Prospects for coal and clean coal technologies in Vietnam

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Abstract

Today, Vietnam's energy economy is largely served by traditional biofuels and oil products. Within the power generating sector, hydropower and gas-fired power dominate. However, Vietnam still maintains a 40 Mt/y coal industry, parts of which have recently undergone a long overdue programme of renovation and expansion. Vietnam has been a successful exporter of anthracite, with more than half of the country's production being shipped or barged to steel mills in Japan or power stations in southern China, as well as most other Far Eastern coal importers. In coming years, the industry is due to take a different form. In recent years, opencast mining accounted for around 60% of production, but these mining methods could be phased out as reserves become more difficult and costly to extract. Consequently, a shift to underground mining is expected, with a greater emphasis on more modern and mechanised production techniques.

Coal is located mainly in the coalfields in Quang Ninh in the north easternmost province of Vietnam. Some lower rank reserves located within the Red River coalfields, close to the existing anthracite operations, may yield many more millions of tonnes of coal for exploitation. There is even the possibility that underground coal gasification could be exploited in the deeper reserves of the Red River Basin, further emphasising the importance of this coalfield to the future of the country's coal industry.

While coal production could rapidly change in future years, the power generation sector is also transforming with the country's 12,000 MWe development programme for new coal-fired power capacity. The economy suffers from a threat of power shortages due to a lack of generating and transmission capacity, while inefficiencies blight both energy production and end-users. Delivering power to the regions of growth remains difficult as the economy and the demand for power outpaces power generation. While hydroelectric power is being pursued, coal is therefore becoming a growing factor in the future prosperity of the Vietnamese economy.

Acronyms and abbreviations

$	US dollar
ACFB	atmospheric circulating fluidised bed
ADB	Asian Development Bank
ARA	Amsterdam/Rotterdam/Antwerp, a major coal hub for European coal imports
ASEAN	Association of Southeast Asian Nations (formed 1967)
BAT	best available technology
bbl	barrel of crude (often quoted on a per day basis)
bcm	billion cubic metres (of natural gas) or bank cubic metres (of overburden removal for opencast coal mining)
boe	barrel of oil equivalent
BFG	blast furnace gas
billion	thousand million, 10^9
Btu/kWh	British thermal units per kilowatt hour
BWE	bucket wheel excavator
°C	degrees Celsius (multiply by 1.8 and add 32 to convert to Fahrenheit)
CBM	coalbed methane
CCGT	combined cycle gas turbine (also commonly known as GTCC)
CCS	carbon capture and storage
CDM	clean development mechanism
CFB	circulating fluidised bed
CHP	combined heat and power (also known as co-generation)
CIA	US Central Intelligence Agency
CIF	cost, insurance, and freight
CO_2	carbon dioxide
dmmf	dry mineral matter free basis
dwt	deadweight
EIA	Energy Information Administration, US Department of Energy
ESP	electrostatic precipitator (for particulate removal)
EVN	Electricité de Vietnam
FGD	flue gas desulphurisation (for SO_2 removal)
FOB	free-on-board
FTS	floating transfer station
FY	financial year
GDP	gross domestic product
GHG	greenhouse gas
GJ	gigajoule
GRIPS	National Graduate Institute for Policy Studies (Japan)
GT	gas turbine
GWe	gigawatt of electrical output capacity (1000 MWe)
GWh	gigawatt hour (1000 MWh; 10^6 kWh)
h/d	hours per day
ha	hectare
IC	internal combustion (typically a diesel reciprocating engine)
IEA	International Energy Agency, Paris
IEA CCC	IEA Clean Coal Centre, London
IGCC	integrated gasification and combined cycle
IMF	International Monetary Fund
IPO	initial public offering
IPP	independent power producer/production/plant
JI	joint implementation
JICA	Japan International Cooperation Agency
JSC	joint stock company
kcal/kg	kilocalorie per kilogramme (multiply by 0.004187 to get MJ/kg)
kgU	kilogrammes of uranium
km	kilometre
kt	kilotonnes
kV	kilovolt
kWe	kilowatt of electrical output capacity
kWh	kilowatt hour

LHV	lower heating value
LNG	liquified natural gas, a form of natural gas at 163°C temperature and 125 kPa low temperature for the purposes of long distance bulk transportation using cryogenic ocean vessels
MEMR	The Ministry of Energy and Mineral Resources (Indonesia)
MJ/kg	megajoule per kilogramme (divide by 0.004187 to get kcal/kg)
Mbbl/d	million barrels per day
MOI	Ministry of Industry
MOSTE	Ministry of Science, Technology, and Environment
MONRE	Ministry of Natural Resources and Environment
MPa	mega Pascals
MPI	Ministry of Planning and Investment
Mt	million metric tonnes
Mtce	million tonnes of coal equivalent (multiply by 0.697 to get Mtoe)
Mtoe	million tonnes of oil equivalent
MWe	megawatt of electrical output (1000 kWe)
MWh	megawatt hour (1000 kWh)
MWth	megawatt thermal capacity
NEDO	New Energy and Industrial Technology Development Organization (Japan)
NOx	nitrogen oxides
OECD	Organisation for Economic Co-operation and Development (*see* Geographical Coverage for country listing)
O&M	operation and maintenance
OLC	overland conveyer
OPEC	Organisation of Petroleum Exporting Countries (based in Vienna, Austria)
PC	power companies
pf	pulverised fuel (hard coal)
PPA	power purchase agreement
PPI	producer prices index
PPP	purchasing power parity (a basis for comparing GDP to reflect living costs)
PV	Petrovietnam (also known as PVN)
RAR	reasonably assured resources (typically refers to uranium deposits)
R/P	reserves to production ratio
RM	reserve margin
ROM	run-of-mine, typically refers to raw mined material
Rp	Indonesian Rupiah
SC	supercritical (typical steam pressure <22.1 25 MPa; main steam and reheat temperatures 540–580°C)
SCR	selective catalytic reduction (for NOx reduction)
SIDA	Swedish International Development Corporation
SO_2	sulphur dioxide
t	metric tonne or 1000 kg (x 0.9844 = long ton; x 1.1025 = short ton)
t/h	tonnes per hour
tcf	trillion cubic feet (of natural gas or equivalent methane deposit)
TFC	total final consumption
TJ	terajoules
TPES	total primary energy supply (includes coal, oil, gas, hydro, other renewables, nuclear power)
TWh	terrawatt hour (1000 GWh, 10^6 MWh, 10^9 kWh)
UNFCCC	United Nations Framework Convention on Climate Change
U_3O_8	uranium oxide (ore)
UCG	underground coal gasification
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USC	ultra supercritical (typical steam pressure >25 MPa; main steam and reheat temperatures >580°C)
VAT	value added tax
VND	Vietnam (Viet Nam) Dong
VRC	Vietnam Railway Corporation
WEC	World Energy Council

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1 Introduction

1.1 Key coal facts

Total coal production (2009 estimate):	43 Mt
Total coal demand (2008 estimate):	20-25 Mt
Exports (2008 estimate):	20 Mt
Imports (2006):	0.3 Mt
Recoverable reserves (2006 estimate):	2000–3000 Mt
Port capacities (2008 estimate):	34 Mt

This report on Vietnam forms one in a range of reports covering coal and clean coal prospects in the major countries which comprise the Association of South East Asian Nations (ASEAN). Vietnam was last researched by the IEA CCC in 1995 in a study entitled *Asian Coal Prospects to 2010* (Daniel, 1995). Vietnam is an established player in the international market for coal, most notably for its export of anthracite coal.

The report examines the country's energy reserves, with a particular focus on coal reserves, coal quality, and distribution. The report also looks at the trends in coal production, consumption, and devotes analysis to coal-fired power generation, within the context of the entire generating fleet of power stations. Coal combustion technologies utilised in Vietnam today are described as well as looking at the range of environmental emissions control systems. Future prospects for coal demand and supply are examined based on power station building programmes along with expectations for coal production and coal importation.

Vietnam's coal industry is concentrated in the most north-eastern province of Quang Ninh, on the border with China. The industry currently produces around 40–45 Mt/y of mainly anthracite quality coal. With such close proximity to the coast, half of the coal produced is exported to customers across the Far East, notably power stations in southern China and steel mills in Japan. Coal is shipped through a few ports located in Quang Ninh.

Half the coal produced is used within the domestic economy, predominantly in industry (60% of domestic demand), but the power market will overtake and exceed industrial consumption in coming years as a drive towards developing coal-fired power within the country is under way.

The country's reserves are currently estimated at 6000 Mt, of which 2000–3000 Mt is thought to be recoverable. The uncertainty in the amount of reserves is being addressed by a joint Vietnam-Japanese survey which could verify the estimates of further reserves in excess of 210 Gt. Before any conclusive results are published, the uncertainty of reserves means that the life of the reserves could be anywhere between 14 and 45 years.

1.2 Geographical profile

The Socialist Republic of Vietnam (or Viet Nam) lies on the eastern side of the Indochinese peninsular bordering China in the north, Laos in the northwest and Cambodia in the south west. The South China Sea makes up the entire eastern coastal border of the country.

With a population of 84 million, the country is the 13th most populous in the world, similar to the populations of Philippines and Germany. Some 88% of the population is ethnically Vietnamese, with 12% being made up of Chinese, Thai, and other groups. According to the FT (2004), more than half the population is Buddhist, with some 7% being Catholic, and 38% of other religions or non-religious. Deaths resulting from past military conflicts means that older generations of women outnumbered men. Women form a high proportion of the labour force and have also risen to greater political prominence in past years.

The most populated areas are along the Red and Mekong Rivers. Vietnam's geography is such that the north has cool winters while the south is tropical. Temperatures are typically 10–30ºC. Central provinces are affected by typhoons, the northern Red River delta is subject to drought, and the Mekong delta in the south suffers from heavy flooding.

Tourism has been encouraged since the 1990s, with Russians, Chinese, Taiwanese, and Europeans accounting for much of the visitor numbers. Vietnam's visitor appeal lies in many areas not least the Red River Delta and Ha Long Bay, which are also close to the current and (possibly) future major coal mining operations of Vietnam. Tourism is also encouraged by local coal operations, and the state-run coal company Vinacomin operates a tourism subsidiary as part of its business.

Over half the country consists of the heavily forested mountain range Chaine Annamitique. The Vietnam War led to half of the country's forest being seriously damaged either from direct hit or from fall-out, much of it due to the defoliant Agent Orange. Some 5% of the forest was destroyed. Logging and coffee crops led to further deforestation and soil erosion; since 1997, timber exports were banned to preserve forests.

2 A brief political history

Vietnam's long history has been coloured by war, much of it from foreign involvement. There has been a history of Chinese control and invasions from other Asian rulers during the Dynastic era of the 1st to 10th centuries. Western dominance came during the colonial era by French military conquests in the 19th century, when the country became part of French Indochina. Plantations and agricultural commodities became major exports, but it was not until 1941 during the Second World War that the nationalist movement of Viet Minh under Ho Chi Minh emerged to oppose both Japanese occupation and seek independence from France.

The Soviet-backed Viet Minh fought French expeditionary forces (supported by the US and Vietnamese loyalists) in the First Indochina War between 1946 and 1954, when French Indochina was dissolved.

In 1954 at the Geneva Conference, Vietnam was in effect split between forces sympathetic to France in the south and the communist nationalists in the north, and in between was the Vietnamese Demilitarised Zone (DMZ) just south of the 17th parallel. The DMZ ran east-west splitting the country and spanned more than 100 km, and was little more than 2 km wide. The Democratic Republic of Vietnam (north) and the State of Vietnam (south) were formed, and political upheaval was already ensuing due to a newly self imposed president Ngo Dinh Diem in the south who then proclaimed himself president of the communist controlled Republic in the north.

The National Liberation Front began a guerrilla campaign in the late 1950s, supported by the government of the north. In the 1960s, Buddhist discontent arose due to Diem's 'discriminatory' policies and eventually as relationships with the USA broke down, Diem was killed in a coup. Northern communists gained ground as the south underwent infighting from one military regime to another.

The communist insurgency during this period of disquiet prompted the infamous Vietnam War as US forces became involved in combat operations, with troop numbers peaking to 500,000. The Paris Peace Accords in 1973 led to the troop withdrawal. In 1975, the North sent troops resulting in the 'Fall of Saigon'. The South later officially united with the North to become the Socialist Republic of Vietnam on 2 July 1976.

After reunification, communist central control took a firm grip of the country, and mass migration led to millions suffering from an international humanitarian crisis. Vietnam's relationship with China was tested as Vietnam invaded Cambodia, thus starting the Cambodian-Vietnamese War in 1978 in an aim to remove the Khmer Rouge from power. Even the Chinese launched a brief incursion into northern Vietnam (Sino-Vietnamese War) in 1979. Vietnam then relied more on Soviet economic and military aid.

Today, the picture is very different. Vietnam is a relatively stable economy with increasing, if not high levels of political and economic co-operation with neighbouring countries. This is evident in the number of hydropower generation and transmission link schemes that Vietnamese corporations are investing into in countries such as Laos, as well as extensive coal trading with China.

Internally, the Socialist Republic of Vietnam remains a single party state, with only the Communist Party of Vietnam permitted to hold power. Although elections are held, only Communist Party approved organisations such as the Vietnamese Fatherland Front, the worker and trade unionist party, are permitted to participate. While the Communist Party of Vietnam remains central to government, it is apparent that the ideology of orthodox Communism has taken a lesser role in governing the country, and instead made way for policies that promote economic prosperity and growth. Vietnam is active in a number of international organisations not least the United Nations, ASEAN, and the World Trade Organisation.

3 An economy in rapid transition

Vietnam is attempting to move towards a market economy without political liberalisation. Traditional communist systems remain firmly in place, with a politburo elected by the party central committee.

Historically, Vietnam has been an agricultural-based civilisation based on wet rice cultivation. The Vietnam War destroyed much of the economy of Vietnam. After the war, the Government operated a planned economy, including the collectivisation of farms, factories, and economic capital. The economy suffered from inefficiency, corruption, and woefully poor productivity. Economic activity and trade were restricted, and further suffered from the trade embargo from the USA and most of Europe.

In 1986, the Sixth Party Congress introduced economic reforms with market economy elements under the programme of 'Doi moi' (Renovation), not too dissimilar to Russia's policy of Perestroika. Hyperinflation and famine almost forced the government to reconsider the old Soviet-style centrally-planned economy and move towards a more wealth generating system. Although far from being a capitalist state, the economic model today in Vietnam is based on a so-called 'socialist market economy', and seems to receive little political opposition within the country. Private ownership is encouraged in industry, commerce, and agriculture. Farmers are able to lease their land back from state collectives, and choose appropriate crops based on profitability as well as suitability while selling the output at market prices.

International diplomatic relations in the past have been tested to varying degrees even amongst its allies with communist roots such as China and Russia. Relations with the USA have improved greatly encouraging a boom in inward foreign investment. Bilateral trade with the USA has boomed. In 2008, Vietnam imported some $3 billion worth of goods and services from the USA. In that same year, the USA in turn bought $13 billion worth of Vietnamese goods and services (Omdahl and others, 2009).

While the Communist Party was adapting to a new approach to governing a country, bureaucracy remained a problem during the early years of economic transition. Following the Asian financial crisis of the late 1990s, party leaders promoted more foreign trade and greater competition. By simplifying the rules for registering companies and the launch of the stock market, private business started appearing in massive numbers and foreign firms returned to the open industrial and manufacturing plants. While bureaucracy remains in any government around the world, Vietnam was clearly taking steps to shake off the image of the past of being tightly controlled by central government.

Manufacturing, information technology and high-tech industries form a large and fast-growing part of the national economy. Chandler and Prasso (2006) reported on the booming recovery that Vietnam is making, and much of this beyond the awareness of the average consumer in the west. In 2006, the US corporate giant Intel announced plans to build a $300 million test and assembly plant north of Ho Chi Minh City. Japanese manufacturers such as Panasonic and Yamaha have set up in business parks outside Hanoi while further north, Canon built the then largest inkjet printer factory in the world.

Vietnam's stock exchange was launched in Ho Chi Minh City in 2000, and despite the political leanings of the ruling party, the government remain focused on the task of building a strong economy. This is evident in the track record of growth since 1990. GDP growth throughout the 1990s averaged 7.6%/y. Growth continues to exceed 7%/y making it the probably Asia's second-fastest growing economy behind China. While growth is likely to exceed 8% in 2007, The IMF reported a possible drop in economic growth in 2009 to 5–6%/y, but this is expected to settle to a steadier 7%/y after 2010.

The IMF also estimated that Vietnam had an annual GDP of $71 billion ($220 billion on a current PPP basis) in 2007. With a population of 86 m, per capita GDP was approximately 829 $/cap in current prices. Per capita GDP is slightly below that for India (940 $/cap), and considerably below that for China (2480 $/cap). Personal wealth has improved especially amongst the middle income bracket. Since 1980, Vietnam has reduced the percentage of its population living on less than 1 $/d from 51% to just 8%, an achievement Chandler and Prasso (2006) state that is still some way off for even China. The percentage of people living in poverty is around 19.5% according to the ADB. Monthly wages for unskilled labour in Vietnam averages $56–65, while monthly salaries in China's coastal cities can reach $132 (Maltby, 2008).

According to the CIA (2008), the unemployment rate in Vietnam is 4.3% (2007 estimate). Agriculture still employs 56% of the workforce, while industry employs 19% and the rest by the service sector. The economy is gradually transforming, with the share of agriculture, fishery and forestry falling from 42% of GDP in 1989 to 20.4% in 2006, as production in industry and services has risen (ADB, 2008b; CIA, 2008). Despite a clear shift away from agriculture as a proportion of total GDP, Vietnam remains a major producer and exporter of rice, cashew nuts, coffee, tea, rubber, and fish.

Price inflation is a problem in Vietnam. In an attempt to limit the upward pressure on inflation from rising world prices, the Government froze domestic fuel prices in late March 2008, imposed a temporary ban on new contracts for rice exports in April, and raised export taxes on crude oil and coal in May and June of 2008 (ADB, 2008b). However, later in 2008 many of the decisions to freeze prices were reversed. Fuel prices were permitted to rise to levels similar to that of neighbouring countries, partly to reduce the burden of subsidies but also in response to the increased smuggling that resulted from the artificial fuel price differential between Vietnam and its neighbours.

Another major inflation risk is a devaluation of the Vietnamese dong currency, which could make imports more expensive and the trade deficit increase. Currency is also traded on the black market, and suffered from a sharp devaluation in the middle of 2008 (compared with the official rate) thus fuelling inflation of imported goods. The exchange rate has since settled to a rate closer to the official rate set by the State Bank of Vietnam. Provided the trade balance can remain in check, and inflation can be kept under control, the economic prospects for Vietnam look optimistic.

4 Institutions and energy policy

The Ministry of Industry (MOI) oversees activities related to the energy sector and other industries in accordance with the decree on 189/2007/ND-CP Issues by the prime minister on 27 Dec 2007. The MOI is responsible for the state management of all energy industries, namely electricity, new and renewable energy, coal, and the oil and gas industries. The MOI presides over the formulation of law, policies, development strategies, master plans and annual plans with respect to these sectors, and submits them to the prime minister for issuance or approval.

The Ministry that oversees power and coal plans is the Ministry of Industry (MOI). The Ministry not only determines first-line policy, it also has the supervisory responsibilities for the energy sector, such as the state-owned companies Vinacomin and Electricité de Vietnam (EVN). The Ministry of Industry (MOI) is responsible for master plans for electricity, coal, oil, and natural gas exploitation and supply; the Ministry of Science, Technology, and Environment (MOSTE) is responsible for overseeing national R&D programmes on energy and electricity planning.

MOI is responsible for supervising implementation of government policy, and recommending and drafting major policy reforms for government adoption. MOI is responsible for review and submission for Prime Minister approval of master investment plans for the sector and all major investment projects. Although these often require review and approval from other agencies as well, including the Ministry of Planning and Investment (MPI) and the Prime Minister's office, MOI is the government window for the energy companies. MOI reviews and recommends retail price adjustments for approval by the Prime Minister. Other major government institutions that are involved in energy issues are listed below:

- The Ministry of Planning and Investment (MPI) is responsible for the country's economic development plans. The MPI's involvement in the energy sector includes reviewing and the provision of recommendations to the Prime Minister for all projects using public funds or other resources.
- The Ministry of Finance (MoF) arranges Government guarantees for export credits, and provides, through its Development Assistance Fund (DAF), public sector loans to qualified users.
- The Ministry of Natural Resources and Environment (MONRE) is responsible for environmental regulation.
- The State Bank of Vietnam (SBV) is responsible for allocation of foreign exchange, and, as such, is the counterpart for international donor lending, and a key agency for implementing guarantees for foreign exchange convertibility.
- Provincial Peoples' Committees (PPCs) are responsible for overseeing local government, including all government functions delegated by the central government. At a provincial level, localised five-year plans can be drawn up, but must still be approved by the PPC prior to submission to the MOI. Other energy bodies carry out a variety of tasks involving R&D and deployment including:
  - Institute of Coal (Vinacomin);
  - Hanoi Technical University (HTU), Ministry of Education & Training (MET);
  - Institute of Oil & Gas (I of O&G), Vietnam Petrol & Gas Corporation (PETROVN);
  - Energy Department (ED), National Centre of Natural Science &Technology (NCNST);
  - Development Strategy Institute (DSI), Ministry of Planning & Investment (MPI).

The Vietnamese government clearly recognises a number of deficiencies in the market that prevent effective energy management across the entire economy. These include a general problem of poor end-user efficiency; low productivity in the energy industry; poor environmental protection; excessive bureaucracy in all decision making; inaccurate energy projection and analysis making planning problematic.

These statements at least suggest that the government and the Ministries intend to move the Vietnamese energy economy forward, part of which will be met by adapting the energy economy into a market-led model for electricity generation and primary energy production, notably coal, although the time frame for this is likely to be long term.

4.1 The National Energy Development Strategy

The National Energy Development Strategy was approved by the Prime Minister on 27 December 2008 (Decision No. 1855/ QD-TTg) and set up the targets for energy development for the period up to 2020, with a less committed outlook to 2050. The main targets are as follows:

- ensuring sufficient supply of energy to meet the demands of socio-economic development, in which primary energy is expected to reach about 68–69 Mtce in 2010, 143–157 Mtce in 2020 and about 443–457 Mtce in 2050;
- developing power plants and power networks, ensuring a sufficient supply of electricity for socio-economic development, and ensuring the reliability of electricity supply is 99.7% in 2010;
- developing refineries, step by step, to meet demand of petroleum products in the country, and increasing capacity of refineries to about 25–30 Mt of crude oil in 2020;
- ensuring national strategic oil stockpiling at a 45 days level in 2010, 60 days in 2020 and 90 days in 2025;
- achieving a share of renewable energy of 3% in the total commercial primary energy supply in 2010, 5% in 2025 and 11% in 2050;
- completing the rural energy program for rural and mountainous areas. Increasing share of rural households using commercial energy to 50% in 2010 and 80% in 2020. By 2010, 95% of rural households will have access to electricity;

- changing the electricity, coal, oil-gas sectors to operate in competitive market mechanisms with State regulation. Establishing competitive electricity retailing market in the period after 2022; establishing a coal and petroleum product business market by 2015;
- actively preparing necessary and harmonious conditions for putting the first unit of nuclear power plant into operation in 2020, then growing nuclear power in the national energy structure. By 2050, nuclear electricity will account for about 15–20% of total commercial energy consumption of the whole country. Vietnam is rapidly transforming into a net-energy importer. Clearly energy security is becoming a growing concern. National energy policy recognises that more effort is needed in exploring and understanding reserves and resources of indigenous energy from fossil fuels, hydropower, and other renewables. Greater efforts in exploration and surveying are being undertaken to increase the proved reserves and potential of energy resources of which coal plays a major part.

While there is a commitment to prioritise a number of issues, the chief priorities seem to lie in the reliable provision of electricity and renewable power. The provision of electricity spans the security of supply of electricity and the delivery of power in the rapidly expanding end-user market. There is greater emphasis on renewables includes, solar, wind, and biomass. Without doubt, hydropower takes precedence over any other form of renewable power.

4.2 Overview of Vietnam's coal industry policy

Coal is seen as an extremely important aspect of energy policy, with a substantial domestic mining industry that currently exports a bulk of its output. The coal export business is encouraged for now in order to earn foreign currency revenues to help finance development and advancements elsewhere in the economy. However, on a broad basis, the coal industry is a highly strategic industry, which will be geared towards exports or towards the domestic market whenever it is felt necessary to do so. It is the government's intention that EVN builds a great deal more coal-fired power to alleviated power shortages. New coal-fired power projects are being urged by the government in order to bring reliable supply of electricity to the main demand centres in the north and south.

While the state coal and mining company Vinacomin will endeavour to expand exploration, surveys and production, there is a possibility that coal that was once destined for the export market will be contained within the country for use by Vietnam's power stations. While this seems like a threat to the anthracite export market, the condition for this to happen will depend on whether the future coal generating capacity will be capable of burning anthracite quality coals. This issue is discussed later in this report.

In January 2003, the government issued a decision (No 20/2003/QD-TTg of 29 January 2003) by the Prime Minister regarding the development of the coal industry in the period 2003-10 with targets for production, and aspirations for the period 2010 to 2020. The plan included a number of commitments that aimed to modify and improve coal industry practice and productivity. This particular decision paper is important as it lists all the main coal mines in Vietnam along with the corresponding production capacities. A subsequent revision to the decision was issued in 2008 under No 89/2008/QD-TTg of July 7 2008. The basic platform for development is essentially the same but extends the plans to 2015, and has a greater degree of emphasis on shifting the coal market to a more competitive regime than in the past.

Many of the points of both decision papers outline the direction in which the coal industry will be developed, especially in the Quang Ninh province. The second plan is more sophisticated in its approach to coal transportation and coal processing, as well as financing projects more through private equity thus relieving the burden of finance from the state budget.

The core plan consists of four Articles:
- Article 1: Development plans for the Vietnamese coal industry;
- Article 2: Allocation of responsibility to various industry parties;
- Article 3: The Decision to take effect 15 days after signing;
- Article 4: Implementation of the Decision by all relevant stakeholders;

Under **Article 1** of the 'decision' the main points are summarised as follows:
- economic and efficient exploration, exploitation, and efficiency;
- manage domestic demand and exports;
- recognise socio-economic developments, tourism, security of energy supply, environmental and ecological protection;
- improve and invest in existing operations;
- boost exploration in deeper fields to raise reserves levels;
- improve production techniques and technologies in existing projects;
- investment capital at VND 14.1 trillion ($0.8 billion) to improve and expand existing projects, and develop new ones.

Article 2 describes the various stakeholders with some of the main responsibilities delegated to the Ministry of Industry, which will oversee and co-ordinate Vinacomin's plans with all other organisations as well oversee mine safety and labour policies. Vinacomin carries out the coal production activities, and organises the implementation of the action plans, responsible for human resource training, R&D, and the advancement of productivity and safety in its operations.

Articles 3 and 4 contain administration issues regarding the implementation of the previous two articles.

Vietmindo is the only other coal company, and operates in the Vangdanh-Uong Bi area of Quang Ninh and is a joint venture between an Indonesian partner and the Uong Bi Coal Company (Vinacomin's subsidiary) and has been operating since 1997 although its first sales started in 1998. Vietmindo's annual production is just 0.6–0.7 Mt/y, with ROM production averaging 1 Mt/y between 2000 and 2004. The company's marketable coal reserves of 36.7 Mt from a total area of 1300 ha can sustain mining beyond the end of its concession period, which lasts for 30 years. In addition, this licence could be renewed for another period in the event that the company still needs more time to achieve longer-term production goals.

4.3 Overview of the Vietnam electricity market policy

With regards to wider strategies to develop the electricity market the Government periodically issues five-year plans through the Ministry of Industry. Plans relate to power system planning, R&D programmes, development of technologies as well as development of the existing infrastructure, and electricity generating capacity. What seems to be lacking is an effective initiative to improve efficiency in the end-user market and the seemingly rampant growth in demand that is exacerbating the problems of power shortage nationwide. It is not being ignored however, as a programme to ensure a greater adoption of energy efficiency measures and awareness is being pushed forward.

As of 1 July 2005, the latest Electricity Law came into effect. Ambitious targets for power generation were put forward, generating 53 TWh by the end of 2005, and 88–93 TWh by 2010, then 201–250 TWh by 2020. These targets were laid down in the Strategy for Electricity Development set out in Decision 176 of the Prime Minister in October 2004. Part of the measures included creating a competitive electricity market, and diversifying the sources of electricity.

The overarching issues cover relatively advanced concepts for market structure, considering the economy is centrally planned. The principles of market forces will prevail in the power market over time, with the aim that increased efficiencies and the realisation of production costs (without subsidy) sets electricity tariffs.

Developments in generation will start with competition in the generating market (under a single buyer system), then progress to the wholesale trading market, and then finally progress to the retail (end-user) market. The Prime Ministerial Decision 26/2006/QD-TTg was approved in January 2006; with the establishment of this legislation the power market will be developed through three steps:

- Level 1 (2005-14): a competitive generation power market will replace the current monopoly and subsidised power situation;
- Level 2 (2015-22): the establishment of a competitive wholesale power market;
- Level 3 (after 2022): the realisation of a competitive electricity retail market.

However, while the principles are in place the likelihood of achieving full competition is small. According to a report by FDB (2005), it may take 30 years for reformation of the markets to take place fully. However, a change in the political regime from a Communist state to a full democracy could potentially bring about a swift change much sooner.

5 Primary energy supply

In 2006, the total supply of primary energy to the economy rose to more than 74 Mtce. The growth in total primary energy supply since the early 1970s has averaged a modest 2.8%/y, mainly attributed to the rise in demand for oil products like petroleum since the 1980s, while the 1990s saw a stronger emergence of hydroelectricity and natural gas. Coal consumption rose steadily, but until recently had not formed a particularly dynamic trend over the long term. In more recent years, this has changed and coal demand has increased at a significant pace. Coal, oil, and natural gas have absorbed a great deal more of the share of primary energy over time. Biomass and waste remain the largest providers of energy in Vietnam today, albeit at a smaller share of total primary energy supply than in the past.

5.1 Biomass – still the dominant fuel

While this report focuses primarily on coal, it is worth looking at the role that biomass such as wood fuel has in the Vietnamese economy, and understand its possible continuing importance. Despite the rise in conventional fuel consumption, Figure 1 shows clearly how the demand for energy in Vietnam remains dominated by demand for combustible renewables (biomass) and waste. This group of fuels includes solid, liquid, and gaseous biomass or waste products such as wood fuel or industrial waste streams. For simplicity, this report will refer to these as biomass and/or waste.

In Vietnam, biomass consists of wood fuel and agricultural residues (rice husk, rice straw, coffee husk, and bagasse). Biomass fuel sources include forest wood, rubber wood, and residues from logging, saw mill, sugar cane, rice and coconut shells. By 2006, biomass and waste still accounted for a massive 46% of the primary energy demand in Vietnam. Petroleum products accounted for 22%, coal 17%, and natural gas 10%. A study by the Business Council for Sustainable Energy (BSCE, 2005) suggested that biomass use in the residential sector in 2000 was mainly for cooking stoves (22 Mtce), while kilns and electricity co-generators used a further 4.3 Mtce, a large proportion of this may have been in the form of charcoal.

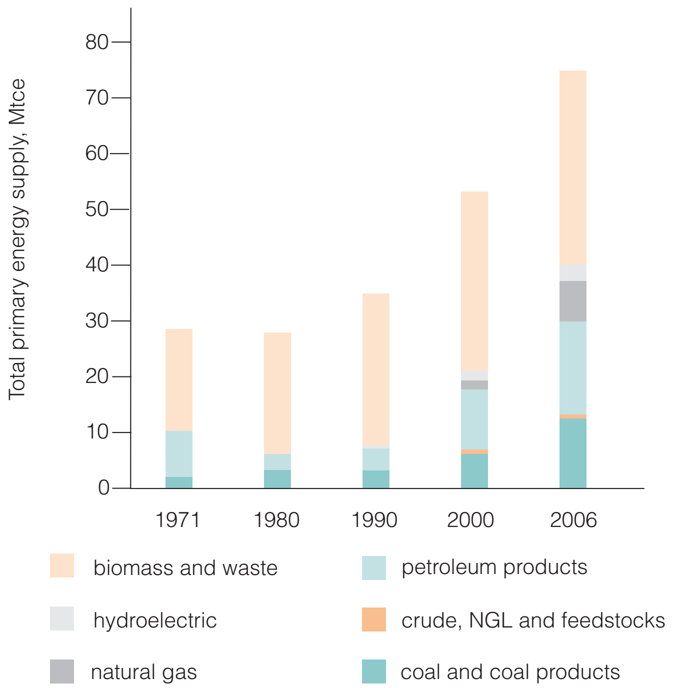

Figure 1 Total primary energy supply 1971 to 2006, Mtce (IEA, 2009)

In total, biomass consumption amounted to 20 Mtce in 2000. IEA data however has consumption of biomass, which was almost entirely burned in the residential sector at 31 Mtce, a figure that is considerably higher than the 20 Mtce published by BSCE. While it is not clear which of the figures is correct, the pattern of estimating wood use is far from straightforward. Wood fuel is generally used for cooking, while water and space heating are also important applications. In some cases, wood fuel provides energy for cooking, heating and lighting at the same time. In some rural areas, wood fuel might be collected by the end-user directly from the surrounding land, so consumption patterns are not readily recorded as a cash crop. Therefore, wood fuel consumption is no longer limited by income, but rather the availability of wood.

