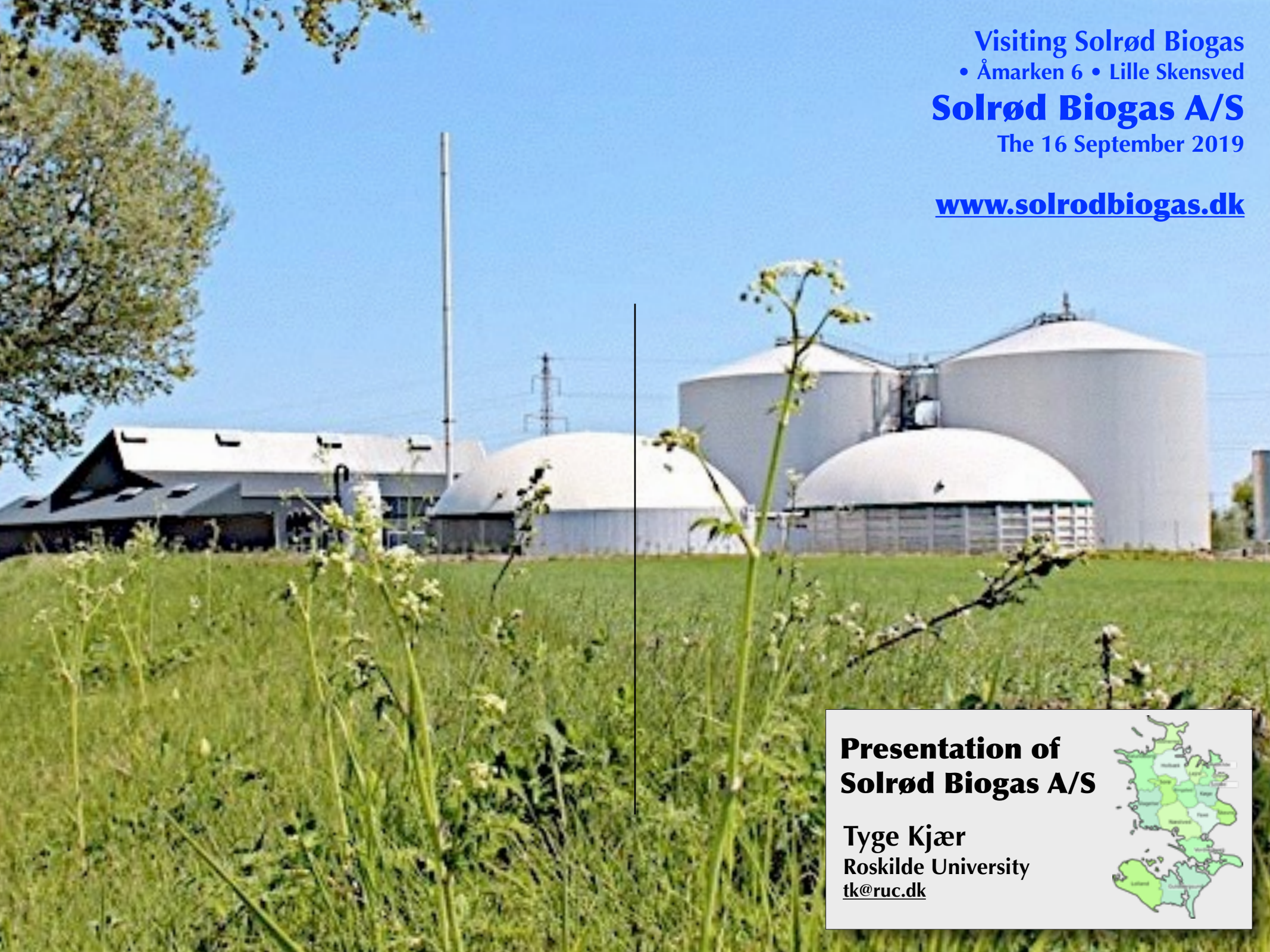


Visiting Solrød Biogas

• Åmarken 6 • Lille Skensved

Solrød Biogas A/S

The 16 September 2019

www.solrodbiogas.dk

Presentation of Solrød Biogas A/S

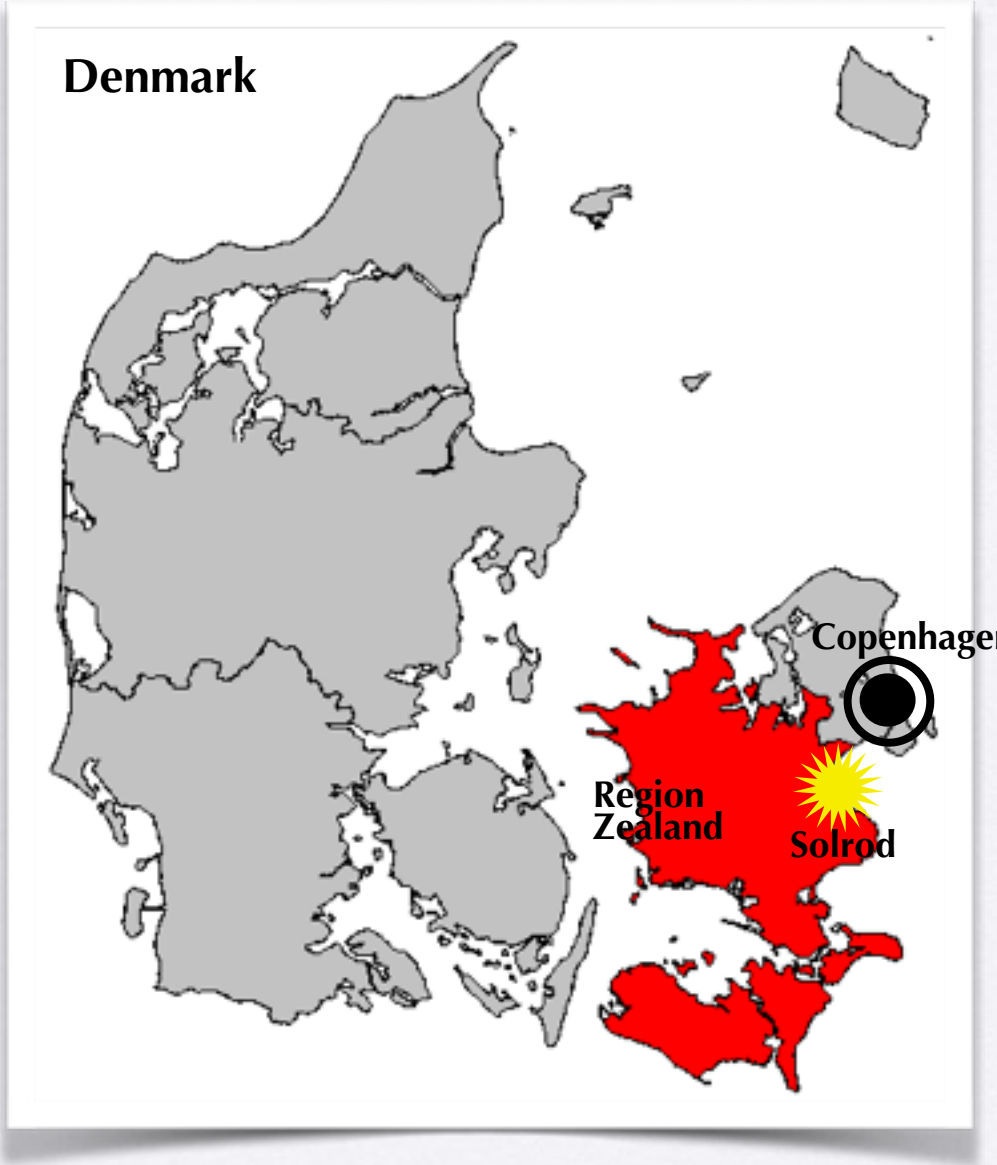
Tyge Kjær
Roskilde University
tk@ruc.dk

Introduction

Solrod / Solrød

Experience of Solrod Municipality

- **Background**
  - The national policy and support
- **Introduction to planning activities in Solrød**
  - Local leadership
  - Construction of the biogas plant
  - The biogas plant - raw materials and production
- **Biogas plant in local community**
  - The circular economy
- **Basic principle**
  - The local services and benefit



SolrødBiogas
- helt naturligt

Danish background

Strong expansion

Biogas plant

- **Larger plants**
  From less than 50 TJ/year
  to typically 200-400 TJ/year

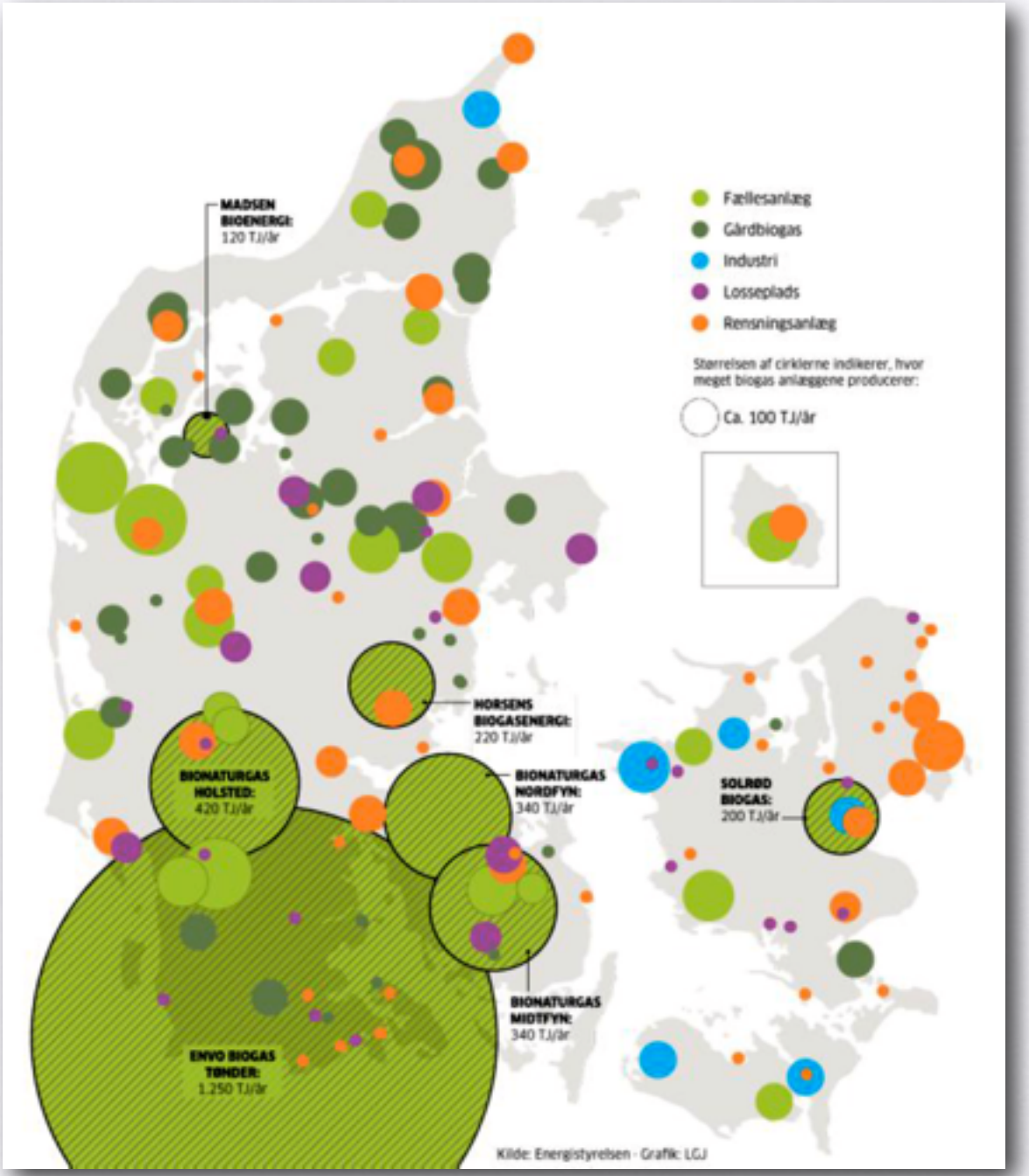
or:

  From 14,000 MWh/year to
  typical 56,000-112,000 MWh/Y

the biggest:

  around 348,000 MWh / year

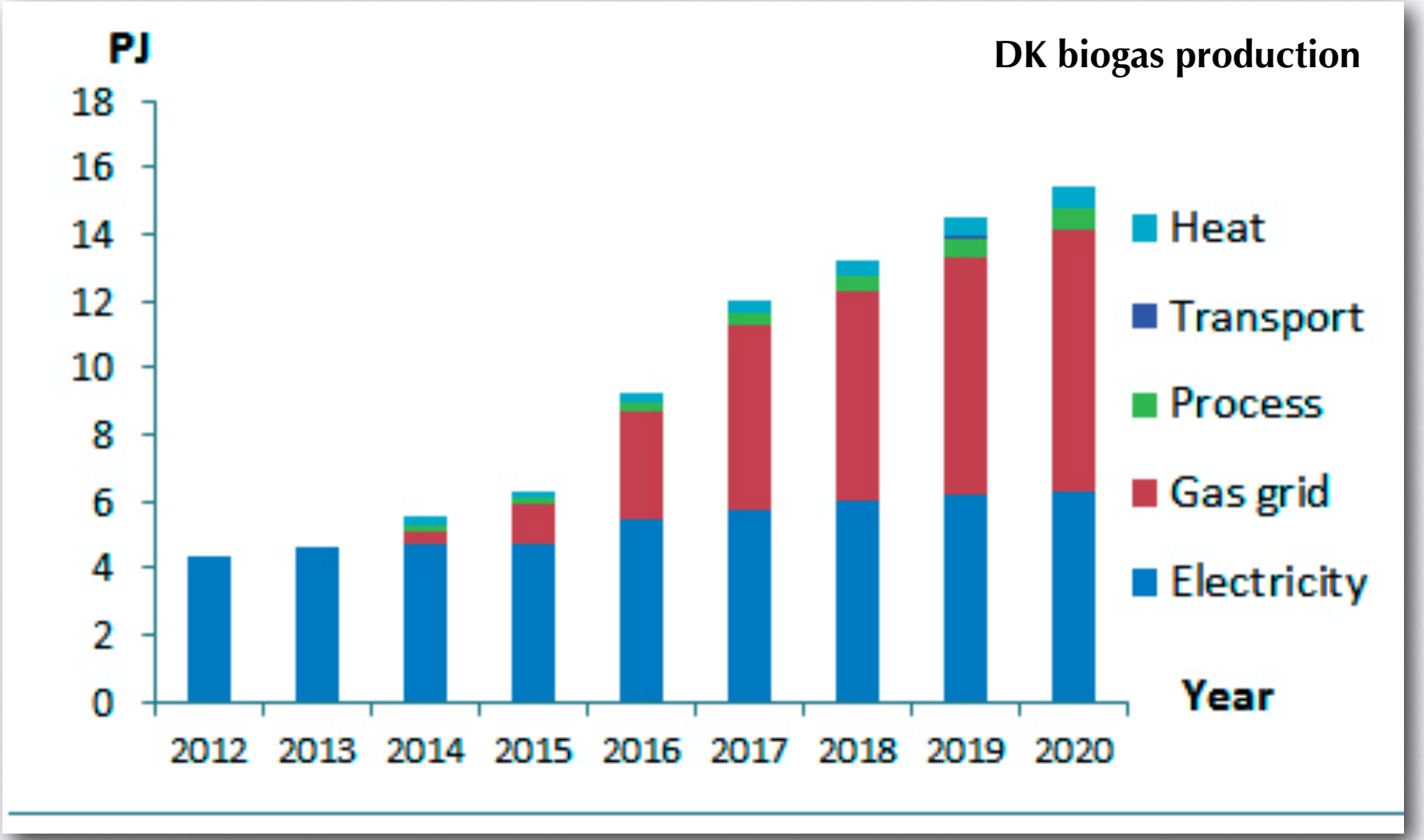
- **Several types of installations:**
  1) Biogas joint plant
     - Manure
     - Industrial plants
     - Mix plant
  2) Farm biogas plant
  3) Industrial plants
  4) Drainage and wastewater treatment plants



Danish background

The development - biogas production

Realized and expected

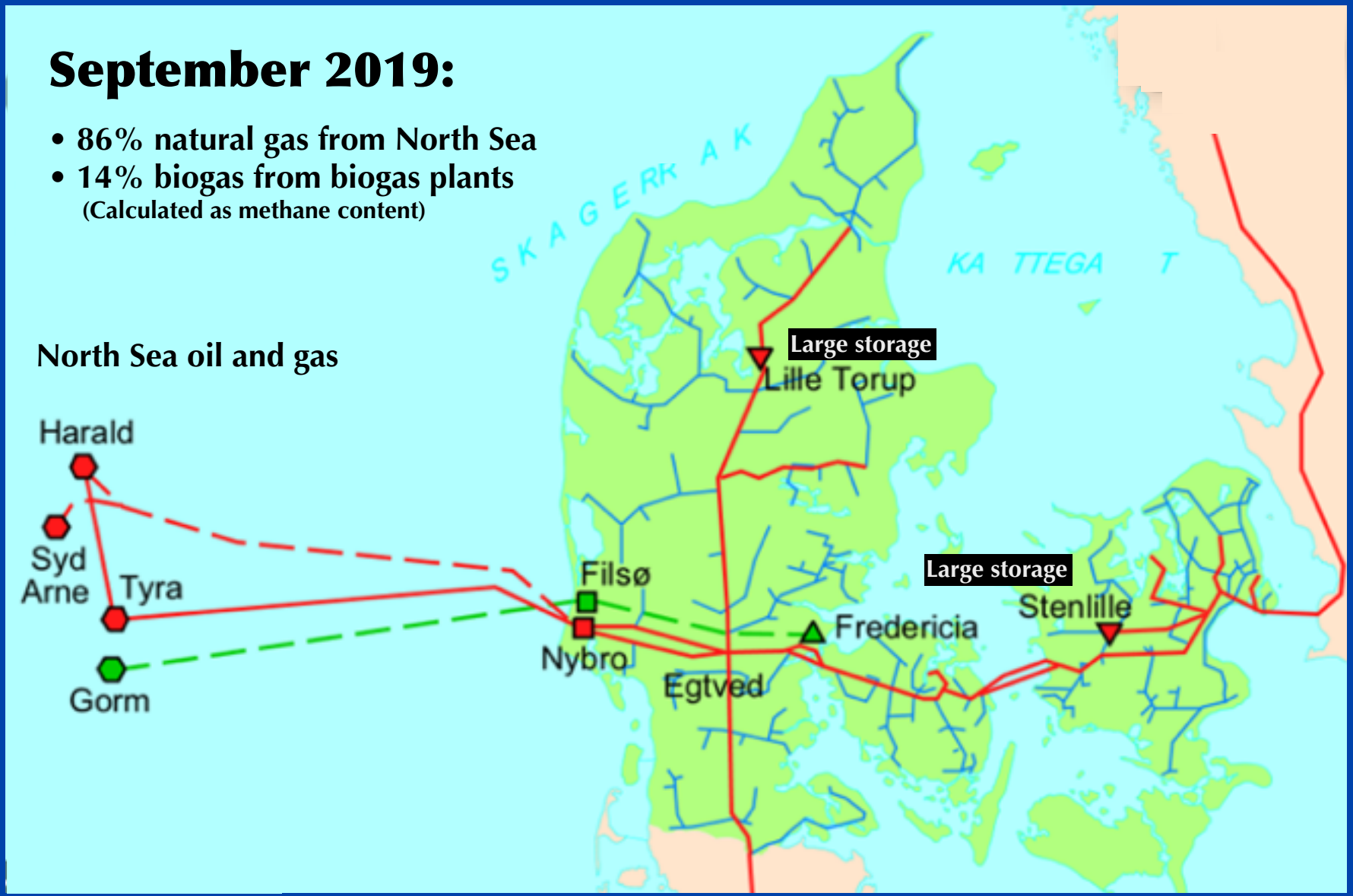


Danish background

Why is biogas important?

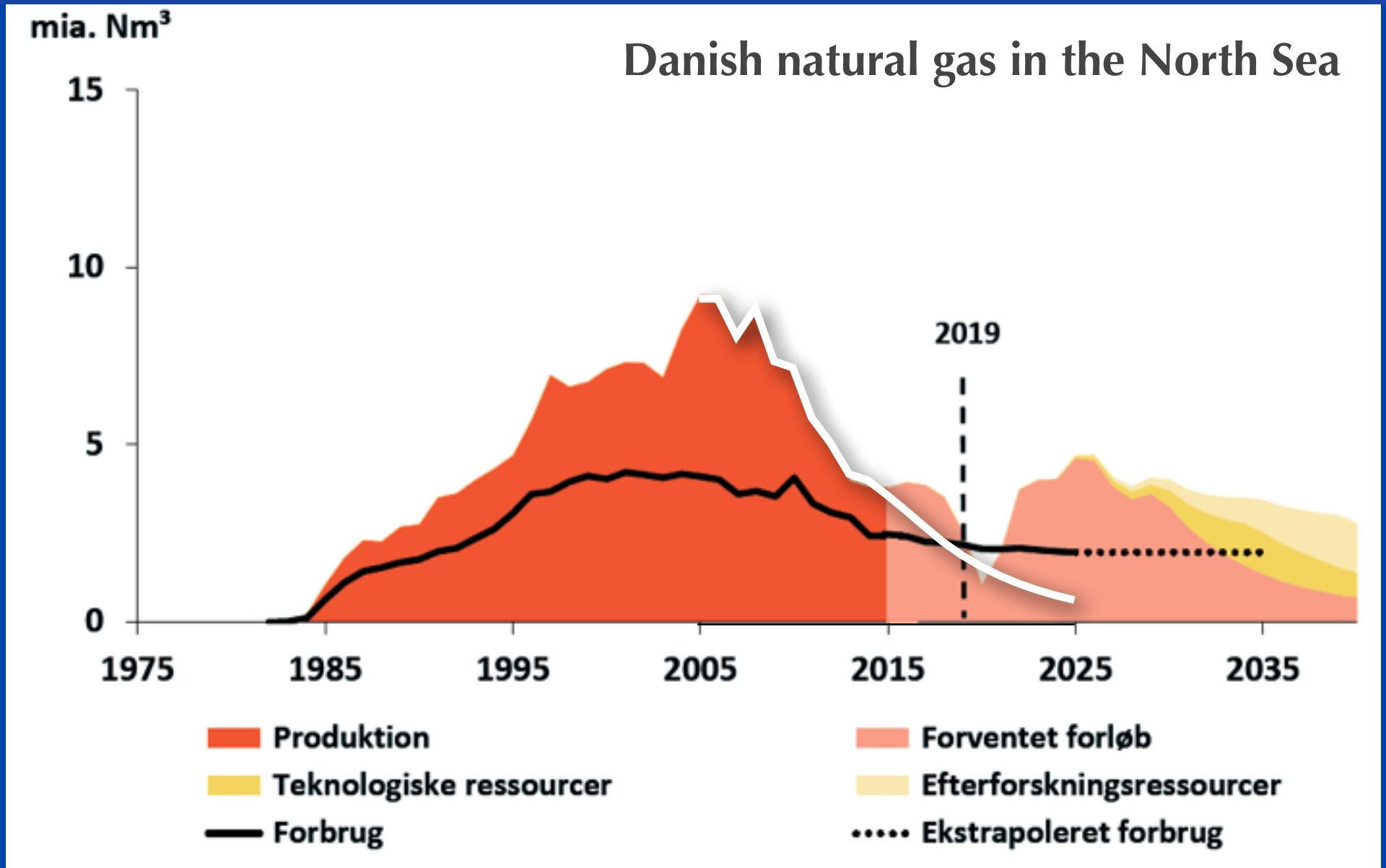
September 2019:

- 86% natural gas from North Sea
- 14% biogas from biogas plants
  (Calculated as methane content)



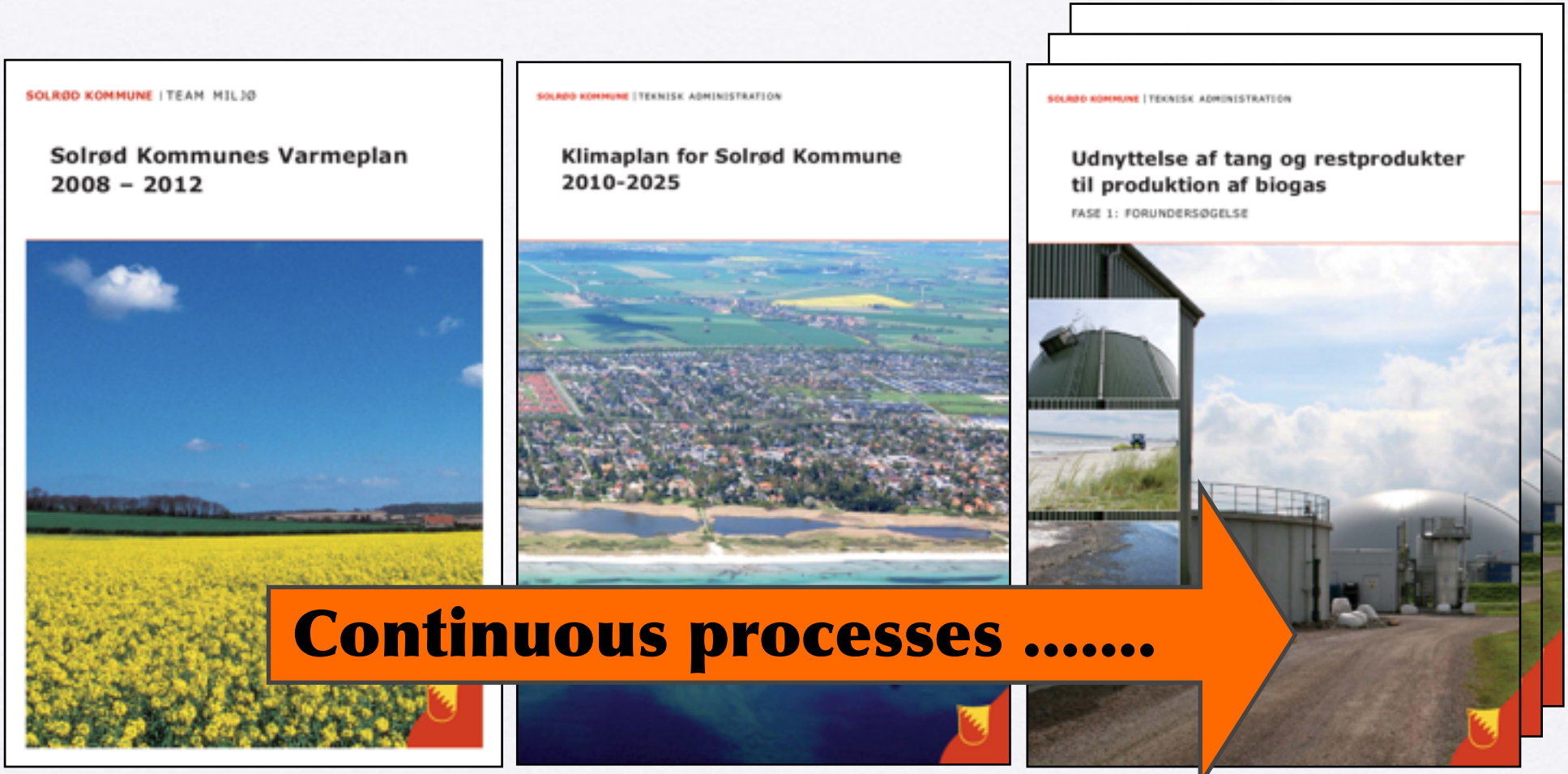
Danish background

Why is biogas important?



Local energy leadership

From Heating plan — Climate action Plan / SEAP — To a number og projects



A starter

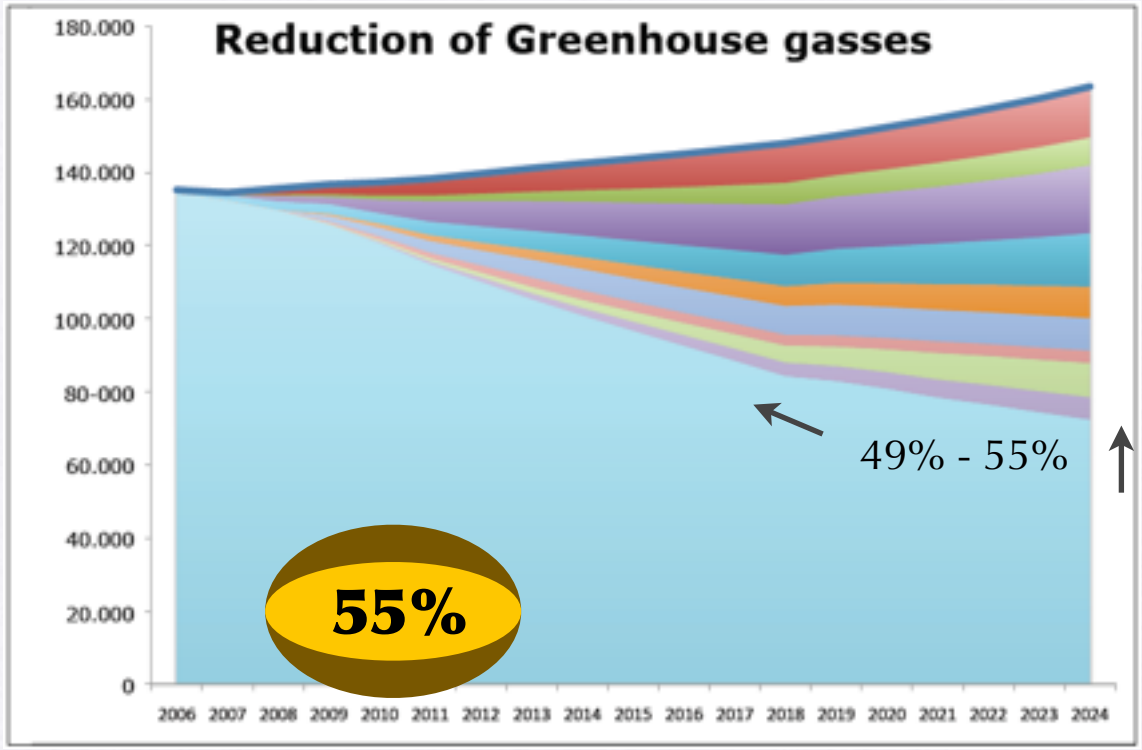
Covenat of Mayors Action Plan

Actions: COM projects

Solrod: The action plan (Covenant of Mayors)

Greenhouse gas reduction in short (2014) and long term (2025):

- Starting point: **143.800 tons**
- Without doing nothing: **161.700 tons** (in 2025)
- Goal for 2025: **72.800 tons** (in 2025)



Reduction of greenhouse gases
Solrød Municipality (whole)

Emissions in 2007:	**143,800 tons**
Business as usual:	**161,700 tons**
Reduction:	
Objective:	
Emission in 2025:	**72,800 tons**
Reduction 2007-2025:	**61,100 tons**
Achieved reduction:	
From 2007-2016:	**52,028 tons**
Hereof the biogas:	**41.400 tons**
Missing:	
Period 2017-2025:	**9.072 tons**

The development

Triple helix - creation of local involvement

- Authority (municipality)
- Enterprises (energy, etc.)
- Knowledge institutions

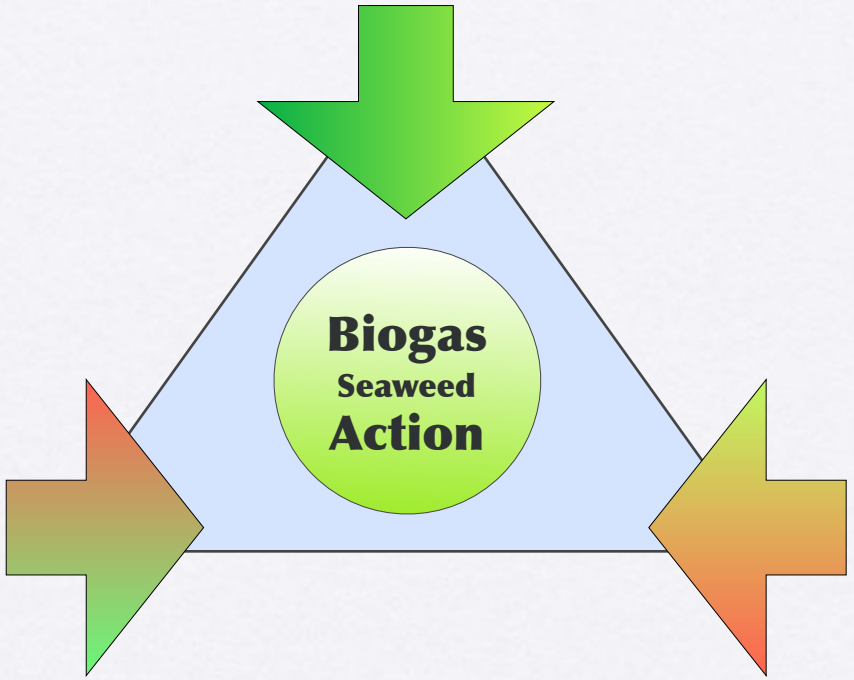
Triple helix:
- not created in advance
- but developed through the proces

See the **timeline** and the Involvement schemes at next page:

The municipality

Three main roles

- Authority
- State Representative
- Entrepreneur
- Energy producer and consumer



Companies

- Private companies
- Municipal company
- Associations

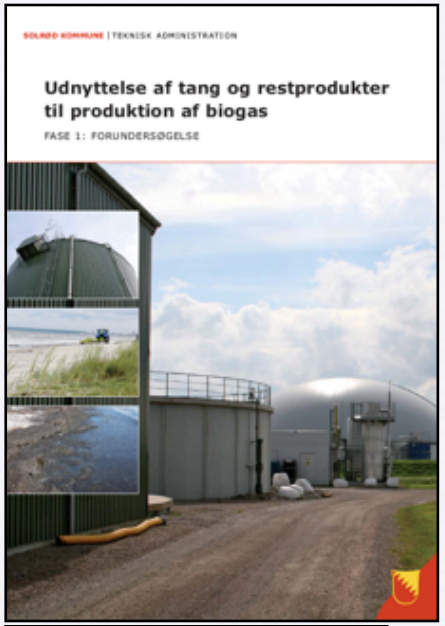
Knowledge

- Knowledge institution
- Advisors
- R&D institutions (universities, etc.)

