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Carbon Circular Economy
CCE Consortium

If existing technologies could effectively and optimally solve existing problems, then there would be no existing problems at all!

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SUSTAINABLE SOURCES OF CARBON MATERIALS

Different ombustible materials at gasification site

Model testing of inlet system and grid dimensions

MSW 19 12 12 + heavy fraction = gasification material

Types of biomass suitable for gasification

CIRCULAR ECONOMY: PRODUCING VIRGIN MATERIALS

- <u>All organic compounds used by man should be recycled in the same way as metals</u>;
- All current reusing and recycling processes of organic materials causing releases of GHG:
  - recycling without decomposition of hydrocarbons is only possible in a few cycles;
  - at the end, used carbonaceous materials are incinerated or disposed;
  - biological materials are left to rot or decay;

Present: the carbon cycle economy exist only in the oceans!

The pot is made of polystyrene, the color contains Chlorine!

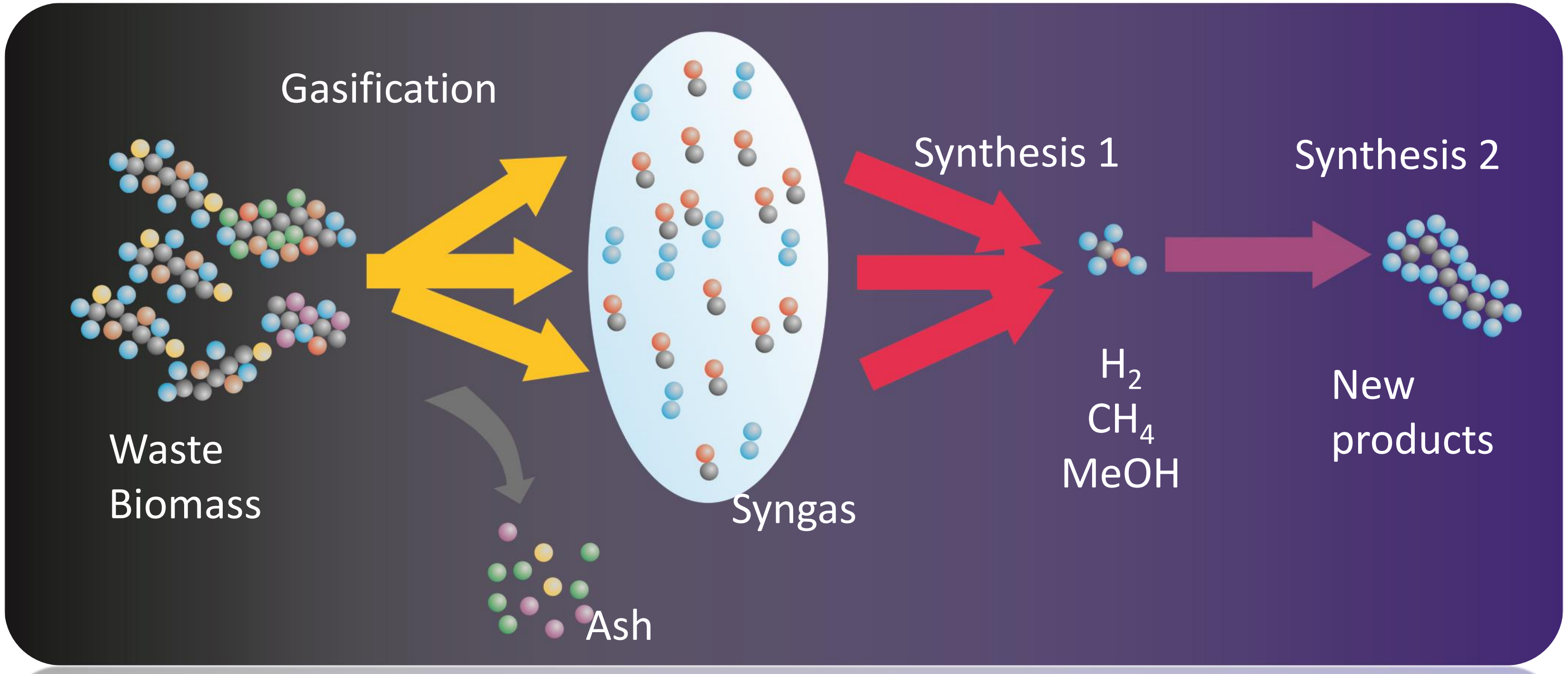
Most products are composed from different materials what is extremely difficult to recycle. In particular, problem presents certain unwanted elements like Chlorine and Sulphur that damage the process equipment and are hazardous to health.

