

# Biogas Research Center

är ett transdisciplinärt kompetenscentrum där samproduktion av kunskap sker genom samarbete mellan ett 20-tal biogasaktörer och 10 forskargrupper vid Linköpings Universitet och Sveriges Lantbruksuniversitet samt Energimyndigheten.

Mats Eklund

Professor in Environmental Technology and Management  
Director Biogas Research Center, Linköping University



# Mode II Science

- Samproduktion av kunskap
- Explorativt angreppssätt
- Transdisciplinärt
- Potentiellt stärkt relevans
- Bättre förutsättningar för implementering

# Scope – Kompetenscentrum, anaerob rötning



## Sustainable cities and regions

Integrated solution for wastewater treatment, waste management, transport and nutrient recycling with global relevance



## Sustainable bioeconomy

Future network based biorefineries contain a biogas solution for valorisation and diversification

# Grand challenges for cities and their surroundings

70% population

80% energy use  
and CO<sub>2</sub>-emissions

86% GDP

Urbanisation and congestion

Air pollution

Climate change

Energy security

Not enough jobs

Amount of waste grows

Nutrient flows between city and surroundings

Water pollution

Soil fertility in agriculture

Biogas solutions  
contributes to  
them all

# Biogas solutions in pulp and paper mills

## Mill level

Better treatment capacity  
and decreased emissions

Reduction needs and costs  
for nutrients

Easier to comply with  
environmental permits

Sludge volume reduction

Economic diversification and  
can enable growth



## Product level

Improved product  
performance

Environmental product  
declaration

**paper profile** **HOLMEN**

|         |                     |
|---------|---------------------|
| Product | Holmen UNIQ         |
| Company | Holmen Paper AB     |
| Mill    | Braviken Paper Mill |

Information gathered from 2017-01-01 to 2017-12-31  
Date of issue 2018-05-14

**Environmental product declaration for paper**

**Environmental Management**  
Certified environmental management system at the mill and the wood procurement org. ISO 14001  
Company systems ensure traceability of the origin of wood. ☒ yes ☐ no ☐ 100% recovered paper  
40% Chain-of-custody certified fibres with CoC certification at the mill  
Copies of certificates can be found at <http://www.holmen.com>

| Environmental parameters                                                                                                                                                                                |                          | Product composition |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|---------------------|------------|
| The figures are based on methods and procedures of measurement approved by the local (or national) environmental regulators at the production site. The figures include both paper and pulp production. |                          |                     |            |
| Water                                                                                                                                                                                                   | COD                      | 4,5                 | kg/tonne   |
|                                                                                                                                                                                                         | AOX                      | 0,008               | kg/tonne   |
|                                                                                                                                                                                                         | Mn                       | 0,09                | kg/tonne   |
|                                                                                                                                                                                                         | Fe                       | 0,085               | kg/tonne   |
| Air                                                                                                                                                                                                     | SO <sub>2</sub>          | 0,02                | kg/tonne   |
|                                                                                                                                                                                                         | NO <sub>x</sub>          | 0,14                | kg/tonne   |
|                                                                                                                                                                                                         | CO <sub>2</sub> (fossil) | 26                  | kg/tonne   |
| Solid waste landfilled                                                                                                                                                                                  |                          | 0,4                 | BCkg/tonne |
| Purchased electricity consumption                                                                                                                                                                       |                          |                     |            |
| /tonne of final product                                                                                                                                                                                 |                          | 2830                | kWh        |

**Product composition**

chemical pulp 0%  
mechanical pulp 0%  
moisture 8%  
inkless 0%  
pulp from recovered fibres 0%  
pigments and fillers 10%

This product contains biomass carbon, equivalent to 1400 kg of CO<sub>2</sub> per tonne of paper.