Process and flow - biogas Solrød

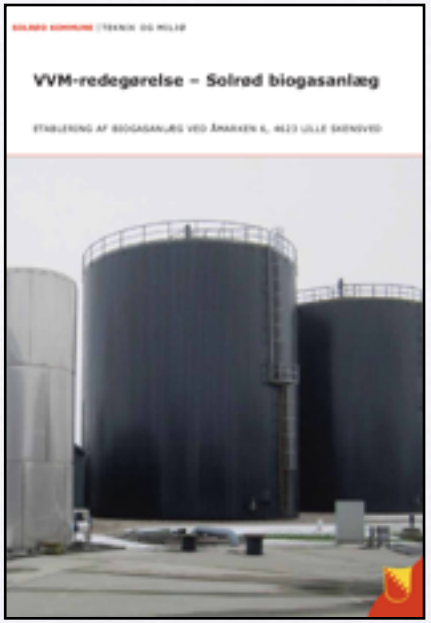
From feasibility to plant

Phase 1



Feasibility study 2010

Phase 2



EIA, Permit, local plan 2011-12

Technical assistance 2012-2014

Phase 3

Solrød Biogas plant
Building period
2014-2015

Organized as a **limited company** owned by the Solrød Municipality

Operated with an private company Bigadan

Fase 1 - Feasibility studies

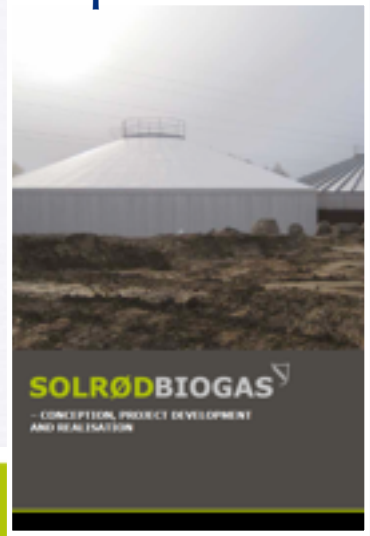
Fase 2a - public approvals

Fase 2b - design & tender

Fase 3 - Construction

Public private partnership - From public to private

The development



The flow - biogas plant

From feasibility to plant

The proces organized in three phases

Phase 1

Initial phase

- possible ideas
- possible potential
- possible needs
- determination of cooperative relationships

Completed for the mentioned project proposals

Next phase →

Phase 2

Project development

- Specification of plant design
- Permits and regulatory approvals:
  - The Danish Planning Act
  - The Danish Environmental Protection Act
  - The Danish Heat Supply Act, etc.
- Supplier contracts (raw materials and output (gas, power, heat, by-products, etc.))
- Ownership – clarification

→ Possible tender → Next phase

Phase 3

Construction contract

- construction of plant
- construction inspection
- initialisation
- guarantees
- etc.

Solrød Biogas Ltd.

PUBLIC-PRIVATE COOPERATION

COMPANY-PRIVATE

Timeline

SolrødBiogas
– helt naturligt

År 2008	2009	2009	2010	2010	2012	2014	2014	November 2015
Years of genes with rotting seaweed on the beach	Local coopera-tion on cleaning the beach	New climate plan in Solrød (55%). Biogas on seaweed	Inital re-search of seaweed. Grants from Regional Fund	Results of survey: Large gas yield. Ad-ditionel biogas surveys	Authority approval 2010-14. Grants from the Regional Fund	Subsidies from the EU for preparing turnkey contracts PDA	Solrød Biogas formed as A/S Contract conclu-ded	Bigadan selected as total contractor plus 5 years operation	The plant completed Official opening Produc-tion starts

Stakeholders
- Creating stakeholder involvement through the planning & constructionprocess

Roskilde University

Research Center Foulum, Aarhus University

CPKelco A HUBER COMPANY

CHR. HANSEN Improving food & health

BIGADAN

BREGENTVED www.bregentved.dk

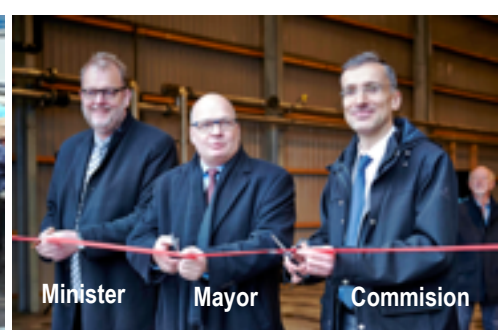
Local farmers pig & cattle

VEKS District heating transmission company

SolrødBiogas – helt naturligt

Operation & Ownership:
- Owned by the Municipallity
- Operated by Bigadan A/S
- Biogas engine owned and operated by VEKS

Solrød Kommune · CPKelco · CHR. HANSEN · VEKS · Landbruget · VÆKSTFORUM SJÆLLAND

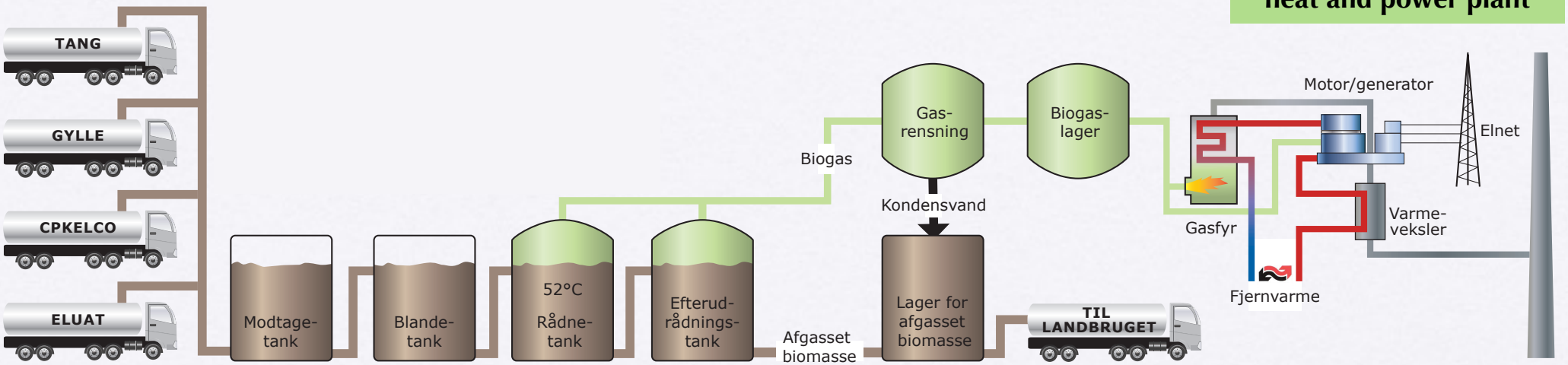


The Biogas plant

Biogas - raw materials

Designed for 226,000 tons

Biogas used in combined heat and power plant



Biomass	Amount (tons)	Biogas	Main contribution
Manure, seaweed, other	51,000	6.0%	Gas production and process stability
CPKelco: Pectin, carrageenan	95,000	59.1%	Gas production
Chr.Hansen: Eluat (BioTech)	60,000	12.6%	Gas production and nutrients
Biopulp (organic waste)	20,000	22,3%	Gas production and nutrients
Ialt	226,000		

