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Putting Coal to the Test: Is Coal Fired Generation Clean, Competitive and Secure?

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Introduction

King Coal seems to be making a comeback in the Dutch power generation fuel mix. Perhaps surprisingly, power generators in the largely gas-based Dutch power market are developing concrete plans to build five new coal plants. The preliminary permission granted to E.ON this past June to build an 1,100 MW coal-fired power station at the *Maasvlakte* near Rotterdam raised eyebrows as well as discontent in some political circles. The current plans to build five additional coal-fired power stations in the Netherlands sparked a debate as to whether this is the right direction for Dutch power companies to be heading. Advocates and opponents entered the arena to explain their positions, covering the whole spectrum from 'blaming coal for everything' to 'coal is the energy source that meets all energy goals'. Opponents argued that investing in coal defeats existing efforts to curb greenhouse gas emissions and that new coal capacity is simply not necessary. Advocates pointed to the fact that carbon capture and storage (CCS) could play an important role in making coal a cleaner energy source, allowing it to become an acceptable option for replacing gas as a fuel source now that Dutch gas fields are becoming depleted. Minister of the Environment Jacqueline Cramer announced that the government will not and can not block the construction of the new coal-fired power stations under the current regulatory and energy policies. But she did stress that energy companies should do all they can to make their installations capture-ready in order to apply CCS within ten years. Moreover, she pointed out that coal will indeed be needed to fulfil our future energy needs and voiced the hope that energy companies will close down their old, more polluting and less efficient coal plants after the new ones are built.

In this paper we will highlight some of the wider policy aspects of the role of coal for power generation in the Netherlands. We will start by focussing on the present plans for new coal-fired power generation in relation to the existing plant stock. After that, we will look at the role of coal in the global energy mix and assess current developments in the global coal market. Next we will discuss the relevant market environment in which these plans have to be assessed, i.e., the Northwest European power market. The role of coal in the national energy balance, however, also has an impact on the more general national energy policy approach that is at stake, including its relation to climate change policies. The main issue that will be discussed here is the carbon question and, with it, the prospects for CCS[1] and the European emissions trading scheme, ETS. A final section concludes.

Current construction plans in the Netherlands

Since the start of the electricity market's liberalisation in 1995, there have been hardly any new power generation capacity additions in the Netherlands. Before liberalisation there was significant overcapacity in generation, which over time has slowly been reduced to economically more attractive levels.[2] More recently, growing power demand and the need to replace aging power plants have raised the need for new capacity.[3] In addition to gas-fired generation and the ongoing expansion of renewable energy-based capacities, five large energy companies have announced plans to build new coal-fired capacity, most with the co-firing of biomass (see Table 1).

Table 1. Operational and planned coal-fired power plants in the Netherlands

Owner	Location	In operation	Capacity (MW)	Type (PC or IGCC)*	Efficiency (%)
Existing					
Electrabel	Gelderland	1981	602	PC	39
Nuon	Hemweg	1994	630	PC	43
E.ON	Maasvlakte	1987	520	PC	40
E.ON	Maasvlakte	1988	520	PC	40
EPZ	Borssele	1987	413	PC	40
Essent	Geertruidenberg	1980	645	PC	41
Essent	Geertruidenberg	1993	600	PC	43
Nuon	Buggenum	1994	253	IGCC	43
Planned					
Electrabel	Maasvlakte	2011	750	PC	46
Nuon	Eemshaven	2011	720	IGCC	46
E.ON	Maasvlakte	2011	1080	PC	46
RWE	Eemshaven	2011	1600	PC	46
Essent	Geertruidenberg	2013	1100	PC	46

Source: Ecofys (2007). * PC = pulverised coal; IGCC = Integrated Gasification Combined Cycle.

The energy companies argue that the Netherlands is well suited to build coal-fired plants near the shore because of ample cooling water and coal import infrastructures. Moreover, they state that they want to improve Dutch power supply security by decreasing the need for electricity imports (now at 22%). Another of their aims is to become less dependent on gas, as gas import dependency is growing and will increase even further when, within 20-30 years, Dutch reserves will be depleted.[4]

[1] Carbon Capture and Storage
[2] Dutch Energy Council. *Markten op de Weegschaal*. 2003.
[3] CIEP. *The European Electricity Market: Some Trends and Consequences for Investments in the Netherlands.* 2006, The Hague.
[4] See the websites of Nuon, Electrabel and E.ON-Benelux.

To date, E.ON and Nuon are the two companies that have received permits to build the coal stations they proposed. The licensing procedures require a full-fledged Environmental Impact Assessment (EIA) to be completed before a license can be issued.[5] The EIA of RWE's project has also been approved, but this project has not yet received the permits from the licensing authorities. The licensing procedures for the Eemshaven and Maasvlakte plants are underway and are not expected to encounter any specific difficulties. It should be noted, however, that an announced plan, or even a granted permit or a contract with the grid operator, is no guarantee that immediate investments will actually be made.[6] For example, Nuon decided in mid-September 2007 to first build a gas-fired plant that can later be expanded with a coal and biomass gasification unit.[7] In general, investors consider the total amount of new capacity arising in the Netherlands (3,000 MW from planned or under construction gas-fired power stations) and the scheduled additional interconnection capacity (about 2,500 MW between Germany and the Netherlands) when making their decisions.[8] The fuel choice is no part of the licensing procedures. Hence, national governments have no authority to block licenses because of different views on the desired fuel choice. In the Netherlands Nuon and Essent are publicly owned, and the shareholders of these companies could block plans if they wish.[9]

