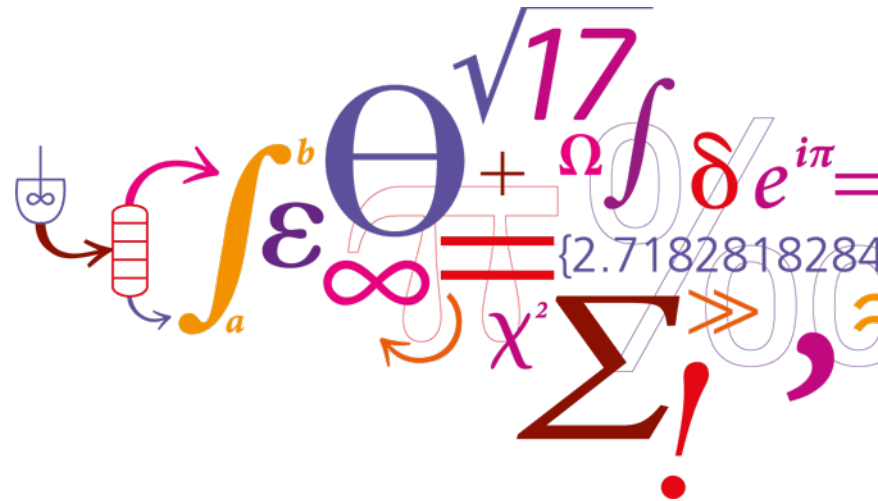


# Butanol for sustainable aviation

Sustainable Aviation Fuel - Workshop  
20.11.2018

Dr. Helena Junicke  
[heljun@dtu.dk](mailto:heljun@dtu.dk)



# Outline

## Introduction

- Alternative jet fuel pathways
- Alcohol-to-jet

## Opportunities for butanol

- Butanol from waste
- The GreenLogic project

## Methods and results

- Continuous enrichment studies
- Thermodynamic system design
- Modelling of full-scale reactors

