IEA Bioenergy
Technology Collaboration Programme

Industrial Process Heat: case study 2

Gasification of paper reject to displace natural gas usage in a pulp and paper process

Contribution of Task 33 to the intertask project on industrial heat

September 2020

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Preface

The role that bioenergy plays in the global energy mix has expanded over the last decades, from predominantly domestic space heating and industrial heat until the 1990's to increased use in the electricity sector and more recently also large scale production of transportation fuels. According to the IEA SDS scenario, the use of biomass to produce high temperature heat in industry will not decrease, but quadruple from 8 EJ today to about 24 EJ in 2060.

Traditionally, the application of bioenergy in industry was performed in industries that can use their own biomass process residues to cover (some of) their own heat demand, e.g. sugar, palm oil, wood processing, pulp and paper, etc. With the increasing motivation in industry to reduce CO_2 emissions, several other industry sectors are also shifting towards biomass based heat generation in cases where there are suitable biomass resources and technologies available nearby.

While there is a large potential to displace fossil fuels with biomass fuels in the large and energy intensive industries (steel, cement, etc), there are also many small and medium sized process industries such as food industries, paper industries, etc. In contrast to the larger energy intensive industries where these case typically require that large volumes of biomass are shipped to an individual site, the heat demand in these smaller industries can often be better matched with the biomass resources that may be locally available, resulting in smaller transporation distances.

This case study is part of a series of reports on the use of bioenergy in industry to supply process heat. In the framework of an intertask project, five of the tasks involved in the IEA Bioenergy Technology Collaboration Programme collaborated to produce four case studies and a policy synthesis report on biomass based industrial heat. The cases were selected carefully to illustrate that a wide diversity of bioenergy conversion technologies is readily available for market application, the optimum configuration depending on local availability of biomass resources, characteristics of the heat demand, availability of space, capital, etc. The cases are:

1. Combustion of wood chips and composting residues for process steam generation in a potato processing industry
2. Gasification of paper reject to displace natural gas usage in a pulp and paper process
3. Process steam in a dairy factory via fast pyrolysis bio-oil
4. Waste-to-Energy for production of steam for paper production

Early in 2021, a policy synthesis report will also be published that provides strategic information on market opportunities/potential and effective ways to address technical and non-technical barriers to implement bioenergy based process heat. The report builds upon the lessons learned in the cases, but also provides a more generic analysis of the market potential, and how its implementation can be supported, in order to unlock the enormous potential already mentioned above. All reports are available on the project website http://itp-hightemperatureheat.ieabioenergy.com/

Summary

The case study on replacing natural gas with a paper reject gasifier is a good example of how industrial processes can be converted from fossil based operation to partly bio-based operated processes. The Eska gasifier successfully managed to reduce natural gas usage and associated CO2 emissions. Besides that, for the site the total waste produced was also reduced and they successfully turned waste into value.

For businesses that have a large usage of natural gas to produce high temperature heat, this example will show how their business can change and manage to be successful. Furthermore it shows that overall the emission profile is improved, hence the marketability of their products will improve.

The message for policy makers is that changes business this way often is not easy. Often companies face difficulties in obtaining the right permits, find social acceptance and/or obtain sufficient funding (for capital investments or for reducing operating costs). However, the when successful the result is a decrease usage of natural gas, additional employment and an improved emission profile.

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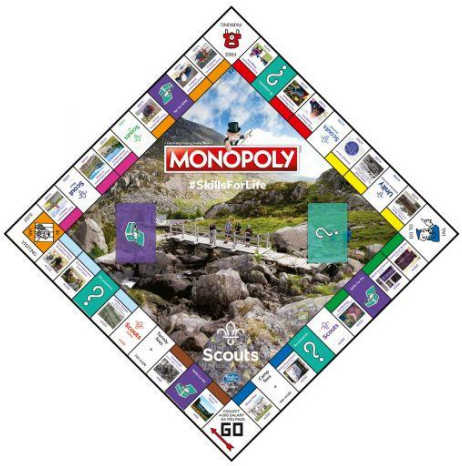
Background information

ESKA was founded in the 1879, with a first mill in Sappermeer, followed by a second mill in 1897 in Hoogezand. These two mills merged in 1993. The initial mills used straw as feedstock for what was called “strawboard”, but already in 1934 they started using recycled paper as a raw material, which was caused by a shortage of straw at the time. In 1970, both mills had fully embraced recycled paper as a raw material. After the second world war, Eska was awarded a contract to produce railway tickets for the Dutch railways. This sparked the name Eska, which stands for Spoorkaartjes Karton (S and K), which stands for railway tickets board. Today, Eska produces 250.000 tonnes of solid board, which is used for books, puzzles, luxury packaging, etc. and can be found almost in all homes over the world.



