



Pre-treatment of feedstock for enhanced biogas production

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IEA Task 37



- Work programme 2013-2015
- Work
 - Knowledge exchange
 - Technical brochures
 - Success stories
 - Studies

- Australia, Austria, Brazil, Denmark, European Commission, Finland, France, Germany, Ireland, Norway, South Korea, Sweden, Switzerland, The Netherlands, United Kingdom

www.iea-biogas.net

Task 37



IEA Bioenergy Task 37

BIOGAS IN SOCIETY
A Success Story from
IEA BIOENERGY TASK 37
"Energy from Biogas"

MORE THAN 10 YEARS PRODUCTION OF FOSSIL FREE AUTOMOTIVE FUEL AND CERTIFIED DIGESTATE FROM FOOD WASTE VERA PARK IN HELSINGBORG, SWEDEN

PUBLISHED: OCTOBER 2014

SUMMARY

The production of fossil free automotive fuel started at the NGF biogas plant in 1996. The substrates used in the co-digestion biogas process are the organic fraction of household waste from municipalities, residues from food production companies and markets. The digestate is distributed to agricultural land via pipeline or by trucks effectively recirculating nutrients such as phosphorus. The purified biogas is used as automotive fuel for buses, waste collector trucks, taxis and private cars.

This plant showcases a successful example of food waste digestion, with almost 15 years before 2000, of biogas production from source separated food waste. Today 60% of the household food waste is source separated, which corresponds to 25 kg food waste per inhabitant each year. The plant also has a very long experience from injecting biowaste into the natural gas grid, which has been in service for over a decade (since 2000). No problems related

to injection of biowaste have been reported by the local grid owner during the entire time period of operation. Today, in 2014, facilities for pre-treatment of household waste, anaerobic digestion, upgrading, gas injection to the natural gas pipeline and biogas refueling are co-located at the site Vea Park in Helsingborg (Figure 1).



Figure 1: Illustration of the NGF biogas plant, 2014.

late produced from the 1000 t established facility in Sweden, a 4.5 Mw established facility in Denmark (1.7 Mw) and the 1.5 Mw established facility in Germany with the Swedish 1.5 Mw than 10% of the 1.5 Mw. The plant also has a very long experience from injecting biowaste into the natural gas grid, which has been in service for over a decade (since 2000). No problems related

to injection of biowaste have been reported by the local grid owner during the entire time period of operation. Today, in 2014, facilities for pre-treatment of household waste, anaerobic digestion, upgrading, gas injection to the natural gas pipeline and biogas refueling are co-located at the site Vea Park in Helsingborg (Figure 1).

REVAQ CERTIFIED WASTEWATER TREATMENT PLANTS IN SWEDEN FOR IMPROVED QUALITY OF RECYCLED DIGESTATE NUTRIENTS

PUBLISHED: APRIL 2015

REVAQ

Renare vatten – bättre kretslopp



Figure 1: At the top, the logo of REVAQ with the slogan "Renare vatten – bättre kretslopp". Below, a typical Swedish wastewater treatment plant, purified through REVAQ.

IEA Bioenergy Task 37

BIOGAS IN SOCIETY
A Case Story from
IEA BIOENERGY TASK 37
"Energy from Biogas"

BIO-ENERGY IN FAMILY FARMING NEW SUSTAINABLE PERSPECTIVE FOR THE RURAL SECTOR IN BRAZIL

PUBLISHED: SEPTEMBER 2013

According to the 2012 National Biogas Report do Agricultura Familiar, starting in 2004, at that time an investment of R\$ 100 million was consolidated as a family farming credit. In 2014, PROINF offered a credit line of R\$ 1.2 billion and today, after exponential growth, it offers credit of R\$ 3.6 billion which may allow family farms to increase the total sharecropping portion of assets. After all, according to the IFA, the family farming segment has been increasing its productivity by 2.8% a year. One of the main reasons for this is that both family farming and industrial farming viewed their operations towards specialization, single cropping and livestock production, all highly dependent on chemical inputs, including for example fertilizers. The prices of the chemical products increase in a roller coaster way with substantial unpredictability. There are no capital funds for promoting the sector's modernization as the investments in environmental services. Brazil is sufficient in its main sources of producing bioethanol, in the production of the main products the sector generates by products with an impact value. There are huge amounts of solid residues and other wastes not being used. This and all becoming significant environmental liabilities at a very large scale. It would be better to transform these environmental liabilities into opportunities for the production of energy and bio-fertilizers.