## Conclusions

## Outlook

# Alternative jet fuel pathways

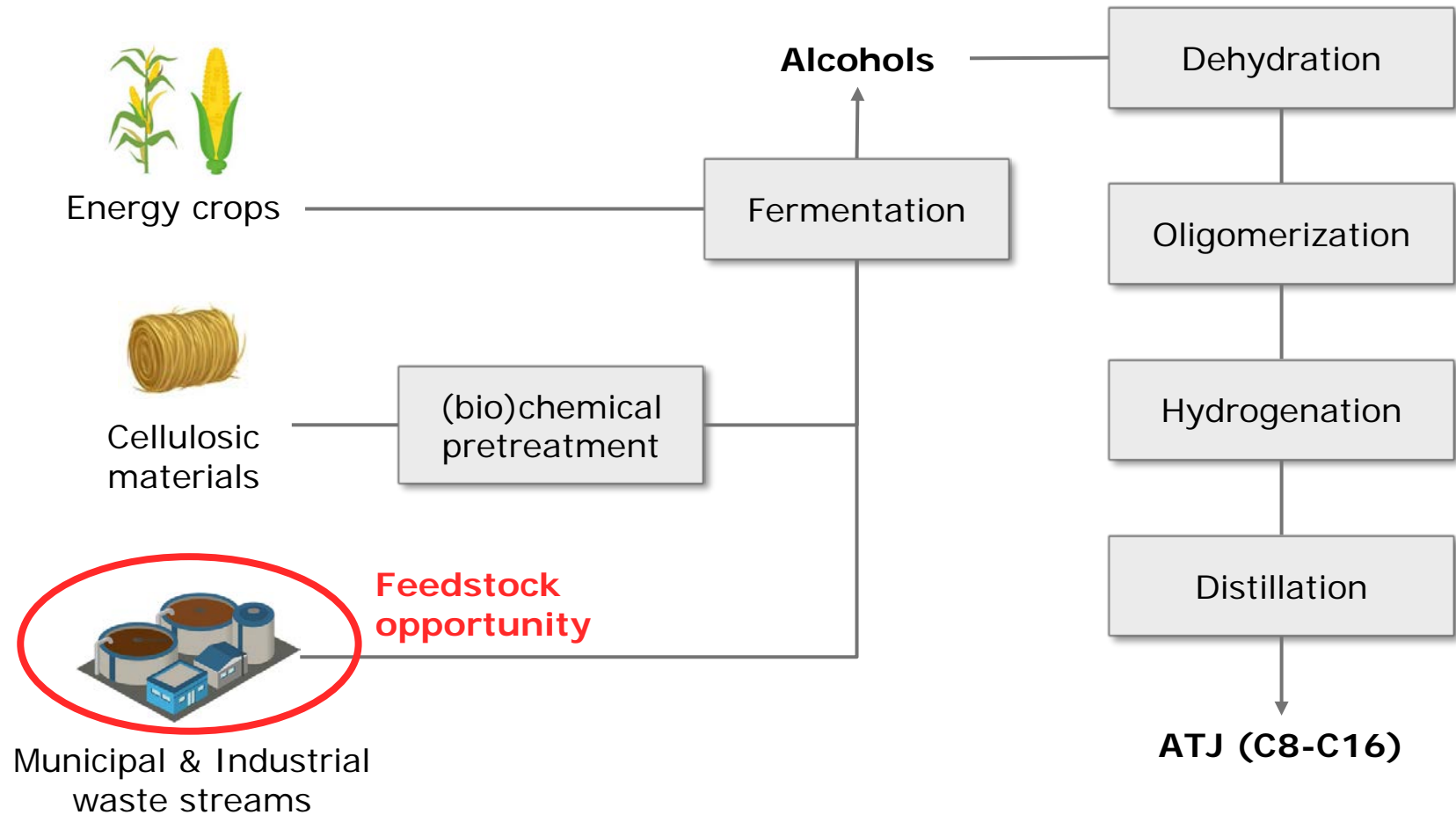
- There are five ASTM D7566 certified pathways for synthetic paraffinic kerosene (SPK) production

Type	Pathway	Description
Gas-to-jet	FT-SPK	SPK from syngas via Fischer-Tropsch (FT)
	FT-SPK/A	FT-SPK with increased aromatic content
Oil-to-jet	HEFA-SPK	SPK from hydro-processed esters and fatty acids (HEFA)
Sugar-to-jet	SIP-SPK	Synthesized iso-paraffins (SIP) obtained via farnesene intermediate
<b>Alcohol-to-jet</b>	<b>ATJ-SPK</b>	<b>SPK from C2-C5 alcohols</b>

**FOCUS**

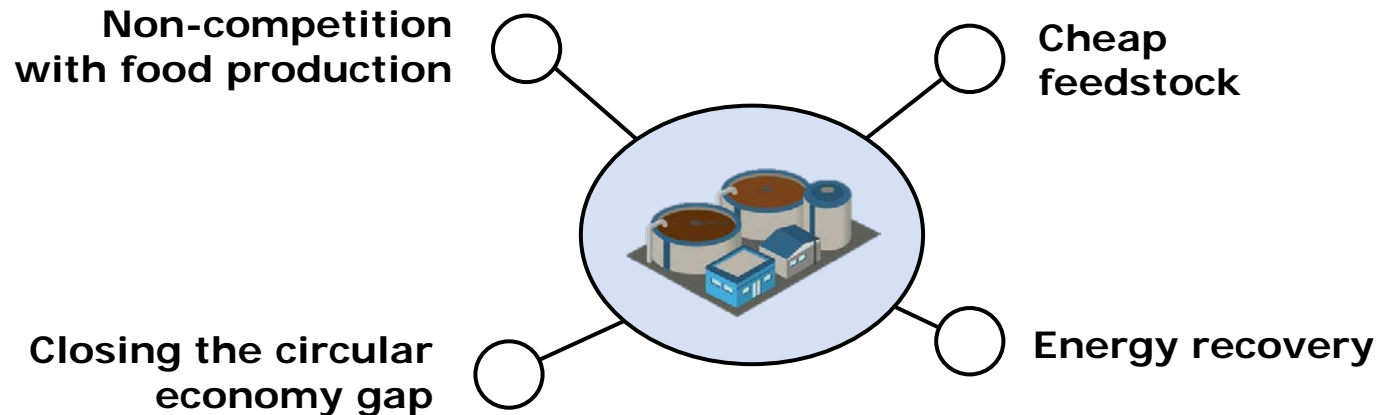
Yang et al. "An overview on performance characteristics of bio-jet fuels." *Fuel* 237 (2019): 916-936.

