

SUCCESS STORY:

# Rural biomass-fired district heating

## INVESTMENT CASE

### Title:

Small scale fixed bed gasifier-CHP for a rural biomass-fired district heating network in Bavaria

### Year (commissioned):

2014

### Location:

Windberg in Eastern Bavaria / Germany

### Stakeholders:

1. The Bioenergy working group of the local council of Windberg\*
  2. The Bioenergie-Windberg-Cooperative\*
  3. Municipality of Windberg\*
  4. KS Ingenieurgesellschaft\*
  5. Monastery of Windberg\*
  6. C.A.R.M.E.N e.V.\*
  7. Technology and Support Centre of Renewable Raw Materials (TFZ)\*
- \* role in detail described on page 5

### Author:

Hans Hartmann, TFZ  
[hans.hartmann@tfz.bayern.de](mailto:hans.hartmann@tfz.bayern.de)

The municipality of Windberg with 1 100 inhabitants, located at the edge of the mountain area of the "Bavarian Forest", invested into a new biomass based heat distribution network with gasifier CHP and wood chip boiler. Three larger heat consumers guaranteed almost half of the heat demand. The project is designed as non-profit concept, initially started as a cooperative. This has proven to be crucial for the successful integration of 44 individual heat consumers in 55 buildings and a 2 000 m heating network. A total annual heat demand of 1 800 MWh is today covered and the project is running at full capacity without any possibility to expand. Net heat prices are kept low at 8.2 €ct/kWh, plus a fixed annual payment for the heat transfer station.

### What?

A fixed-bed wood gasifier CHP (120 kW<sub>th</sub>, 45 kW<sub>el</sub>) and a wood chip boiler (360 kW<sub>th</sub>) were erected in a new boiler house in the center of the village. The gasifier-CHP is designed to provide a very high annual base load of 7 500 hours, it is always operating at ambient temperatures below 14° C. A total of 280 000 kWh of electricity is

produced annually. The system has a central heat buffer storage capacity of 20 m<sup>3</sup> and 25 decentralized heat buffers, each having a capacity of 0.8 m<sup>3</sup>, located in the supplied buildings.

A total investment of 1.9 million € was made and substantial public subsidies were granted from a Federal and a Bavarian investment program, either for renewable heat in general or specifically for small-scale wood gasifiers (for more info see DE policy case). Additionally, the German infeed tariffs of bioelectricity (19.7 €ct/kWh in 2014) were at that time still favorable enough to guarantee the return of investment.

The experience and acceptance gained in the project are generally good. However, a small-scale gasifier-CHP is not a technology which allows an easy "press-button"-operation. The investors had underrated the complexity of the task at the beginning. But given a high willingness to communicate and solve operational problems with the gasifier manufacturer and the fuel provider, the project has significantly contributed to a steady process of increased technological readiness. Operating staff was directly recruited from the project area, they are employed on

**Fuel type:**

Forestry residuals, wood chips

**Feedstock origin:**

- Domestic silviculture residuals from thinning, tops, branches etc
- Domestic forestry by-products/ residuals: bark, wet wood chips, etc
- Domestic wood manufacture by-products / residuals: dry chips, shavings, dust
- Domestic sustainable energy crop (agriculture or forest)

**Conversion system:**

- Boiler combustion, e.g. stand-alone boiler plant including co-firing and combined heat and power
- Pyrolysis, e.g. for the use in a boiler or combined heat and power (gas-engine)

**Co-fire:**

- Heat generator (i.e. boiler) is 100 percent biomass-fired.

**Heating system heat sources:**

- Heat generator is part of a system with fossil fuel fired boilers

**Comments:**

- In this project hardly any fossil fuel is used (only 5 percent of all fuel)



Dry high quality wood chips are required for the gasifier-CHP

hourly basis but highly motivated; they have achieved a high number of operating hours. A high consciousness for the importance of maintenance and a high avoidance of onoff-operation has delayed the need for engine-replacement until 2018, when an impressively high number of 24,300 operating hours had been achieved.

## The investment and its technology

In 2012 the municipality of Windberg, decided to invest in a sustainable and economical district heating system. The system was built for those areas of their community where higher heat demand was present due to a compact building structure with three larger heat consumers; a

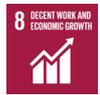
monastery plus education and conference centre, the municipality offices and the church administration. These three together constitute 46 % of all heat demand in the project area. A feasibility study was first performed in 2011, by KS Ingenieurgesellschaft, to assess the options for an initial number of 23 heat customers in a new district heating network. A total specific heat provision cost of 9.2 €/kWh was estimated for this concept, at that time this was without any combined electricity production. Based on this promising concept a cooperative for district heating was founded in September 2012. At that time all foreseen heat customers were also direct members of this cooperative.

They supported the next project step - the detailed technical planning - by an inlay payment of 2 000 € per

## Relation to Sustainable Development Goals:



**Ensure access to affordable, reliable, sustainable and modern energy for all**



**Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all**



**Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation**



**Make cities and human settlements inclusive, safe, resilient and sustainable**



**Ensure sustainable consumption and production patterns**



**Take urgent action to combat climate change and its impacts**

membership, regardless of the individual heat demand. When KS began the detailed planning, further customers announced their interest and the membership in the cooperative soon doubled. But these new members were not all situated along the prospected heating line and therefore a network expansion was required too. Thus, a complete redesign of the heating network and new dimensioning of the heat generation had to follow, all paid for by the member's inlay to the cooperative. At this stage the integration of a gasifier-CHP was also decided, as specific subsidies had then become available.

At the same time the financing via local banks turned difficult. Due to the modification in the network the total capital need had risen and banks decided that the share of equity capital had now fallen below a critical level. To avoid a project abortion, the municipality of Windberg then decided to step into the roles of investor, debtor and operator, while the cooperative seized to exist. However, the inlay payment of all members, which had already largely been spent on planning costs was made into a connection fee.

### Technical concept:

A new boiler house was built while the two existing older heating oil boilers (166 +230 kW<sub>th</sub>) remained in place in the monastery to serve as back-up or peak load boilers. In the planning phase the aggregated peak power demand of all heat customers was 1 050 kW with a simultaneity factor of 0.74 which leads to a peak power demand of 775 kW and a total annual heat demand of 1 800 MWh, plus a calculated network loss of 13 % over the total length of 2 000 m for 55 buildings (44 customers). The project is running at full capacity, there is currently no possibility to expand. The district heating network is designed to operate at supply and return temperatures of 87 and 57 °C.

Both, the wood gasifier CHP by Spanner Re<sup>2</sup> GmbH (120 kW<sub>th</sub>, 45 kW<sub>e</sub>) and the wood chip boiler by Schmid AG (360 kW<sub>th</sub>) are situated in a newly erected building in the center of the village. For noise reduction, the building was made

of concrete, which would have been decided differently if only a wood chip boiler was needed to be accommodated. The gasifier CHP was designed to provide base load over 7 500 hours annually to follow the heat demand. It is always operating when ambient temperatures is below 14 °C. At higher ambient temperature a heat buffer storage capacity is loaded to cover variation in heat demand. The system has a central heat buffer storage capacity of 20 m<sup>3</sup>, and 25 decentralized heat buffers, each having a capacity of 0.8 m<sup>3</sup>; they are located in 25 supplied buildings. All buffers and heat transfer stations are completely owned by the municipality. The gasifier can also operate in a reduced power mode (at about 70 %), or it turns into an on-and-off-operation, but this should be avoided to reduce labor costs and operational failures.

### Economical data and costs:

A total investment of 1.9 million € was made, including the newly built heat distribution, all buffer storages and all heat transfer stations. Substantial public subsidies were granted from a federal investment program for renewable energy (KfW EE Program), and the gasifier itself was subsidized via a specific Bavarian wood gasifier program "BioSol". All together, the direct subsidy was 367 000 €. Together with the connection fees the equity capital was around 475,000 € (25 % of total). Additionally, the 20-year-guarantee for the infeed tariff of bioelectricity (19.7 €/kWh in 2014) is a reliable basis to achieve the return of investment.

In the project area each heat consumer pays a net annual base fee between 280 € for the smallest (15 kW) till 8 400 € for the largest (300 kW) of heat transfer units. The net price for heat provided is 8.2 €/kWh (excl. VAT). Heat prices could be kept constant during the years of operation. At the same time electricity production became more reliable over the years, therefore an aggregated surplus of about 50 000 € is now available for future reinvestments. Around 280 000 kWh of bioelectricity are now annually sold to the grid.

**Replicability potential:**

- Medium local replicability
- Medium regional replicability
- Medium national replicability

**Scale-up potential:**

- Low local potential
- Low regional potential
- Low national potential

**Connection to policy case:**

- Bavarian demonstration programme for small scale wood fuel gasifier CHP's (BioSol)

Prices for the dry high quality wood chips for the gasifier are currently around 27 €/m<sup>3</sup>, while the fuel provider for the boiler is paid according to the net heat produced at the boiler output (price is around 27 € per MWh thermal).

**Operation and management**

Revision of the gasifier is performed regularly, when the ambient temperature is above 21 °C and it requires a period of about 18 days annually. The engine requires regular maintenance (e.g. engine oil change every 450 hours). The engine was replaced in 2018 after a total of 24,300 operating hours.

Fixed bed wood gasifiers require dry fuels at a moisture content between 10 and 12 % and a carefully adjusted particle size distribution fulfilling the P31,5-requirement according to ISO 17225-4; such fuels can usually only be produced from stem wood. Fuel supply to the gasifier happens once a week.

For the 360 kW moving grate boiler the storage capacity only allows for 8 days of operation at full boiler load, but this fuel can be of much lower quality (e.g. moisture content below 45 %). During winter, usually 3 fuel transports of 40 m<sup>3</sup> take place in one week. Bottom and fly ash from the multicyclone of the boiler are collected and disposed by the fuel provider while the high energy containing ash from the gasifier is disposed to the municipal waste.

Currently the staff, a total of 7 persons, is on stand-by for the operation and is paid for the hours they work on a non-permanent basis. They are sometimes highly qualified personnel from within the project area, with high devotion to the project. E.g. a early retiree is the engine expert, a caretaker of the monastery and a retiree ensure the fuel management, an electrician maintains the remote access to the control of the plants and a heating installer cares for the grid and infrastructure.

## Factors behind the decision

When the decision for the investment was made in 2012, heating oil prices had already been high over several years. This had stirred up the emotions and raised concern about the future heat sources in the village of Windberg where 95 % of the space heating was oil based. It was easy to reach a consensus in the community about becoming independent from oil and the vast availability of biomass in the area strongly suggested to move to this energy source, particularly as no access to the natural gas grid was given.

The biomass solution was also the declared priority of the monastery's financial controller who is also a member of the local council. Enthusiasm grew when a feasibility study, on behalf of the monastery, showed promising low heat generation costs. Furthermore, the idea of a joint ownership of a commonly managed heating network created some additional enthusiasm among the involved heat users. Apart from the expectation to save heating costs, it was also a motivation to get rid of the burden to finance and to maintain individual boiler appliances in all houses. Additionally, this opened the possibility to make better use of the space, currently taken by boilers and oil tanks, and to avoiding the annual fees for chimney sweeper inspections and emission measurements.

To achieve a non-profit business, with equal participation for each member, a cooperative was established. This decision proved to be crucial and psychologically important. When it became apparent that the cooperative would not be considered creditworthy by the financing banks, the project was temporarily threatened. At the same time much of the inlay payment of 2,000 € per member had already been spent for the planning. Thus, there was a strong incentive for all members to stick together and to continue although the cooperative seized to exist when the municipality stepped into the investor's role. At this moment it also proved beneficial, that the municipality had been involved from the very beginning of the project and fully supported it.

### Stakeholder – details:

- The Bioenergy working group of the local council of Windberg: Idea and promotion
- The Bioenergie-Windberg-Cooperative: Assignment of planning and application for governmental subsidies
- Municipality of Windberg: Commissioning, operation, ownership
- KS Ingenieurgesellschaft - Initial and subsequent detailed planning
- Monastery of Windberg: They triggered the earliest thoughts about district heating due to a required refurbishment of their heating system, they set a strong early focus on biomass use
- C.A.R.M.E.N e.V. (Bavarian Agency for Biomass and Bioenergy): Technical advice during feasibility study
- Technology and Support Centre of Renewable Raw Materials (TFZ): Promotion and approval of Bavarian subsidy within the BioSol-Program

Apart from these "societal" factors, which have been relevant in the background of the project, it was the favorable business plan that was crucial for the investment decision. With the subsidies that were now available for the gasifier CHP the investment was helped above the critical threshold. Furthermore, the base load operation concept with a high number of annual operation hours of the gasifier-CHP was the key for an economical viability of this part of the investment. As the German infeed tariff for bioelectricity (19.7 €/kWh in 2014) guarantee a return of investment over 20 years, this income now largely reduces heat generation costs.

### A description of the underlying policy framework

The decision was pushed by the availability of one-time non-refundable public subsidies from two programs, the Bavarian demonstration program for small scale wood fuel gasifier CHP's (BioSol) and from the governmental KfW-Bank which provides subsidies via the program "Renewable Energy Premium".

The BioSol-Program (2013 till 2014) was a Bavarian subsidy program for a limited number of wood fuel gasifier CHP's having a maximum power output of 250 kW<sub>el</sub>. A total of 30 % of the eligible investment could be subsidized (max. 200 000 € per installation), provided that a minimum of 5,000 annual full load hours was achieved and more than 60 % of the heat produced was used.

The [KfW-program "Renewable Energy Premium"](#) is still active today. It provides 100 % of the credit at reduced interest rate (in 2014 this was at 2.05 %, today: 1.0 %). It is also providing a one-time non-refundable subsidy for both investments, the boiler and the heating network. For the boiler the basis payment is 20 € per kW of nominal heating power (max. 50 000 €), plus some bonus for low pollutant/low emission, if proven. Extra bonus is paid for newly built heat buffer storages (+10 € per kW, given that the total storage volume is above 30 l/kW). For an investment into a renewable-energy-based district heating network the payment is 60 € per meter (max 1 Million. €).

Finally, at the time of commissioning the German infeed tariff for bioelectricity provided favourable conditions, in 2014 the tariff was 19.7 €/kWh. It guarantees a return of investment over 20 years, this income now largely reduces heat generation costs in the project.

## Lessons learned

During the planning phase, it would have been useful to integrate the local banks more intensively as designated financiers.

## Success factors

The success factors are:

- The non-profit approach
- Early involvement of all stakeholders and officials in the discussion.
- A lively community with enthusiastic inhabitants.
- A well developed wood chip industry with high capability to serve particular fuel quality needs (as required for gasifiers).
- Well trained and motivated labor which is willing to be involved on hourly basis (partly they are project members, too).
- Willingness to communicate operational problems with the gasifier manufacturer and to participate in a steady process to increase technological readiness (as applicable to the CHP installation).
- High transparency and participation of all project members (the initially planned cooperative structure was helpful).
- Annual release of the cost balance calculations, thus both groups in the area; the heat customers and the local tax payers, gain the proof that no profits are fed into the municipality nor is the local budget used to subsidize heat provision prices.
- Available non-refundable subsidies from governmental programs

- High number of base-load operational hours for the CHP which contributes to reduce heat generation cost.
- Guaranteed infeed tariffs for bioelectricity.

## Constraints

Financing problems were larger than estimated. With the re-dimensioning of the heating network the banks evaluated the projects risks differently: the investor, being a cooperative, was now not found sufficiently creditworthy anymore, and thus the municipality stepped into the role of the investor while conditions remained unchanged.

Small scale gasification is not a technology which allows an easy "press-button"-operation and the complexity of a biomass gasifier CHP was underrated.

The disposal of the gasifier-ash has proven to be more difficult than estimated, as the composition of this carbon rich ash wasn't known. The ash needed to be investigated over 1.5 years before it became clear that disposal to the municipal waste was acceptable.



Wood gasifier CHP (right) and wood chip boiler (left)



Boiler house in the centre of the municipality



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**Web sites:**

<https://www.windberg.de/index.php?id=1751,144> (in German only)  
[www.ri.se](http://www.ri.se)  
[www.energimyndigheten.se/en/](http://www.energimyndigheten.se/en/)  
[www.iea.org/tcp/](http://www.iea.org/tcp/)  
[www.ieabioenergy.com](http://www.ieabioenergy.com)

**Contact:**

Hans Hartmann, TFZ  
E-mail:  
[hans.hartmann@tfz.bayern.de](mailto:hans.hartmann@tfz.bayern.de)



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