**More information**  
Contact person: Leonard Dahlberg  
Address: Holmen Paper AB, Braviken Paper Mill  
601 88 Norrköping, Sweden  
Phone: +46 11 236180  
E-mail: [leonard.dahlberg@holmenpaper.com](mailto:leonard.dahlberg@holmenpaper.com)

## Corporate level

Fossil-free goals

Climate positive

Contributing to sustainable  
development goals



# Verktyg

1. Långsiktiga forskningsområden
2. Projekt för förstudier, synteser, kunskapssammanställningar och teknikutvärdering
3. Kommunikation och nätverksaktiviteter
4. Internationalisering av kunskap och teknik
5. Kursverksamhet för doktorander och partner/medlemmar
6. Syntesarbete

# Forskningsområden

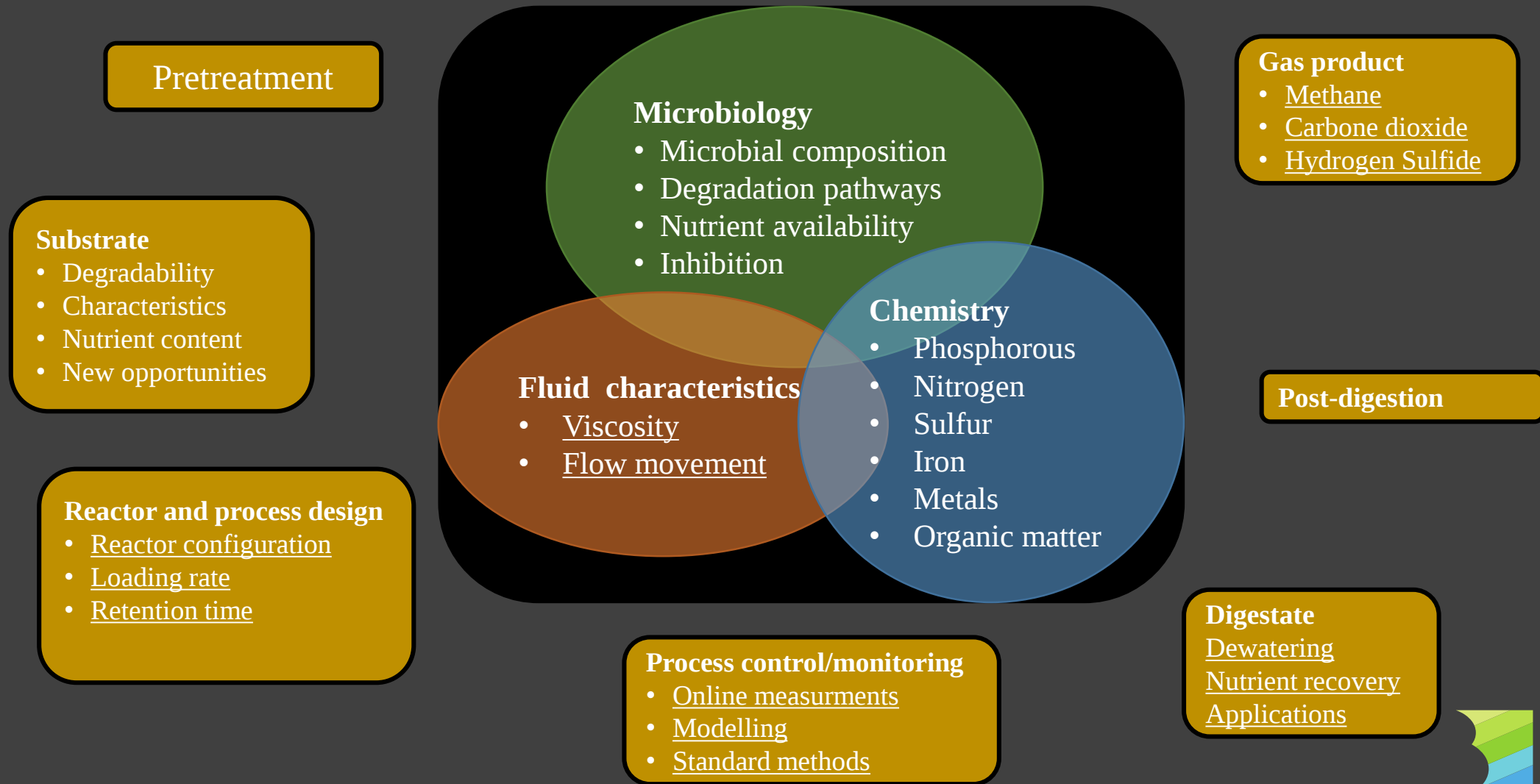
- FO 1 Utveckling och utvärdering av effektivare rötningsprocesser
- FO 2 Ökat värde ur digestat
- FO 3 Resurseffektiva värdekedjor för biogaslösningar
- FO 4 Biogaslösningarnas roll i bioekonomin
- FO 5 Kommuner och regioners roll i att utveckla hållbara biogaslösningar
- FO 6 Utvärderingsscenarier för nationell och internationell policy
- FO 7 Internationalisering av svenska biogaslösningar