In the solid board making process a lot of steam is used for drying, which traditionally is done using fossil fuels. At Eska a CHP on natural gas was operated to produce steam in boiler for usage on the site in Hoogezand. The pulping of recycled paper resulted in a stream of paper rejects, that were transported off-site to be further processed. This came with additional costs.

Sustainability has always been important to Eska, with the change from straw to recycled paper as a good example. For the last 25 years, sustainability has been high on the agenda, resulting in a reduced impact of 1 – 1.5% per year. Investing in an alternative for the natural gas operated CHP is part of the ongoing strategy of Eska to be an example company on sustainable processing. The switch from natural gas to a gasification process was driven for two reasons.

- Paper rejects had to be disposed from the site in Hoogezand, and natural gas was used in the CHP, both came at additional costs.
- Eska had for years a strategy to reduce its own emissions. Both the transport of the rejects off-site and the CHP were creating emissions. By developing the circular approach to the paper rejects both could be reduced.

Besides the vision of Eska on sustainable production of hard board, there are additional drivers that helped the realization of this project. In the Netherlands a covenant was created by large industrial players in the Netherlands with the goal to reduce energy consumption. Eska has included this particular project in that covenant. A dedicated financial incentive from the government for CFB gasification was created, however in the end they did not pay out to what was expected.

Fuel sourcing and logistics

The site in Hoogezand is in the middle of the municipality, which for obvious reasons is located there. It is a rather old site, so the town grew around it. Furthermore, the plant is located next to a waterway, which in the old days was used to bring in the raw materials.

The choice to use the paper rejects is simple. The material is produced onsite, has an energy value and the disposal comes with additional costs. Also trucking the material off-site creates additional emissions and affects the town itself. So instead of maintaining this approach, the utilization of the energy in the rejects would make the production process more circular, reduce emissions and reduce costs for disposal and energy.

Ever since 1970 both of the mills in Hoogezand and Sappermeer are utilizing recycled paper for their production process. This reclaimed paper is send to the pulper to obtain the fibers for the hard board. The waste resulting from this process (paper reject) is used as an energy source to replace the natural gas. The plant takes in reclaimed paper, which arrives in bales by trucks, therefor the fuel for the gasifier is produced on site. There is also an influx of rejects from third parties. On site, the rejects are transported automatically via a conveyor belt to the gasifier.

What are paper rejects? In the pulping process for reclaimed paper the goal is to obtain the fibers for the card board making process. In the reclaimed paper there is also plastic and staples. These impurities end up in the rejects, but 100% separation is not possible. Hence, the paper rejects also contain a significant portion of biogenic components.

Technical implementation

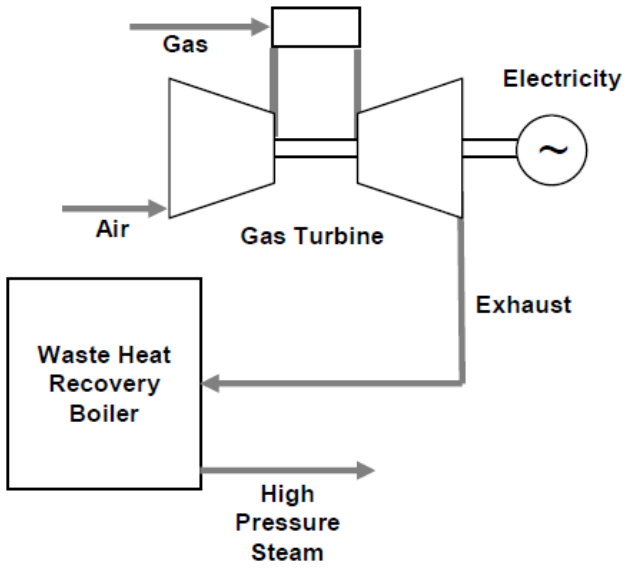


Figure 1. Schematic overview of a gas turbine based CHP (source: www.eon-uk.com

At the site in Hoogezand, Eska used to operate three combined cycle gas turbines with heat recovery boilers. These systems produced electricity and heat for the factory on site. A simple overview of this commonly used system is shown in Figure 1.