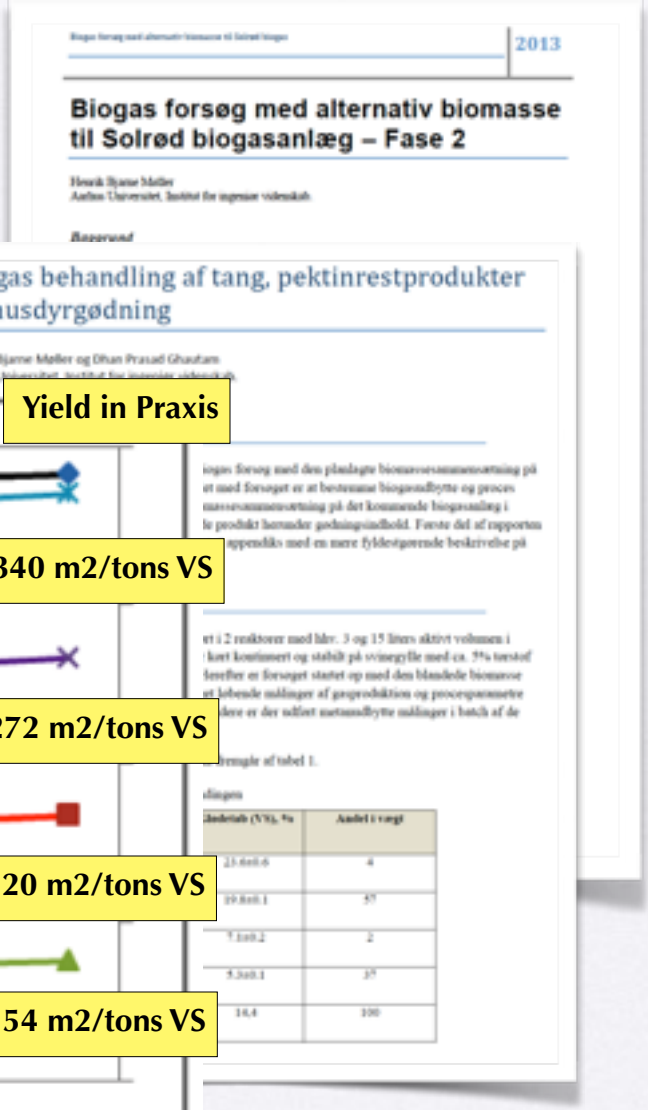
* Eluate from lactic acid production

The Biogas plant

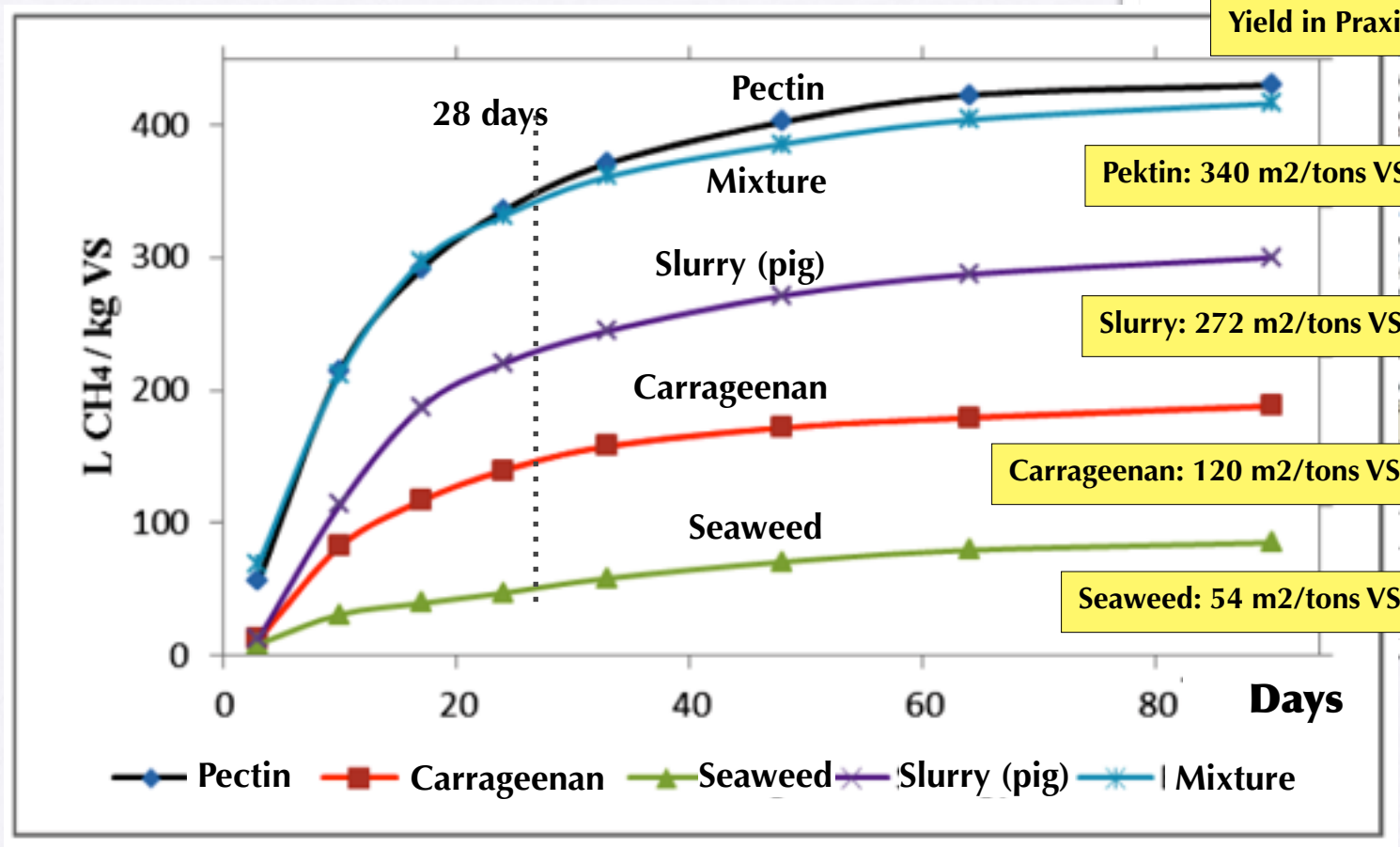
Tests of raw materials

A number of tests has been initiated. Operation assumption:

- 320 m3 of methane per tons of dry matter
- 30 m3 of methane per tons of raw material
- or 1,060 m3 of biogas per hour



Yield in Praxis



Pektin: 340 m2/tons VS

Slurry: 272 m2/tons VS

Carrageenan: 120 m2/tons VS

Seaweed: 54 m2/tons VS

The Biogas plant

Supplies

Landbruget skal levere gylle og aftage afgasset biomasse fra Solrød Biogas

Solrød Kommune CPKelco CHR. HANSEN VERS Landbruget

CPKelco skal levere restprodukter fra pektinproduktionen til Solrød Biogas

rød Kommune CPKelco CHR. HANSEN VERS Landbruget

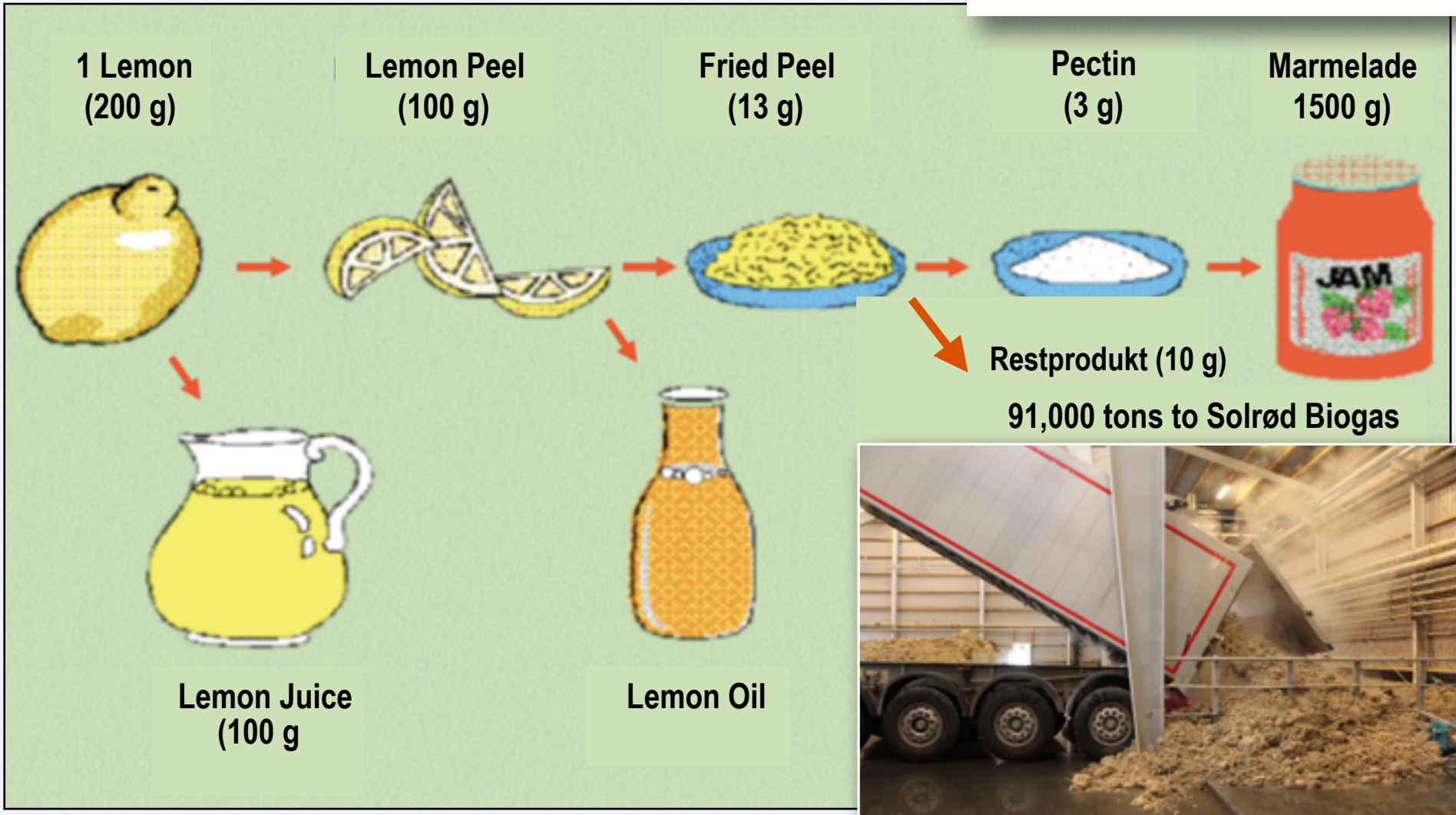
SolrødBiogas
- helt naturligt

The Biogas plant

CPKelco
A HUBER COMPANY

Supply from CPKelco

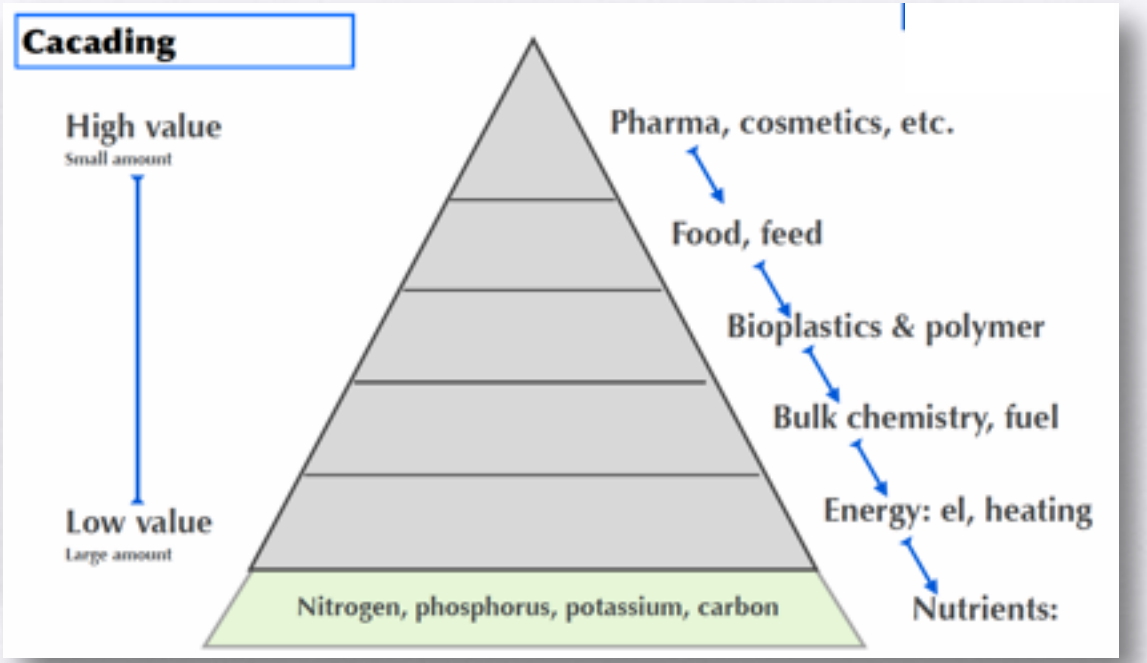
Nature-based ingredient



The Biogas plant

Cascading and circulating

Lemon juice Lemon oil	+	Pektin	+	Biogas
Input: 2.140.000 tons Production 1.070.000 Waste: 1.070.000		Input: 1.070.000 tons Production 32.100 Waste: 107.000 (dried waste)		Input: 107.000 tons Production 7.6 mio m3 metan Waste: 0



If not cascading:

- Use of resources: 3.317.000 tons - or 55% more rawmateriale
- Produced waste: 1.177.000 tons, compared with 0 (zero)