# BRCs partners

- Linköpings Universitet
- Sveriges Lantbruksuniversitet
- Energimyndigheten
- Tekniska Verken
- Scandinavian Biogas
- Gasum
- E.ON
- Scania
- Region Kalmar län
- Region Jönköping
- Region Östergötland
- Region Gotland
- Purac
- Wärtsilä Puregas Solutions
- Econova
- NSR, Helsingborg
- Borlänge Energi
- Härnösands energi och miljö
- Renahav
- Lantbrukarnas Riksförbund
- Econova
- Biototal
- Norrköpings kommun
- Linköpings kommun

# Forskning om rötningsprocesser

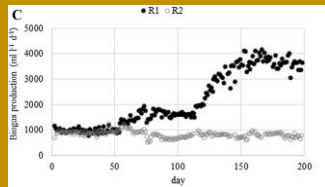
# Components of AD systems



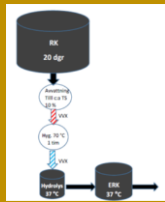
# Biogas (technical) solutions

## Pretreatment

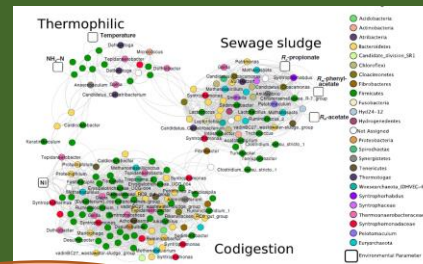
## Substrate



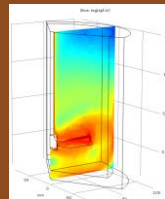
## Reactor and process design



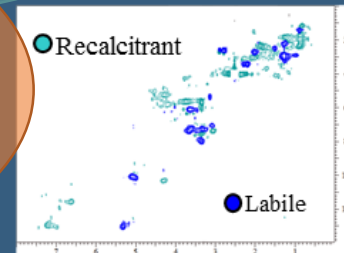
## Microbiology



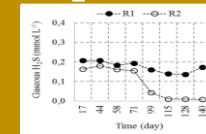
## Fluid characteristics



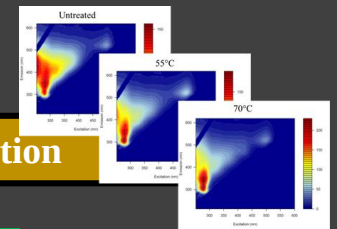
## Chemistry



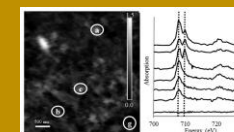
## Gas product



## Post-digestion



## Digestate



## Process control/monitoring

- Online measurements
- Modelling
- Standard methods

# Composition of residual organic matter in digestate

## In food waste digestates:

- ca 10 – 20 % of VS is undegraded carbohydrates (mainly glucose)
- ca 36 – 56 % of VS is undegraded lignin
- ca 29 – 58% of VS is protein
- ca 0 – 25% of VS is lipid (other than above)