Eska has performed a study to find a solution for the production of steam based on the rejects that are generated on site. From this study it was concluded that a system using gasification was a technical and economically beneficial process.

A gasifier is flexible towards feedstock (variations in moisture, plastic content, ash etc.) and is quick to respond to capacity changes. The thermal efficiency of a gasification system is high and the resulting emissions are low. The PM and NO_x emissions from a gasifier will be below 5 and 150 mg/Nm^3 respectively (@6% O_2). This in combination with the promise of a subsidy finally made Eska decide to go for gasification.

The gasifier at Eska in Hoogezand had to comply with existing noise and odour permits. The site in Hoogezand is a very old location where space is limited and the gasifier also had to be integrated with the existing infrastructure, such as the steam circuit. The third big challenge was the feedstock characteristics. Since, it is not purchased from an external party, but produced onsite, additional measures had to be taken in order to control the quality of the feedstock (composition paper and plastic, as well as the moisture content). In Figure 2 some of the measures are clear from the design and the pictures.

- Flue gas cleaning to comply with regulations
- Reject storage and handling indoors, to avoid odor and comply with permits

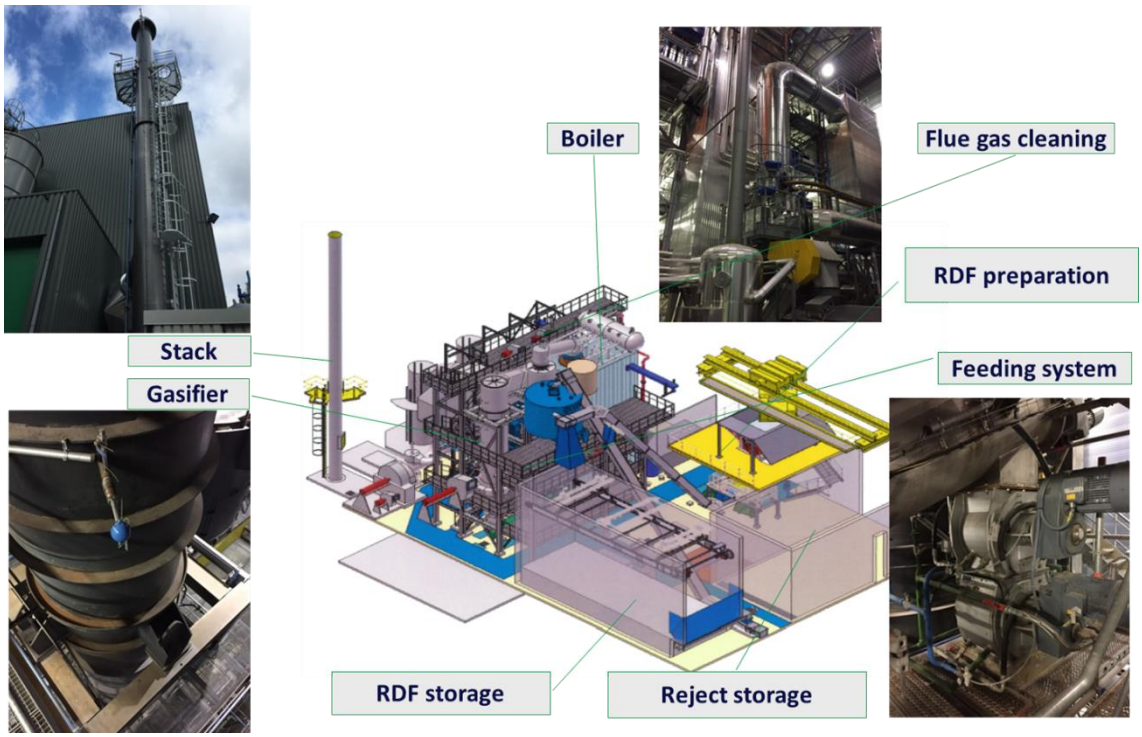


Figure 2. 3D model for the Eska plant, with pictures from various parts

Economical aspects

The economic and environmental savings with this plant are given in Figure 3. They are indexed based on the historic profile of the site in Eska and all the relevant parameters showed a reduction, compared to this fossil based operation.