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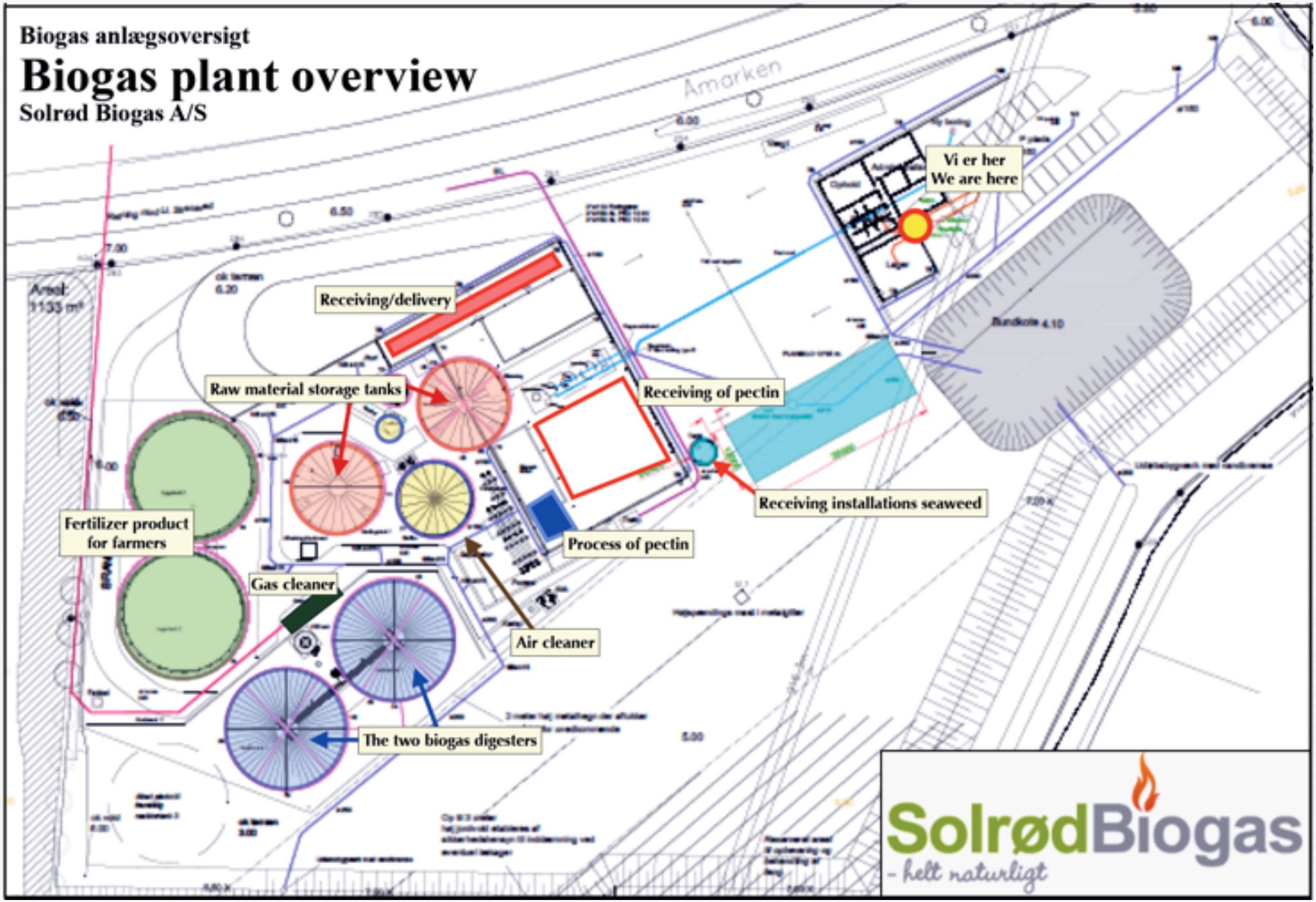
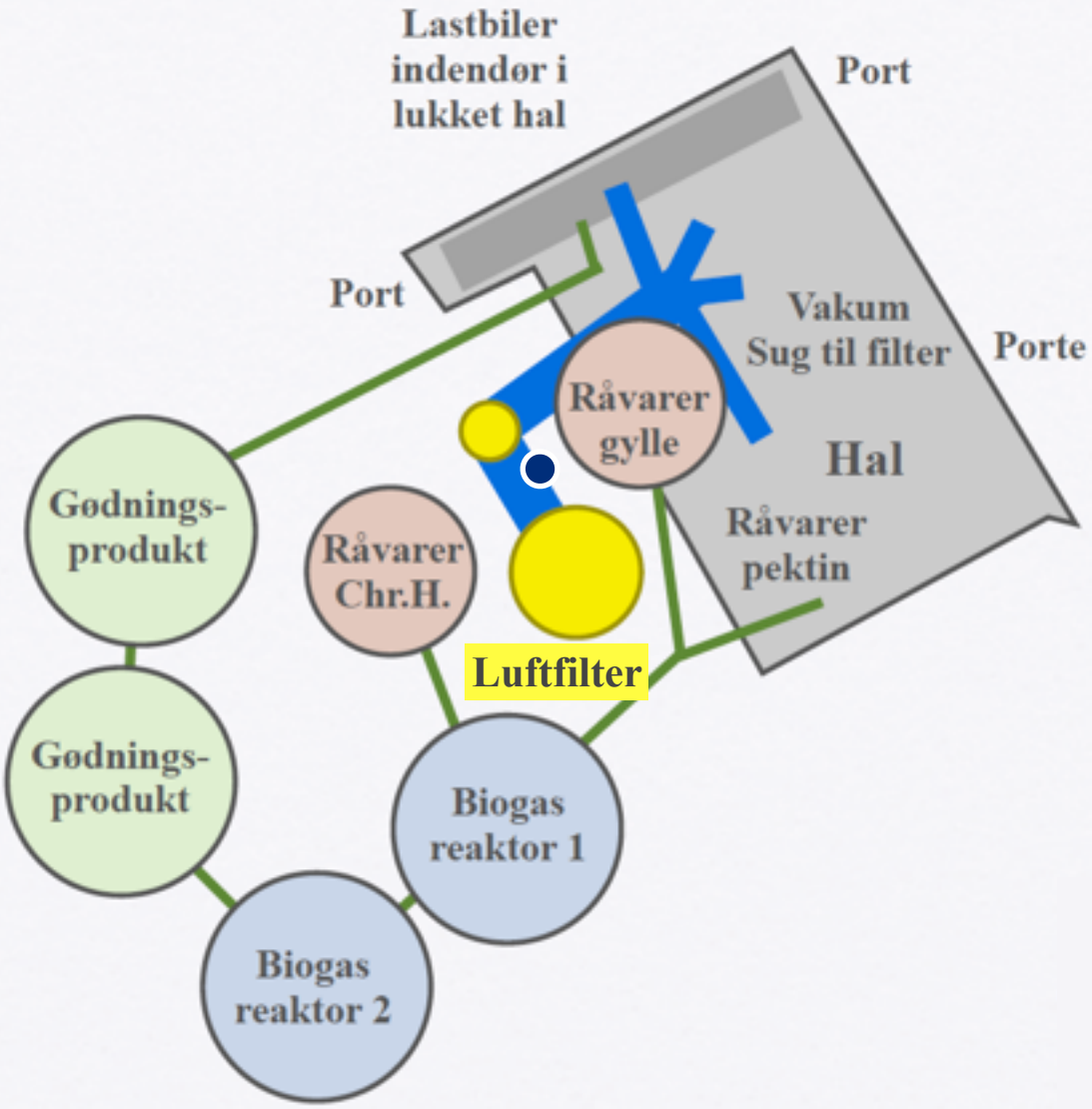


The Biogas plant

The Biogas plant Fight against odor



Vakum in the halls, so all the bad air is pumped to air filter

Alle tankene er lufttætte
Testes løbende samt årligt
gennem specialundersøgelser
(lugt og metantab)

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The biogas plant

Fuel: Going from abroad to the hinterland

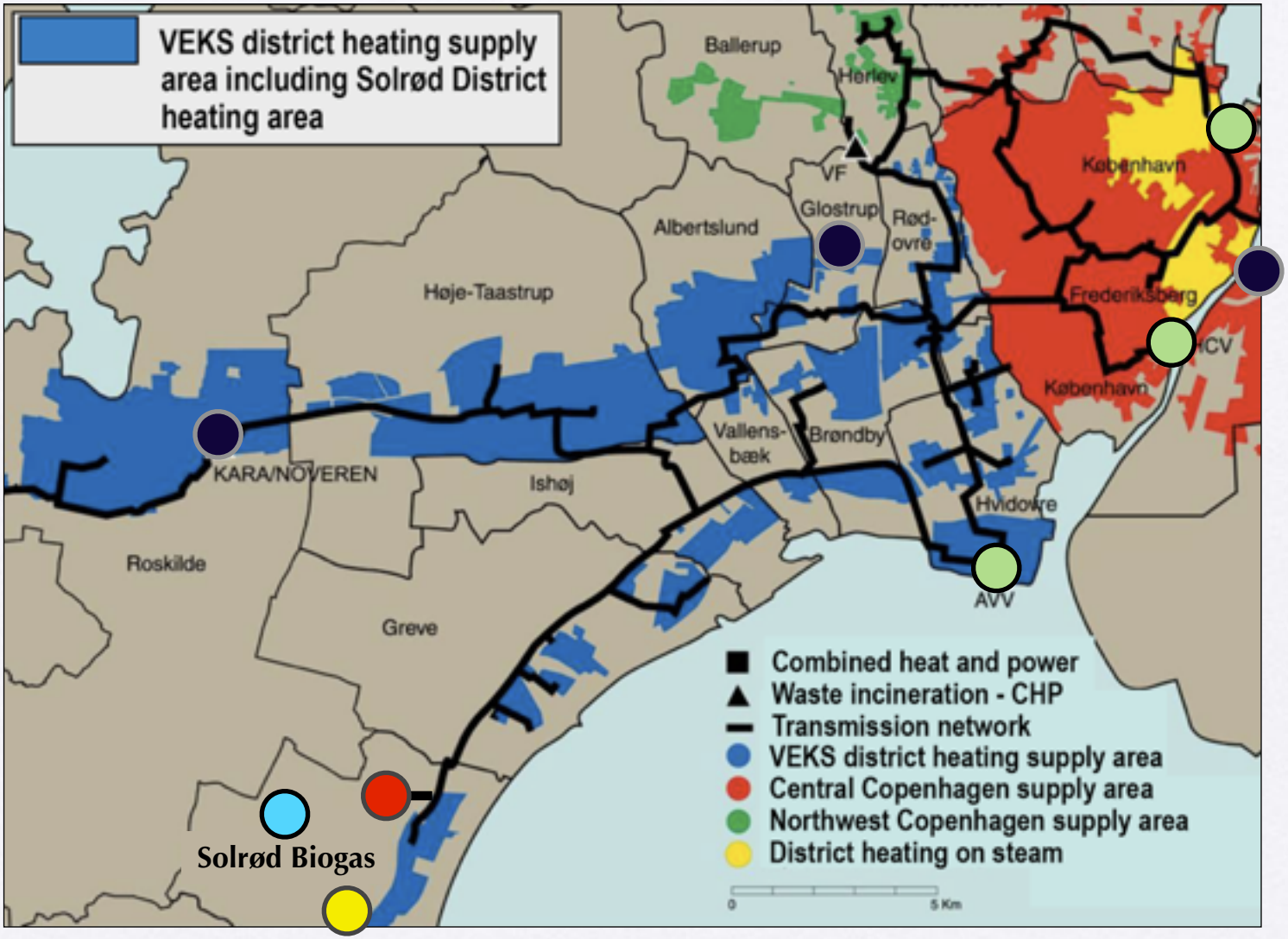
An example - district heating system

Goal from 68% fossil today to 0% in 2025

New heat sources
- CHP Køge (wood)
- Biogas Solrød
- Wood pellets on power plants
- Industrial sources