IEA Bioenergy Task 37 Country Reports Summary

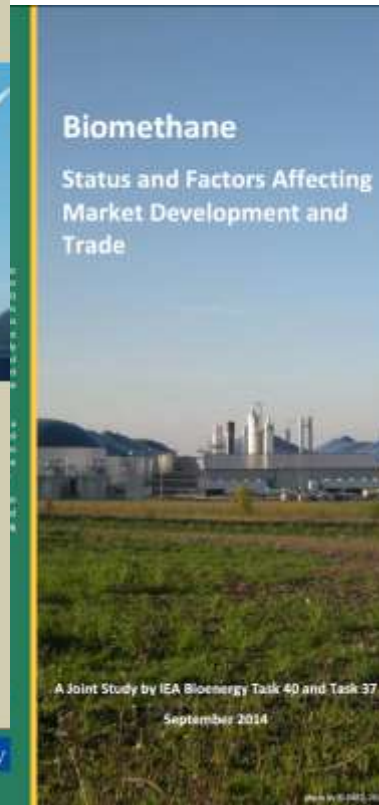
This summary contains a compilation of summaries of reports from members of the Bioenergy Task 37. The individual country reports include the number of biogas plants in operation, active sites, how the biogas is utilized, the biogas upgrading plants, the number of vehicles fueled as well as the number of businesses using biogas. The summary also includes the number of biogas research and development projects. The publication is an annual update on information collected in 2014.

<http://www.iea-bioenergy.org/>



IEA Bioenergy

Recently published brochures



Aim of pretreatment technologies

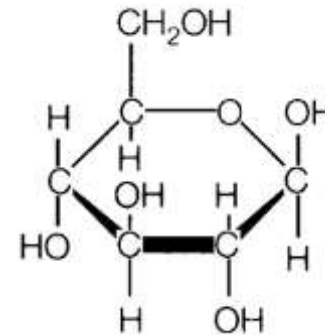


- Reduction of specific production costs
 - Substrate costs (%)
 - Investment costs (%)
 - Operation costs (%)

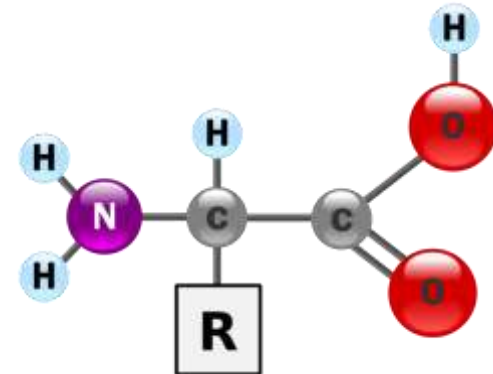
- Realisation by
 - Increasing the biogas yield
 - Increasing degradation rate
 - Increasing the plant efficiency
 - Reduction of operation costs

