



Twence: A Top Supplier of Sustainable Energy

District energy is picking up steam

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Why was the programme implemented?

Twence realised the importance of heat alongside electricity. While some two-thirds of the energy consumed in the Netherlands goes to heating, the public debate on how to achieve a more sustainable supply of energy had long focused on electricity. The positive effects of using the residual heat from electricity production and even replacing the production of electricity by supplying heat and steam (especially as a replacement for natural gas) would be greater, both for the environment and for a more efficient use of the energy generated from waste (WtE) and biomass. Since 2005, both municipalities and private companies have become more aware of the urgency of climate issues and the need to find sustainable alternatives to fossil fuels.

How was the programme implemented?

First of all, the source of energy not only had to be sustainable but above all also reliable. Ensuring a reliability of supply of over 99% would require at least two different production sources. To that end, and to enable better economies of scale in the production of energy from waste, Twence invested in a new WtE line and a dedicated biomass power plant. We then discussed and negotiated with our two main potential customers: AkzoNobel for steam (to evaporate brine in their salt-production plant) and Essent for heat (for district heating), in both cases to replace their gas-fired boilers and CHP plants. The main challenge was to forge partnerships with contracts that would enable investments to last 20 years.

What has been achieved?

With two long-term contracts, the supply started in 2011. In two years, some 120 million Nm³ of natural gas had been saved and some 220,000 fewer tonnes of CO₂ emitted. An energy conversion-and-supply station was installed in our WtE plant and adapted to our partners' processes. The innovation lays not only in the replacement of fossil fuels by sustainable energy (at no extra cost and partly even at much lower costs) but also in the "cascading" use of energy. High-pressure steam is first converted to electricity, then steam at 4 bar (135°C) goes from the turbine to AkzoNobel to help produce salt. Finally, the condensate is returned and reused. Water at about 90°C is transported to Essent for its district-heating system in Enschede.

1 Summary

For years, the public debate on how to achieve a more sustainable supply of energy had focused on electricity. Waste processor Twence realised that using residual heat from the production of electricity and even replacing the production of electricity by supplying heat and steam (especially to replace natural gas) would have greater positive effects, both for the environment and for a more efficient use of the energy generated from waste (WtE) and biomass.

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In 2009 and 2010 we invested over €15 million to connect our power plants to Enschede's municipal district-heating system. This involved technical in-plant modifications to enable the sourcing of steam and heat as well as long-distance transport pipelines connecting our plants to the main system in Enschede. This was done in close cooperation with energy company Essent, which operates that system to provide heat to end-users.

In close cooperation, Twence and AkzoNobel invested over €10 million in technical plants and a pipeline for transporting steam to AkzoNobel's salt production plant in Hengelo. In 2011 and 2012, using steam from Twence, AkzoNobel already managed to reduce its natural gas consumption by some 90 million Nm³ and to avoid emitting more than 165,000 tonnes of CO₂. This led the AkzoNobel board of management to recognise the Hengelo site as one of the company's most sustainable plants.

In two years, starting in 2011, both projects saved a total of over 120 million Nm³ of natural gas, and some 220,000 tonnes of CO₂ emissions were avoided. The setup was further expanded in late 2012 with a major increase in the supply of steam to AkzoNobel. Studies are investigating the possibility of extending the system to supply the district-heating networks in Hengelo and other communities in Twente.

2 History

Twence (www.twence.nl/en/) is a waste-processing company located in the urbanised area between the cities of Hengelo (81,000 inhabitants) and Enschede (158,600 inhabitants) in the region of Twente in the eastern part of the Netherlands. The company's predecessor, aviTwente, started operating a waste-to-energy plant there in 1997. From the very start in 2001, Twence (the result of a merger between aviTwente and the waste-management activities of the local authorities in Twente) began looking for opportunities to supply energy to district-heating systems in Enschede and Hengelo. A 2003 study had already concluded that, in combination with the combined heat and power (CHP) plant at AkzoNobel' salt-production plant and the CHP plant of Enschede's existing district-heating system, the supply of heat from Twence's waste-to-energy plant would be sufficient both for elaborating the existing district-heating system in Enschede and for starting a new district-heating system in Hengelo. It took until late 2010 before the supply of heat to Essent's district-heating system in Enschede and supply of steam to AkzoNobel's salt-production plant became operational.

