LoCaGas

Interreg South Baltic

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Dual fuel engine

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BEIC

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GDAŃSK UNIVERSITY OF TECHNOLOGY · BEIC · LITHUANIAN ENERGY INSTITUTE · Universität Rostock Traditio et Innovatio · NSR · ECO CONSTRUCTION · Klaipeda University · Addeco

Outline of presentation

1. Engine technology
   a. Otto cycle – premixed combustion
   b. Diesel cycle – compression ignition combustion
   c. Dual fuel engine (DFE) combustion
2. DFE for power production from landfill gas with low methane content
   a. Danish experience
   b. Swedish paper study
3. LoCaGas DFE experiments
4. Conclusions/discussions

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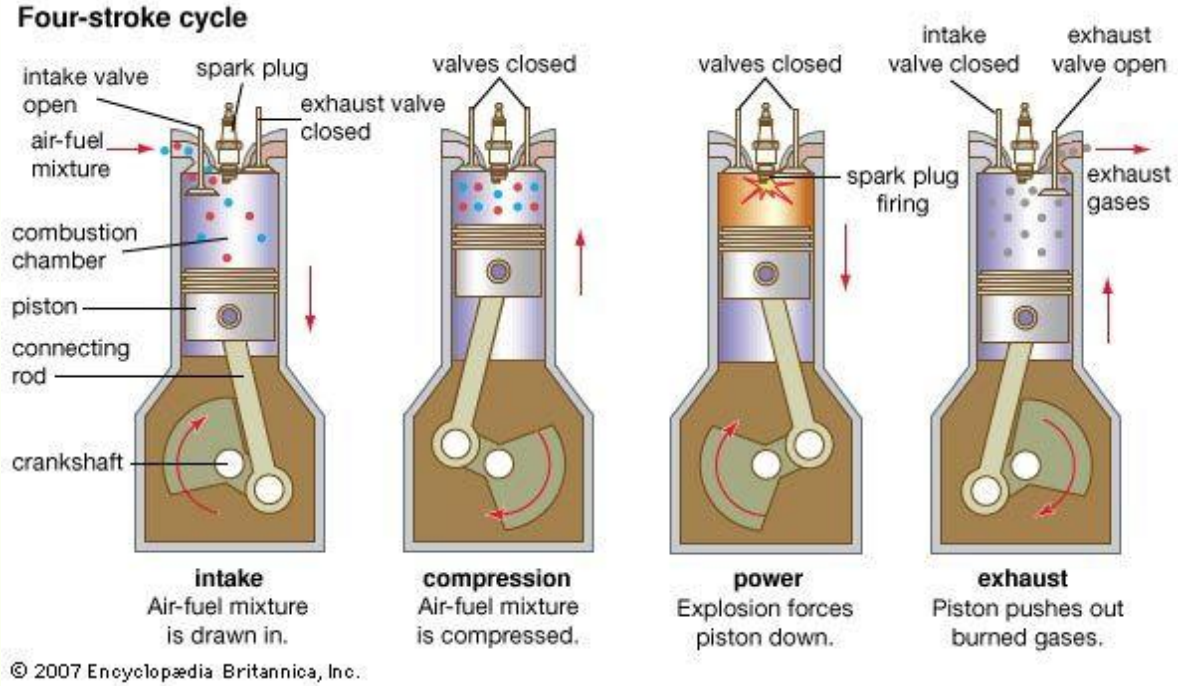
Otto cycle – premixed combustion



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Otto cycle - premixed combustion

I. A spark ignites the premixed air/fuel.

II. The flame propagates through the air/fuel mixture.

III. If the air/fuel mixture is too lean, the heat from the flame (conduction and radiation) is not enough to create radicals (e.g., OH^-, CH_3^- and H^-) and sustain the flame.

IV. If the methane content in the landfill gas drops below ~40% it is difficult to obtain a stable and complete combustion with an SI (spark ignited) engine.

V. Preheating of the combustion air improves the ability for the flame to propagate through the air/fuel mixture.

VI. The octane number, is a standard measure of a fuel's ability to withstand compression in an internal combustion engine without causing engine knocking. Methane has a high octane number (~120).