# The alcohol-to-jet pathway



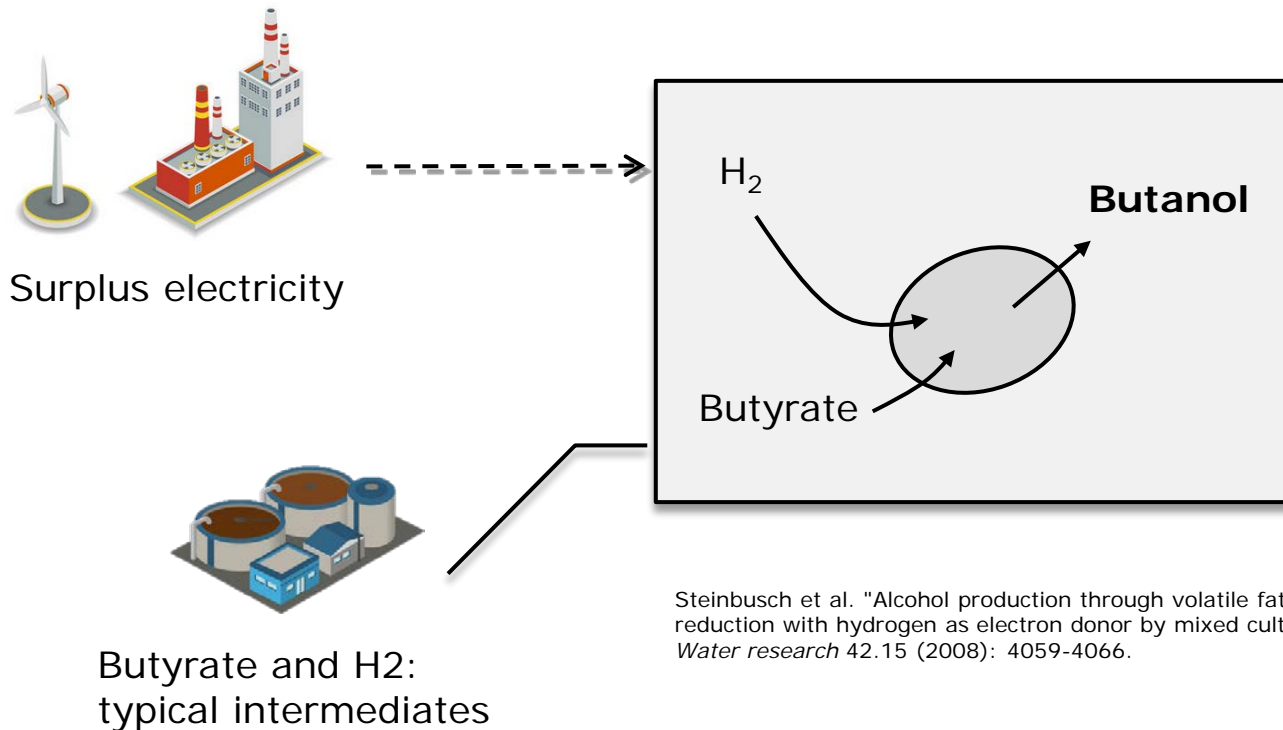
# Opportunities

- ASTM D7566-18 permits blending iso-butanol and ethanol derived SPK with conventional jet fuels of up to 50%
- Sourcing **C2-C5 alcohols from waste**