A breakthrough came in 2005 when Twence decided to expand the capacity of its existing waste-to-energy (WtE) plant. By building a new line with a separate steam cycle and turbine to start operating in 2009, Twence could guarantee sufficient reliability in its supply of the energy required.

In the same period, other major changes made the supply of energy for district heating and to the largest vacuum salt plant in the world more favourable. In the energy market, natural gas prices rose and investments were made in new electricity-generation capacity in the Netherlands. Locally, the demand for electricity by AkzoNobel decreased due to the closure of its chlorine-production plant in Hengelo, and the transformation of the "Hart van Zuid" (www.hartvanzuid.nl) industrial complex into a residential and commercial district got under way in that city as well.

It turned out that supplying heat directly to the new district-heating system of Hengelo would be too expensive due to the need for major investments in the infrastructure on one hand and to the foreseen slow increase in the demand for energy for the "Hart van Zuid" area during its transformation on the other. Instead, efforts were focused on connecting Twence's WtE plant to the CHP power plants of both AkzoNobel and Essent (which has operated the district-heating system in Enschede since the early 1980s), by a steam pipeline and a supply of hot water, respectively.

Contracts between Twence and AkzoNobel on one hand and Twence and Essent on the other were designed to be mutually beneficial in terms of both energy savings and flexibility in adapting electricity production to peak and off-peak demand and the corresponding wholesale prices.

In 2009 and 2010, a 5km pipeline with a thermal capacity of 80 MW was built to supply hot water to Enschede, as was a 1.5km pipeline capable of supplying over 200 tonnes of steam per hour to AkzoNobel.

3 Configuration of the systems

District heating in Enschede

The central district-heating system in Enschede (www.enschede.nl) supplies heat to 6,000 households and over 200 companies, including the University of Twente. It was built in the 1980s to help implement the municipality's energy policy. That system's CHP plant consists of two gas turbines (with a total electric power of 59 MWe and a maximum heat supply of 48 MWth) and a gas-fired boiler (30 MWth). Another gas-fired boiler (30 MWth) supports the supply of heat halfway through the system. Operated by Essent (www.essent.nl/content/overessent/index.html), the system requires a total of some 700,000 GJ each year. Smaller district-heating systems that might eventually be connected have an annual heat demand of about 100,000 GJ to serve approximately 2,000 households.

AkzoNobel

The world's largest vacuum salt plants, located in the Dutch cities of Hengelo and Delfzijl, are both operated by AkzoNobel. The plant in Hengelo (www.akzonobel.com/hengelo/) produces some three million tonnes of salt annually by evaporating and purifying the brines produced during the mining and dissolving of salt below the ground. The heat required to evaporate the brine is supplied by low-pressure steam (225 tonnes/hour) from AkzoNobel's CHP plant. Since 2006, when AkzoNobel closed its chlorine-production plant in Hengelo, which had been a major electricity consumer, only a small part of the electricity produced by the CHP plant is used to run the Hengelo site of AkzoNobel (about 15 MWe); most of it (about 80 %) is now supplied to the public grid.

Twence

The waste-management activities at Twence include the operation of a waste-to-energy (WtE) plant with three lines, a biomass power plant, an anaerobic digestion plant and a composting plant. Since the newest line of the Twence WtE plant went into operation in 2009, that plant processes some 650,000 tonnes of residual combustible waste and RDF each year. Both the new and the older lines have a separate power-production unit with a capacity of 25 MWe. The biomass power plant uses waste wood as a fuel to produce a maximum of 23 MWe. The biogas produced in the anaerobic digestion plant, which began operations in 2011, is used in two gas engines with a total capacity of 2.4 MWe.

District heating in Hengelo

The district-heating system in Hengelo (www.warmtenhengelo.nl) began supplying heat to "Hart van Zuid" and the surrounding area in 2009 and there are now plans to expand its current capacity of about 7 MWth (which served about 500 households and the Regional Community College of Twente in 2012) to 17 MWth in 2015. The system's operator is investigating the feasibility of replacing the temporary gas-fired support boilers with a supply of (low-temperature) waste heat from the nearby AkzoNobel salt plant.

In April 2013 both AkzoNobel and the municipality of Hengelo (www.hengelo.nl) signed a letter of intent to reach an agreement regarding the supply of heat both to the district-heating system in Hengelo and to the Twentekanaal industrial site (www.twentekanaal.com) in the vicinity of AkzoNobel and Twence.