CIRCULAR ECONOMY THROUGH THERMAL DEGRADATION

Incineration and using carbonaceous materials for energy only / rotting process of bio fractions (one way process)

Pyrolysis of organic materials (most of C remains in crude form as soot what is unusable for synthesis processes)

Thermal conversion of organic materials (as the most optimal process for circular economy):



GASIFICATION, WELL KNOWN PROCESS

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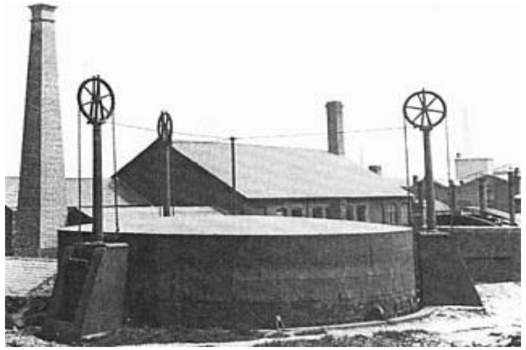
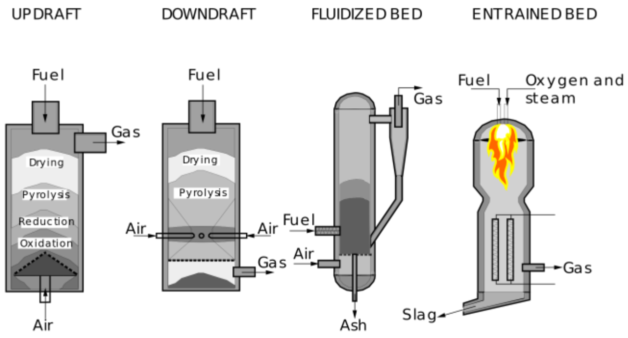
Gasification is old technology and there are a lot of gasification systems:

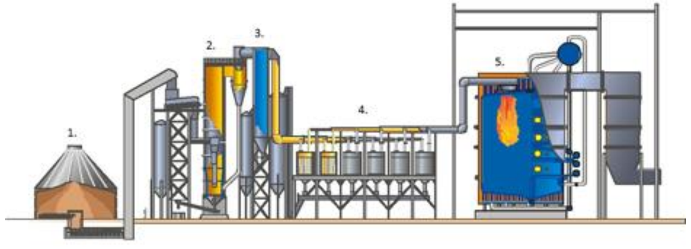


19th century fix bed gasifier



Wikipedia: numerous types of gasifiers

Canada: Nexterra's fix bed updraft gasifier



Finland: Lahti waste and biomass gasification project, fluid bed gasifier

https://www.milenatechnology.com/

http://task33.ieabioenergy.com/

https://www.vttresearch.com/en/news-and-ideas/complete-production-chain-biomass-residues-fischer-tropsch-products-successfully

But gasification technology has its mayor problem:

Comment about gasification technology problem:
"Tars are still considered to be the major bottleneck or even stumbling blocks in the application of biomass Gasification".
(R.W.R. Zwart, Gas cleaning downstream biomass gasification, ECN Netherlands, JUNE 2009)

- Gasification has been used in many ways throughout history (from steel production, to power plants, to even cars running on gasified wood).
- However, gasification technology to date has always produced impure gas which contained tar.
- Current complex gasifiers on the market must either use homogeneous material which introduces limits of application or use heterogeneous materials but are therefore extremely costly to operate due to the need for excessive energy in the process.
- Solutions to date have created high content of tar and other particles in the gas – requiring complex cleaning process.