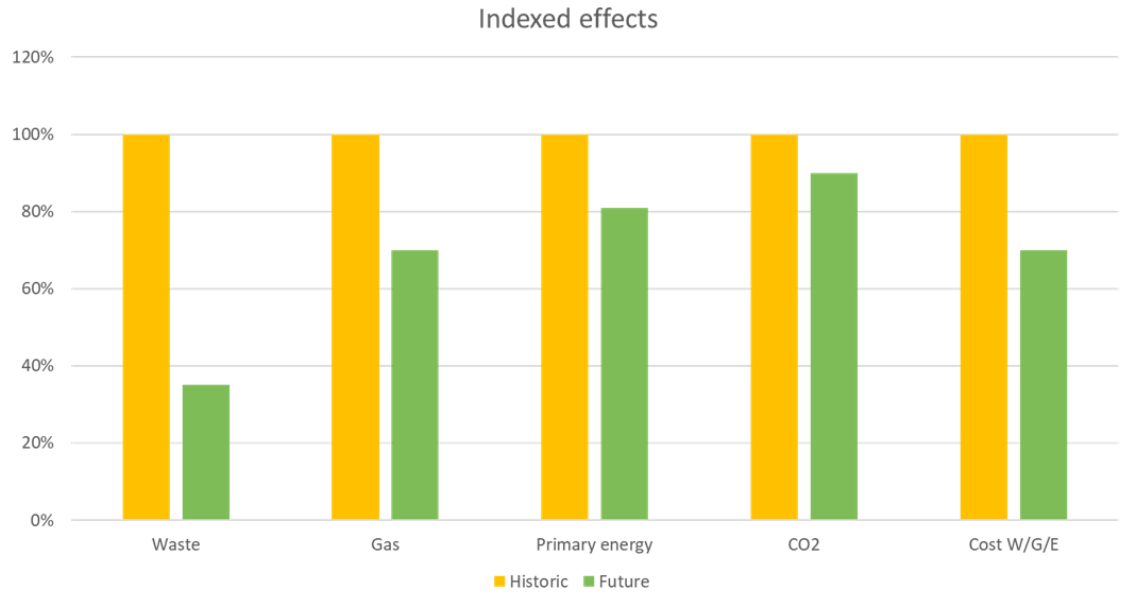


Figure 3. Savings of the gasifier on several key indicators

The first parameter is the amount of waste generated at the site that needs to be transported off-site. By sorting the waste localy and reclaiming fibers for the card board and rejects for the gasifier, this was reduced to about 35% of the original amount.

By utilizing the waste generated at the site the natural gas consumption as well as the primary energy use was reduced to about 70% and 80% respectively.

By consuming less natural gas the CO_2 emissions were also reduced. Installing a gasifier led to a reduction of 10% of the CO_2 emitted at the site.

An important parameter is the amount of money saved on water, gas and electricity by installing this gasifier at the Hoogezand site. It went down to about 70% of its original number.

Realizing this plant was done with financial support from the government. Although all project targets were fully met, the aid was largely rejected and reclaimed by the government, due to a necessary change in contractor for the supply of the CFB gasifier.

Environmental aspects

In the figure below the lay-out at the site in Hoogezand is given. This depicts the location of the plant and immediately it shows the difficulties that are associated with such a site. As can be seen on the Google Earth image, the Eska site in Hoogezand is located amidst residential areas, with shops and schools nearby. In the lay-out, numbers are given that explain something about the necessary measures taken to deal with various environmental aspects.