Substrates

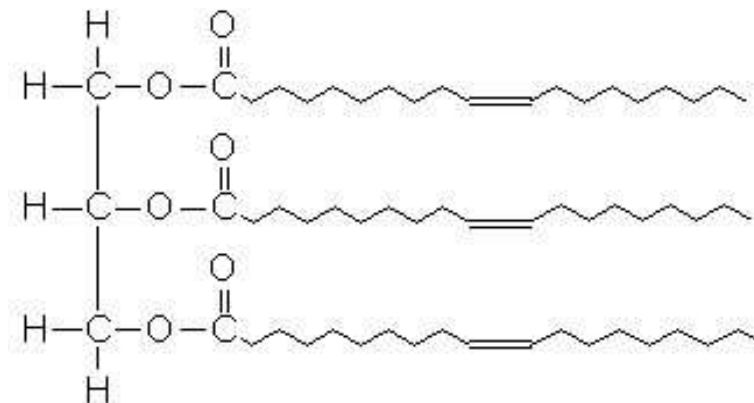
- Kohlenhydrate



- Proteine

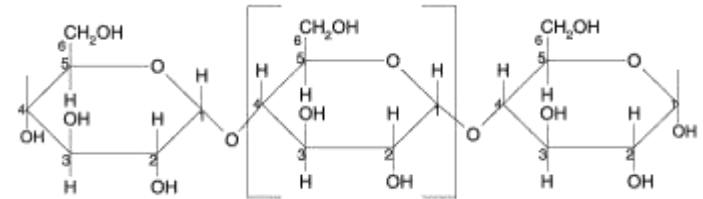


- Fette



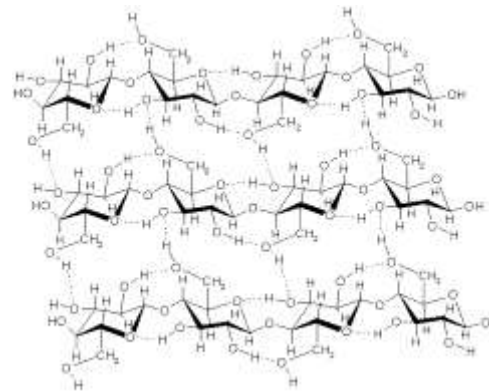
Carbon hydrates

- Starch

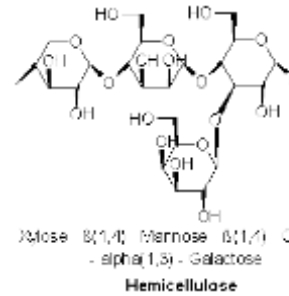


Ausschnitt aus der Formel eines Stärkemoleküls nach HAWORTH

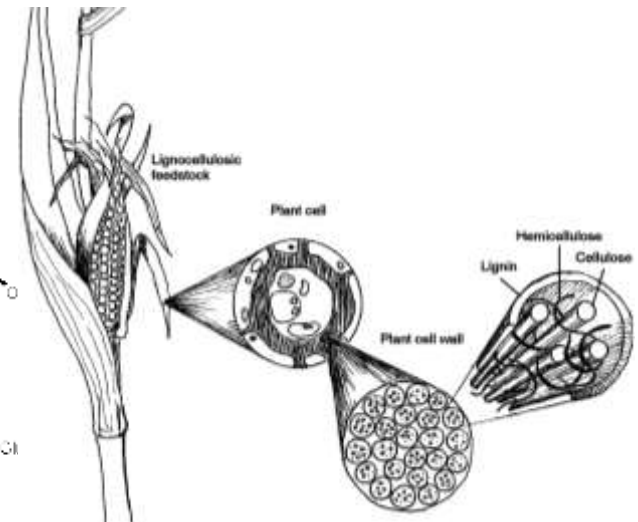
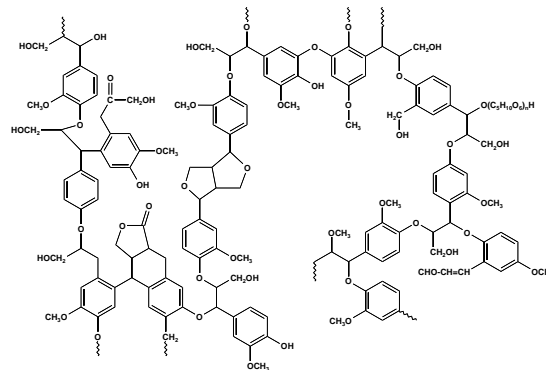
- Cellulose



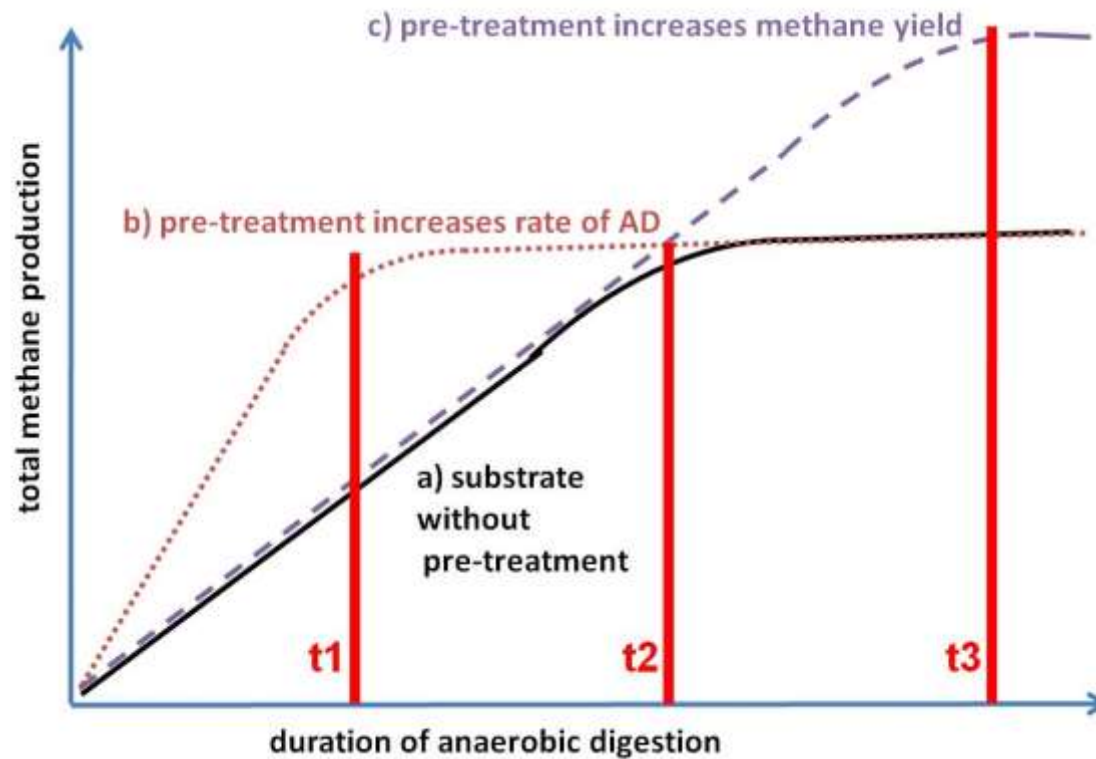
- Hemicellulose



- Lignin



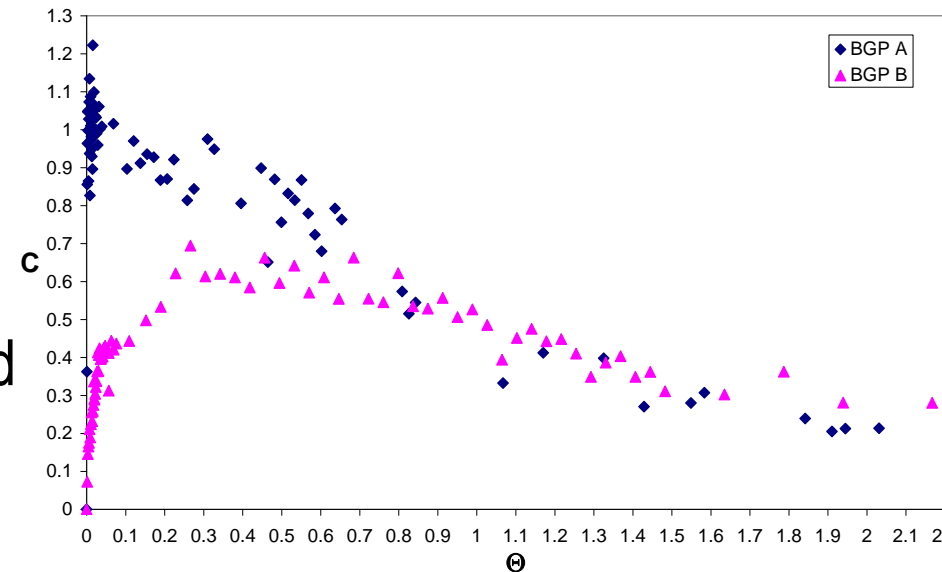
Impact pre-treatment



Impact pretreatment on AD



- Higher gas production can occur
- HRT
- Specific retention time in digester
- Digester system need to be included
- Viscosity
- Substrate characteristics



Pre-treatment technologies



| | | | | |
|-------------------------------|------------------------|--------------------|------------------------|--|
| Physical | Mechanical | Thermal | Ultra sound | Electrocinetical Desintegration |
| Chemical | Alcaline | Acidic | | |
| Biological | Microbiological | Enzymatical | | |
| Combined processes | Steam Explosion | Extrusion | Thermo-chemical | |

Mechanical



Principle

Mechanical crushing
e.g. cutterbars

Mode of action

Increasing of specific surface



Quelle: IKTS Frauenhofer

■ Advantage

- Relatively low investment costs
- Relatively low energy demand

■ Disadvantage

- Interfering materials reduce life time of unit significantly

Thermal



Principle

Thermal pretreatment leads to disintegration of hard degradable substances

Mode of action

Solving of hemicellulose and swelling of biomass



Quelle: Dr. Franke ATZ/D

■ Advantage

- Higher gas yield
- Exclusively heat demand

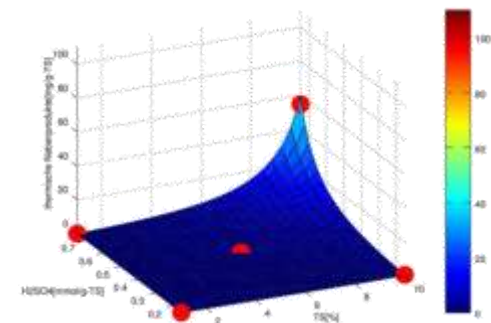
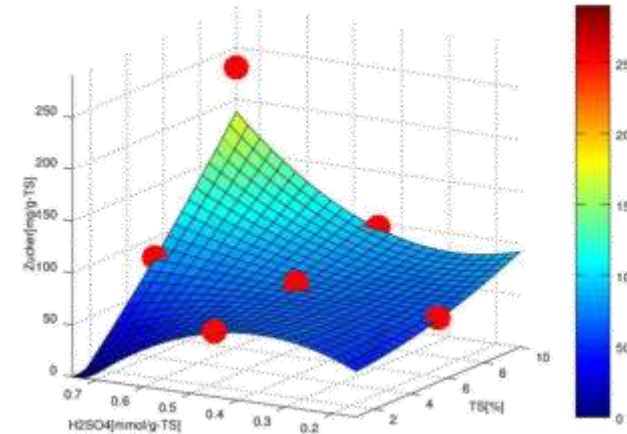
■ Disadvantage

- High investment costs
- Production of inhibiting substances

Thermal processes



- Non-enzymatic browning reaction
- Maillard reaction
 - 3 step process
 - End products melanoidines
- N-catalysed process
- pH-value essential for pathway
- Bacteriostatic effect of intermediate products