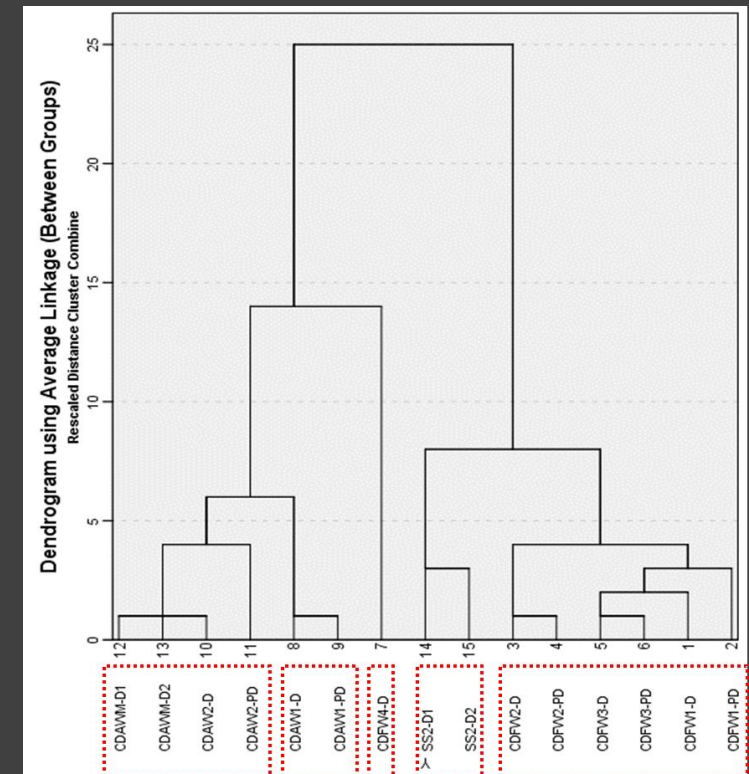
## In agricultural waste digestates

- ca 25 – 50 % of VS is undegraded carbohydrate (mainly xylose and glucose )
- ca 34 – 48 % of VS is undegraded lignin
- ca 15 – 32 % of VS is protein
- ca 0 – 10 % of VS is lipid (other than above)

