Power sector scenarios for Thailand: An exploratory analysis 2002–2022

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Abstract

Power sector scenarios for Thailand are constructed in this paper to represent the range of opportunities and constraints associated with divergent set of technical and policy options. They include Business-As-Usual (BAU), No-New-Coal (NNC), and Green Futures (GF) scenarios over a 20-year period (2002–2022). The results from the BAU scenario show that fossil fuels will continue to dominate electricity generation in Thailand during the study period. Similar results are obtained for the NNC option, although the dependence shifts from coal and oil towards natural gas-based power generation. This may represent a better environmental pathway but an all out shift from coal to natural gas is likely to increase Thailand’s dependence on imported fuel, making it more vulnerable to unstable global oil and gas prices. The GF scenario offers a more optimistic route that allows the country to confront its energy security dilemma whilst fulfilling its environmental commitments by giving renewable energy technologies a prominent place in the country’s power generation mix. Over the study period, our result showed little difference between the three scenarios in terms of financing new generation plants despite an early misgiving about the viability of an ambitious renewable energy programme. This paper also goes beyond the financial evaluation of each scenario to provide a comparison of the scenarios in terms of their greenhouse gas emissions together with the comparative costs of emissions reductions. Indeed, if such externalities are taken into account to determine ‘viability’, the GF scenario represents an attractive way forward for the Thai power sector.

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1. Introduction

Growth in electricity use is often correlated with a rise in GDP and improvements in the quality of life especially in earlier stages of industrial development. Todoc et al. (2005) argue that Thailand represents this picture quite well. They point at the strong correlation between electricity consumption, income and status of value-added manufacturing activity. This was also demonstrated by the Asian Financial Crisis of 1997–1998, where a decline in GDP was accompanied by a plunge in electricity demand, particularly in the residential and industrial sectors. With the recovery of the economy in 2000, growth in electricity consumption in Thailand is back to its pre-crisis years, and more power supply systems are being constructed to boost capacity.

Clearly, the type of technologies that will be deployed to meet future energy demand is contingent on wide-ranging economic, environmental and political factors that will have a bearing on the direction of future policy orientations. In addition to growing international pressure to take environmental issues seriously, there are also demands within Thailand itself concerning matters of security and reliability of supply that will influence future policy directions. There may also be market pressures that ‘incentivise’ the use of renewable technologies as a way to penetrate new markets and capitalise on financial resources that may become available through schemes such as the Clean Development Mechanism (CDM) and other emissions trading initiatives.

In this paper, three long-term scenarios consisting of different ‘storylines’ which show the different ways in which the energy market could develop are assessed. The scenarios include Business-As-Usual (BAU), No-New-Coal (NNC) and Green Futures (GF) options. The period
of study begins in 2002 and end in 2022, with 2002 taken as the base year. The Long-range Energy Alternative Planning (LEAP) model is used to construct the scenarios. The first section of this paper provides background information about the electricity sector in Thailand and the wider context. The second section introduces the energy scenario approach as a useful tool for long-term energy planning and sketches the BAU and two alternative scenarios. The third section examines the scenarios using energy modelling techniques to evaluate future energy consumption patterns, composition of electricity generation, future investment and running costs, and the GHG and SO2 emissions linked with each of the three scenarios over a period of 20 years.

2. The structure of the power sector in Thailand

The power sector in Thailand is heavily dependant on fossil fuels. Much of this capacity is based on thermal and combined cycle generation where natural gas alone contributes to over 72% of the total electricity generation, followed by lignite and coal at about 16% and fuel oil at 3%, respectively (see Fig. 1). The contribution from hydroelectricity amounts to about 7% with the remaining balance imported from neighbouring countries, namely Laos PDR and Malaysia to serve electricity demand along the border areas (DEDE—Department of Alternative Energy Development and Efficiency, 2002). This form of energy transaction across national borders is endorsed by the ASEAN Vision 2020 which aims to establish ‘inter-connecting arrangements for electricity and natural gas within ASEAN through the ASEAN Power Grid and a Trans-ASEAN Gas Pipeline’ (ASEAN, 2004, p. 3).