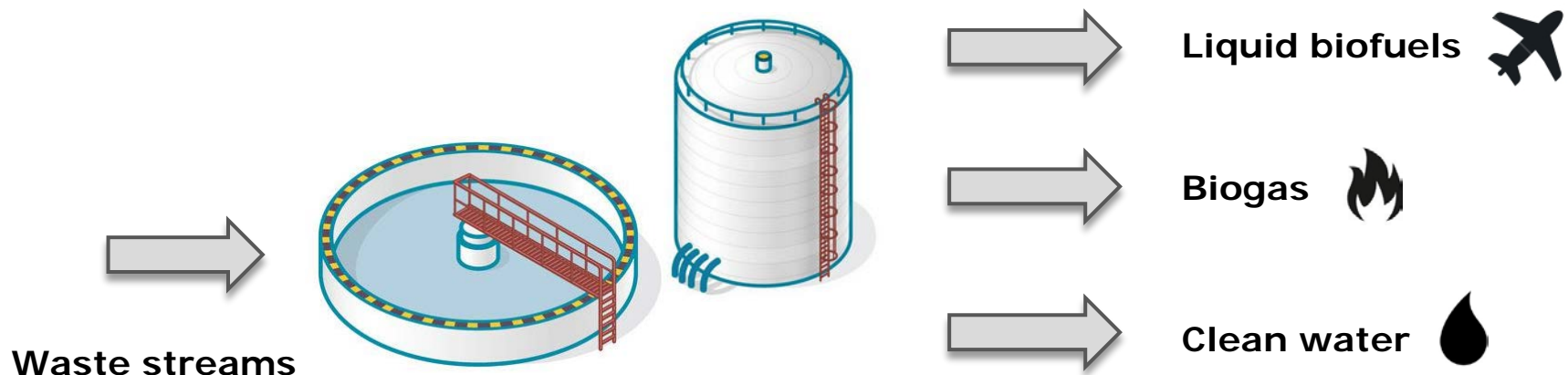
# Butanol from waste – How?

- Anaerobic mixed microbial cultures
- Non-standard conditions (pH 5, increased  $pH_2$ )