## In sewage sludge digestate

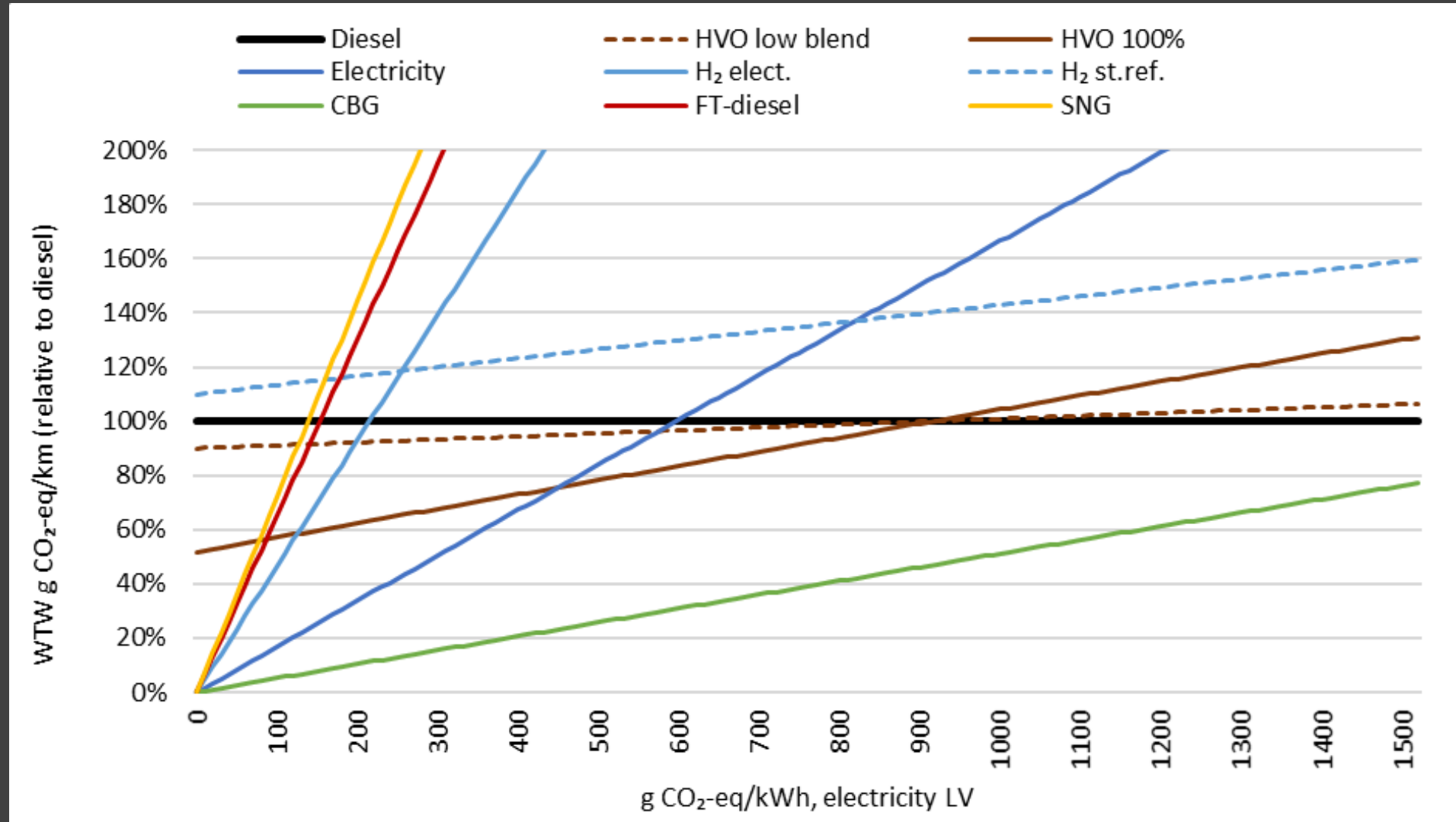
- ca 12 – 18 % of VS is undegraded carbohydrate (mainly glucose)
- ca 37 – 39 % of VS is undegraded lignin
- ca 28 – 42 % of VS is protein
- ca 6 – 25 % of VS is lipid (other than above)