There are three principal end-use sectors in Thailand, which include industrial, commercial and public services, and residential sectors with shares of 46%, 32% and 22%, respectively. The industrial sector is the largest electricity consumer with demand for power growing at an average of 7.5% per year over a period of 20 years. Current industrial activity in Thailand is largely dominated by energy-intensive industries such as petrochemicals, steel mills, refineries and cement plants. There is also evidence that Thailand’s economy has moved into high value-added (knowledge-intensive) industries such as electronic products and machinery and away from labour-intensive activities such as garments, jewellery and furniture. According to Dhanani and Scholtes (2002), the energy-intensive industries listed above will continue to be important in the country’s future industrial complex given Thailand’s growing market positioning in these export products. Similar rate of average growth in electricity demand is also expected in the commercial sector as Thailand expands its service industry in line with that expected in a rapidly developing economy. Hence, for sometime to come Thailand’s economy will rely heavily on both the industrial and commerce sectors for development and employment (Clemes et al., 2003). Maintaining growth in these sectors will require the continued expansion of the country’s electricity generation capacity to satisfy increasing demand for power. This will have both resource and environmental implications.

At present, Thailand has a comparatively high percentage of households with electricity compared to many of its neighbours. The National Plan for Thailand Rural Electrification programme, which came into effect in 1972 was largely responsible for the almost universal coverage of electricity. Through this programme electricity was extended to large parts of rural Thailand as part of the country’s modernisation plans, increasing electricity access to rural villages from a very low base of 7% in the early 1970s to about 97% by 2000 (Shrestha et al., 2004).
Moreover, the past two decades have seen a sharp increase in the number of households using appliances such as lighting, refrigeration, television and radio. According to Todoc et al. (2005), this increase in the number of ‘electrical appliances per household along with the increase in the utilisation of existing electrical appliances’ has led to a rise in electricity consumption per household intensity (kWh/household). It is estimated that about 58% and 87% of urban residents have access to refrigeration and air conditioning in their home, and wealthier homes in rural areas are steadily acquiring appliances such as washing machines and refrigerators that had been restricted to urban dwellers in the past (Price et al., 1998; Sajjakulnukit, 2001). However, it is also worth noting that there are differences in the per capita consumption (intensity) of electricity of metropolitan and provincial areas as well as between households in different income groups. In 2003, the per capita electricity consumption in the metropolitan area stood at 4790 kWh, which was nearly four times higher than the daily per capita electricity consumption of a provincial end user at 1258 kWh (DEDE—Department of Alternative Energy Development and Efficiency, 2003).

The institutional structure of Thailand’s electricity supply industry consists of three main generation groups, which includes the Electricity Generating Authority of Thailand (EGAT), which is responsible for about 60% of power generation and exclusive control over transmission. The other two generation groups are the Independent Power Producers (IPPs), and Small Power Producers (SPPs) who sell much of their electricity to EGAT who then sells power to the distributors: Metropolitan Electricity Authority (MEA) and Provincial Electricity Authority (PEA). Moves to privatise EGAT was dramatically cancelled in March 2006 through a court decision because the judge deemed the sale to be mined in conflict of interest and would create an unfair monopoly for the new owners (Asia Times, 2006).

3. Study method: scenario development

Current high oil prices are keeping energy issues at the forefront of public attention in Thailand given the country’s heavy dependence on imported fuels. Environmental concerns associated with reliance on fossil fuels are also calling into question the compatibility of existing energy systems with the natural environment. For example, thermal power generation accounts for over 90% of the total electricity generated and is only second to transport in CO₂ emissions. Hence the twin, and at times contradictory issues of energy security and environmental protection point to the constraints faced by energy planners and policy makers in addressing this uncertain and changing energy context.

Scenario planning is a useful approach to design and plan long-term electricity infrastructures to cope with the uncertain future demand for power. It allows the construction of a repertoire of possibilities that are tied to a variety of policy and technical pathways with the aim of capturing effectively the uncertainties that lie ahead in the energy, economic and environment domains (Craig et al., 2002). In energy research, long-term energy scenarios therefore usually consist of different storylines that offer a ‘set of alternative contexts for exploring the different ways that the future may unfold’ (Ghanadan and Koomey, 2005, p. 1121). These are quantitatively analysed using energy modelling techniques whereby changes and impacts associated with each scenario are evaluated and compared.

Three energy scenarios are prepared in this paper, which includes BAU, NNC and GF options. Each scenario is linked to a particular ‘philosophy’ that inspires the framing of particular policies and defines the supply side characteristics and assumptions used. We then employ energy modelling techniques to quantitatively analyse the three scenarios, evaluate them and compare them against each other.

4. BAU scenario

The BAU scenario represents the energy pathway that follows the continuation of current trends by using official state-level forecasts and plans. Consumption trends in residential, commercial and public services, and industrial sectors, as well as steady growth in population and GDP characterise the BAU pathway. This scenario will also take into account current and anticipated government policy related to the power sector and how these policies actually shape the direction of the sector in the coming two decades.

The aim of this scenario is to show the future through the prism of current policies and strategies, and delineate the relationship of the power sector with political, economic and the environmental institutions. Furthermore, since the government has set a broad target to reduce the elasticity index² from its current value of 1.4–1.1 by 2007 (EPPO—Energy Policy and Planning Office, 2003), analysing this scenario would make it possible to evaluate if the target is indeed achievable under the current policies or if some modifications may be necessary.

The growth of electricity demand in residential, industrial, and commercial sectors is assumed to follow the Load Forecast Report 2002 (Load Forecast Committee, 2002). In general, the growth of demand will be divided into three periods, which are 9th plan during 2002–2006, 10th plan during 2007–2011, and 11th plan during 2012–2016 (see Table 1). Load forecast is calculated by interpolation method.

For urban and provincial areas in the residential sector, the growth is assumed to follow the demand forecast of the Metropolitan Electricity Authority (MEA), and Provincial Electricity Authority (PEA). Since the projected

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²Elasticity Index reflects the proportion of growth in energy consumption to economic growth. Hence, high elasticity index implies the growth of electricity (in our case) consumption is higher than economic growth, and vice versa.
information concerned with the growth of electricity demand in industrial and commercial sectors is not available, it is assumed that growth of the demand in these two sectors would follow the total demand forecast of the EGAT system. This demand configuration will also be used as the demand portfolio for the two other scenarios as well.

Insofar as the supply profile is concerned, some existing natural gas and oil-fired power plants will reach their end of service period. These will be taken up by a combination of supply systems that use coal and natural gas, but not necessarily under the EGAT system. EGAT will still remain an important and dominant generator of electricity, but substantial proportions of new capacity are expected to be added by independent power producers (IPP). The government’s plan to increase the share of electricity from renewables is obtained from renewable sources to 8% by 2011 is also an important strategic realignment that will strengthen the hand of small power producers (SPP). In order to meet this target, the power sector is expected to deliver at least 1609 MW of electricity from renewables between 2005 and 2011. A 5% renewable obligations is imposed on power producers that wish to sell electricity to EGAT (Todoc, 2006). As illustrated in Table 1, these will constitute the supply-side assumptions used to construct the BAU scenario.

5. NNC scenario

Thailand has modest amounts of recoverable coal reserves estimated to be about 1.4 billion tonnes, which it uses to generate parts of its electricity (EIA, 2006). However, the indigenous coal largely consists of lignite or sub bituminous, which has a lower thermodynamic value than coal. Lignite also has high sulfur content, which has both local and global environmental consequences. With growing environmental concerns, new power plants in Thailand must use imported high-grade coal from neighbouring countries such as Indonesia (Todoc, 2006). Already, modest quantities of coal are imported to fuel power plants (EPPO—Energy Policy and Planning Office, 2005).

Even if the country imports large quantities of high-quality coal, there is still uncertainty as to how far it can pursue the coal option for electricity generation without...
resistance. For example, excessive levels of sulfur dioxide (SO₂) and leakage of sulfur from the Mae Moh power station in Lampang was linked to large number of deaths from heart failure and a high occurrence of chronic respiratory problems (Thanh and Lefevre, 2001; APERC, 2006). Aware of the legacy of Mae Moh on health, there is a growing opposition to coal-based plants by local residents and NGOs for fear of impact on their health, livelihoods and their environment. Two recent high-profile cases in Ban Krut and Bo Nok in the Prachuab Khiri Khan Province that mobilised local opposition supported by powerful NGOs have provided a glimpse of the challenge coal-fired plant projects could potentially face in future years (Mekong Watch-Japan, 2002). Agreements are yet to be reached with local residents in the case of Ban Krut, while in the Bo Nok project has been forced to switch its supply system to natural gas. It is worth indicating here that these resistances are largely motivated by local air pollution problems rather than the ‘remote’ concerns of greenhouse gas emissions that coal-based generation plants tend to provoke.

The NNC storyline argues that Thailand should shift to a cleaner technology to meet its environmental obligations and to avoid expensive payoffs to contractors due to intractable community/NGO resistance. As indicated in Table 1, the NNC pathway requires decommissioned coal power plants to be replaced by a combination of natural gas and renewable energy. By 2022, renewable energy sources account for 15% of the total electricity used.

6. GF scenario

The GF scenario is inspired by the Greenpeace study entitled ‘Positive Energy Choices’ (Greenpeace SEA—Southeast Asia, 2002) that argued 35% of Thailand’s electricity capacity could be derived from renewable energy sources. The study itself was spurred by the controversy relating to the planned construction of the two coal-fired power plants discussed earlier. It would therefore serve as a practical response from the NGO community by offering concrete solutions.

The GF scenario is a fairly aggressive promotion and implementation of renewable energy technologies in the overall energy mix. It explores how the country can diversify its energy source in the light of the uncertain international energy market and for the benefit of greater energy independence. Given the country’s heavy reliance on natural gas, of which about 25% is imported, reducing dependence on gas becomes a key energy security concern. Hence, not only does renewable energy symbolise real environmental commitment but it also becomes a strategic resource for negotiating future electricity generation beyond fossil fuels. Moreover, Thailand becomes well placed in the region as the hub for renewable energy activity whereby ‘good practise’ in a sustainable energy future would spread to neighbouring countries and beyond.

7. The analytical framework

The BAU scenario serves as a reference scenario based on assumptions that reflect actual plans and forecasts by the EGAT and the policy-making body, Ministry of Energy (MoE). The NNC and GF are constructed with some plausible policies and choices considered to be rational within the parameters of each scenario storyline.

In this study, the long-range energy alternative planning (LEAP)³ system is used to characterise the composition and structure of electricity, fuel use and greenhouse gas (and SO₂) emissions for each scenario between 2002 and 2022. The year 2002 is used as the base year which provides the basis for building the various scenarios and establishes the analysis within the current energy system in Thailand. Electricity generation calculations depend on the level of electricity consumption by the demand sector. The inputs required for the demand analysis include the level of activities and final energy intensity for each sector. In this case, levels of activities are the number of electrified consumer units, while final energy intensity used is electricity consumption per electrified consumer. It is assumed that the effect of the energy efficiency programme on the demand structure is already taken into account by the National Load Forecast 2002 data. The demand side consists of three demand sectors that include residential, industrial, and commercial sectors. For the residential sector, electricity demand is disaggregated into urban (metropolitan) and in rural (provincial) area demands. Based on the level of electricity needed to meet the annual demand requirements, the model ‘dispatches’ technologies to meet electricity demand.

The supply sector in Thailand is modelled using a range of technology categories that include various types of steam turbines, combustion turbines, combined cycle, cogeneration, hydroelectric (large and small-scale), biomass (steam cycle and gasification), PV systems and wind turbines. For each technology type, the capacity, base year output, maximum capacity factor, efficiency, and fuel shares are specified. Electricity losses from transmission and distribution are 7.3% at present but expected to fall to 4.3% by the end of the analysis period (DEDE, 2002). New and additional capacity are added either exogenously or endogenously⁴ to the generation infrastructure in accordance to planned additions or as and when the demand sectors call for more capacity. This study also assesses

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³LEAP is an accounting scenario-based energy modeling platform. The scenarios are based on how energy is consumed, converted and produced in a given region under a number of alternative assumptions. The tool is developed by Stockholm Environmental Institute, Boston. ⟨www.sei.org/leap⟩

⁴Exogenous capacity additions are planned additions with a specific quantity and type of capacity added at a specific time in the future, which implies building new capacity that is independent of demand requirements. Endogenous capacity additions are specific technologies that are built as needed to meet the electricity consumption requirements as specified by the demand sectors (SEI—Stockholm Environment Institute, 2004).
greenhouse gas emissions associated with fuel use in the electricity generation in Thailand. These emissions are estimated using the emission factors based on values recommended by the Intergovernmental Panel on Climate Change (IPCC) guidelines for national Greenhouse Gases inventories and 1996 Tier 1 average emissions factors (IPCC—Intergovernmental Panel on Climate Change, 1997). The Technology and Environment Database (TED) is contained in the LEAP system, making it possible to link each technology and the corresponding quantity of fuel used in electricity generation to average emissions factors.

8. Energy consumption of demand sectors

Demand for electricity is expected to rise sharply over the coming two decades (Fig. 2) with nearly 330% increase predicted between 2002 and 2022. Much of this increase is driven by higher demands for electricity in industry to sustain the high economic growth anticipated by the policy makers. The dominance of industry in electricity consumption, in both absolute and relative terms, indicates the significant role that this sector plays in shaping the future of Thailand’s power sector. The country will continue to focus on export-oriented economic development to which the industrial sector often plays the leading role. Recognising that a reliable electricity supply system is therefore central to sustaining this economic programme, for two decades policy makers in Thailand have successfully nurtured a sound electricity infrastructure. Furthermore, as shown in Fig. 2 a rising demand in energy is expected in the residential sector, largely to do with increased energy use brought about by economic prosperity and the material affluence associated with it.

9. Electricity generation over 20 years

In 2002, over 72% of the electricity generated to power Thailand’s economic recovery was derived from natural gas (Table 2). The remaining balance came from lignite (and coal), hydro and oil-fired power stations with a small, albeit important, proportion of electricity imported from neighbouring countries. By 2022, the BAU scenario reveals that the share of natural gas drops to about 66%, and coal increases its share to just under 23% and biomass entering the picture as an important contributor to overall electricity generation. This is in line with the government’s plan to increase the share of renewable energy systems to 8% by 2011 to which hydro, solar and wind make modest contributions.

Examining the BAU trends in real terms brings into sharp focus the enormous challenge ahead in meeting the country’s electricity demand. Fig. 3 shows that delivering the 330% increase in electricity demand between 2002 and 2022 requires the expansion of generation from various sources. Most notably, the BAU scenario shows a three-fold increase by 2022 at a rate of about 7% growth per year in natural gas-based electricity generation, which would include combined cycle, combustion turbines and cogeneration in its range of technologies. This may well require Thailand to look increasingly beyond its borders to supplement its domestically produced natural gas to satisfy its expanding power sector.
Further increases in production are expected for coal-based power generation in the BAU scenario, which would see a 5-fold increase (about 10% per year) over the 20-year study period. Due to the low quality of Thailand's indigenous coal resources, the incremental growth in coal will have to be imported, and in due course retire thermal plants using coal (Todoc, 2006). From the viewpoint of ‘energy security’, using coal (imports included) remains a credible strategic decision, and will continue to play a major role in electricity generation of the BAU scenario. The positive contribution of coal is somewhat tempered when viewed from an environmental standpoint. The BAU scenario results indicate that the combined effect of the increases in the country’s energy intensity and per capita energy consumption, and the bigger share of power generation expected from coal lead to a marked increase to carbon intensity. This raises a number of policy concerns, not least over the growing anxiety about Thailand’s energy security, which can be overcome either by deploying readily available but environment-compromising technologies or by significantly augmenting the shares of electricity generation from renewable energy sources.

The choice between these two strategic options does not appear to be clear-cut, and there is no weighty reason why they ought to be mutually exclusive. Indeed, the BAU scenario appears to incorporate elements of both, i.e. increasing the share of coal to over 22% and that of renewable energy sources to nearly 8% by 2022. To deliver the contribution from renewables, the growth rate for hydro is increased by about 66% over the study period (at 5% growth per year), while the figures for the other renewable sources are even more impressive (Fig. 3). The scenario result shows that since 2010 when biomass and solar and wind resources began to appear in the generation balance, they have increased at an average of about 50% and 150% per year, respectively. Although, the overall contribution of renewables still remains quite low in the larger scheme of national electricity generation, the figures are still noteworthy given that these resources are starting from a negligible base and only begin to make their mark during the second half of the analysis period. Imports in real terms from neighbouring countries also increase markedly in the BAU scenario, rising by about 290% (average of 7.8% per year) between 2002 and 2022.

The alternative scenarios tell a different story. Both the NNC and GF show decreased shares of coal, driven by the policy of bringing to an end the construction of new coal-fired plants (Table 2). But electricity shortfall that would result from effectively phasing out coal would need to be met through other generation options. Here there are differences in the strategies pursued in the two scenarios. In the NNC scenario, the deficit is alleviated by going deeper in the direction of expanding the natural gas generation capacity from 80 to 374 GWh between 2002 and 2022 (Fig. 4).

The NNC scenario also demonstrates an increased share of renewable energy generation at about 14%. Natural gas still remains important in the GF scenario, but it is less dominant than in the BAU and certainly NNC scenarios (Table 2). However, the distinctive aspect of the GF scenario as illustrated in Fig. 5 is the repertoire of renewable sources that are deployed for electricity generation that includes biomass (conventional steam cycle and gasification), hydro, wind and solar. These resources are harnessed in sufficient quantities to meet the shortfall caused by moving away from coal-fired generation and maintaining a relatively low growth (6% per year) in natural gas utilisation. The GF scenario represents an ambitious approach to future power sector development that places a high premium on diversifying generation capacity as an important strategy to reduce dependence on fossil fuels. In addition to slowing down the depletion rate of natural gas reserves and avoiding potential controversies associated with the construction of coal-fired plants, the strong emphasis on renewables brings useful experience in a group of technologies that are likely to play a significant role in the future.
9.1. The economics of the three scenarios

As given in Table 3, a number of fuel cost and economic assumptions are made to construct the scenarios. In addition, the sunk capital costs that pre-date 2002 are excluded from this analysis given the difficulty of obtaining data on retrospective cost of new generation plants and years of construction. Instead, the focus here will be to quantify the capital investment and running costs incurred between 2002 and 2022 thereby allowing the comparison of the scenarios to take place on future costs.

The difference between the BAU and the NNC scenarios in terms of the future investment and running costs do not appear significantly different (Fig. 6). Indeed, the annual cost pattern shows a generally stable trend across the study period with the NNC path increasing slightly in the latter half of the study period as the country gradually abandons coal in favour of more expensive options such as natural gas and biomass. The GF scenario gives a rather different picture. Capital investment here shows a consistently higher trend than the BAU and NNC during the middle third of the study period, mainly attributed to the high capital cost associated with the renewable technologies then sharply decreasing thereafter. The proportion of power generated by renewables reaches 28% by 2015 in the GF scenario, which is a considerable increase from 16% only 5 years earlier. As illustrated in Fig. 6, this rise in the share of renewable power generation capacity is characterised by the significantly lower running costs in the GF scenario in comparison to the fossil-fuel-dominated structure that represents both the BAU and NNC paths.
The above observations are supported further when all the costs are discounted over the 20-year study period. The left-hand diagram in Fig. 7 illustrates the total capital investment and running cost of new generation plants commissioned during the study period at discount rates of 4%, 7% and 10%. The BAU scenario appears the cheaper route at all discount rates compared to the alternative scenarios. Comparing the alternative scenarios, NNC shows high figures at lower (4% and 7%) discount rates mainly because of the high running cost associated with the NNC. In contrast, the GF scenario is more costly at the higher discount rate (10%) owing to its markedly higher capital investment compared to the NNC. It is however worth noting here that the total cost differences between the two alternative scenarios remain marginal.

The right-hand diagram in Fig. 7, which shows relative (and disaggregated) net present costs, offers additional insight into the distribution between capital investment and recurrent costs. What is most striking here is that the distribution of investment and expenditures in the GF scenario, in relation to the BAU, is characterized by higher capital costs ($14.8 billion) and large savings ($13.8 billion) in fuel consumption. The incremental discounted cost (at 7%) over the study period of providing new power supplies is estimated at $31.5 billion for the GF with about 74% of the costs going to investment in renewables. The discounted cost for new power supplies in the BAU scenario is about $16.7 billion, out of which about 17% is spent on renewable energy options. This indicates that the recovery of the initial investment of renewable energy systems needs to be approached over a longer time horizon where the displaced cost for fossil fuels is part of the calculation to measure long-term cost effectiveness. Moreover, if social and environmental costs (externalities) associated with the use of fossil fuels are included in the final cost of electricity, the GF scenario instantly becomes competitive.

10. Greenhouse gas emissions: three scenarios compared

The evolution of greenhouse gas emissions from power generation, measured in terms of tonnes of CO₂ equivalent (tCO₂ eq.), shows three distinct patterns representing the different scenarios (Table 4). In the BAU scenario, the GHG emissions increase steadily with the construction of new coal-fired and natural gas plants until about 2015 when GHG emissions reach their zenith. Over this period

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<tr>
<td>Natural gas</td>
<td>615</td>
<td>10.34</td>
<td>0.002</td>
<td>0.014, rising to 0.025 in 2005</td>
</tr>
<tr>
<td>Coal fired</td>
<td>837</td>
<td>60</td>
<td>0.003</td>
<td>0.005, rising to 0.011 in 2005</td>
</tr>
<tr>
<td>Oil fired</td>
<td>736</td>
<td>10.34</td>
<td>0.00414</td>
<td>0.009, rising to 0.017 in 2005</td>
</tr>
<tr>
<td>Hydro</td>
<td>2,000</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Biomass</td>
<td>1,730</td>
<td>60</td>
<td>0.007</td>
<td>0.0017</td>
</tr>
<tr>
<td>Solar (PV)</td>
<td>4,500, down to 2900 by 2010</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wind</td>
<td>1,015</td>
<td>26.4</td>
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<td>0</td>
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Study period = 20 years (2002–2022); discount rate = 7%; base year for prices = 2002.
(2002–2015), GHG emissions increase by 94% from 58 to 112.6 tCO2 at a rate of about 5.2% increase per year. From 2015 onwards, the trend shows a decline in GHG emissions reaching 101.6 million tCO2 eq. This declining trend can be explained by the increasing efficiency with which natural gas is converted into electricity towards the latter years of the study period, and to a lesser extent the modest expansion of Thailand’s renewable energy programme. Nonetheless, the BAU scenario has significantly higher emissions than the other NNC and GF scenarios, largely to do with the higher contribution of coal-fired generation to the overall electricity balance.