30%

more district heating



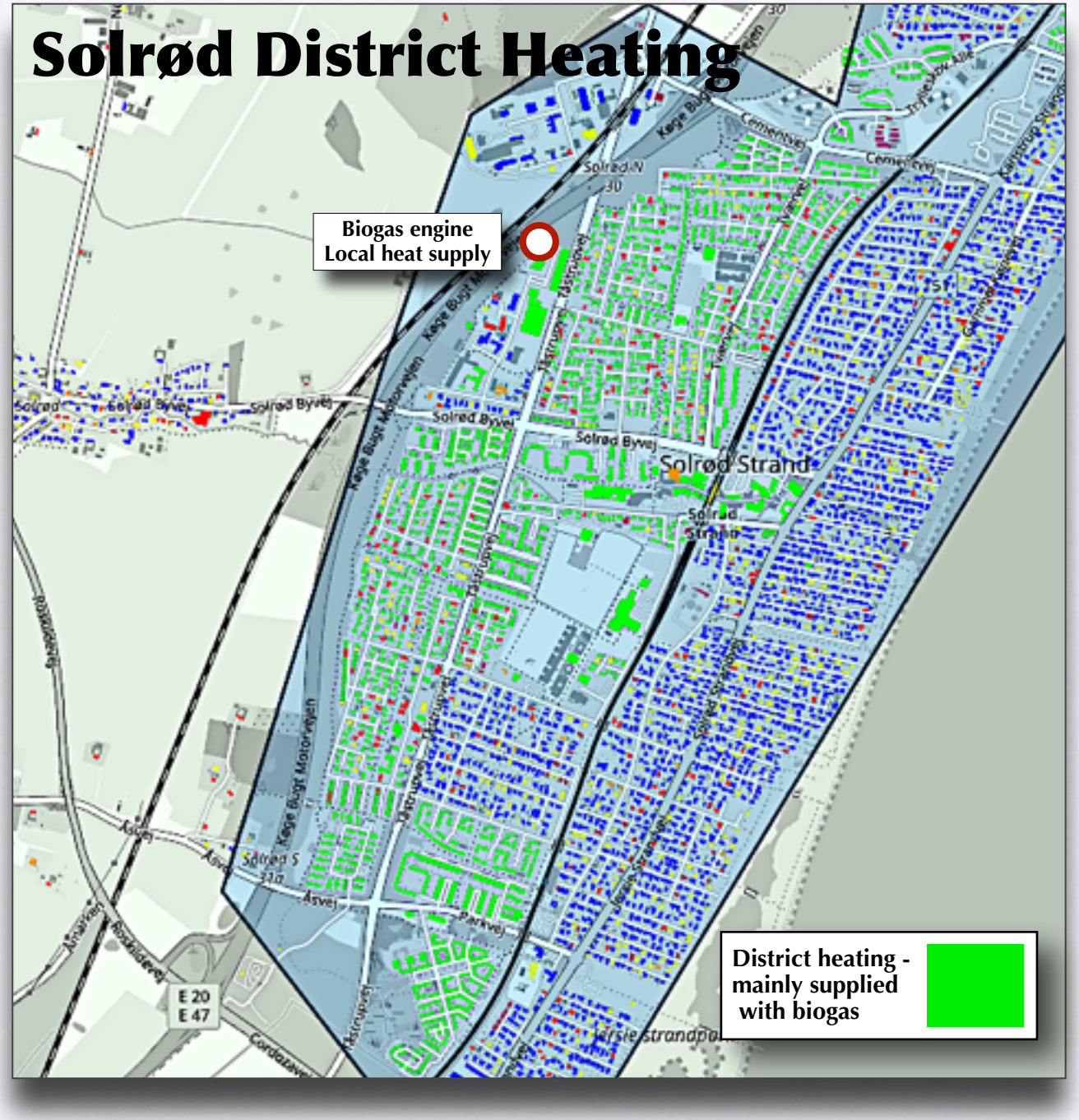
The biogas plant

Local heat supply and regional electricity supply

Local heat supply
~ 27.400 MWh
See the green areas

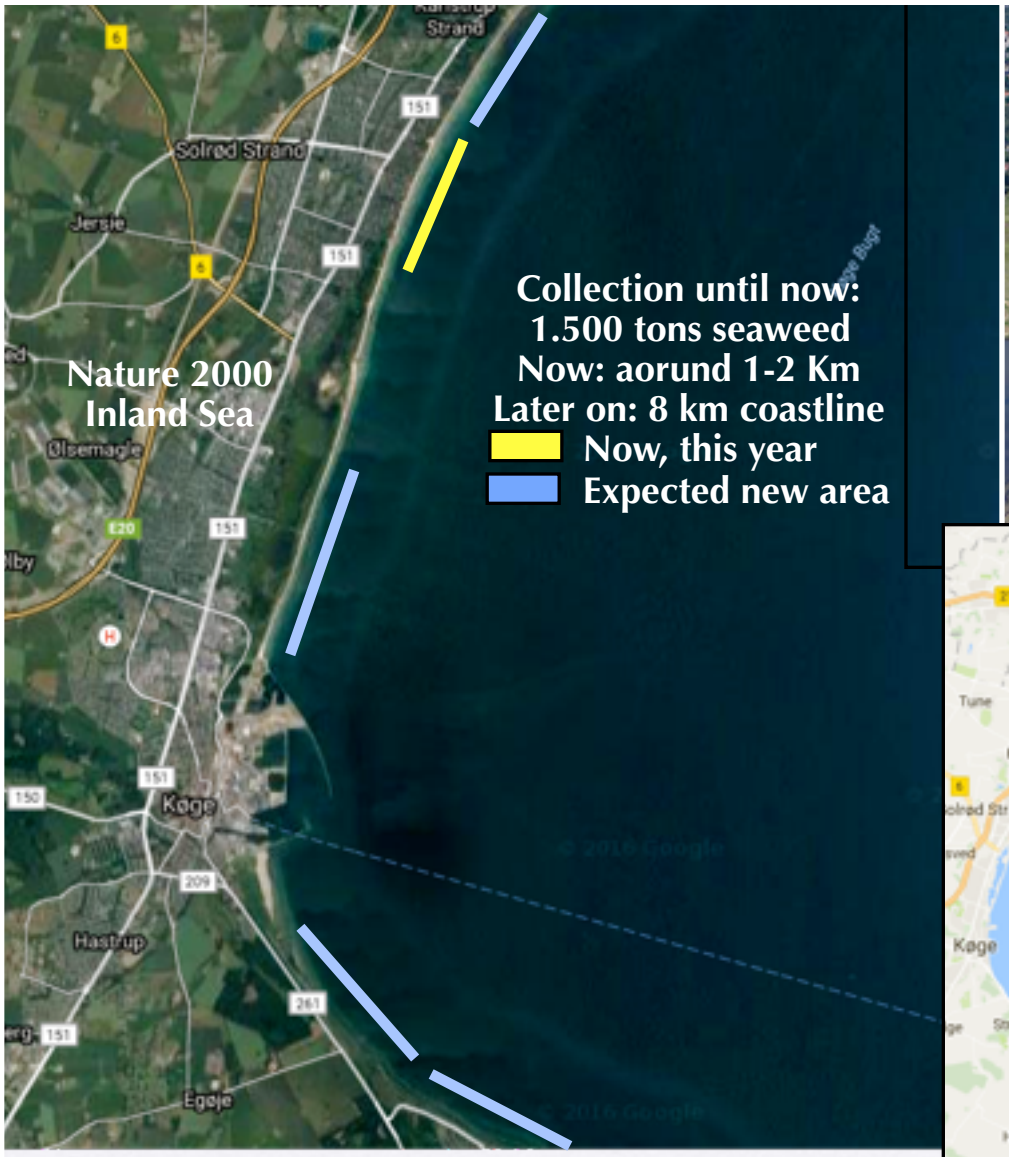
Actual greenhouse effect:

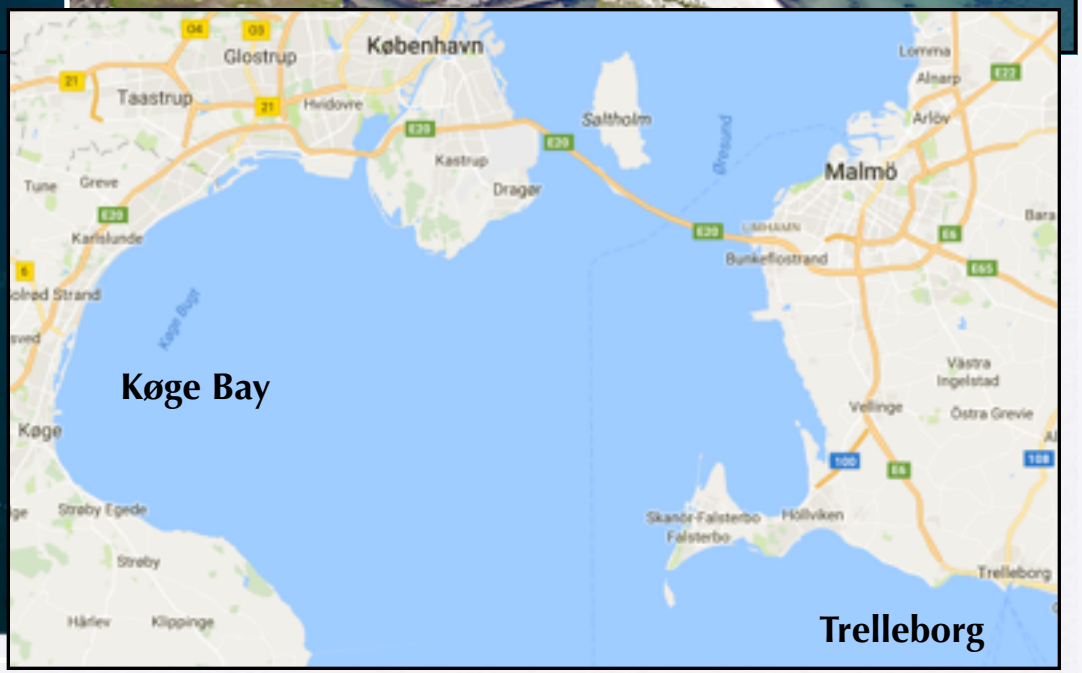
Reduction:	46.000 tons/Year
Herof:	
Electricity:	21.000 tons/Year
Heat/biogas:	12.100 tons/Year
Fertilizer:	7.800 tons/Year
Organic waste:	7.700 tons/Year
Negative:	÷ 1.700 tons/year



Raw materials

Seaweed - Collection area





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Current solution

Three steps in the collection

First step
The seaweed on the beach is collected with a grab and thrown into the water's edge to reduce the content of sand

Second step
The seaweed are picked up with a grate grab

Third step
The seaweed are transportet to the plant - as fresh as possible

Local company

Three steps in the collection

The first step
The seaweed on the beach is collected with a grab
and thrown into the water's edge
to reduce the content of sand

Three steps in the collection

The second step

The seaweed are picked up with a grate grab

Three steps in the collection

The third step

The seaweed are transportet to the plant -as fresh as possible

Collection of seaweed

Seaweed - The new methods

Supplier: Solrød Strand Beach Cleaning Laug

Delivery requirements:
Cadmium and other below limit values
No visible plastic, metal and big stone
Sand maximum of 60% of dry matter

Actual collection - Continuous collection - three steps
- Experiments with a variety of methods