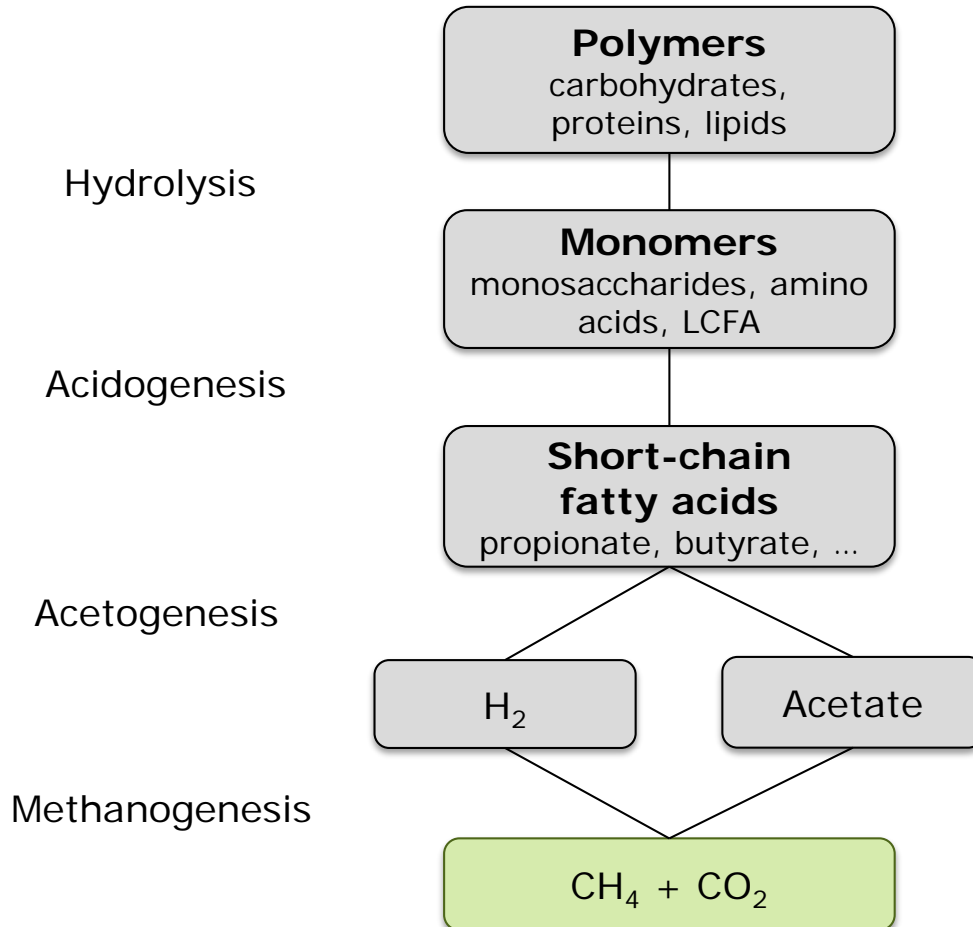


# The GreenLogic project

- ⊕ Production of **C2-C5 alcohols** from industrial and municipal waste streams
- ⊕ Upgrading waste water treatment plants (WWTP) into water **resource recovery** facilities (WRRF)



# Anaerobic digestion: The classical view

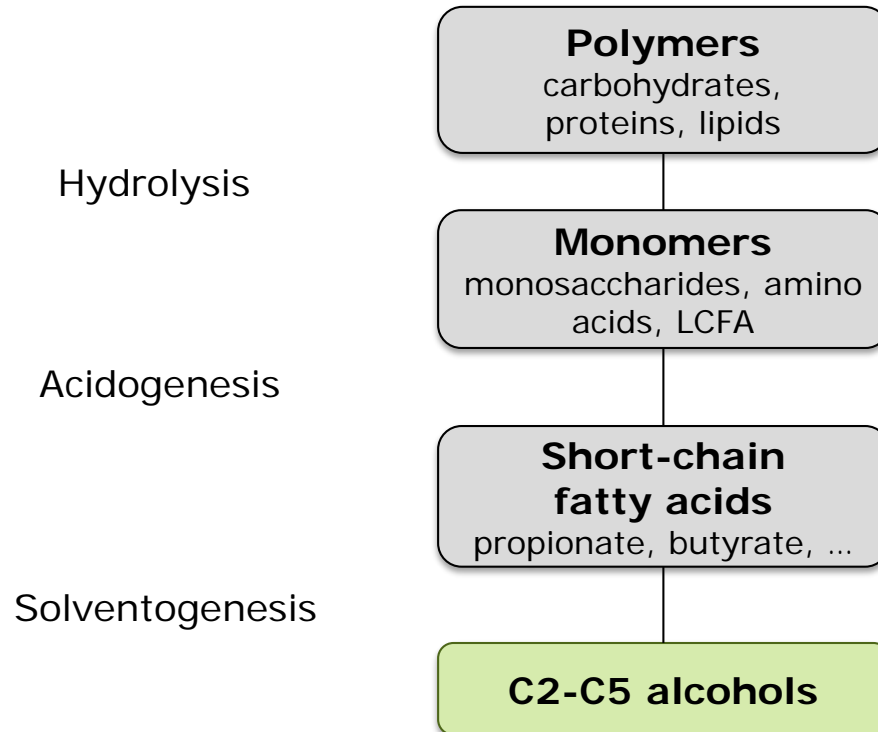


## Current focus

Different microbial groups degrade complex waste streams into biogas.

