present clear, concrete goals, as well as encouragements and penalties. Policies have become increasingly strict, to include specific measures such as control on total amount of emissions, emission fees, and control of major pollution sources and use of continuous emission monitors in conjunction with increasingly stringent emission standards have forced local cities and enterprises to adapt advanced technologies.

4.5. Challenges and Opportunities for CCT Development in China

Though there are numerous variations of CCT programs in China, there are several challenges, mainly in the institutional system, legal and regulatory framework, and technologies. In particular, China lacks a national coordination body for CCT development within the national energy ministry; as a result, there is no overall promotion and consistent discussion for the technologies, and few special policies and plans involving CCT.

China has identified the following CCTs that can increase combustion efficiency: supercritical (SC) units and ultra-super units (USC); CFB combustion; IGCC; and PFBC. Comparisons between the technology show that no one technology can do everything, but each technology provides either a technical, economic, or environmental benefit. Subcritical units plus FGD and SC units plus FGD have the highest technical maturity and availability; USC units come from the highest generating efficiency; IGCC has the lowest unit coal consumption and best SO_2 emission reduction effect; CFBC has the lowest capital cost (Zhang et al, 2004). SC, USC, CFB are technologies suitable for long-term development but commercial demonstration of these technologies are still untested in China.

5. Recommendation for Viet Nam's CCT Innovation

In review of the above barriers and challenges, this study has developed recommendations to support CCT innovations in Viet Nam. The subsequent sections will review each recommendation.

5.1. Institutional Strengthening: Develop a Cross-sector CCT Planning and Coordinating Body to Support CCT

Viet Nam has multiple energy regulatory authorities who have been effective at setting energy policy and monitoring compliance. The Ministry of Science and Technology (MOSTE), Ministry of Industry and Trade (MOIT) and Ministry of Planning and Investment (MPI) have been the primary government bodies responsible for the policies, regulations, legislations and other related activities in the energy field including the coal sector. The Ministry of Natural Resources and Environment (MONRE) has traditionally been designated as the monitoring and implementation body of emissions reduction initiatives. MONRE is responsible for inventorying emissions of GHGs nationwide and ensuring compliance with multilateral environmental agreements to which Viet Nam is a contracting party. A committee for CCT promotion and development selected from each of these ministries would help to share ideas, maintain attention on CCT, and pool resources to enhance CCT implementation and monitoring. To further enhance the authority and autonomy of the CCT promotion group, this cross-sector body should be placed directly under the prime minister so that inter-ministry rivalry and egotism does not stall CCT implementation.

5.2. Utilize Regional and International Cooperation to Coordinate and Finance Clean Coal Technologies (CCT) in Viet Nam

Viet Nam has already received a wide range of financial and technical support from regional and international agreements and partnerships in the area of CCTs, coordinated by the MOIT. The common areas of collaboration are divided into three stages, i.e. (1) to set up an early clean energy sector, (2) to initiate CCT, and (3) to develop advanced CCT. This next section of

the report summarizes the major regional and international cooperation activities supporting clean and efficient energy development in Viet Nam. Working under these collaborations can help Viet Nam to overcome domestic regulatory, technical, and financial challenges.

5.2.1. Cooperation for Clean Energy Development

Viet Nam's regional collaboration includes membership in the Greater Mekong Sub-region (GMS), the Association of Southeast Asian Nations (ASEAN), and the Asia Pacific Economic Community. International cooperation arrangements exist with the World Bank, United Nations (UN), Asian Development Bank (ADB), and various bilateral aid agencies. The majority of cooperation arrangements support Viet Nam's National Energy Efficiency Program (VNEEP) and Energy Sustainable Development Program.

5.2.2. Regional Cooperation and Agreements

Under the GMS regional cooperation, the member nations created a roadmap of power interconnection and expanded energy sector cooperation. ADB approved in 1992 the Technical Assistance (TA), supporting study using Model of Energy Supply Systems Alternatives and their General Environmental Impacts (MESSAGE) assessed the impacts of various scenarios among the six GMS-affiliated countries (Figure 6), namely Cambodia, the People's Republic of China (PRC), Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, and Viet Nam (Economic Consulting Associates, 2010). Results from MESSAGE indicate that GMS integration provides a vehicle for achieving low carbon and sustainable development via South-South cooperation model. Cooperating members can share information, spread costs, and develop feasible and mutually beneficial action plan for environmental protection.