Integrated systems

To enable the supply of heat to the district-heating system in Enschede and steam to AkzoNobel, major adjustments to the Twence WtE plant and to the CHP units of both AkzoNobel and Essent were necessary. Adjustments were also necessary to regulate the flow of steam and hot water in the steam pipeline between Twence and AkzoNobel and for the transportation of hot water from Twence to Essent for Enschede's district-heating system.

For smooth operations in the supply of steam from Twence to AkzoNobel, the water-steam cycles of the lines of the WtE plant at Twence had to be connected to the power units of AkzoNobel's power plant via the condensate return piping, especially since AkzoNobel's own steam production fluctuates along with the electricity prices for off-peak and peak hours. The combined lines of the WtE plant at Twence can supply AkzoNobel with about 150 tonnes of steam per hour. The steam (4 bar, 135°C) normally originates from the low pressure part of one of both turbines, but it can also originate from a pressure-reduction valve when a turbine is put out of operation for (unexpected) maintenance as happened in 2012.

Twence's hot-water transport system is directly connected to the primary network of Enschede's district-heating system to enable the delivery of 80 MWth at 15 bar to the system at Essent's CHP plant. During the winter, water is delivered to the district-heating system at 120°C and returned from there to Twence at 90°C (in the summer: 90°C and 70°C, respectively). During the winter, Essent has a preferred-customer status to ensure the supply heat to the households and companies that are connected to the district-heating system.

The delivery of heat is largely enabled by heat exchangers in the water-steam cycle of the lines of the WtE plant. Heat exchangers that transfer heat from the flue gasses in the new line of the WtE plant at Twence as well as the gas engines of the anaerobic digestion plant at Twence are used for a baseload of about 5 MW, which is nearly sufficient to meet the demand for heat in the district-heating system in summertime.

4 Data and Efficiency of the District Energy System

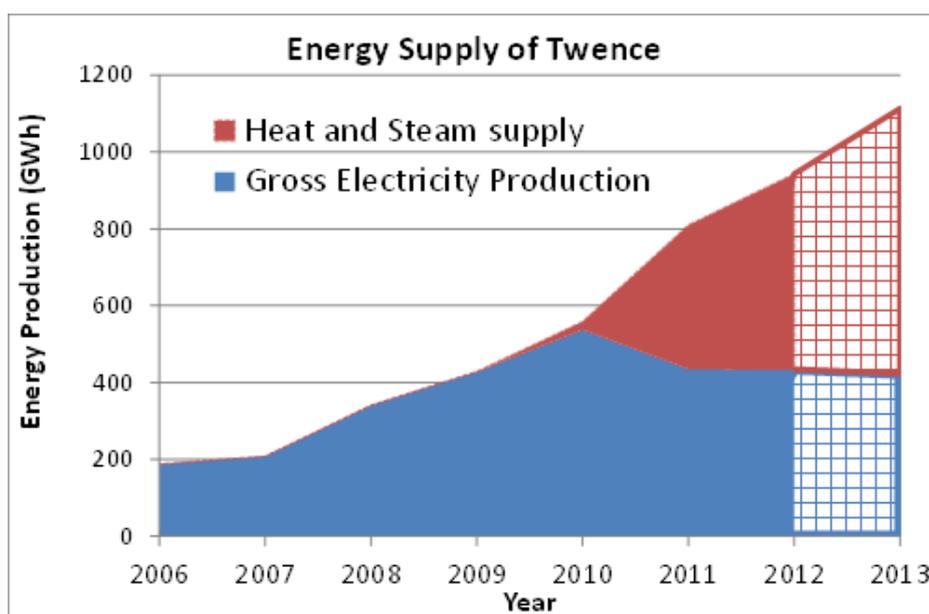
	Steam supply to AkzoNobel	Heat supply to Enschede
Investment	€10,000,000	€15,000,000
Dimensions	1.5 km in length 1.0 m in diameter	2 pipelines of 5 km in length 0.65 m in diameter
Capacity	over 200 tonnes steam/hour	80 MWth
Characteristics	4 bar at 135 °C 30 m/s	15 bar 120 - 90 °C (winter) 90 - 70 °C (summer)

Steam supply to AkzoNobel

Steam supply	2011	2012
Reduction of natural gas use	278 GWh	368 GWh
	40 million Nm ³	53 million Nm ³

Heat supply to Enschede

Heat Supply	2011	2012
Reduction of natural gas use	95 GWh	162 GWh
	12 million Nm ³	20 million m ³



Twence is by far the number one renewable energy supplier of the province of Overijssel (www.overijssel.nl/thema's/economie/nieuwe-energie). The supply of heat and steam to the Essent district-heating system in Enschede and to the AkzoNobel salt plant has meant a major increase in the total amount of energy that Twence supplies.