In the alternative scenarios, one striking feature illustrated in Table 4 is the sharp decline in GHG emissions around 2010—the year when the coal-fired plant at Mae Moh with the capacity of 2625 MW is decommissioned. The replacement for this comes mainly from natural gas in the case of the NNC scenario and from renewable energy sources (mainly) in the case of the GF scenario. This is reflected in the GHG emissions beyond 2010, where the NNC scenario shows an increasing trend in emissions until 2015, stabilising thereafter until 2022. In contrast, the emissions in the GF scenario follow a levelling and gradually declining trend starting in 2005, which is consistent with what can be expected as more and more renewable energy-based generation systems come on stream to replace the outgoing coal-fired plants. It is important to emphasise here that biomass represents the main renewable source in the GF scenario balance. Combustion of biomass to produce electricity releases CO2, but biomass is classified as ‘carbon neutral’ provided that the resources are grown and harvested sustainably. Both alternative paths therefore offer better environmental performance than the BAU path with respect to global air pollutants. The avoided emissions over the study period...
amount to 325 and 692 million tonnes of CO₂ equivalent for the NNC and GF scenarios, respectively, which represents reductions of about 17% and 36% relative to the BAU path.

Estimating the cost of GHG emissions is contentious since different electricity generation sources are associated with different forms of impacts, which vary over spatial, temporal and social dimensions (Kammen and Pacca, 2004). The cost can be estimated either using the economic valuation of the damage costs or by calculating the cost of emissions abatement initiative. In 1996, the IPCC’s Working Group III published a range of $5-$125 per tonne of carbon emitted as damage costs due to changes in health, agriculture, etc. In the subsequent years, a number of studies emerged that attempted to put value on the social cost of a tonne of carbon. However, a number of uncertainties remain on assigning monetary value for non-market impacts, aggregation of estimates across regions and what discounting figures to use to determine the value of future impacts (Clarkson and Deyes, 2002).

In this study, the CO₂ abatement cost for the two alternative scenarios is compared to the BAU. As illustrated in Table 4, the CO₂ reduction costs of the NNC and GF over the study period are estimated at $11.55/tCO₂ and $4.55/tCO₂, respectively. When the investment cost to avoid 1 tonne of carbon emission is low (or negative), it is regarded to be the more effective abatement strategy for CO₂ reduction, and in this case the GF scenario represents the better option of the two. However, the fact that the net present costs (NPC) of generation are higher in the two scenarios than the BAU scenario means neither of them qualify as ‘no-regrets’ options since they do not represent opportunities to reduce CO₂ emissions at zero cost or with cost savings. Hence, in the absence of a deliberate intervention to reduce emissions as a strategic priority, none of the two alternatives represent realistic pathways. It remains the case that mitigating the effects of climate change is yet to register as a high policy priority in the development radar of many countries, including Thailand, over that of economic growth and raising living standards. Therefore, for energy-related climate issues to be given serious policy attention, many argue that creating incentives for engagement is a precondition to encourage participation by a variety of actors, particularly investors. At the moment, there is little incentive for investment in CO₂ reductions alone. It means looking at two possible avenues: exploring the emissions trading avenue or reducing local air pollution as a matter policy priority. The latter option is discussed below.

The World Bank estimates that air and water pollution costs Thailand 1.6–2.6% of GDP per year (World Bank, 2002). More specifically, airborne particulate matter was estimated to have caused 3300 premature deaths and to have led to almost 17,000 hospital admissions, at a total health care cost of up to US$6.3 billion (EIA—Energy Information Administration, 2003). Improving local environmental quality therefore brings tangible economic and health benefits. The power sector accounts for 12% of air pollution in Thailand, estimated at around 280,000 tonnes of sulfur dioxide (SO₂) emissions for 2002. As illustrated in Fig. 8, over the study period, the NNC and GF scenarios show a declining pattern, a large part of which is attributed to the substitution of lignite with natural gas and renewables.

The incremental abatement costs are also presented in Table 5, which use similar principles employed in Table 4. The most salient feature here is the remarkable similarity in the total amount of SO₂ reduction in both alternative scenarios relative to the BAU scenario. A reduction of about 162% and 155% in SO₂ emissions are obtained for the NNC and GF, respectively. However, differences begin to emerge when comparing the abatement cost of each alternative scenario relative to the BAU scenario. As
shown in Table 5, for every tonne of SO2 displaced in GF, the cost involved amounts to US$475, which compares favourably from the NNC (at US$565/tSO2). It is also clear from this that neither scenario represents as an opportunity to reduce emissions at zero cost. In essence, the purpose of reducing SO2 emissions has to be part of a wider strategy to improve air quality, public health and general welfare. This could translate into lower healthcare bills and GDP gains for the country thereby justifying investments in SO2 reduction initiatives.