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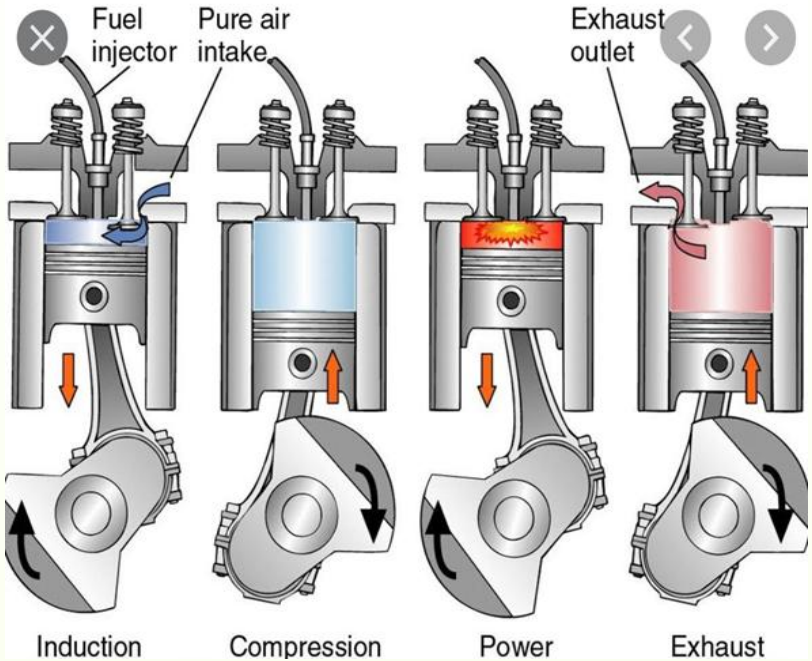
Diesel cycle – compression ignition combustion



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Compression ignition combustion

I. The cetane number is an indicator of the combustion speed of diesel fuel and compression needed for ignition.

II. Fuel with a high cetane number is injeceted into the compressed and hot air, and ignites.

III. The combustion takes place in the interface between the diesel spray and the surrounding air, resulting in high temperature (NOx formation) and soot formation inside the spray.

IV. A diesel engine has a higher efficiency than an SI engine due to a higher compression ratio.

Dual fuel engine (DFE) combustion

I. In a dual fuel engine, air and landfill gas with low methane content are introduced to the cylinder during the intake stroke.

II. The temperature of the air/fuel mixture increases during the compression stroke. A spark wouldn't be sufficient to ignite the lean air/fuel mixture.

III. A pilot fuel with high cetane number (typically diesel) is injected to ignite the air/fuel mixture. The rapid increase in temperature allows the flame to propagate through the lean air/fuel mixture.

IV. In this way, the dual fuel engine takes advantage of the high compression ratio (and hence, high efficiency) associated with a diesel engine and the good emissions performance of an SI engine.

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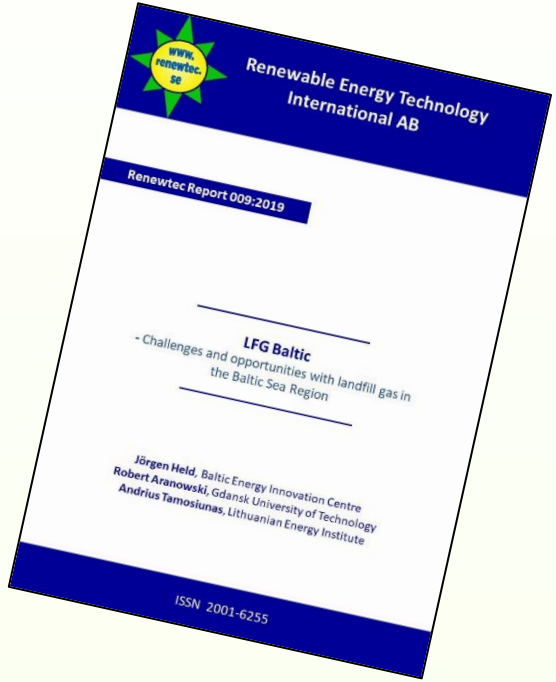
DFE for power production from landfill gas with low methane content – Danish experience