5 Spectacular reduction of greenhouse gas emissions

The supply of steam and heat by Twence is responsible for a significant reduction in the demand for natural gas at both AkzoNobel's CHP plant in Hengelo and Essent's CHP plant in Enschede.

According to the agreement with AkzoNobel, the reduction in the demand for natural gas for that company's CHP plant in Hengelo was calculated to be 93 million Nm³ in 2011 and 2012 thanks to the supply of steam from Twence. This means some 165,500 tonnes of CO₂ emissions were avoided in 2011 and 2012 as well. According to Dutch authorities (www.emissieautoriteit.nl), AkzoNobel's CHP plant in Hengelo emitted an average of some 410,000 tonnes of CO₂ each year from 2005 to 2010, while the Essent CHP plant in Enschede emitted an average of some 122,000 tonnes of CO₂ annually. For reference: the Dutch companies in the EU Emissions Trading System (ETS) collectively emit between 80 and 85 million tonnes of CO₂ each year.

The calculation of the CO₂ emissions avoided by means of the supply of heat to the district-heating system of Enschede is based on the reduced demand for natural gas as a result of not using the gas-fired boilers at Essent's CHP plant, the operation of which is very much influenced by day-ahead electricity prices. The demand for natural gas decreased by 32 million Nm³ in 2011 and 2012. This meant an avoidance of about 57,000 tonnes of CO₂ emissions in 2011 and 2012.

Both AkzoNobel and Essent were able to reduce their CO₂ emissions by more than 20% in 2011 and 2012, and both will further reduce their CO₂ emissions much more than that amount in the years to come as well.

Besides the avoidance of CO₂ emissions, the avoidance of NO_x emissions is also significant. Essent was able to avoid more than 55 tonnes of NO_x emissions in 2011 and 2012, while AkzoNobel managed to avoid 145 tonnes of NO_x emissions in the same period. These savings amount to about 0.17% of the total NO_x emissions by all companies that are required to participate in the Dutch NO_x trading system.

Another important benefit is the reduction in the amount of cooling water used by AkzoNobel. Especially in the summer, this means less of a temperature increase in the Twente Canal, the main waterway to Twente.

6 Innovation starts with collaboration

While the main innovative aspect of the supply of heat and steam is not a technical one, several innovations in technology have also been achieved. A breakthrough in the realisation of the systems for transporting both steam and hot water was the understanding of the mutual benefits of the agreements for Twence as well as for AkzoNobel and Essent, respectively.

The 20-year contract with Essent is based on the understanding that Essent's CHP unit, which has been operating since the 1980s, has a limited lifetime with a limited number of remaining operating hours. It was therefore agreed that Twence will supply all of the heat required by the district-heating system when Essent stops operating its CHP unit. That saves Essent from having to invest in new supply capacity. The capacity of the hot-water transport system has been designed to allow a supply of 80 MW of heat. It was agreed that Essent will have the flexibility to operate its CHP unit when electricity prices are favourable to the company. In return, Essent will guarantee to use a minimum annual amount of heat supplied by Twence to replace the heat supplied by the gas-fired boilers of the district-heating system in Enschede.

Since Twence and AkzoNobel both operate so-called baseload power plants it was agreed to use the costs and benefits of operating those facilities as a reference point for the supply of steam to AkzoNobel by Twence. It was therefore decided that both would invest equally in the building of the steam pipeline. Moreover, the price for the supply of steam would be set in such a way that AkzoNobel and Twence would both share equally in the costs and benefits operating the steam pipeline system. The main advantage of this for both companies is that they can operate their respective plants partly as peak-load power plants during the 15-year agreement. The operation was so successful in the first year that AkzoNobel's CHP power plant was adapted in 2012 to increase the supply of steam from the initial 415,000 tonnes to at least 650,000 tonnes on an annual basis.