Global coal markets and the worldwide energy mix

Today 80% of the world's energy demand is met by fossil fuels. The share of coal is around 25% and will remain, according to the IEA, the second largest fuel – after oil – until at least 2030.[10] Coal is the fastest growing conventional energy source and is expected to grow at 2.2% per year until 2030.[11] Coal is abundantly available in a wide variety of countries and is therefore regarded as a secure fuel. This is especially true for countries with large domestic coal reserves like China and the US, but also in Germany and Poland coal is often the fuel of choice for power generation. Moreover, in countries where coal is abundantly available, the mining industry historically has formed an important part of the economy, and reforming this sector is politically sensitive. This has to do with the fact that in the coal mining regions there are often few alternative employment possibilities.[12]

Coal is generally perceived as relatively competitive and stably priced. The surge in energy demand, especially in China and India, has led to a sharp increase in the use of coal. Investments in coal-fired power stations in Europe and elsewhere have also created a further demand for coal. At the end of 2003 the coal price started to rise (see Figure 1a) but until recently remained relatively stable, fluctuating somewhere between \$60 and \$80/t. When looking at the price per unit of energy (not taking into account the value of carbon), coal is still 2-4 times cheaper than oil or gas.[13] Although relatively cheap, the price of coal can no longer be seen as stable or certain, and as such reflects the current developments in the energy sector.

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[5] The provinces are the licensing authorities and cannot influence the choice of fuel.

[6] Until 2014, 13GW generation capacity is planned in the Netherlands. Existing operational capacity is around 22GW. So, if all capacity would be built, operational capacity would increase by 58%, which seems unlikely. (TenneT, *Rapport Monitoring Leveringszekerheid 2006-2014.* July 2007).

[7] Nuon press release: *Nuon faseert bouw multi-fuel centrale vanwege hoge bouwkosten*. 18 September 2007.

[8] Slingerland, S., Tönjes, C. *The European Electricity Market: Some Trends and Consequences for Investments in the Netherlands.* 2006, CIEP, The Hague.

[9] Both companies are basically owned by provincial governments.

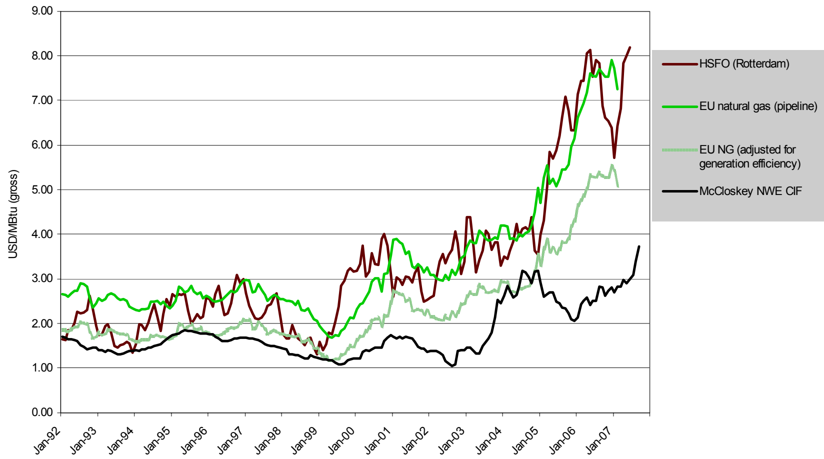
[10] International Energy Agency (2007). *World Energy Outlook,* 2007. Paris, OECD.

[11] Compared to 1.3% for oil and 2.1% for natural gas. IEA (2007), *World Energy Outlook,* 2007. Paris, OECD.

[12] In Germany the coal industry is annually subsidised by €80,000 per employee. ("Regierung Beschlieβt Kohle-Ausstieg". *Die Welt*, 8 August 2007.)

[13] A coal price of \$120/t relates to a price of around €3/GJ. The same amount of energy from oil at an oil price of \$90/bbl costs €12/GJ; for gas at related market prices (23ct/m^3) this amount of energy costs €7.20. (*Inzet van Biomassa in centrales voor de opwekking van electriciteit,* ECN, 2005 and "Europe pays to ship U.S. coal as price sinks". *International Herald Tribune*, 5 November 2007.)

Figure 1a. EU import prices for coal, natural gas and heavy fuel oil. Source IEA, 2006.



Lately, coal prices have jumped to unprecedented levels (see Figure 1b), reaching $151/t in November 2007.[14] The increase can be explained by a number of factors. A very important one seems to be the fact that China has started to import coal.[15] The Chinese imports cover only a small proportion of the country's total coal need but already make up a major part of international coal trade, and will continue to do so, especially in the short to medium term.[16] India has long been a coal importer, but its share of imports is also growing quickly (see Figure 2), putting extra pressure on the world's coal market. In general, when there is little spare capacity, increased demand directly leads to higher prices. Although there are plenty of remaining coal reserves, increases in supply are slow, due to time lags in the value chain.

Figure 1b. Coal price development 2004-2007. Source: Verein der Deutsche Kohlenimporteure;

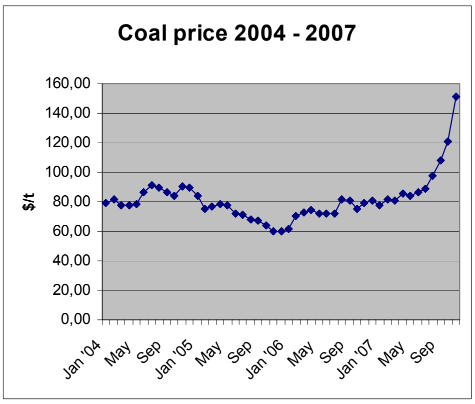
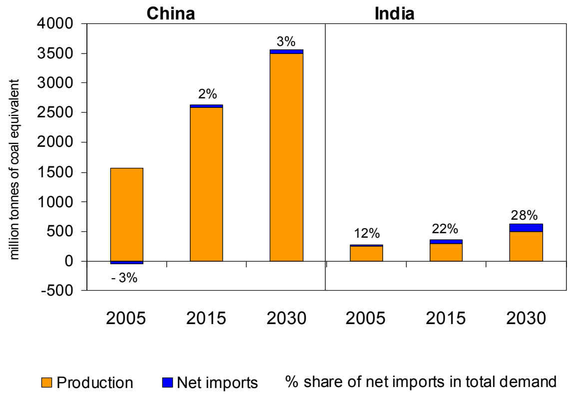


Figure 2. Coal Balance India and China in the IEA reference scenario. Source: IEA, WEO 2007.