Steam explosion



Principle

Heating and abrupt decompression

Mode of action

Rupture cell structures

■ Advantage

- Higher gas yield
- Only thermal energy



Quelle: Boku

■ Disadvantage

- Higher investment costs
- Formation of inhibiting substances

Thermo-mechanical



Principle

Extruders crush biomass

Mode of action

Increasing of specific surface

- Advantage
 - Degradation rate
 - Relatively low investment costs
 - Low energy demand



Quelle: IFA Tulln



- Disadvantage
 - Interfering materials reduce life time of unit significantly

Principle

Addition of lye or acid in an additional pre-treatment step

Mode of action

Solving of lignocellulose complex

- Advantage
- Higher gas yield
- Faster degradation



Quelle: enbasys

- Disadvantage
- Operation costs
- Production of inhibiting products

Thermo-chemical



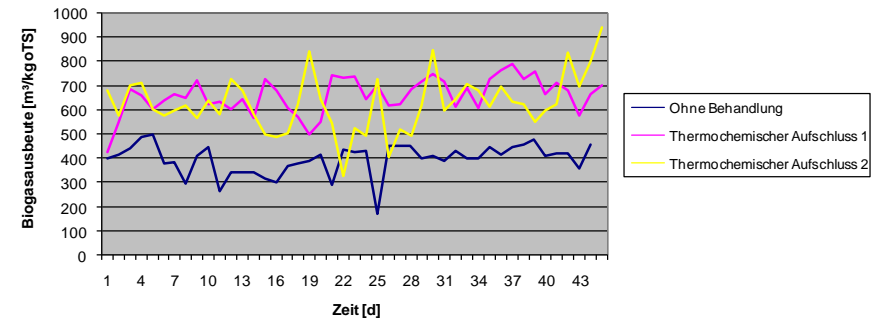
Principle

Support of chemicals through heat

Mode of action

Solving of lignocellulose complex

- Advantage
- Higher gas yield
- Faster degradation



- Disadvantage
- Operation costs
- Production of inhibiting products

Microbiological



Principle

Additional digester

Mode of action

Reduced pH enables enzymes to work in their optimum

■ Advantage

- Faster degradation
- Higher methane concentration



Quelle: AAT

■ Disadvantage

- No higher gas yields to be expected

Preacidification



- Or dark fermentation
 - Formation of VFA and alcohols
 - H_2 and CO_2
- pH value important
 - Increased enzymatic activity
- Recirculation
 - Microbiology
 - Increasing buffer capacity
- H_2S formation

Ultra sound



Principle

Ultra sound into digester

Mode of action

US frequencies lead to cavity or the formation of gas bubbles and their implosion

- Advantage
 - Low energy demand
 - Low investment costs



Quelle: ULTRAWAVES /D

- Disadvantage
 - No direct degradation of biomass

Electrocinetical disintegration



Principle

Addition of high voltage impulses

Mode of action

Electrical field destroys ionic bounding of cell walls by changing the charge

- Advantage
- Low energy demand
- Low investment costs



Quelle: ATRES Group/D

- Disadvantage
- No direct degradation of biomass

Overview influences of the pretreatment technologies



| Pretreatment method | Cellulose decrystallisation | Hemicellulose degradation | Lignin degradation | Increasing specific surface |
|--------------------------|-----------------------------|---------------------------|--------------------|-----------------------------|
| Biological | | | | + |
| Milling | + | | | + |
| Steam explosion | | + | + | + |
| Concentrated acid | | + | + | + |
| Diluted acid | | + | | + |
| Alkali | | - | + | + |
| Extrusion | | | | + |

Summary/conclusion



- Many tests have no reliable data
 - 2 points for BMP tests
 - Sufficient duration
- Pre-treatment technologies specific to substrate
- Pre-treatment technologies specific to plant
- Awareness of investment and operation costs
- Energy balance
- Awareness of higher gas yield
- Additional effects of pre-treatment technologies

Thank you



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