Projektinfo **09**/2014

Detailed information on energy research

Energy from waste water supplies urban district

Concept for development area in Hamburg combines renewable energy technology with urban waste water drainage

BINE Information Service

Using waste water with organic substrates to produce biogas makes it possible to meet a large part of the electricity and heat demand in urban districts. This is being implemented on the site of former army barracks in Hamburg. This is where the new Jenfelder Au urban neighbourhood is being created with around 770 residential units. The drainage and energy concept provides for separate drainage of the domestic sewage already within the buildings and the conversion of the black water into biogas. The aim is to supply CO_2-neutral heating.

Since the ground-breaking ceremony in October 2013, the largest inner-city residential area in Europe to have ever combined sewage and energy on a larger scale is currently being built in Hamburg's Wandsbek district. The new district is located on the site of two army barracks, which were abandoned in 1998. In 2006, an urban design competition was held to develop the area, whereby the Jenfeld Community Conference and interested citizens were able to contribute with their own proposals. Part of the old barracks buildings are listed as historic monuments and, together with the former parade ground, shall remain as an architectural ensemble. The "Jenfeld 23" land-use plan, which came into force in April 2011, provides the legal planning basis for implementing the urban development concept.

The development area covers approximately 35 hectares on which about 770 residential units will be created. 630 will be provided in new-build schemes, thus providing affordable housing for approximately 2,000 residents, in addition there will be supporting commercial facilities. Urban two- to four-storey townhouses and apartment buildings will complement the residential offer in Hamburg-Jenfeld. The urban concept envisages ensembles of different urban townhouse types that are combined and terraced in various ways. This is intended to create a varied townscape.

This research project is funded by the

Federal Ministry for Economic Affairs and Energy (BMWi)

A neighbourhood park with a newly created pond, which also acts as a retention basin for rainwater, will form the heart of the district and provide a high amenity value.
The new buildings must meet the legal standards of the Hamburg Building Code (HBauO) and the Hamburg Climate Protection Ordinance (HambKliSchVO). Beyond this there are no provisions for the building insulation. If the plans are implemented consistently, the future energy efficiency standard of the buildings should roughly correspond to the KfW Efficiency House 70. In 2011, the first building plots were tendered to investors and joint housing ventures. The various plots have been developed since 2013 and the first residents will move into the new urban district from 2015.

Holistic waste water utilisation concept

Jenfelder Au will be the largest residential district in Europe in which decentralised heat and power are generated from local waste water. This is made possible by a holistic sewage disposal and energy provision system in the urban environment. The most important component is the separate capturing, collection and treatment of different types of waste water, known as partial flow treatment. With conventional drainage systems, all domestic waste water flows together and is elaborately treated in a remote sewage treatment plant. In the new district, the partial waste water flows consisting of "black water" (from the toilets, very dirty), "grey water" (from the kitchen and bathroom, slightly dirty) and "rainwater" (precipitation water, hardly polluted) are drained off separately and treated locally.
In order to maximise the energy potential of the black water, comprehensive use is made of vacuum toilets. These ceramic vacuum toilets are not comparable with those used in aeroplanes or trains and are quieter in operation. They hardly differ from conventional flush toilets in terms of their design and use. With their very low flush water requirement ranging from 0.8 to 1.2 litres of water per flush, they ensure a high concentration of the biomass fraction in black water. Via a vacuum line, this concentrated black water flows to HAMBURG WASSER's new purpose-built operational facility on the edge of the district where it is anaerobically treated together with other organic substrates – as is the exhaust air resulting from the vacuum technology. The treatment removes odours so that there are no unpleasant smells in the residential area. This creates biogas, which is converted into electricity and heat using micro gas turbines and is then made available to the households in Jenfelder Au. This enables up to 40 % of the heating requirement and up to 50 % of the electricity requirement to be generated locally in a climate-neutral manner. The remaining heat demand is generated locally using bio natural gas in CHP plants.
The housing investors and individual owners are required to install vacuum toilets and a domestic vacuum drain pipe. It is only then that the energy efficiency benefits of the concept can be fully exploited. As is usual in Hamburg, the responsibility of the homeowners ends at the boundary of their properties. There the two waste water flows are connected to the two separate public sewer networks (receiving water courses) – the black water to the "vacuum sewer" and the grey water to the grey water sewer. Rainwater no longer flows directly into the sewer but is instead fed, retained and buffered in the newly created Kühnbach pond before being discharged into the receiving water course. In the pond the rainwater can also evaporate and thus improve the microclimate.
The technical concept was developed by HAMBURG WASSER under the name HAMBURG WATER Cycle® (HWC). It can also be supported by using geothermal and solar thermal energy. Fed-in and distributed via a local heating network, this enables a CO_2-neutral heat supply to be achieved for the entire neighbourhood.