There are a large number of coal-exporting countries, evenly spread over the world. Therefore coal can be regarded as a relatively secure source of energy. Top exporters in 2006 were: Australia,

[14] CBS. *Kolenprijs stabiel op hoog niveau.* 16 October 2006; RWE, "Coal price developments". *Facts and Figures 2007.*
[15] China is world's largest coal producer, producing 2482Mt a year, followed by the US with 990Mt. (World Coal Institute, 2007, *Coal Facts.*)
[16] IEA (2007). *World Energy Outlook 2007.* OECD, Paris.

Indonesia, Russia, South Africa, China, Colombia and the USA.[17] CBS data show that the Dutch coal imports are relatively secure. They originate from a large number of different and politically stable countries and regions: South America (35%), South Africa (30%), North America (12%), Europe (10%) and Australia (7%). The chance of sudden shortages of coal has always been relatively low. However, in a tight market, even a small disruption in supply due to inflexibility can lead to a shortage and provoke a price increase.

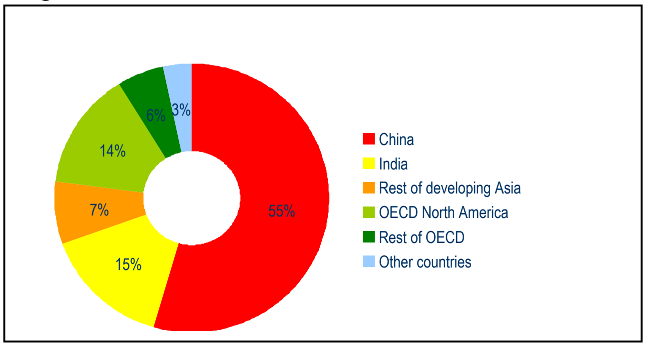
The port of Rotterdam is Europe's largest coal port. It handles around 27.6 million tons of coal a year. As a comparison, it is interesting to note that the largest Chinese coal port now handles around 200 million tons a year, and the province of Hebei is developing a new port facility that can handle 400 million tons a year.[18] In total, approximately 45.6 million tons of coal arrives annually in the Netherlands, of which more than 70% is exported again to other countries, particularly Germany.[19] In Germany, coal is mostly used for power generation. Shipping coal from the Netherlands to Germany and then importing back electricity from coal-fired power stations is evidently less efficient than using the imported coal in the Netherlands for power generation. Such import flows become particularly irrational when the availability of cooling water in Germany becomes a problem. Demand for power, availability of cooling water and opportunities for CO_2 capture and storage should be the determining factors with regard to the location of new coal-fired power plants. So, in the discussion about the desired power generation fuel mix, the fuel mix of imported power should also be taken into account, because banning coal in the Netherlands while importing coal-fired power from abroad does not contribute to the climate change issue.

Figure 3 shows that the increase of coal-fired power generation will mainly come from developing Asia, as will the resulting CO_2 emissions. Tackling the issue of global climate change caused by coal-related CO_2 emissions should consist of measures that aim to not only reach domestic goals but also to meet international policy agreements. Only then can climate policy really be effective.[20] This should certainly not be not an argument to, in the case of no international agreement, refrain from taking measures that make the domestic energy system more sustainable, as not taking action gives others an argument to also remain inactive. Moreover, each country should take on its share in reducing CO_2 emissions.

Table 2. Share of coal (incl. lignite) in power generation. Source: Euracoal (2007).[21]

Country	Share
The Netherlands	23%
Germany	45%
Belgium	11%
Poland	92%
European Union (EU25)	29%
USA	50%
China	89%

Figure 3. Incremental Coal-fired power generation by region, 2004-2030. Source: IEA, 2006.[22]

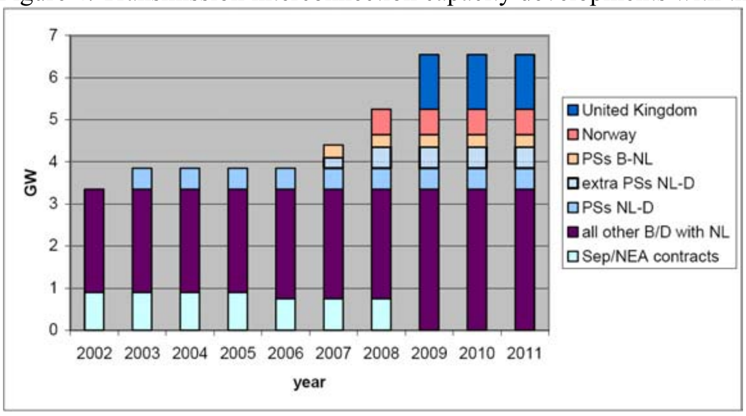


[17] World Coal Institute, 2007. *Coal Facts 2007 Edition.*
[18] Port of Rotterdam, 19 September 2007. *Chinese belangstelling voor Rotterdamse energiehaven.* www.portofrotterdam.com
[19] CBS. *Kolenprijs stabiel op hoog niveau.* 16-10-2006; www.cbs.nl
[20] In 2005 greenhouse gas emissions of the several countries were as follows: Netherlands, 212.1 Mt; EU-15 were 4192 Mt in 2005; US 7262 Mt; China 6,100 in 2004. Around 65% of these levels is CO_2. www.unfccc.org.
[21] Euracoal. *Market Report 2007*; E.ON, *Annual Report 2006*; MIT, *The Future of Coal,* 2007. Zhang Qingyu, Tian Weili, Wei Yumei and Chen Yingxu. "External costs from electricity generation of China up to 2030 in energy and abatement scenarios". *Energy Policy.* Vol. 35, Issue 8, 2007. IEA, 2007, *World Energy Outlook 2007.* OECD, Paris.
[22] IEA, 2006. *World Energy Outlook 2006*. Paris, OECD.

Dutch coal plants in the context of the Northwest European power market

The Dutch power market must increasingly be seen in the context of the wider Northwest European regional market. Cross-border interconnection capacities already exist with Germany, Belgium and Norway, and wider extensions are being planned with the UK. Total interconnection capacity is presently rated at 4.5 GW and is planned to be increased to around 6.5 GW by 2011 (Figure 4). Interconnection capacity therefore adds more than 20% to the present total generation capacity in the Netherlands of some 21 GW. The physical and commercial cross-border linkages are further enhanced at the political, policy and regulatory levels. Under Dutch political initiatives, political contacts with Belgium and Germany were enhanced in recent years, finally resulting in agreements to create a Pentalateral Energy Forum in 2004, where policy discussions were organised to promote electricity market integration between the Benelux, France and Germany. In a more formal meeting in early 2007 ministers, regulators, the respective transmission system operators (TSOs) and power exchanges agreed to a trilateral market coupling between the Benelux and France, with the intention to include the German market in due course. With the NorNed line starting at the end of 2007, interconnecting the Netherlands and Germany, markets are further integrating. In addition, there is ongoing work to expand further cooperation between the TSOs and the power exchanges, which will result in the Northwest European power market becoming more and more integrated in the coming years. These developments mean that companies will increasingly take regional instead of only national conditions into account in their investment decisions. Trade flows of power will be able to run freely within this region, resulting in a preference for least cost power. However, cheap in price often means dirty for the atmosphere. Thus, in order to design effective climate policy, policy makers should also take the regional rather than the national situation into account.

Figure 4. Transmission interconnection capacity developments with the Netherlands (Source: TenneT). [23]



There are some European issues that will have particular impact on power plant investment in the Dutch electricity market:

1. Investment decisions are becoming more and more contingent upon the further integration of national electricity markets. The relevant power price for investments in Dutch power plants is therefore derived from the price in the Northwest European market, potentially leading to lower prices in the Dutch electricity market due to existing structural differences in the fuel mix.
2. Although the overall energy mix policy remains a national sovereignty, formulating policies will need to be done at relevant market/EU levels. The 2007 EU targets for cutting CO_2 emissions and of having 20% of overall energy use coming from renewable sources by 2020 will heavily influence investment behaviour. The questions of how much and how far will be

[23] TenneT, 2004. *Development of import and export capacity for the market.*

determined by the more concrete policy instrumentation, such as the ETS and the incentives for renewables. In addition, policies on clean fossil fuels, including CCS pilots, will play a further role, whereas national policies will largely determine the position of nuclear energy.
3. Location choices must also be seen in the relevant market/EU context. Important factors to take into account are the availability of cooling water, demand for power (the market) and the potential for storage and transport of CO_2.
4. Concerns regarding global security of supply could lead to further EU policies. In the context of power generation, this will be important especially for gas imports. It is likely, however, that such policies, if any, will remain the purview of national governments for the near future.

In addition to these more policy-oriented impacts on investment decisions, it should be stressed that the prevailing industry structure is not a stable one. The consolidation process is still in full swing, and M&A activities could involve Dutch market players, such as Nuon and Essent. As Dutch distribution networks will have to be ownership unbundled, a further shake-out is expected, leading to a further internationalisation of the Dutch energy industry landscape. There is no doubt that this will have a wider impact on investment decision-making for the Dutch market, bringing it further under control of companies from neighbouring countries. Such developments are more generally a continuation of already ongoing trends, and there is no apparent reason to believe that they will conflict with the Dutch Government's options in setting conditions for power plant investments. The determining policy factors involve issues such as the European regulatory climate, the competitiveness of the home market, the licensing processes, the status of the national gas market, the availability of cooling water, potential for CO_2 storage and transport, the overall grid and network-related issues.

Irrespective of size or national origin, basic strategies of key electricity companies all comprise the search for a stable basis in a national home market and a diversified generation portfolio, with investments into environmentally friendly production capacity as well as growth through mergers and acquisitions. Regarding the generation portfolio, there is presently an apparent shift away from gas towards coal and nuclear energy. Whether this will result in a substantial shift in the overall primary energy mix in Europe and in individual countries is another question. What can be expected is that we will see all sorts of operational and market-based arbitrages between various fuels, including the carbon-price component, in the overall Northwest European market environment. What this will mean in practice for the fuel inputs is an interesting question. It could imply that national merit orders are developing into a more regional, Northwest European one. The already existing and further developing market-coupling devices in the region could contribute to this. It could imply different shifts in cross-border trades, where different national policy or licensing requirements, such as the condition for capture-readiness for new coal plants, could force clean and efficient coal plants to stand idle on the Dutch side. On the other side of the border the 'dirtier' low-cost coal power plants would be running at full capacity, exporting power across the border. Whether these effects will occur and to what extent, will depend on the willingness of policymakers to limit this behaviour. It will no doubt lead to a wider need for further energy policy coordination between the national governments in the region. One crucial element will be the allocation of emission rights under the extended ETS after 2012, including modalities for auctioning, if that is decided. Another element might be a joint approach for CCS-policies. It would therefore be highly appropriate to reassess the national energy policy context in the Netherlands with these wider regional developments in mind.

New coal plants in the Dutch energy policy context

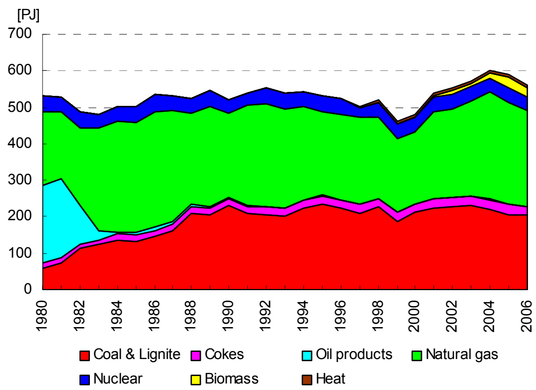
As already mentioned, the level of surprise at the announcement of the permits to build coal plants was high, including from a number of shareholders of Nuon and Essent.[24] The main reasons were the high levels of CO_2 emissions that would result and their perceived negative impacts on the newly stated

[24] "Essent en Nuon, investeer in schone energie". *Volkskrant*, 16 July 2007.

government policy goals with respect to energy and climate. When coal and these policy goals were further discussed in political circles, there appeared to be quite some frustration that the government had no instruments for influencing the fuel choice of the generators concerned. Before 1998 the electricity sector made, every two years, an 'Electricity Plan' via the Sep for the coming 10 year period, in which electricity supply and demand were forecasted and the resulting necessary investments in grids and generation were defined. Fuel choices were an integral part of this plan. The Minister of Economic Affairs, in consultation with the Parliament, could approve or disapprove of this plan. After liberalisation, this procedure was abandoned and fuel choices were left to the market, whereas the role of the government was limited to setting the appropriate conditions. In the current situation the Dutch government cannot influence investment plans in generation anymore, other than through its permitting procedures at the local level.[25] Policy can still be formulated concerning the boundary conditions, especially with regard to the environmental aspects. To this end, the central government is exploring its options to enforce cleaner coal-fired generation. In addition to promoting CCS, the government investigates also the possibility of closing down old coal plants earlier than initially planned. This could leave the generators with sunk costs if the old plants are not yet fully amortised. In cases where the old plants are already amortised, closing them down leads to a loss of profits. Closing down existing plants could theoretically bypass additional opportunities for CCS. But this seems unrealistic, as efficiencies of the existing fleet of pulverised coal power plants would drop to such low levels (between 22 and 35%) that they would no longer be economically viable.[26]

All these discussions reflect the debate about striking a balance between the three priorities of energy policy: clean, affordable and secure. Clean energy mostly refers to the impact of burning fossil fuels on the global climate, in addition to local air pollution considerations. Affordable energy entails that all customers should be able to fulfil their energy needs at efficient and reasonable prices and that industrial users would have no competitive disadvantage compared to industries in other countries. A secure energy supply implies a stable flow of reasonably priced energy sources, including such flows for power generation. Fulfilling two of the three goals is in general relatively easy, but fulfilling all three of them has appeared to be fairly difficult. Therefore, a suitable and diversified mix of energy supplies is usually seen as an appropriate policy objective. The fuel mix for power generation therefore gives an indication of the policy effectiveness in this respect. Figure 5 gives an indication of the fuel mix over time.

Figure 5. Fuel mix in electricity generation Netherlands. Source: ECN.



Until now coal has been relatively cheap and abundantly available, but it emits a lot of CO_2. Gas has relatively low carbon emissions but has a much more volatile price due to oil indexations. Moreover,

[25] The present regulatory framework does, however, still contain provisions for a government role concerning the grid investments.
[26] Ecofys. *Making CCS Work Policy, Technology and Organisation. Large scale carbon capture and storage in the Netherlands, an agenda for 2007-2020.* 2007.

there are increasing gas supply risks associated with importing from a small number of countries. Other alternatives for power generation, such as renewable energy (clean and relatively secure, but still more expensive than fossil fuels) and nuclear power (stable pricing with secure supplies but with safety and nuclear waste issues that are socially very controversial), also have their pros and cons. It therefore seems inappropriate to formulate a policy approach specifically for coal plants. The issues surrounding fuel specifics in power generation should rather be addressed in an overall energy policy context, taking due note of the three policy objectives we mentioned earlier. This requires a continuous balancing act between the fuel options, and it is precisely the search for that balance is the heart of the discussion regarding coal in the energy policy mix.

Both national and international policy

In this context, it would be useful to make distinctions between national and international (EU) policies. International policies are, for instance, needed to coordinate or harmonise national ones, or to ensure that national efforts are comparable and that a sufficient number of parties is involved in meeting global challenges such as the ones concerning energy and climate. National policies are then a further translation, implementation and, where necessary, instrumentation of the approaches upon which international agreements have been made. Also in the case of coal, this wider and global dimension has to be considered. The current Dutch government, however, seems to have failed to consider the global dimensions and the different priorities in energy policy when ambitious targets were set in 2007 to change the current fossil fuel-based energy system towards a more sustainable one.[27] By 2020 therefore, CO_2 emissions have to be cut by 30% compared to 1990 levels, energy efficiency has to increase annually by 2%, and the share of renewable energy sources in the overall energy balance has to rise from its present 2-3% to 20%. Although these targets are largely consistent with the so called triple-20 targets the EU set in March 2007 for 2020, they fail to take due account of the prevailing liberalised market model and the more general long term security of supply issues.[28] To meet these targets, radical policy measures are required, especially for cutting CO_2 emissions. From this perspective, the discontent and incredulity about the plans to build five new coal-fired power plants is fully understandable, but also narrow-minded when seen from the global energy policy perspective. A further discussion about the merits of cleaning coal burning for power generation is therefore imperative.

Is clean coal the answer?

Dutch energy companies are concerned with climate issues and are generally promoting electricity production in an efficient and environmentally friendly way, as long as this fits with required rates of return. The efficiency of the newly proposed plants is among the highest possible (around 46%). Also, all companies announced in their plans that they are planning to use biomass in addition to coal, but the amounts are plant specific and dependent on local circumstances, possibilities and licensing conditions, as well as on the price development of coal, biomass and carbon. Furthermore, all companies show an interest in the development of CCS, and all plans include the option to design their facilities with CCS, entailing that the new power stations will be 'capture ready'.[29] To that extent, Nuon, the Ministry of Environment and Spatial Planning and the Province of Groningen signed an

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[27] Ministry of the Environment (2007). *Nieuwe Energie voor het Klimaat.* The Hague, Netherlands.

[28] By 2020, the European Union wants to improve its energy efficiency by 20%, increase the share of renewable energy sources to 20% (incl. 10% biofuels) and cut CO_2-emissions by 20%. When international agreement with major emitters (like the United States, China and India) is found, this target will be upped to 30% ("EU agrees bold deal on climate change". *Financial Times*, 08 March 2007).

[29] What capture readiness exactly means remains open to discussion. Bohm et al. use the following definition: "A plant can be considered 'capture ready' if, at some point in the future it can be retrofitted for carbon capture and sequestration and still be economical to operate." (Bohn, M. et al. "Capture-ready coal plants-Options, technologies and economics". *International Journal of Greenhouse Gas Control*, Vol. 1, 2007).

agreement to collaborate in the development of large scale CCS.[30] Despite these intentions, the overall impact of the proposed co-firing of biomass and the 'capture readiness' on the transition towards a cleaner energy system is still unclear. Large-scale application of CCS-technology and the allocation of CO_2 emission rights under the ETS will be decisive factors that will be further discussed in the coming sections.

Carbon capture and storage

A global response to address climate change should consist of a portfolio of mitigation technologies. CCS is one of the technologies and might, according to the IEA, contribute to 20-28% of total CO_2 emission reductions by 2050, which would make it the technology with the second largest potential impact after energy efficiency measures.[31] Carbon capture potential is the highest at large point sources, such as power stations or large industries, preferably when clustered to help development the infrastructure.

There are three basic steps involved with CCS: capturing, transporting and storing. Post-combustion capturing of CO_2 is a well-understood technology and is economically viable when it is used for enhanced oil recovery.[32] Another capturing technology, pre-combustion, is widely applied in fertilizer manufacturing and hydrogen production. This converts the primary energy source to carbon monoxide (which can be stored) and hydrogen. With coal as primary energy source, this type of capturing is only applicable in IGCC plants. Up to now these plants have been only a very small part of total installed capacity.[33] Transport of CO_2 via pipelines is also a well-known technology, and the same applies in principle for storage. There are several forms of storing CO_2, e.g. in depleted oil and gas fields, saline formations, unrecoverable coal beds, aquifers or in the ocean, but all these storage options need more proof of underground retention on a large scale in order to gain public acceptance.[34]

The main share of the costs of CCS are involved with capturing the CO_2; about 5/6 is for capturing and 1/6 for transportation and storage.[35] In general, CCS technologies will not be deployed when CO_2 has no price, as there are few economically viable applications in which large amounts of CO_2 can be used. Nevertheless, there is already a CO_2 pipeline connecting petrochemical industry in Pernis to greenhouses that can productively use CO_2 in horticulture. Alternatively, CO_2 can be used for enhanced oil recovery.[36] The processes of capturing, transporting and storing CO_2 leads to additional energy use and hence to reduced efficiency, which drops by about 9% for a PC plant and 7% for an IGCC plant.[37] Current capturing technologies capture about 85-95% of the CO_2, so in combination with the efficiency losses, CCS can avoid 80-90% of the emissions.[38] The cost level that will be associated with CCS is still uncertain and depends on the type of technology used for power

[30] Nuon. *Nuon Magnum Nieuwsbrief,* May 2007.
[31] IEA. *Energy Technology Perspectives*. 2006. Paris, OECD.
[32] With enhanced oil recovery, CO_2 is injected into oil or gas fields to increase the pressure in the field, which enables the producer to extract more resources from the field.
[33] See Table 2; Worldwide IGCC accounted for 0.1% of total installed capacity in 2004. IEA, *World Energy Outlook 2004,* 2004. Paris, OECD. Ecoal, *Coal Gasification and IGCC – Light at the End of the Tunnel?* July 2006.
[34] IEA. *Legal Aspects of Storing CO_2: Update and Recommendations*. 2006. Paris, OECD; IPCC, *Carbon Dioxide Capture and Storage,* 2005. New York: Cambridge University Press.
[35] MIT. *The Future of Coal,* 2007.
[36] Enhanced Oil Recovery (EOR) could play an important role in this respect, as it is one of the few cases in which CCS can be applied commercially viably without an incentive and could as such contribute to the progress of CCS in general. (Ecofys. *Making CCS Work Policy, Technology and Organisation. Large scale carbon capture and storage in the Netherlands, an agenda for 2007-2020.* 2007.) It should, however, be noted that Shell and Statoil ended a technically feasible pilot project for EOR on economic grounds. The geological structure of the fields was not suitable for EOR. However, the companies continue their research on these fields to explore opportunities for CO_2 storage ("Shell en Statoil blazen groot proefproject af". *Financieel Dagblad*, 3 July 2007).
[37] Ecofys. *Making CCS Work Policy, Technology and Organisation. Large scale carbon capture and storage in the Netherlands, an agenda for 2007-2020.* 2007.
[38] IPCC. *Carbon Dioxide Capture and Storage,* 2005. New York, Cambridge University Press.

generation and CO_2 capturing as well as on the transportation distance and utilisation of CO_2 transportation capacity. Cost ranges lie between €20 - 70/tCO_2. This corresponds to €2-3ct/kWh for new coal-fired generation and could fall to €1-2ct/kWh by 2030.[39] The main challenges for the future of CCS are, therefore, improving the technology, reducing costs and making sure that the costs will be reflected in the price of electricity.

Required cost levels and efficiencies can only be reached when experience in each step of the CCS chain is gained, e.g. through large-scale demonstration projects. But government assistance appears to be needed, among others financially, to get these projects off the ground. Especially because there is still uncertainty about technological progress and what the carbon price will be after 2012.[40] The importance of the government's role became clear in the UK, when in the BP announced in May 2007 that it would pull out of a pilot project to build a power plant with CCS.[41] The reason for pulling out was the prolonged uncertainty about future support. The Dutch government has clearly indicated that it will promote CCS and make financial support available. Prime Minister Balkenende even announced in March 2007 that the Netherlands wants to become a front runner in clean coal technologies and CO_2 storage.

Another issue related to the deployment of CCS is CO_2 transport infrastructure. EnergieNed, the Dutch energy industry association, welcomes the rapid deployment of CCS in the Netherlands, but states that the government should take the lead in realising the transport infrastructure and the storage facilities, due to many uncertainties about storage and transport liabilities in case of leakages and expected future cost levels.[42] The companies are prepared to pay a tariff for using the infrastructure.

Moreover, there is a growing concern that available storage capacity can become a bottleneck. Viable storage capacity is lower than realistic (technically achievable) capacity, which is again much lower than theoretically availability capacity.[43] Viability of storage capacity depends on a large number of factors like the economics of infrastructure, project lead times, permeability of fields (this determines how fast CO_2 can be injected), concentration of storage space and competition with gas storage. In addition, the regulatory environment is still undefined, including with respect to a spatial policy for Dutch depleted gas fields.

The potential of CCS is large enough, but, as outlined above, many uncertainties still exists that must be resolved before large-scale commercial application will be seriously considered. It is therefore debatable as to whether the ambition of the Dutch government to implement large-scale CCS within ten years in the planned coal power stations is a realistic one.[44]

The impact of the European Union Emissions Trading Scheme on coal

The other relevant instrument that determines the role of coal in climate policy is the European Union emissions trading scheme (EU ETS). The EU ETS was launched on 1 January 2005 and is the largest 'cap and trade' system in the world, setting limits on almost half of EU-25 CO_2 emissions. The system is Europe's core instrument for Kyoto compliance. Under this system, of which the first phase ends in

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[39] The lower range cost levels require that the CO_2 is used productively, e.g. for enhanced oil recovery. Ecofys. *Making CCS Work Policy, Technology and Organisation. Large scale carbon capture and storage in the Netherlands, an agenda for 2007-2020.* 2007; IEA. *Legal Aspects of Storing CO_2. Update and Recommendations.* 2006. Paris, OECD. IEA uses a higher upper limit.

[40] MIT. *The Future of Coal,* 2007.

[41] "BP axes plan for carbon capture power station". *Financial Times*, 23 May 2007.

[42] EnergieNed. *"Tijdige aanleg van infrastructuur meest kritische factor voor commerciële toepassing van CO_2-opslag in 2020"* 16 July 2007.

[43] Bradshw, J. et al. "CO_2 storage capacity estimation: Issues and development of standards". *International Journal of Greenhouse Gas Control.* Vol. 1, 2007.

[44] Ministry of Environment and Spatial Planning. Kvl2007058621.

2007 and the second phase runs from 2008-2012, emitters of CO_2, like power generating plants, are granted a certain amount of emission rights. If an emitter emits more than the amount of granted rights it has to buy extra credits or, reversely, if it emits less than its allowance it could sell its excess rights. National governments make an allocation plan specifying emission rights per industry and type of installation. The EU Commission has to approve the plans. The idea behind this market-based instrument is that emission reduction takes place on the basis of the lowest costs.

Emission trading has therefore established a price for carbon. The impact of the scheme to date is still unclear.[45] This is due to the generous allocation of emission rights by the Member States for a variety of reasons, including support of the industry and concerns about competitiveness and employment. When it became clear in May 2006 that emission levels in 2005 were largely in line with the allocated rights, carbon prices suddenly collapsed.[46]

What the first phase taught us further was that carbon pricing did influence operational behaviour, especially in the power industry. Although emission rights were allocated freely, they had a value and were therefore calculated as an opportunity cost in pricing strategies within the power market. Rising electricity prices in a number of spot markets brought heated debates about perceived and partially real windfall profits by power generators, leading to strong recommendations to stop free allocations in the following phases. In addition, allocation procedures for coal plants were also criticised, as they were designed in such a way that gas inputs were apparently underrated.[47]

The method of allocating emission rights until 2012 is becoming clearer, now that Member States have handed in their emission schemes to the European Commission. It is expected that in the second phase of the EU ETS there will be a tighter allocation than in the first phase. It remains unclear if this will be enough to create a well-functioning market.[48] For the period after 2012, much uncertainty still exists, and this is the period in which the new Dutch power stations will start to operate. The method of allocating emission rights, the degree of scarcity and the way coal will be treated in relation to other primary energy sources is still open. The Dutch government announced that they prefer a system in which all emission rights for power generators would be auctioned at the EU level instead of a national allocation.[49]

In general, the first phase of the ETS was a very large demonstration pilot acquainting the industry, the governments and the European Commission with the organisation, application and verification of an EU-wide emission trading scheme. Moreover, it taught us how to assess and control the impacts on industrial behaviour. It is therefore understandable that the first phase hardly had an impact on technological changes and on investments in new and more effective abatement technologies. This can only happen in conjunction with a long-term perspective on carbon pricing mechanisms and their modalities. These perspectives will become clearer when the Commission has made the final decisions about the Allocation Plans for the 2008-2012 period, but more important will be what will happen with the ETS as such after 2012. The Commission will present further proposals for the post-2012 ETS in early 2008. It should be stressed that the EU's legal basis for the ETS is independent of the

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[45] Open Europe. *Europe's dirty secret: Why the EU Emissions Trading Scheme isn't working.* August 2007.

[46] Another reason why the EU ETS has not yet caused a change in investment patterns of energy companies has to do with the manner of allocating emission rights. In the first place there is the problem that emission rights are granted for free ('grandfathering') to all emitters, instead of being auctioned to the highest bidder. The fact that emission rights are allocated at a national level (with the possibility for member states to favour national companies), rather than on a European level, also leads to a distortion of the system. (Open Europe, 2007)

[47] The Dutch National Allocation Plan (NAP2) for the second phase of the EU ETS calculates emission allowances by using an assumed efficiency of 39%. All the plans for new power stations have efficiencies of 46% and would, under current regulations, receive more emission permits than needed.

[48] For more details on this topic see: Neuhoff, K. et al. "Implications of announced phase II national allocation plans for the EU ETS". *Climate Policy*, Vol. 6. pp. 411-422, 2006.

[49] Ministry of Environment and Spatial Planning. Kvl2007058621.

outcome of the post-Kyoto negotiations, so it can be expected that the EU will continue with a kind of carbon pricing scheme.

Conclusions

Coming back to the three priorities of energy policy, the analysis shows that coal meets the goal of security of supply (as expected), because there are a large number of exporting countries. Prices have become less stable over time but have not risen more than other commodities, and in fact, coal is still cheaper than oil or natural gas. This briefing paper has focussed especially on the performance of coal on the third energy goal, clean energy, and has assessed this performance in the context of the Netherlands.

Dutch, but also European, policy that aims to tackle climate change should see its task as two-fold, both national and international. It should ensure that domestic goals that have been set can be met. However, energy and climate policy can only have a globally meaningful impact when international measures are also taken, as the majority of new coal-fired capacity will be built in developing countries, including China and India.[50]

New coal-fired power plants in the Netherlands challenge the ambitions of the Dutch government to reduce CO_2 emissions by 30% by 2020. However, forbidding coal-fired power stations, apart from being legally very difficult, seems to be too simplistic an approach – one that fails to take into account the current developments of market integration in the Northwest European region. This market integration causes free flows of power across the region, without the possibility to distinguish between energy sources and cleanliness of these sources. Avoiding coal power stations in the Netherlands therefore holds the risk of increasing imports from other sources, including those from old (and hence dirtier) coal plants in, for example, Germany. In addition, the Netherlands with the port of Rotterdam, its availability of cooling water and its geological opportunities for CCS, is well suited for new coal-fired power plants. As long as coal is part of the energy mix in Northwest Europe, a Dutch ban on coal could contribute towards meeting national targets, but would not contribute to the wider EU and international climate goals.

There are a number of options available for avoiding the adverse climate impacts of coal. First of all, the Netherlands should urge for a strong European Trading Scheme to come about after 2012 (i.e., one with a scarcity of emission permits) that is based on auctioning, rather than allocating rights for free. Moreover, auctioning should be done at the European level to avoid incentives for favouring domestic industries. If the emission rights are not auctioned, the allocation of rights for power stations should not distinguish between the type of fuel used, and the efficiencies of state-of-the-art power plants should be used in the calculations, rather than an average of existing coal plants. In case there is no follow-up of the EU ETS after 2012, the Dutch government could consider imposing a tax or cap on carbon. Another option to safeguard the 2020 policy goals could be, in that case, to close down existing (less efficient) coal plants in exchange for new ones. This could be an interesting option in theory, but the practical implications are substantial and could even lead to strains on the government's budget.[51] The government could, by stating very clearly that it will reduce emission ceilings over time by a certain amount, create an environment in which market parties might decide themselves that the old plants are no longer economical and close them down. If under such an environment (where emission ceilings are being reduced) companies still want to use coal, this should

[50] IEA (2007). *World Energy Outlook 2007.* OECD, Paris.

[51] Otherwise there will be no incentive for energy companies to increase efficiencies themselves. Moreover, more efficient CO_2 curbing options, such as increasing energy efficiency, might be available, on which government funds could better be spent.

not be seen as a problem. In fact, it could even be regarded as beneficial, as it would improve security of supply.

CCS is evidently a key technology for a cleaner energy future, but there are still many unknowns and a lot of research will be required to reach the desired cost levels.[52] In addition, the growing uncertainty about the availability of viable storage capacity increases the uncertainty of this technology's success. A lack of economically viable storage capacity could dramatically change the potential of CCS. It therefore seems unlikely that CCS can already contribute to the 2020 goals of the Dutch government. Cost decreases of CCS are unlikely to materialise purely through market forces as long as the value of carbon is low or unpredictable. As the latter is expected to be the case over the coming years, strong additional policy efforts and public-private partnerships are needed to help CCS technology to progress further. These policies should include very clear statements about future emission ceilings, responsibilities to build infrastructure and liability for associated risks.

The current plans for new coal plants present an opportunity to gain knowledge about CCS. This may be beneficial for the Netherlands when CCS technology can be exported. In fact, it seems unlikely that CCS will get off the ground in the Netherlands if no new coal-fired power plants are built, because the required CO_2 price to apply CCS in gas fired power plants will probably not be reached in the near future. At a later stage the technological knowledge might be used to clean up coal generation in emerging economies such as China and India. Supporting CCS in the Netherlands in such a way can contribute to global climate change mitigation. To allow this to happen in practice, an active policy on disseminating the CCS technology is required, e.g. via bilateral treaties or development aid. Otherwise there is a large risk that required innovation will not materialise and that the new power stations will fail to meet all three energy goals.

[52] See, for example: Enkvist, P., Nauclér, T., Rosander, J. "A Cost Curve for Greenhouse Gas Reduction", *McKinsey Quarterly,* 2007, No. 1.; IEA, *Legal Aspects of Storing CO_2. Update and Recommendations.* 2006. Paris, OECD; Jaccard, M. "Fossil fuels and clean, plentiful energy in the 21st century: the example of coal". *EIB Papers.* Vol. 12, No.1 2007.