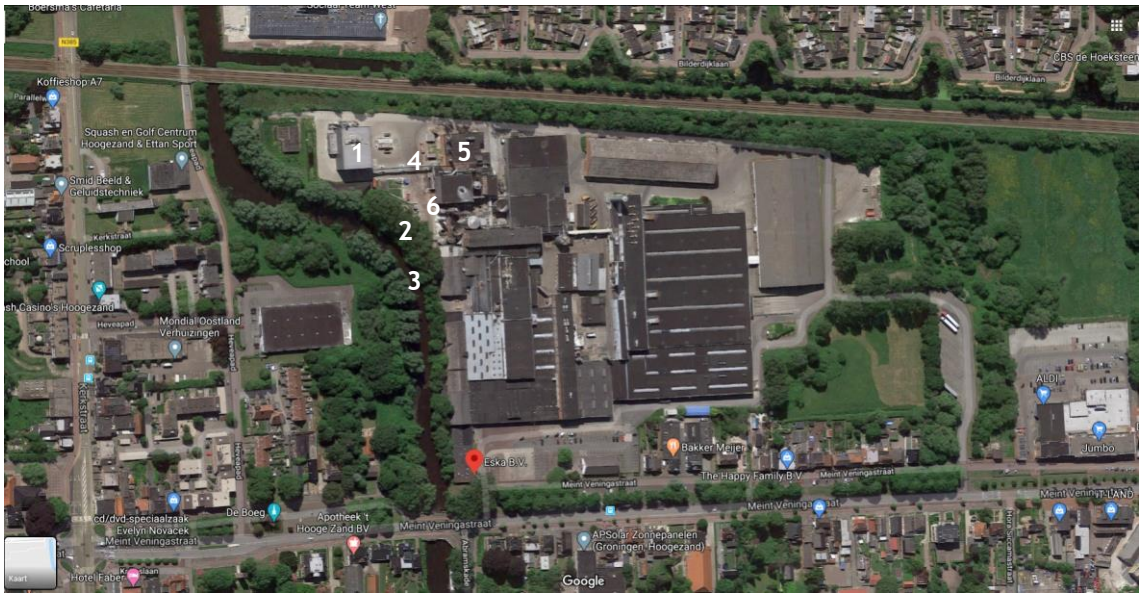


Figure 4. Google Earth image with the situation of the plant in its surroundings

The most important environmental aspects to be considered are smell, safety and air quality.

1. **Smell.** The gasifier produces no odour, it is completely enclosed and the high temperatures at which is operated prevents any smell to come from the installation. The gasifier has no adverse effect on any of the existing processes and therefor there has been no increase in smell.
2. **Safety.** The gasifier contains, during operation, a very limited amount of flammable gas. The amount of gas in an LPG tank of a regular gas contains 25 times more energy than the gasifier at Eska. State of the art safety measures are employed to prevent any dangerous situation to the personnel of the site and the surrounding area.
3. **Air quality.** Installing the gasifier at the site, implies also partial removal of an existing CHP installation and the gasifier is fitted with state of the art flue gas cleaning, which result in a process that emits very little impurities to the air. The Dutch regulation apply to the installation and all emission standards are easily achieved. The graph shows what is achieved compared to the regulations, with bars of 100% being equal to the set limits by the government. Figure 5 shows that for SO_x, dust, C_xH_y, HCl and HF, the emissions even improve to regulations. All the others are on spec.

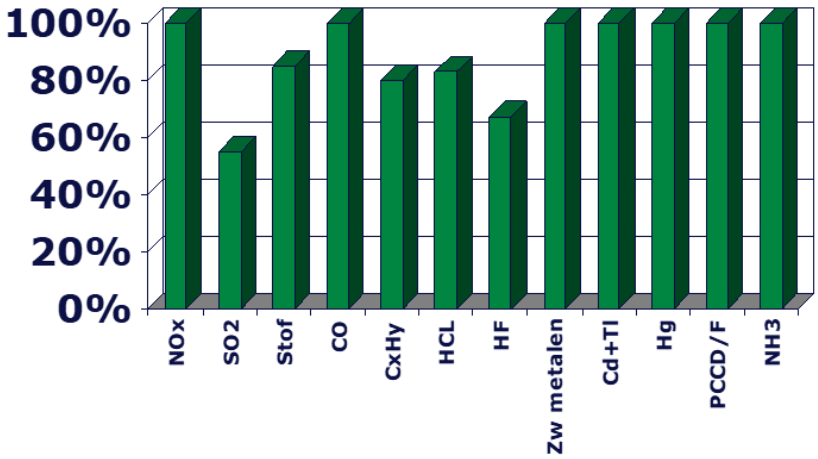


Figure 5. Actual emissions as a share of emission limit values

Compared to the previous conventional way to energy production, the use of the gasifier improved the total annual plant emissions significantly:

- CO_2: 23% less (causes global warming)
- C_xH_y: 41% less (caused global warming and is not safe for men and animals)
- NO_x: 14 less (not safe for men and animals, caused smog formation)
- CO: 35% less (not safe for men and animals)

Other environmental issues considered are:

1. **Optical view.** As mentioned, the site is surrounded by residential area and shops. A natural border of trees and bushes is preventing direct view to the site. At the edge of the site location a new earth wall is placed to minimize direct view to the buildings and the building height is minimized as much as possible.
2. **Waste water.** The gasifier and cleaning system are designed in such a way that no waste water is produced. Therefore, there is also no emission of chemically polluted water to the waterways from this plant. There is a small stream of water used for cooling that is emitted.
3. **Process waste.** Installation of the gasifier resulted in 80% less process related waste products at the ESKA site. Normally these waste streams had to be taken off site to be further processed and now they provide fuel for the gasifier.
4. **Truck movements.** Previously the waste products of the recycled paper processing needed to be loaded onto trucks and transported of site. In the new line up these waste streams are transported via a conveyor belt to the gasifier. No truck/shovel movements are required anymore. This results in a reduction of freight movements (about 800 trucks per year) through the municipalities of Hoogezand-Sappemeer and as such a reduction of about 95.000 litre of diesel that is not combusted.
5. **Energy.** Steam produced with the gasifier is fitted into the existing steam grid to be used in the process. The steam is produced with a high efficiency (~85%), resulting in a high utilization of the energy in the reject.
5. **Replacement.** The gasifier is not built to expand the site but is used to replace part of the existing CHP on site. This CHP is operated using natural gas and the instalment of the gasifier results in about 18 million m^3 less natural gas consumption. This is equivalent to the annual consumption of natural gas for 11.000 average Dutch families. With the gasifier, less energy is actually produced onsite, resulting also in lower emissions.

6. **Noise.** The gasifier is placed inside a building. This prevents the noise from process related actions throughout the day escaping into the environment. During the day there will be some truck movements but are limited to day-time operation. Overall there is a reduction in truck movements, which reduces the noise burden to environment compared to previous situation.

From the processing of paper reject three other residue streams are obtained, which are all put to good use.

- Bottom ash is disposed and recycled to be used for concrete flooring
- Fly-ash is disposed to be used as cover material in landfilling of hazardous waste
- Metals are recycled as metals.

Organisational aspects

A gasifier, unlike a CHP system on natural gas, requires more operators to supervise the process. It also requires special skilled maintenance personnel and process technicians. There are also logistical implications related to the fuel and even more important managing the quality of the fuel going to the gasifier. The legal issues with a gasifier are much more complicated than for natural gas burning.

The staffing of the plant is done by Eska itself. To operate the gasifier, 3 new FTE's were created (technical services and a process engineer) and the existing operator staff of 5 FTE were trained in order to be able to operate the plant.

Project financing

The plant is fully owned by Eska who also made part of the investment in the plant. Also external partners and other financers provided investment.

Social and marketing aspects

In order to have a social acceptance for this plant, specific public relations were started. It must be said that it started negatively. Spatial planning procedures triggered some stakeholders to reject the idea of local waste gasification and incineration to take place in the centre of the town. Eska is located in Hoogezand_. Eska had to repair the relations and even went to court because some neighbours were not convinced that it would work and would not result in deterioration of the local environment.

For Eska the shift from natural gas, to a more sustainable fuel fits quite well in the corporate sustainability strategy. For Eska and its customers it is very helpful to sell our and their products. Sustainability is becoming very important.

For the preparation of the project no local inhabitants were involved. Local NGO's and GO's were contacted in an early stage. However, they did not react positively (!) We believe due to the negative atmosphere that was already created and from which they were already involved by opponents to the project.

Lessons learned / policy recommendations

Social acceptance to circular solutions, as biomass or waste processing plants, is poor. NIMBY rules. It is vital that the facts are known and as often as possible told to citizens and policy makers to “pave the road” for actual implementation. Positive aspects of these projects need to be emphasised, specifically formulated for various stakeholder groups.

Technology and shareholder value is not what most people are interested in. In that respect it is good to ask the question: ”What is the Stakeholders value?” In this project for instance, the reduction in truckloads going through town helped convincing local inhabitants to support the project.

Further Information

IEA Bioenergy Website
www.ieabioenergy.com

Contact us:
www.ieabioenergy.com/contact-us/