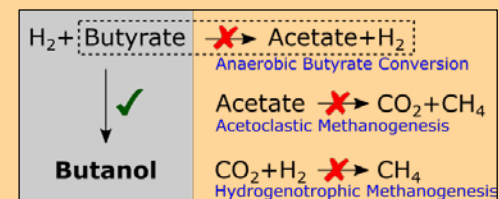


# Anaerobic digestion: Butanol enrichment



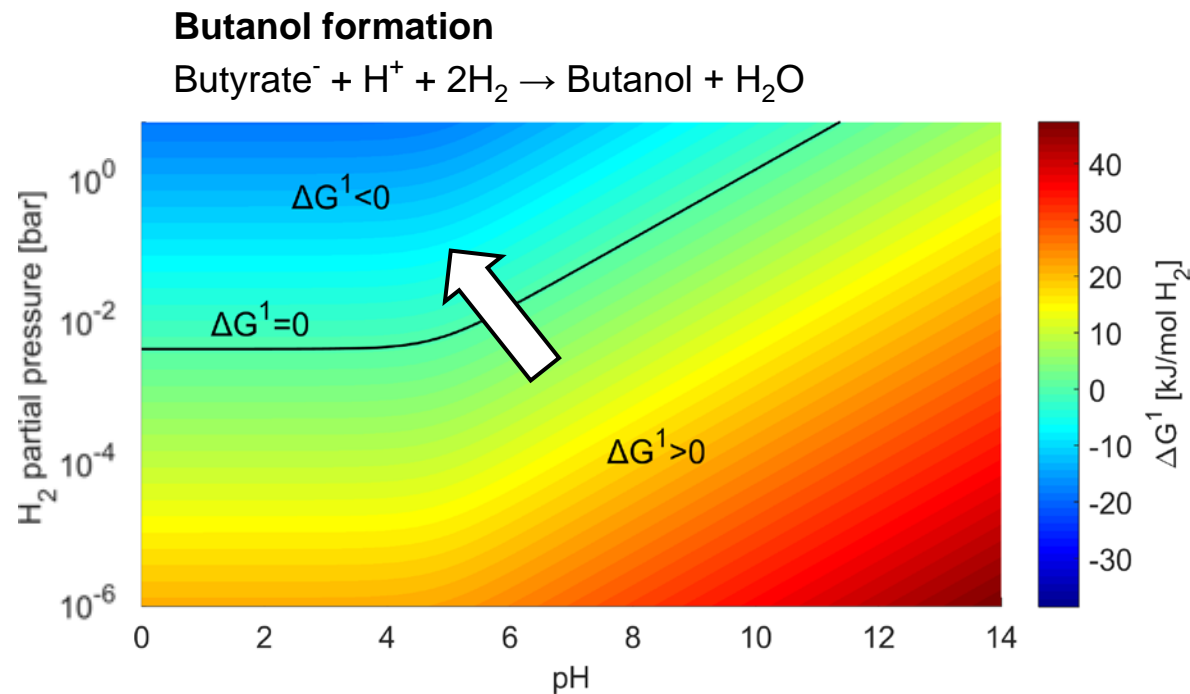
## New focus

Operate at **pH 5** and **high  $pH_2$**  to promote alcohol formation.



# Thermodynamic system design

- Unlocking butanol formation
- Increase  $H_2$ , decrease pH (see arrow)



# Modelling of full-scale anaerobic digesters

- From biogas towards butanol formation



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# Conclusions

- **Butanol production** from waste under non-standard conditions
- **Mixed culture biotechnology** as a solution for cheap feedstock conversion into ATJ-SPK
- ATJ-SPK approval for C3-C5 alcohols expected in the **mid-term**; ethanol and iso-butanol are certified already

# Outlook

- **Techno-economic analysis** of upstream ( $H_2$  and butyrate sources) and downstream processing
- **Enrichment of new biocatalysts** for butanol formation (microorganisms, enzymes)
- Municipal and industrial waste streams as **cheap and sustainable feedstock** for jet fuel production

# Thank you for your attention!

Project partners:

