Combined heat and power in the Netherlands:
issues for the electricity market

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Summary

CHP is important for the efficient working of the electricity markets as it accounts for about 40% of installed capacity. If this capacity were to become uneconomic to the extent that a large fraction ceased to generate electricity, peak demand could no longer be met by domestic supply and current imports, causing risks to security of supply and wholesale prices. We find no evidence that this is likely, even in the absence of new subsidies targeted at existing CHP. That is not to say that new investment in CHP is necessarily profitable, although as planned investment shows, it may well be for dedicated plant. Future investment decisions in electricity generation capacity should be informed by a proper accounting of the environmental costs of alternative technologies. We consider that stability in the emissions and eco-tax regime is therefore important for guiding future investment decisions in generation.

CHP is often operated in a relatively inflexible manner, either because of the priority of heat demands, or the inflexibility of contractual arrangements. We have therefore attempted to see whether there is scope for increasing the flexibility of CHP response to changing electricity market conditions. Here the evidence is less strong, but we have not found evidence that existing arrangements unnecessarily impede market participation for the overwhelming fraction of CHP capacity.

There is a lack of information about the availability and operation of CHP units. As a result it is very difficult to monitor developments in CHP electricity supply, and hence difficult to be sure that problems will be detected and addressed in a timely way. We therefore recommend that operating statistics for all CHP above 5 MW be collected by relevant network operators and provided both to DTc and the Ministry of Economic Affairs to assist in market monitoring and in policy making related to issues of security of supply.

As the economics of CHP depend quite sensitively on the cost of gas and substitute fuel as well as on grid charges and electricity prices, and as larger CHP units may find it economic to replace their CHP systems by heat-only systems under some configurations of prices and charges, with a possible threat to electricity security, we recommend that all planned disconnections of electricity capacity above 50 MW be notified to DTc and TenneT with at least 6 months notice.
We note that in the past policy towards CHP has had unexpectedly perverse economic effects, and that investment in future conventional generation capacity, as well as CHP and renewables will depend on future emissions and environmental policies and taxes. Uncertainty about such policy is likely to cause investors to delay investment beyond the point at which it would be economic, possibly prejudicing security of supply. We therefore trust that the Government will make its intentions and proposed policies clear, coherent, and economically rational to encourage efficient and timely investment in new generation capacity.
Introduction

Even without having done detailed calculations it is clear that CHP generation plays an important role in security of supply in the Netherlands. A little over 40 percent of installed production capacity is CHP. Total centrally installed non-CHP domestic capacity amounts to 9,953 MW. Normally one can only count on 85% of installed capacity being available, so non-CHP capacity available would be only 8,460 MW, while the interconnectors can supply nominally 3,350 MW (in 2001), giving a total of 11,810 MW. With a peak demand of 14,424 MW (maximum measured demand in 2001 by Tennet\(^1\)) the Netherlands would be unable to meet peak demand without CHP capacity. The conclusion is that at least for the next few years, co-generation is important for security of supply.

CHP capacity

A breakdown of the installed CHP capacity of 5 MW and above is shown in the table below. Between 1,000 and 1,200 MW of capacity below 5 MW (for which detailed information is lacking) are excluded from the table. Industry is the largest contributor and over two-thirds of total capacity (and 75% of capacity over 5 MW) is in units larger than 60 MW.

<table>
<thead>
<tr>
<th></th>
<th>MW and percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Industry</strong></td>
<td></td>
</tr>
<tr>
<td>CHP 5 - 60 MW</td>
<td>1,263</td>
</tr>
<tr>
<td>CHP &gt; 60 MW</td>
<td>2,728</td>
</tr>
<tr>
<td><strong>District heating</strong></td>
<td></td>
</tr>
<tr>
<td>CHP 5 - 60 MW</td>
<td>139</td>
</tr>
<tr>
<td>CHP &gt; 60 MW</td>
<td>1,957</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6,087</td>
</tr>
</tbody>
</table>

Source: Cogen (2001).

Note: (a) Novem, ECN and CBS report on different numbers on the installed CHP capacity, ranging between 7,400 and a little over 8,000 MW.