Fuel switching away from wood fuel to conventional alternatives is common especially where incomes rise more rapidly in more urban areas, but despite strong economic growth, one would expect a fall in biomass consumption as traditional rural lifestyles are modernised. While the efficiency of heat and availability of wood fuel is of less concern, switching to more efficient stoves that are heated using cleaner conventional fuels can have major positive impacts on health and is often promoted through government schemes. Interestingly, Vietnamese biomass consumption has not fallen. Biomass usage appears to have actually increased since 2000, from around 31 Mtce to 34 Mtce, indicating a continued preference for biomass.

Figures 2 and 3 show the domination of the residential sector in the energy market and the importance of biomass. An interesting observation is the apparent lack of electrification amongst Vietnamese households accounting for a much smaller percentage of overall residential energy demand, possibly a reflection of the more agricultural past. The transports sector unsurprisingly makes the most use of petroleum products, while industry is a major user of coal, consuming some 7 Mtce out of a total 13.7 Mtce for that sector; the rest is electricity and petroleum products. Between 2000 and 2006, overall energy and coal demand in the industry sector rose at a rate of 17–18%/y, although the impact on air emissions and CO_2 rose significantly also.

Aside from the power generation sector, the major end-users of coal include the cement, paper, and fertiliser industries.

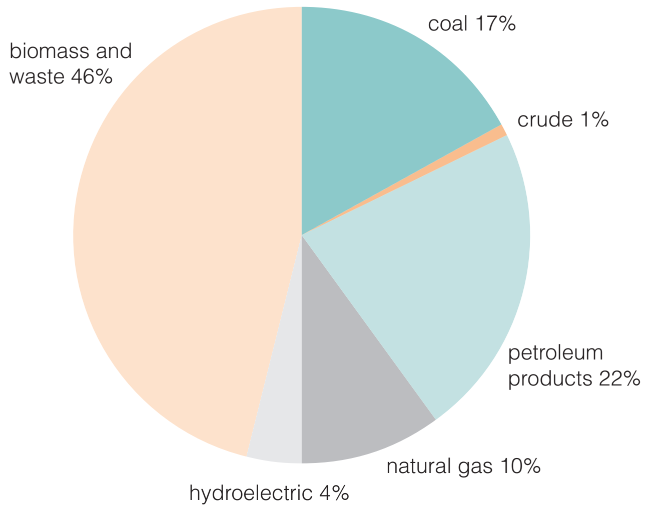

Figure 2 Total primary energy supply (74 Mtce) in 2006 (IEA, 2009)

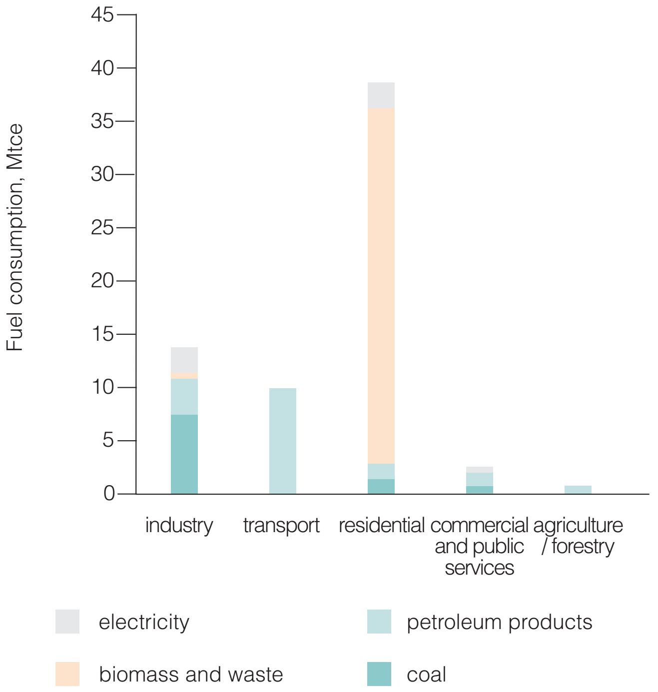

Figure 3 Fuel use by end-user in 2006, Mtce (IEA, 2009)

However, finding disaggregated data on coal usage in these industries is not straightforward. It is possible to gain an understanding of potential growth by looking at trends in the production of cement, which in turn may be influenced by other indicators such as the rate of construction of infrastructure and buildings in the country. According to the Vietnam Cement Association, domestic cement production could increase from 25 Mt in 2004 to 50 Mt by 2010 while tentative estimates suggest that production already reached 32 Mt in 2006-07 (VNCA, 2008). This would suggest that in the six years between 2004 and 2010, cement production increased by an average 12%/y, considerably faster than economic growth and overall coal demand in the industry.

The paper industry also grew at a similar rate to cement production at 12%/y, but does not fully explain the growth in industrial coal demand >17%/y. Between 2001-05, the Vietnamese Paper Industry (VPC) increased output by 13.3%/t reaching a level of production of 1.3 Mt. In 2005, the growth reached 13% and turnover increased by an even bigger 31% (VND 3.4 trillion, or $212 million), but not likely to form a significant rise in the demand for coal. The paper industry intends to increase paper production to 1.4 Mt, and 0.6 Mt of pulp. The intention is to reduce paper imports and eventually cater for 70% of the domestic consumer market by 2010 .

The fertiliser industry is also a major consumer of coal, but accurate energy consumption figures are not readily available. Needless to say, some parts of the industry are gearing up for a major increase in coming years. There are a number of types of fertiliser for different crops and uses, but for urea fertiliser production capacity is expected to almost double to 1.7–1.8 Mt by 2011 from the current 0.9 Mt. Total fertiliser production in the country was estimated to be around 8–9 Mt/y. All these industries expanded production and output, but at a rate considerably below that of the 17–18%/y in coal demand recorded for industry. This could be due to fuel substitution away from oil and gas in favour of coal.

6 Energy resources of Vietnam

Pinpointing accurate figures for reserves or resources of fossil fuels is rarely straightforward for Vietnam, and frequently comes under scrutiny by a number of studies. Often the resource figures for some countries are stated incorrectly as reserves or even misinterpreted as economically recoverable.

Minchener (2009) and Kavalov and Peteves (2007) are two examples of studies that have attempted to examine the issue of reserves reporting in an objective way. Figure 4 illustrates how confidence in reserve/resource estimation diminishes depending on geological certainty and economic feasibility.

The most meaningful section of this graph is the proven reserves that are considered economically accessible.

The following section attempts to describe the amount of economically recoverable reserves of energy that exists in Vietnam, and the remaining life of the existing reserves. This does not preclude further reserves being made readily available as a result of enhanced recovery techniques and further exploration, but is the best assessment with the current data that are available.

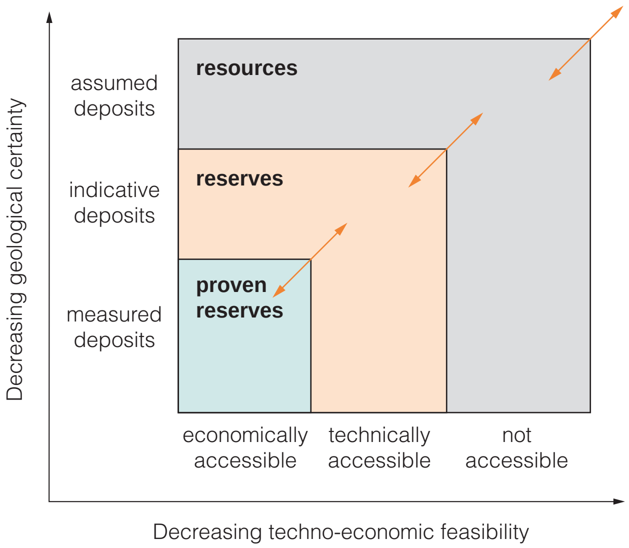

Figure 4 Depiction of resources and reserves (Kavalov and Peteves 2007)

6.1 Oil resources

Oil production started commercially in 1986. During the first half of the 1980s, oil was first discovered offshore in three fields (Bach Ho, Rong and Dai Hung). Further discoveries were made to help avert a reserves depletion in coming years. The production of crude oil (averaging 34° API) began in 1986 and rose steadily until 2004, but then fell by about 8% in 2005 and has barely recovered. Historically, all the crude oil output was exported for refining in other countries, and then refined oil products were imported back again for domestic consumption. Oil products sold to Vietnamese users were therefore subject to exchange rate risks twice, once for crude oil going out of the country, and second for oil products coming back in. For reasons of cost and security of supply, Vietnam was keen to move away from this dependence on international markets.

In recent years, Vietnam has been developing its first oil refinery. The $2.5 billion project at Dung Quat will output 0.14 million barrels per day (Mbbl/d) of products. Construction began in November 2005 after several years of delay in securing investment. The main problem was location, whereby Dung Quat is located 600 miles from the Bach Ho oilfield, and some distance from the population centres of Hanoi and Ho Chi Minh City. Transportation by pipeline would therefore be a cost consideration, nevertheless, operation was expected to start in 2009. A second refinery is also expected in the north of the country, which could be located closer to end-user markets and could produce 150,000 barrels per day (bbl/d). Plant construction is expected to start in 2010.

Vietnam is a relative newcomer to oil production, but production has steadily fallen in recent years, with production in 2004 at 21 Mt/y (0.4 Mbbl/d) to 18 Mt/y (0.34 Mbbl/d in 2007 (BP, 2008).

Today, production occurs at nine offshore oilfields, the largest of which is the Bach Ho (White Tiger) field operated by Vietsovpetro, the joint venture between the national oil company Petrovietnam and the Russian company Zarubezhneft. This joint venture forms the largest oil company in Vietnam.

The decline in production has been largely due to a fall in production at Bach Ho, which accounts for around half of the country's crude production. Several new projects are expected to come online such as the Su Tu Vang (Golden Lion) field, which could ramp up to 0.1 Mbbl/d before the end of 2008, equivalent to a third of the production level in 2007. Other projects such as Phuong Dong and the Ca Ngu Vang field, with production expected to be around 20,000 bbl/d, are also due to come online in 2008.

The oil market is dominated by the Vietnam Oil and Gas Corporation (Petrovietnam) which is fully state-owned. Petrovietnam is controlled by the Ministry of Industry, but the oil company is in practice directed by the Politburo and several other central government agencies. Petrovietnam's interests also lie in power generation and, as this report shows later, is a large investor in the nation's future power generating capacity.

Given the relative openness of the Vietnamese economy, Petrovietnam has formed a number of partnerships with international oil companies including BP (UK), ConocoPhillips (USA), Korea National Oil Corp, Petronas (Malaysia), Nippon Oil (Japan), and Talisman (USA).

The involvement of foreign companies should improve oil reserve reporting and methods of estimation. However, the information on current oil reserves is not entirely conclusive. The World Energy Council's latest survey of Energy Resources (2007) uses 2006 data from the BP Statistical Review. According to sources quoting the Oil & Gas Journal, Vietnam held 600 Mbbls of proven oil reserves as of January 2007 (EIA, 2008). In the same report, Vietnam is said to have produced roughly 0.4 Mbbl/d of oil, which would imply a low R/P ratio of 4–5 years. If this is a realistic assessment then Vietnam is heading for reserves depletion very quickly and will become an importer of crude oil before 2012.

However, according to the BP Statistical Review (BP, 2008) Vietnam has 3400 million barrels of crude oil in proven recoverable reserves. Based in this figure, Vietnam has 27 years of oil production left. This higher reserves figure published by BP and the WEC is supported by the German Institute BGR, which puts the R/P ratio at around 20–25 years based on year end 2006 production and reserves figures.

6.2 Natural gas

The natural gas industry operates in combination with the oil industry and is under the control of Petrovietnam. Much of the natural gas is produced from associated fields, which are oilfields that also have reserves of natural gas existing in pockets that, due to being a lower density, sit above the surrounding oil reserves but capped below an impermeable rock strata. These are also colloquially known as 'wet' gasfields.

The Bach Ho oil field produces a significant amount of 'wet' natural gas, while two major 'dry' gasfields include the Lan Tay and the Lan Do fields. These fields contain more than 56 billion cubic metres (bcm) of recoverable gas reserves, a quarter of the country's total. A further 26 bcm could be contained in the Rong Doi (Twin Dragon) and Rong Doi Tay (Twin Dragon West) gas fields.

The Lan Tay and Lan Do fields are of particular interest as they incorporate the Nam Con Son Gas Project (NCSGP) which is an integrated gas-to-power project that takes gas offshore and transmits it via a 230 mile subsea pipeline and onshore to the Phu My power complex. This power complex is also a potential source for CO_2 capture from the 4000 MWe combined cycle gas turbine project which will lead to the capture and storage of CO_2 for enhanced oil recovery (EOR) at the Bacj Ho oil field.

Pinpointing the volumes of gas reserves is not straightforward given that the reserves range widely from 192 billion cubic metres (bcm) to 1200 bcm (263–1644 Mtce). This wide range is probably attributed to a difference in definitions of what is reserve and what is resource. The EIA (2008) reported proven natural gas reserves as at 190 bcm as of January 2007, or 262 Mtce. The BP Statistical Review estimates that proven reserves of gas are a little higher at 301 Mtce (approx 220 bcm). Other estimates suggest that Vietnam has some 1643 Mtce of gas reserves (Hoang Loung, 2006), but is more likely to include reserves that are not yet economical to extract, or indeed proven from detailed exploration.

In 2007, Vietnam produced 9 Mtce of natural gas (IEA, 2009), which constitutes just 10% of the country's primary energy production. Assuming the most conservative reserve of 262 Mtce, the R/P ratio will be less than 30 years.

6.3 Hydroelectricity

Being a largely mountainous country, Vietnam has abundant hydro resources, particularly in its central and northern regions. Vietnam's geography spans the South China Sea and the Gulf of Tongking. The geography means there are sharp local contrasts in the climate. In the north, winters are cool, while the south is more tropical with more even temperatures all year round. Central provinces are affected by typhoons but, with regard to hydropower, the northern Red River is regularly subject to drought while the Mekong in the south suffers from heavy rainfall and flooding at the delta is common.

Hydroelectric development has historically received high priority in Vietnam. Generation from hydroelectricity plants grew 9.7%/y between 1990 and 2006. In 2006, hydro output reached 23.6 TWh. The potential resource for hydroelectricity, if exploited economically, could be as high as 75–80 TWh/y (WEC, 2007). The 'technical' capacity is 123 TWh/y, but these figures must be treated with caution. Technical capacity assumes that every conceivable natural flow of water to sea level (or to the border of Vietnam) is utilised provided current technology can exploit it. Clearly, the ecological ramifications of exploiting hydroelectricity to these limits would be a major issue. The Son La province is in the northwest of the country and the geographical relief is mountainous and perfect for hydropower.

There are social and environmental impacts of building hydro plants in economies with large rural populations which account for 75% of the total population. The Son La hydro project (due online between 2012 and 2015) is one example of the environmental impact such a project can have and where the resettlement of 70–90,000 people since 2001 was not straightforward. In future, hydroelectricity may have a lesser role in the power sector, although this does not render hydropower obsolete in project development terms. There is still plenty of potential for business to invest in hydroelectric schemes.

All power generation is susceptible to periodic downtime in operation, but none as fundamental as when renewable energies are impacted by sudden and prolonged outages due to weather related incidents. In 2005, electricity shortages resulted from low reservoir levels. Year-to-year, this is a common feature of economies such as Vietnam, Spain, and Norway with large supplies of renewable hydro energy. Some of these eventualities can be prepared for using back-up thermal capacity. Unlike wind and solar power, hydroelectricity is a form of power storage that makes hydro far more controllable than other renewable sources.

6.4 Uranium

Vietnam is not commonly associated with uranium resources, but exploration has been carried out since 1955. Since 1997, exploration centred around the Nong Son Basin in the Quang Nam province of central Vietnam.

It is worth outlining the method used for assessing uranium reserves. Like any energy commodity, uranium reserves are dependent on the cost of uranium (U_3O_8). Resources are reported in the publication Uranium 2005: Resources, Production and Demand (Red Book), a joint report of the OECD Nuclear Energy Agency and the International Atomic Energy Agency (NEA/IAEA, 2006). The resources reported by 44 countries are classified by the level of confidence in the estimates, and by production cost-categories. The 2005 Red Book deviates somewhat from the resource categorisation used in former Red Book editions. Identified Resources consist of two categories:

(a) Reasonably Assured Resources (RAR) – recoverable within a specified cost range;

(b) Inferred Resources – in addition to proved reserves that are recoverable, but inferred based on direct geological evidence and not proven.

For each category, recoverable uranium is grouped into three subcategories based on production cost-ranges in dollars per kg of uranium; these subcategories are equivalent to <40 $/kgU, <80 $/kgU and <130 $/kgU. Costs include the direct costs of mining, transporting and processing uranium ore, the associated costs of environmental and waste management, and the general costs associated with running the operation (as defined by the NEA).

Figure 5 shows the historical price of uranium since 1987. There has been a long period of steady prices between 1987 and 2004, averaging within a narrow band of 22–33 $/kgU.

After 2004, the price of uranium oxide began to trend upwards, but at a rate not seen in the previous period. The price spiked massively, reaching 300 $/kgU in 2007. However, the upward spike stopped abruptly, and common with almost all other commodity prices, effectively collapsed, dropping to around 110 $/kgU in 2008.

Uranium reserves figures change depending on the cost bands, but given the trend over the last few years it is not easy to settle on an appropriate band. Taking the 2008 price of 130 $/kgU – which lies between the historical low and high levels – it is possible to make comparisons with published data. The WEC (2007) reported Vietnamese RAR reserves at <130 $/kgU to be 1337 tU. Inferred resources at this price were also estimated to be 7244 t. In both RAR and inferred reserves, some 75% was expected to be economically recoverable.

These data alone give little idea of the scale of the reserves since none is produced. However, according to the Australian Uranium Association, about 200 t of uranium (or 160–170 tU) is required to keep a large 1000 MWe nuclear power reactor generating for a year. At 2008 prices, Vietnam’s reserves do not contain enough uranium to feed a large reactor for much more than eight years. However, with further exploration and greater certainty of deposits, there is potential to feed a large reactor for several decades.

Approximately 15% of the inferred reserves were reported to fall into the <$80 cost bracket, therefore improving the chance of this potential. Undiscovered in situ conventional resources recoverable at up to 130 $/kgU consisted of 7860 t in the prognosticated resource category (PR) for which the evidence of uranium is mainly indirect but is believed to exist in well-defined geological trends or areas of mineralisation with known deposits. A further 230,000 t could be contained in speculative resources, 40% of which could be at <130 $/kgU, and the rest in a cost range that is not

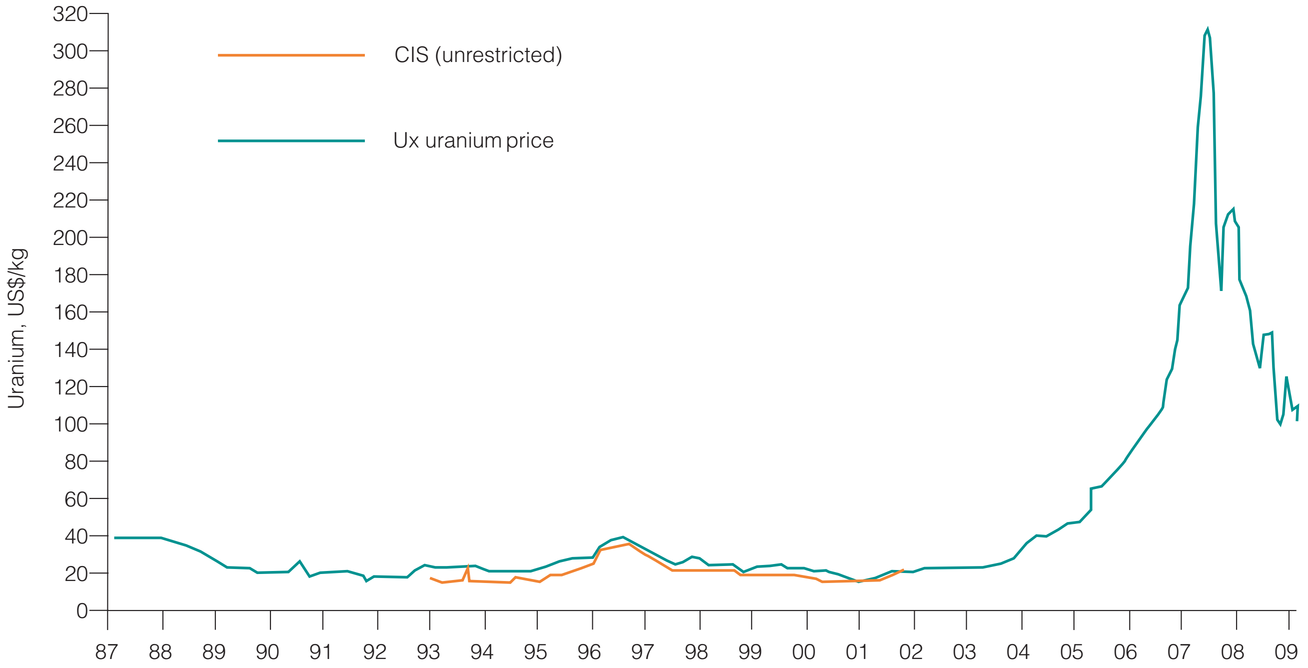

Figure 5 World price of uranium US$/kg (UxC, 2009)

determined. Hoang Luong (2006) reported that Vietnam had some 218,167 Mt of uranium deposits, although the accuracy remains unconfirmed. However, if even a fraction of this could be confirmed as mineable then the potential to run a large nuclear reactor in Vietnam could be closer to reality.

There is no large civil nuclear reactor operating for the purposes of public power generation existing in the country today. The country's sole nuclear reactor in the Da Lat Nuclear Institute in Central Highlands Lam Dong province has a capacity of a mere 500 kW. It is used for training and research purposes. The Da Lat reactor was built in 1963 by the USA, and later upgraded by the former-USSR.

The Da Lat reactor is fuelled using low-enriched uranium (LEU), part of which is converted from highly enriched (HEU) uranium. The Vietnamese authorities signed a tri-party agreement with Russia and the USA to remove stocks of highly enriched uranium, and return unconverted weapons grade material to the country of origin. The Vietnamese Agency for Radiation and Nuclear Safety and Control reported the return of HEU fuel rods to Russia as part of anti-terrorism agreements with the USA and Russia.

6.5 Renewables and geothermal

At the present time, there is no geothermal power generation, although geothermal resources do exist. A pre-feasibility report for six plants (total capacity, 112.7 MWe) in central Vietnam has been prepared but the project has been postponed. The government-supported exploration and evaluation of the country's geothermal resource has shown that there is a total of 269 prospects and a potential of 649 MWth. The south-central, north-western and north-central regions are the areas of Vietnam with the greatest potential. Direct utilisation is limited to the provision of industrial process heat (iodide salt production, 1.4 MWth) and bathing and swimming (29.7 MWth).

Wind, solar and other forms of power generation from renewables are almost non-existent except for a small 30 MWe project that has been approved at Cau Dat, for which the project developer is Cavico. This is in stark contrast to the massive quantities of biomass that are consumed in the various economic sectors.

7 Coal resources and reserves in Vietnam

A wide range of coals are available for potential exploitation. Every coal rank is found in Vietnam, from the large amounts of anthracite already mined, to bituminous, subbituminous, lignite coals, and peat. Figure 6 illustrates the current proven reserves; as more resources are explored and surveyed, this chart may well change. Vietnam currently has a greater wealth of proven anthracite reserves compared to any other coal rank. This notable emphasis on anthracite coal is a reflection of the geographical concentration of coals and coal production in just a few areas of the country. This section discuses the distribution of coals, while coal qualities are discussed in greater detail in Section 7.4.

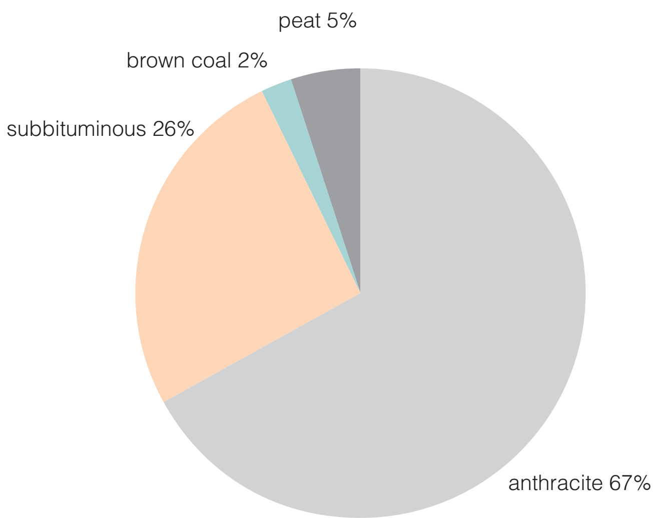

Figure 6 Proven coal reserves by coal type (Total = 6.1 Gt) (Thanh Son, 2006)

7.1 Where the coal is found

Before discussing the distribution of coal across the country, it is worth mentioning there is currently a re-evaluation of Vietnam's coal reserves and resources through increased survey work, which is being done in conjunction with Vinacomin and several Japanese organisations such as JCOAL, NEDO, and JBIC. These surveys are yet to be completed, some time after 2009 for the Quang Ninh basin and after 2011 for the Red River basin. However this section draws on the current knowledge and availability of data.

Despite some optimism regarding coal reserves in Vietnam, coal is not evenly distributed across the country. The major deposits are currently concentrated in just two geological basins, the Quang Ninh and the Red River basins, both located in the far north of the country (*see* Figure 7). Coalfields have also been identified in numerous sites in the central and southern regions of the country. Coal reserves have been identified offshore in basins along the continental shelf of Vietnam; although this report will not consider these reserves, the potential for their exploitation using underground coal gasification is discussed in detail by Couch (2009).

Onshore coal resources are spread across the country and shown in Figure 7 as a nationwide map showing the locations of the main coalfields (Hung, 2007) and combined with this the indicators of coal rank that can be expected to be found in various parts of the country (Vinacomin, 2009). The first striking feature is the vast area of land that seems to contain coal, although the map does not indicate the volume of coal found. Areas of land could contain thin or fragmented seams, and so the actual reserves could be poor, despite apparently covering a wide area as Figure 7 suggests.

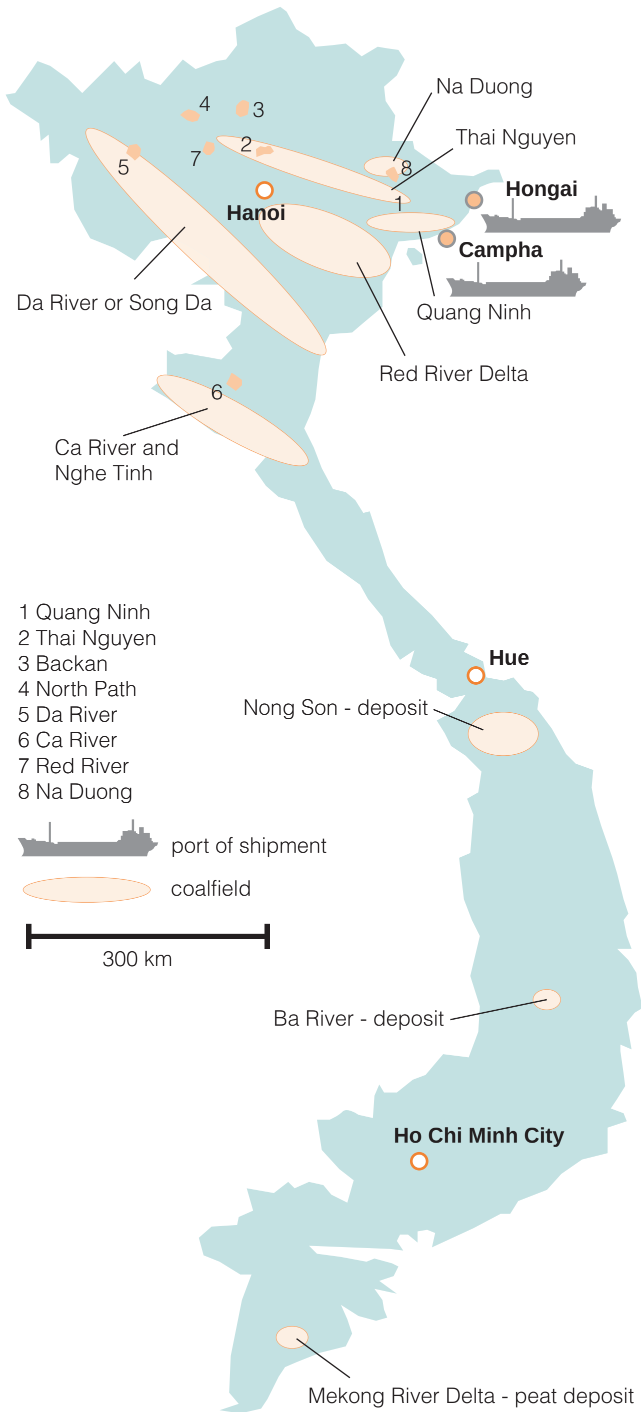

Figure 7 Map of Vietnam's coal reserves (Ritschel and Schiffer, 2007; Bui and Drebenstedt, 2004)

Quang Ninh is probably the most explored coalfield and is where current production is almost entirely concentrated. Almost all discussion on recoverable, or mineable reserves refers to those found in Quang Ninh. Coal has been exploited in Quang Ninh province for 100 years. It is one of the farthest northeast provinces bordering China. The location of major coal reserves are shown in Figures 8 and 9.

Quang Ninh occupies a total area of about 5900 km², of which 2800 km² is forest land, and 510 km² is agricultural. Around 40% of the population is concentrated in and around the city of Ha Long, which suggests that Quang Ninh is more urbanised than many other parts of Vietnam where the average urban population accounts for just 25% of the total. The Quang Ninh coalfields are located close to the coast and

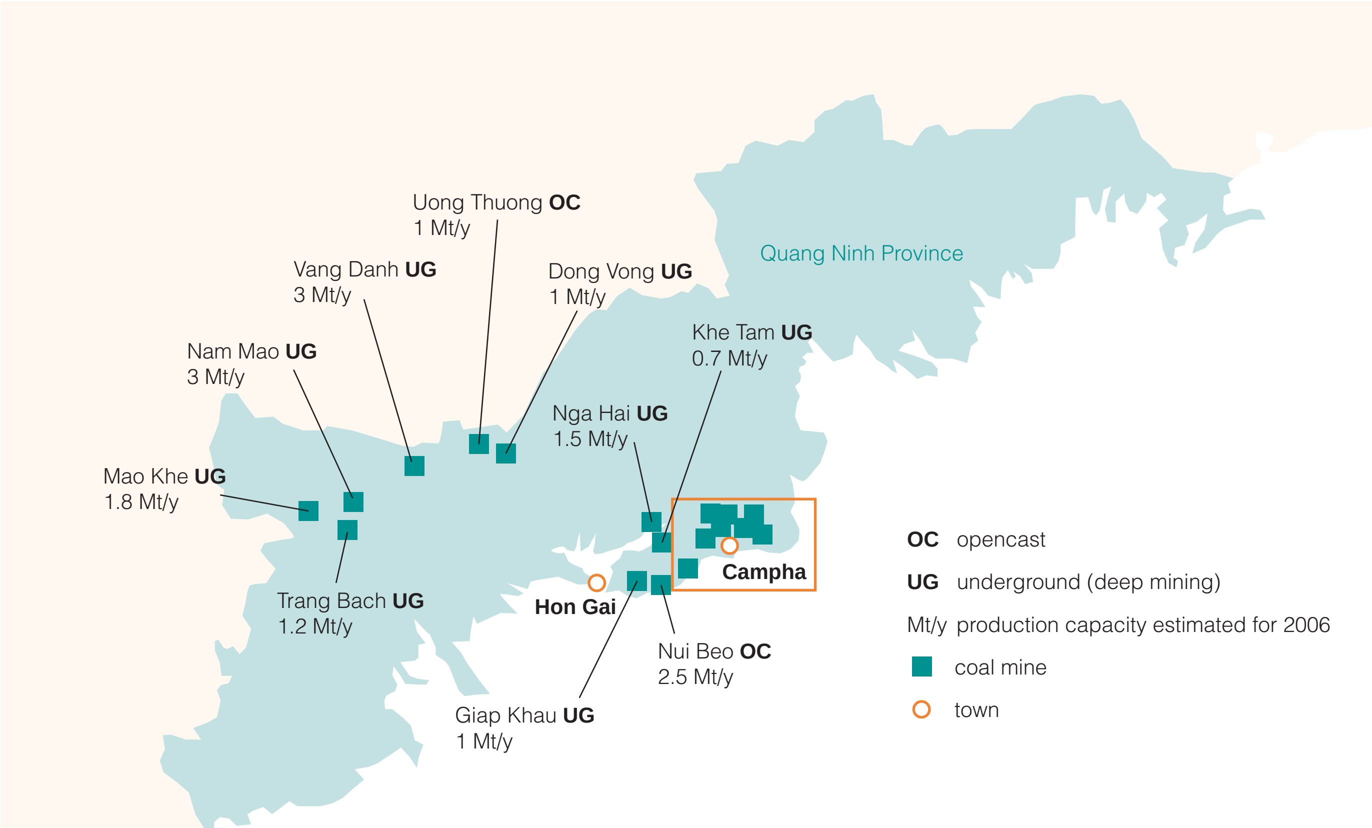

Figure 8 Coal deposits in Vietnam

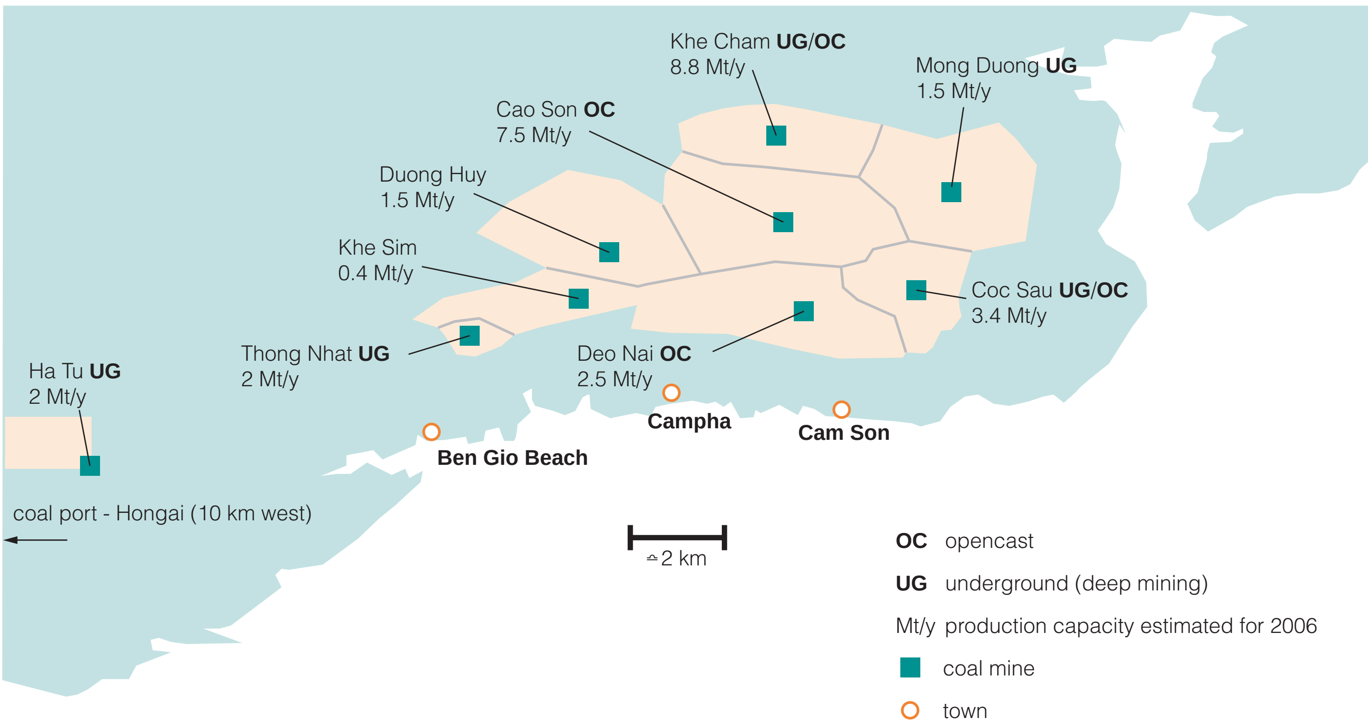

Figure Major coal mines around the Campha region

so are ideally located for exporting coal to the international seaborne market, as well as for transit by ship to ports in the south of Vietnam where there is a dearth of coal resources. The coalfields are close to the major coal ports of Campha (or Cam Pha), which is also the name of the province which is a major centre of coal production (*see* Figures 8 and 9). Another major port is located several km west of Campha in the province of Ha Long around the major town of Hon Gai (or Hongai).

