HAL
open science

Synthesis Report on Socio-environmental Impacts of Coal and Coal-fired Power Plants in Vietnam

Minh Ha-Duong, an Ha Truong, Hong Nam Nguyen, Hoang Anh Nguyen Trinh

To cite this version:

Minh Ha-Duong, an Ha Truong, Hong Nam Nguyen, Hoang Anh Nguyen Trinh. Synthesis Report on Socio-environmental Impacts of Coal and Coal-fired Power Plants in Vietnam. [Technical Report] Vietnam Sustainable Energy Alliance. 2016. hal-01441680

HAL Id: hal-01441680

https://enpc.hal.science/hal-01441680v1

Submitted on 20 Jan 2017

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Synthesis Report on Socio-environmental Impacts of Coal and Coal-fired Power Plants in Vietnam

Minh Ha-Duong, An Ha Truong, Nam Nguyen, Hoang Anh Trinh Nguyen

Hanoi, June 30th, 2016

About this publication

The research was financially supported by GreenID, and is based on original work performed by VSEA members under the leadership of GreenID. The four authors of this report work at the Clean Energy and Sustainable Development lab (CleanED) in the University of Science and Technology of Hanoi (USTH), an academic think-tank whose mission is to contribute to the green growth of the energy sector in Vietnam.

Lead author Minh Ha-Duong is the director of CleanED, and Directeur de Recherche CNRS affiliated with the Centre International de Recherche sur l'Environnement et le Dévelopement in Paris, France. He contributed to chapters 1, 2 and 4 and overall editing. An Ha Truong and Nguyen Hong Nam are doctoral students at CleanED, USTH. They contributed to chapter 3 and to the Vietnamese translation. Nguyen Trinh Hoang Anh is an assistant professor at USTH, and contributed to chapters 1 and 4 as well as managing the project.
The USTH does not approve or disapprove the views expressed in this report, published under the responsibility of its authors.

Cite as: Minh Ha-Duong, An Ha Truong, Nam Nguyen, Hoang Anh Trinh Nguyen (2016) Synthesis Report on Socio-environmental Impacts of Coal and Coal-fired Power Plants in Vietnam. Clean Energy and Sustainable Development lab report, Hanoi.

Reproduction and redistribution allowed, with attribution.

Table of contents

List of tables....3

List of figures....3

Acronyms....4

Abstract....5

Executive summary....6

1. Introduction....8

2. National and global context....11

2.1. Coal in the power sector of Vietnam....11

2.2. Global and national impacts of burning coal....16

2.3. Technology context: the energy transition....19

3. Local impacts....21

3.1. Air quality....22

3.2. Water quality....27

3.3. Soil quality....31

3.4. Livelihood of local people....33

3.5. Public health....35

4. Summary and concluding recommendations....38

4.1. Summary on the observed and expected impacts of coal....38

4.2. Recommendations....39

4.3. Concluding remarks....41

List of tables

Table 1. Summary of the 8 case-studies selected in the report.....10

Table 2. Coal power plants in Vietnam by project development stage. Source: Global Coal Tracker (consulted 2016-06-23).....14

Table 3. Power capacity and electricity generation by 2020 and 2030 in the 7th Power Development Plan (PDP VII, 2011) and the adjustment (PDP VII revised, 2016).....15

Table 4. Dust concentration at some coal mining sites (Unit: mg/m^3) (MONRE).....23

Table 5. Quality of water source near Quang Ninh power plant as judged by informants.….30

Table 6. Estimated health impacts of coal power plant in Vietnam through number of coal related premature death (Myllyvirta 2015).....37

List of figures

Figure 1: The partial unbundling of EVN. Electricity generation, transmission and distribution in Vietnam in 2013 (MOIT, 2015).....14

Figure 2. Power generation capacity share in the electricity market by ownership in 2014...15

Figure 3. The process blocks and emissions in coal production (Loi and S. H. 2008).....22

Figure 4. Impact of coal to air quality from its whole life cycle.....23

Figure 5. Estimated pollutants emissions from coal power plant (MOIT 2010).....24

Figure 6. Coal ash transportation (left) (Le Truong 2015) and air pollution in the project site (right) in Vinh Tan coal thermal power plant (Hoang Linh 2016).....25

Figure 7. Impact of air pollution to local people based on GreenID survey (GreenID 2015). 26

Figure 8. Emission limits for coal-fired power plants (Myllyvirta 2015).....27

Figure 9. Impacts of Quang Ninh coal-fired power plant on water quality of studied areas…29

Figure 10. Current (left) and projected in 2030 (right) PM2.5 concentration (Koplitz 2015). .36

Acronyms

ABD	Asia Development Bank
CCS	Carbon Capture and Storage
COP21	21st UN Climate Change Conference
EVN	Electricity of Vietnam
EGAT	Electricity Generating Authority of Thailand
GHG	Greenhouse Gas
INDC	Intended Nationally Determined Commitment
IPCC	Intergovernmental Panel on Climate Change
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources and Environment
PDP	Power Development Plan
PM	Particulate Matter
REN21	Renewable Energy Policy Network for the 21st Century
UNFCCC	United Nation Framework Convention on Climate Change
VINACOMIN	Vietnam National Coal – Mineral Industries Holding Corporation Limited
VSEA	Vietnam Sustainable Energy Alliance
WHO	World Health Organization
WWF	World Wild Fund

Abstract

This report shows the impacts of coal mining and coal-based electricity generation on the Vietnamese society and environment. It summarizes the results of eight local studies conducted from 2013 to 2016 by members of Vietnam Sustainable Energy Alliance (VSEA). The studies were conducted in six coal-fired power plants, one coal waste dump site and one ash pond embankment. They are located in the North, the Centre and the South of Vietnam with an emphasis on the Quang Ninh province, where most coal reserves of Vietnam are.

Five impacts categories were examined: water, air and soil pollution, local people's livelihood and health. We studied impacts now and extrapolated according to Vietnam's current Power Development Plan –namely PDP VII revised– which prescribes to expand the coal-fired power capacity from about 10 GW today in 2015 to 55 GW by 2030. Results show that coal mining and coal-based electricity generation have high, unsustainable, local impacts. Our studies found that levels of dust in the air systematically exceeded the legal safe standards. So did the level of heavy metals and other toxic pollutants in the water we studied. We observed resettlement issues which were not solved appropriately, and local job creation promises which were not followed up in action. We assess that by 2030, Vietnam's coal power plants would create 30 million tonnes of coal ash to be disposed.

We estimate that the PDP VII entails importing at least 50 million tonnes of coal per year in 2030. This would compromise energy independence, creating national security risks. We argue further that a fivefold expansion of coal power generation capacity is incompatible with the humanity's goal of stabilizing climate change below 2°C of global warming. In conclusion, we propose engineering and public policy recommendations towards the green growth strategy of Vietnam, which would better integrate the country in the world's energy transition towards a low carbon society.

Executive summary

Vietnam's electricity demand is expected to increase two or three times over the next two decades. This challenges the country's engineers, entrepreneurs and policy-makers to build a sustainable energy supply. The recently revised Power Development Plan VII of Vietnam suggests to expand the coal-fired power capacity from 10 GW today to 55 GW by 2030. This report summarizes the high socio-economic and environmental costs associated with that:

- Air and water quality would deteriorate to unacceptable levels. Monitoring by MONRE shows that at 100% of coal mining and processing facilities, the concentration of dust in the air is above the Vietnamese standard from 30 to 300 times. Study in Mao Khe coal power plant shows concentrations of heavy metals and toxic in Gao Stream exceed Vietnamese standards. More than 75% of people around the Duyen Hai Coal Power Center declared they had to change their daily activities due to low air quality condition such as closing windows and sweeping the house more often.

- Soils quality would be impacted: The quantity of solid waste consistent with the original PDP VII is 30 million ton of coal ash. To dispose of this, Vietnam would need to allocate 28 000 ha. This is a dumpsite 39% of the area of Singapore.

- The livelihoods of many will be degraded: Coal plant projects cause resettlement issues. We found that the job opportunity for local workers and training programs included in the project planning documentation were not always carried trough as promised. Polluting emissions can negatively affect the agricultural activities and food production industries, for example by blackening reduced the quality and value of salt produced near the Duyen Hai power plant.

- The health effects would be comparable to traffic fatalities today: Currently, coal pollution in Vietnam causes 4300 premature deaths per year. This number could reach 21 100 cases in 2030 if coal use grows as planned. This compares to the number of traffic fatalities in Vietnam, about 22 000 in 2013 according to World Health Organization (WHO).

- Greenhouse gas emissions of Vietnam would rise above sustainable levels: Humanity should not emit more than 1 000 Gt of CO_2 over the next centuries to avoid 2°C of global warming. Existing coal power plants are already committed to use 30% of that number. "*The battle against climate change will be decided in Asia*" means that if Indonesia, China, India and Vietnam proceed to open new coal power plants according to their plans, then there is no hope to avoid dangerous global warming.

- Fossil fuel imports would burden on trade balance: Vietnam has started importing coal. We estimate that the PDP VII revised implies importing 56 Mt to 123 Mt of coal in 2030, at a cost in the range of 2.8 – 4.9 billion USD per year, which is about the

same order of magnitude of the current trade balance. Moreover, there may be barriers to trade against countries relying on CO_2 intensive sources to power their industry.

- National energy security would be jeopardized. Energy security is a vital interest. Importing more than half fuels used in the power sector would create dependence from abroad sources. Rich countries, if not the whole international community, are setting up a ban on new coal power plants.

Coal-based electricity should not be developed as in current plans, which would certainly cause these serious negative impacts to the society. Reliance on coal, especially imported, should be reduced. VSEA suggests that in the decades to come, energy efficiency and renewable energy sources should be given more attention than expanding coal, in terms of technology development and economic incentives. We propose that the cost of electricity produced from coal should be increased to include external cost of polluted electricity.

Any coal-fired power plants should be built compatible with the green society that Vietnam is developing towards. Project owners should apply the best available advanced generation technologies to produce at high efficiency and reduce emissions and wastes. Rather than designed for base-load, coal plants should be flexible to operate, to integrate well in a grid with intermittent energy sources. Any new coal plant should be ready to co-fire a high fraction of biomass mixed with coal, as it is already done in other countries. The plant should be ready to be retrofit with carbon capture and storage.

Environmental standards should be defined and enforced better. The local authorities should strengthen the monitoring of waste slag yard and processing in coal-fired power plants before releasing into the environment. Local agencies such as the Department of Natural Resources and Environment of the provinces should enhance the monitoring of waste water quality and perform extraordinary as well as periodic inspections to ensure strict compliance with national standards.

Local authorities should involve other local stake-holders -social organizations and local people--in the monitoring processes of coal-fired power plants to ensure compliance. For example, they can create a follow-up dialogue committee, open a public hotline or release an app to report transparently any environmental damages caused by the power plants.

Social organizations should coordinate with the national authorities to strengthen awareness of people as well as local authorities on the impacts of coal-based activities. They can promote renewable energy and energy efficiency through independent research programs, communication campaigns, and awareness and capacity building activities for the local communities. They should be involved in monitoring of the application of the environmental standards in coal mining and coal-fired power plants, along with the local authorities and the local people. They should coordinate with research institutes to carry out studies of cumulative impacts of coal-fired power plants.

1. Introduction

In 1993, less than half of Vietnamese households had access to electricity. By the end of 2015, more than 98% did. This great expansion of the electricity sector has provided immense benefits to the economy and society. However, these benefits came with commensurate economic, environmental and social costs.

At first, the electrification of Vietnam relied on hydro power. That resource being limited, further capacity expansion was achieved by adding new fossil fuels burning power plants: natural gas, then coal. In 2000, three coal plants were used. That number reached eleven in 2010, and according to Global Coal Tracker (2016, database query 2016-05-10) twenty one more generating units have been opened since. Coal is on track to become the first primary energy source for electricity in Vietnam.

Many historical cases all over the world show that the unchecked development of coal leads to very harmful air pollution levels. For example, the city of Pittsburgh, Pennsylvania, was widely known as “Smoky city” or more poetically “Hell with the lid off” in the 19th and early 20th century because of coal pollution (Conway 2012). More recently, environmental protection reasons have contributed to the shutdown of several[1] coal power plants near Beijing, China. This and other reasons related to climate change, national energy security and global technological trends explain why it is more and more widely recognized that using coal is not sustainable.

Since 2013, Vietnam Sustainable Energy Alliance under GreenID’s facilitation started to monitor the development of coal power in Vietnam and to investigate its full social cost. The Alliance’s independent reporting and public awareness raising aim to avoid in Vietnam the adverse consequences of coal power illustrated above. To this end, from 2013 to 2016, the Alliance members conducted eight local studies which showcase the impacts of coal mining and coal-based electricity generation on the Vietnamese society and environment. This report offers a synthetic overview of the main findings from these studies, which are currently being published individually by VSEA members.

The studies include six coal-fired power plants, one coal waste dump site and one ash pond embankment. They look at different stages of coal electricity generation’s life-cycle: coal mining, power plant in planning, construction, and operation, and coal waste processing. In addition to exposing the consequences of daily operation activities of the power plants, the investigations extend to the impacts of the industrial accidents. For example, the July 2015 floods and landslides in northern Vietnam inundated major open-pit coal mines and killed at least 17 people in the Quang Ninh province (Viet Nam News 2015). While coal compares favourably to nuclear when it comes to the potential for catastrophe, a rigorous assessment

[1]Plants owned by China Huaneng Group Corp., Guohua Electric Power Corp., Beijing Energy Investment Holding Co. and China Datang Corp.

of impacts has to consider both high and low frequency events (Ha-Duong and Journé, 2014; Ha-Duong and Loisel, 2011).

Table 1 presents more details on these eight original case studies. All three regions of Vietnam: the North, the Centre and the South were looked at. Half of the case studies lie in the Quang Ninh province, where about 90% of Vietnam's coal reserves are found (VINACOMIN 2013). This province embodies the problems with coal. On one hand, the main road to the Ha Long city is flanked by coal plants with criss-crossing conveyor belts, red-and-white smoke stacks, and heaps of jet-black coal. On the other hand, this is the Ha Long Bay, a UNESCO World Heritage site renowned for its environment, and the South-East Asia Sea.

The research teams have applied a number of survey methods, which depend on type of case studies and nature of impacts, to obtain necessary information and data. The methods vary from desk research, face-to-face interviews, and questionnaires to taking air and water samples from the examined sites that suffer externalities from coal-related activities and incidents. The interviews and questionnaires have been carried out with various stakeholders, such as local people, local authorities, experts, and investors/owners of the power plants. Contents of the surveys are designed specifically for each type of stakeholders, depending on their involvements, their awareness, and their knowledge to the impacts identified. In these studies, a strong attention has been addressed to local people who are the most affected stakeholder from the coal-related industries.

This summary report is organized in two parts: The first part frames the question of coal in the Vietnamese and the global contexts. It describes the state and trends of the electricity market, the larger scale impacts of coal on the environment and society, and the technological implications of the energy transition. Such constraints are critical to inform coal policy in the 21st century. The second part of this report looks in details at the local impacts of coal-fired power generation, based on studies listed in Table 1. It is organized by environmental target, addressing successively the impacts on air, water, soil, livelihood and health. The final section concludes by summarizing the key findings on the social and environmental impacts of coal power development in Vietnam and proposes recommendations to relevant stakeholders: policy-makers, social organizations, and local people.

Table 1. Summary of the 8 case-studies selected in the report

No.	Case-study	Capacity	Status	Location	Impacts	Causes
1	Dong Cao Son coal waste dump site (from three open-pit mines: Cao Sơn, Cọc Sáu and Đèo Nai)	295 million m^3	In operation Overload	Mong Duong ward (Cam Pha city, Quang Ninh province)	Soil and water environment	Incidents during flood rains lasting from 25/7 to 5/8 2015 in Quang Ninh
2	Ash pond of Quang Ninh coal fired power plant			Ha Khanh ward (Ha Long city, Quang Ninh)	Soil and water environment	Incidents at the embankment during the flood rains 2015
3	Hai phong coal fired power plant I & II	4 x 300 MW	In operation	Tam Hung commune, Thuy Nguyen district, Hai Phong	Quality of Surface and groundwater sources	Daily electricity generation activities
4	Quang Ninh coal-fired power plant	4 x 300 MW	In operation	Ha Khanh ward (Ha Long city, Quang Ninh)	Water quality Groundwater in the residential area nearby, Dien Vong river, Sea water along coasts of Cua Luc and Ha Long Bays	Daily electricity generation activities
5	Mao Khe coal-fired power plant	2 x 220 MW	In operation	Trang An and Xuân Son villages, Đong Trieu, Quang Ninh	Water pollutants in Gao stream, general impacts to the communities nearby	Daily electricity generation activities
6	Thai Binh Coal-fired power plant I & II	2 x 300 2 x 600 MW	In construction	My Loc Ward, Thai Thuy District, Thai Binh	Land use, resettlement, potential socio-economic and environmental impacts	Plant construction, electricity generation activities
7	Vung Ang Coal-fired power plant I	2 x 600 MW	In operation	Ky Loi Ward, Ky Anh District, Ha Tinh		
	Vung Ang Coal-fired power plant II	2 x 660MW	In planning			
8	Duyen Hai Coal-fired power plant I, II, III, & III extension	7 x 600 MW	1 unit in testing period	Dan Thanh Ward, Duyen Hai District, Tra Vinh		

2. National and global context

This chapter frames the question of coal in Vietnam in three contexts. First, we discuss the position of coal in the electricity generation sector of Vietnam. This sector is rapidly expanding by installing new generation capacities. It is also undergoing deep institutional changes, such as the unbundling of the historical public operator EVN. The goal is to introduce more market mechanisms to attract private investments. In this context, the future importance of coal is more uncertain than what the official power development plans show. Plans can be revised. As this chapter will show, the place of coal has been played down in the latest power development plan revision. High-level policy signals suggest that further revisions shall follow in this direction.

The second context is environmental: burning coal has global and national impacts. Before this report turns to summarizing the eight local case studies (chapter 3), considering socio-economic development, technical and natural constraints, climate policy and other geostrategic constraints is critical to inform coal policy in the 21st century.

The third context is a global historical trend: the world is undergoing an energy transition to a low carbon society. In this context, the development of coal is challenged by a rapidly expanding financial and technological trend moving away from fossil fuels and towards renewable energy sources. Massive investments in renewable energy are pushing the costs of solar and wind down the learning curve, eroding the economic competitiveness of coal.

2.1. Coal in the power sector of Vietnam

Status and trend of electricity consumption

Following the 1986 reform from a centrally planned to a market economy, and the end of the embargo in 1994, Vietnam industrialized and urbanized, and achieved the middle income country status in 2008. Economic growth rates have been in the 5% to 8% per year during the last two decades. Domestic energy and electrical power consumption have been growing even faster, to achieve the spectacular result that electricity is now available to almost all households, up from less than half in 1993. "*By the end of 2014, 100% of the districts were connected to electricity; 99.59% of the communes with 98.22% of rural households were electrified*." (EVN 2015). This great expansion of the access to electricity has provided immense benefits to the economy and society in Vietnam.

The results of development and access to lower middle income country status can be seen in the electricity use statistics, which show that nowadays there is enough electricity for more than basic needs in Vietnam. Average power consumption per capita is over 1 400 kWh (EVN 2015). This is equivalent to using 160 W of power, 8 765 hours per year. In the residential sector, the average Vietnamese person uses the equivalent to 56 W of power on year-round average.

Power consumption by sector was as follows: industrial (53.9%), residential (35.6%), commercial (4.8%), agriculture (1.5%), and other sectors (4.3%) (ADB 2015). The industrial sector is the largest consumer of electricity and also the most important sector economically. It accounts for 41% of GDP, 29% of the workforce, and 87% of export revenues by 2015. In addition to directly benefiting consumers, national electrification has contributed to economic development by allowing and attracting international industries.

Electricity prices in Vietnam are not determined by the market but fixed by the government at reasonable and affordable levels. Conflicting goals influence these tariffs. On the one hand, energy prices can be used to control inflation, when needed – as in 2008 and 2011, when consumer prices did increase by around 20%. Access to clean energy at affordable prices also contributes to other social objectives like poverty and hunger eradication, education or gender equality. On the other hand, the historical operator Vietnam Electricity is in debt. Production costs are structurally increasing with the higher share of fossil fuels and lower share of hydro. Further capacity expansion requires investment, and in order to mobilize private capital for new power plants, the profitability of investments has to be attractive, regardless of the primary energy sources for the plant: coal, biomass, solar and wind-based electricity generation operators all look forward to higher sales prices.

The tariff in 2015 was 1.622VND per kWh, about 7.4 UScents per kWh. This is for the first un-subsidized 100kWh block of electricity. The tariff is progressive: consumers drawing more than 100kWh per month pay a higher price for each block. Consumers drawing less than 50 kWh per month are subsidized. According to our analysis of Vietnam Household Living Standards Survey data, in 2014 the median price paid by Vietnamese households was 1 500 VND, and the median monthly consumption 100 kWh.

Wholesale cost of electricity is lower than the retail price. In 2015, the prices of electricity for production are from 869 VND per kWh to 983 VND per kWh at normal times and 2459 VND per kWh to 2 735 VND per kWh during peak time. This relatively lower cost of energy for business and industry has been detrimental to energy efficiency, which is low in Vietnam. Industries in Vietnam use a higher amount of energy to produce wealth than industries elsewhere, even compared to other countries in the region with a similar development level.

Compared to the price of electricity in other ASEAN countries, the tariff for households in Vietnam is in the same ballpark as the tariff in Lao PDR and Thailand. Tariffs in Singapore, Cambodia, Philippines, Malaysia and Indonesia are higher than in Vietnam. Tariffs in Brunei Darussalam (a natural gas rich country) and in Myanmar (a poorer economy) are lower.

Electricity tariffs have been regularly increasing in nominal terms. It was 550 VND per kWh (retail) in 2003-2004. Most recently, it went up 7.5% in March 2015 to 1 533 VND per kWh. Recently the inflation rate in Vietnam has been going down to 0.6% in 2015, and before that over 7% per year was common. According to our calculations, if the price of electricity had increased as fast as inflation it would be 1 793 VND per kWh. In real terms, the electricity tariff has been going down since 2003.

Status and trend in power production

Starting from a production level of 14.3 TWh in 1995, the power sector of Vietnam has expanded at a rapid two-digit growth rate since. This continues today. According to EVN (2015) "*In 2014, Total power system production and purchase in 2014 were recorded at 142.25 TWh, an increase of 10.76% compared with 2013; power sales reached 128.43 TWh which was 11.41% higher than 2013.*"

Qualitatively, this growth has been marked by two changes in how the electricity is produced. Initially, hydro power dominated: in 1995, hydro produced 10.4 TWh out of these 14.3 TWh. The first change was an expansion of electricity production from natural gas. Its share in the primary energy mix increased from practically nothing in 1995 to 44% in 2010. In 2010, hydro produced 27.5 TWh on a total of 100.0 TWh, and natural gas 44.2 TWh. The second change was an expansion of electricity production from coal. In 2000, three coal plants were used. That number reached eleven in 2010, and according to Global Coal Tracker (2016) twenty one more generating units have been opened since.

Coal is on track to become the first primary energy source for electricity in Vietnam. (EVN 2015) states that regarding the power generation capacity added in 2014, coal was 1 544 MW while hydro was 156 MW. Regarding the plants under construction and scheduled to start operating between 2015 and 2018, according to the same EVN report coal represents 6 688 MW while hydro represents 2 311 MW. In total, sixteen new coal units (a single coal power plant can contain several units) or 8.2 GW installed capacity will be opened in the five years period centred around 2016. In summary, EVN is opening one 514 GW unit every trimester.

EVN was historically a national electricity monopoly, but the situation as changed in recent year. The electricity production activities of EVN have been unbundled into three generation companies who still provide a lion's share of the national electricity production. As Figure 1 shows, the unbundling is only started, since in addition to holding a majority of the generation market, EVN still directly controls transmission and distribution. Figure 2 shows that the next two big players are also national energy companies, PetroVina's PV-Power and Vinacomin-Power Holding Corporation Limited.

Table 2 summarizes the pipeline of coal power plants in Vietnam, for all owners. The complete list is attached to this report as electronic Annex 1. Even if the liberalization of the electricity market far from complete at this stage, in 2016, Vietnam succeeded in attracting investors from all Asia. To name a few of these independent power producers: Tata, Keangnam, Daewoo, Sumitomo, EGAT all have coal power plant projects in Vietnam (see the full list in Annex 1). In summary: there are enough projects to increase the generation capacity, and the corresponding pollution, by 680%.

Power development plan

On 18th March 2016, the Government of Vietnam published the revised 7th Vietnam Power Development Plan in the period 2016 - 2020 with an outlook up to 2030 (The Government of Vietnam 2016). This official decision aims to ensure the national energy security and meet the socio-economic development objectives of the country with an average GDP growth of about 7.0% during the period. This rate is 1.5% lower than in the original 7th Power Development Plan (PDP VII) issued in 2011 (The Government of Vietnam 2011).

Table 2. Coal power plants in Vietnam by project development stage. Source: Global Coal Tracker (consulted 2016-06-23)

Status	Number	Total capacity (MW)	Total annual CO (Mt/yr)
Operating	22	8 448	39
Construction	25	12 140	53.9
Permitted	27	14 820	65.1
Pre-permit development	14	10 400	65.1
Announced	16	11 620	50.8
Total	105	57 428	252.8

The lower projections of economic growth and energy use in Vietnam reduce the demand for total electricity generation by about 20% and 18% by 2020 and 2030, respectively. As a consequence, the total power installed capacity of Vietnam in the adjustment would reach only 265 GW by 2020 and 572 GW by 2030 as compared to 330 GW and 695 GW in the original PDP VII. Table 3 presents the main changes in the electricity power mix of Vietnam in the updated version of the PDP VII, referred to as PDP VII revised.

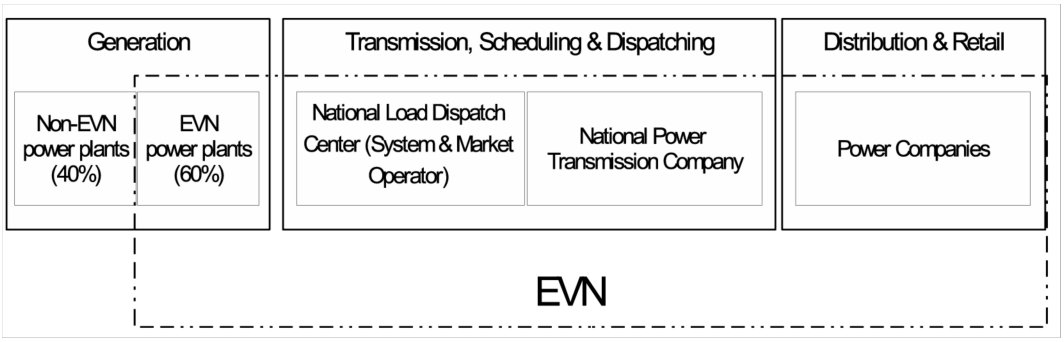

Figure 1: The partial unbundling of EVN. Electricity generation, transmission and distribution in Vietnam in 2013 (MOIT, 2015)

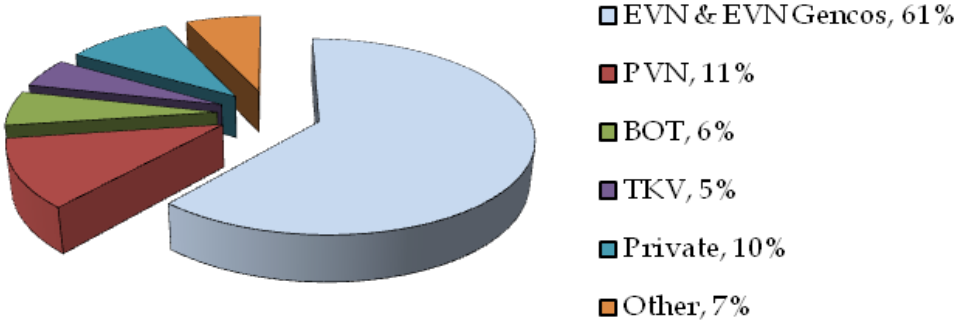

Figure 2. Power generation capacity share in the electricity market by ownership in 2014(MOIT 2010)

EVN Genco: EVN's subsidiaries; PVN: PetroVietnam; TKV: Vinacomin

This adjustment represents a significant political step towards a sustainable energy sector in

Table 3. Power capacity and electricity generation by 2020 and 2030 in the 7th Power Development Plan (PDP VII, 2011) and the adjustment (PDP VII revised, 2016)

		2020		**2030**	
		PDP VII	**PDP VII revised**	**PDP VII**	**PDP VII revised**
Total generation	TWh	330	265	695	572
Total capacity	GW	75	60	146.8	129.5
Hydro (- small hydro)	GW	19	18	23	22
Coal	GW	36	26	76	55
Natural gas	GW	12	9	17	19
Renewables	GW	4	6	14	27
Nuclear	GW	1	-	10	4.6
Import	GW	2.3	1.4	7.2	1.6

Yet in the revised plan, fossil fuel-based technologies still heavily dominate the electricity generation. The 27 GW capacity of renewable energy may appear to be half of the coal capacity. But wind and solar farms have a lower capacity factor than coal plants: about 35% versus 70%, since the sun and wind are intermittent sources. So their share in the final production will be two times lower compared to coal.

The plan to increase the coal-based generation capacity from 26GW in 2020 to 55 GW in 2030 would require the addition of 2.4 GW per year. This installation rate amounts to four units of 600 MW per year. The revised power development plan does not suggest to any slowdown in opening new coal power plants. Since the capacity in 2030 matches well the current projects summarized in Table 3, it can be considered that the PDP VII revised approves the status quo.

In summary, the most notable points in the PDP VII revised are: (1) Vietnam still plans a massive expansion of coal; (2) the revision leans towards more renewable and less fossil fuels or nuclear; (3) excluding hydro power, solar power is expected to be the most important renewable resource for electricity generation in Vietnam with its total capacity by 2030 is about 12GW; and (4) nuclear is delayed.

There are signs that the expansion of coal is losing momentum. Prime Minister Nguyen Tan Dung announced in January 2016 his government's intention to "review development plans of all new coal plants and halt any new coal power development." More specifically, mid-January 2016, he signalled a reduced role for new coal fired power stations in the country's forthcoming power plans and an expanded role for renewable energy by stating [in Vietnamese]:

> *"There is a need to closely monitor environmental issues, especially in stringent monitoring of coal-fired power plants; to review development plan of all coal-fired power plants and halt any new coal power development; to begin replacing coal with natural gas; to responsibly implement all international commitments in cutting down GHG emissions; to accelerate investment in renewable energy, including building market mechanisms, encouraging policies and initiatives, and attract investment for solar and wind energy…"*

It is not yet clear how and at which speed these policy goals may be implemented. There is a potential to move to a cleaner electricity generation system, but it would require curbing the current trends identified above. For alternative scenarios discussing a lower carbon future for the power sector in Vietnam, refer to (Trinh and Ha-Duong 2016; Hoa Nguyen Thai et al. 2012; Cecilia Tam et al. 2016; WWF-Vietnam and VSEA 2016).

2.2. Global and national impacts of burning coal

Global impact: coal causes climate change

Climate change is one of the greatest environmental issues worldwide. According to Vietnam's Intended Nationally Determined Commitment (MONRE 2016):

> *Viet Nam is one of the countries severely affected by climate change and its related disasters. The Mekong Delta is one of the deltas in the world most susceptible and vulnerable to sea level rise. Climate change adaptation is vital for Viet Nam and is regarded by the Government as one of the priority tasks to reduce the vulnerability level.*
>
> *Over the past 50 years, the average temperature in Viet Nam has increased by approximately 0.5°C and the sea level has risen by about 20 cm. Extreme climate events have increased both in frequency and intensity. Climate change has made hazards, especially storms, floods and droughts, more intense.*
>
> *According to Viet Nam's climate change scenario (2012), by 2100 the annual average temperature in Viet Nam is expected to increase by 2°C to 3°C, precipitation will increase in the rainy season and decrease in the dry season and the sea level will rise between 78 cm and 100 cm.*

Burning fossil fuels emit greenhouse gases (GHGs), primarily carbon dioxide (CO_2) which is the leading cause of climate change (Zimmer, Jakob, and Steckel 2015). Cumulative CO_2 emissions from fossil fuel combustion, cement production and flaring since the industrial revolution were 420 $GtCO_2$ in 1970. That total had tripled to 1 300 $GtCO_2$ in 2010. This number should not double again if humanity wants a good chance to keep the global warming below 2°C over the next centuries. More precisely, IPCC (2013) found that the carbon budget that we can afford to emit in the future is around 1 000 $GtCO_2$.

Coal-fired power plants are the largest contributors to the atmospheric CO_2 concentrations. Existing coal and other fossil fuel-fired power plants account for about 26% of global greenhouse gas emissions. Worldwide, coal-burning released 14.4 billion tonnes of CO_2 in 2011. Over their lifetime, existing power plants operating today are committed to emit 300 billion tonnes of CO_2, which is 30% of the carbon budget. Replacing these plants by identical ones at the end of their lifetime would blow up the humanity's carbon budget. Greenhouse gases emissions from fossil fuels have to be zero by 2070 to achieve the stabilization goal.

It is said that "T*he battle against climate change will be decided in Asia*" because between them Vietnam, China, India, and Indonesia, these four countries account for 75% of new coal-based power plants expected to be built worldwide in the next five years. "*If Vietnam goes forward with 40 GW of coal, if the entire region implements the coal-based plans right now, I think we are finished*," the president of the World Bank said in the first week of May 2016. "*That would spell disaster for us and our planet and it would make it highly unlikely that we would be able to get to 2°C*" (The Guardian 2016).

In Vietnam the energy system is responsible for the largest share of total greenhouse gas (GHG) emissions (Finenko and Thomson 2014; N. T. Nguyen and Ha-Duong 2009; Pham, Kurisu, and Hanaki 2011; Zimmer, Jakob, and Steckel 2015). The increase in national GHG emissions is largely attributed to an increase in fossil fuel use and most notably coal consumption in the country. According to Ministry of Industry and Trade (MOIT), CO_2 emissions from coal-fired power plants in Vietnam increased from 28 Mt by 2011, to 40 Mt by 2013, and then 73 Mt by 2015. The figures even would much higher if all coal-related CO_2 emissions are taken into account.

In Intended Nationally Determined Commitment (MONRE 2016), Vietnam has committed to cut unconditionally its GHGs emission down by 8% over next 15 years against its business-as-usual scenario. The revised Power Development Plan VII for the period 2015 – 2030 realizes the commitment, on the paper.

But the PDP VII revised does not particularly slow the increase of the GHGs emissions in the country in next two decades, in absolute terms. Reductions below a business-as-usual baseline may be a politically convenient concept, but they are not verifiable numbers since they are based on a non-factual plan. Moreover, in this case the mitigation of emissions appears to be a side benefit, because experts agree that the original PDP VII overestimated the demand (Nguyen-Trinh and Ha-Duong 2016). Given that EVN reported 142 TWh generated in 2014 with a reserve margin of 14%, a planning for 330 TWh in 2020 means more than doubling in 6 years. This is economically unrealistic. Thus the reduction is justified enough by the necessity to avoid over-capacity and stranded assets, a.k.a. "hot air".

National impacts: coal macroeconomic and geostrategic risks

Energy policies often have broad impacts on the macroeconomic and geostrategic position of countries, because they influence the national trade balance, the security of the production system, and the diplomatic posture.

Historically, Vietnam has been self-sufficient in coal. This has changed. In 2016, Vinacomin will start to import around 2 million tonnes of coal. This quantity is expected to gradually increase in the future and could reach between 18 million and 20 million tonnes by 2020 (Le Minh Chuan 2013). Assuming coal prices at 50$/t, that amounts to 1 billion dollars per year in 2020. This is a lot of wealth, even for a large middle income country. Since 1990 the annual trade balance of Vietnam has run between -16 billion USD (2008) and +2 billion USD (2012). Coal import could become a significant burden on national accounts. Box 1 offers another illustration on how fossil fuel dependency can turn a national trade balance in the red.

In 2030, the PDP VII revised proposes that coal ensures 53.2% of the 572 TWh generated, that is over 300 TWh. Assuming an emission factor of 7 10^{-4}tCO_2/kg, this amounts to about 0.2 Gt of CO_2 per year. With a plant efficiency in the 0.34 to 0.38 range (Institute of Energy-MOIT 2014), there would be a need for 3.2 10^{18} J to 2.9 10^{18}J. The domestic coal production has been peaking at 40 Mt per year, but the Coal Master plan forecast 75 Mt in 2030. If we assume that domestic coal is high grade anthracite containing 25 MJ/kg while imported coal is low grade at 18 MJ/kg, the quantity of coal needed to satisfy the plan is between 56 Mt to 123 Mt in 2030. Assuming the cost of imported coal will be between 40 to 50 USD/t, this amount to 2.8 – 4.9 billion USD/yr.

Box 1: How fossil fuel dependency impacts the trade balance and security, two examples in Japan

Through the 1930s, Japan's oil consumption was dependent at 90% on imports, 80% of it coming from the United States. America opposed Tokyo's expansionist policies in China, the East Indies and the Pacific Islands. On July 26, 1940 the U.S. government passed the Export Control Act, cutting oil exports to Japan. By 1940, the American share of export of oil on the Japanese market dropped to 60%. A full embargo was imposed on Japan in July 1941. All oil shipments were held back. Since only 4.5 million barrels of oil were coming in from the Dutch East Indies, Japan's reaction was to organize an attack of the United States on the Pacific front. The attacks on Pearl Harbor were strongly influenced by the energy insecurity which the embargo created.

The more recent history of Japan also illustrates the impact of importing fossil fuels on the national trade balance. Between 1980 and 2010 Japan had been recording trade surpluses every year due to rising exports. But since the tsunami and the Fukushima nuclear disaster in March 2011, the trade balance swing to deficit due to the weakening of the Japanese yen, disrupted export production and mostly increased purchases of fossil fuels and gas.

Depending on imports for a vital need like energy, produces a security vulnerability. For energy, its magnitude should not be underestimated on the grounds that Vietnam has been self-sufficient in coal and oil in the recent past. As shown in the previous paragraph, imports are starting. This is not only because the reserves are depleting, but also because the demand is increasing. The PDP VII revised proposes that the number of coal power plants could grow from about twenty now to about sixty four in 2030. Most of these new coal power plants would have to run on imported coal. Then an essential part of the national generation

capacity would depend on abroad. A high level of dependence is associated with a high energy security risk, because of the possible international interference. Regionally, coal providers are Indonesia, Australia and China. Vietnam would import its energy through a contested sea. Box 1 shows that armed conflicts can arise over fossil fuels trade disputes.

Countries relying on coal to power their economy have to face another economic security risk: Trade sanctions. International trade agreements have clauses against environmental dumping. They allow barriers against products coming from countries that do not follow environmental protection standards agreed upon by other countries. For example, countries which have a carbon tax can set tariffs based on the carbon content of imported goods. This option is already seriously discussed in Europe, where some energy-intensive industries feel they suffer from a competitive handicap compared to other parts of the world.

Pursuing a coal-intensive power development plant engages the diplomatic posture of a country in international arenas. At the COP21 in Paris, countries agreed on a system where they watch each other's acts. Politics can and will tie the seriousness of domestic mitigation policies with any other international issue. For example, even if it is not written, it is morally hard to imagine that a coal developing country will be given the most favourable access to climate change adaptation funds.

The question of coal has received a clear answer in the international climate change mitigation debate: rich countries are now actively trying to dry up the sources of capital to build coal plants. At the Paris Conference on Climate COP21 in 2015, many rich countries made it clear that they were moving to a policy against building any new coal power plants. For example, in September 2015 French President F. Hollande declared that France would no longer provide financial support for coal-fired power plants overseas unless they are equipped with technology to capture and store the carbon dioxide emissions. His announcement follows in the steps of President B. Obama, who announced in 2013 a ban on support for coal plants overseas except in very limited circumstances, and provides a model for other rich countries who are dragging their heels on adopting similar bans. The financing plan for the new coal power plants must therefore consider sources which are not participating in this ban. For example, to the best of our knowledge, the China-led multilateral Asia Infrastructure Investment Bank (AIIB) has recently financed coal projects.

In summary, avoiding an increasing dependence on coal makes also sense for Vietnam for macroeconomic and geopolitical reasons.

2.3. Technology context: the energy transition

The global finance industry is divesting out of coal. Globally, investment flows in renewable energy have become larger than investments in fossil fuels. According to REN21 (2016) global new investment in renewable power and fuels rose by 5% in 2015, and "*at USD 265.8 billion was more than double the USD 130 billion allocated to new coal- and natural gas-fired power generation capacity.*"

The rest of the world has turned away from fossil fuels and is now investing much more in renewable energy options such as wind, solar PV and geothermal energy. Learning by doing and technological progress has driven down their costs to the point where renewable energy is cost-competitive with coal in many places. According to REN21 (2016):

"The power sector experienced its largest annual increase in capacity ever, with significant growth in all regions. Wind and solar PV had record additions for the second consecutive year, accounting for about 77% of new installations, and hydro power represented most of the remainder. The world now adds more renewable power capacity annually than it adds (net) capacity from all fossil fuels combined. By the end of 2015, renewable capacity in place was enough to supply an estimated 23.7% of global electricity, with hydropower providing about 16.6%."

The context is not simply a development of renewable energy, but a system-wide switch to low carbon society. In energy planning, this switch starts by improving efficiency. Energy efficiency is always more urgent than adding generation capacities. The energy efficiency of Vietnam's economy is currently very low by international standards, so it surely can be improved a lot. Then more realistic and reliable demand forecasts are a necessary prerequisite to more efficient power development planning. The risk of building system overcapacity, exemplified by the high levels of curtailment enforced in China in 2015, should be considered.

Another policy actively pursued by many countries as a low-cost option to improve the electric system is to integrate the grid. Connecting to trade power with neighbouring countries can be done on a bilateral basis. There is no need to complete the liberalization of the interior market first.

Because the energy transition is unavoidable, new power plant build today will operate in a low-carbon electricity system. This should have implications of the design of coal plants:

1. Traditionally, coal has been used as base load power. Today electricity from sun and wind is dispatched first. Its marginal production cost is zero, but they are intermittent. In very windy times, electricity prices can even go negative, as coal plant operators are paying to keep their turbines running. To avoid these money loosing situations, new coal plants should be flexible, have a low minimum stable level, and a high ramp-up/ramp-down rate.

2. Carbon Capture and Storage (CCS) is a technology which consists of capturing the CO_2 and other pollutants in the exhaust of the fossil fuel burning power plant, and disposing it underground. Today the technology is expensive. However, new plants being build today should be CCS-ready. It should be designed so that retrofitting CCS is technically feasible, when it makes economic sense.

3. In order to mitigate CO_2 emissions, several countries like South Korea, Belgium or United Kingdom have taken to mix some biomass with the coal. This is not the case in Vietnam, even if the country started to exports biomass pellets for co-firing. Here again, engineering choices at the conception influence how much biomass a coal power plant can co-fire.

3. Local impacts

One of the most important reasons for justifying coal power plant development in Vietnam is that coal helps to quickly respond to the shooting demand in energy for national economic growth. Implementation and operation of coal power plant projects also offer socio-economic benefits to some extend at local and regional scale. Coal is a fuel for many sectors and industries such as thermal power plants, cements, bricks, limestone, etc., in which the electricity generation accounts for 40% of total domestic coal needs (Loi and S. H. 2008). In many cases, achieving electrification would not be possible without coal power plants.

The impact of coal on infrastructure development is important in developing nations like Vietnam due to the absence of pre-existing infrastructure. The roads and ports that are built to transport coal from the mine to the power plant can be utilised by a variety of industries.

Job creation is also another advantage that coal sector brings to the society. Vietnamese government statistics indicate that coal mining accounted for approximately 31% or 77 486 of the 249 321 people employed in the mining and quarrying sector (USGS 2009). Coal units, with big investments, can provide a significant boost to local economies, as well as domestic equipment suppliers. The power plant construction requires skilled workers and engineers, therefore creating job positions with high wages. In addition, the capital equipment, labour, chemicals and jobs from coal treatment facilities all contribute to the economic benefits of Vietnam. Furthermore, the Vietnamese government has received a significant amount of revenue from taxing coal-related activities. The coal sector contributed to the national budget with the total amount of 500 billion VND annually, i.e. about 31 million USD (Loi and S. H. 2008). Coal exports brought in the foreign currencies in Vietnam.

Coal was and is still one of important sectors contributing rapidly to the economic development of Vietnam. However it would be incomplete if we just only look at these benefits when consider choosing coal as a key solution for energy shortage in Vietnam. The true cost of coal extends far beyond economic costs. It includes the environmental and social costs that harder to see or to quantify. These costs arise from environmental (air, water and soil) degradation, human health damage, and many more adverse impacts due to coal-related activities and their dangerous by-products. Figure 3 summarizes impacts to environment (air, water and soil) for each step in the coal process. These negative impacts of coal on environment and on socio-economy will be discussed further in this chapter.

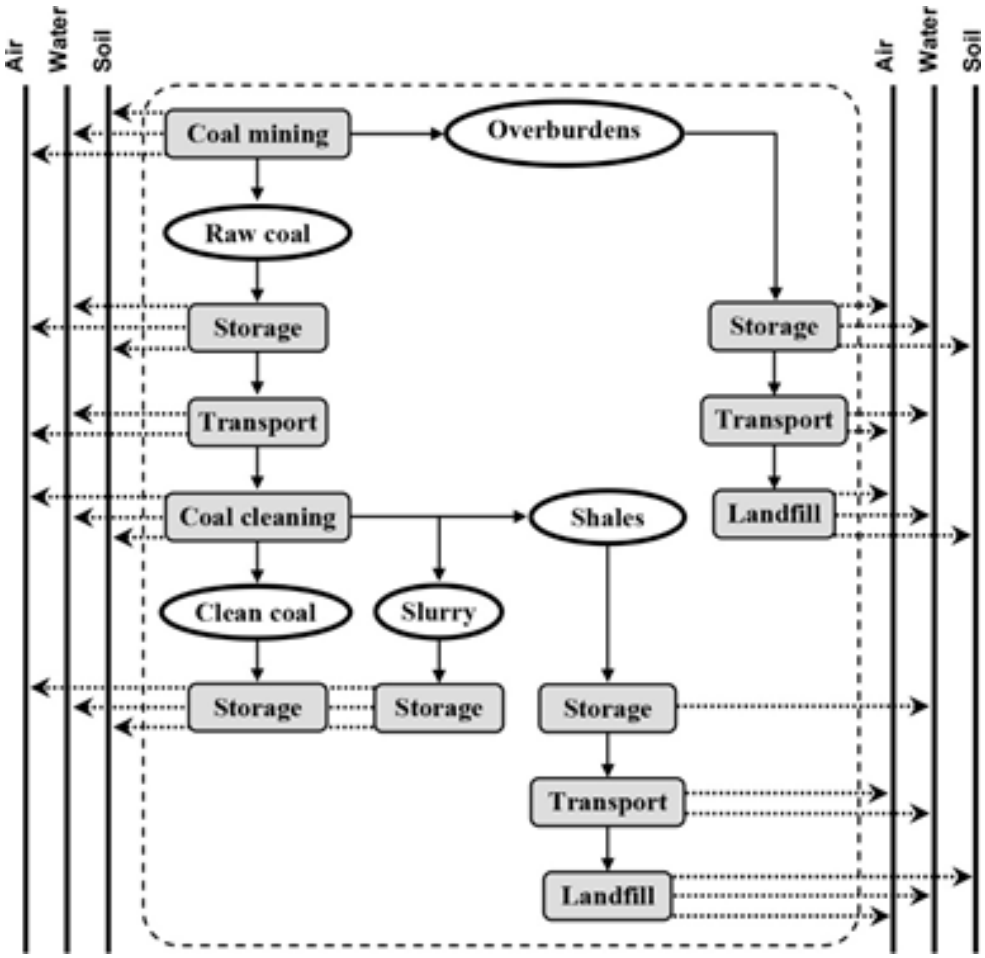

Figure 3. The process blocks and emissions in coal production (Loi and S. H. 2008)

3.1. Air quality

The main air pollutants produced from coal related activities are particulate matters, toxic gases (SO_2, NO_x, CO…) and greenhouse gases (CO_2, CH_4…). Electricity generation from coal is responsible for producing airborne pollutants throughout its life cycle from coal mining, processing, and transportation to coal burning and coal ash handling (see Figure 4).

Among the various pollutants, dust (including particulate matters) is the one causing the most important air problem in and around the coal mining areas and coal processing facilities. Despite that the business owner has applied several mitigation measures such as installing dust treatment system, covering trucks during transportation and improve the production lines, monitoring results from Ministry of Natural Resource and Environment (MONRE) showed that 100% of coal mining and processing facilities are having the concentration of dust in the air exceeded the Vietnamese standard (QCVN06:2009/BTNMT) from 30 to 300 times (see Table 4) (GreenID 2015). According to QCVN06:2009, the maximum allowed dust concentration is 0.15mg/m^3.

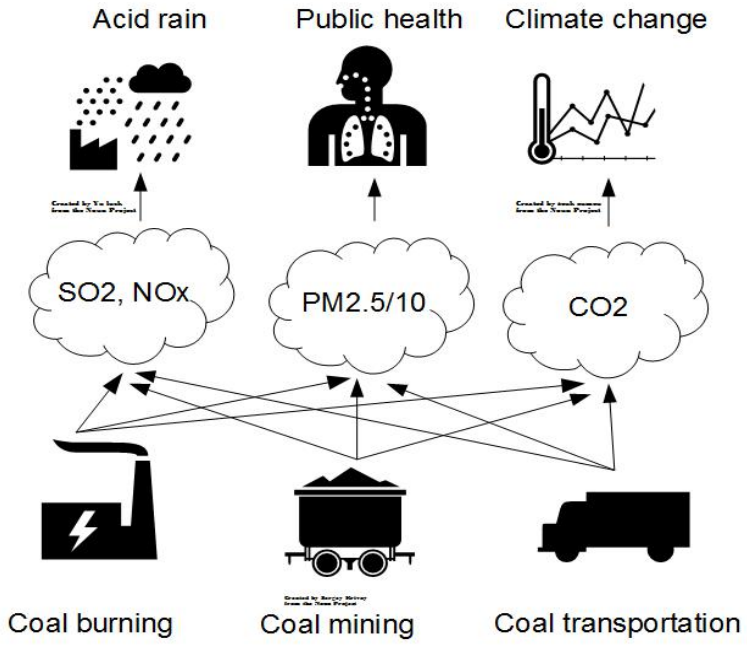

Figure 4. Impact of coal to air quality from its whole life cycle

Table 4. Dust concentration at some coal mining sites (Unit: mg/m^3) (MONRE)

	Mining & processing	**Transportation**	**Dumpsite**	**Residential area**
Ha Tu	2.0 - 8.8	10.2	1.2	0.57 - 0.73
Nui Beo	47.7 - 75.9	1.9	1.4	1.4
Cao Thang	16.3 - 38.4			
Tan Lap -Quang Ninh	20 - 30.1			
Hon Gai	2.6 - 5.3	1.4 - 1.8		0.1 - 0.9
Mao Khe	1.08 - 2			0.1
Hong Thai	37.6	15.2		1.3

Coal power plants affect air quality during both plant construction and operation phases. Transportation and other activities occur in construction stage produce a significant amount of dusts. In the survey conducted by GreenID in 2015, the team has interviewed people who lived around two coal power plant projects in construction (Duyen Hai and Thai Binh) about the air quality in the area. In Dan Thanh Commune, Tra Vinh Province (where Duyen Hai Coal Power Center is located), 100% surveyed people claimed that the air quality is lower

since the project started. They also stated that air pollution is caused by the construction and test run of the plant. 76.76% of interviewee said that they had to change their daily activities due to low air quality condition such as closing windows and sweeping the house more often. Higher concentration of dust in the air also affects physical and mental health of people, according to 77.27% of interviewee. For example, children get sick more frequent, adults avoid to go outside and to organize outdoor activities during daytime. 68.18% claimed that dust and smoke reduced the salt productivity and thus affect their livelihood. Moreover, 2 households have to relocate themselves because they could not adapt to poor air quality condition. In case of Thai Binh coal power plant 40.7% surveyed people stated that air is polluted by transportation of construction materials.

In plant operation phase, air pollutants are also emitted during coal combustion in boilers and during coal ash handling. The majority of coal-fired power plants in Vietnam are currently using sub-critical technologies with relatively low efficiency compared to supercritical and ultra-supercritical technologies. Low efficiency means higher pollutant emissions. In addition, these coal power plants are mostly located in big cities thus putting pressure to the local air quality. Total air pollutants emissions from coal power plants operation are estimated by Industrial Strategy and Policy Institute-Ministry of Industry and Trade in 2010 as shown in Figure 5 (MOIT 2010). Carbon dioxide (CO_2) is the main exhausted gas from the coal power plant's chimneys with total emissions of 72.7Mt per year by 2015. This number is 2.6 times higher than the carbon emission in 2011 reflecting the average annual increasing rate of 11% from 2011 to 2015. SO_2 and NO_2 emission also increase by 1.5 times during 5 years and reach 50 kt in 2015.

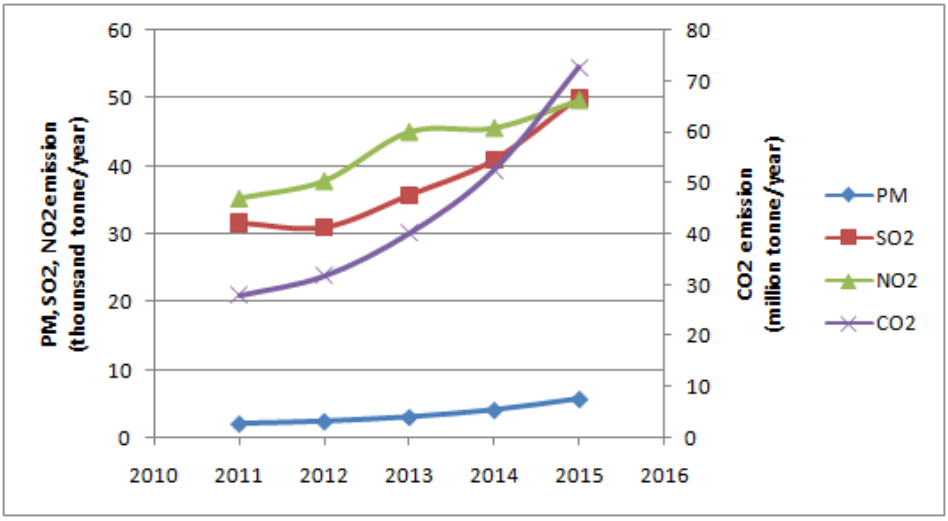

Figure 5. Estimated pollutants emissions from coal power plant (MOIT 2010)

The amount of sulphur oxides and nitrogen oxides released to the atmosphere from coal burning will increase the frequency of acid rains. Impact of acidification to soil and water quality will be discussed further in the following sections. According to the report conducted by Department of Natural Resource and Environment - University of Agriculture and Forest of Ho Chi Minh City in 2009 (Phan et al. 2009), eighty percent of atmospheric SO_2 is emitted from energy producing equipments, fifty percent is from burning activities of different industries and the rest is from other sources. One-third of national NO_2 emission is from

energy generation, another one-third is from fuel burning for energy generation. These numbers demonstrate that energy sector is the biggest SO_2 and NO_2 emitter in Vietnam.

While impact to health and acid rains are more local and regional impacts because particulate matters and sulphur and nitrogen oxides are dispersed in the area around the sources, greenhouse gas emissions have global scale impacts covering global warming and climate change. These impacts will be discussed in more details in later parts of this report.

Coal ash, the main solid waste derived from coal combustion process in coal power plants, is also a major contributor to air pollution. Coal power plants in Vietnam are producing huge amount of coal ash. It is estimated that all operating coal power plants in Vietnam release millions tonne of coal ash each year. Coal ash is affecting air quality by its transportation and storage. An example of poor coal ash management severely impact air quality is from Vinh Tan Coal Power Plant in Binh Thuan Province. Vinh Tan produces 4 000 tonne of coal ash per day. Coal ash is transported to the dump site by trucks and piled up without any coverage. Dust is carried by strong winds causing air pollution that significantly impact local people (see Figure 6).

Figure 6. Coal ash transportation (left) (Le Truong 2015) and air pollution in the project site (right) in Vinh Tan coal thermal power plant (Hoang Linh 2016)

Air pollutants, especially dusts, produced from coal power plant operation (coal transportation to the plant, coal combustion, ash transportation and storage) is significantly affecting people's health and daily activities in the area around the plant sites. Survey on air pollution from three operating coal power plants (Vung Ang, Hai Phong and Quang Ninh) shows the high percentage of interviewed people who think the air quality is negatively impacted by the plants' activities. For example, 89.2% of surveyed people lived near Hai Phong Coal Power Plant claimed that air pollution is due to plant activities. For the case of Vung Ang Coal Power Plant, this number is 60.6%. Impacts of low air quality to local people include changing daily living habits, affecting human health, reduce crops productivities and relocation. The survey results in Vung Ang and Quang Ninh power plants are illustrated in Figure 7. Results are expressed in percentage of interviewed people who answered yes to the question whether air pollution adversely affecting their life.

Box 2: Air pollution and impacts on human health

In Tam Hung commune, which is the commune closest to Hai Phong coal fired power plant, coal reserve piles are very near to the kindergarten (around 10-20 meters), secondary and high school. As mentioned by the leaders of Tam Hung' People's Committee, a great amount of coal dust is blown towards the kindergartens, causing nuisance and annoyance for the teachers and children there. Currently, there is a decision on relocating this kindergarten far away from the coal fired power plant, which has been approved by provincial People's Committee (PC) in 2014.

Reference: Facts about the Hai Phong coal-fired power plant project in Vietnam
Green Innovation and Development Centre (17 th April, 2015)

The Government of Vietnam did promulgate clean air laws and regulations such as National Technical Regulation on Industrial Emission of Inorganic Substances and Dusts QCVN 19:2009/BTNMT and National Technical Regulation on Emission of Thermal Power industry QCVN 22:2009/BTNMT. Figure 8 from (Myllyvirta 2015) show that emission limits in Vietnam are comparatively higher than in other countries. Most coal power plants operating in Vietnam as of 2016 are based on old technology (sub-critical power plants), and some lack emission control equipment. This leads to relatively high emissions at these plants. Therefore, it is a barrier for applying stricter regulations on emissions from coal power plant at the moment. However, considering the adverse impact of air pollution to human health and other aspect, it is necessary to have a roadmap to adopt new technologies for the planned coal power plants in the future as well as to have new limits on pollutant emissions.

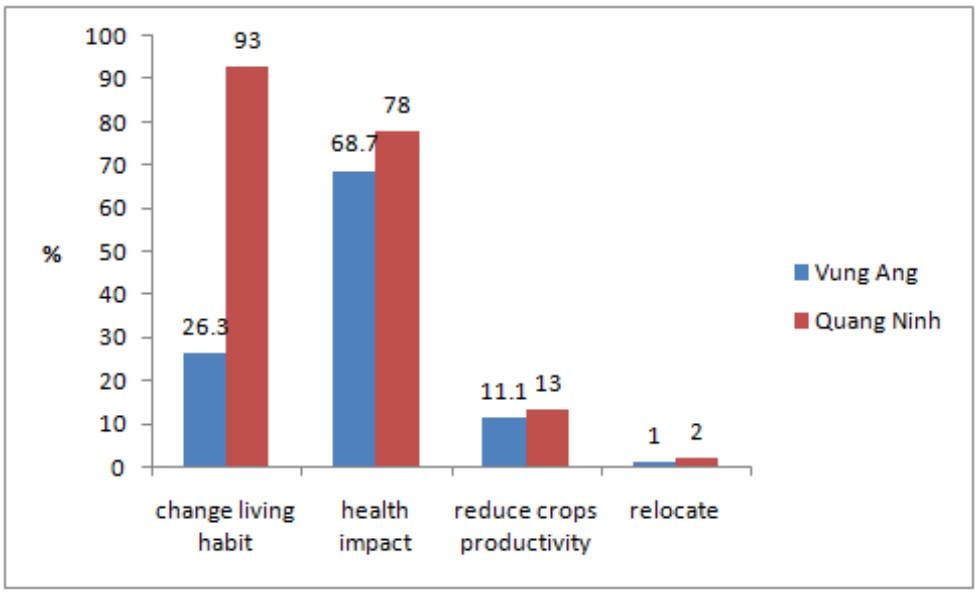

Figure 7. Impact of air pollution to local people based on GreenID survey (GreenID 2015)

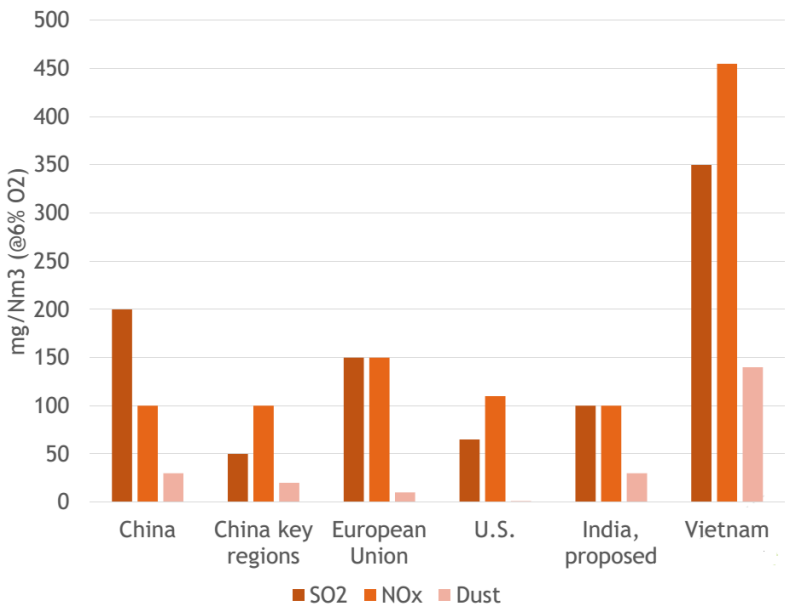

Figure 8. Emission limits for coal-fired power plants (Myllyvirta 2015)

3.2. Water quality

Water pollution from coal includes negative effects from the mining, processing, burning, and waste storage of coal, including acid mine drainage, thermal pollution from coal plants, acid rain, and contamination of groundwater, streams, rivers, and seas from heavy metals and other toxins and pollutants found in coal wastes.

Acid mine drainage

Vietnam has around 200 coal mines with total reserves of almost 8 billion tons, mostly concentrated in the northern provinces of Quang Ninh (H. Nguyen and Howell 2015). Annually, 15 to 20 million tonnes of coal are extracted in this province. Coal mining requires large amounts of water for dust suppression and needs of workers on site. This water once being returned may contaminate both groundwater and nearby streams for long periods of time. Deterioration of stream quality results from acid mine drainage, toxic trace elements, high content of dissolved solids in mine drainage water, and increased sediment loads discharged to streams. When coal surfaces are exposed, pyrite comes in contact with water and air and forms sulphuric acid. As water drains from the mines, the sulphuric acid moves into the waterways and contaminates it. As long as rain and coal remains in the mines, the acid mine drainage continues even after the mines stop its operations. A study on Lo Tri coal mine in Quang Ninh showed a high risk of streams around the coal mine being acid contaminated in the dry season (Le and Nguyen 2012).

Thermal pollution from coal power plants

Thermal pollution is the degradation of water quality by any process that changes ambient water temperature. Coal power plants need an important quantity of water for the cooling systems. After that water is released back into the lake, river, or ocean. At the point of discharge of cooling water the environmental average temperature is often higher than the

water temperature of the normal water flow, high velocity and waste water also contains chlorine at a certain amount. A recent survey of Quang Ninh coal power plant showed that water quality at area receiving waste water of the cooling process has high temperature, ranging from 38.1°C to 38.9°C; this temperature is 7.9°C to 12.9°C higher compared to that of water source before entering the plant and 6.2°C – 16.1°C higher compared to that after exiting the plant as input of the cooling process. The survey of Mao Khe coal power plant in 2015 also revealed the same problem of thermal pollution at the point of discharge of cooling water to the Suoi Gao stream (CEWAREC 2015).

The sudden increase of temperature of water will cause the temperature shock of living organisms in the ecosystem, increasing the living activities in water and the dissolved oxygen (DO) in water as well as the dissolution of toxic matters in water, resulting in imbalanced ecosystem due to the increase of thermophiles and decrease of psychrophilic or species difficult to adapt to environment temperature changes. Especially high water temperature can whiten coral and damage seaweed plantation, aquaculture areas or reduce sensitive ecosystems in the area. Power plants can also potentially harm fish eggs, larvae, and other aquatic biota in their early stages, as they require particular combinations of fresh water flow and temperature.

Contamination from heavy metals and other toxins

Coal mining, processing, transportation and burning activities can release a large amount of coal wastes such as coal sludge, coal ash and other pollutants. Coal wastes contain many heavy metals that may cause acute or chronic toxicity, such as lead, mercury, nickel, tin, cadmium, antimony, and arsenic, as well as radioisotopes of thorium and strontium. Once these toxics enter the river ecosystem, it can enter the food chain and bio-accumulate, leading to serious harm to wildlife, as well as threatening people.

Coal transportation may cause pollution risks to water environment along the carriage road. Specifically, waste water containing pollutants from ships and boats or coal losses to the sea/rivers during transport also causes water pollution. In addition, the construction of buildings such as coal shipping piers waterway causes changes in natural environment areas, negative impacts on the water environment and reduce fishing area of people around the area. Surface water samples in the section of Dien Vong River upstream of Quang Ninh coal-fired power plant and where coal transport take place revealed that water is being polluted by total suspended solids, ammonium cation, manganese, hexavalent chromium, oil and grease. Water quality in the rainy season is worse than in dry season because in the rainy season, rain water will wash away all substances on the surface, especially coal and soil and stones layers from coal stockpiles located on the bank of Dien Vong River into the river flow, increasing pollutants especially suspension solids. The amount of oil and grease here then is much higher due to the operation of ships, boats and barges transporting coal for consumption in other areas.

Coal power plants can use millions of litres of water every day, so most power plants sit on or near a water body. This means that coal plants discharge into hundreds of rivers, lakes, and streams all across Vietnam. Water samples from Quang Ninh power plants and Mao Khe power plant showed that the plant activities affect all groundwater, streams, rivers and sea water. After receiving waste water from Mao Khe coal-fired power plant, the turbidity, conductivity and total dissolved solids of Suoi Gao stream water are also increased. The

increase in conductivity and total dissolved solids proves that water contains large amounts of salt, such as Cl^- and, SO_4^{2-}, NH_4^+, NO_2^-, NO_3^-, $CaCO_3$. Similar to the concentration of ions and salts, heavy metals content such as iron (Fe), copper (Cu), lead (Pb) and cadmium (Cd) are also presented in water bodies. The impact of Quang Ninh power plant on water bodies can be summarized in

Figure 9.

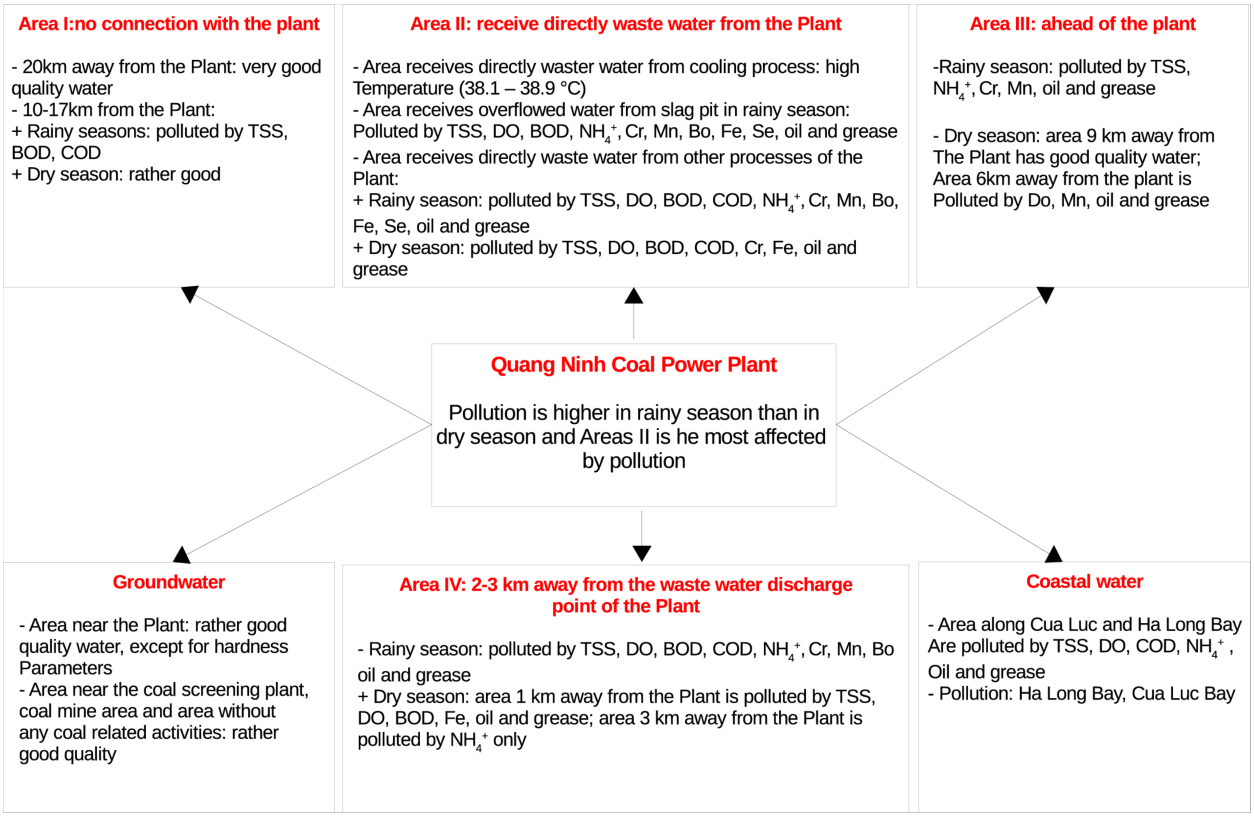

Figure 9. Impacts of Quang Ninh coal-fired power plant on water quality of studied areas

Leaks or spills of coal wastes from accidents can also heavily endanger water bodies. On 26 July 2015, heavy rains had broken stream dam 9.8 of Dong Cao Son in Mong Duong ward, Cam Pha city, thousands of m^3 of coal waste from the Dong Cao Son dumpsite has spilt down to residential areas in Mong Duong Ward who are living at the foot of the dumpsite. The recent analysis of water samples at these locations revealed that the breach of 9.8 stream dam of Dong Cao Son coal waste dumpsite was seriously affecting water environmental in Mong Duong Ward, Cam Pha city. Water quality in streams H10 and 9.8 which receive wastewater from Dong Cao Son coal waste dumpsite has low pH and DO contents and is contaminated by TSS, COD, NH_4^+, oil and especially heavy metals such as As, Cr (VI), Mn, V, Tl which all exceed the permissible standards.

On 28 July 2015, the failure of dyke embankment of ash pond of Quang Ninh coal-fired power plant in Ha Khanh ward, Ha Long city caused a large amount of waste water in the ash pond to be spilt to the environment, bringing with them toxic and contaminated substances from coal burning process. The analytical results of waste water samples from this ash pond in the environment showed high harmful effects on water resources. The contents of ammonium, oil and grease and heavy metals such as Mn, As, Fe, Mn, Bo and Se

are high and exceed the permitted standards. According to QCVN 08:2008/A2: NH_4^+ exceeds the allowable limit by 3.7 times; oil and grease by 4.5 times, Fe by 1.52 times. According to the Canadian standards: As content exceeds by 1.2 times, Bo by 2.24 times, Se by 2 times. According to TCVN 5942-1995 Mn exceeds by 1.1 times. Also the water quality in this area has low pH and DO and is unqualified in accordance with QCVN 08: 2008/A2, with the pH which is 1.22 times and DO 1.27 times lower than the standard.

Table 5. Quality of water source near Quang Ninh power plant as judged by informants

Water source	**Characteristics**			
	Odour	Taste	Colour	Other
River water	No	No	Turbid	Quite turbid during rainy season
Stream water	No	No	No	Shallow, no stream
Canal water	Fishy, stinky	No	Black	Turbid, black with oil film near coastal coal storage site. Affected by soil and stone from coal exploitation (washing coal)
Groundwater (well water)	Fishy, stinky	Salty	Yellow	To be filtered before use
Tap water	Fishy, stinky	No	Yellow sometimes	oil film, coal dust from air intruding into drinking water tank
Rain water	Fishy, stinky	No	Yellow, green black, moss	Turbid with coal dust
Coastal water	No	No	Green	oil film near ship anchorage, more turbid than before

The recent survey of 567 households living near 5 coal power plants at Tra Vinh, Thai Binh, Hai Phong, Ha Tinh and Quang Ninh showed that domestic water is also being polluted by the power plants. The negative impacts on domestic water are shown clearly with the plants that are being active. More than 75% of people living around the coal-fired power plant in Quang Ninh and Hai Phong said that water sources have been contaminated and the cause of pollution is from coal-fired power plants and mining process. They only use rainwater, well water for bathing or watering the front line to smother the dust. The streams and canals in the area close to the exploitation and processing of coal contain black and viscous water with stench and scum, the slurry are also found with high quantity. Households here have to change their daily habits to adapt to environmental changes. Besides, the coal transport vehicles do not cover up carefully and may drop a lot of sludge or coal dust that obstruct the drainage of sewage systems and roadside ditches.

3.3. Soil quality

Soil erosion from mining

Impact to the soil of most mining projects is the change of use from forest land into industrial land; reduce soil properties such as soil fertility, the workability of soils. Coal mining activities creates a huge volume of soil and stones. In opencast mining, in order to exploit up to 1 tonne of coal, it is necessary to remove 10-13 m^3 of soil and stones (Hoang Nga and Viet Hoa 2015). As an example, currently the opencast mining sites in the Cam Pha has coal output from 14-16 million tonnes per year, corresponding to a volume of soil removal of 180-200 million m^3 per year. When trees, plants, and topsoil are cleared from the mining area, it leads to soil erosion and destruction of agricultural land. Topsoil, which is high in organic matter, fertility and soil life, is removed and relocated elsewhere. A study of environment impact at Nui Beo coal area showed that the soil has a low nutrient concentration of nitrogen (N), phosphorus (P) and potassium (K) compared to the standard for gray soil standard and this was due to the mining activities at this location (Nui Beo Coal JSC 2010). These nutrition criteria are indispensable in the growth and normal development of crops. In addition, soil samples also showed a pH = 5.31 - 6.08, which presents a slight acidity of soil.

Soil contamination

Coal mining can contaminate the nearby soils, and is one of the most common sources of pollution in soil. Various mining operations like top-soil handling, drilling, blasting, and overburden-handling by draglines and conveyors; coal handling, loading, unloading, etc. generate huge amounts of dust and ultimately settle on nearby soils. A study of rice paddy soil composition in Cam Pha, Quang Ninh province, showed the presence of Cd, Cu, and Pb at higher concentrations than calculated background concentrations (Martinez et al. 2013). Metals and metalloids in Cam Pha rice paddy soils, including Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Manganese (Mn), Nickel (Ni), lead (Pb) and Zinc (Zn), were found in concentrations ranging from 0.2 to 140 mg/kg, which were in close agreement with toxic metal contents in mine tailings and Coc Sau coal samples, suggesting mining operations as a major cause of paddy soil contamination.

Solid waste is also one of the causes of changes in soil properties in the area. Coal mine wastes of Nui Beo contain high levels of Iron and Manganese to the flow through the soil surface will increase metal concentrations of iron, manganese in the soil.

Soil acidification

Coal-fired power plants are the largest human-caused source of sulphur dioxide, a pollutant gas that contributes to the production of acid rain as mentioned in the previous session. The phenomenon is explained by the chemical interactions between SO_2 and NO_2 gases and vapour in the atmosphere under environmental radiations that form various kinds of acid such as H_2SO_4, HNO_3 and H_2SO_3. These acids fall to the ground with rain drops or stay in the clouds and are carried away to the surrounding areas by the winds. Acid rain reduces the alkalinity and increases the acidity of the water and soil. Chronic acidification may exhaust nutrients in soil and water, thus cause damage to plants and crops as well as to aquatic species and aquaculture.

Ash fallout

Solid waste, mostly coal ash, from coal power plant operation is another significant source that impact soil quality. During combustion stage, 20% of unburned inorganic matters aggregated to form big particles and fall to the bottom of the boiler (called bottom ash). The remaining 80%, too small to be aggregated (called fly ash), can be captured by different technologies such as electrostatic precipitation (ESP) before the flue gas released to the atmosphere.

Coal ash, including both bottom ash and fly ash, contains heavy metals that can be harmful for soil quality if leaked to the environment. As an example, after the burst of streams 9.8 dam of Dong Cao Son dumps it in Mong Duong ward, Cam Pha city and dyke failure of ash pond in Quang Ninh coal-fired power plant in Ha Khanh ward, Ha Long City, thousands of m^3 of coal wastes has spilt down to the residential area in Mong Duong Ward at the foot of the dump-site. According to the analysis results, soil quality in this area was being polluted with Arsenic. Arsenic content is very high in this area, ranging from 17-21 mg/kg, compared with QCVN 03: 2008 /BTNMT standards, the Arsenic content exceeded 1.13 - 1.4 times.

As the amount of coal ash generated by all coal power plants in Vietnam is enormous, environmental threat from coal ash is a great challenge to plant operators and local authorities. According to the survey of Japan Bank for International Cooperation (JBIC), 673 600 tonnes of coal ash is produced every year from just 5 EVN's coal power plants (with total capacity of 1 500 MW, which account for 10% of total installed capacity of all coal power plants in Vietnam) in the Northern region. When the installed capacity of coal power plants reach 35 000 MW by 2020 according to Power Development Plan VI, the coal ash released will be 16 million tonnes per year. This number could be doubled by 2030 when the capacity of coal power plants increase to 75 000MW. With this amount of coal ash by 2030, Vietnam will need to allocate 28 000 ha for coal ash dump-site. This means if we do not have an efficient and sustainable solution for coal ash we will have to use a total surface of land equivalent to 39% area of Singapore to store coal ash in 2030 (Hoang Nga and Viet Hoa 2015).

To manage solid waste (coal ash in particular), the Prime Minister has issued Decision 1696/QD-TTg on coal ash treatment to produce construction materials. This Decision obligates the project investor on coal thermal power to invest on coal ash treatment process to meet relevant standards for producing construction materials. Moreover, each plant is only allowed to have a dump-site with maximum capacity to store coal ash for 2 years. However, up to now, only Pha Lai Coal Power Plant has utilized coal ash. This account for only 10% of total coal ash produced in Vietnam (Tran 2016). While in the United States, 40% of coal ash is treated and recycled. This number is 67% in China. Lacking regulations and supporting mechanisms to recycle coal ash are the main causes of the underdevelopment of coal ash treatment and reuse in Vietnam. If this situation continues when new coal power plants are being built then the impact of coal ash will be a real challenge. At first it will be a waste of land resource just for storage of coal ash as describe in the previous paragraph. Moreover, coal ash is a source of dust and fine particles as well as other toxics such as Hg and As. These harmful substances could cause serious environmental and health problem as demonstrated further in the session.

3.4. Livelihood of local people

Coal mining has reduced forestry and cultivation area. Coal mining is one of causes of deforestation. Reducing foliage coverage facilitates soil erosion both in frequency and intensity which removes the fertile layer of soil at the surface. Soil erosion and degradation is the main cause of reducing cultivation land. Coal mining in Quang Ninh province impacted 750 ha of forest, caused the agriculture land to shrink by 79 ha compared to 1985 value, of which 30 ha lost was paddy field (GreenID 2015). The coal mines do not have effective measures to restore the cultivation land, thus affect the agricultural activities of local farmers and reduce crops yield. Coal mining also impact biodiversity, reduces the number of animal and plant species due to losing habitats and changing the ecosystems. This affects the quantity and quality of aquatic and forestry products and thus directly impacts the livelihood of local people.

Coal mining activities also impose risks to daily life of people. In Quang Ninh, illegal underground coal mining cause land sinking in the residential area. This phenomenon was threatening the stability of houses and buildings in this area and affecting 80 households and forced them to relocate.

Operation of coal power plants in thermal center located next to the sea is affecting aquaculture production and farming. According to local people, Vung Ang Coal Power Plant discharge to Mui Dung Sea is one of the reason for decreasing fishery products and aquaculture. Nevertheless, more studies are needed to have concrete evidences to prove this link. Duyen Hai Thermal Power is also located on the coastline of Tra Vinh Province, thus it also has potential of affecting fishery and aquaculture. However, since the center is still in construction phase the impact of plant operation to the fishery resources could not be determined yet.

The most important impact to the livelihood of local people comes from land acquisition and resettlement. A coal thermal power plant project requires land to be constructed. In most of the case, both agricultural and residential land is acquired for this purpose. For the construction of Thai Binh Coal Power Plant, 254 ha agriculture land acquired in 6 out of 7 villages in My Loc commune, of which, 100% paddy field in 4 villages has been taken. Land acquisition impacts 1 370 households with 5 200 people which is 75% total population of the commune. According to the estimation of People's Committee of My Loc commune, total agriculture land of the commune has been reduced by 48% due to the construction of Thai Binh Coal Power Plant.

In Duyen Hai Coal Power Plant, land acquisition has directly impact the livelihood of people in Dan Thanh commune. Dan Thanh commune has 2011 households with the population of 8 012 people. The main livelihoods are cultivation, salt making and aquaculture. The commune has 419 resettled households, of which 318 households (about 2 000 people) have compensated land, the rest are compensated by cash (average 50 million VND per household). Resettlement area is still close to the production area of Duyen Hai Thermal Power Center. Some households have sold their compensated land and move to another place. The land for aquaculture has been reclaimed and the remained land is no longer suitable for that purpose. People have to rent land from other location to continue their production. Salt makers also claimed that salt productivity has declined due to the construction and operation of the plant.

Box 3 Air pollution and land acquisition from Duyen Hai coal power plant impact livelihood of local people (GreenID 2015)

Ngo Thi Mong (age 61) - a salt maker in Mu U village, Dan Thanh commune, Duyen Hai district - said that the salt production of her family has decreased by half due to the smoke and dust from Duyen Hai Coal Power Plant. Normally, she could sell 30 tonne salt for 25 million VND. However, during the test run of Duyen Hai 1 Coal Power Plant smoke and dust from plant operation have blackened the salt which caused the price to drop to 16-17 million VND for 30 tonne salt. Especially, in some salt fields, salt is too black so it could not be sold or sold at one third of market price.

Nguyen Phuong An (age 48) - representative of a shrimp farming household in Mu U village, Dan Thanh commune - revealed that two third of his shrimp farming land has been acquired for the construction of Duyen Hai Coal Power Plant. The rest one third has not been compensated but could not continue farming. His family is now renting 30 000 m^2 of land in another place to resume shrimp farming. Land rental cost has significantly reduced the benefit and his family income.

Although the investors always have an approved resettlement plan before the implementation of the project, affected people are not always happy with the resettlement and compensation. People that live around the planned dump-site of Vung Ang Coal Power Plant are good example for that. According to the officers of Ky Anh District and technical staff of Vung Ang Coal Power Plant, the plant not yet has coal ash dump-site as described in the Environmental Impact Assessment. The current dump-site is just temporary and do not have the capacity to store 1.01 million tonne of coal ash per year. Based on the project plan, 132 ha of land in Ki Trinh commune will be recovered for the construct of the plant's dump-site. Of which, 40 ha is currently paddy fields, 5ha is vegetable planting area, 3.4 ha is for aqua-farming, 2,7 ha of eucalyptus planting and the rest is bare land. However, local authority as well as local people are not yet agree with the compensation plan proposed by the investor. Their reason was that the dump-site is located too close to the residential area, which could have significant impact to environment and people's health.

It is true to say that investment on coal power plants could create jobs. However, it is also traded off by the unemployment situation of local people when they have lost their current jobs due to land acquisition for the plants. For example, due to the construction of Hai Phong Coal Power Plant, 53% of affected people became unemployment after their land is acquired. Of which, only 20% has found new jobs or new ways of making a living such as opening small restaurants or entertaining services. Only a few got a job in Hai Phong Coal Power Plant.

During the planning stage for the project, impact to the livelihood local communities is always mentioned in the social impact assessment. Job opportunity and training are included in the mitigation measure to ensure the living condition of affected people will be improved or at least remain the same. However, in case of Duyen Hai Coal Power Plant, job transition for people who lost their land is not yet effective. Project investors does not have commitment and plan for training local people or using the local labours as promised before people

handover their land. During Duyen Hai 1 and Duyen Hai 3 Coal Power Plants construction and operation, only a limited number local people was hired to work in the construction site, mostly for temporary and low paid positions. Recruiters used many excuses not to accept local labours including the reason of “not qualified and lack of skills”.

3.5. Public health

As demonstrated in the previous sections, coal has significant environmental impacts to all media (air, water and soil) during its entire life cycle. These impacts then affect human health in various ways. Of which, the most obvious causes of health problem to local people are air pollution and water pollution.

Among the air pollutants, particulate matter (PM) is the main source that directly and severely impacts human health. According to EPA (United State Environmental Protection Agency), particulate matter is “a complex mixture of extremely small solid particles and liquid droplets” and it contains number of component such as acid, organic chemical, heavy metals and dust. It is the size of particulate matter that determines their potential for causing health problem. The size of particles is expressed by the number (in micrometers) after the initial PM (for example, PM10 refers to the particles that are smaller than 10μm in diameter). PM10 and smaller particles are the most dangerous to human health. Once inhaled, they can deeply penetrate the lung and bronchus causing severe respiratory diseases. PM2.5 or fine particle contains many chemicals. Short-term exposure to fine particles pollution is linked to cardiac effects, including risks of heart attack (Goenka and Guttikunda 2013). WHO confirmed that long-term exposure to fine particle can adverse birth outcomes and childhood respiratory diseases (WHO 2013). It is also linked to the increased risks of death from lung cancer and cardiac and respiratory diseases (Goenka and Guttikunda 2013). The Vietnamese standards on Ambient Air Quality (QCVN05:2013/BTNMT) set the national standards for PM10 concentration at 50 $\mu g/m^3$ (measured as an annual mean) and 150 $\mu g/m^3$ (measured as a daily concentration). Standard for PM2.5 is 25 $\mu g/m^3$ and 50 $\mu g/m^3$, respectively. Figure 10 illustrates the current (2015) and projected (2030) concentration of PM2.5 in Vietnam (Koplitz 2015). The modelled image highlights that concentration of PM2.5 is highest in the region where coal thermal power plants are concentrated.

According to National Environmental Report 2013, almost 50% of total cases of silicosis in Vietnam are concentrated around the mining areas. When the air is polluted, it will adversely impact human health, accelerate the ageing process and reduce life expectancy. The most vulnerable groups to low air quality are pregnant women, children under 15, people with heart/lung disease and people who work outdoor. Common diseases related to air pollution includes chronic pulmonary disease, lower respiratory infections, and cancer of trachea, bronchitis and lung.

Water pollution poses a significant threat to public health. Using polluted water source that does not meet standards for domestic consumption causing digestive diseases such as diarrhoea. Water sources contaminated with heavy metals have potential risks of chronic diseases. Heavy metals contained in coal ash released to the environment are accumulated in the food chains and could penetrate into human bodies through ingestion of contaminated foods and drinks causing serious effects in different organs. Mercury (Hg) is a highly potent

neurotoxin that impacts the function and development of the central nervous system. The most vulnerable groups to Hg exposure are pregnant and breastfeeding women as well as small children because Hg is most harmful in the early stage of development (National Wildlife Federation 2011). Excessive Selenium (Se) will lead to nervous problem such as reducing vision, paralytics or even death. Chromium hexavalent (Cr VI) could impacts intracellular operation and directly affects DNA causing gene mutations. Excessive Boron (B) causes testicle problem, kidney, liver and brain damage. Long-term exposure to arsenic (As) in drinking water could cause lung, skin, bladder and kidney cancer.

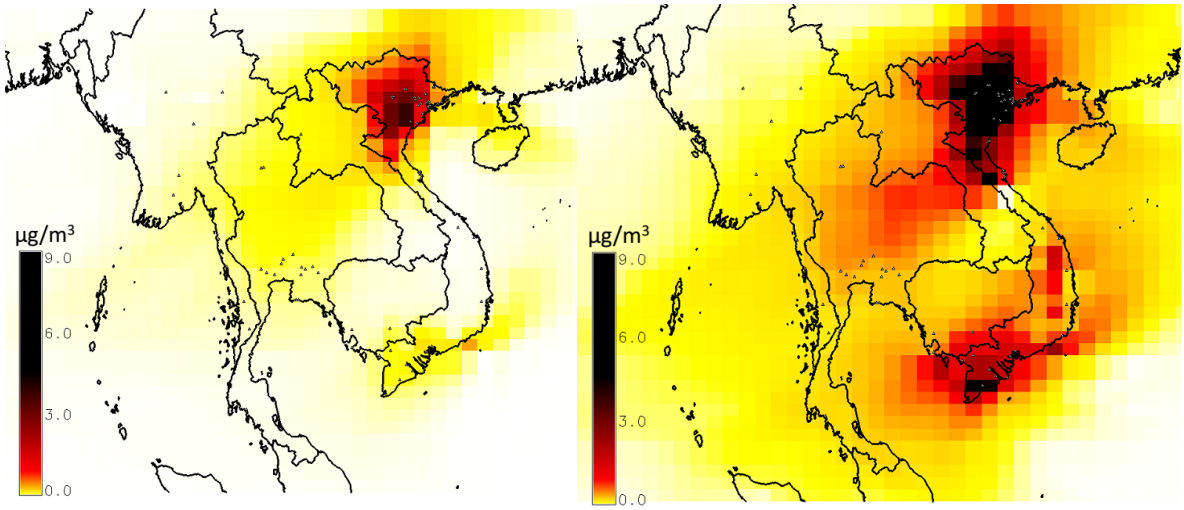

Figure 10. Current (left) and projected in 2030 (right) PM2.5 concentration (Koplitz 2015)

Highest PM2.5 concentration is in the northern of Vietnam, where most of coal mines and coal power plant are located.

Noise pollution is another source that adversely impacts human health. Noise from equipment (boilers and turbines) affects the residential areas nearby, especially when starting up boilers. Transportation during plant construction and operation (such as coal ash transportation by heavy duty trucks) also results in noise and vibration. Construction activities could generate noise at 70 dB to 80 dB and even could reach 125 dB. Inspection in mining areas revealed that the noise intensity there could reach 97 – 106 dB. This noise exceed the allowed value of 75 dB according to the Vietnamese standard TCVN 5949:1998 which results in many cases of occupational deaf among mining workers.

Health impact from coal power plant construction and operation is assessed through the survey (GreenID 2015). Around Duyen Hai Coal Power Plant, 73% surveyed households said that their health care expenses have increased substantially since the plant construction started compared to previous years. 51% interviewed people live near Vung Ang Power Plant claimed that their physical and mental health is affected by water pollution. Some households even planned to relocate due to low water quality in the neighbourhood. Respiratory diseases is the most common health problem in the area (69%) followed by eye diseases (32%), skin (26%) and digestive diseases (19%). Health care expenses of 45% survey households have increased in 2014 (when Vung Ang coal power plant was in construction). This number is 48% in case of Hai Phong coal power plant. In Ha Long city,

where main coal mines are concentrated and Quang Ninh Coal Power Plant is located, health impact is a serious problem. One third of the interviewed households said that the frequency of hospitalization in 2014 was higher than previous years. 77% households have family members who have respiratory diseases, of which 44% households have members who diagnosed with chronic diseases.

Table 6. Estimated health impacts of coal power plant in Vietnam through number of coal related premature death (Myllyvirta 2015)

		Number of premature deaths	
		2015	**Projected to 2030**
PM2.5 exposure to adults	Stroke	1 670	8 200
	Ischemic heart disease	1 130	5 210
	Lung cancer	310	2 300
	Other cardiovascular diseases	350	1 420
	Respiratory diseases	500	2 710
PM2.5 exposure to children	Lower respiratory infections	60	130
Ozone exposure to adults	Respiratory diseases	240	1 170
	Total	4 300	21 100

Another way to evaluate health impact from coal is to estimate the number of coal related premature deaths. Premature mortality is an estimate of the cases of death before a reference age, which correspond to the life expectancy of the population under study. A recent study (Koplitz 2015) has estimated that the coal power plants in operating in Vietnam are responsible for 3 827 cases of premature death in 2011 due to exposure to airborne pollutant emissions. In 2015, the estimated number of premature death is 4 300 and if Vietnam continues to develop coal power plants as planned in the current PDP, this number could reach more than 21 000 cases (Myllyvirta 2015) (see Table 6).

As demonstrated above, health impact from coal is a significant drawback of electricity generation from coal. Therefore, public health is definitely one of the most important aspects to be considered when developing coal power plants in the future. To minimize the health impact from current coal power plants in operation, reinforcement of current regulations on pollutant control is also a good option.

4. Summary and concluding recommendations

Vietnam's electricity demand is expected to increase two or three times over the next two decades. This challenges the country's engineers, entrepreneurs and policy-makers to build a sustainable, reliable and economical energy supply. According to the recently revised Power Development Plan VII of Vietnam, the country would expand its coal-fired power capacity from about 10 GW by 2015 to 55 GW by 2030. This report has demonstrated that this plan to develop coal mining and electricity generation from coal carries high socio-economic and environmental impacts. In this final chapter, we summarize these impacts observed today and expected tomorrow before proposing some ideas to avoid them.

4.1. Summary on the observed and expected impacts of coal

This report exposed the global, national and local impacts from coal in Vietnam observed today. We also looked at these expected in 2030 if projections of the PDP VII revised are carried out fully. The impacts hit from many angles such as water, air and soil pollution, contributions to climate change, local people's livelihood and health problems. There are also national economic and geostrategic impacts.

- Air and water: Monitoring by MONRE shows that at 100% of coal mining and processing facilities, the concentration of dust in the air is above the Vietnamese standard from 30 to 300 times. Study in Mao Khe coal power plant shows concentrations of heavy metals and toxic in Gao Stream exceed Vietnamese standards. More than 75% of people interviewed around the Duyen Hai Coal Power Center declared that they had to change their daily activities due to low air quality condition such as closing windows and sweeping the house more often.

- Soils: To dispose of the quantity of coal ash consistent with the original PDP VII, Vietnam would need to allocate 28 000 ha. This is a dump-site 39% of the area of Singapore.

- Climate: The increase in GHG emissions in Vietnam is largely attributed to an increase in fossil fuel use and most notably coal consumption. According to MOIT, national CO_2 emissions from coal-fired power plants increased from 28 Mt by 2011, to 40 Mt by 2013, and then 73 Mt by 2015.

- Livelihoods: Coal plant projects cause resettlement issues. We found that the job opportunity for local workers and training programs included in the project planning documentation were not always carried trough as promised. Polluting emissions can negatively affect the agricultural activities, for example by blackening reduced the quality and value of salt produced near the Duyen Hai power plant.

- Health: Currently, coal pollution in Vietnam causes 4 300 premature deaths per year. This number could reach 21 100 cases in 2030 if coal use grows as planned.

- Economy: Vietnam has started importing coal. In the future, fossil fuel imports could significantly bear on the trade balance, 1 billion USD per year as soon as 2020. There may be barriers to trade against countries relying on CO_2 intensive energy sources to power their industry.

- Geostrategic position. Energy security is a vital interest, and the high share of imported fuels in the power sector would create a dependency from abroad. Rich countries are setting up a ban on new coal power plants.

To reduce these impacts, there is an urgent need to find cleaner pathways for the power development of Vietnam in decades to come. Based on these findings, VSEA would suggest recommendations to relevant stake-holders.

4.2. Recommendations

To national policy-makers

The national power development plans should be revised more frequently to respond to rapid changes in socio-economic and technological conditions. We propose that:

- Coal-based electricity should not be developed as in current plans. That would certainly cause many serious negative impacts to the society. Reliance on coal, especially imported, should be reduced. The government should act now with both short and long term policies to reduce the place of coal in electricity generation.

- Environmental standards for each stage of the full life-cycle of coal should be defined clearly and applicable nation-wide.

- For project under development consideration, environmental assessment reports should include all impacts and external costs. The projects should design and implement effective plans for environment protection of the areas affected by their activities and report frequently to the local authorities and communities.

- The full social and environmental cost of coal-fired power plants should be internalized into the power production cost. That will bring the cost of electricity from coal at much higher levels than it is today. In this circumstance, renewable energy will be more competitive and attractive to investors in the sector.

Power plants have a lifetime of over 30 years. The government should keep open the options for policies it may want to apply in the future. Future coal-fired power plants should be build compatible with the green society that Vietnam is developing towards. These considerations should be integrated in the plant project at the early stage, and influence the precise design and technology choices. More specifically, to be allowed to proceed, project owners should specifically demonstrate that the proposed plant:

- Applies the best available advanced generation technologies to produce at high efficiency and reduce emissions and wastes. This process must be verified and monitored strictly by government bodies with full competence.

- Can operate with high fraction of biomass fuel co-fired with coal, more than 10%.
- Can be retrofit with carbon capture and storage, it should be CCS-ready.
- Is flexible to operate, to integrate well in a grid with intermittent energy sources. This implies that the minimum stable generation level should be lower, and that ramp-up and ramp-down rates should be higher than conventional base-load plant designs.

Worldwide, renewable energy technologies such as solar and wind power are mature, commercial and expanding much more rapidly than fossil fuel generation technologies. Not yet in Vietnam. Energy efficiency and renewable energy sources should be given more attention, in terms of technology development and economic incentives.

- The government should step up its inter-ministerial efforts to organize the socio-economic readiness conditions for a large scale expansion of renewable energy. It implies for example to implement the legal framework, to train administrative, financial and technical experts, and to answer industry specific development needs in terms of infrastructures such as electric grid, access roads, ports, cranes availability.
- The development of renewable energy and higher efficient use of energy should be paid more attention by both direct and indirect subsidies and supports, i.e. feed-in-tariffs, tax exemptions, favourable conditions for grid-connecting, etc. Even if in the long term sun and wind can be expected to compete with coal on a purely lower cost basis, these mechanisms are necessary in the short run, especially when the full environmental costs of coal are not yet fully internalized.

To local authorities

The local authorities should strengthen the monitoring of waste slag yard and processing in coal-fired power plants before releasing into the environment to ensure that the processes are in compliance with relevant environmental standards.

- Local agencies such as the Department of Natural Resources and Environment of the provinces should enhance the monitoring of environmental standards of waste water and coal-fired power and extraordinary periodically to ensure the discharge of wastes into the environment in compliance with strict standards and regulations of the country.
- Local authorities should involve other local stake-holders, i.e. local people, in the implementation and monitoring processes of coal-fired power plants to ensure no violation of environmental regulations happened. For example, a public hotline for reporting any environmental damages caused by the power plants could be very helpful and efficient.

To social organizations

Social organizations should coordinate with national authorities to increase the awareness of people and authorities about the impacts of coal-based activities. Social organizations should act to reduce coal consumption, increase energy efficiency and renewable energy

sources. They should promote independent research programs, communication campaigns, and awareness and capacity building activities for the local communities.

- Independent social organizations should involve themselves in monitoring of the application of the environmental standards in coal mining and coal-fired power plants, along with the local authorities and the local people.

- They should coordinate with research institutes to carry out studies of cumulative impacts of coal-fired power plants. Such joint activities would bring more science-based evidence to policy-makers for their policy making process towards a cleaner future of the energy sector in particular and of the country in general.

To local people

Citizens should learn pro-actively about the impacts of coal-based industries as well as relevant regulations, to participate meaningfully in monitoring the compliance of coal mines and coal-fired power plants with environmental standards. They need to record the evidence and report to the relevant authorities whenever anomalies are observed. Citizens should actively participate and coordinate with social organizations in research and surveys on the impact of coal-fired power plants.)

4.3. Concluding remarks

That report summarized eight studies carried out by VSEA members, which presented a number of negative impacts of coal on Vietnamese society and environment. Studies considered impacts caused by coal activities at all stages, from the mine to the power plant to the ash dump.

Air pollution emerged as a critical impact, which will be investigated more in coming studies. VSEA is monitoring air quality in selected areas, to find out the main pollution sources and propose appropriate solutions.

VSEA members are also studying the impact of climate change on the implementation of the revised Power Development Plan VII. How will sea level rise, temperature increase, water availability and other changes impact coal-fired power plants, and how to adapt?

Finally, VSEA members are conducting studies considering the full coal mining - transport – combustion - waste management chain. Both normal and exceptional conditions caused by low frequency events such as flood, hurricanes, and heat/cold waves are studied. These life cycle analysis will identify the primary sources of variability and estimate possible reduction of GHG emissions and socio-environmental and economic impacts.

References

ADB. 2015. “Vietnam Energy Sector Assessment, Strategy and Roadmap.”

Cecilia Tam, Muhamad Izham Abd Shukor, Chrisnawan Anditya, Martin Brown-Santirso, Elvira Torres Gelindon, Alexey Kabalinskiy, Juan Roberto Lozano Maya, Takashi Otsuki, and Michaelo Ochoada Sinocruz. 2016. “21. Vietnam.” In *APEC Energy Demand and Supply Outlook - 6th Edition*, II:343–60. Asia-Pacific Energy Research Center, Asia-Pacific Economic Cooperation. http://aperc.ieej.or.jp/publications/reports/outlook.php.

CEWAREC. 2015. “Study of Impacts of Coal Fired Power Plant on Water Source of Ha Long City, Quang Ninh Province.” Centre for Sustainable Water Resource Development and Climate Change Adaptation/Vietnam Sustainable Energy Alliance.

CEWAREC. 2015. “Assessment of Coal Related Incidents Impacts on Soil and Water Environment during Flood Rains Lasting from 25 July to 5 August 2015 in Quang Ninh Province.”Conway, By Lawrence. 2012. “Hell with the Lid Taken off: The Pictures of Bygone Pittsburgh and Its Residents Choking under Clouds of Thick Smog.” *Mail Online*, June 7. http://www.dailymail.co.uk/news/article-2155742/Hell-lid-taken-The-pictures-bygone-Pittsburgh-residents-choking-clouds-smog.html.

EVN. 2015. “Vietnam Electricity Annual Report.”

Finenko, Anton, and Elspeth Thomson. 2014. “Future Carbon Dioxide Emissions from Vietnam’s Coal Power Generation Sector.” *Energy Procedia* 61: 1519–23. doi:doi:10.1016/j.egypro.2014.12.160.

Global Coal Tracker. 2016. “Global Database of Coal Power Plants and Projects.” http://endcoal.org/tracker/.

Goenka, Debi, and Sarath Guttikunda. 2013. “Coal Kill: An Assessment of Death and Disease Caused by India’s Dirties Energy Source.” Urban Emissions, CAT and Greenpeace.

GreenID. 2015. “Survey on some coal fired power plant in Vietnam.”

Minh Ha-Duong and Venance Journé. Calculating nuclear accident probabilities from empirical frequencies. Environment Systems and Decisions, 34 (2):249-258, May 2014.

Minh Ha-Duong and Rodica Loisel. Actuarial risk assessment of expected fatalities attributable to carbon capture and storage in 2050. International Journal of Greenhouse Gas Control, 5:1346-1358, 2011.

Hoang Linh. 2016. “Vinh Tan 2 Coal Power Plant Cause Pollution in Binh Thuan Province.” Laodong.com.vn. January 26. http://laodong.com.vn/chung-toi-len-tieng/nhiet-dien-vinh-tan-2-treu-nguoi-tinh-binh-thuan-511896.bld.

Hoang Nga, and Viet Hoa. 2015. “Land Slide in Coal Waste Dumpsites: Need Sustainable Solutions.” *Http://www.baoquangninh.com.vn/xa-hoi/201512/bai-2-Xung-Quanh-Tinh-Trang-Sat-Lo-Bai-Thai-Cua-Nganh-than-Can-Giai-Phap-Mang-Tinh-Ben-Vung-2292050/*. December 12.

Hoa Nguyen Thai, Kei Gomi, Matsuoka Yuzuru, Junichi Fujino, Toshihiko Masui, Shuzo Nishioka, Tomoko Ishikawa, et al. 2012. “A Low Carbon Society Development towards 2030 in Vietnam.” Kyoto University, Asia-Pacific Integrated Model Team (AIM).

Institute of Energy-MOIT. 2014. “Development of greenhouse gas control measures in coal-fired thermal power and proposed schedule to apply these measures.” Report on

Implementation of National Progam on Climate Change Response of Ministry of Industry and Trade 2013-2014. Ministry of Indutry and Trade.

IPCC. 2013. *Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Edited by Thomas F. Stocker, Dahe Qin, Gian-Kasper Plattner, Melinda M.B. Tignor, Simon K. Allen, Judith Boschung, Alexander Nauels, Yu Xia, Vincent Bex, and Pauline M. Midgley. Cambridge University Press. http://www.ipcc.ch/report/ar5/wg1/.

Koplitz, Shannon. 2015. "Burden of Disease from Rising Coal Emission in Asia." presented at the International Symposium on Climate change and Coal, Tokyo, Japan, May 29. http://acmg.seas.harvard.edu/presentations/2015/koplitz_japan_symposium_20150529.pdf.

Le, Dinh Thanh, and The Bau Nguyen. 2012. "Study to Propose Solutions for Envvironmental Restoration in Lo Tri Mine, Quang Ninh." *Journal of Science and Technology of Irrigation* 39 (December). http://www.vjol.info/index.php/DHTL/article/viewFile/12432/11342.

Le Minh Chuan. 2013. "Current Status of Coal Demand and Supply in Vietnam and Plan of Vinacomin in the Coming Time." http://www.jcoal.or.jp/coaldb/shiryo/material/day2_session2_3.pdf.

Le Truong. 2015. "Live Together with Coal Ash and Dust." *Nld.com.vn*. April 6. http://nld.com.vn/news-20150406215144374.htm.

Loi, Dinh Chinh, and Gheewala S. H. 2008. "Importance of Coal and the Quantification of Important Environmental Impacts from Coal Activity in Vietnam." *Asian Journal of Energy Environment* 9 (3 adn 4): 197–214.

Martinez, Raul E., J. Eduardo Marquez, Hoàng Thị Bích Hòa, and Reto Gieré. 2013. "Open-Pit Coal-Mining Effects on Rice Paddy Soil Composition and Metal Bioavailability to Oryza Sativa L. Plants in Cam Pha, Northeastern Vietnam." *Environmental Science and Pollution Research International* 20 (11): 7686–98. doi:10.1007/s11356-013-2030-1.

MOIT. 2010. "Estimation of Pollutant Emissions from Thermal Power Plants in Vietnam 2009."

———. 2015. "Transparency in Electricity and Petrol Business." Governmental webiste. *Ministry of Insutry and Trade*. http://minhbach.moit.gov.vn/?page=electricity_define&key=electricity_thongso&menu_id=72.

MONRE. 2008. *National Technical Regulation on Surface Water Quality*. Vol. QCVN 08: 2008/BTNMT.

———. 2009a. *National Techical Regulation on Industrial Emission of Inorganic Subtances and Dusts*. Vol. QCVN 19: 2009/BTNMT.

———. 2009b. *National Technical Regulation on Emisison of Thermal Power Industry*. Vol. QCVN 22: 2009/BTNMT.

———. 2013. *National Technical Regulation on Ambient Air Quality*. Vol. QCVN 05:2013/BTNMT.

———. 2014. "National Environmental Report 2013 - Air Quality."

———. 2016. *Intended Nationally Determined Contribution of Vietnam*. Accessed June 23. http://www4.unfccc.int/submissions/INDC/Published%20Documents/Viet%20Nam/1/VIETNAM'S%20INDC.pdf.

———. 2009. *National Technical Regulation on Hazardous Substances in Ambient Air*. Vol. QCVN 06 : 2009/BTNMT.

Myllyvirta, Lauri. 2015. “Impacts of Planned Coal-Fired Power Plant Expansion on Air Quality and Health in Vietnam.” presented at the Coal and coal power: The unknowns, Hanoi, Vietnam, September 29.

National Wildlife Federation. 2011. “Mercury Pollution from Coal-Fired Power Plants.” https://www.nwf.org/~/media/PDFs/Global-Warming/NWF-Mercury-Power-Plant-Factsheet_March2011.ashx.

Nguyen, Hoa, and Bill Howell. 2015. “Vietnam and Cambodia Mining Market Briefing.” Sydney, January 22. http://www.austmine.com.au/Portals/25/Content/Documents/2015/Vietnam %20Mining%20Briefing%2027Jan%202015.pdf.

Nguyen, Nhan T., and Minh Ha-Duong. 2009. “Economic Potential of Renewable Energy in Vietnam’s Power Sector.” *Energy Policy* 37 (5): 1601–13. doi:10.1016/j.enpol.2008.12.026.

Nui Beo Coal JSC. 2010. “The Environmental Impact Assessment - Nui Beo Coal Mine.”

Pham, Thi Mai Thao, Kiyo Kurisu, and Keisuke Hanaki. 2011. “Greenhouse Gas Emission Mitigation Potential of Rice Husks for An Giang Province, Vietnam.” *Science Direct* 35 (May): 3656–66.

Phan, Bao Minh, Hoai Vu Do, Thuy An Dang, Thi Dieu Le, Huu Dat Duong, Thi Hien Nguyen, Thi Thien Ly Pham, et al. 2009. “Climate change and impacts from climate change.” University of Agriculture and Forest of Ho Chi Minh City. http://www2.hcmuaf.edu.vn/data/quoctuan/Bien%20doi%20khi%20hau.pdf.

Prime Minister. 2014. “Decision 1696/QD-TTg on Measures to Treat Coal Ash and Plaster from Coal Power Plant and Fertilizer Chemical Plants to Produce Construction Material.”

REN21. 2016. *Renewables 2016 Global Status Report*. Renewable Energy Policy Network for the 21st Century. http://www.ren21.net/status-of-renewables/global-status-report/.

The Government of Vietnam. 2011. “The 7th Power Development Plan of Vietnam.”

———. 2016. “The Adjustments of 7th Vietnam Power Development Planning.”

The Guardian. 2016. “Plans for Coal-Fired Power in Asia Are ‘Disaster for Planet’ Warns.” http://www.theguardian.com/environment/2016/may/05/climate-change-coal-power-asia-world-bank-disaster.

Tran, Dinh Sinh. 2016. “Opportunities and Challenge Regarding to Ash from Coal Power Plant - A Case Study from Vinh Tan Thermal Center.” presented at the Coal ash from coal power plant in Vietnam, Hanoi, January 12.

Nguyen-Trinh, Hoang Anh, and Minh Ha-Duong. 2016. “Low Carbon Scenario for the Power Sector of Vietnam: Externality and Comparison Approach.” *GMSARN International Journal* 4 (3): 137–46.

USGS. 2009. *2007 Minerals Yearbook Vietnam*. http://minerals.usgs.gov/minerals/pubs/country/2007/myb3-2007-vn.pdf.

Viet Nam News. 2015. “Mountains of Coal Sludge Still Threat to Lives in Quang Ninh.” *Vietnamnews.vn*. August 18. http://vietnamnews.vn/society/274612/mountains-of-coal-sludge-still-threat-to-lives-in-quang-ninh.html.

VINACOMIN. 2013. “Coal Mining Industry in the World.” *Vinacomin*. September 13. http://vinacomin.vn/tin-quoc-te/cong-nghiep-khai-thac-than-tren-the-gioi-6115.htm.

WHO. 2013. “Environment: Newly Found Health Effects of Air Pollution Call for Stronger EU Air Policies.” Press Release. *European Commission*. January 31. http://europa.eu/rapid/press-release_IP-13-72_en.htm.

WWF-Vietnam, and VSEA. 2016. “Sustainable Scenario for the Vietnamese Power Sector until 2050.”

Zimmer, Anne, Michael Jakob, and Jan Christoph Steckel. 2015. “What Motivates Vietnam to Strive for a Low-Carbon Economy? — On the Drivers of Climate Policy in a Developing Country.” *Energy for Sustainable Development* 24 (February): 19–32. doi:10.1016/j.esd.2014.10.003.