Since Twence has demonstrated the combined supply of heat and steam to be a great success, several other WtE plants in the Netherlands have decided to take Twence as an example and increase their energy efficiency by supplying both heat and steam. Those include the WtE plants of HVC in Dordrecht and AVR in Rotterdam. The combined supply of heat and steam gives Twence the possibility to use the residual heat from both the biogas engines of its anaerobic digestion plant and the flue-gas purification facility at its WtE plant.

The uniqueness of these projects has been acknowledged by (local) authorities, the municipalities of Enschede and Hengelo, the Province of Overijssel, the Regge-en-Dinkel District Water Board and the Dutch Ministry of Economical Affairs. They have supported a smooth permitting process and were willing to provide substantial investment subsidies to ease the investment decisions.

Once it turned out that investing in a hot-water transport system to the district-heating system of Hengelo would be too expensive, the possibility of supplying low-temperature residual heat from AkzoNobel to Hengelo's district-heating system was explored. This can be supported by using part of the heat from the condensate that AkzoNobel returns to Twence. In this way we can achieve a cascade of energy from Twence to the district heating system of Hengelo.

7 Serving the Community: A good neighbour is worth more than a far friend

As a waste-management company, Twence feels strongly about its responsibility to inform all of its stakeholders – including those who live in the vicinity – about the environmental impact of its activities. The company has succeeded in achieving a good balance between its own interests and those of the neighbours, especially those in the rural district of Twekkelo (www.twekkelo.nl), located in between Twence, the AkzoNobel salt plant and Essent's CHP power plant.

Since the hot water transport system runs right through rural Twekkelo, much attention has been given to the alignment of the transport pipes. This has included some horizontal directional drilling in order to avoid cutting down trees as much as possible.

The routing of the steam pipeline has been incorporated in a total vision for the landscape development of the area east of the Twence complex. It marks the transition between the industrial park at the AkzoNobel site and the valuable natural landscape of Twekkelo. Once the steam pipeline had been put in place, a line of trees and bushes was planted on both sides to help the pipeline blend into the landscape.

In a close collaboration between the municipality of Hengelo, the Regge-en-Dinkel District Water Board, AkzoNobel, Twence, the inhabitants of Twekkelo and the environmental group "Natuur en Milieu", the work of incorporating the steam pipeline into the landscape was also combined with water-retention measures. The restoration of streams in one part of that area was already finalised in 2012 and serves as an example of the total reconstruction of the area. For its extensive efforts to encourage collaboration among stakeholders in the project, Twence was awarded the "Groene Twinkeling" (<http://www.landschapoverijssel.nl/groenetwinkeling>) prize in 2013, a joint initiative by the main nature and environmental organisations in the province of Overijssel.



Twence is convinced that its supply of steam to the AkzoNobel salt plant plays a major role in keeping that plant competitive and contributes to a healthy employment situation in the region of Twente.

8 Fit for the future: New opportunities for district energy in Twente

The existing configuration gives Twence, AkzoNobel and Essent the opportunity to optimise the supply of heat and steam and to reduce the demand for natural gas to a minimum. Since the increase in the steam supply went into effect in 2012, Twence has been planning to prepare an outlet for low-pressure steam from the (new) turbine of its biomass power plant.

Once Twence starts supplying all of the heat required by the district-heating system of Enschede it will become feasible to build a hot water buffer capacity to level off fluctuations in the demand for heat. That will make it possible to integrate the smaller district-heating systems with the major district-heating system of Enschede, and to maximise the supply of steam to AkzoNobel from 150 tonnes/hour to more than 200 tonnes/hour.

The cascading of the heat supply to the district-heating system of Hengelo with low-temperature heat from AkzoNobel and the buffering of hot water in supplying heat to the district-heating system of Enschede also offer opportunities for the creation of a single district-heating system in Twente that would have great potential for extensions.

In order to support this expansion, Twence and the local grid operator Cogas (www.cogas.nl) are planning to build a biogas network that will connect to the biogas production facilities of the landfill sites which Twence manages together with new anaerobic digestion plants and possibly some of the wastewater treatment plants facilities of the Regge-en-Dinkel District Water Board (www.wrd.nl). Supplying biogas to support the local supply of heat to the district-heating system in Hengelo by means of gas engines can reduce the need for investments in the primary network of the district-heating system and help optimise its exploitation.

Twence is showing this project as a bright example of what is possible when local authorities, residents and companies are willing to work together.

**Thinking about what lies ahead
brings people together and creates energy for our common future.**