The greatest concentration of coal mining activity is clearly seen in Figures 8 and 9 showing the Quang Ninh province and the coastal area of Campha. The Campha region probably has half of the production capacity available in Vietnam today. There are a number of production facilities in the western areas of Quang Ninh (*see* Figure 8) where operating mines serve local power stations by truck and rail as well as having access to rivers by barge. These are found mainly in the area of Uong Bi close to the western border of Quang Ninh.

Figure 10 shows the percentage share of major coal regions where production exists, and presumably refers mainly to anthracite reserves. As seen in the figure, at least 66% of the reserves published by Thanh Son (2006) were found in three regions of Quang Ninh. Other regions accounted for 34%, which are referred to as Interland, or otherwise known as the Vietnamese Interior, which probably refers to the provinces west of Quang Ninh such as Bac Giang, Lang Son, Thai Nguyen to name just a few.

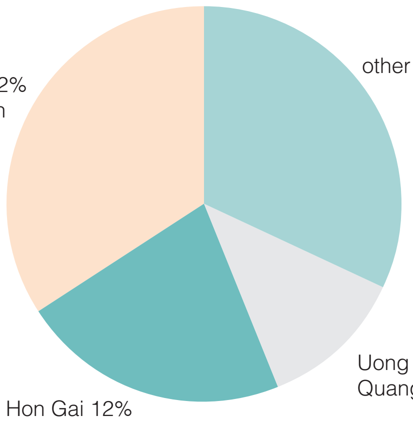

Figure 10 Proven coal reserves by region (Thanh Son, 2006)

7.2 Anthracite reserves

Establishing a clear picture of coal resources in Vietnam is extremely difficult given the current knowledge. Publicly available data are fraught with uncertainty. Reserves have been quoted at being anywhere between 0.6 Gt and 3.5 Gt (Ritschel and Schiffer, 2007; Vinacomin, 2009). Given that Vietnamese coal production was close to 45 Mt in 2007, this would suggest that the country's reserves of 0.6 Gt could be depleted in around ten years at these production rates. Vinacomin itself recognises the potential shortage of coal that may occur at around 2015 if new sources, both domestically and imported, are not explored.

Table 1 Comparison of world anthracite reserves (Marston and Ewart, 2007)

Country	Estimated recoverable resources (as of 2006)	Nominal production rate	Remaining resource life
	Mt	Mt/y	Years
China	6350	275	23
Russia	6870	15	458
Ukraine	5860	20	293
Vietnam	2230	40	56
North Korea	1425	22.5	63
South Africa	710	1.5	473
South Korea	240	3	80
Spain	195	3.9	51
USA	50	3.5	14
Poland	62.5	0.25	250

According to a report published by the ADB (2007) some 3.4 Gt of mineable reserves existed, of which 2.8 Gt was anthracite, 0.5 Gt was subbituminous, and 0.04 Gt was 'fat' coal (metallurgical coal). Since the calorific value of anthracite is typically high compared with lower rank coals, reserves in energy terms are overwhelmingly dominated by the anthracitic coals. But herein lies the problem of quoting total reserve figures in terms of tonnage.

Table 1 lists the major reserves of anthracite as of 2006 according to the international mining consultants Marston; with reserves of 2.2 Gt, Vietnam has the fourth largest anthracite reserve behind Russia, (6.9 Gt), China (6.4 Gt), and Ukraine (5.9 Gt). It is important to note that this table refers to only those countries which have worked reserves that are currently in production. This figure for anthracite reserves is slightly less than the figure given by ADB of 2.8 Gt.

7.3 Prospective reserves

Figure 6 illustrates the approximate estimates for proven coal reserves by rank, inclusive of peat. This figure is based on data published by Thanh Son (2006) which estimated total proven reserves to be 6 Gt, substantially more than that quoted by other sources. However, in 2006 Vinacomin announced it had discovered a significant coal seam in the Song Hong (Red River) Delta in northern Vietnam estimated to contain up to 100 Gt. The Red River Delta is spread across the provinces of Thanh Binh Nam Dinh, and Hung Yen, just south of Quang Ninh (*see* Figure 7). However, quite how much coal the country has remains uncertain. Projected reserves could be as high as 210 Gt, although only 1.6 Gt may be available at depths of less than 1000. This leaves a phenomenal amount of reserves that may lie at extreme depths.

Vinacomin has started to carry out surveys of some mines, such as Binh Minh, Khoai Chau 1 and Khoai Chau 2 which are at a depth of 400 metres to 1200 metres. At these depths, underground coal mining will be costly. In addition, the province of Thanh Binh is described as the 'rice bowl' of Vietnam where the impact on the rural environment and agricultural livelihoods. The Chinese import-export company CMC, and the US group Bantry Bay Ventures-Asia LLC will develop two coal mines at Binh Minh (Thanh Cong and Khoai Chau II), while the Japanese company Murabeni will explore Khoai Chau I (VBF, 2008b).

To explore the Red River Basin may require $200–500 million in just the first phase. A further $1 billion may be required to develop the three mines. The Red River Basin in total covers an area of 3500 km^2 (MTM, 2008). The dip of the seams suggests that around half the resources will be accessible by opencast mining while the rest would be by underground methods. As mentioned earlier, coals at depths of more than 1000 m may be extracted using non-conventional means and could provide potential for future (yet experimental) methods such as underground coal gasification (*see* Section 19.4).

Interestingly the Red River reserves may not be dominated by anthracite in the way Quang Ninh is. Consequently, the exploitation of Red River resources could lead to a change away from anthracite demand towards lower ranks coals, although at this stage this remains speculative. Vinacomin (2009) quoted a report by NEDO that surveyed the Red River coal deposits in 1998-2003, and stated that there could be 30 Gt of coal, much of which is subbituminous (6000 kcal/kg AD, 40% VM, 0.6% S). This greatly boosts coal resource figures, although the quantities of reserves would probably be less than this. Interestingly, this reserve is considerably below the 210 Gt that is often quoted. The importance of the Red River coal resource is reinforced by the creation of the Red River Coal Company, a subsidiary of the state-owned Vinacomin which is developing two operations, the Khoai Chau and Thanh Cong. The developments have raised controversy over environmental issues of resettling people, but also the impact on the agricultural economy that is abundant in rice crops, a staple commodity for Vietnam.

7.4 Coal geology and quality

According to Thomas (2002), the Vietnamese hard coals are of Mesozoic age and were laid in the Triassic period (200–250 million years old), although some older texts also refer to some coals being laid down even earlier in the Palaeozoic era (250–540 million years old).

While many hard coals across the world were laid down in the Palaeozoic era (*see* Figure 11), curiously, most of Vietnam's coals started to form in the Triassic period, which is also the period of the event called the 'Coal Gap'. The Triassic 'Coal Gap' is aptly named as the only period when little or no coal was laid at all. The reason for the large absence of Triassic coals is primarily due to two major periods of extinction, both within the Triassic period, the first in the beginning and the second towards the end.

The first extinction leading to the Coal Gap was the most devastating episode of mass extinction in the history of earth, eliminating almost all life on earth. This mass extinction also known as the 'Great Dying'. Some say that up to 99% of the living species of the world were gone in an extremely short

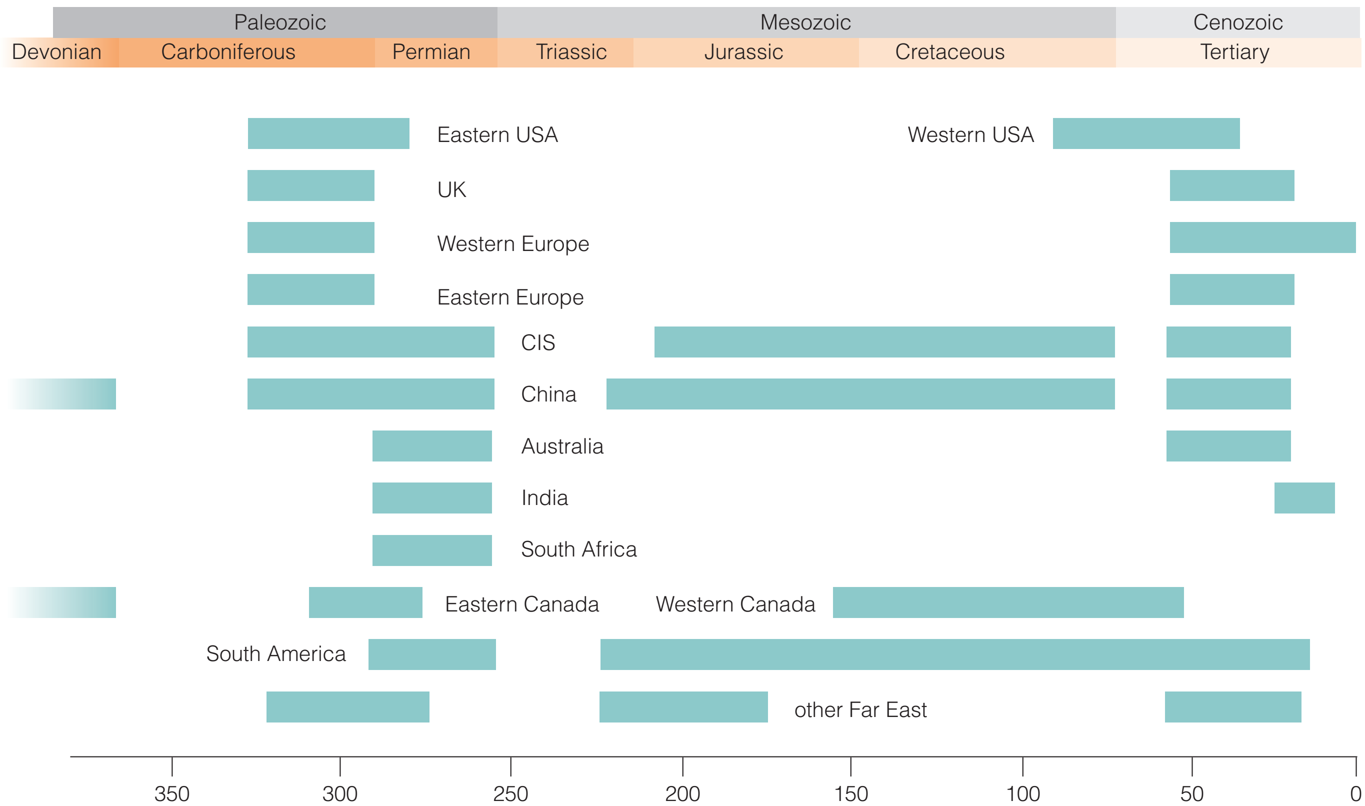

Figure 11 Geological age distribution (Thomas, 2002)

period in geological time, including the plant life that would have formed the peat-forming material around this period. There is no surprise therefore that while coals in their various forms have been forming throughout the entire history of the planet, almost none was formed in this period.

A second, and less severe, extinction episode occurred towards the latter part of the Triassic Period; neither of these extinctions should be confused with that of the dinosaurs, which occurred much later at the end of the Cretaceous period. Peat-forming plant recovery eventually occurred towards the late-Triassic period in what is now China, South America, and which is probably when the Vietnamese anthracites began forming and was in the early period when the great dinosaurs dominated earth. The coal in Quang Ninh lies in a complex geological structure with many faults and folds. The mineral deposits comprise a number of coal seams of different thicknesses also interspersed with waste partings of various thicknesses. As mentioned in previous sections of the report, Vietnam's coal industry is concentrated in this northern province where the anthracite reserves exist.

Anthracite is a high rank coal, which has a high carbon content, very low volatile and moisture contents and generally relatively low levels of impurities compared to other coals. Figure 12 shows the representative qualities of coals of

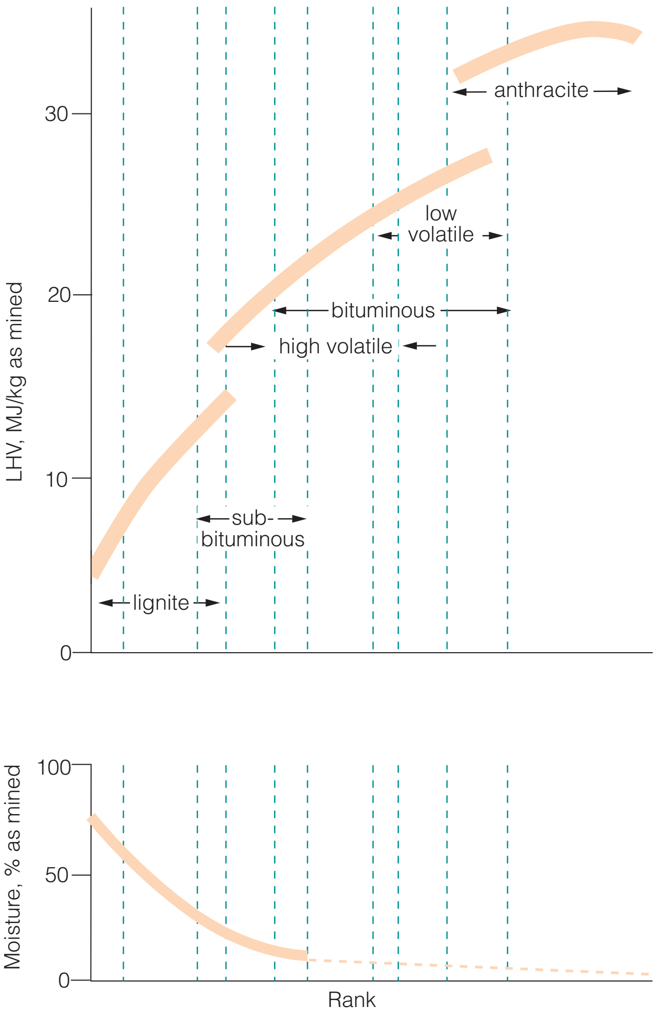

Figure 12 LHV and moisture content of coals (IEA CCC, 1983)

different rank. Anthracite appears on the far right of the chart with high heating values, well in excess of 30 MJ/kg and extremely low moisture contents. However, Whitehouse (2004) published a review of anthracite use in power generation around the world, and this paper included a summary list of properties of low volatile coals from around the world.

Interestingly, the coals in Cam Pha, Hon Gai, Mao Khe, Trang Bach, and Vang Danh consist of fairly high ash content (31–39%), and modest (gross) calorific values (20–24 MJ/kg) when compared with hard coals found elsewhere around the world. Other information sources suggest that typical Vietnamese coals have calorific values that exceed 29 MJ/kg (7000 kcal/kg), making Vietnamese hard coal readily exportable. Some anthracites have a calorific value as high as 33–35 MJ/kg (8000–8300 kcal/kg) with a sulphur content of typically 0.5–0.6%, and 4–8% (dry mineral matter free or dmmf basis) volatile matter. Clearly, there is a wide range of coal qualities, in Vietnam, which is demonstrated by data published by the Hanoi University of Mining and Geology that summarised the proximate qualities for Quang Ninh coals as shown in Table 2.

Amongst the more commonly mined anthracites, the high carbon content is key to the very high heating values. While high heating values are advantageous, there are other quality facets of anthracite that make these types of coal unsuitable to burn in conventional power station boilers, and have been described as some of the most difficult coals to burn anywhere in the world (Hough, 1998). Anthracites generally have a low volatile content of 10% (dmmf) or below. Vietnamese anthracites found in Hon Gai and Uong Bi have volatile contents of 5–8% (dry basis). Most bituminous coals may have volatile contents of 10–45% (dmmf). Anthracite's low volatile content makes it a rather inert material during combustion compared with higher volatile materials. This makes it more difficult to ignite and so anthracite burning boilers have to be modified to accommodate the slower burning fuel. Power plant design is discussed later in Chapter 19 of the report.

According to Vietnamese classification, coal products are graded according to the size of product, which does not seem consistent with international convention. A possible reason is that traded coals are almost uniformly anthracite from the same region, and so quality variability is less of an issue than say comparing bituminous coals from different parts of the

Table 2 Run of mine coal qualities in Quang Ninh (Bui and Drebenstedt, 2004)

Quality criteria	Minimum	Maximum
Inherent moisture, %	0.4	14.2
Volatile matter, %	2.8	24.5
Sulphur (natural), %	0.01	2.7
Heat content, kJ/kg	25.8	39.3
Density, t/m³	1.37	1.5

world. Under the Vietnamese classifications, coals that are less than 15 mm are categorised under ‘dust’ (or ‘fine’) coals. For coals of greater than 15 mm, the products are named ‘coarse’ (or ‘lump’) coal. As a general observation, the finer the coal, the lower the quality.

The ranges that are shown in Table 2 encompass all the quality parameters that are discussed earlier in this section, and demonstrate the wide variety of coal qualities that exist in the Vietnamese producing mines. However, it is reasonable to assume that a bulk of the production is of a quality that is exportable to the international market. The higher ash content coals tend to be of low calorific value, some as low as 4600 kcal/kg. While these might indicate lignite brown coals, according to Vinacomin, the moisture content of some of these poorer quality coals is little more than 8%.

Vietnam is known to have subbituminous coal, found in the Red River Basin, and even lower rank coals such as lignite and peat. Much of these resources are not found in Quang Ninh but rather around the Red River Basin. The subbituminous coals have a respectable calorific value of 6000–6200 kcal/kg, are low in sulphur, and suitable for thermal power generation and metallurgy. Given these qualities, they are comparable to some Indonesian coals, and so perhaps some of the better quality Red River coals could be developed for both domestic use and export. The lowest rank coal is peat, distributed throughout the whole country, and is used for fertiliser and a residential cooking and heating fuel for rural areas. While peat reserves are quite sizeable, the use has probably not gone beyond local usage.

8 Coal resources and reserves in Vietnam

The coal industry of Vietnam dates back almost 170 years. Until 1995, all the national industries including the coal mining industry were underdeveloped in modern terms. According to Thai Van Can (2007) coal mining technology was described as backward and suffering from poor productivity.

Before 1995, the coal industry comprised five companies, four of which operated under the Ministry of Energy. The four Ministry companies were the Hon Gai Coal Company, Campha Coal Company, Uong Bi Coal Company, and the Interior (or Interland) Coal Company. Other coal mining units were also owned by the army. Under the Ministry, there was the Coal Import-Export and Materials supply Company (Coalimex) whose tasks were to import equipment and materials for the coal industry and to export coal on behalf of the entire industry.

In 1995 however, Government of Vietnam sought to modernise the industry, and in doing so established a new corporation, the Vietnam National Coal Corporation (Vinacoal). Vinacoal became a consolidated entity incorporating all the coal production operations and trading businesses, exploration, infrastructure such as mine roads, dedicated railways, and sea ports.

Vinacomin was later formed in 2005 from the merging of Vinacoal and Vietnam Mineral Corp (or Vimico). Vinacomin has become a large economic group of diversified businesses, including its core business of coal production and export, and the production of other minerals such as bauxite as well as all the other activities which were undertaken by Vinacoal. In 2010, Vinacomin intends to commission an aluminium factory that will have a capacity of some 1–1.5 Mt/y of production (VDG, 2006) and could lead to future expansion given that Vietnam has the world's third largest bauxite (aluminium ore) reserves.

Currently, coal production is central to Vinacomin's operations. The coal business comprises of 58 member units. There are 21 coal companies, which probably account for 95% of the nation's coal output. In addition to the coal production operations, there are seven engineering, machinery and mine equipment and materials companies, five transport machinery and logistics companies, and three major power companies. The remaining companies include management, finance, tourism, education, and human resources.

9 Coal production trends for Vietnam

Precise production figures are difficult to ascertain, although based on exports of 30 Mt and domestic consumption of 14 Mt, production in 2006 could have reached 44 Mt (Ritschel and Schiffer, 2007). This is probably a slight over-estimate for that year, but nevertheless a logical assumption. Official figures suggest that Vinacomin produced around 40 Mt/y in 2008, and accounted for 94% of the country's output. Scaling this figure up to a total national figure suggests that the country's total output was 42–43 Mt/y. Production could reach about 43.5 Mt of coal in 2009, of which 24 Mt is for domestic demand and 20 Mt is for the export market.

Demand for coal in the power sector for 2008 was estimated to be 6.5 Mt, with a possible 2.5 Mt rise in 2009. Under the Vietnam Coal Industry Development Strategy, coal production could reach 48–50 Mt in 2010, 60–65 Mt in 2015, and 70–75 Mt in 2020, and 80 Mt in 2025.

The 2003 Decision paper listed the coal mines due for upgrades and investment for the period 2003-10. Table 3 lists the 52 mines identified in the Decision Paper that were due for investment; 39 of the mines were to undergo renovation and expansion, just three were to undergo maintenance, and ten were new mines due to be opened by 2010. The third column lists the known production capacities published officially at the time of the Decision Paper in 2003. The capacities of these mines amounted to 31 Mt/y. The newly commissioned mines were expected to add 9 Mt/y to the existing 31 Mt/y, a massive increase of 30%. It is worth stating that this production may refer to ROM (run of mine) production, and not saleable product, so some caution has to be taken when interpreting these data. When balancing these figures with future demand projections, some consideration will need to be made to account for any such discrepancies.

However, given the renovated facilities would logically lead to higher productivity levels, it is difficult to ascertain whether the increase in capacities was due to increased capital expenditure to increase the number of mine faces, or simply due to better performance at the existing faces. In 2006, Thanh Son (2006) presented updated figures for operations owned and operated by Vinacomin, and went further to disaggregate the opencast and underground mines. The list is not exhaustive, but covers the main mines that were operating in this period. It is possible changes have occurred to the statuses of mines since.

Of those mines that have been identified, 48 Mt/y out of a total of 65 Mt/y of capacity is located in the Quang Ninh coalfields. Quang Ninh has at least 20 mines that exceed an annual capacity of 1 Mt/y. The average capacity for these mines as just above 2 Mt/y per mine, the largest being the Cao Son opencast mine located in the Campha region of Quang Ninh, and which has a substantial capability of 7.5 Mt/y.

The few Red River projects that are under current exploration are potentially large operations if they are successfully implemented in forthcoming years. According to Table 3, there are two mines in Binh Minh province (most notably the Khoai Chau operation). In future years, the Red River projects could output 9 Mt/y, but these remain unfulfilled until foreign investment can be secured and environmental matters can be resolved to a satisfactory degree. As such, the Red River projects may face delays in commissioning or not realise their full potential for some years.

Table 3 contains some discrepancies when comparing like for like mine data for both 2003 and 2006; the 2006 list appears to have more gaps. The 2006 list is short of around 6 Mt/y of mine capacity that appears in the 2003 list. It is possible that the operations that appear in the 2003 list are the names of smaller mines which, when grouped, form fewer yet larger operations named in the 2006 list. For example, the Cao Son and Dong Cao Son mines (in 2003) may be classified as just 'Cao Son' (in 2006). Similarly Mong Duong and Mong Doung (northeast) may have been combined to form the 'Mong Duong' operation.

Interestingly, Thanh Son (2006) names four additional operations that do not appear in the older 2003 list, they are Trang Bach (1.2 Mt/y), Lo Tri (4 Mt/y), Nui Hong (0.3 Mt/y), and Hong Thia (1 Mt/y). These mines amount to 6.5 Mt/y. This could more or less explain the 6 Mt/y gap. As a result, the total headline figures for mine capacity show some consistency from different Vinacomin sources, despite some inconsistency on a mine basis.

9.1 Utilisation of coal mine capacity

Based on the headline figures for production capacity, it is possible to determine the utilisation, or capacity factor, of Vietnam's coal mines. The results show there is a massive level of under utilisation in the coal mine capacity. In 2003, the production capacity for the country stood at 40 Mt/y, while production was just 20 Mt/y (Dac and others, 2008); therefore the utilisation rate was just 50%. In past years, coal production from the underground mines was operating at 30–35% capacity, although this could rise in coming years following several years of investment in the industry. Mechanisation in many mines was antiquated based on old Russian equipment but, more importantly, there is little incentive to increase performance since the coal industry was, and still is, operating in a non-competitive market.

Some surface mines have closed due to the depletion of reserves, and so Vietnam is seeking to increase production of its deeper anthracite reserves. Purchase of heavy mining equipment from Australia has enabled the expansion of existing underground mines and development of new facilities. By 2006, the production capacity of the (known) mines operated by Vinacomin was estimated to rise to 65 Mt/y (while producing 38–39 Mt). This would suggest that Vietnamese mines had increased capacity utilisation from

Table 3 Statusof coal mines in Vietnam in 2003 and 2006 (MOJ, 2003; Thanh Son, 2006; VIC, 2009)

Mine/project name	Investment, 2003-10	2003 capacity kt/y	2006 capacity, kt/y	Opencast /Underground (where known)	Coal basin (where identified)
Bang Nau mine	Renovation	500	1300	OC	Quang Ninh
Binh Minh (Khoai Chau) mine	Construction before 2010	1500	5000		Red River
Binh Minh (Thanh Cong) mine	Renovation	600	1000	UG	Red River
Cao Son (Dong) mine	Renovation	1200			Quang Ninh
Cao Son mine	Renovation	1500	7500	OC	Quang Ninh
Cao Thang mine	Renovation	500	400	UG	
Coc Sau (North) mine	Construction (in 2005)	500	700	UG	Quang Ninh
Coc Sau mine	Maintenance	1500	2700	OC	Quang Ninh
Da Mai (Eastern) mine	Renovation	380			Quang Ninh
Da Mai (Northwest) mine	Renovation	350			Quang Ninh
Da Mai (Southwest) mine	Renovation	300			Quang Ninh
Deo Nai mine	Renovation	1500	2500	OC	Quang Ninh
Dong Ri mine	Renovation	600	1000	UG	
Dong Vong mine	Renovation	500	1000	UG	Quang Ninh
Giap Khau mine	Renovation	800	800	UG	Quang Ninh
Ha Lam mine	Renovation	800	2400	UG	Quang Ninh
Ha Rang-Nui Khanh mine	Renovation	500	500	UG	
Ha Tu mine	Maintenance	1000	2000	UG	Quang Ninh
Ho Thien mine	Construction	300			
Ke Bao mine	Construction	600			
Khanh Hoa mine	Renovation	400	500	OC	
Khe Bo mine	Maintenance	20			
Khe Cham 1 mine	Renovation (in 2004)	600	1100	UG	Quang Ninh
Khe Cham 2 mine	Construction (in 2007)	1200	3500	OC/UG	Quang Ninh
Khe Cham 3 mine	Construction (by 2010)	2000	2500	UG	Quang Ninh
Khe Cham 4 mine	Construction (in 2003)	1500	1200	UG	Quang Ninh
Khe Chuoi mine	Construction	500	500	UG	
Khe Sim (Eastern Eastern) mine	Renovation	100			Quang Ninh
Khe Sim (Western Eastern) mine	Renovation	200			Quang Ninh
Khe Sim (Western) mine	Construction	100			Quang Ninh
Khe Tam (North) Mine	Renovation	300			Quang Ninh
Khe Tam (South) mine	Renovation	800	700		Quang Ninh
Khe Tam also Duong Huy	Renovation	1,500	3000		Quang Ninh
Lang Cam mine	Renovation	100			
Mao Khe mine	Renovation	2000	1800	UG	Quang Ninh
Mine 917	Renovation	300	400	OC	
Mong Duong (Northeast) mine	Renovation	800			
Mong Duong mine	Renovation	850	1500	UG	
Na Duong mine	Renovation	600	600	OC	
Nam Mau mine	Renovation	1200	3000	UG	Quang Ninh
Nga Hai mine	Renovation (by 2006)	1500	1500	UG	Quang Ninh
Nong Son mine	Renovation	232	200	OC	
Nui Beo mine	Renovation	1500	2500	OC	Quang Ninh
Nui Hong mine	Renovation	300		OC	
Pham Hong Thai mine	Renovation	500		UG	
Quang La mine	Renovation	600			
Quang Loi mine	Renovation	300			
Tan Dan mine	Renovation	300	300	UG	
Thong Nhat mine	Renovation	1500	1750	UG	Quang Ninh
Vang Danh mine	Renovation	1800	3000	UG	Quang Ninh
	Totals	39032	64850		

49% in 2003 to 59% (on average), a marked improvement as a result of the increased investment in the industry. This figure will vary from mine to mine depending on the scale of the operation and the degree of investment that the mine has undergone to improve production efficiency per tonne of coal mined.

9.2 Coal supply trends – domestic production and world trade

Even though coal production has been occurring for 170 years, IEA data records show that between 1978 and 1994, coal production stayed almost flat at around 5–6 Mt/y. However by 2008, Vietnam's production had increased to more than 40 Mt/y of coal. The growth surge occurred after 1994, when Vietnam experienced a sudden growth of coal demand from the industry sector, as well some increased demand from power stations. Industry and manufacturing were beginning to expand as the economy opened up to foreign direct investment. Energy demand grew rapidly as the economy expanded, and to help fuel the growing energy needs, so did the coal industry through a programme of modernisation and investment.

Around this time, Vietnam also embarked on a move to supply more coal to the world export market. Throughout the 1980s, most of Vietnam's exports were destined for China, but volumes were very small. In the 1990s, Japan became the leading buyer of Vietnamese coal. Then by 2005, the emphasis had clearly shifted back towards coal exports to China again. In 2008, China's demand for Vietnamese coal had grown from just 1% of 3.5 Mt/y to 90% of 20 Mt/y.

A vast majority of the exports are destined for Chinese power stations, however the 2–4 Mt/y of anthracite that is shipped to Japan is typically of a higher quality for use in Japanese steel mills. Anthracite mined in Hon Gai has commonly been shipped to Japan with exports of just 1–2 Mt/y (Kobayashi, 2004). Hon Gai is close to the ports of Hon Gai and Campha, and therefore inland transport costs are low and so ensuring a lower cost on an FOB basis. The major role that anthracite has in Japanese steel mills is as a pulverised coal injection fuel, although anthracite is also useful as a lower cost replacement for coke.