Fig. 1 *The listed buildings belonging to the former barracks have been refurbished and preserved.*

Fig. 2 *The Jenfeld 23 land-use plan designates the residential, mixed, core and commercial areas (brown, red and grey colours) as well as the HAMBURG WASSER operational facility (blue colour) in the commercial area.*

Balancing and testing

The implementation of the HAMBURG WATER Cycle is being funded by the EU LIFE + programme along with government funds provided by the German

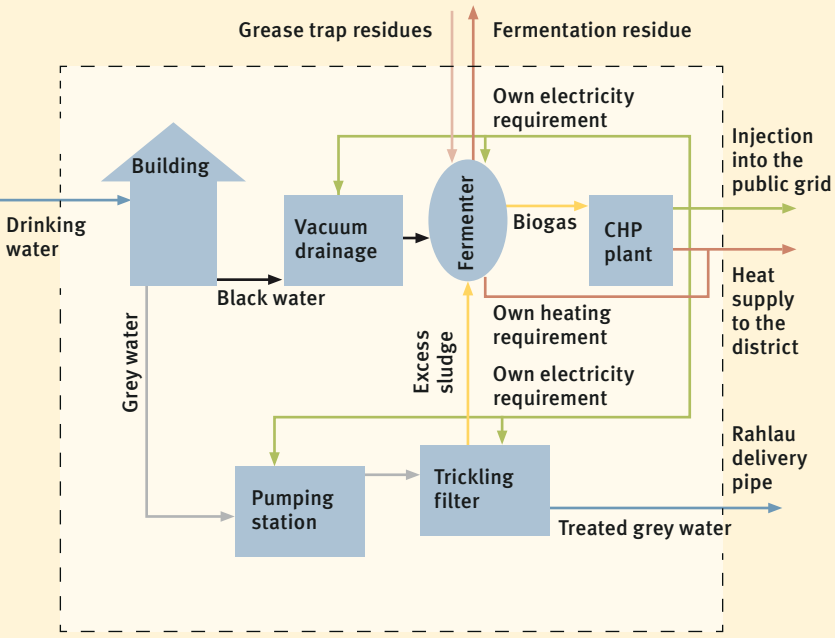

Fig. 3 *The illustration and schematic diagram explain the energy recovery and waste water utilisation concept.*

*Data: [kWh/(E*a)]*	***HAMBURG WATER Cycle***	***Conventional waste water disposal Hamburg***
Drinking water savings	*6*	*---*
Waste water transport	*– 10*	*– 4*
Grey water treatment	*– 5*	*– 29*
Black water treatment	*– 5*	
Electricity production	*22*	*21*
Total electricity balance	***8***	***– 12***

Fig. 4 *The use of vacuum technology for transporting waste water in the HWC system requires more electricity than Hamburg's existing waste water system. However, less electricity is required for treating the waste water. The reduction in drinking water also saves electricity in the HWC system. Overall, the HWC system produces electricity, whereas power is consumed with conventional waste water disposal in Hamburg.*

KREIS – interdisciplinary support research

The testing of the HWC system is being scientifically supported by the KREIS research consortium (Coupling of Renewable Energy Generation with Innovative Urban Waste Water Drainage), which is funded by the German Federal Ministry of Education and Research. It is intended to further develop and research new concepts and methods for supplying energy and disposing of waste water in urban areas. KREIS is aimed at supporting the planning and construction process as well as the commissioning of technical systems with preparatory investigations and the evaluation of their subsequent operation. The findings and experience gained will be utilised not only in Jenfelder Au but also in similar projects outside Hamburg.

Biocoal as a business model?

In this EnEff:Stadt project, methods were also investigated that were concerned with the hydrothermal carbonisation (HTC) of fermentation residues, i.e. with the conversion of organic substances into biocoal. In this thermochemical conversion, chemical reactions create solid products that have a greater energy density (calorific value and carbon content) than the starting biomass. In contrast to periods covering several millions of years in nature, products similar to lignite are already created after reaction times of just a few hours. HTC can be integrated into both innovative waste water and sanitation systems as well as into existing waste water treatment plants. Their products could be used as higher quality fuels and nano-structured materials, and as fertiliser for improving soils. However, the soil-improving effect of HTC coal is disputed. According to research conducted in the "HTC in Lower Saxony" project, phytotoxic compounds are suspected in the coal. A coal type created by the alternate pyrolysis process may be far better suited. It is therefore still unclear whether the residues from the biogas plant in Jenfelder Au can be used for creating high quality products for soil improvement and fertilisation by means of HTC.

Federal Ministry of Education and Research and the German Federal Ministry for Economic Affairs and Energy. With different focal areas they support the planning and construction of various innovative components and the continual optimisation of the future operation. The research work in the EnEff:Stadt project in Jenfelder Au was aimed at optimising the energy use and evaluating the neighbourhood concept in economic terms. For this purpose various versions of the HAMBURG WATER Cycle (HWC) system were balanced for new buildings – ranging from the homes and waste water disposal to the heat supply. It was shown that the implementation of the concept generates energy instead of consuming it, as is the case with conventional waste water disposal. This incurs, however, greater investment costs, mainly because of the double line system for black and grey water and the need to build a dedicated on-site operational facility for the district to house the plant systems. This is essential, however, in order to complete the cycle and produce and use heat on site.

The first ground-breaking ceremony for constructing the sewer system was held in October 2013. Since then all the sewers have been undergoing construction around the Kühnbach pond.

Sewer system as a heat source

In addition to local waste water, the sewer channels belonging to central urban drainage systems also provide a heat source. This is because despite improved thermal insulation, even energy-optimised buildings often have a heat leak – the sewer line. Domestic or industrial waste water flows with high temperatures into the sewer system without being further utilised. And because energy efficient buildings generally do not require more energy for heating than for producing hot water, an enormous waste heat potential lies in the sewers. The German Heat Pump Association (BWP) estimates that with around 6 billion cubic metres of sewage water produced each year, which cools by about 3 K, it is possible to recover at least 20 TWh/p.a. of heat energy. That corresponds to approximately the heating requirement of 5 % of all buildings in Germany.

Neckarpark Stuttgart utilises heat from sewage channel

A new urban district with highly energy-efficient buildings is being created on a 22-hectare derelict site that once belonged to the former Bad Cannstatt railway freight depot. This will provide space for approximately 450 apartments, hotels as well as service-based and commercial enterprises. Future developers will be required to undercut the requirements of the German Energy Saving Ordinance (EnEV 2009) by at least 45 % (KfW Efficiency House 55). Waste heat from a nearby large sewage channel provides an opportunity for supplying heat. This is because traditional district heating with high supply temperatures and corresponding pipe losses often proves to be inefficient and uneconomic for supplying heat to such nearly zero-energy areas. In 2009, the City of Stuttgart adopted the “Neckarpark” urban framework plan. The main energy source for supplying heat and cooling will be waste water, whose energy will be utilised via a low-temperature local heating network by deploying heat exchangers and cascaded heat pumps. The combination of nearly zero-energy buildings and waste water heat is intended to create an optimum overall system for supplying heat to buildings that is both ecologically and economically sustainable. The energy concept is currently being developed and will be implemented from 2015. The energy centre and heating network shall be constructed in 2016, whereby the heat supply system is expected to be fully operational from 2020. The project is being funded as part of the German Federal Ministry of Economic Affairs and Energy’s EnEff:Wärme research initiative.

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Links and literature

- www.hamburgwatercycle.de
- www.eneff-stadt.info
- www.kreis-jenfeld.de
- www.uni-oldenburg.de/htc

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Fig. 2: Freie und Hansestadt Hamburg

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