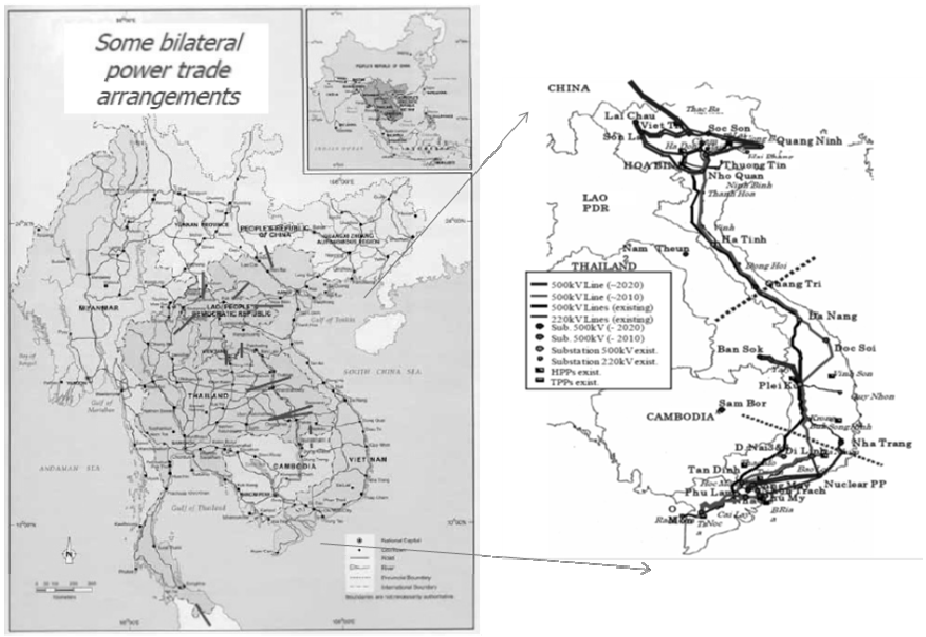

Figure 6. Transmission grid among the six countries GSM and Viet Nam border countries (Economic Consulting Associate, 2010)

Within the ASEAN cooperation, the group established an ASEAN Forum on Coal (AFOC) in 1999 to develop the coal subsector network focused on five strategies: (1) strengthen Institutional and Policy Framework, (2) promote CCT, (3) promote Private Sector Investments, (4) promote Intra-ASEAN Trade on Coal, and (5) promote Environmental Impact Assessment (EIA) of Coal Projects (ASEAN Program Report, 1999). To promote EIA for coal-fired power, the Asia Pacific Economic Cooperation (APEC) network provided assistance for CCTs, e.g. SC, USC, PFBC, IGCC and CCS, in developing APEC countries included China, Indonesia, Philippines, the Russian Federation, Thailand, and Viet Nam (APEC Energy Working Group, 2007).

Regional regulations targeting air emissions, water use and discharges, and solid waste by-products were also considered as the coal-fired power results that can be used for emission trading under the Kyoto Protocol's Clean Development Mechanism (CDM) or the other scheme like Carbon Fund or the Post Kyoto Reduction Emission from Deforestation and

Forest Degradation (REDD).

5.2.3. Build off the Frameworks from International Cooperation and Agreements

A variety of international agreements have spurred Viet Nam's action to promote and adopt clean energy and emissions reduction strategies. These include the Organization for Economic Cooperation and Development's (OECD), Agenda 21 and the United Nations Convention on Climate Change. International cooperation include programs with World Bank, UN, ADB, Agence FranÇÉaise de DÇÖveloppement (AFD), Danish International Development Agency (DANIDA), and Japan International Cooperation Agency (JICA) are representative of the donor support and activities in the field of energy efficiency in Viet Nam.

5.2.3.1. Agenda 21

In 2001, the OECD called for nations to develop a strategy to achieve sustainable development, as previously defined during the 1992 UN Conference Environment and Development in Rio de Janeiro, Brazil. Based on Agenda 21, Vietnamese government released in August 2004 the document "Orientation of sustainable development strategy in Viet Nam," known as Viet Nam Agenda 21, which provided an implementation strategy for achieving sustainable development within the context of Viet Nam.

Viet Nam's Agenda 21 is a framework for developing a legal basis for industries including the energy industry, in supporting national energy development strategy and policy. The key principles for sustainable development identified in the Agenda include a human-centered approach, emphasis on economic development as a key component for sustainability, protection and improvement of the environment, and emphasis of new science and technology as the tools for achieving sustainability.

Considering the focus on human and economic development, some of the principles clearly support introduction of low carbon technology. The third principle identifying improvements in the quality of the environment as well as the fourth principle that provided a common definition of sustainable development especially support clean technology innovation.

The programs under the World Bank since 1997 focused on four (4) activities: (1) Demand Side Management (DSM) planning and pilots with Electricity of Viet Nam (EVN); (2) initiation of load management and research functions, also with EVN; (3) development of initial equipment standards with Ministry of Science and Technology (MOST); and (4) development of a commercial building code with Ministry of Construction (MOC). The UN, through United Nations Development Programme (UNDP) and United Nations Industrial Development Organization (UNIDO), has promoted "Energy Conservation in Small and Medium-Scale Enterprises" since 1977. In the program period 2005-2010, the UNDP program included incorporation of energy efficient building codes, energy efficient appliance labeling and standards, capacity building for implementation of the Energy Conservation Law, promotion of Energy Management Standards via ISO 500001 Management Standard, was well as coordination of climate change adaption and mitigation efforts.

Other international cooperation include an ADB program, in 2007, supporting implementation of the National Energy Efficiency Program with five component studies, namely: (1) Survey of Energy consumption in Industrial Enterprises; (2) Development of a Training Program for Energy Managers; (3) Conducting Energy Audits of Selected Large Industrial Enterprises; (4) Upgrading the Capacity of Existing Energy Centers into Professional ESCOs; (5) Devising a Mechanism for Financing Energy Conservation Plans for Industrial Enterprises. AFD provided support to Viet Nam's development targets in its Partnership Framework Document (PFD) on energy efficiency policies signed between France and Viet Nam in 2006. DANIDA programs generally provided capacity building and knowledge transfer in Vietnamese institutions and targets key energy sectors identified by the Vietnamese government in 2006 to support the energy efficiency program of the MOIT. JICA has also implemented the development study "Study on National Energy Master Plan in Viet Nam." The project objectives are to: (1) establish the National Energy Master Plan up to 2025 including energy security, energy diversity, power import-export, rural electrification, promotion of renewable energy utilization, CO_2 emission, energy conservation, investment plan, socio-environmental impacts and international cooperation; (2) develop national database of Viet Nam including socioeconomic data and energy data covering electric power, coal, oil and gas, renewable energy, etc.; and (3) build capacity of the bodies under MOIT. JICA is currently working to develop a roadmap for VNEEP to enhance program results and better help MOIT meet their national targets.

5.2.3.2. United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (KP)

Viet Nam has signed and approved two important international agreements regarding the problem of climate change: the UNFCCC and the Kyoto Protocol (KP). Furthermore, it has also developed a legal and policy framework to minimize, respond,

and adapt to climate change, although as a non-Annex 1 country it does not have specific GHG emission reduction commitments. Viet Nam is responsible for:

1. Building national policy and legislation and correlated measures to mitigate adverse climate change through reducing GHG emissions;
2. Developing a national inventory of emission sources and setting up and executing national programs containing measures to mitigate climate change by responding to anthropogenic emission.
3. Cooperating with other countries to respond to the effects of climate change, exchanging information, scientific research, technology, education, training and public information; and
4. Developing policy and legislation to implement CDM.

The framework of Regional and International Partnership related to CCT development in Viet Nam is presented in Figure 7. The proposed Framework is useful for energy sustainable management in Viet Nam based on green innovation and technology.

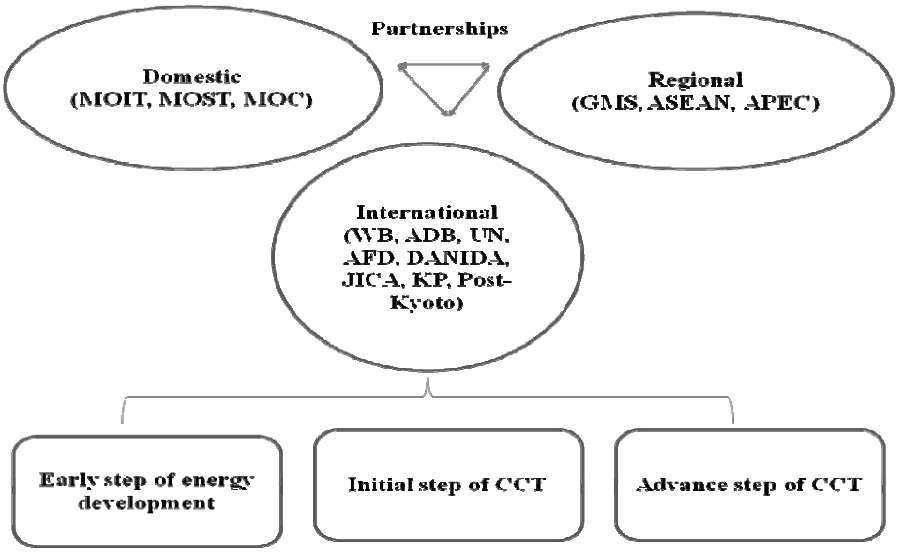

Figure 7. Framework of Regional and International Partnership for CCT in Viet Nam