The southern province of Guangdong in China in an example of a region which has anthracite-fired power stations that were designed for the local Chinese anthracite, but following rapid economic growth (in some years exceeding 13%/y for Guangdong), the provinces own reserves were not able to meet the rise in demand for power. The Vietnamese reserves in Quang Ninh are closer to Guangdong than much of China's other coal reserves that are located in the northern regions of Mongolia. In addition, shipping costs between Vietnam and China would be lower than that of shipments from the more distant Australian ports due to the shorter voyages (assuming the same vessel size), and therefore reducing daily charter costs.

The cost of Vietnamese coals arriving at the southern Chinese port of Guangzhou was quoted at 81 $/t (550 yuan/t) for January 2009, while equivalent products from Chinese mines in the province of Shanxi cost 84–87 $/t (570–590 yuan/t) at the northern Chinese port of Qinhuangdao (China Daily, 2009). Considering Qinghuangdao coal requires ongoing shipment to Guangzhou in the south, coal from Vietnam is considerably more competitive while meeting the same quality specification.

In 2007, the southern Chinese state of Guangdong imported 14.6 Mt/y of coal, of which Vietnamese anthracite accounted for 5 Mt/y. The autonomous region of Guanxi in China imported 14 Mt/y of coal in 2007, of which 13.3 Mt/y was sourced from Vietnam (Energy Daily, 2008). Combined, these two regions imported more than 18 Mt/y of Vietnamese anthracites accounting for a considerable proportion of Vietnam's total exports.

In recent years, disruptions and the forced cessation (due to a clamp down on smuggling) of supply have become commonplace between Vietnam and China, although the

Table 4 Vietnamese hard coal exports by destination country

	1978	1980	1985	1990	1995	2000	2005	2006	2007	2008
Total exports	1430	640	604	745	2821	3526	15560	25128	30931	20604
Belgium	–	–	–	–	93	240	166	105	222	92
France	–	–	–	–	179	100	155	123	87	48
Japan	–	100	100	150	1469	2227	2805	3319	3668	1972
Korea	–	–	–	300	400	516	496	644	1295	916
Brazil	–	–	–	–	100	88	388	125	54	160
Bulgaria	–	–	–	–	–	–	–	102	387	372
China, People's Republic	–	540	504	100	150	27	10532	20079	24611	16906
Chinese Taipei	–	–	–	–	63	52	118	43	17	22
Other	1430	0	0	195	200	156	887	371	590	116

impact on the larger Chinese market is minimal. Illegal coal trading is not unknown in Vietnam. Interestingly, news reports in 2009 suggested that staff at Vinacomin were allegedly involved in falsifying invoices for coals heading for China, and instead declaring them as going to Vietnamese customers (VBF, 2009a). Coal thefts and smuggling have long been rife, but theft is usually from legally produced coal. Consequently, while illegal production is likely to exist, it may not be significant, or easy, to quantify.

Illegal coal mining has been a problem in the past. In 1999, a report of government attempts to close bandit mines was published (Philion, 1999). Interestingly, the term bandit mines refers to mines that refuse to sell all or part of its output via the official channels of (former) Vinacoal and instead sell coal directly to end-consumers. Some bandit mines are state-owned, and controlled by any number of parties such as Communist Party officials, military units, criminal gangs and private trading companies.

It was claimed at the time that the formation of Vinacoal in 1995 would reestablish state control in the mining industry and bring an end to bandit mining which was fragmented and difficult to control. Philion commented that Vinacoal simply centralised the purchase of coal from bandit mines and encouraged expansion of bandit operations, especially if the output could be exported. Even some of the largest export operations operated bandit mines, but since the 1990s, there has been less reporting of these types of operations, and the subsequent formation of Vinacomin appears to have consolidated the mining industry even more.

9.3 Coal imports

As Figure 13 shows, coal imports are negligible, however, future coal-fired stations located in the southern regions of Vietnam could rely increasingly on imported coal from Australia, Indonesia, and perhaps Russia as a cost-effective source of coal (*see* Chapter 16.3). It seems ironic that Vietnam is capable of shipping coal to southern China competitively, but the country may need to draw on foreign coal to supply future power stations in the south. Perhaps this is a trend towards building a different fleet of coal-fired power stations designed to burn bituminous coals rather than specific designs geared towards burning just local anthracites (*see* Chapter 19). Part of this need to import more coal will diversify the sources of coal. While security of supply is an essential remit for most energy policies worldwide, it is interesting that Vietnam is resorting to the international seaborne coal market as an economic and secure form of coal supply.

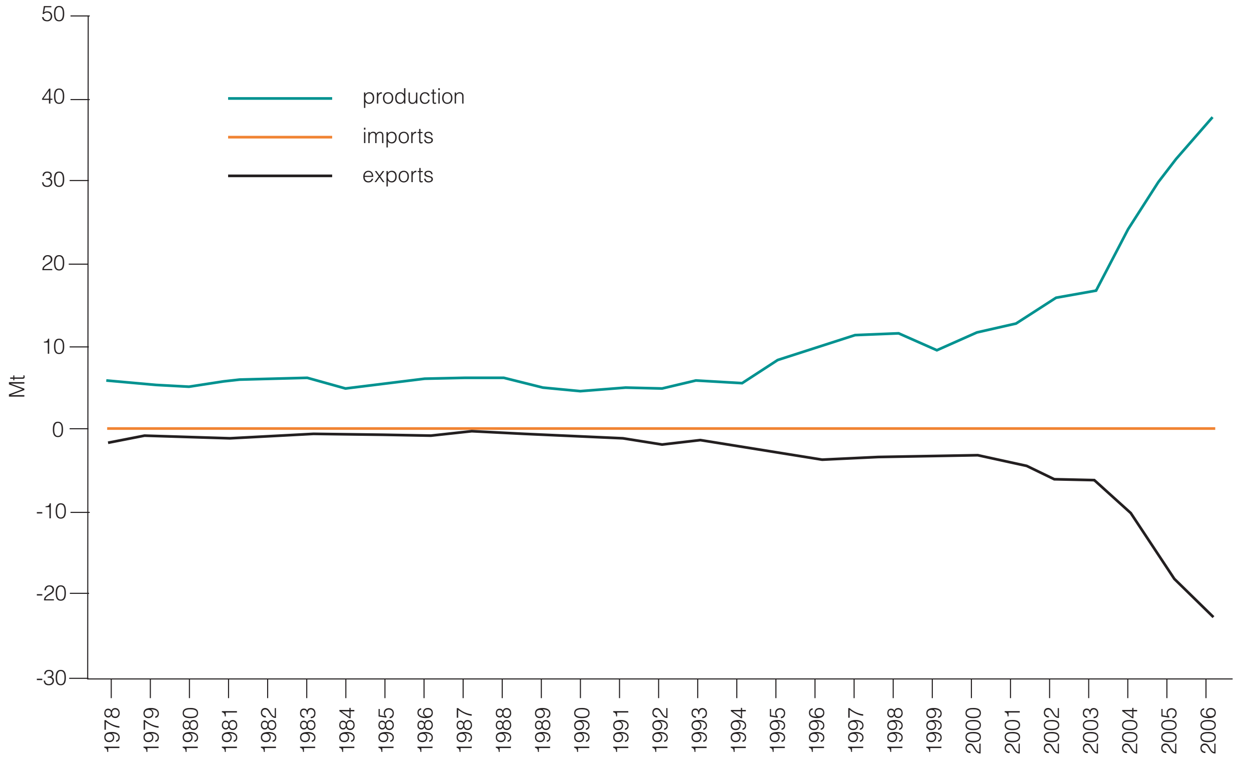

Figure 13 Development of Vietnamese coal production and international trade since 1978, Mt (IEA, 2009)

10 Methods of mining coal

More than two thirds of Vietnamese coal output comes from opencast mines (Dac and others, 2008). This is supported by evidence presented by Van (2007) who reported that surface mining made up 60% of annual yield and that opencast mining has historically been the main form of coal mining in Vietnam (*see* Figure 14). However, this seems at odds with the fact that two thirds of the country's capacity is geared towards underground mining. In 2005, the estimated mining capacity of coal was 65 Mt, of which opencast was 27 Mt and underground 38 Mt.

10.1 Opencast coal mining

Opencast mining in Vietnam is currently dominated by truck and shovel methods (Ritschel and Schiffer, 2008). For example, the Indonesian company Indominco operates a small opencast mine of 0.6 Mt/y, although mines of this modest capacity account for around a third of the country's total mine capacity. According to official Indominco reports, the mining operation is carried out by conventional truck and shovel methods with a multibench system (Sumampow, 2004).

Bui and Drebenstedt (2004) described in detail the typical equipment that was used throughout the (opencast) coal industry in 2003. Some of the major kit used for the important task of earth moving included Russian EKG hydraulic shovels. Overburden and rock haulage was carried out using 27–50 t dump trucks from manufacturers such as BelAZ (Belarus), Komatsu (Japan), and the Caterpillar 769C (USA). Coal haulage is done using smaller 10–30 t payload trucks from Russia, Japan, and Sweden.

In most opencast mines in Quang Ninh, about 70% of overburden/interburden is blasted prior to hauling to a disposal area. The coal itself (hardness factors of 4 on the Mohr scale) is extracted without the use of explosives. Where coal is significantly harder, coal is ripped to improve the excavation process. The complex geology of the Quang Ninh coal seams means that dragline mining is not possible, and hence the use of excavators and trucks is common practice. The factors that affect the choice of opencast mining methods are discussed briefly in Baruya (2007).

Opencast mining conditions vary depending on the depth of the seams, the thickness of the coal seams, and the continuity of the seam. Discontinuities and geological movements can create difficult operating conditions for opencast mines especially when the seams dip steeply. This often leads to multiple benches for the safe operation of heavy equipment, and as the seams dip deeper into the earth the overburden removal becomes more of a cost factor. One example is Vinacomin's Deo Nai mine, which is an opencast operation with a capacity of some 2.5 Mt/y (recorded in 2006), although subsequent output figures from the official company website suggests production of 2.8 Mt/y. The overburden removal before coal extraction is considerable, with removal in 2008 estimated to total 21 million m^3. With an output level of 2.8 Mt/y, the 'stripping ratio' was 7.5. This means 7.5 billion cubic metres per tonne (bcm/t) of output.

Projections for 2009-11 showed that the overburden removal would increase to 23.6 million m^3, while output in this period would be lower at 2.6 Mt/y (from 2.8 Mt/y in 2008). This infers two things, the seams are occurring deeper in the

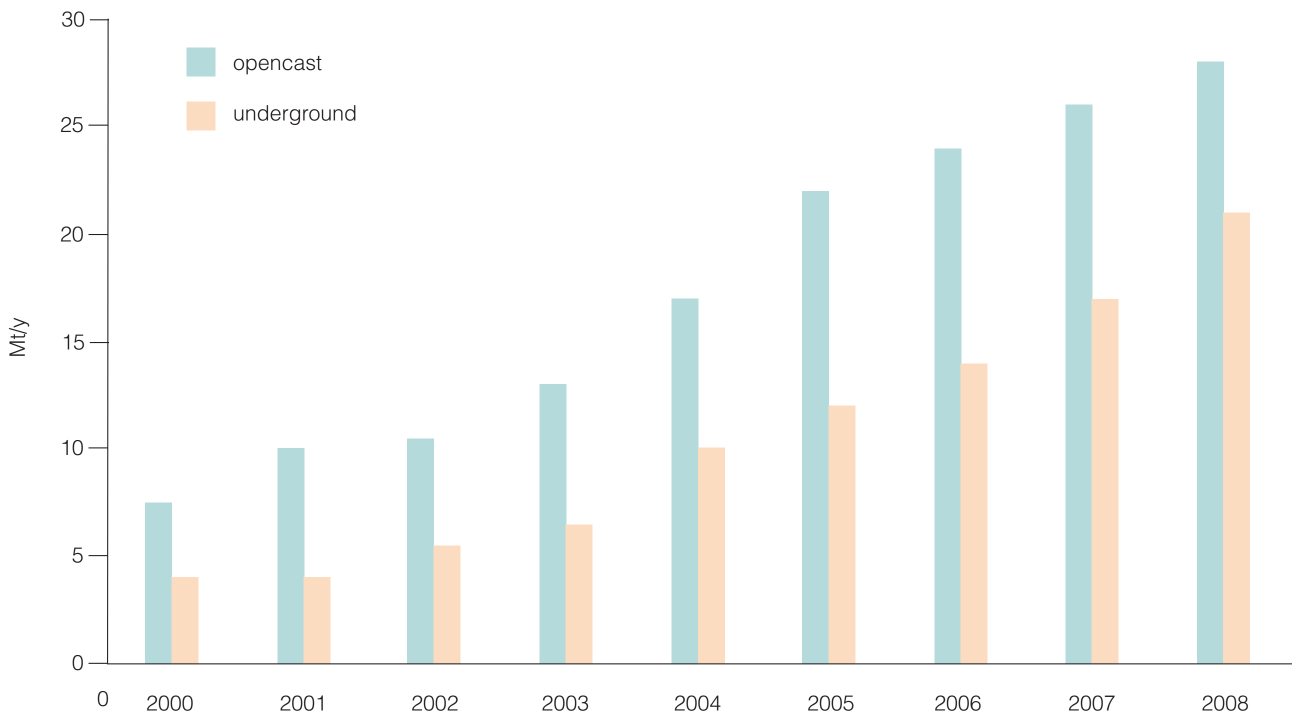

Figure 14 Coal production split by opencast and underground in 2000-08, Mt (Dac and others, 2008)

ground, while the occurrence of coal is lessening. Extracting less coal can be due to any number of reasons, either the seams are thinning or there is greater fragmentation in the seam. Either way, the stripping ratio is expected to increase by 16% to 8.7 bcm/t of coal.

Interestingly, Thanh Son (2006) published projected overburden material trends along with projected raw production to the year 2025. Dividing the overburden material by the raw production shows the average stripping ratio could increase from around 6.8–7.8 in 2005-08, to more than 8.0 by 2012, and gradually increasing to around 10.0 by 2025. Historically, stripping ratios averaged 4.5–6.5 in the period 2000 to 2005. The projected trend suggests future coal extraction will incur rising costs and face even more difficult mining conditions as the coal seams get deeper and possibly more complex.

10.2 Underground coal mining

Deep mined coal accounts for some 40% of the country's output. Underground coal mining is currently done at depths of 300 m, but new deposits of coal are being found at depths of 1000 m and more. While today's industry is marred with poor adherence to safety measures, the future underground coal mining industry must adopt safer working practices at even greater depths.

One of the key initiatives to improve performance in underground mines is the move to enhance safety measures in the daily operations. In 2006, the coal industry accounted for 20% of deaths related to occupational accidents in Vietnam. In 2008, accidents claimed the lives of 39 mine workers in 29 incidents. Accidents are increasing, which is partly due to carelessness and also the increasing complexity of the geology of the mines, but above all, the ramping up of operations of coal mines (MNRE, 2009). Part of the trend that is leading to increased reported accidents is the move away from opencast mining towards the more hazardous underground mining.

One of the development plans that was announced in the Prime Minister's Decision of July 2008 was to improve the facilities at existing mines where safety was inadequate. Pit props in existing underground mines were to be upgraded from wood and metal to modern hydraulic supports, although this would suggest that mining techniques would shift from crude bord and pillar to longwall systems. In addition, the industry is increasing the use of anchor bolts in the main areas of mine works, where previously the workings would have been relying on wooden props or coal seam pillars.

The coal industry spent $106 million on modernising mine facilities. Part of the investment has been the increased use of hydraulic props and gas detection equipment. However, aside from the technical solutions, a great deal of change has had to occur in the regulatory and enforcement aspects of coal mining safety. Training, supervision, and enforcement of procedures remain a problem amongst some workers. Worker discipline is considered to be lacking on occasions. Procedures and rules exist, but it is not unknown for workers to lapse and be found smoking cigarettes in hazardous areas. Another major problem causing loss of life is water ingress into the underground workings. Improving monitoring and modelling of water levels in the ground is being co-developed with the Japan Coal Energy Center.

10.3 Labour productivity – considerable potential for improvement

The coal industry employs 83,000 people, more than 80% of which are employed directly (Van, 2007). This figure is lower than in previous years, but not by a significant amount. Mechanisation is in its infancy and the manning levels of the coal industry remain high with a great deal of manual labour still prevalent. Employee figures for coal mining range from 68,890 employees employed directly by the industry to 83,000 in total for the sector (Van, 2007). Assuming a production level of 44 Mt in 2007, then labour productivity was around a mere 530–639 t/man-year, comparing with some of the poorest performing mines in China. At this level, productivity is low.

Much of the productivity in other exporting countries is attributed to the mechanised nature of modern coal mining, efficiency and reliability of the capital employed, and training and education of the workforce. Vietnamese mines probably operate at a tenth of the productivity of other major exporting countries (Ritschel and Schiffer, 2008). Clearly, there is a great deal of scope for rationalisation and potential for capital expenditure in the industry. While the industry has already gone through a period of major rationalisation, clearly more could feasibly be done. According to Philion (1999), the Vietnamese coal industry rationalised the workforce, which stood at 86,000 in 1999. Some 70,000 were on long-term contracts, while 16,000 were on short-term contracts and were subject to either temporary (seasonal) or permanent redundancy. During a period of stoppages in 1999, lasting at least three months at certain mines, it was deemed that miners would receive a wage of around 18.5 $/month. Presumably this would be to cover basic necessities and living expenses, but some wages during this period were as low as 7.2 $/month.

In the 1990s, wages were notoriously irregular, and some smaller mines were unable to pay their miners for up to three months. In 2000, it was estimated that 20,000 of the 70,000 permanent staff would be made redundant. The IMF and World Bank had been pushing for a major reduction in the workforce since the 1980s. These two international organisation had been extensively involved in technical projects advising the Vietnamese government on privatisation and deregulation. Interestingly, the European coal industry itself was still largely state-run or operating under monopolistic market conditions, and the UK coal industry had only been privately run for little more than a decade, so passing on this wisdom to the Vietnam industry was bold. By this time, more of Vietnam's coal mining workforce was moved to temporary and seasonal contracts.

Much of the rationalisation was because coal stocks were too high, and production had to be reined back to rebalance the market. Today, the Vietnamese industry is an export business that can relieve much of its stockpiling by supplying more to the world's market for anthracite. However, there is clearly continuing pressure to reduce the headcount of mining personnel, but this will prove extremely problematic where some mines have given rise to townships that provide almost all the employment in the local region. For example, the coal industry is a major, if not the largest employer, in Quang Ninh. In the mid-1990s, 90% of Campha's population derived their income from the coal industry (Thuren, 2000).

According to Van (2007), the income for an employee in the coal industry in Vietnam was VND 1.5–5.0 million, averaging VND 3.8 million. Assuming an average exchange rate for 2007 of 16421 VND per US$ (OandA, 2009), then the income averages 230 $/month, but can range from 91 $/month to 304 $/month. This figure however does not take into account the purchasing power parity, which would inflate the wage figure by three times in the case of Vietnam. The coal industry attracts a great deal of labour since it is a comparatively well paid profession. Some factory workers are reported to be earning as little as 50 $/month, suggesting the premium that is applied to being a mine worker in Vietnam.

While the pre-rationalisation labour figures suggest that wages were low, low productivity meant that the labour cost per tonne remained relatively high. Based on the average labour salary of 230 $/month for 2007, this equates to an annual salary cost of $230 million (assuming a total workforce of 83,000 people). Assuming the country produced roughly 43 Mt of coal in 2007, this labour cost estimate equates to an average cost of 5.4 $/t, ranging between 2 and 7 $/t. It is worth noting that this figure considers the cost of salaries alone. Van (2007) does not indicate what further costs are incurred by Vinacomin to employ staff or provide pensions, occupational health and medical expenses, bonuses, insurance, etc.

Using salary as a proxy for labour costs, it is reasonable to assume that the actual cost incurred by Vinacomin is indeed higher than that specified here. Nevertheless, given the extremely low productivity in the Vietnamese coal industry, this cost level of 5 $/t is higher than the average of most of the other major coal exporting countries, which range between 1 and 4 $/t (Baruya, 2007). As such, the high average cost of Vietnamese labour in the coal industry does not mean such cost levels do not exist elsewhere. In the most expensive mines in China, labour can cost in excess of 20 $/t, but these do not make up the norm where the average can be as low as 1 $/t in large modern mines.

Therefore, the potential to improve productivity is immense through further rationalisation of labour and improved mechanisation. Vietnam would need to adopt a firm management approach through Vinacomin, in much the same way the industry in China has been transformed. At the moment, Vietnam has few competitors in the international market for anthracite, while the domestic coal market is entirely controlled by Vinacomin, and so the need for reducing labour costs might not be urgent. However, when developing newer fields, it is more likely Vinacomin will adopt more westernised methods of coal extraction, more mechanisation, and much safer monitoring and practice.

11 Estimating the cost of coal production in Vietnam

Estimating the cost of producing coal is difficult due to the provision of subsidies for poor performing mines. Total production costs can be derived using clues from reported prices paid by Vietnamese industrial end-users, published export FOB costs, and/or establishing cost components such as labour costs and exports taxes which can help build a partial picture of representative costs associated with Vietnamese coal mine operations.

The degree to which coal prices to power stations are subsidised is not openly published, but some evidence points to the delivered prices paid by power utilities, chiefly the state monopoly utility EVN. A report by the World Bank (2007b) investigating the country's power infrastructure stated the uncertainty in domestic coal pricing. Clarity on how coal prices move is important for the power industry, as the optimal role of coal-fired plant is sensitive to fuel prices. An immediate concern is the costing of fuel for power projects, to achieve positive returns on investment especially amongst the private power industry, which is being encouraged by government.

11.1 Making a loss from Vietnamese end-users

In 2004, Vinacoal sold coal to EVN at a Government regulated price of 22 \$/t, a level considerably below that of prevailing international prices at the time, even when adjusted for fuel quality. The price of 22 \$/t was considered below the cost of production. Vinacoal was therefore making a financial loss on every tonne of coal it supplied to the domestic power market.

However, the World Bank study team went further to observe that the price of 22 \$/t appeared quite high, compared to several large open pit mines producing similar coal in China.

In 2009, the price of coal paid by power generators was reported to be 26–27 \$/t, compared with an average cost of production of 38 \$/t. Whether this includes rail or barge transport is not clear. If it is included in the price (say 2–6 \$/t), then the cost ex-mine could be 32–36 \$/t. With production costs exceeding the price to end-users, losses for coal sold to power generators could therefore be 2–9 \$/t depending on what assumptions are made. In 2006, the demand for coal in the power sector was around 4–5 Mt/y. Logically, the losses to Vinacomin could mount to \$36–45 million per year. Estimated demand for domestic coal in 2010 could be as high as 10 Mt/y, and so assuming the same cost and price levels as 2009, the losses could therefore be double.

The World Bank observed that there existed a wide disparity in unit costs between different collieries. Efficient lower cost producers cross subsidised higher-cost, inefficient producers. Inefficient producers at the time were given little incentive to improve performance at the mine as individual collieries were not trading coal in a transparent market. Vinacoal undertook all sales at standard prices, and then distributed funds to all collieries to cover their respective costs, inevitably yielding winners and losers. Reforming a system is not a simple undertaking, but necessary.

11.2 Deriving the component costs of production

Figure 15 shows the approximate shares of various input factors that make up the cost of production in the Vietnamese coal industry. The split combines the cost elements associated with both opencast and underground mines. Consequently, the cost profile for each type of mine, and indeed, for each individual mine may look very different to this. What is not shown obviously, but may be categorised under 'Other' is the tax imposed on producers to finance environmental protection measures. An environment fund was established in 1996 by Vinacoal, which drew 1% of the cost price of coal mining and other related activities to fund environmental protection methods.

Haddad (2006) examines cost structures for a number of coal exporting countries, and uses representative costs for Australian mines. At the time Haddad published the article in 2006, it was shown that opencast mines had a much greater share taken up by the cost of oil products and explosives (20% and 28% respectively). Underground mines had little or no expenditure on fuel and explosives, but had additional elements such as roof bolts, and a higher proportion of energy use to run ventilation and pumps. Spare parts for shovels, haulage trucks, cutting tools, ancillary machinery, conveyor systems, tyres, safety supports, and other hazard equipment all fall into the items labelled materials and others.

If these component splits are representative, it is possible to construct a total cost of production based on the knowledge attained from establishing the average salary of staff

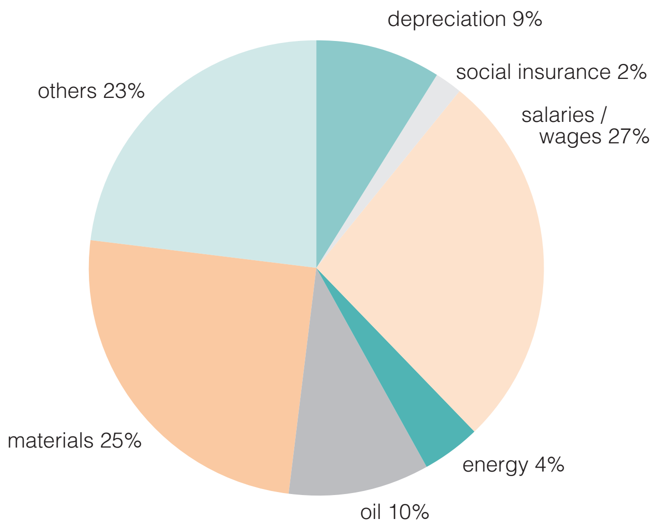

Figure 15 Percentage split of coal production costs (Thanh Son, 2006)

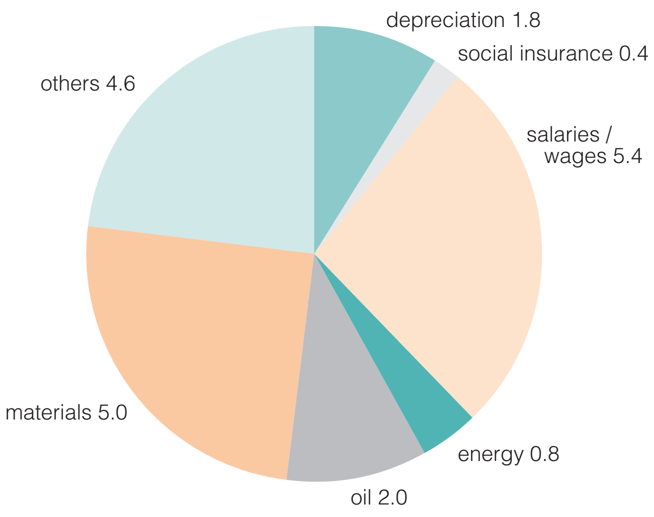

Figure 16 Estimated costs of production based on 20 $/t total cost (author's estimates)

mentioned earlier. If the average labour cost is 5 $/t, then the percentage split shown in Figure 15 would suggest the costs of production would be as illustrated in Figure 16.

The likelihood of the cost of mining in Vietnam being 20 $/t is not impossible, but could be too low. An unconfirmed report of the cost of production being closer to 40 $/t was published in early 2008 (MCIS, 2008a). At 40 $/t, this would suggest that actual production costs were double that of the author's estimates. Further evidence is suggested by The Vietnam Business News, which reported in 2009 regarding the cost of coal paid by power plants. The report stated that power plant operators were paying 26–27 $/t, presumably delivered to the station (VBF, 2009). According to the news agency, this was 70% of the actual cost of production, and so when scaling up, the Vinacomin cost of production is probably 38 $/t (assuming transport and storage is included within this cost).

This means Vinacomin was probably making a loss of at least 9 $/t on every tonne of coal sold to the power generators (*see earlier*). The price of export steam coal averaged 54 $/t, yielding a profit of 28 $/t. The export market therefore would remain an important part of the business to keep Vinacomin profitable (assuming half of Vinacomin's production was export related).

As anthracite sometimes trades internationally at a price closer to world coking coal prices (at times double that of steam coal), it is little wonder that the Vietnamese industry is in little rush to greatly rationalise the workforce. Given the low productivity and high manning levels, it is possible that the cost of production could range anywhere between 20 and 40 $/t, with some mines operating at a lower cost, especially larger opencast mines and possibly some longwall operating underground mines.

11.3 Deriving end-user prices from Vietnamese export coal

The reporting of Vietnamese prices tends to be limited to that for export trade. A number of reports allude to the cost of export coal from Vietnam. According to news reports, it is known that FOB export prices for Vietnamese anthracite destined for Japanese steel mills (JSM) track the prices of Australian coking coal to the JSMs (Reuters, 2008). Evidence of FOB prices suggest that Vietnamese coals were being exported in 2007 at 70 $/t. This later increased to 260 $/t in 2008 in line with the trend in world energy prices (Reuters, 2008). Other price information reported by the IEA in Paris and Vinacomin suggest that Australian coking coal was trading at similar prices, supporting other reports of parity with Australian coking coal.

A consultant's report suggests that a mine in the Uong Bi region was supplying coal in 2009 at an FOB cost of 35.7 $/t. A coal mine in Campha close to the port was supplying coal at 33 $/t. While it is not clear what the cost of operations are, the two figures are remarkably similar considering that the coal sourced further inland in Quang Ninh, and from an underground operation, sold for just 2–3 $/t more than the coal that was supplied from an opencast mine close to the coast.

The Tex Report (2009) published FOB cost figures for Vietnam steam coal, with average export prices being around 57–58 $/t (FOB) in September 2009 (averaging 52 $/t for the first nine months of 2009). The equivalent FOB Australian (export steam coal) Newcastle price published by McCloskey showed steam coal prices trending at an average 70–80 $/t in the last quarter of 2009. At a level of 57–58 $/t, Vietnamese FOB prices for steam coal are therefore competitive compared with some other major Far Eastern suppliers.

While the price of export coal is relatively straightforward to assess, the price of coal to Vietnamese end-users is discussed briefly in news reports, but not frequently quoted. The prices of coal to industry were estimated to have risen sharply in 2008 in line with world prices, causing major inflationary pressures on the major coal using industries (outside of power generation). The industries that were most affected were the paper, cement and chemical production industries. Depending on the coal product, the estimated price of 'coal dust' (which is a relatively low calorific value product) ranged between 40 and 70 $/t (0.8–1.2 million VND/t for products ranging 3a-4b under the Vietnamese classification (VBF, 2008a) in the period 2007-08.

Vietnam news reports also stated that the cost of coal to main industrial buyers, namely cement, paper, and chemicals was around 50% of the price of export coal (Vietnamnet, 2008). However, in 2008 the tax on coal exports was 20%, and the end-users might be paying 5% VAT (typically refundable). So when all taxes are accounted for the price paid by Vietnamese end-users may well be closer to 60% of the export cost of coal, rather than 50%, but without firmer evidence this is not possible to verify.

Adding to the confusion of how accurate prices can be derived, the tax on export coal was 0% prior to 2007. It then increased to 10% in January 2007, rising to 15% in April 2007, and again to 20% in July 2008. Exports taxes have undergone extreme changes in recent years. Taxes apply to crude oil and mineral products as well as food commodities.

In January 2009, the National Assembly Standing Committee approved Government proposals to raise the ceiling export tax rate on coal from 20% to 45% (QNTD, 2008). The possible rise in export tax was deemed acceptable since the price controls on coal within the country's internal market were partially lifted, thus freeing up opportunities for Vinacomin to charge Vietnamese end-users higher tariffs. However by February 2009 the Ministry of Finance announced that instead of tax rising to 45%, the tax would be halved from 20% to 10%. This was done with the aim of Vinacomin to raise more funds for capital investment. It also gives Vinacomin the opportunity to lower export prices if they need to compete with other foreign exporters. If this is the case, then the price of export steam coal would be somewhere around 80–140 $/t. Given this period was during a major upheaval in world energy prices it is difficult to draw any firm relationships with domestic and export prices. Given the FOB price of coal to the Japanese steel mills ranged between 70 and 260 $/t, then the author's estimates for domestic coal prices to industry are not unreasonable given the current turbulence in energy markets.

If the price of coal to Vietnamese power stations is considered, the delivered cost of coal to EVN's power stations are estimated to be 45% of export prices at around 40–70 $/t. It is most likely that the price of coal would be at the lower end of the range since the power generation sector remains exempt from market set coal prices, but even at this level it could be considered too high.

Vinacoal (World Bank, 2007b) and others advocated a gradual increase in the coal price to Vietnamese end-users until prices reached parity with imports (at least on a CIF basis to Vietnamese ports) and adjusted for quality. It is considered that competition in the domestic coal market between a larger number of domestic suppliers will best achieve the price parity with international prices. This however suggests that the market needs to be liberalised and suggests the possibility that significant parts of the coal industry will need to be privatised. Joint stock companies have emerged as major operators but Vinacomin remains the primary corporation that produces, trades, and sells coal.

If pricing policy remains one where the Government sets prices, it is not advisable to fix coal prices at import parity levels until (a) a strong, independent review of production costs and efficiency incentives is completed, (b) a transparent and clear way of estimating the economic rent which will accrue to Vinacomin is developed and agreed, and (c) clear agreement is reached in the Government as to how such rents will be collected and used.

12 Inland transport and port infrastructure

There is little published material regarding coal movements around Vietnam, and the modes by which coal is transported. This section provides a representative picture of how some power stations procure coal supplies in some parts of northern Vietnam. Export coal is trucked from the mine face to processing and crushing plants, from which coal can be barged or hauled by rail, or a combination of both to the major ports on the coast.

12.1 Truck and rail

Vinacomin operates a vehicle fleet consisting of mainly Russian and Ukrainian vehicles. Truck capacities vary from 5 to 20 t, and articulated trucks from14 to 30 t. The equipment and components are designed to cope with tropical climes, and batteries and tyres are manufactured in Vietnam. Trucks are also built within Vietnam, although most trucks are foreign branded such as Russian truck makers Kamaz and Kraz. It is likely that the unit costs of transport by road are higher than by rail (*see* Baruya, 2007).

Many of the major coal power stations are minemouth, so are located close to the mine or mine processing facility. Under these circumstances coal can easily be trucked or transported by conveyor directly to the power station silos. Rail is also used where there is suitable access to a rail line and where the journey from mine to power station is longer.

For example, coal supplied for the 100 MWe Cao Ngan power plant is exploited from the two mines Khanh Hoa and Nui Hong and transported to the plant by the existing railway network to Quan Trieu station (Duc Thao, 2004). At the station, the coal was stockpiled in a 50/50 blend of products from each mine and transferred to the plant by conveyors. In the first ten years, the 50/50 blend of the two mines' coal was to be used. When Khanh Hoa mine is depleted of coal reserves, coal will be supplied entirely from Nui Hong.

Another example of coal logistics is the Na Doung, a 100 MW lignite-fired station. The plant is a CFB boiler system (*see* Section 19.2) and in this case will be located at the minemouth. Coal is transported by truck to an unloading hopper station at a screening plant, and then taken to the power station by conveyor to the storage area at the plant site.

For larger plants, such as the 400 MWe Uong Bi power plant, a rail line transports coal directly from the Vang Danh coal mine to the power plant in larger quantities (Smith, 2007). The Uong Bi is a subcritical plant burning anthracite and the largest and newest unit (300 MWe Uong Bi 3) was commissioned in 2006. Bigger still is the 1000 MWe Pha Lai plant, one of the largest coal-fired stations in Vietnam. Like Uong Bi, it is served by rail for receiving large coal loads from the local Quang Ninh mines in Cam Pha, Hon Gai and Uong Bi fields.

There is scant information regarding the cost of rail freight, but some clues are provided by a major coal using industry, the cement industry. The cement association has raised cost issues on transport fees between mine and cement plants. According to the association, Vinacomin charged cement companies 5.9 $/t (98,000 VND/t) in 2008 to carry coal from Ninh Bin port to Nho Quan cement workshop. However, the cost of hiring other carriers reduces the cost significantly, to around 2.0 $/t (30–35,000 VND/t). At these relatively low costs, it would suggest the coal is transported by rail or barge.

The Vietnam Railway Cooperation (VRC) is the sole supplier of rail services in Vietnam. VRC's internal business has been restructured into four main business groups: two passenger train operating entities (North and South), a freight train operating company and a looser grouping of regional infrastructure administrations. The train operating entities are quasi-independent management and accounting entities.

The Vietnam Railway Administration remains responsible for planning development of the sector, for new construction and for securing resources for maintenance. The VRC pays 10% of its gross revenues as a track access charge. These funds are generally used toward infrastructure maintenance. Despite a network which is small, old and has received negligible investment for upgrading, the VRC has performed reasonably well.

Vietnam does not have the concentrated flows of bulk raw materials or the long distances which give rise to heavy rail freight flows. The average passenger train load in Vietnam is around 370 passengers which is relatively high, but average freight load of 225 t is low, as a result of low axle-weight infrastructure, short crossing loops and possible sub-optimal freight operating plans.

The Vietnamese railway network consists of seven lines with a total length of 2632 km. All lines are single track, 2169 km of which is one metre (narrow) gauge. The rest consist of standard gauge (1.425 m) which accounts for 178 km, and 253 km of double gauge tracks towards the Chinese border which runs along the narrow and standard gauge track (VNR, 2009)

Narrow gauge tracking is easier to construct and maintain than standard gauge, but also limits the ability to take large loads for freight and passenger traffic. Narrow gauge railways however have the benefit of tighter turning radii, and so in a country predominated with hilly or mountainous terrain, narrow gauge track offers a cost effective solution to rail infrastructure. According to the Tokyo National Graduate Institute for Policy Studies or GRIPS (2003), Quang Ninh operated an additional 64 km of railway that has a gauge of 0.8 m dedicate to coal transportation, suggesting that rail cars would be small and the load capacity poor (GRIPS, 2003). However, a bulk of the country's coal rail links are most likely to operate on the 1.435 m gauge.

Vietnam aims to gradually modernise the rail network, but it is unlikely to completely replace the 1 metre gauge system. Improvements and expansion will be consistent with the existing system, although high speed rail routes will use 1.435 m. The need to increase rail will go some way to relieve the pressure on road transport, and the increase in the speeds of freight and passenger rolling stock will help increase the performance of the system.

12.2 River and canal

According to the World Bank (2007a), Vietnam has 41,000 km of natural waterways, of which 8000 km are used commercially. Of these, the Vietnam Inland Waterways Administration manages about 6000 km as well as the main river ports; local governments manage the balance of the commercial waterways.

Despite limited investment, the waterways remain attractive for the transport of coal, rice, sand, stone, gravel, and other usually high weight low value goods. Livelihoods and personal transport depend heavily and successfully on waterway transport in the delta regions of the Mekong and Red River. The inland waterway system is managed by nine state waterway management companies. Inland waterway transport services are provided by state-owned enterprises operating under two state corporations attached to the Ministry of Transport Northern Waterway Transport Corporation and Southern Waterway Transport Corporation; specialised state-owned transport companies under other ministries carry materials to cement plants, paper mills and construction material enterprises, and private for-hire operators.

Private operators have expanded their market share significantly in recent years. Foreign companies can provide transport services on the waterways through joint ventures in which the foreigner's share does not exceed 49%. Freight and passenger transport rates are freely determined by negotiation.

In 2005, the Transport Development and Strategic Institute carried out a study on inland waterways in the northern region of Vietnam, part of which encompassed the coal producing region of Quang Ninh, but concentrated mainly on the demand and economic centres around Hanoi. According to this study, some 20 Mt of coal was transported by river barge (World Bank, 2008). This makes river transportation a significant provider of infrastructure for the coal mines and power stations, possibly contributing to the movement of a quarter of the country's coal and also a quarter of the tonnage carried by the waterways (legally) in 2005. Coal-fired stations and cement works may be sited close to such waterways, partly for coal transport, but power stations are often adjacent to rivers for cooling water.

One of the most important outcomes of the study is the growth in volumes of coal, and coal related goods that will make use of inland waterways, recognising a massive need for investment in improving equipment and services throughout all the main courses, tributaries, and canals in and around the Red River, Duong River, and Da Bach River regions. By 2020, coal movements could rise to a considerable 50 Mt/y resulting primarily from the demand for coal from power stations within Vietnam, as well as the potential for exports. Barge capacities are little more than 2500 dwt, and so shipments are small. Coal theft is rife in parts of Vietnam, especially along the hundreds of miles of winding waterways.

12.3 Port export capacity

Vietnam has some 30 ports along the northern, central and southern coast of the country. According to Thanh Son (2006) of Vinacomin, in 2006 the total export capacity for ports in Vietnam is around 34 Mt (*see* Table 5) operating through six operations that are localised largely in just two places, CamPha and Hon Gai, the former handling a bulk of the country's exports. Both port terminals serve the region of Quang Ninh in the north east where the coal export business is concentrated.

The chief port is Campha (or Cam Pha), which is operated by the Campha Port and Logistics Company, a subsidiary of Vinacomin. This therefore puts much of the coal supply chain firmly under the control of Vinacomin. Campha Port was built long before the formation of Vinacomin in the 1990s. The port was built in 1894 and put into operation in 1924.

Today's Campha port can handle vessels of up to 78,000 dwt and has a port storage capacity of 600,000 t. According to the official website of Campha port (www.camphaport.com.vn) the 2007 throughput was 20.4 Mt, of which 18 Mt was exported to foreign destinations, and 2.4 Mt was transported to other Vietnamese users within the country.

Campha port has four main shiploaders, with a combined capacity of 38,000 t/d. Freak weather events in 2008 put much of the loading capacity out of action. With so much coal being funnelled through few ports, it creates potential bottlenecks for export supply of anthracite. However, few reports of such events seem to occur, and supply disruptions do not seem to be a major issue for Vietnamese coal exports.

Campha Port handles 80% of Vietnam's 20 Mt or so of exports, of which 75% is destined for China, and the rest to Japan (MCIS, 2008c). Other reports state that a significant proportion of Vietnamese exports are barged across the

Table 5 Capacity of coal export ports (Mt/y) (Thanh Son, 2006)

Port name	Mt/y
Total	34
Cam Pha/Cua Ong	15
New ports in Cam Pha	10
Hon Gai/Nam Cau Trang	3
Hon Gai/Dien Vang	1.5
Hon Gai/Troi	1.5
Uong Bi/Dien Cong	3

Chinese border in small 1500 t barges (MCIS, 2008b). It is possible that the barges pass through Campha, but Campha is not on the border with China, rather it is within easy reach of it. Assuming barge movements carry coal directly over the border via river passage only, some 10 Mt/y is barged this way (MCIS, 2008c), meaning that just under half of all the exports coming from Vietnam are using this method. Of the 10 Mt/y, it is estimated that 5 Mt/y comes from Vinacomin, and 5 Mt/y from other small suppliers. The voyages take just eight hours, but the government has been keen to take better control over these shipments and stop smuggling, which avoids tax exports (20% as of 16 June 2008). There is therefore some inconsistency in the throughput figures of exports and the mode by which coal is transported out of the country.

Much of the eastern coastal waters off Vietnam are fairly shallow which in the past has limited ships to a deadweight of 10,000. However, excavation work at the port of Campha in recent years has meant that 65,000–80,000 dwt ships can be handled. Hon Gai port handles smaller Handysize/Panamax ships 10,000–65,000 dwt, and it is unlikely there will be any development to expand due to its status as a UN National Heritage site. It is more likely operations will be more tightly controlled.

In Central Vietnam, where coal resources exist in more limited amounts, a new deep water port is planned for Khe Ga. The port will serve primarily the export of aluminium, but there could also be facilities to import coal. The port could handle 80,000 dwt Panamax vessels and so fairly large vessels could operate in and out of Khe Ga.

13 Environmental standards

Environmental degradation created from coal operations is a serious concern for Vietnam's Quang Ninh province, and increasingly expenditure on protection measures is being made, but arguably falls short of what is required. Since 1996, an environment fund was established by the former Vinacoal, and drew 1% of the cost price of coal mining and other related activities to fund environmental protection methods. As of 2005, VND 60–70 billion had been spent to implement programmes and projects for minimising environmental pollution, protecting biological diversification and solving environmental matters in coal mining activities (UNESCAP, 2007).

13.1 Opencast mining

Opencast mining is a method of mining that has been fraught with environmental degradation. In the past, mining equipment was old and obtained from old eastern European and Russian mines. This has changed and modernisation is under way in all mines but, despite productivity gains, opencast mining could cease to exist by 2020.

Coal mining activities result in discharges of waste water, dust, and overburden removal into the natural environment. Air pollution is produced from coal dust and mine blasting, while acidification of surface waters (pH2–4) and river and stream sedimentation is caused by runoff from overburden disposal sites. Deforestation and land degradation is a major problem from coal mining. During rainy periods, overburden can destroy 200 ha of agricultural land every year. Relocation of homes and families has been common.

Bui and Drebenstadt (2004) discuss the characteristics of the Quang Ninh region as being tropical with a rainy season from May to October, while the cool dry season is from November to April. The heavy rainfall affects surface water, which supplies underground aquifers of a thickness of 50–100 m, and can cause flooding problems. Lower aquifers are 50–80 m and sourced from underground water. Where water can drain naturally, channels and canals are dug to carry water away from the mines. Where water sits below this natural drainage level, pumps are used. So during high rainfall a great deal of pressure to pump water away from working areas greatly hampers coal operations.

13.2 Coal washeries

The environmental performance of coal mines and preparation plants has been improved for operations such as dust suppression, water drainage, waste water treatment, land restoration (UNESCAP, 2007). However, despite these well intentioned efforts to improve side-effects of coal mining facilities, a large problem still exists in a considerable proportion of the industry. In 2009, the deputy director of the Vang Danh Coal Mining Company admitted that the company discharged untreated wastewater directly into a nearby stream that sources the Lan Thap Water Plant (Steelguru, 2009).

A report by researchers at the Uong Bi Natural Resources and Environment Agency and the Hanoi University of Natural Sciences stated that 750 t to 800 t of coal dust floated into Vang Danh Commune every year. The researchers also said dust contamination exceeded safety levels by a factor of ten throughout the town. The report found open water sources were contaminated by harmful substances at levels hundreds of times higher than regulations allow. In 2003, Vinacomin declared in a press release that two of its affiliates, Coc Sau Coal JSC and Deo Nai Coal JSC, were discharging pollutants into the natural environment. In 2008, three other operations were found causing similar problems at Mong Duong, Thong Nhat and Nam Mau.

Clearly, modern production techniques of dust suppression and waste water treatment must be adopted industry-wide and enforced with proper regulatory measures to alleviate these problem. According to UNESCAP (2007), the environmental monitoring is regularly conducted according to regulations at most mines and preparation plants. Funded by UNDP, the project VIE-95/003 on environmental protection in opencast mining in Quang Ninh has been implemented. Moreover, other environmental protection projects sponsored by SIDA, JICA have been set up or implemented. While these may set standards for a few mines, the outreach to all operations will be limited by the regulatory regime and enforcement of standards.

13.3 Other environmental issues

Vietnam signed the United Nations Framework Convention on Climate Change (UNFCCC) in November 1994, and ratified the Kyoto Protocol (KP) in August 2002. Vietnam fulfils requirements to host Clean Development Mechanisms (CDM) projects.

The government is concerned by climate change issues and considers climate change is a real threat to Vietnam being one of the most vulnerable countries. By participating in CDM, Vietnam can seek additional investment and opportunities for technology transfer. In June 2003, the government designated the National Office for Climate Change and Ozone Protection (NOCCOP), part of the International Cooperation Department (ICD) of the Ministry of Natural Resources and Environment (MONRE) as CDM National Authority or CNA. The CDM National Executive and Consultative Board were established in April 2003, composed of government officials from MONRE and other Ministries.

In August 2004, the Prime Minister signed the Decision No 153/2004/QD-TTg issuing Vietnam Agenda 21 in order to develop the economy in a sustainable manner. According to this document, the energy industry is one of the key industries and also has the biggest impact on the environment due to coal mining activities, oil and gas exploitation on the seabed, and the release of waste from energy production and consumption. The main environment policy for the energy sector from the strategy is the following:

- strengthen the legal basis for production and business activities, energy consumption and environmental protection;
- support research and development, transfer and application of energy systems that cause little impact to the environment including new and renewable energy sources. Priority should be given to developing renewable energy sources through financial incentives, other policies in the strategy for national energy development;
- actively participate in international co-operative and exchanging activities related to the UNDP framework convention on climate change in 1992.

14 Electricity demand and generation trends

Economic growth is strong, with GDP growth throughout the 1990s averaging 7.6%/y. Growth continues to exceed 7% making it probably Asia's second-fastest growing economy behind China. Between 1990 and 2006, the average growth rate for electricity demand was an astonishing 14%/y, quite out of proportion with the GDP growth. According to the Asian Development Bank (ADB, 2009), power generation reached 76 TWh in 2008, more than double that being generated in 2002.The Vietnamese now generate more electricity than Austria.

Sixteen years of high growth from all sectors of the economy appears to be just a beginning for the country's power markets. In just ten years, Vietnam's customer numbers have increased from 2 million in 2995 to almost 10 million today. In 2006, sales of electricity were approximately 50 TWh, while the country generated approximately 60.5 TWh. Demand continued to grow, and by 2008, an estimated 76 TWh was generated to meet 67–68 TWh of demand (calculated from generation minus estimated losses of 11–12%).

14.1 Prospects for growth

Per capita electricity demand is around 600 kWh/head (579 kWh in 2006), it still remains one of the lowest in Asia (*see* Figure 17). With increased urbanisation and improved living standards, growth in electricity demand is inevitable, however, whether a sustained growth of 14%/y is likely during a period of global economic turmoil in the few years after 2008-09 is not certain, and is likely to be below this. Growth in household appliance ownership has probably been even more influential on demand because disposable incomes have risen from very low levels in the mid-1990s. Per capita electricity consumption was 598 kWh in 2006 (IEA, 2009). With consumption at such a low level, the possibilities for growth are immense in all sectors. Vietnam's per capita electricity consumption is on par with The Philippines and Indonesia, but considerably less than its neighbouring economies China and Malaysia.

Demand growth is expected to remain high, with per capita electricity consumption expected to double from 600 kWh/head in 2006 to 1300 kWh/head in 2012. Even by 2012, consumption per head will remain half that of China or Thailand. In 2008, EVN reported a continuation of electricity demand growth over the long term to 2025 at some 11–12%/y. Demand will be partly met by imports, but domestic generation will form most of the country's supply and so is expected to grow in line with demand and economic growth.

14.2 Sectoral demand for electricity

Figure 18 shows the sectoral split for electricity demand in 2006. Industrial demand accounts for the largest proportion of demand, and will continue to be so in the future. As mentioned earlier, residential demand will increase with rising rural electrification, but also in the urban metropolitan areas where 100% of households have access to electricity. Considering a vast amount of biomass is already used in the residential sector, it is likely electricity will not replace a massive proportion of the biomass, but rather add to the energy consumption by providing increased lighting, refrigeration, and other appliances.

The sharp, steady increases in residential electricity demand follow both an increase in household access and addition of

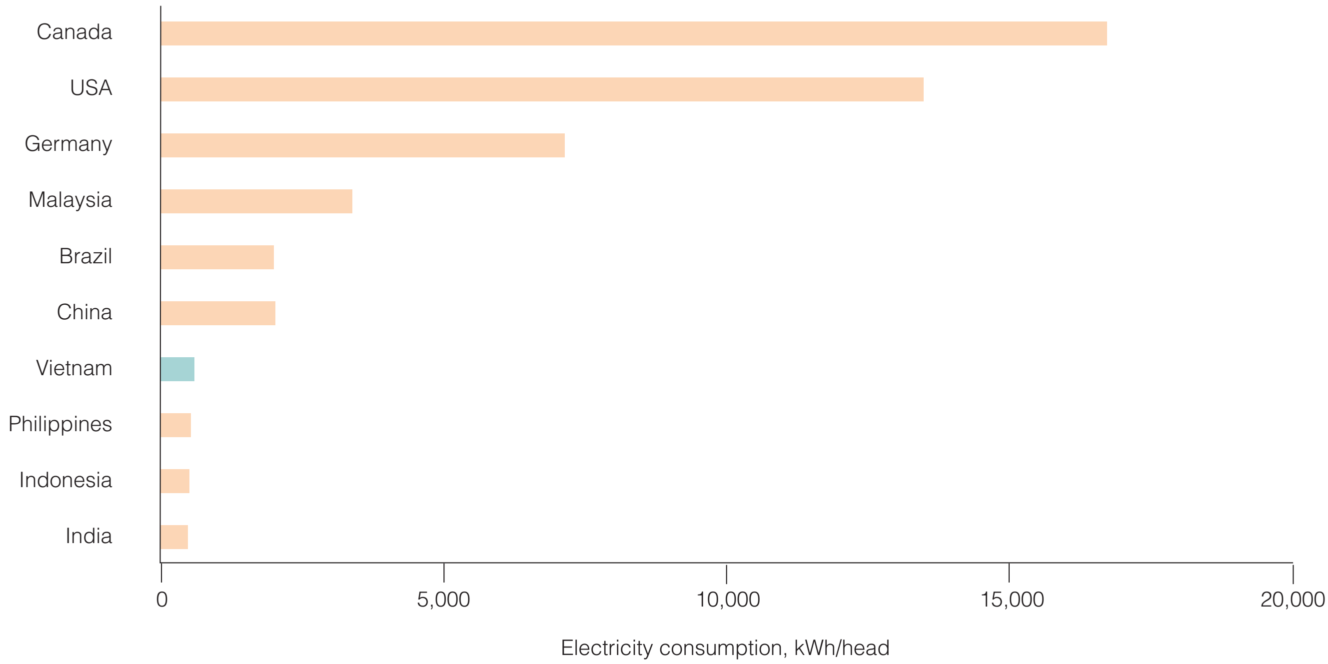

Figure 17 Per capita electricity consumption in 2006 (IEA, 2009)

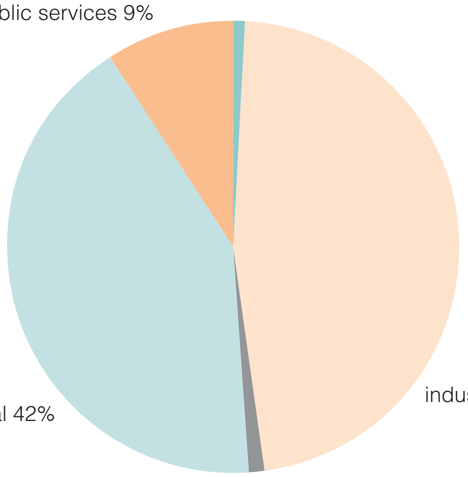

Figure 18 Electricity demand in 2006 by end-user (Total = 48.7 TWh)

loads other than the basic lighting load. With both increases in the urban population and the success in rural electrification about 30 m new people were added as power users from 1995 to 2004, representing some 37% of the total population.

Light industries are growing fast in Vietnam and include food and beverage processing, textiles, light chemicals, and light consumer durable goods. These often tend to increase power use per unit value added as development proceeds, due to increasing automation, packaging and (for food, beverages and textiles) increased use of cooling. Industrial electricity demand growth increased especially fast during the last few years (for example 18.5%/y during 2001-04) and is expected to continue to be a key demand driver (World Bank, 2007b).

While urbanisation and industrial growth are major drivers, rising electricity consumption is being driven partly by the expansion in rural demand that is taking place as more communes are connected to the national grid. At the end of 2006, 93% of rural households had access to electricity, compared with 51% in 1995. This figure is set to continue rising over the next few years, particularly following the recent financial support provided by the World Bank for the Rural Energy II project, which aims to supply power to 2.5 million households by upgrading the electricity network in 1200 communes in 30 provinces. The Bank has agreed to make $220 million credit available for the project, which began in 2005 and will run until 2012. In addition, in mid-2008, the Bank approved $150 million in financing to upgrade rural energy infrastructure.

Access to electricity in rural areas has increased dramatically during 1996-2004, marking one of the most successful recent rural electrification programme in the world. The number of rural households with access to electricity has increased from 50.7% in 1996 to 88.0% in 2004. Rural household access rates are expected to further increase during the next several years, although achievement of access among the final 5% of rural households will not be easy. The success of Vietnam's programme lies principally with the commitment of the Government to rural electrification, and the definition and systematic implementation of national plans as a matter of priority, with public investment support to match local community funds.

Table 6 Electricity market projections between 2007 and 2025 (Du Son, 2008)

Official power development plan VI					
	2007	2010	2015	2020	2025
Sales, TWh	58.4	96.2	210	340	450
Generation, TWh	66.9	105.8	227	363	484
Peak demand, MW	11.5	18	38	60	79
Generating capacity, MW	13.1	25.7	50	78	100

14.3 Future trends in electricity demand

Vietnam is facing sharp increases in power sector investment requirements. The original Fifth Power Master Development Plan projected an increase in power generation averaging 13.4%/y during the period 2001-10, and power generation actually grew by 15%/y during 1995-2005. EVN revised its development plans in 2003, and despite foreseeing shortfalls in capacity, the country still found itself ill prepared to cope with a serious shortage in supply capacity in 2005, leading to the forced large-scale load shedding.

In the early 2000s, the growth rate in electricity demand was averaging 12–17%/y. Whether an electricity demand growth could drop to below 10% is not impossible, and when compared with official statistics, it is probable. The government has been prone to underestimating demand growth which partly led to the slow development in generating capacity. If demand did indeed fall to 7–8%, it would enable the generating and transmission capacity to play catch-up. However, there is a real danger that demand outpaces generating capacity the way it has done so in the past (*see* Section 15.4). Recent base-case scenarios point to a slowdown in power demand growth to 11%/y between 2011 and 2015, followed by 9.1%/y during 2015 to 2020.

While GDP growth is expected to rise by 8–9%/y during 2006-15, updates to the outlook for economic growth in Vietnam may well alter the projections. Reports suggest that the target sales by the government are rather more optimistic, and certainly not implausible. The Ministry of Industry targeted an increase in power generation of 12.5%/y of public grid generation, with sales increasing by 13–14%/y in 2009 (PiA, 2009a). This drop in economic growth will probably impact industrial output and residential energy demand.

Based on multiple linear regression analysis done by IEA CCC using GDP (in constant VND) and population forecasts (obtained from the IMF), there is some agreement with other long-term forecasts published elsewhere. The author's analysis suggests that the growth in electricity demand in 2009 might only be 7.6%/y, but then rising to 8.9%/y in 2010, and 10–11%/y in 2011-13. These rates are considerably lower than past 12–17%/y actually experienced in the 2000s. Even these predicted growth rates may be too high. Some reports suggest that electricity demand may only grow by 6–7%/y in 2009 (Binh Minh, 2009). IMF data show GDP sustaining an 8.5% growth rate in 2007, in line with the assumptions, the growth in real GDP dropped to 6% in 2008, and then an estimated 5.5% in 2009. IMF projections suggest that a growth rate of some 7–7.5%/y is likely between 2009 and 2013 and 8–9%/y after 2013.

15 Electricity supply in Vietnam

The Vietnamese electricity market is based on a single buyer structure. This effectively means that whoever generates power, whether it be EVN or an IPP (foreign or Vietnamese owned) must sell all of its output to EVN. On-site industrial (auto) production clearly does not apply for the power that is used on the same site. Any power from an industrial site that is delivered to the public grid must be sold to EVN. Therefore, the supply of electricity is in the hands of a state monopoly.

15.1 Structure of the electricity market – the monopoly of EVN

Electricité de Vietnam comprises a number of units which have a controlling stake in power generation, transmission, sales and distribution. These units include the National Load Dispatch Center, 14 power plants, four transmission companies, and the Institute of Energy operating as dependent accounting units under EVN. The independent accounting units are seven distribution power companies, four design and engineering companies, two power equipment manufacturing companies, and one electric telecommunication company. EVN owns and operates a bulk of the power generation, especially hydroelectric plants. EVN also owns shareholding stakes in a number of independent power plants (IPP) which include generators owned by other state-run corporations.

In 2000, IPP projects accounted for just under 9% of the total generating capacity in the country. By 2007, this proportion had grown to 22% of generating capacity. According to IEA CCC estimates, based on proprietary information, 95% of the IPP capacity is thermal generation. This means that IPPs are an increasingly significant proportion of the overall generation. Interestingly, IPP developments in Vietnam are occasionally owned by state-owned entities. For this reason, the term IPP can be misleading in some instances. For example the Ca Mau and Non Trach stations are both CCGT with a combined capacity of 1800 MWe, and account for 40% of the IPP capacity in Vietnam. Both the stations are owned by the state oil company Petrovietnam.

Petrovietnam operates some of the largest power stations in the country. The Ca Mau 1 and 2 plants are 1500 MWe in total and were built using turbines and generators supplied by Siemens. The next largest IPPs include the build, own, and operate (BOT) project at the Phu My power complex which was built in 2003-04. While EVN operates the bulk of the capacity on the Ca Mau 2800 MWe power complex, 940 MW is owned and operated by the Phu My Power Company (460 MWe) and the Mekong Power company (480 MWe). The entire complex consists of gas-fired plants, many of them in combined cycle.

The Quang Ninh Thermoelectric Power Company is a joint stock company owned by a pool of investors, but appears to remain in the ownership of the state. The coal-fired station is located at Ha Long in the north east of Vietnam. The plant is a sizeable project at 1200 MWe comprised of four 300 MWe steam turbines. The whole operation is an IPP complex where EVN has the majority stake. Minority stakes are held by Vinacomin, the state coal company, and the Pha Lai Thermoelectric Power Company (PiA, 2009e), whose parent company is EVN.

EVN's financial accounts are strictly separate from the Government budget. According to official reports, EVN receives no subsidy for investment or its operations, with the exception of funding for the resettlement of populations during specific hydroelectric schemes. EVN has several methods of raising finance. Most of the funds are raised under commercial terms, although concessional loans are raised for the purposes of improving rural electrification as well as DAF loans used for resettlement costs, which carry interest rates that are charged at a 2–3% discount below commercial rates.

According to the World Bank (2007), EVN was able to steadily maintain profitability throughout 2004, covering all of its costs, including depreciation and financing costs, from internally generated revenues. While raising finance is done on a commercial basis, EVN's generation and network development plans, and all major investment projects must be approved by the Government. The Ministry of Industry is responsible for executing bidding and contracting procedures for large IPPs. State policy has increasingly encouraged development of independent power generation by investors outside the EVN system.

15.2 Power transmission network – system losses remain high

With power generation growing at a rate desperately trying to catch up with the soaring demand, system losses remain high. Losses occur across the entire power generation to end-user network. The bulk of the losses occur in transmission and distribution. Losses can be estimated by calculating the difference between sales (or final demand) and generation.

According to Du Son (2008), system losses in the mid-1990s exceeded 20%. This was a phenomenal amount of power loss in the transmission and distribution grid. However, through investment and expansion, EVN is reported to have cut transmission and distribution losses down to 10.8% in 2006 (EVN, 2008). Much of this could be attributed to the recent expansion from around 13,135 km of power lines in the year 2000, to 20,000 km in 2006. While the medium (220 kV) and low voltage (110 kV) grid has experienced significant growth in kilometres laid (up to 50% increase), the high voltage grid (500 kV) has doubled.

Although losses are high, it is not clear whether the estimate of losses at 10.8% is entirely accurate, and could be underestimated. Using generation and sales data from Du Son (2008) gives a simple percentage difference of 12.6%.

However, the Ministry of Industry targeted sales of public grid electricity of 74.9 TWh in 2009, at the same time as generating 83.3 TWh, which would imply a loss factor of 10% (PiA, 2009a). Regardless of the accuracy, losses are high but improving and must continue a path of loss minimisation in future years.

The purpose of building new power stations to meet growing demand will be continually countered by high losses, and will prove costly for EVN over the long term. The Government's Sixth Master Plan shows how EVN aims to bolster the network system by trebling the length of the transmission network between 2007 and 2025. More crucially, EVN aims to treble the capacity by 2015, and increase it sevenfold by 2025 (on 2007 capacity). Press reports suggested that Vietnam's power shortages will not be dealt with without a seemingly unfeasible development programme. EVN stated that power shortages could be around 7–63 TWh. The wide range covers any number of growth scenarios for demand. By 2020, the shortfall could be 115–225 TWh. The problems arising from power blackouts are discussed in Section 15.4.

In Vietnam, there are substantial regional differences in the availability of natural energy resources, with particular reference to hydro, coal, and natural gas for power generation. The North has an excess of hydro and coal-fired power resources, and power surplus is now being transported to the Centre and the South over a high-voltage transmission line at 500 kV with a length of about 1500 km.

This transmission line effectively interconnects the electric systems of the three regions of the country. The level of electrification has been expanded step by step not only in urban but also in rural and to some extent in mountainous and highland areas.

Figure 19 shows the major 500 kV high voltage line that acts like the backbone of the north-south grid. The central region is served largely by hydroelectricity while the north is served by coal-fired power while the south is rich in gas-fired power. Clearly the metropolitan region and surrounding provinces around the cities of Hanoi (north) and Ho Chi Min (south) are the key focal points for demand from industry and urbanisation. What is clear from the representation is how a disruption in the transmission line would cause major problems in certain regions if there was a shortage of hydro or fuel for that region.

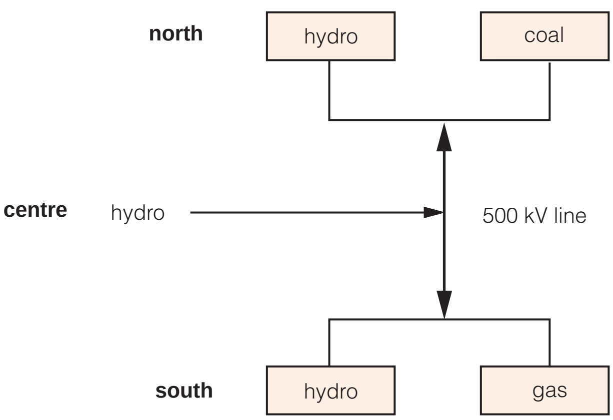

Figure 19 Regional character of Vietnam's Power System (Ritschel and Schiffer, 2008)

While this simplistic graphic illustrates some of the fragility in the network system, EVN plans to add considerably more capacity with cross-border connections with neighbouring Laos, Cambodia, and China. The governments of Vietnam and Laos PDR signed an Agreement on energy co-operation. Under this accord, Vietnam will import 1600–2000 MWe of electricity from Laos by 2020 (Du Son, 2008; APEC, 2009). The governments of Vietnam and Cambodia have also signed an agreement on energy co-operation, through which Vietnam will supply 80–200 MWe of electricity to Cambodia via a 230 kV transmission line, which could expand further by 2019. In the future, Cambodian hydro developments may also participate in the regional electricity market, Vietnam will conversely buy electricity from Cambodia. Vietnam joined The Inter-Governmental Agreement on Regional Power Trade in the Greater Mekong Sub-Region (GMS), which was signed by six GMS countries in November 2002.