In both the NNC and GF scenarios, it is possible to observe that CO2 emission reduction is accompanied by deep cuts in SO2 emissions. Leaving aside the potential opportunities from carbon trading through CDM schemes, at least until 2012 developing countries are exempt from adopting GHG reduction targets under the Kyoto Protocol. This means that they are driven by local imperatives of air pollution and waste disposal than they are motivated by global issues. In the case of Thailand, a compelling case can be made that focusing on local pollution first is likely to deliver large health benefits. Ancillary carbon benefits can also be important outcomes. The NNC scenario demonstrates that although its driving philosophy (see Table 1) is clean technology and avoidance of resistance to coal-fired power plants, the considerable reductions in SO2 emissions are accompanied by significant carbon benefits. Similarly, multiple benefits are observed in the GF scenario although the reverse policy logic applies in that the driving philosophy is to confront the issue of energy security and reduce CO2 emissions. The secondary outcome of the GF scenario is SO2 emissions reduction. Thus, in view of the compatibility in the practise of reducing CO2 and SO2 emissions, incremental changes to ongoing policies that are designed to deliver local benefits may be an effective way to gradually embark on a carbon mitigation programme.

11. Conclusion

Energy security is a significant public policy issue that conjures fears and anxieties about reliability of future supplies and uncertainties in the way markets behave. For most developing countries, security of supply means the level of confidence with which they can expand their supply in line with their economic growth. For some, this may be accompanied by an increasing demand for imported energy and investment in import infrastructure in their single-minded pursuit of high economic growth. More or less, this describes the situation of Thailand, which is currently faced with the problem of sinking deeper into a state of energy dependency on its immediate neighbours and countries in the Middle East. The country’s continuing growth in energy consumption is outstripping the modest fossil fuel resources available within its borders. But the scenario analysis presented in this paper shows that Thailand still has options that it can take advantage of, which consist of straight technological interventions and political ones.

Based on the input assumptions of the analysis, natural gas remains a dominant fuel in all scenarios. This has two separate features to it. Firstly, Thailand does not possess large reserves of natural gas and therefore it would need to enter into mutually agreeable long-term arrangements with its neighbours and other suppliers. Secondly, the heavy reliance on natural gas means that electricity generation will remain an important emitter of carbon into the foreseeable future. Although all three scenarios show an improvement in carbon intensity (tonnes/MWh) resulting from the combination of improvements in natural gas technology and replacement of coal-fired plants with natural gas and renewables, the sheer volume of projected electricity demand during the study period will mean total emissions will rise in both BAU and NNC scenarios.
The exception to the observation above is the GF scenario, which registers lower CO₂ emissions at the end of the study period (2022) compared to the base year (2002). What is remarkable about this result is that this seems to be occurring by diversifying the country’s fuel mix to include resources that are locally available (e.g. biomass, wind and solar). Moreover, these important gains are happening at a marginally higher cost than the BAU scenario without taking into account the costs associated with CO₂ emissions. There may also be opportunities in the world of carbon trading. The mechanisms for CDM are there but still being debated 10 years after Kyoto came into being on issues of allocation and accounting. At present, there appears little in the way of incentives for investment in CO₂ reduction given that developing countries are not required to adopt GHG reduction targets under the Kyoto Protocol, although some countries such as India, the Philippines and Brazil have taken proactive steps towards entering the CDM market. The wisdom of pursuing cleaner electricity pathways in Thailand are however influenced more by local impacts than global issues, and enthusiasm for CDM projects in Thailand remains low. Further analysis shows that in the NNC and GF scenarios, SO₂ emissions are significantly reduced, which implies both direct and indirect improvements in the health of communities surrounding decommissioned coal-fired power stations. Furthermore, the secondary, but still important benefits of pursuing cleaner electricity pathways in Thailand should not be under-estimated. Other factors include new business opportunities, employment and expertise that could potentially bring enormous commercial opportunities from the ASEAN region and beyond as these ‘alternative’ technologies begin to force their way into the mainstream energy market.

Although, there is an enormous uncertainty about what the post-Kyoto agenda will look like once the current protocol expires in 2012, there is a growing global consensus that urgent action is needed in reaching lasting and meaningful agreements in climate negotiations. Many believe that the US position will have changed in 2012 with the likelihood that developing nations—exempted from emission cuts under Kyoto may come under increased pressure to set goals for ecologically sound development aims, including setting national emissions targets. If indeed this happens, the low carbon options in power generation will begin to assume a critical role and begin to deliver on the promises they hold towards a low carbon future.

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