5.3. Seek North-South and South-South Cooperation for Research and Development

Coal is a finite resource and world supply will inevitably diminish. Considering this fact, there are major efforts in both developed and developing countries to improve the efficiency of each unit of coal. At the same time, the GHG emissions and climate change has global impacts and mitigation plans are also being considered across regions. Research and Development (R&D) for cleaner coal technologies addresses both of the issues above. The Vietnamese government needs to increase its information of these existing R&D research and utilize its regional and international cooperation agreements to finance and test some of the prototype CCT programs in Vietnam. Technologies being developed that could be easily implemented in Viet Nam with reasonable coordination and financing include USC boiler, steam turbine, flue gas cleanup system, boiler, coal gasification, coal liquefaction technologies and related IGCC technology.

5.4. Improve Market Mechanisms for CCT

Once Viet Nam obtains the knowledge (through shared R&D discussed above) for CCT, the next step is to improve the investment and business climate in Viet Nam to attract investors to develop CCT and make CCT-based cost of energy more competitive to conventional coal-fired power. There are several incentives that the government of Viet Nam can offer foreign investors for developing CCT. Top among these are complete ownership, tax waivers, subsidies, and other trade incentives. Taking a lesson from China, the government of Viet Nam can promote competitive energy prices by unilaterally reorganizing logistics and transportation infrastructure, deepen integration between coal extraction, production, supply, sales, transportation, and distribution to lower cost of coal inputs in CCT plants.

5.5. Invest in Capacity Building and Explore Alternative Financing

Investments in CCT in Viet Nam will have little success unless there are skilled human resources to oversee these investments. As Viet Nam is facing a scarcity of qualified, highly trained labor, the government should strengthen the existing

educational systems, perhaps implementing a target curriculum in secondary and postsecondary schools for energy and environment innovation. Additionally, educational exchange programs where Vietnamese students, faculty and professionals go to study abroad and trained foreign counterparts are brought to Viet Nam should be expanded. Another way to increase human capital is to require foreign companies and investors to train and hire locals to be the majority of their management and technical staff.

In the area of financing for CCT, there are a myriad of new alternative financing schemes that support CCT research and implementation in developing countries. Government of Viet Nam needs to exploit its position as a developing economy to take advantage of such support from the international community. Among these opportunities are carbon trading and financing schemes under the Kyoto Protocol such as Certified Emission Reductions and Clean Development Mechanisms that allow developed countries to invest in clean and low carbon technology in developing countries in exchange for carbon credits for their country. Additionally, there is also carbon funding from multilateral organizations such as the World Bank's climate investment funds, as well as bilateral funding from OECD countries.

6. Conclusion

Viet Nam is a developing country with aspirations to become a middle-income country within the next 20 year by continuing and accelerating its industrialization process. Hand in hand with this plan is the potential for more devastation in the environment because coal, a known dirty energy source, will be the fuel that powers Viet Nam's economic growth. Viet Nam's geography and large population leaves it exposed to many climate disasters and externalities from increased coal consumption may increase its vulnerabilities.

CCTs are a necessary solution for not only sustainable economic prosperity but also for the health and survival of the country. Among the CCTs, this study found that IGCC could deliver the best benefits for efficiency and emissions reduction.

However, CCTs, including IGCC, have several issues, especially in Viet Nam's context. First, there is the high capital investment cost; secondly, Viet Nam lacks the human capital to develop and maintain these modern and complex technologies, and finally, the existing market mechanisms make CCT-based energy much less competitive than energy from conventional coal plants.

Within Viet Nam, there are additional barriers to CCT implementation. These include the lack of a domestic institutional framework to support and oversee environmental and clean energy initiatives, weak legal and regulatory framework, as well as common socio-economic limitations that afflict developing countries.

To address these issues and barriers, this study reviewed CCT implementation in the context of China for lessons learned. Based on China's experience, CCT can be implemented in Viet Nam by employing both large scale and incremental CCTs coupled with a stronger mandate in technical requirements and environmental regulation through the state's command and control authority.

Additionally, this study also found several opportunities for strengthening regional and international cooperation and programs for knowledge sharing, capacity building, costs-sharing, and institutional strengthening. Furthermore, there are emerging carbon financing and funding schemes that could be available to Viet Nam because of its developing economy status and help the country overcome financial and technical limitations for implementing CCT.

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