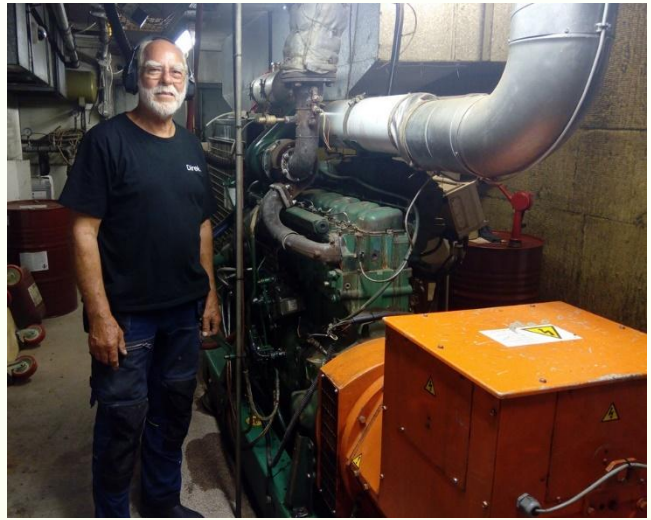
- LEI, GUT and BEIC, investigated challenges and opportunities with landfill gas in the Baltic Sea Region in 2018/19 with public co-funding from the Swedish Institute.
- First contact with Deponigas ApS (DK) who operates dual fuel engines at several Danish landfills.



Renewtec_Report_009.2019_webb.pdf (beic.nu)

DFE for power production from landfill gas with low methane content – Danish experience

- Deponigas ApS operates 9 engines on landfill gas with low methane content and Diesel as pilot fuel.
- Approx. 15% of fuel energy comes from the pilot fuel.
- One engine operates with landfill gas with a ~10% methane content.



Ole Elmose, CEO Deponigas ApS, besides a Volvo Penta modified to run in dual fuel mode at Hedeland, Denmark.
Photo: Jörgen Held

DFE for power production from landfill gas with low methane content – Swedish paper study

- RME (15% of the fuel energy) was used as pilot fuel in the paper study.
- The cost of the pilot fuel constituted ~70% of the cost for the produced electricity.
- Ideas how to lower the cost were identified.
  - Less pilot fuel (risk for coking)
  - Cheaper pilot fuel (pyrolysis oil)

Renewtec_Report_011.2023.pdf (beic.nu) in Swedish

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LoCaGas DFE experiments

- The combustion engine laboratory at Lund University will be used for the tests with a renewable pilot fuel (RME).
- 13 litre 6-cylinder Scania engine.
- Model gas (80% CO_2, 20% CH_4).
- RME and blends of RME and pyrolysis oil as pilot fuel.

Source: Lund University

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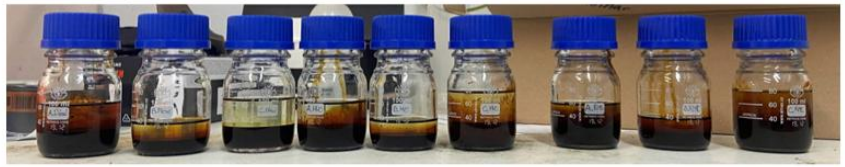
LoCaGas DFE experiments

- NSR AB provides pyrolysis oil made from wood pellets.
- Blending tests of pyrolysis oil have been performed with diesel, HVO and RME.

Pyrolysis oil mixes		Diesel	HVO	RME
A	Oil trap I 530c,35min, Trä, test 241202cb	A.Diesel	A.HVO	A.RME
B	Oil trap II 550c, 35min. Trä test 241202 cb	B.Diesel	B.Diesel	B.RME
C	Condensate 550C, 35 min, trä 2441202 cb	C.Diesel	C.HVO	C.RME

Before mixing



A.Diesel B.Diesel C.Diesel A.HVO B.HVO C.HVO A.RME B.RME C.RME

After mixing

A.Diesel B.Diesel C.Diesel A.HVO B.HVO C.HVO A.RME B.RME C.RME

Source: Lund University

Conclusions/discussions

- DFE technology admits power production using landfill gas with low methane content (Danish experience)
- Pyrolysis oil is a low-cost “waste product” when producing biochar.
- Pyrolysis oil has approx. ½ the energy content/volume compared to diesel.
- Potential to reduce the cost for the pilot fuel in two ways, less energy (less kWh while maintaining the cooling of the injector) and lower cost per kWh.
- Within the LoCaGas project, LCA (emissions) and TEA (efficiency and cost) of the DFE technology will be done as input for a decision support tool.

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THANK YOU FOR ATTENTION

Do you have any question?

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