**Substrate origin** is the primary factor determining the organic matter composition of the digestate



# System- och samhällsforskning för implementering av biogaslösningar

# Long haulage truck CO<sub>2</sub>-emissions, WTW in different electricity systems



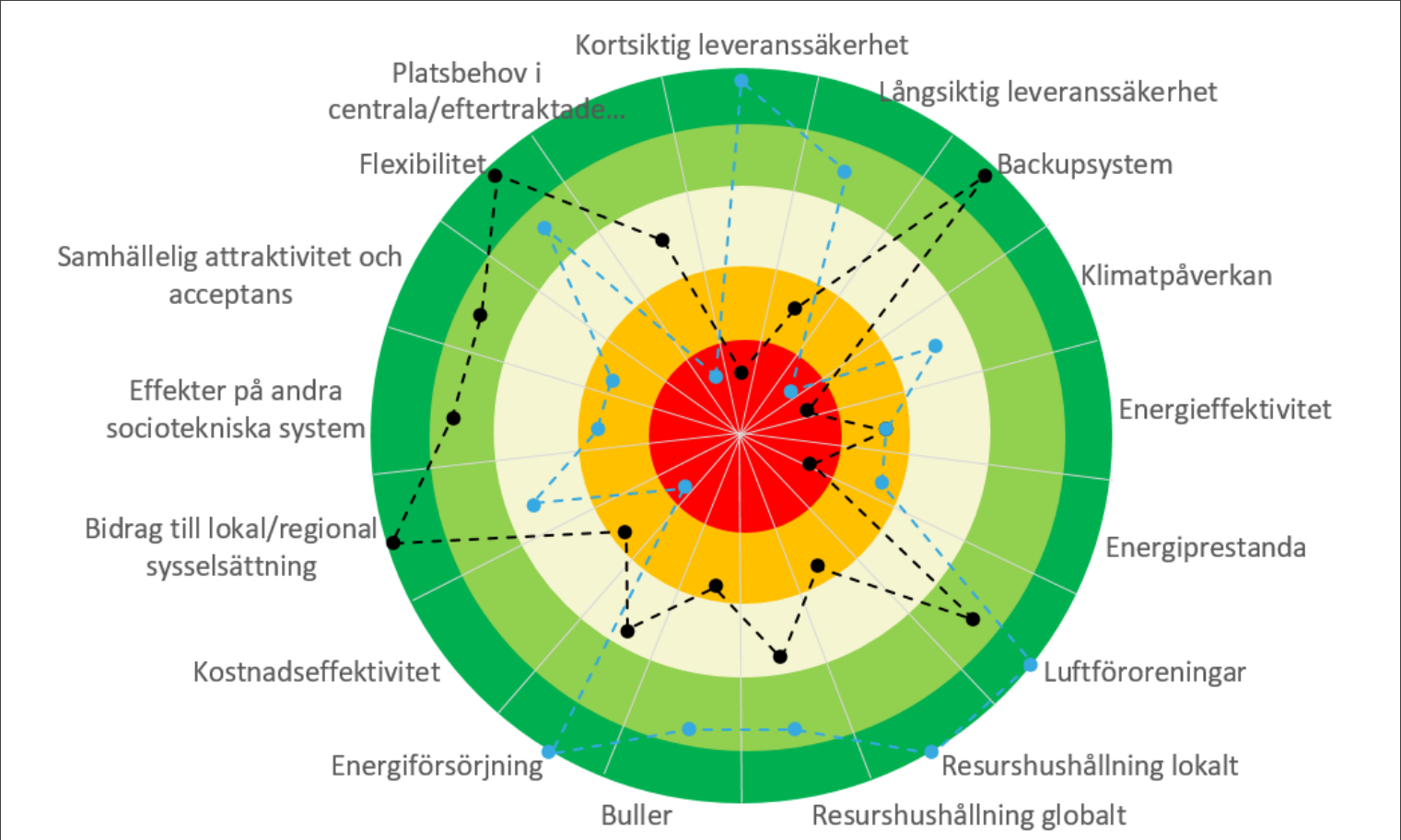
# Swedish environmental goals and UN sustainable development goals as frameworks for assessment – decrease risk for problem shifting