\(^1\) Because Tennet does not have complete information about the load, it is likely that the true maximum by Tennet measured demand in 2001 exceeds the number (14,424 MW).
**CHP dispatch and efficient electricity market operation**

CHP capacity is thus critical to assuring security of supply in the Netherlands. In order to see whether there is a danger that existing CHP may not be made available, we need to know the avoidable cost of generating electricity from existing CHP in the short and medium term, and hence the position of CHP in the overall merit order of electricity generation. This will depend on the structure of subsidies for which CHP may be eligible, the price of heat (which we assume will be set by the cost of alternative heat raising), the structure of grid charges, the price of gas, and the avoidable costs of other non-CHP generation (which will depend on the price of fuel).

Existing CHP capacity affects the wholesale price of electricity in several distinct ways. That part of CHP which supplies base-load inflexible electricity for all (industrial process heat) or part of the year (district heating) potentially lowers the average cost of base-load power, and indirectly lowers the cost of peak-load power by moving higher cost units further up the merit order. Flexible CHP is able to vary electricity output in response to higher electricity prices, and increases the supply elasticity of electricity into tight markets, thereby reducing price spikes. Flexible CHP connected to the FVR system allows Tennet as System Operator to call on such units to balance the system in real time. The larger the number of independent suppliers into the Balancing Market and the larger the available capacity offered, the more competitive the Balancing Market, and the lower will be the costs of delivering wholesale power.

In addition to the technical characteristics of existing CHP which influence the extent to which they can participate in contract, spot and balancing markets, there may be contractual features of these markets and of current CHP arrangements that impede their efficient participation. Charges for gas services (flexibility, balancing, etc) and grid charges may also influence the extent to which the capabilities of CHP are actually exploited.

**Competitiveness**

We would expect generators to run a unit whenever system marginal price is (expected to be) sufficiently high so as to cover its avoidable cost. Revenues will contribute to fixed costs whenever price exceeds avoidable unit cost. If this contribution is sufficiently large, then new investment may be justified, but we do not consider this here. In case of CHP, the marginal cost of power also depends on the value of the co-generated heat, which, in the medium run, is the alternative cost of producing heat in a stand-alone system.

Gas prices for CHP have increased in 2001, which was mainly due to an increase in the oil prices. Figure 1 shows the wholesale prices of gas (to which must be added various transport and ancillary service charges to give the delivered price) and the average annual price of electricity.
ECN has calculated the financial position (costs and revenue) for several standard existing CHP units, using a simulation model. The aim was to calculate the economics of existing plants, excluding district heating CHPs.\(^2\) Hence, some of the fixed cost (depreciation costs) were not taken into account, although interest on the original capital (amounting to about 0.2 Euro ct/kWh) \(\text{is}^{3}\) included. The summary results of the six selected case studies are presented in Table 2. These cases are considered to be the standard cases and were selected in collaboration with the sector. Note that governmental support and subsidy programmes are included in the calculations, which also include avoided “Eco taxes”, described below, on auto-consumption. Eco-tax refunds are excluded, however. The cost price calculations include gas (commodity) costs, maintenance and service costs, interest, cash flows from heat supply, and avoided grid charges for auto-consumption.

Table 2. “Marginal” cost and “value” of six relevant standard cases of CHP units, Euro cents kWh, 2001

<table>
<thead>
<tr>
<th>Technology</th>
<th>Legal form</th>
<th>Utilisation (hours)</th>
<th>Capacity (MWe)</th>
<th>Auto-consumption</th>
<th>“Cost” (a) (Euro ct/kWh)</th>
<th>Electricity value (Euro ct/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas turbine</td>
<td>Joint venture</td>
<td>7,500</td>
<td>7.5</td>
<td>25%</td>
<td>3.85</td>
<td>3.2</td>
</tr>
<tr>
<td>Gas turbine</td>
<td>Private</td>
<td>7,500</td>
<td>8.3</td>
<td>75%</td>
<td>1.8</td>
<td>3.4</td>
</tr>
<tr>
<td>STAG/co-firing(b)</td>
<td>Joint venture</td>
<td>7,500</td>
<td>28.3</td>
<td>25%</td>
<td>3.2</td>
<td>3.2</td>
</tr>
<tr>
<td>STAG(b)</td>
<td>Joint venture</td>
<td>7,500</td>
<td>47</td>
<td>25%</td>
<td>3.56</td>
<td>3.2</td>
</tr>
<tr>
<td>STAG(b)</td>
<td>Joint venture</td>
<td>7,500</td>
<td>250</td>
<td>25%</td>
<td>3.1</td>
<td>3.2</td>
</tr>
<tr>
<td>Gas engine (c)</td>
<td>Energy company</td>
<td>3,500</td>
<td>0.35</td>
<td>0%</td>
<td>3.2</td>
<td>4.3</td>
</tr>
</tbody>
</table>

\(^2\) ECN did not include CHPs supplying district heating since it is complicated to estimate the value for heat which depends of the amount and profile type of consumers connected to the distribution grid.

\(^3\) More cases were calculated by ECN, however the results are not presented here.
The last two columns show the avoidable “cost” (including interest) per generated kWh electricity, and the value of the electricity. Two cases appear unprofitable, the rest show a positive contribution that is due to positive profits during peak hours compensating for losses during off-peak hours. The first case (top line, gas turbine) appears to have a higher variable cost (even excluding interest) than the value of electricity, but this type of CHP accounts for less than 3% of total capacity. The more worrying figure is on the fourth line where the average avoidable costs appears to be below the average value of the electricity. Such units account for a larger share of the market, though still less than 7% of the total. ECN data, however, show that if these units are able to run only 4,500 hours, then they cover their avoidable costs, and so it will still be economic to make them available for the most important periods. We conclude that the overwhelming proportion of the CHP studied by ECN is economic at 2001 gas and electricity prices, and that there is no reason to expect any large-scale reduction in electricity supply from these CHP units.

We do not have information about the future economics of the nearly 2,000 MWe of large district heating units, when their current contracts expire, which will begin to occur in 2003. This will depend on the new contract prices for heat. We understand that at present heat is under-priced, and if that were to continue the financial viability of the district heating companies might be at risk, and with that possibly their supply of electricity. Given that heat is unregulated, one should not necessarily expect such underpricing to continue, however.

If gas prices were to rise, then we would expect electricity prices to rise as gas is the marginal fuel for the higher priced periods of the year when CHP is important. If electricity prices were, hypothetically, to fall relative to gas prices (e.g. to levels such as those prevailing in France and Germany) then some CHP supply might become uneconomic. If there were no increase in interconnector capacity, any consequential fall in domestic electricity supply would be likely to cause even greater congestion on the interconnectors, isolating prices in the Netherlands from those in neighbouring countries, and allowing prices to return to levels at which CHP continues to be viable. If interconnector capacity increased and prices fell to neighbouring levels, then some CHP might become uneconomic without further subsidies, and the Netherlands would become more dependent on imports.

There is an additional issue concerning the competitive effect of CHP on the wholesale market. At present more than half the total CHP is sold to or controlled by major distribution and generation companies. If this CHP were to be bid directly into the wholesale market by independent companies then the wholesale market should become more competitive and prices might fall. Small CHP units face natural entry
costs (mainly in acquiring information, and incurring extra management and ICT costs) but collectively they only account for a small fraction of total production, and would not have much effect on competition whether they sell to distribution companies or directly.

We therefore ask whether there are obstacles that discourage larger CHP units from selling directly into the wholesale market. The most obvious is the nature of the refunds for the REB (“Regulerende Energie Belasting”), which is an Eco-tax on the consumption of energy. This Eco-tax appears to hamper the commercial freedom of CHP owners, as they have to sell through the distribution companies in order to collect the REB refund.

Another possible obstacle to the efficient use of CHP could be the non-cost-reflective nature of CDS gas charges. For CHP owners, in particular in the greenhouse sector, the CDS-tariffs have slightly increased the prices for gas contracts. But even ignoring the level of the tariff itself, quite a few CHP plant owners would be helped if the CDS-system would be made transparent and user-friendly. Cost-reflectivity and further transparency in the gas market would probably assist the efficient use of CHP.

CHP and environmental policy

There is a potential market failure because fuel prices do not include their environmental costs when used for electricity production. The major environmental externality that influences the economics of CHP arises from CO\textsubscript{2} emissions. A carbon tax or CO\textsubscript{2} emission trading could have important implications for the future development of CHP. The amount of CO\textsubscript{2} emissions for CHP will normally be lower than the total emissions from the alternatives of raising the same amount of heat and generating the same amount of electricity in stand-alone units, and a new proposal under consideration would give CHP owners credit for the reduction in CO\textsubscript{2} compared to this alternative.

Past policy towards CHP has had unexpectedly perverse effects. From 1990-1993, co-generation increased strongly in the Netherlands due to government policy motivated by a growing concern for increasing emissions. A specific tariff system for the remuneration of electricity from co-generation resulted in favourable price conditions for co-generation. Also, the government provided additional financial support to co-generation projects. The number of new CHP plants was such that SEP had to limit output from existing, economic base-load plants to accommodate over-capacity from the expensive new CHP plants. This led to under-utilised capacity and higher unit cost. Prices, which would normally fall in a market with over-capacity, instead rose to recover SEP’s higher unit costs. Higher SEP prices in turn encouraged decentralised suppliers to build more CHP.

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\textsuperscript{4} In 2001 a REB refund level for CHP was put in place of Euro 0.57 ct/kWh for each kWh supplied to the grid, with a generation upper limit of 1000 GWh per plant. Eligible plants have a minimum thermal efficiency (“Senter efficiency”) of 60%. This efficiency is defined as follows: electrical efficiency plus 2/3 of the thermal efficiency.
Environmental policy and taxes or subsidies should be carefully designed to address the underlying market failure. Conceptually, energy taxes can be thought of as corrective environmental taxes (such as a carbon tax), possibly with an additional revenue-raising tax. The present system of charging the REB on consumption and giving a rebate for eligible CHP is roughly equivalent to a lower revenue tax on energy (paid by everyone) and an emissions tax (paid by everyone not eligible for the rebate). The new proposal for an explicit carbon credit carries forward this principle but in a more focused way. If in future carbon taxes or carbon trading were to be introduced then some part of the current REB could presumably be replaced by this new instrument, and rebates might no longer be necessary.

Investment in future conventional generation capacity, as well as CHP and renewables, will depend on future emissions and environmental policies and taxes. Uncertainty about such policy is likely to cause investors to delay investment beyond the point at which it would be economic, possibly prejudicing security of supply. We therefore trust that the Government will make its intentions and proposed policies clear, coherent, and economically rational to encourage efficient and timely investment in new generation capacity. This requires that policy will have to be compatible with future EC legislation and Directives.

**CHP information requirements for assuring security of supply**

There is a lack of information about the availability and operation of CHP units. As a result it is very difficult to monitor developments in CHP electricity supply, and hence difficult to be sure that problems will be detected and addressed in a timely way. We therefore recommend that operating statistics for all CHP above 5 MW be collected by relevant network operators and provided both to DTe and the Ministry of Economic Affairs to assist in market monitoring and in policy making related to issues of security of supply.

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**Recommendations**

1. We recommend that operating statistics for all CHP above 5 MW be collected by relevant network operators and provided both to DTe and the Ministry of Economic Affairs to assist in market monitoring and in policy making related to issues of security of supply.

2. We recommend that all planned disconnections of electricity capacity above 50 MW be notified to DTe and the Ministry of Economic Affairs with at least 6 months notice.

3. We repeat our earlier recommendations that all CDS gas tariffs be made cost-reflective to encourage efficient and flexible operation of generation plant, including CHP.
4. We recommend that the present requirement that REB rebates are only offered through distribution companies be reconsidered and future environmental treatment of CHP should be neutral as to ownership and supply.

5. We consider that a stable emissions and eco-tax regime is important for guiding future investment decisions in generation. Uncertainty about environmental policy is likely to cause investors to delay investment beyond the point at which it would be economic, possibly prejudicing security of supply. We recommend that the Government will make its intentions, and proposed policies clear, coherent, and economically rational to encourage efficient and timely investment in new generation capacity. We consider that eco-taxes that act as carbon taxes or CO₂ trading are the most suitable way in which the special emissions advantages of CHP can be addressed.