Two fundamental problems that prevent the expansion of gasification technology were addressed with innovative gasification technology:

1. Gasification process problem: tar formation in the process;

2. Problem of input materials: content of Cl and S elements in mixed wastes;

INNOVATIVE TECHNOLOGY CHARACTERISTICS

The new gasification system is the first and only one that meets the legal requirements regarding the purity of the gas produced from waste in accordance with directive 2010/75/EU, article 42, chapter 1, second paragraph (R3 – end-of-waste process). That means there is no need for downstream filters for syngas cleaning:

Novel gasification characteristics:

- Simpler gasification material preparation:
  - No need for any separation into fractions – usage of heterogenous materials;
  - No drying, dust removal or removal of materials containing S and Cl;
  - The material must be ground on sizes between 50 – 100 mm;
- No S and Cl compounds, ash or dust in downstream gas;
- The process does not generate new hazardous waste - they are all products except condensate water, which is used in the process;
- Tar treatment and energy production integrated into gasifier;
- No downstream filters;
- No air emissions;
- Higher efficiency - Production of new virgin materials (such as syn-methanol) in economically acceptable way;

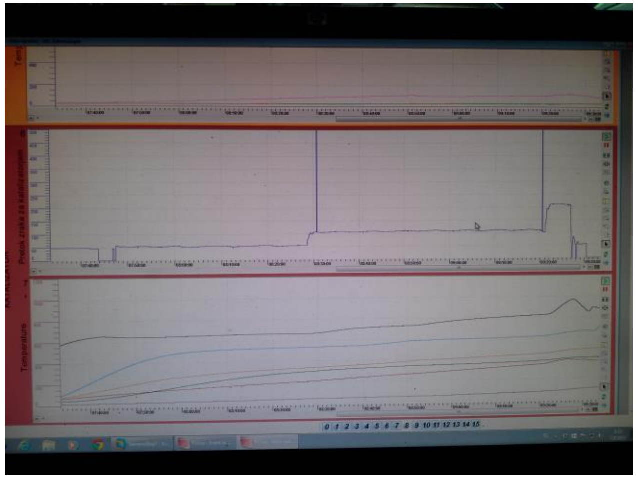
0,7 MW PILOT GASIFICATION SYSTEM

During 10 years of development several gasifying technologies was tested and several model types of basic equipment developed. Gasification process itself is well controlled due to water/steam injection under the grid, which lowers process temperature below 1.000 ^{0}C. The tar concentration reaches up to 15% what supported catalyst tar cracking concept. Construction of the catalyst was well adopted to heterogenous product gas conditions.

Preparing the testing line (input capacity of 600 kWth) by colleague. The line was tested on Vransko, between 2015 – 2017.

Testing in action: one of the prototype of catalyst – syngas broke through metal housing (left) and end result, clean syngas (down).

Burning of clean syngas which does not contain unwanted compounds like Furans, Dioxins, NOx, Tars or dust particles.



Measuring graph from computer.

3 MW TAR REFORMING PILOT CATALYST

The hearth of technology innovation is tar reforming catalyst which was developed into standalone product with input thermal power of 3 MW. This device was installed on the line with 3 MW Ankur gasifier in Ruše 2016.

CCE CONSORTIUM

The consortium partners have been working on the development of a new gasification technology for 7 years. Based on the current development, pilot projects of individual applications will be implemented in order to move to higher stages of product development. In addition to the basic tar gasification and conversion technology, additional development tasks will be opened for the integration of industrial fuel cells into the gasification system and the development of low-temperature metal catalysts for primary synthesis. Consortium partners are:

- Inštitut Jožef Stefan, Ljubljana (https://ijs.si/ijsw/V001/JSI)
- Faculty of Mechanical Ingeneering UL, Ljubljana (https://www.fs.uni-lj.si/en/)
- Chemical institute Ljubljana (https://www.ki.si/en/)
- KSSENA, Velenje (http://kssena.si/en/)
- SRIP Circular Economy, ŠGZ, Maribor (https://srip-circular-economy.eu/)
- Elektroinsitut Milan Vidmar, Ljubljana (https://www.eimv.si/en/)
- Alpe Adria Green, Jesenice (https://alpeadriagreen.wordpress.com/)
- TRATES GmbH, Muenchen
- Grozd Plasttehna, Celje (http://www.giz-grozd-plasttehnika.si/index.php/en/)
- Geopolis, Ljubljana (https://www.geopolis.si/)

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