The broader the assessment – the better the result for biogas solutions

| 10 Key areas                                                |
|-------------------------------------------------------------|
| 1. Biomethane yield and suitability for anaerobic digestion |
| 2. Nutrient content and suitability for biofertilizers      |
| 3. Accessibility                                            |
| 4. Amount of biomethane                                     |
| 5. Amount and value of biofertilizers                       |
| 6. Technological feasibility                                |
| 7. Profitability or cost efficiency                         |
| 8. Control and competition                                  |
| 9. Institutional support and societal acceptance            |
| 10. Environmental and energy performance                    |

# Multi-criteria assessment tools for feedstock, bus transport, public procurement



## Biogas Production

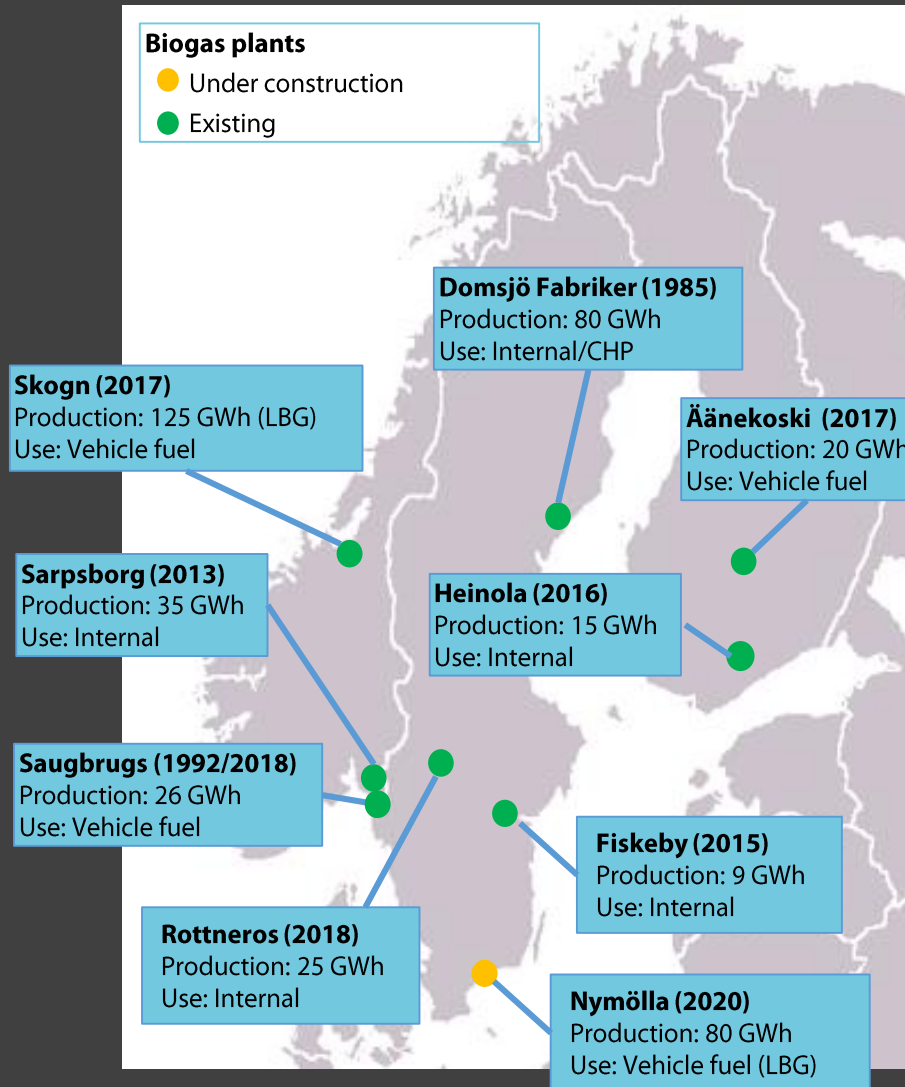
1. Improved resource recycling
2. Increased investments
3. Increased biodiversity
4. Less ecotoxicity
5. Less acidification
6. Less eutrophication
7. Increased regional employment
8. Increased regional sum of wages
9. Higher share of renewable energy
10. Increased nutrient recycling
11. Improved energy security

## Biogas Use

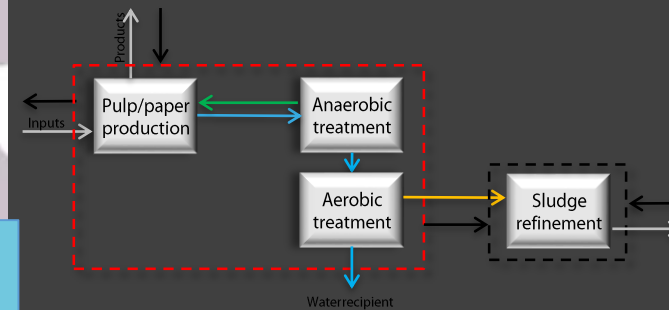
1. Improved air quality
2. Lower accessibility
3. Less noise
4. Less acidification
5. Less eutrophication
6. Less climate impact



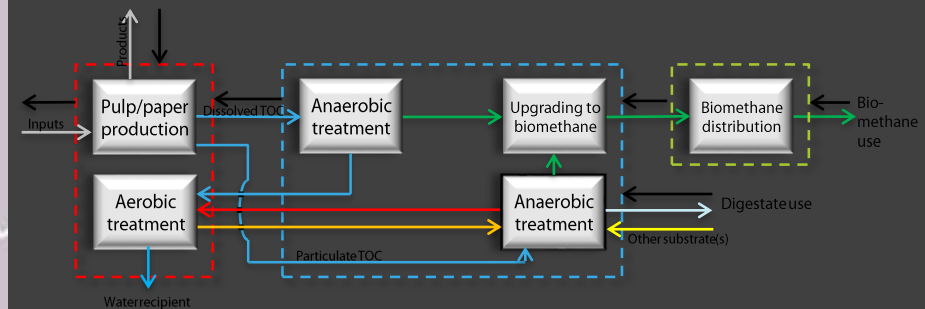
# Variety of biogas plants in the Nordic P & P industry