At present, Vietnam supplies electricity to Laos and Cambodia by medium voltage lines at some places in bordering provinces and buys electricity from China by 110 kV lines. In 2006, Vietnam imported nearly 400 GWh from China. Power shortages in Vietnam may force EVN to seek more electricity from China over the next few years. To provide access to Chinese power, EVN began to build two 220 kV transmission lines in early-2005 – the Ha Khau (China) to Viet Tri (Vietnam) line and the Van Son (China) to Soc Son (Vietnam) line. These lines were completed step by step in 2008. With a total transmission capacity of more than 500 MWe, the lines will meet a part of the rising demand for electricity in coming years.

15.3 Local power distribution

The local distribution network is controlled by EVN subsidiaries, which includes seven regional power companies (PCs) that are each in charge of power transmission and distribution from 110 kV downwards. These companies are in effect the 'distribution companies' which take power from the high transmission grids to the end-user. These companies will be responsible for metering and billing.

The three largest PCs are named PC1 (northern Vietnam), PC2 (southern Vietnam), and PC3 (central Vietnam) and cover the major regions of the country; the four remaining distribution companies cover the metropolitan areas of Hanoi, Ho Chi Minh City, Hai Phong and Dong Nai. The PCs each maintain separate financial accounts, although the companies are consolidated within EVN's overall accounts. In most rural areas, local communities own and operate the low-voltage electricity distribution systems. The basic approach adopted for rural electrification in Vietnam has been for EVN's PCs to develop the medium-voltage network, and for local communities to develop the low-voltage system (although EVN has undertaken this role for about one-fifth of Vietnam's communes).

Provincial People's Committees oversee rural electrification in their provinces, and provide substantial financial support for the local share of investment. Until 2004, local power distribution was handled by informal Commune Electricity Groups or other informal entities in about two-thirds of Vietnam's electrified communes. According to Government regulations, however, all of these entities are now required to convert to formal legal entities, such as co-operatives or joint-stock companies.

15.4 Blackouts – the recurring theme in developing Asia

The Vietnam power system is prone to disruption: with increasing power demand, seemingly small breakdowns and failure can cause considerable disruptions. In 2006, Fon Anne Lee (2006) published some representative events that were provided by the Vietnamese News Agency that illustrate the problems faced in Vietnam. Power shortages resulted from rapidly rising peak demand, while supply disruptions ranged from low hydro availability, breakdowns of gas- and coal-fired plants, and limited transmission capacity to cope with the rising demand. Interestingly, thermal power stations are susceptible to excessive heat, possibly linked to the low availability of water supplies, which is intrinsically linked with the low hydro availability. Clearly, while flooding is a problem in some lowland parts of Vietnam, drought causes serious problems elsewhere.

While the longer-term projections for power generation have a wide range (*see* Section 16.5), it suggests there is great uncertainty in the future demand needs of the country, while the future supply will be somewhat constrained by developments in more transmission and generating capacity.

One of the most important features of Vietnam's energy market is how the economy suffers from periodic blackouts, especially in the dry season when hydroelectric power is in a lull. This is not an uncommon feature of electricity in many developing countries with inadequate capacity. Dapice (2008) wrote that one of the reasons that blackouts are frequent in Vietnam is the high ratio between peak demand and off-peak demand. Maximum demand can be 11,500 MWe, while off peak demand can drop to 6800 MWe. Such a massive swing in demand requires considerable amounts of idle peak capacity as well as flexible mid-merit capacity that the country currently lacks.

The major contributors to the increase in peak loads and energy consumption are various end-users (motors, process loads, lighting, etc) in large industrial and commercial customers, and lighting loads in the residential and small commercial customers.

Hydroelectric power in 2006 accounted for more than 30% of capacity and more than 40% of generation. Reservoir capacity is limited in Vietnam, and current facilities can supply power for up to a week under normal conditions. Dry seasons lead to limited hydro availability in succeeding months and create major shortages in the availability of electricity.

EVN has undertaken an efficient compact fluorescent light lamps (CFL) programme for the residential sector and embarked on a time-of-use metering programme for the industrial sector. Both of these programmes have helped reduce about 150 MW peak load demand. EVN plans to expand the time-of-use programme for the residential sector.

Typical peak generators include diesel generators, which may come in the form of turbines, internal combustion engines, or less commonly boilers. Other useful contributors to peak load will be natural gas-fired turbines, but both oil and gas generators can be extremely costly to operate on a per kWh output basis especially when oil prices are high.

The Vietnamese government has responded to the surging demand growth and blackouts by approving 48,000 MWe of generating capacity between 2007 and 2015, equivalent to 400% of the capacity that was operating 2006 (Dapice, 2008). Some 18,000 MWe of thermal power plants (coal and gas) are planned for commissioning between 2009 and 2016, and these new plant additions will also address the low reserve margin in the power system. In the two years between 2010 and 2012, at least 3000 MWe of new coal-fired power capacity is scheduled to be commissioned in northern and central Vietnam.

16 Power generating capacity in Vietnam

Figure 20 is a representative despatch curve of the Vietnamese generating capacity as of 2008 (based on the average percentage utilisation for the period 2000-07). Historically, coal-fired power has provided a considerable amount of electricity, but as can be seen from Figure 20, Vietnam's electricity supply has been dominated by two main forms of generation, hydroelectricity and oil products.

In reality, the despatch of power stations is not carried out in such discrete blocks. On a day-to-day basis, the despatch curve is smooth and generation for individual station units is spread across the curve. Station despatch changes hourly as well as annually depending on the availability of the plant and the cost of generation. Nevertheless, the illustration provides a useful simplified picture of the way a fleet of stations operate over a typical year.

The vertical axis indicates the amount of generating capacity the country had operating in 2006-07, and the horizontal axis shows the percentage of the year for which these fleets of power stations operated, otherwise referred to as utilisation (100% being 365 days or 8760 hours). The area of each block indicates the amount of power generated in GWh (convert % utilisation to hours by multiplying by 87.6), which is also represented by the pie chart in Figure 21 (for the year 2006).

In 2008, the main forms of generation were unsurprisingly hydroelectricity (5.4 GWe) and gas CCGT (5.6 GWe), which according to IEA CCC estimates accounted for more than 90% of the gas generating capacity, the rest being single cycle gas turbines, internal combustion engines or boilers whose primary fuel is likely to be oil, but are capable of firing gas. Coal generating capacity was 2 GWe, but is destined to expand rapidly. Oil-fired generation is approximately1 GWe, which is about half based on fuel oil and half on gasoil. This is peaking capacity, and may or may not expand as a proportion of total generation.

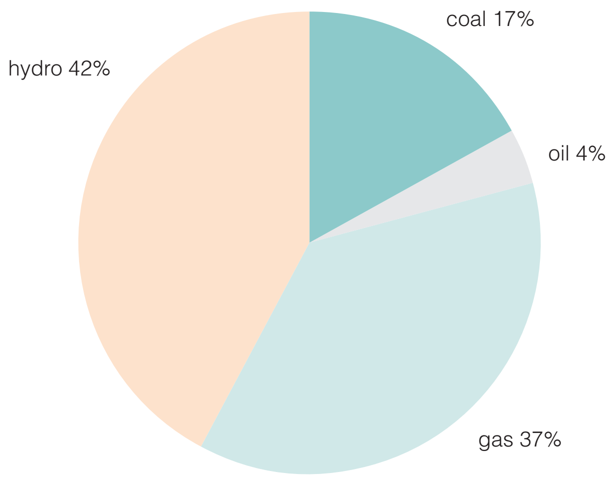

Figure 21 Total generation in 2006, split by generating source (IEA, 2009)

While these utilisation figures fluctuate, it is worth explaining some of the dangers of drawing immediate conclusions from such an analysis. In 2007, hydroelectricity achieved a utilisation of 56%, a little over the average shown in the figure, and significantly more than any of the preceding seven years. So, 2007 itself may be unrepresentative and therefore it may be more logical to average utilisation data over a longer period to encompass hydrological variability when drought periods may have occurred also.

For thermal generation, the average utilisation has been

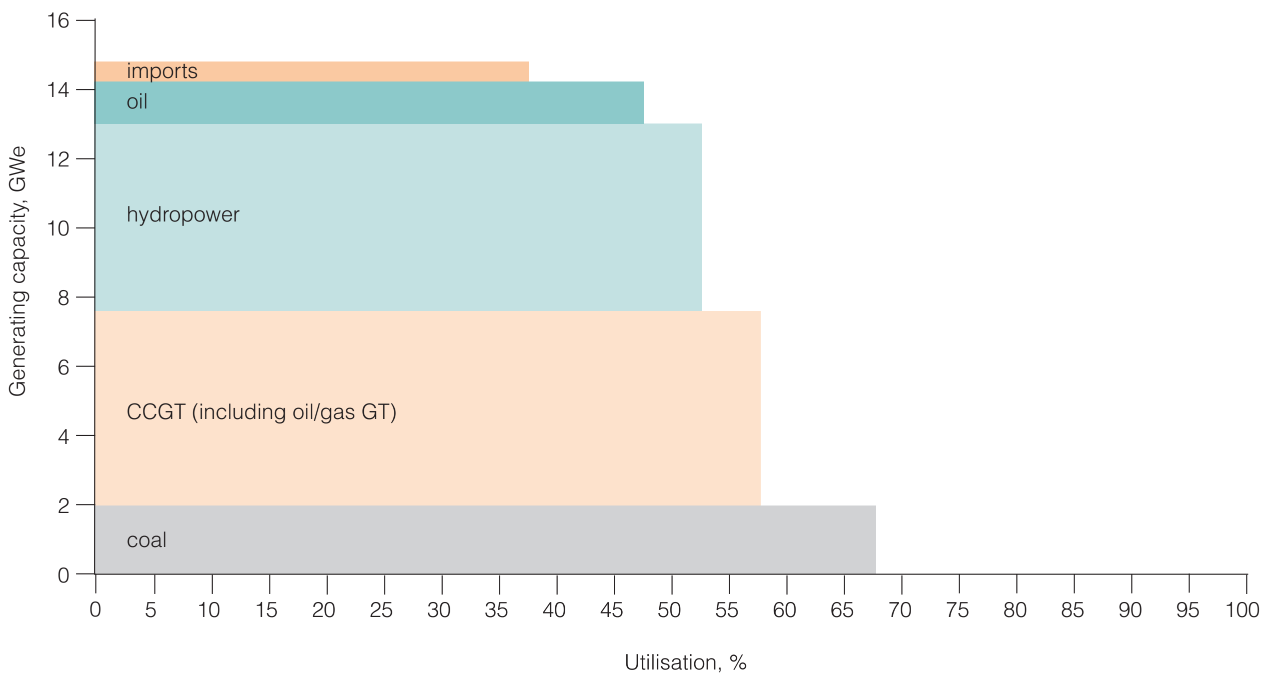

Figure 20 Despatch curve for power station fleet in Vietnam (author's estimates)

around 55–67% for gas GT and coal, with utilisation rates rising gradually over the years. These utilisation rates may well be underestimating the true potential for fossil-fulled generation in Vietnam in the future.

In the period 2000-07, EVN's thermal capacity more than doubled for both coal- and gas-fired power. IPP developments increased eightfold, more than 95% of which was thermal generation (mainly gas), and only a small proportion was hydro or renewables. This massive rate of development can affect performance statistics for power stations for the following reason. When new plants are being commissioned part of the way through the year, testing and final commissioning can take weeks. If the capacity comes on line in the latter half of the year, its average annual utilisation will therefore be very low. For this reason, year-on-year utilisation of thermal plants may seem low as each year brings on new capacity, often large scale. Therefore, the average thermal utilisation of 55–67% for the CCGT and coal stations may underestimate that achieved by modern existing stations that have been running for a year or more. This relatively low utilisation may continue for some years as power developments continue in large incremental steps.

16.1 Existing coal-fired capacity

Table 7 lists all the coal-fired power plants that were in operation in 2007 in chronological order. The list comprises of nine power plants, although Uong Bi 7 is separated from the remaining units as it was built 30 years after the remainder of the site. Uong Bi 5–7 (410 MWe), Pha Lai 1 & 2 (1040 MWe), and Ninh Binh (220 MWe) are owned by EVN subsidiaries. This leaves three smaller power stations ranging from 12 to 126 MWe amounting to 370 MWe that are operated by IPPs. IPPs provide around 18% of the total coal-fired capacity. Na Duong (100 MWe) and Cao Ngan (100 MWe) are still owned by the state via Vinacomin and so are independent of EVN, but not privately owned.

Coal-fired power development in Vietnam was slow before 2000. It took almost 20 years to build 800 MWe of coal-fired capacity. Some 1.2 GWe was built between 2001 and 2006 with the construction of Pha Lai 2 and Uong Bi under EVN, and a number of plants owned by Vinacomin, Formosa, and Ha Bac Nitrogen Fertilizer.

Some of the early power stations were built by Lilama, now an EVN subsidiary that specialises in construction. In the past, foreign firms such as Siemens and Fuji have been involved in power projects as far back as the 1980s when they supplied equipment for a small IPP Bai Bang Mill.

16.2 Coal – the preferred method of reliable power generation

As mentioned throughout the report, developments in power projects have shown a major shift away from hydroelectricity towards thermal generation. Figure 22 illustrates the capacity developments that occurred in the period 2008 to the first half of 2009. There is a clear shift towards coal-fired developments, an indication of the way power generation will move forward in future years.

The Platt's Power Tracker monitors the status of major power projects, however, some may be omitted due to the fast pace of change that occurs in the power industry in developing countries. Nevertheless, these Tracker projects are likely to form a larger proportion of the country's generating fleet. In the period 2008 to the first half of 2009, Vietnam commissioned 5 GWe of new capacity, much of which was gas-fired (2.7 GWe) but also included coal-fired (1.4 GWe), and hydroelectric (1.3 GWe) projects. At the same time, the total plant capacity that was still under construction amounted to 9 GWe. Nearly all of this 9 GWe was coal-fired and due to come online during the period 2010-13.

Interestingly, the plants that were in various stages of planning were also largely made up of coal-fired capacity. Early stages of planning might include plants with local or central government approval, or been announced, or where

Table 7 List of existing coal-fired power stations, 2007

Plant name	Owner or operator	MWe	Fuel	Date of commissioning
Uong Bi 5 & 6	Uong Bi Thermal Power Co	110	Anthracite	1965 & 1974
Ninh Binh Ninh	Binh Power Co	220	Anthracite	1974-76
Pha Lai-1	Pha Lai Thermal Power JSC	440	Anthracite	1983-1987
Bai Bang Mill	Bai Bang Paper Co	28	Anthracite	1982
Pha Lai-2	Pha Lai Thermal Power JSC	600	Anthracite	2001
Na Duong	Vinacomin	100	Lignite	2004
Nhon Trach Formosa	Hung Nghiep Formosa	126	Anthracite	2004
Cao Ngan	Vinacomin	100	Anthracite	2006
Uong Bi 7	Uong Bi Thermal Power Co	300	Anthracite	2006

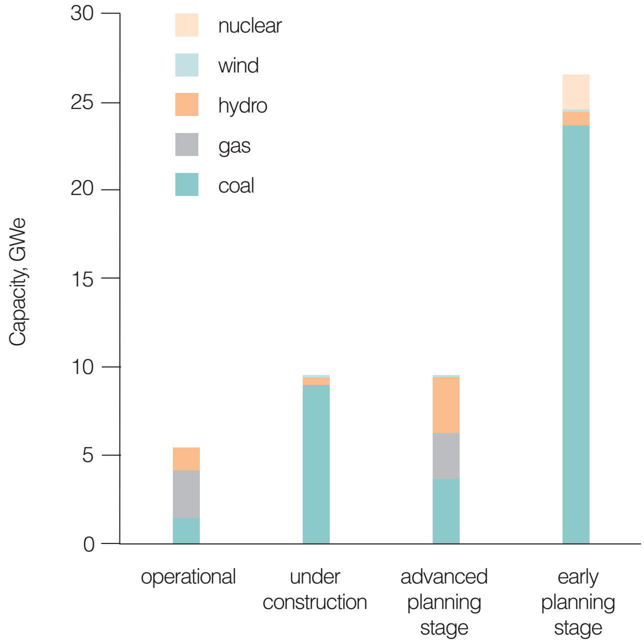

Figure 22 Platt's Power Station Tracker – power development status in 2008-09

partners in the development are yet to be chosen. Plants that are considered to be in the advanced planning stages are those where contracts for construction have been awarded; where debt or investor finance has been secured; or where a power purchase agreement has been signed. While there is significant interest in coal-fired projects, the credit crisis that is afflicting the global economy may impact capital intensive projects such as coal plants. Many of these projects may yet be deferred or cancelled altogether, but there is no evidence of this yet.

Table 8 lists all the major stations that were listed in the Platt's Power Station Tracker for the period 2008 for Vietnam. The list provides plant specific details on developers, capacities, and the status as of this period. The list was constructed using the Platt's Power in Asia journal in which the Tracker is published regularly. Other sources for power station projects were used to supplement the Platt's list wherever possible. While some of the details may be subject to change, particularly for the plants in the planning stage, the most accurate information was provided at the time of preparing the table.

Some of the difficulties of identifying power plants is that they may be known by location, typically the province, but also after the local town, or project developer. Where duplication of projects was identified, they were omitted. Where actual operating capacities differed from design capacities, the operating capacities were shown.

The larger coal projects that were under construction were being built by state-run firms; for example, Lilama Corp is the major construction and heavy manufacturing firm that is state-owned under EVN and it is responsible for the building of many of the country's largest power stations, from hydro plants to thermal stations. Gas turbines may still be provided by foreign firms such as Siemens, but Lilama are invariably responsible for the construction at a plant level. The other major power developer seen is PV Power. This is the name of Petrovietnam, the state-owned oil and gas company.

16.3 The Sixth Power Development Plan – 15 GWe of new capacity by 2013

The development programme for power capacity gave rise to a 15,000 MWe programme planned for commissioning in 2009-16. The high growth rates of demand coupled with the disproportionate reliance on hydroelectricity in the past has left Vietnam with little or no reserves during annual dry seasons. The Sixth Power Development Plan was approved in 2007 and recognised the need to tackle the system imbalances and seasonal shortfall from hydroelectric energy by building more thermal capacity. Hydropower is still part of the plan, especially from cross border links with Vietnam-financed hydro schemes in neighbouring countries such as Cambodia and Laos. The 15,000 MWe programme originally consisted of some 13 large-scale projects, with some small-scale projects included also, although more than 13 projects of varying scale are either in operation or are under construction.

A number of large-scale thermal projects have been commissioned since 2008-09, not least Ca Mau (2 x 750 MWe) and Nhon Trach (1200 MWe) gas-fired stations. The largest projects are however coal-fired and these include Quang Ninh (1200 MWe) which was commissioned during 2009-10. Projects under construction include the 1200 MWe Vung Ang coal-fired station, Thai Bin (1800 MWe), and the most interesting thermal power project of all, the Long Phu plant, also known as Soc Trang. Long Phu is earmarked to be a 4400 MWe station and will be a supercritical design capable of achieving efficiencies of 45% for some if not all of its units. The plant is located in the south of Vietnam and so the distance from the northern coal fields will mean the project could rely more on imported coal as well as coal shipped by sea from the Quang Ninh ports. The project is being partly funded by the Asian Development Bank (ADB, 2008c).

Since mid-2008, there has been a flurry of restructuring in the power development programme and it is surprising that many of the projects have not been deferred or cancelled altogether, however, the programme seems to be forging ahead. According to PiA (2009c) EVN announced it would be unable to finance the development plan in accordance to the time schedule. A number of other corporations swiftly stepped in, one notable corporation being Petrovietnam, or PV Power.

Plans for the 2400 MW Quang Binh (also known as Quang Trach) were jeopardised when EVN announced the finance problem, but Petrovietnam (PV) Power rescued the project. Another project advanced as a result of the Malaysian power investor Janakuasa Sdn Bhd who agreed to build the Duyen Hai-2 plant on an IPP basis. EVN remains the single buyer of electricity from all thermal IPPs, and so Janakuasa aimed to secure a 30-year PPA with EVN in order to secure the future of the project. EVN still remains the single buyer of electricity from the thermal IPPs, and so Janakuasa had hoped to sign a 30-year PPA with EVN in order to secure the future of the project. While EVN's involvement in the project development was withdrawn for a number of these thermal

Table 8 Platt's Power Tracker – major power project developments 2008-09				
Project name	Developer	Capacity, MWe	Fuel	Status 2
Son Dong	Vinacomin	220	coal	Operation imminent
Quang Ninh-1	EVN/Vinacomin/Lilama	1200	coal	Initial operation
Ca Mau-2	Petrovietnam Power	750	gas	Commercial operation
Ca Mau-2	PV Power	750	gas	Operation
Nhon Trach-1	Petrovietnam	750	gas	J-Power buys equity
Nhon Trach-1	PV Power	450	gas	Commercial operation
Dai Ninh	EVN	300	hydro	Commercial operation
A Vuong	EVN	210	hydro	Initial operation
Pleikrong-1	EVN	50	hydro	Operation
Tuyen Quang-3	EVN	114	hydro	Operation
Buon Kuop	EVN	280	hydro	Operation begun
Binh Dien	BDHPC	44	hydro	Commercial operation
Pleikrong	EVN	100	hydro	Commercial operation
Song Ba Ha	EVN	220	hydro	Commercial operation
O Mon-1/1	EVN	330	oil/gas	Initial operation
Subtotal				5768
Project name	Developer	Capacity	Fuel	Operation/construction status
Nong Son	Nong Son Coal	30	coal	Construction begun
Uong Bi 2/2	EVN	316	coal	Construction begun
Vung Ang	Lilama	1200	coal	Construction begun
Long Phu also called Soc Trang 1,2, & 3	PV Power	4400	coal	Construction begun
Thai Binh 1 and 2	EVN/PV Power	1800	coal	Construction begun
Cam Pha 1 & 2	Vinacomin	660	coal	Construction begun
Hai Phong	Hai Phong thermal power	600	coal	Construction begun
Dong Nai-2	Dong Nai PC	70	hydro	Construction begun
Nam Pung	Nam Pung Hydro	9	hydro	Construction begun
Son La	Visaween Hydro	27	hydro	Construction begun
Serepok-4	Dai Hai Power	80	hydro	Construction begun
Nam Chien-2	Northwest Power	36	hydro	Tunnel completed
A Luoi	EVN	170	hydro	River damming started
Binh Thuan	EVN Renewable	30	wind	Equipment delivered
Subtotal		9428		

projects, it seems that from the list, hydroelectric stations remain firmly within the hands of EVN. Out of all the planned developments, EVN has a direct interest in just two projects, both at the Vinh Tan power complex. The first was reported to be a consortium with Oneenergy (a joint venture between Hong Kong CPL Group and Japan's Mitsubishi Corp). The second Vinh Tan project on the same complex is being planned by EVN in a consortium with China Southern.

A total of 5.8 GWe was commissioned, while 9.4 GWe was under construction. Other smaller power projects may be in development but not included in the list. A total of 15.2 GWe of power capacity will therefore be commissioned between 2008 and 2015. This is more or less consistent with the 15 GWe of capacity needed under the Sixth Power Development Plan. Although the list is not completely comprehensive, most of the known projects are included. The plant capacities and specification may change in the light of the economic circumstances of funding bodies and corporations around the world.

A great deal of assistance has been sought to finance this development plan. Amongst a number of non-EVN corporations, international finance organisations such as the ADB, Japan Bank for International Cooperation (JBIC), World Bank, and the Swedish International Development Cooperation Agency (SIDA) have all contributed to financing the developments.

Table 9 Major coal power developments as of 2008-09

Project name	Developer	Capacity, Mwe	Fuel	Status of project as of mid-2009	Expected start date
Son Dong	Vinacomin	220	coal	Operation imminent	2009
Quang Ninh-1	EVN/Vinacomin/Lilama	1200	coal	Initial operation	2009-2010
Sub total of newly commissioned plants		1420			
Cam Pha 1 & 2	Vinacomin	660	coal	Construction begun	first unit 2009; second unit 2010
Nong Son	Nong Son Coal	30	coal	Construction begun	2009
Uong Bi 2/2	EVN	316	coal	Construction begun	2009
Hai Phong	Hai Phong thermal power	600	coal	Under construction	2010
Vung Ang	Lilama	1200	coal	Construction begun	first unit 2011- final unit 2012
Long Phu also called Soc Trang 1,2, & 3	PV Power	4400	coal	Initial construction	2013
Thai Binh 1 and 2	EVN/PV Power	1800	coal	Initial construction	first unit 2013; final unit 2015
Subtotal of plants due online by 2015		9006			
Ly Son	Vinacomin	5	coal	Project announced	2011
Phu Quoc	Vinacomin	100	coal	Project announced	2011
Kien Luong	Tan Tao Group	4200–5200	coal	Investors sought	2013-17
Vinh Tan	OneEnergy/EVN	2000	coal	MOU signed	2014
Duyen Hai-2	Janakuasa	1200	coal	Investor selected	2015
Quang Binh or Quang Trach Project	PV Power	2400	coal	Project announced	2015
Quang Ngai	Saigon-Dung Quat Power	2400	coal	Project announced	2015-19
Duyen Hai - 3.1 & 3.2	EVN to award contract	3200	coal	announced	
Van Phong	Posco/Vinashin	1000	coal	Joint venture agreed	NA
Khanh Hoa	Viet-Trung Power/Vinacomin	100	coal	Project announced	NA
Vinh Tan	China Southern/EVN	1200	coal	FSA agreed	
Subtotal of planned projects		17705			

While foreign institutions are readily providing funds, foreign corporations such as equipment manufacturers and power consultants are eager to get the business of building stations in Vietnam. While Lilama, the EVN subsidiary, is a major recipient of construction projects, Chinese corporations such as the Wuhan Kaidi Electric Power company have been awarded sizeable contracts of $430 million (out of a plant budget of $530 million). UK firms such as Mott Macdonald have benefited from winning consultancy contracts for the Song Bung 4 hydro project.

The World Bank has provided loans for upgrading transmission and distribution, rural energy projects and also assisting EVN in hydropower developments. Coal capacity developments due for commissioning between 2008 and 2015 accounted for more than 10 GWe of capacity. This is equivalent to two thirds of the 15 GWe development programme. Interestingly, there is an additional 19 GWe of plants that are in the planning stage (*see* Table 9). If these projects proceed successfully, a further 12 GWe of coal-fired capacity could have their first units operating before 2015, and completion by 2019.

16.4 The advent of developing coal import projects

While there is greater ongoing upgrading of some of the more promising mines in Quang Ninh, the potential for new coal reserves in the Red River Delta region, the Kien Luong project, takes a different approach and could provide Vietnam with a more diverse source of coal. The project is some 300 km outside of Ho Chi Minh City in south Vietnam and costs $2.5 billion. Within the project are a number of sub-projects which not only include a major power centre, but two coal and cargo ports to be built at Nam Du as well as at Kien Luong (PiA, 2008d). Coal supplies will be imported from Australia, Indonesia and Russia. If it is completed, some 3 Mt/y of imported coal could supply Vietnam's largest coal-fired station if (or when) the full 5200 MWe is commissioned. A number of foreign firms have shown interest in this major power and coal supply project, including Sojitz Corp (Japan), Kyushu Electric Corp (Japan), and International Power (UK).

The Kien Luong port could also provide a route for other future developments. Australian coal mining company Ensham has expressed interest in a 3600 MWe station that could use imported coal at the Binh An project, and investors are being sought. The proposed ports at Nam Du and Kien Luong could be capable of importing 10 Mt/y of coal. Other plants that could be importing coal include the 2400 MW Quang Binh (or Quang Trach) project and the 2400 MWe Quang Ngai plant, both possibly due online after 2015.

The Nghi Son 1 coal-fired plant is in the advanced planning stages, and together with another planned Nghi Son 2 plant could be operating in the Nghi Son Economic Zone located in Thanh Hoa Province on the coast of Vietnam some 40 km north of the town Vinh. The plants are part of a larger port and industrial development programme. The harbour and coal receiving jetty is being developed at Nghi Son, where coal for Nghi Son1 will be barged from Vietnamese ports from the north, while that for Nghi Son 2 will come from imported foreign sources. Nghi Son 1 is due by 2011, while Nghi Son 2 remains tentative and could be online in 2013/14. Coal imports of some 4 Mt/y are expected.

16.5 Projections for power generation

It has already been established that Vietnam plans to build 15,000 MWe of new capacity between 2008 and 2015-16. The question arises whether this be enough new power capacity to serve the needs of Vietnam's booming economy? Figure 23 illustrates some past electricity supply projections that have been presented by EVN between 2006 and 2008. In almost all cases, the growth projections contain an element for imports, but forecast electricity imports rarely contribute much more than 8% of the overall supply, and so these projections assume that more than 92% of the supply will be met by domestically generated means.

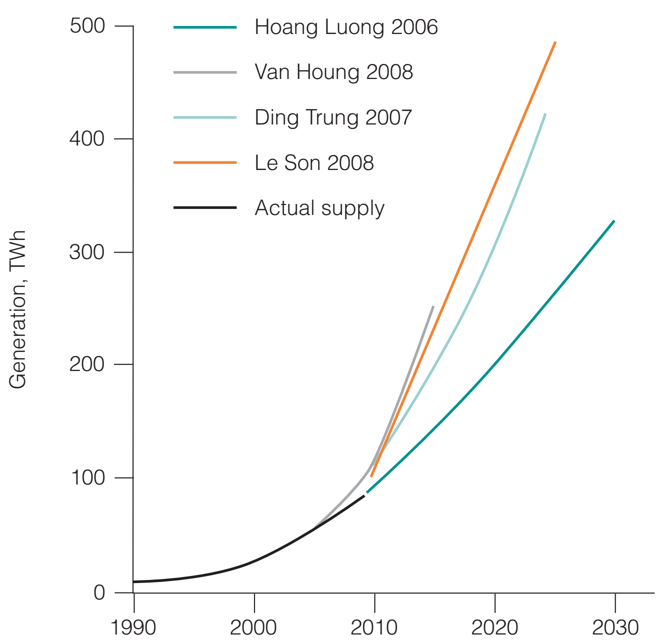

Figure 23 Base case electricity supply projections (including imports), TWh (various sources)

The more recent projections have been increasingly optimistic particularly the long-term growth trends presented by Van Huong (2008) and Le Son (2008). An estimated 430–480 TWh of electricity may be required by 2025. These projections assume that the growth in demand for power continues at levels of 11–12%/y. Surprisingly, the expected downturn in demand for electricity in 2009 may mean that the projections may need to be recalibrated to a lower 2009 level to account for the slower growth. Consequently, the actual historical trend seems to be following a plot represented by Hoang Luong (2006). However, as mentioned elsewhere in this report, the government has been wrong-footed by underestimating electricity demand in the past, and so perhaps Hoang Luong (2006) would be considered too low, albeit appearing to be a better trend line than the other base case projections.

For comparison, a generating output of 430–480 TWh expected in 2025 is equivalent to one tenth of that produced by the USA in 2006 (4300 TWh), or 80% of all the power generated in Africa (590 TWh in 2006); Vietnam's power generating ambitions are not small.

With such a dynamic economy like Vietnam, it is almost impossible to obtain an accurate forecast. One way of determining the growth rate is to analyse the building programme of power generation, and obtain a plausible projection for the amount of power that could be delivered by Vietnam's power stations in 2015 and estimating future build rates thereafter.

Figure 25 illustrates the potential development in power capacity in Vietnam as estimated by the author based on the published Platt's Power Station Tracker, and other media sources to determine new projects. The estimated capacity level for 2009 is around 17 GWe: this could more than double to 40 GWe by 2015 with the addition of more than 20 GWe of new capacity by 2015.

Roughly 60% of the 23 GWe of new capacity between 2009 and 2015 is already under construction and due for commissioning by 2015 (*see* Figure 25). These plants are therefore committed, and unless there is a catastrophic collapse in finance, these plants are likely to go ahead, albeit with possible delays. The remaining 40% of the capacity growth between 2009 and 2015 are plants that are in various stages of planning, either at a more advanced stage of finance, or a stage where investors or developers are being sought.

16.6 Reserve margin in crisis

The problem of supply shortages for electricity has been discussed; this section looks specifically at the future power commissioning trends and their possible contribution to the country's power reserves margin. Figure 25 illustrates the possible trend in peak demand following the same trajectory as Hoang Luong (2006) stated earlier, which sets growth between 2005 and 2025 at 8%/y (compared with other estimates of 11%/y). The reason for following this lower trend is to demonstrate the pressures Vietnam's power system could be under even with modest growth in demand.

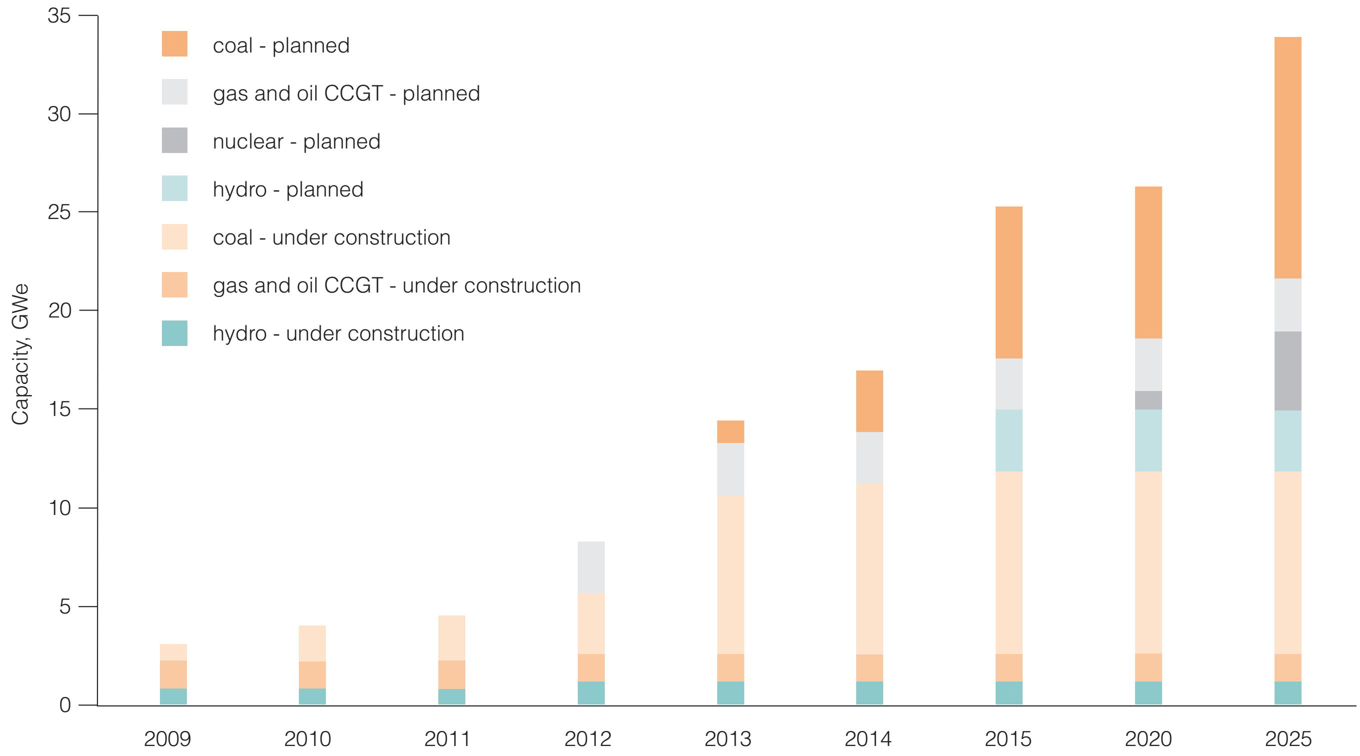

Figure 24 Potential new generating capacity build, 2009-25 (author's estimates)

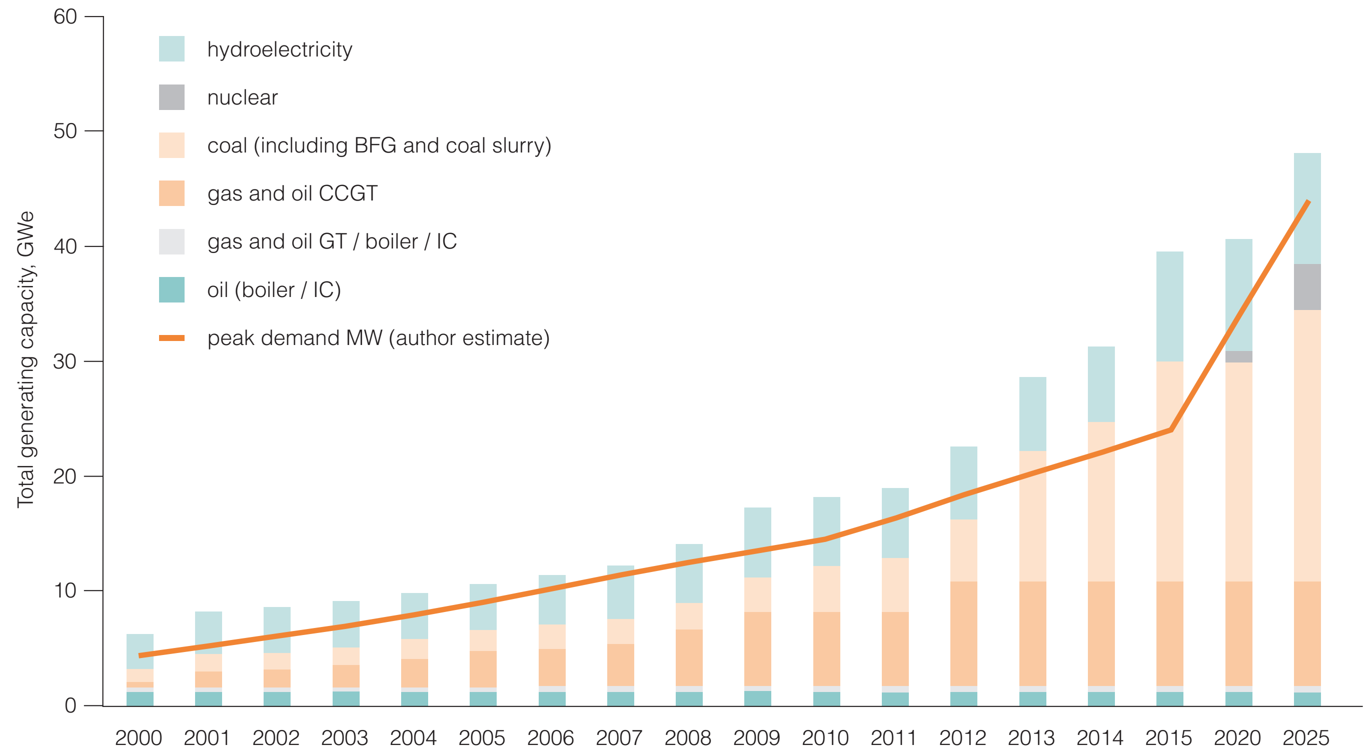

Figure 25 Power generating capacity trends in Vietnam, 2000-25 (author's estimates)

As mentioned earlier Dapice (2008) points out that Vietnam experiences a massive swing in demand within a day from as much as 11.5 GWe in peak periods, to just 6.8 GWe during off-peak periods. EVN therefore has a mammoth task in co-ordinating power station output with demand at any moment in the day. Choosing the right technology to meet this is therefore a key criterion, and is the reasons why coal-fired power is not only preferred, but necessary.

While there has been discussion on transmission losses running at high levels, at worst 20% in past years, but closer to 10% today, less is discussed regarding capacity reserve margin. The reserve margin (RM) is expressed as a percentage using the a simple calculation:

$$RM = [\text{Peak demand (MWe)} - \text{Max avail. Capacity(MWe)}] \div \text{Max avail. capacity (MWe)}$$

This calculation however is made more complex by the dynamic nature of power demand and supply which can alter for a multitude of reasons along the power supply chain, and which varies within different periods of time ranging from one hour to several weeks.

Assuming a simple annual RM calculation, in 2007 peak demand was 11.5 GWe, while total capacity was 12.3 GWe. While at first glance this would suggest a capacity margin of +6.7%, which is low, the reality is different. The 12.3 GWe capacity included thermal and hydroelectric plants. However, since hydroelectric plants have been averaging a utilisation of around 50% (*see* Figure 20), the available capacity for hydroelectric plants should perhaps be much lower while, theoretically, thermal plants are assumed to be fully available (with some planned downtime for maintenance). Assuming only 50% of the hydro capacity is available (based on the average utilisation of hydro plants since 2000), available power capacity drops to 9.9 GWe, although it is possible that reservoir hydro plants can still provide 100% peak capacity if the water levels permit.

Nevertheless, using the conservative assumption that 50% of the hydro is available for providing peak supplies, the reserve margin of Vietnam in 2007 drops from +6.7% to –5.7%. This is illustrated in Figure 25 by the orange line, which represents the trend in peak demand. Peak demand in 2007 is just below the capacity level of thermal (coal, gas, and oil) and hydrogeneration. If only half the hydro capacity was available, Vietnam barely has enough available capacity to meet the peak demand in this year. This is visible in almost all other years thereafter until 2013.

Provided the current construction programme goes ahead with little delay (as in Figure 24), and the additional planned capacity comes online also, Vietnam may still suffer from reserve margin problems for some years. However, the large coal-fired plants due to come online around 2013 and planned thereafter will ease the country into a state of reserve margin stability provided demand does not follow a higher trajectory. More of the station capacity will be thermally based, with less hydroelectricity. Other renewable energies will be small, and play little part in the generating mix.

By 2020, the growth in capacity is considerably more speculative and even introduces Vietnam's first nuclear station if it is successfully built after 2020 (*see* Figure 24). Quite unlike countries like North Korea and Iran, Vietnam has actively sought international co-operation, which has been ongoing since the 1980s. Within this period, the International Atomic Energy Agency (IAEA) based in Geneva helped upgrade and restore a 500 kWe research reactor. Since then, Japan, South Korea and Canada have assisted Vietnam in studying the feasibility of running a large civilian reactor. Since 2006, moves to develop a power station were proposed by the government, and by September 2008, a National Committee was set to appraise the proposal for a named plant, the Nunh Thuan nuclear station. It is envisaged that the station will be 4000 MWe, the first unit to be commercially operating in 2020, the remaining units to come online in 2021-24. Further plans to develop 10–20 GWe by 2030 and 2040 respectively are being envisaged such that nuclear could form a significant proportion of the country's future electricity output.

While these plans seem ambitious, Vietnam's desire to foster international relations remains positive, and makes nuclear power a real possibility. Vietnam signed the South East Asian Nuclear Weapon Free Zone Treaty in 1996 and several agreements for peaceful use of nuclear with India, Korea, China, Argentine, and Russia. Japan and France have closely co-operated with Vietnam, and recently co-operation with the USA has been established. The nuclear ambitions of the future could be as significant as the coal-fired plans for the period 2009-15.

17 The impact of future power generation on coal demand

Given the expected growth in power generating capacity of coal-fired plants, growth in all forms of power generation is also likely to be substantial. The previous chapter has shown that even if demand grows at a modest rate of 8%/y, the current plans for power station construction will only alleviate reserve margin shortages by around 2014, and then the power shortage problems may worsen again by 2020. At higher growth rates of demand, some 11%/y and higher, the country could suffer greatly from power shortages indefinitely without the substantial build programme that is already planned. Assuming a successful build programme over the next 15–20 years, diurnal peak demand may still suffer, even if enough capacity is being built to meet the annual average needs.

Figure 26 illustrates the author's estimates of future power generation output based on the capacity growth shown in Figure 24, and logical assumptions on the future utilisation of the existing and newly constructed power generating fleet.

When compared with the generation projection published by Hoang Luong (2006), there is good agreement in the overall level of generation, although after 2013, the author's estimates show a potential surplus of electricity on an annual basis. This trend excludes the extra power that will be made available from future imports from neighbouring hydroelectric projects in Laos, Cambodia, and China. While imports may be relatively small compared with generation, the projection relies solely on specific assumptions. These assumptions include:

- the successful completion of all plants both under construction and those that are planned;
- the projection does not speculate any further plant announcements, or project cancellations, hence there are few or no additions to the gas-fired stations due to the current status of plants as of mid-2009;
- one of the most important considerations is the utilisation of new plants. There is around 5 GWe of new capacity with published planned output data in TWh. Based on published TWh generation, it is straightforward to infer the plant utilisation of these plants. Consequently, these plants are expected to operate in the range 60–79% of the year. As a fleet, they could run for a weighted average of 69% of the year;

Figure 26 is based on both the successful scheduling of plants on their anticipated start dates, but also assumes a 69% utilisation in a typical operating year, and half of this (35%) in a commissioning year. For this reason, there is an unusual pattern of low utilisations in later years as some of the largest stations come online, and so decreases the average utilisation of the new fleet. The existing coal and gas fleet operate in accordance to historical averages. At least seven years of operating data are used where possible to consider variations in climatic phenomenon such as El Niño. Further assumption are as follows:

- new gas CCGT plants operate at around 10% points above the coal fleet, a figure seemingly consistent with historical averages, but by no means certain for future operation if gas prices remain high.
- new nuclear plants operate at 80% in a normal operating year;
- new hydro plants operate as existing plants do and are entirely dependent on historical averages;
- the utilisations of existing stations as illustrated in the despatch curve in Figure 20, page 48.

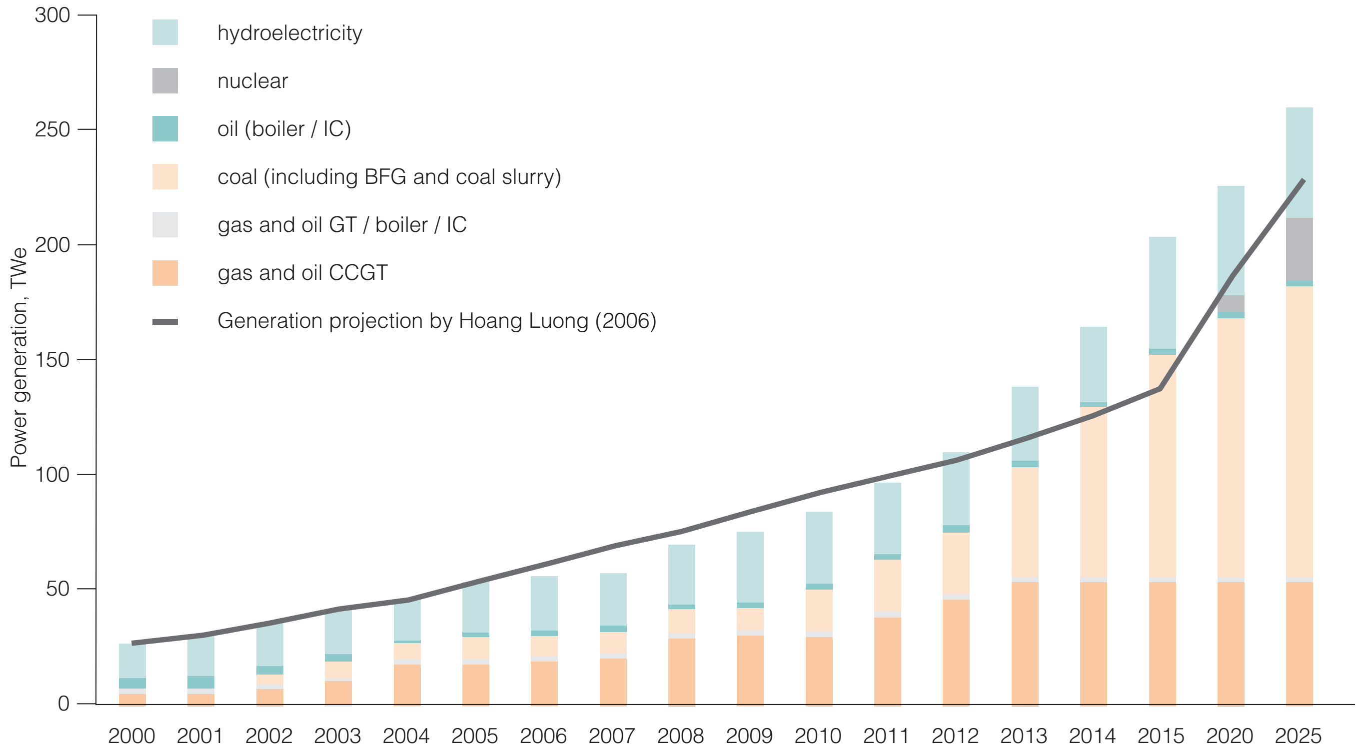

Figure 26 Comparison of power generation projections, 2000-25 (author's estimates)

Huang Luong (2006) shows a different scenario, which shows less development in coal-fired power, and a greater emphasis on gas-fired and hydropower. These are perfectly plausible scenarios, however, this is not evident in the current proposals to build more capacity.

Regardless of the expected scenario for the growth in coal-fired power, there is certainty that Vietnam will consume more coal than it did before, and will participate as a coal importer in the world market. However, the extent of this growth will be determined by several factors:

- the rise in coal-fired capacity capable of burning bituminous coals in conventional pulverised fuel (pf) boilers as well as 'W-flame' boilers which will be discussed later in this report;
- the utilisation of the existing and new power station fleet;
- the efficiency of the existing and new power station fleet.

These factors combined allow fuel input to be calculated and provide an idea of the coal consumption that could arise from future power trends. The first two issues have been discussed in the previous section, the next section will look at some of the issues regarding the efficiency of the power station fleet in Vietnam.

18 Power plant efficiency

The efficiencies of plants were calculated using IEA data for power station output from coal-fired plants, and the energy flow into electricity producers and autoproducers for coal (expressed in ktoe then converted to TJ) :

$$\% \text{ Efficiency } (\eta) = [\text{TWh output x } 10^5] \div [\text{Fuel input in TJ} \div 3.6$$

In 2006, the average efficiency of the thermal fleet (coal, gas, and oil) amounted to around 34% (*see* Figure 27). The efficiency of the coal-fired fleet was 36%, which is surprisingly respectable and evidence of this is shown by the performance data published for the massive Pha Lai station (Hagiu and Ito, 2008). This efficiency may only apply to the later units constructed in 2001, while the older units built in the 1980s might be achieving less than 26%. Issues that lead to the deterioration of efficiencies in existing older stations are discussed in the next chapter, which include lack of maintenance and variable fuel qualities.

Oil and gas stations operated at around 33%, but the results are clearly skewed by the performance of single cycle turbines and boilers, while CCGT plants, which make up more than half the oil/gas capacity are likely to be operating at an efficiency of 50–55%. Understanding the operation of the oil-fired and gas-fired fleets is complicated in Vietnam since many gas turbine based generators burn both gas and oil distillates. Therefore, allocating oil and gas flows into power stations can be complicated, hence these station types were combined for convenience.

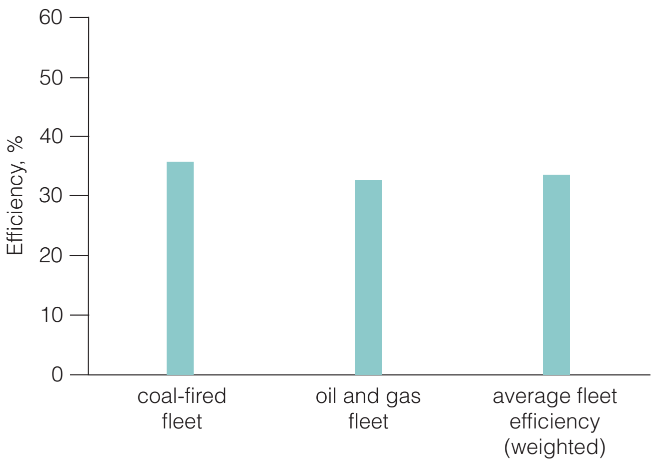

Figure 27 Estimated efficiency of the thermal power generating fleet in 2006 (author's estimates)

19 Coal-fired power and cleaner coal technologies

Vietnam's coal-fired plants are all subcritical stations, including those that are currently under construction. There is a move to supercritical steam conditions in future designs (for example the 1200 MWe Long Phu plant), but the roll-out of these technologies remains amongst planned plant, and not yet realised in any of the current plants that are under construction, let alone the existing fleet. Furthermore, much of the current capacity and those being built are plants located in the north and so designed for the local anthracite. Given the fuel qualities of Vietnamese coals, boilers and furnaces have to be specially adapted to deal with many of the difficulties faced by burning such high rank coals due to low volatility. Whether these plants may switch to the international seaborne market for coal is not certain, but it appears that much of the power capacity is designed for anthracite coals at the moment. Another risk to any projection is the possibility that the Red River Basin gives rise to a wealth of lower rank coals, which could skew projections in the future.

19.1 Combustion of 'difficult' fuels

Low volatile anthracite coals present particular combustion difficulties in terms of achieving low unburnt carbon levels, good ignition, flame stabilisation and minimum load without requiring oil support firing. Most anthracite-fired boilers use a 'downshot' firing technique where the fuel is fired downwards at an angle as opposed to the horizontal flames utilised in a typical bituminous steam coal boiler. One notable example of a downshot-fired boiler is the Pha Lai 2 power station. This type of boiler is also called the W-flame or arch-fired boiler due to the shape of the combustion flow. The residence time of the unburnt fuel is increased to ensure that the fuel is fully utilised while travelling down the boiler sides in the primary combustion zones, and then up through the centre or secondary combustion zone (*see* Figure 28).

Low volatile coals such as high carbon anthracite are therefore burned with a greater effectiveness than they would be in a standard boiler. The station is a 2 x 300 MWe subcritical plant that was commissioned in 2001 in the state of Hai Duong. The two units were funded by Japan's Overseas Economic Cooperation Fund (OECF), with contracts for equipment being signed with a number of foreign firms including Sumitomo, Stone and Webster, Doosan Babcock (then Mitsui Babcock), and Hyundai Engineering & Construction.

The station will comprise of two Doosan Babcock natural circulation boilers capable of burning 922 t/h (*see* Figure 28). The boiler can raise main steam at a temperature of 541ºC, and reheat steam at the same temperature. Main steam pressure is 17 MPa (174.6 kg/cm^2) to two GE D5 tandem-compound double flow steam turbines. The plant includes FGD and a new coal handling and blending facility. The technology for burning anthracite is proven and based on Doosan Babcock's plant at Yue Yang in China, which of similar size to the Pha Lai 2.

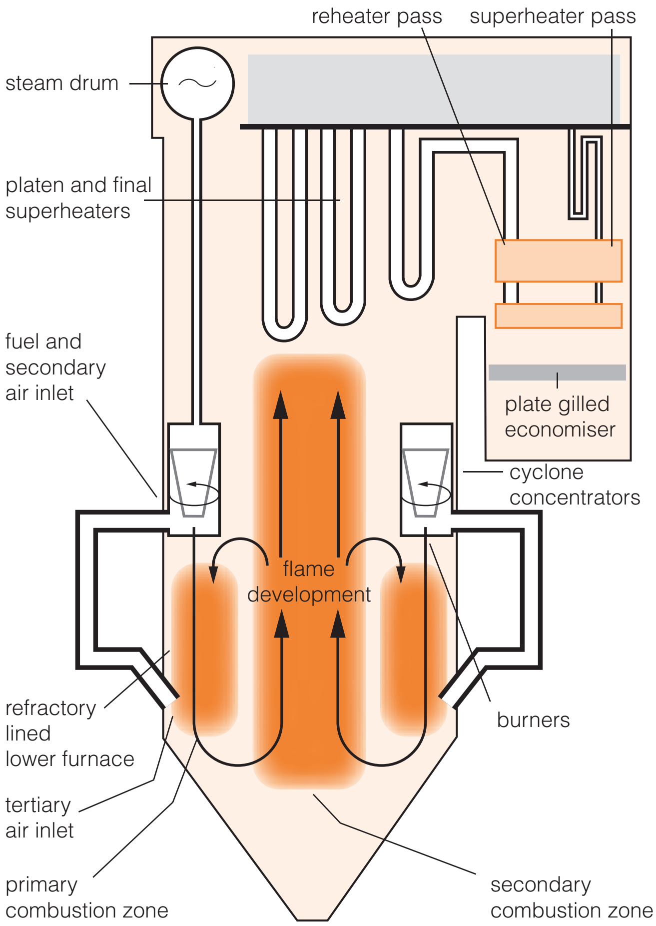

Figure 28 Downshot furnace and firing arrangement (Hough, 1998)

The fuel is pulverised and passed through the cyclone concentrators to reduce the air:fuel ratio before entering the burners. The concentrated fuel enters the furnace, forced downwards. The combustion air is received through the firing arch, providing momentum for the downward force needed to keep the flame pointing down. The key to the technique of burning the anthracite is to keep absorption and circulation of the combusting fuel efficient. This is helped by the extensive use of ribbed tubing throughout the furnace, as well as designing the furnace in an octagonal shape in plan. Other features include special designs to minimise material fatigue and erosion considering the fuel is much harder than bituminous coal and will be prone to greater wear and tear.

The design coal is a blend of five coals, which come from the major coal producing regions in Campha, Hon Gai, and Uong Bi coalfields. The fuel is a blend, which will have a volatile content of 3.75% (dmmf) and 30% ash content. Some coals had volatile contents of 1% and more than 30% ash, making them some of the most difficult coals to burn, anywhere in the world, at this scale. Much of the development was carried out on a 160 kWe single burner facility based in the UK, which received shipments of Vietnamese and Chinese anthracites.

In some ways, the demonstration of this technique is proven in the relatively good efficiencies achieved by the coal-fired fleet in Vietnam. According to Tavoulareas (2008) there is some 54 GWe of coal-fired capacity that can burn anthracite around the world; 43 GWe of this is in China. As of 2008, Vietnam had around 2 GWe of anthracite burning capacity.

A few supercritical plants exist in the world that are fuelled using anthracite. China has 4300 MWe of supercritical capacity, which can burn 100% anthracite, or a blend. Russia also has 1600 MWe of capacity that can burn a blend of anthracite and bituminous coal under supercritical conditions.

While subcritical plants are the plant of choice, Vietnam should move towards supercritical arch-fired plants, which also employs the W-flame system (or indeed any design capable of burning anthracite). Modern designs can use low NOx multi-level air staging and fuel preheating. ACFB is already being utilised by plants operated by Vinacomin.

19.2 Circulating fluidised bed technology

One of the benefits of circulating fluidised bed combustion (CFBC) is the ability for the boiler to burn low quality coals. The term 'quality' is loose, but in this context refers to coal which might have a low calorific value which results from having a high ash content. The residence time is increased to ensure that the low calorific value coal is burned effectively.

CFBC is an extremely effective technology for burning coal while reducing sulphur emissions using sorbent injection within the boiler, enabling the sulphur in coal to be extracted before the flue gases exit the boiler. There are two main types of fluidised bed combustion, atmospheric (AFBC) and pressurised (PCFB).

Vietnam has 800 MW of AFBC capacity at three power sites. These are Cao Ngan (100 MWe), Cam Pha (600 MWe), and Na Duong (100 MWe). All were built after 2004, and so are relatively new plants. The Cao Ngan power station is an IPP project built by Vinacomin and was commissioned in 2006. The plant is located 70 km north of Hanoi, and the coal will be supplied by the Nui Hong and Khanh Hoa coal mines. The plant was financed by the Chinese Export Bank based on a long-term loan. The Chinese contractor HPE was awarded the turnkey contract to build the station. Alstom supplied the two steam generators as well as other ancillary equipment.

The coals used in the Cao Ngan come from the Thai Nguyen province and are classified as semi-anthracites which have high sulphur contents and low volatile content. Combustion of the coal blend was tested in Germany at the University of Bochum in a pilot AFBC combustor. As it is a 2 x 50 MWe plant the units are small but, nevertheless, set new standards for plant performance for the country. Steam temperatures are 538ºC while steam pressures are around 9.8 MPa (Kluger and others, 2004). Water for domestic and technological services as well as cooling purpose of the Cao Ngan plant will be supplied from the Cau river.

The environmental performance for the station exceeds national standards by a considerable margin. Particulate controls can give emissions of 50 mg/m³ (the national standard being 200 mg/m³). NOx is controlled by air staging in the furnace and appropriate furnace temperatures. NOx levels are well within emissions standards, with emission levels of 500 mg/m³ (the national standard being 1000 mg/m³ which is high by international standards). The plant would achieve SO_2 emissions of 300 mg/m³ (compared with the national standard of 500 mg/m³) (*see* Tables 10 and 11). SO_2 control is achieved by the inherent desulphurisation within the furnace due to lime residing in the fuel ash, but also by limestone injection. The limestone is transported to the plant by truck, and milled and stored in silos. From there, the processed limestone is pneumatically transported and injected together with the fuel into the lower section of the furnace (*see* Figure 29).

The key to the technology is achieving the correct residence time for the fuel in the furnace. This is aided by using high-efficiency cyclone systems. A good circulation rate allows for high heat transfer, while an even heat transfer in the furnace prevents the excessively hot gases at the inlet of the cyclone (on the second pass) from causing slagging and high temperature problems in the cyclone.

The largest and newest CFBC plant in Vietnam is the Campha thermal power plant. It is located in the area of Quang Ninh Province. The plant will come online during 2009-10. The plant comprises 4 x 150 MWe. The fuel consists of waste coal slurry (40% of fuel feed) from the Cua Ong Coal Preparation Company as well as Campha dust coal No 6 (60%). The average heating value for the fuel is low at just 4265 kcal/kg (Duc Thao, 2004). In order to meet the required SO_2 emission standard of 500 mg/m³ in the flue gas, the limestone consumption at full load would amount to 6 t/h.

The third and oldest CFBC plant makes use of low rank coal, a local lignite. Similar to Cao Ngan plant, it is operated by Vinacomin. The Na Duong thermal plant was commissioned in 2004. The plant uses coal from the Na Duong coal mine some 2 km from the plant. The distance is such that the coal is transported by truck to unloading hopper stations where the coal is screened, and then transported by conveyor to the power plant. Na Duong has a configuration similar to that of Cao Ngan, including two units with net output of 50 MW each, both using a circulating fluidised bed boiler technology. Na Duong also has a closed circulating cooling system with

Table 10 Vietnam air quality standards (Findsen, 2008)

Parameter	Fuel type , mg/nm³		
	Coal	Oil	Natural gas
PM_{10}	200	150	50
NOx	650 (coal with VOC content >10%) 1000 (coal with VOC content ≤10%)	600	250
SO_2	500	500	300

Figure 11 Samples standards for new individual coal-fired plants, depending on location (mg/nm³)

	<2 km from heritage site (Type I)		Inside or <2 km from industrial zone or urban area (Type V)		Mountain area	
	300 MW	600 MW	300 MW	600 MW	300 MW	600 MW
PM_{10}	120	84	200	140	280	588
NOx >10% VOC	39073	650	455	910	637	
NOx ≤10% VOC	600	420	1000	700	1400	980
SO_2	300	210	500	350	700	490

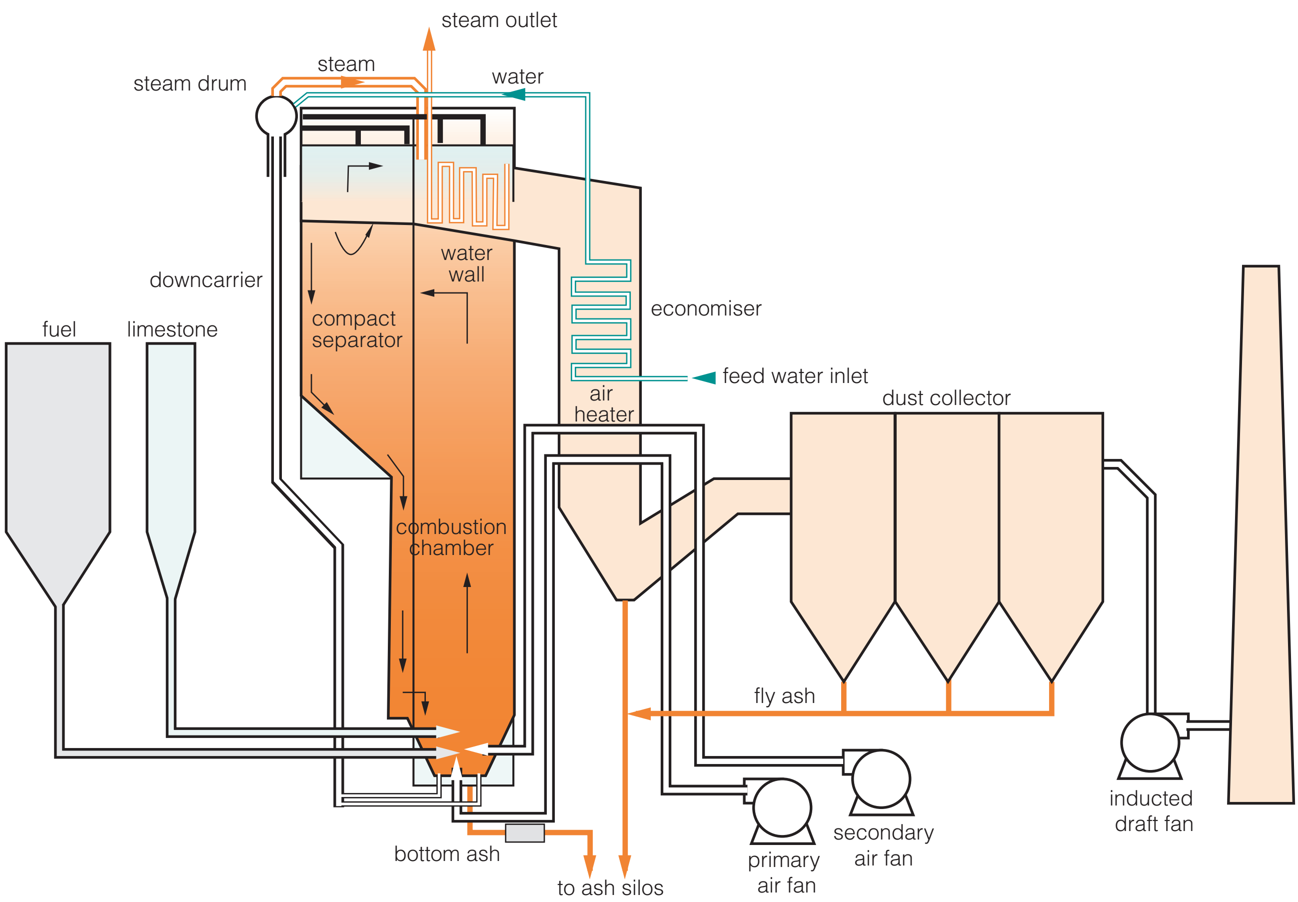

Figure 29 Schematic of the Na Duong lignite-fired CFBC (Duc Thao, 2004)

forced type cooling tower. The boiler will be designed to burn Na Duong lignite, which has volatile levels of 27.6%, and a very high sulphur content of 5.4% (Duc Thao, 2004). The boiler is designed to reduce SO_2 by the injection of limestone into the furnace, a common feature of the CFBC. Like the rest of the CFBC capacity in Vietnam, Na Duong is a subcritical plant consisting of two units with main steam temperatures of 540ºC.

19.3 Emissions control at Vietnamese coal-fired stations

While the country's 800 MWe of CFBC capacity utilises sorbent injection to reduce SO_2 in its plants, Vietnam also has another 900 MWe of coal-fired capacity fitted with flue gas desulphurisation (FGD). Wet limestone FGD systems are fitted to two 600 MW units of the Pha Lai power station, which are also equipped with low NOx boilers and ESP particulate control.

Particulate controls are fitted to 1400 MWe of capacity at selected units at the Uong Bi and Pa Lai Po power complexes. In all, roughly 2000 MWe of existing and newly constructed capacity has some form of equipment to deal with SOx, NOx, and or particulates (including standard pulverised fuel and CFBC boiler systems). This leaves a significant amount of capacity that exists or is under construction that may not be fitted with any form of emission control, although this cannot be confirmed for all stations. Without these measures in place, coal-fired power could lead to a considerable amount of uncontrolled emissions.

In 2008, Ha Long City hosted a discussion on cleaner coal technology for meeting energy demand. The aim was to discuss the options for improving standards and regulations for coal-fired power plants. Enhancing the standards would then promote higher efficiency technologies in new plants, use less fuel and hence reduce emissions. Further to the adoption of new technologies would be the clean-up of older power plants such as retrofitting with emission clean up equipment, along with finance options available to achieve these goals.

However, adopting regulations to set emission standards also requires a standard for monitoring emissions and creating an inventory of emissions from stacks across the power and possibly industrial sector. These data have to be publicly available, and an agency set up that will audit emissions from all the power plants, and which will collate the emission data from a reliable method such as Continuous Emissions Monitoring System (CEMS), stack/source testing, stack source testing or other similar method. Clearly, adopting cleaner technologies has far reaching benefits of reducing fuel use, and hence preserves indigenous production, requiring fewer imports, reduction or limitation of CO_2 emissions, as well as reducing the need for expanding coal mine operations which will themselves have their own impacts on the environment.

A common thread throughout the discussions at the Ha Long City meeting in 2008 was the adoption of supercritical power technology, in addition to the conventional clean up equipment for SOx, NOx, and particulates. These steps would benefit the Vietnamese power industry immensely. Further solutions to eliminate CO_2 through CCS will not be considered until such technologies are commercially adopted worldwide.

In 2003, the IEA CCC published a report on improving efficiencies of coal-fired power plants in developing countries (Henderson, 2003). This section draws on Henderson's work, and highlights some of the issues that might occur in operating Vietnam power stations. Firstly, the New Energy and Industrial Technology Development Organization carried out investigations on the Uong Bi plant in the 1990s. The report recognised that many of the difficulties faced resulted from the coal quality, and not the design of the power plant. This is an interesting outcome since the power stations are built minemouth in many cases, and so are captive power stations to the local coals. Turbine efficiency was recorded at 26–27%, an extremely low figure (*see* Figure 27). The NEDO report recommended the replacement of numerous components, as well as combustion systems, ash handling equipment, dust removal systems, and turbogenerators.

Henderson (2003) observes some of the day-to-day operational factors that affect plant efficiency, and some of the issues seem to apply to Vietnam. He considered that optimum operating conditions in some industrialising nations do not get achieved in older plants due to a lack of incentives to keep plants well maintained, and therefore suffer from excessive wear. There are many ways in which plant performance can be degraded by a lack of proper maintenance strategy. This gives rise to deterioration of turbines generators and other equipment. Inspection is important, and in developing countries, Henderson goes on to state that there is often too much reliance on breakdown maintenance, and less preventative maintenance (replacement or repair).

In the case of Vietnam, coal-fired stations may suffer from this, but thermal plants also operate as a load-follower depending on the availability of hydroelectricity. The incentive to operate optimally is also low if the major plant operator is a monopoly, and/or has access to large volumes of low cost fuel. This may well be the case for many of the minemouth stations. Some of the older coal stations may also lack boiler feed and flame control systems, as well as not having features such as bleed steam feedwater heaters.

It is likely that the latest additions to the power station fleet will be focused more on plant reliability and optimal performance. The operation of combined cycle gas turbines for instance will require specialist expertise in operation and maintenance, which will be locally sourced, and/or contracted in.

Henderson also points out the need for auxiliary power to supply coals that may fall outside of the standard specification of the fuel feed. However, as a generality, anthracite is a harder coal than say typical bituminous products traded on the international market, and so may require a great deal more crushing and milling to obtain the necessary fuel quality. Coals with a low volatile matter may suffer from problems with unburned fuel. Some Vietnamese anthracites do benefit from lower ash contents and so slagging and fouling would be less of an issue than other coals with higher ash contents.

Vietnam's coal-fired power station fleet is modernising rapidly with a recent build programme that will bring the technology more up-to-date, with improved boiler performance, and improved pollution control. One of the major problems of Vietnam's older stations is simply deterioration of the plant.

19.4 Underground coal gasification

Gasifying coal in situ within the coal seam deep underground is gaining interest and momentum in the pursuit to produce cleaner energy, but also importantly, to utilise vast resources of coal that remain untapped and unmineable using conventional mining methods.

Underground coal gasification, or UCG, is not a new concept, but the rising demand and price of energy means UCG is being seriously considered as a possible alternative to conventional coal production. The IEA CCC has undertaken a study on UCG by Couch (2009) and analyses in detail the current and past methods of UCG, its ongoing progress and possible impact it could have in greatly expanding the world's coal reserves.

UCG involves reacting (burning) coal in situ in a mixture of air/oxygen, possibly with some steam, to produce a syngas. The steam may come from water which leaks into the underground cavity, from water already in the coal seam or from steam deliberately injected. The technology remains in the pilot-scale stage. There is now a better understanding of the numerous by-products, some which are detrimental, as well as the environmental and geological difficulties that face underground coal gasification with the current technologies and knowledge available.

Vietnam appears to be a willing participant in investigating techniques and methods of utilising coal that would otherwise be less accessible using conventional mining. This seems like a contradiction since many existing operations have been criticised for the adverse environmental impact. Yet, Vietnam has invested in CFBC, is looking to UCG, and supercritical boiler technology.

Vinacomin is reported to have completed negotiations with Linc Energy (USA) and Marubeni Corporation (Japan) to undertake stage 1 of the Tonkin underground coal gasification project in the Red River Delta (Ecplaza, 2009; ABNnewswire, 2009). The site is 60 km southeast of Hanoi in the northeast of Vietnam where large reserves of bituminous coal are found. The project could use Russian technology provided by the Russian gas giant Gazprom which signed an agreement to supply technology to Vietnam's Dong Duong Co (VBF, 2009)

19.5 Coalbed methane

Another non-traditional energy source is coalbed methane (CBM). Reports suggest that Australia's Arrow Energy is investigating some of Vietnam's coal reserves for CBM (PiA, 2009b). Arrow energy recognised Vietnam as having considerable potential in the northern coalfields, which are suitably located for the markets in the north, and are on the opposite end of the country from where the gas reserves reside. Arrow is focusing on exploration on the Thai Binh area of the Red River Basin. It holds rights to a 2600 km^2 block on the coast south of Hanoi.

20 Future coal demand scenarios and supply issues

Figure 30 shows the possible rise in coal demand as published by Ding Trung (2007), and Thanh Son (2006). It is interesting to note how within the same year, the Ding Trung projection for 2025 is double that of Thanh Son, without any clear explanation, other than the higher build rate and higher utilisation possibly expected by Ding Trung. The author's estimates are based on optimistic forecasts of all planned plants becoming commissioned, but are consistent with the more conservative projection by Thanh Son. Even the low projection leads to a quadrupling of coal consumption in the power sector. This level of increase over a twenty year period is not unusual. China, Pakistan, and the Philippines have all increased the consumption of coal in the power sector sevenfold since the mid-1980s.

Figure 31 illustrates the rise in overall coal demand in the economy between 2005 and 2025 by three different EVN presentations. Thai Van Can and Thanh Son both have a consistent trend and the only difference is likely to be revisions in the base year consumption of 2005. These older projections for 2025 are consistent with reports published in 2009 by Vinacomin (VnDG, 2009). However, VnDG (2009) reported a more accelerated growth in the interim, with 2015 demand reaching 60 Mt. Some 26 Mt of this demand between 2015 and 2025 is expected to be met by imported supplies. This would suggest that some time in the next 15 years, new coal-fired capacity build beyond what is currently under construction and at an advanced planning stage will almost certainly be fuelled partly by internationally traded bituminous coals. All the primary energy projections seem to agree on one aspect of future consumption trends. The electricity generation sector's share of total coal demand will rise from around 30–32% in 2005 to 75–77% in 2025 (as shown in Figure 32). Coal-fired power is therefore the primary driver of coal demand in the future.

In the latter part of 2009, coal prices could increase from an estimated 26–27 $/t to Vietnamese power stations, to a value closer to costs of production, perhaps 38–40 $/t (*see* Chapter 11). Whether the price of coal will increase by such a substantial amount is not yet determined. Price negotiations are expected to be more competitive, and less fixed. Coal negotiations are meant to take a more market-led approach, and so while it is almost certain prices will rise, costs could fall if Vinacomin carry out efficiency and productivity improvements. The rise in coal prices may well affect future coal-fired power investments, particularly if power tariffs do not increase to reflect the cost inflation.

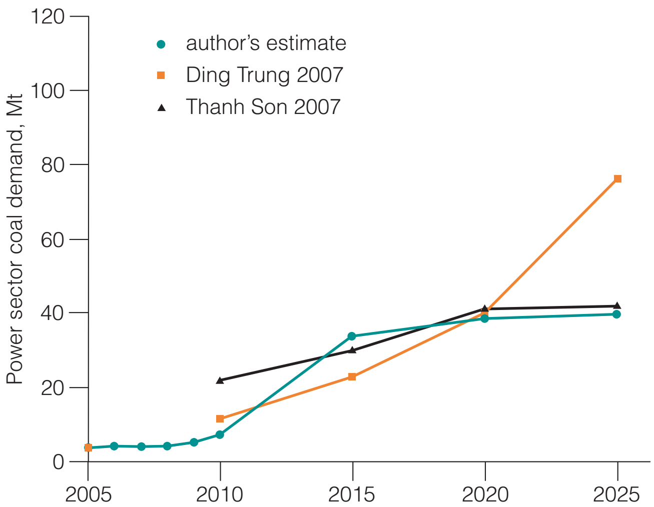

Figure 30 Coal demand projections for power generation (various sources)

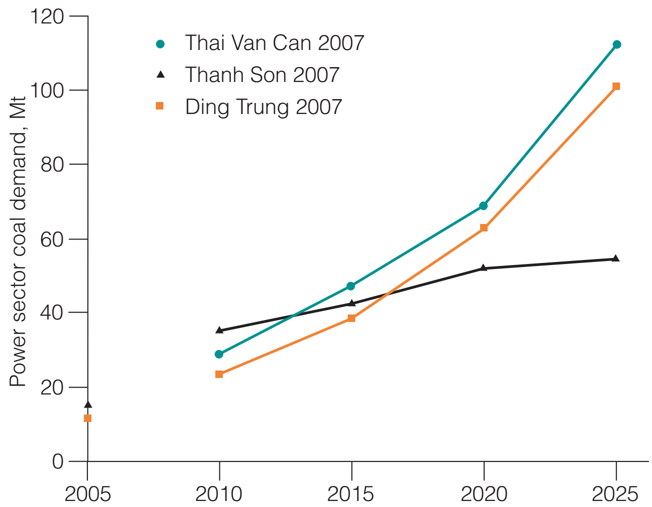

Figure 31 Coal demand projections for all economic sectors, Mt (various sources)

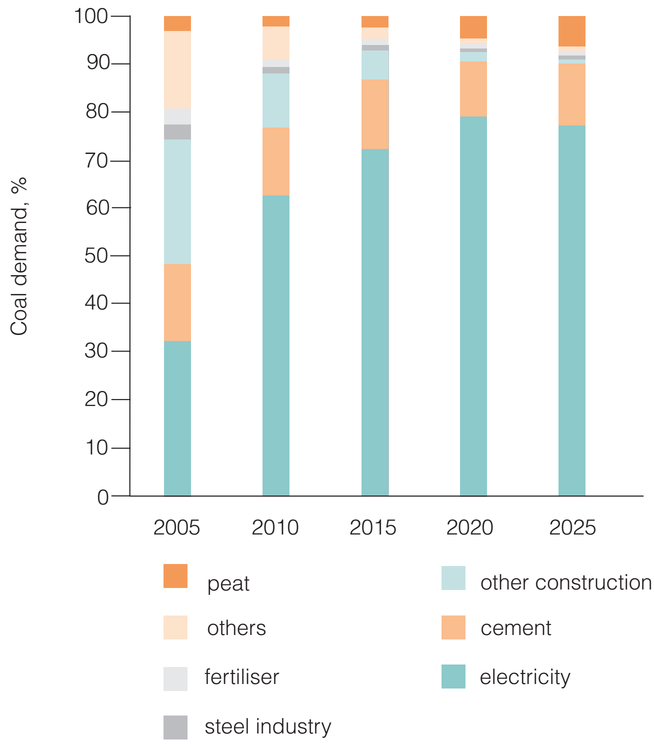

Figure 32 Sectoral coal demand scenario for 2025, % (Thanh Son, 2007)

20.1 The role of non-power sectors

It is not clear why the proportions of many of the other sectors seem to suffer a massive withdrawal of coal, but fuel substitution is the most logical explanation. Natural gas and biomass fuels could replace coal but one of the major growth sectors for coal demand (apart from power generation) is cement production.

Vietnam's urban developments are driving up the demand for construction materials, not least cement materials. Vietnam is aware of its need for cement and so has been driven to raise capacity and output to ensure Vietnam is not subject to rising costs of imported materials. According to Thanh Son (2006), cement production was expected to increase from 25 Mt/y in 2005 to 73 Mt/y by 2025. By 2010, Vietnamese industry was aiming to cease being an importer of cement and rely solely on domestically produced output. Previous chapters describes how the cement sector grew at a rate of 12%/y in recent years, while demand in other sectors was also growing apace. The paper industry grew at a similar rate to cement production, although interestingly coal demand in the industrial sectors grew at a higher rate of >17%/y. Clearly, the market for coal goes well beyond just those of power, cement, and paper industries. The fertiliser industry is also a major consumer of coal, but accurate energy consumption figures are not readily available. Some parts of the industry are gearing up for a major increase in coming years.

20.2 Coal supply

Previous chapters in this report allude to production levels in 2008 being around 40 Mt/y, and subsequent reports in July 2009 suggested that planned production of coal was closer to 43 Mt for 2009 (VnDG, 2009). In 2007, the coal industry was estimated to reach 40–43 Mt of cleaned coal by 2010. Coal yield is usually lower than the gross output, and so it is possible that Vietnam will reach this in gross terms.

It is generally considered that half of the production will be exported, but future exports of Vietnamese coal at levels of around 20 Mt/y seem increasingly doubtful. For some years, the government have been intent on withdrawing from the export market, and diverting coal production to domestic markets. This will have considerable implication on the world market for anthracite exports. Under these circumstances, certain anthracite consumers in China and Japan will need to revert to other sources of coal to satisfy their needs.

Vietnam's coal exports were due to be cut in 2010, according to announcements made by Nguyen Chien Thang, Vinacomin's deputy director. This long-term initiative is with a clear realisation that any major rise in power generation and coal-fired power will need to be met with adequate supplies but as Figure 30 suggests, a great deal more power capacity will need to be built that goes above and beyond what is currently planned.

Coal importation appears to be a good prospect for some years, although, this is dependent on the success of exploration and development of reserves in new prospective regions in the Red River delta. Production capacity has been increased in recent years from around 40 Mt to more than 60 Mt/y. Regardless of the efforts to achieve the production required for domestic demand, it is not possible to fully satisfy all the expected production capacity, which may well mean imports could increase even more, if demand continues to grow. Furthermore, assuming much of this capacity will be constrained by transport bottlenecks and increasingly difficult geology, the international market offers a source that can partly meet the increase in demand from the Vietnamese coal stations.

20.3 Future trends in coal-fired technology

In 2007, EVN hosted a meeting in Hanoi which was supported by the USAID Eco-Asia Clean Development and Climate Program (ECO-Asia CDCP) called Designing a Cleaner Future for Coal (USAID, 2007). The ADB were also associated with the workshop where the importance of improving efficiency in the future coal-fired fleet through super and ultra supercritical steam conditions were seen as priorities for the Vietnamese power industry. It was recognised that the existing fleet of coal-fired stations had a high proportion of unburnt carbon in the fly ash due to low combustion efficiencies. It was considered that supercritical technologies were currently limited to non-anthracite coals, and so the workshop recommended the increased role of imported bituminous coal.

Based on the list of coal-fired stations in Tables 9 around 6 GWe of capacity was being built in the North of Vietnam. In 2008 and 2009, the only coal plant of any notable size that was under construction in South Vietnam was the initial 1200 MWe unit of the 4400 MWe Long Phu plant complex located in the state of Soc Trang.

Out of some 10–11 GWe that was under construction, or was at least in the early stages of construction in 2008-09, most were North Vietnam projects, but the Long Phu still accounts for a large proportion of this. In terms of plants that are planned, some 80–90% of the 18 GWe of coal-fired plants that were announced were all in South Vietnam provinces. Where before coal-fired plants were restricted to being located near the indigenous coal production, the planned plants and the accompanying infrastructure to import the coal by sea from either the north Vietnamese mines or the international market is considerable. The assumption of increased imports is not speculation but firmly embedded in EVN's strategy to bring coal-fired power to regions which lack coal reserves, but not necessarily displace coal where it is being mined.

In the 2007 Designing a Cleaner Future for Coal workshop (*see earlier*), EVN presented a possible scenario for coal sourcing between 2007 and 2015. It showed an escalating coal import trend for both EVN and IPP projects that could even outpace the growing demand for domestic coal.

Figure 33 is considerably more optimistic than any of the

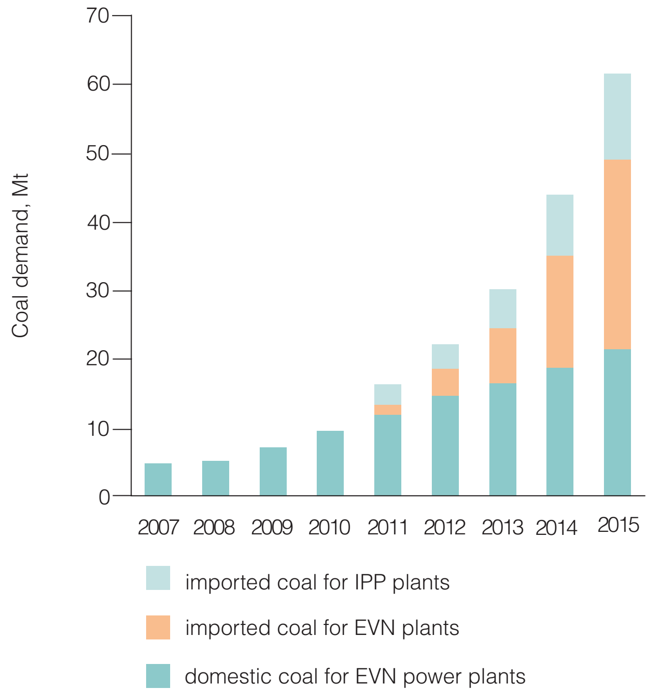

Figure 33 EVN vision of future coal sourcing (EVN, 2007)

other projections shown in this report, but illustrates a commitment of EVN to direct greater investment towards coal-fired stations that will use more imported coal. In this case, imported coal would emerge as a relatively small contributor around 2011, and then by 2015 could account for more than two thirds of the country's source for coal for power generations.

Coal import contracts have already been signed in recent years, indicating Vietnam could be a regular buyer of coal on the international market in coming years. In 2008, Vinacomin signed a contract to buy 3.5 Mt/y of coal from Indonesian companies, PT Berau and Indonesian-based Maintime company of Hong Kong (TJP, 2008). The coal was destined for the Vinh Tan 1 thermal power plant, which is part of the Vinh Tan power complex designed to have a capacity of 4400 MW in southern Binh Thuan province. This single trade accounts for 8% of the country's current annual production (43 Mt in 2009). Whether this deal is the start of a trend for more contracts will depend on the price of international coal and the availability of suitable products.

While there seems to be a great deal of interest in coal imports, it is important not to neglect the yet unknown potential for domestic coal resources. Besides developing plans to open 7–10 new coal mines in the period 2008-15 (Kuo, 1997), the national coal group was negotiating with partners to import coal mostly for use in power plants. The approach to developing the domestic coal industry remains largely unchanged. The programme to increase coal production was set out by the Ministry of Industry to increase basic exploration works to increase the country's coal resources and reserves. Investment was made for exploration to upgrade proven reserves and ensure a greater degree of certainty for future coal resourcing from domestic reserves. The exploration of reserves at depths of more than 300 metres will be completed between 2010 and 2015 in the Quang Ninh Coal Basin, as well increased surveying of the Red River Delta Basin.

It is quite possible that many more power plants in the future may be designed for lower rank coals found in the Red River Basin, but until more information is available on this new and promising reserve, this is little more than speculation. The chief impediment to the development of the Red River reserves would be the extreme depths of coal seams which may suffer from excessive water ingress, causing substantial hazards to conventional methods of mining, as well as the need for environmental preservation of one of the major regions of rice production for Vietnam. Some of the impediments to future coal production are summarised as follows:

- increasingly difficult mining geological conditions at depth;
- exploration works not bearing as much useful extractable coal as envisaged;
- opencast mine seams descending to deeper levels;
- opencast mine operations facing increasing environmental pressure as conditions of disposal discharge, water drainage, transport and mine bank stabilisation become more stringent to deal with a history of environmental neglect in some operations;
- underground mines are below the self-discharging level of water and getting deeper so that a series of problems in terms of technology and safety aspects are required to be settled such as control of mine pressure, ventilation, transport, prevention of water inrush, as well as emission of CH_4;
- prospective coals in the Red River delta are at a very deep level, and there is the possibility that the overlying rock structures within which coal seams reside could be relatively weak or fissured making for more hazardous extraction.

20.4 Co-operation agreements with foreign countries

In recognition of the uphill struggle that Vietnam will face in modernising its industry and adapting to deeper coal seam extraction, Vietnam has fostered dialogue with Japan to strengthen expertise in coal and mineral resource exploitation, despite the fact that Japan has produced no coal since 2000. The country faced increasingly difficult mining conditions which were largely the cause of the closure of large-scale coal mining in Japan. Japan's coal expertise nonetheless still exists as a legacy from the coal industry, but also as being one of the most important markets for export coal in the world. Japan is the single largest importer of hard coal in the world (2007: 180 Mt), and the largest PCI consumer (2006: 11 Mt). Vietnam is the largest source of anthracite used by the Japanese steel companies. Ensuring a stable supply of this coal is considered crucial to Japan.

Japan and Vietnam commenced the 'Japan-Vietnam Coal and Mineral Resources Policy Dialogue' a ministerial-level meeting engaging private and public sector stakeholders (METI, 2009). The meeting is part of a wider cooperation agreement 'Agenda Towards a Strategic Partnership between Japan and Vietnam' which was agreed in Nov 2007 between Prime Minister Yasuo Fukuda and President Nguyen Minh Triet. In the area of coal, technology cooperation between Japan's JCOAL and Vinacomin agreed information exchange on domestic coal supply, demand, production, safety, and cleaning. Exploration cooperation has been conducted between NEDO and Vinacomin, which agreed to define Pha Lai-Dong Trieu as a candidate site for joint exploration. Resource development and information on financial assistance is being carried out between JBIC and Vinacomin.

Interestingly, all this cooperation has a political dimension, but an important trade aspect also. With this in mind, it seems apparent that the announcements to halt coal exports to serve domestic markets could be misleading. Rather than Vietnam halting exports, it is more likely exports will continue, but imports will expand such that Vietnam becomes a 'net' importer.

Co-operation between Japan and Vietnam is not limited to coal exports. Vietnam has explored possibilities for **carbon capture and storage (CCS) to capture CO_2 for use in enhanced oil recovery**. The White Tiger Oil Field Carbon Capture and Storage project was assessed in 2003/04 in a feasibility study presented by Mitsubishi Heavy Industries. It as one of several possible CCS projects associated with gas-fired CCGT plants in the Far East (GCCSI, 2008 and 2009).

CO_2 would be collected from the combined cycle gas turbine plants in the Phu My industrial area (Roed Larsen, 2006). The plant is 70 km south east of Ho Chi Min City in the southern region of Vietnam. The CO_2 would then be transported 144 km by pipeline to the injection field at the White Tiger Oil Field, of the coast of Dinh Co. The project is forecast to capture and store 4.6 Mt of CO_2

The system proposed makes use of the KS-1 process which utilises solvents in a process designed by Kansai and MHI of Japan (Imai and Reeves, 2004). The system is due to start in 2010, and will consist of two pipelines (Phase I at 9000 t/d in 2010; Phase II 21,000 t/d due in 2016). This project marks an important start in Vietnam's interest in enhancing oil recovery; it is also a small step towards zero-emissions power generation and climate change mitigation. However, the most immediate issue for Vietnam is **adapting to climate change**. In 2009, financial support was announced between Denmark and Vietnam to provide $40 million to Vietnam to help fund measures such as dykes, establishing warning systems, and developing methods of purifying waste water. Denmark recognises that Vietnam's CO_2 emissions remains limited, and the most pressing challenge is to adopt adaptation measures (Mogensen, 2009).

21 Conclusions

Although far from being a capitalist state, the economic model today in Vietnam is based on a so-called ‘socialist market economy’, and seems to receive little political opposition within the country. Private ownership is encouraged in industry, commerce, and agriculture. Since 1970, the economy has also driven a steady growth of primary energy at a rate of 2.8%/y, averaging a much higher 7%/y in later years between 2000 and 2006. Most of the growth has been attributed to fuels like oil products, which have been used widely in road transport but also as a boiler fuel and power generation.

Despite strong economic growth and urbanisation, biomass consumption in rural and some urban areas has not fallen. Biomass usage appears to have actually increased since 2000, from around 31 Mtce to 44 Mtce, indicating a continued preference for biomass in residential dwellings and the strong element of agriculture in the economy. In 2006, biomass and waste fuels still accounted for a massive 46% of the primary energy demand in the country. Petroleum products accounted for 22%, coal 17%, and natural gas 10%. Conventional energy production in Vietnam consists of crude oil production, natural gas, coal, and hydroelectricity.

The country’s coal reserves are still undergoing exploration and surveys in the major coal basins. An estimated 6.1 Gt or so of proven coal reserves has so far been said to exist, consisting of 2–3 Gt of economically recoverable coal, plus an additional 3–4 Gt of further reserves. While the quantity of reserves is potentially in dispute, most sources agree that the major deposits are concentrated in just two geological basins, Quang Ninh and the Red River basins, both located in the north of the country. This also explains the geographical concentration of coal-fired power plants in the north of the country. The Red River basin has a range of coals from low ranks coals to anthracite, but it is Quang Ninh where today’s coal industry operates and where some 60% of the country’s known reserves exist.

Amongst the more commonly mined anthracites in north province of Quang Ninh, the high carbon content is key to the very high heating values. While high heating values are advantageous, there are other quality facets of anthracite that make these types of coal unsuitable to burn in conventional power station boilers, and have been described as some of the most difficult coals to burn anywhere in the world. Anthracites generally have a low volatile content of 10 % (dmmf) or below, some as low as 2–3%; bituminous coals typically have volatile contents of 10–45 % (dmmf). Coal production methods in past years have been a mix of opencast (60%) of output, and underground mines (40%) of output. However, over the long term opencast mines will be shut due to the depletion of surface accessible reserves. By 2006, the production capacity of the (known) mines operated by Vinacomin was estimated to be 65 Mt/y, which produced 38 Mt. This would suggest that Vietnamese mines had a capacity utilisation of 59% (on average).

In terms of the cost of production, actual figures are difficult to determine, but power plant operators are reported to be paying 26–27 $/t in 2009. This is claimed to be 70% of the actual cost of production, and so when scaling up, the Vinacomin costs of production are probably averaging around 38 $/t. This means Vinacomin was probably making a loss of at least 9 $/t on every tonne of coal sold to the power generators. It is not clear from the reports whether the cost of rail is included, but if not, the losses could be even higher.

In 2008, power generation in Vietnam reached 76 TWh, more than double that being generated in 2002.The Vietnamese now generate more electricity than Austria. In just ten years, Vietnam’s customer numbers have increased from just 2 million to almost 10 million since 1995. With per capita electricity demand of around 600 kWh per head (579 kWh in 2006), it still remains one of the lowest in Asia. This is why demand growth is expected to remain high. Per capita electricity consumption is expected to double from 600 kWh per head in 2006 to 1300 kWh per head in 2012. Yet by 2012, consumption per head may still remain half that of China or Thailand.

According to official reports, the country was estimated to suffer a shortfall in electricity of 8–10 TWh in 2008-09. By 2015, the shortage could be 7–63 TWh depending on whether a low or high growth scenario for demand is applied. The power shortage could increase to 115–225 TWh by 2020. While the longer-term projections have a wide range, it suggests there is great uncertainty in the future demand needs of the country, while the future supply will be somewhat constrained by developments in more transmission and generating capacity. Power planning therefore remains an extremely difficult task for the state monopoly EVN.

On a day-to-day basis, Vietnam experiences a massive swing in demand from as much as 12 GW in peak periods, to just 6–7 GW during off peak periods. EVN therefore has a mammoth task in coordinating power station output with demand at any moment in the day. Choosing the right technology to meet this is therefore a key criteria, and is why coal-fired power is not only preferred, but necessary. Dependence on hydropower, which can be very high, regularly suffers during drought and puts pressure on the entire system.

To help meet the needs for more electricity supplies, EVN saw thermal capacity more than double for both coal and gas-fired power in 2000-07. IPP developments increased eightfold, more than 95% of which was thermal generation (manly gas), and a small proportion was hydro or renewables.

After 2007, the shift to coal-fired generation for new builds became apparent.

Between 2008 and the first half of 2009, Vietnam commissioned 5 GWe of new capacity, much of which was gas-fired (2.7 GWe) but also included coal (1.4 GWe) and hydroelectric (1.3 GWe) projects. At the same time, the plant capacity that was still undergoing construction amounted to a considerable 9 GWe. Nearly all of this 9 GWe was coal-fired and due to come online during the period 2010-13.

The estimated generating capacity in 2009 was around 17 GWe, and could double to 40 GWe by 2015. Roughly 60% of the additional 23 GWe of capacity that could be commissioned between 2009 and 2015 is already under construction. This level of plant investment (possibly reaching US$42 billion assuming 1800 $/kW capital costs) is committed. However, the aftermath of the global credit crisis in 2008-09 that afflicted the global economy may impact capital intensive projects such as coal plants, and many of these projects could be deferred or cancelled altogether.

Regardless of the expected scenario for the growth in coal-fired power, there is certainty that Vietnam will consume more coal than it did before, and will participate as a coal importer in the world market after being an exporter for many years. Even low projections for coal demand leads to a quadrupling of coal consumption in the power sector. This rate of growth is not impossible. China, Pakistan, and the Philippines have all increased the consumption of coal in the power sector sevenfold since the mid-1980s.

Other industries such as cement production which is also energy intensive will push up demand. Various projections suggest that coal demand could rise from a current level of around 20–25 Mt, to more than 40 Mt in 2015, and then anywhere between 50–100 Mt by 2025. The pressure on Vinacomin to produce more coal will be somewhat relieved by the increased demand for imported coal, although this may well be a major driver to shift domestic coal prices up towards world market levels. By 2015, coal imports could account for a massive 50% or more of the total coal demand from the power generating sector. This could mean a significant shift away from traditional anthracite power stations to bituminous coals. This could enable power generators to exercise more flexibility in coal procurement and greatly enhance security of supply of coal.

The whole energy market is changing rapidly and it is not clear whether the repercussions of the shifting to a market led energy economy will affect coal-fired generation, or future coal investments. Coal-fired stations based in the southern provinces of Vietnam will be financed on the basis that coal supplies will be shipped in, either from the north of the country, or from the international seaborne market. New or modified port infrastructure will therefore need to be factored into the project finance and planning.

The biggest uncertainty will come from the potential for Red River coals to provide coals to power stations equipped to run on either lower rank coals, or gas derived from underground coal gasification.

The release of possible reserves in the Red River may open up many more possibilities for Vietnam, but remains inconclusive until full surveys are completed. Thus far, it seems as though the Red River resources are at depth, from between a few hundred metres to over a thousand metres. The coal quality is expected to be lower rank than the Quang Ninh anthracites, although a range of coals are found there. Environmental problems are rife amongst many mine operations and safety inadequacies will need to be addressed to bring the industry up to date with modern practices. These are all issues that the Vietnamese industry will no doubt invest for years to come.

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