## From Fiskeby ...



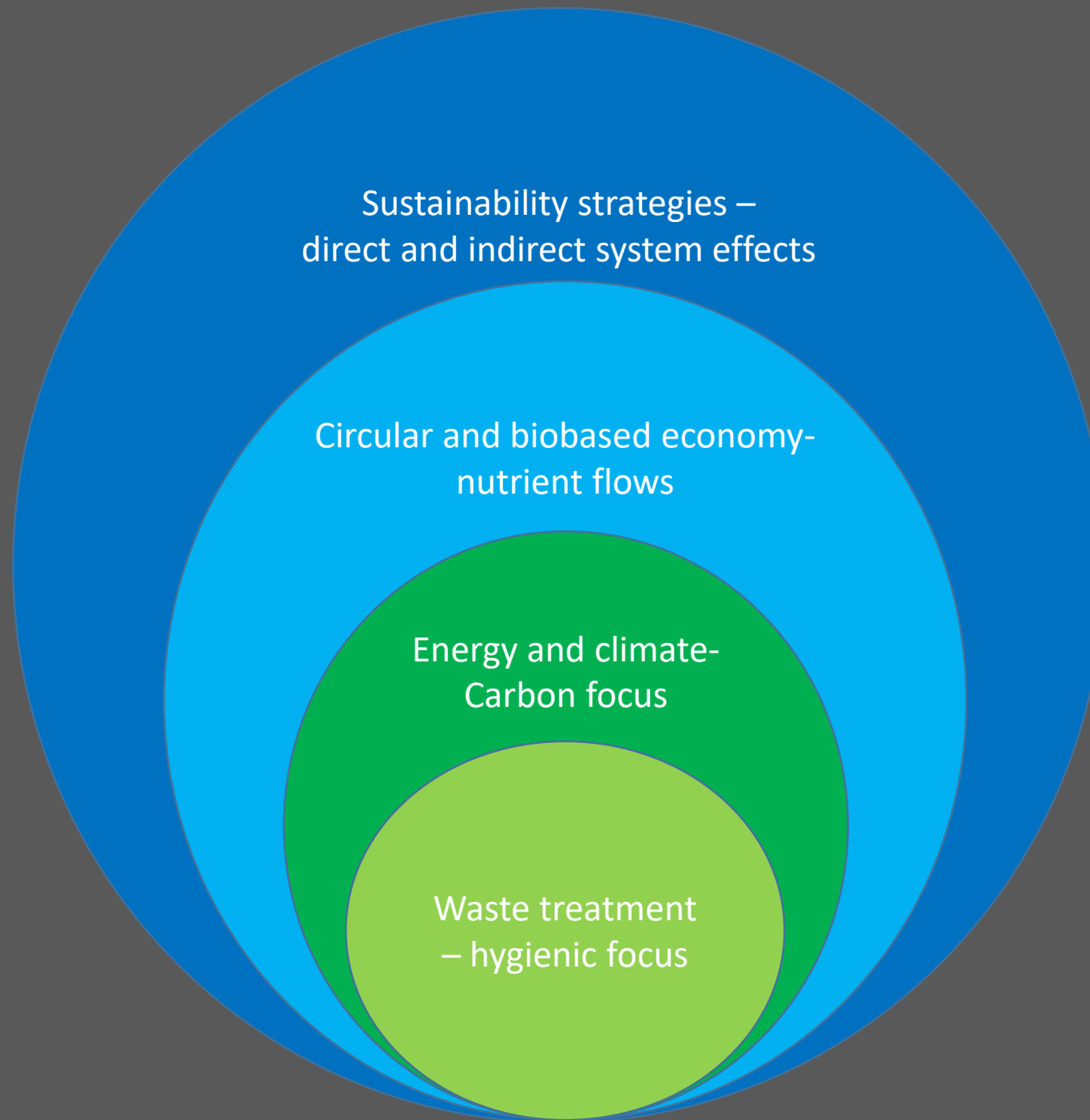
## ... to Skogn



**“The way issues are discussed matters in  
the political debate about business and  
sustainability... because such discourse may  
have a performative function in producing  
the effects that it names”**

(Ihlen and Roper 2014)

# The framing and identity of biogas solutions





Nätverkande o  
kommunikation