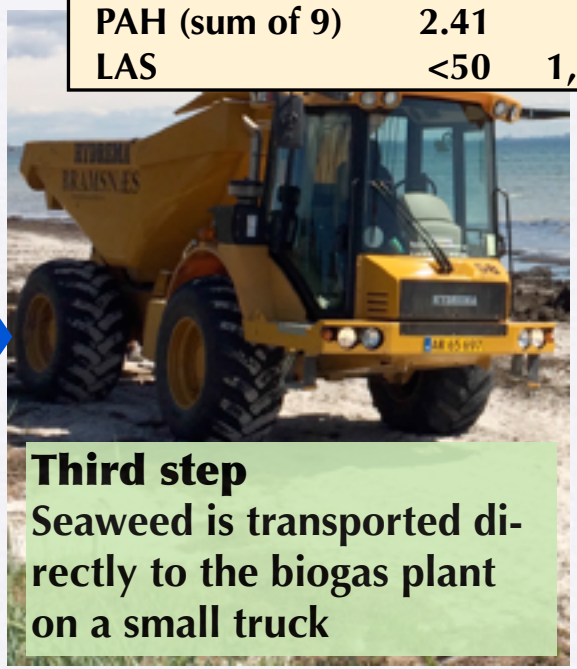
Measurement

2009-2013 - mg/Kg dry matter

Parameters	Average	Limit value
Nitrogen, total	46,340	Non
Phosphor, total	732	Non
Leed (Pb)	<3.58	120
Cadmium (Cd)	0.52	0.80
Chromium	<2.40	100
Mercury (Hg)	<0.01	0.80
Nickel (Ni)	3.5	30
Zinc	38	4,000
DEHP	<0.50	50
Nonylphenol	0.64	10
PAH (sum of 9)	2.41	3
LAS	<50	1,300

First step
Seaweed on the beach is collected and thrown back to the sea (beachfront) to reduce the content of sand

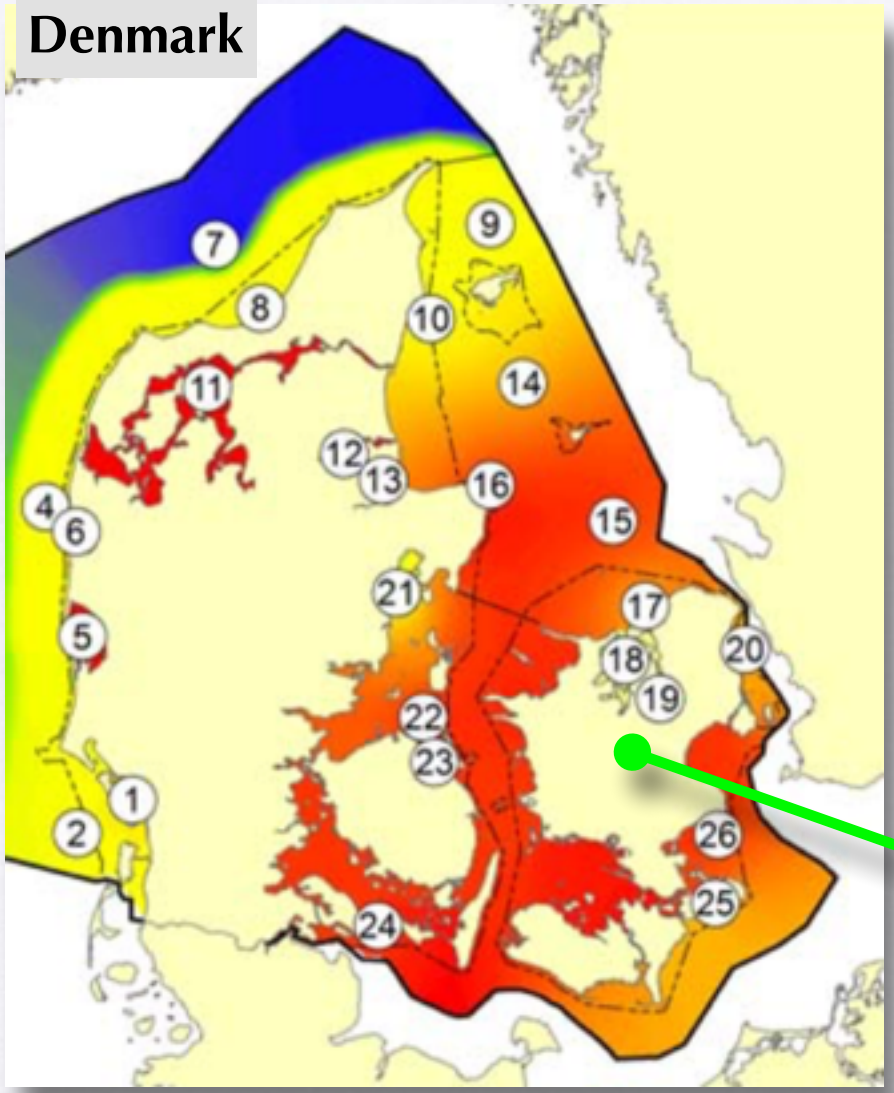
Second step
The seaweed is picked up in the water with a reduced content of sand

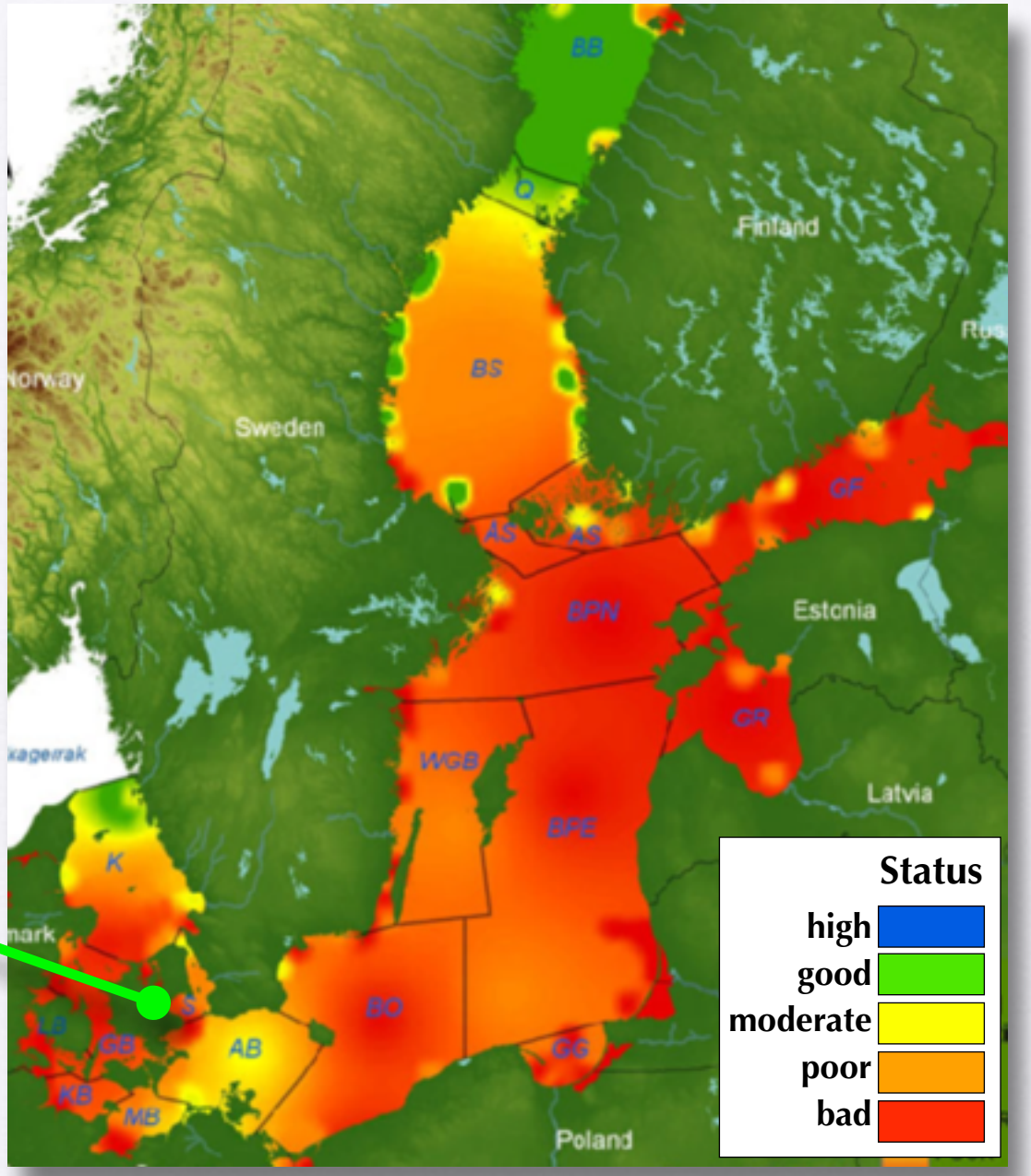


Third step
Seaweed is transported directly to the biogas plant on a small truck

Eutrofication - Baltic Sea

Agriculture, industri, etc.





Nutrients recovery - Baltic Sea

The seaweed collection as cost effective solution

Expected fertilizing value
Around 65%-70%
(due to lower bioavailability of N)

Nutrients extraction through seaweed

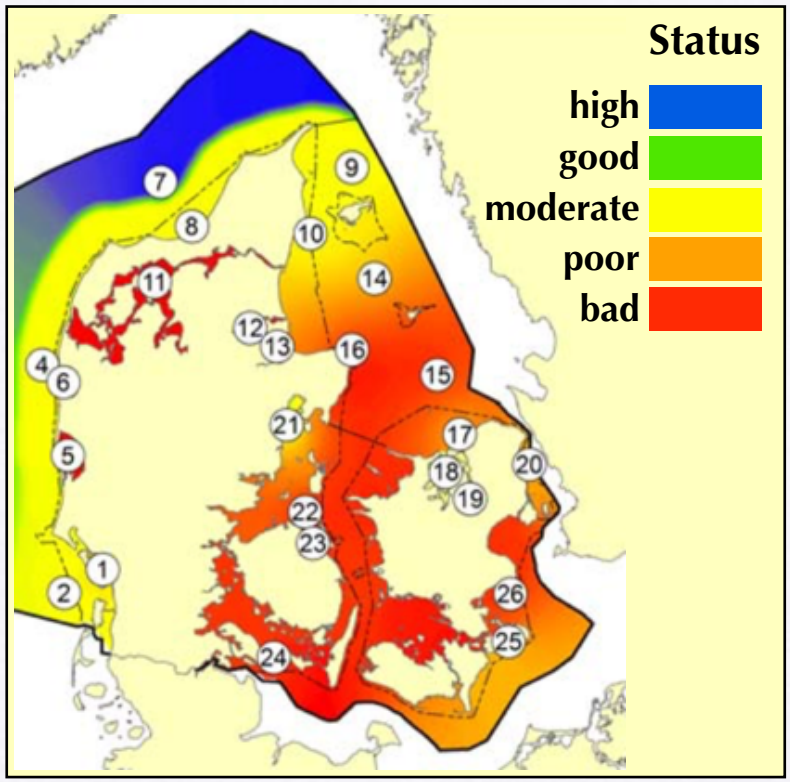
N and P emissions
Agriculture
Natural background
Fish farm Aquaculture
Waste & rain water
Industry

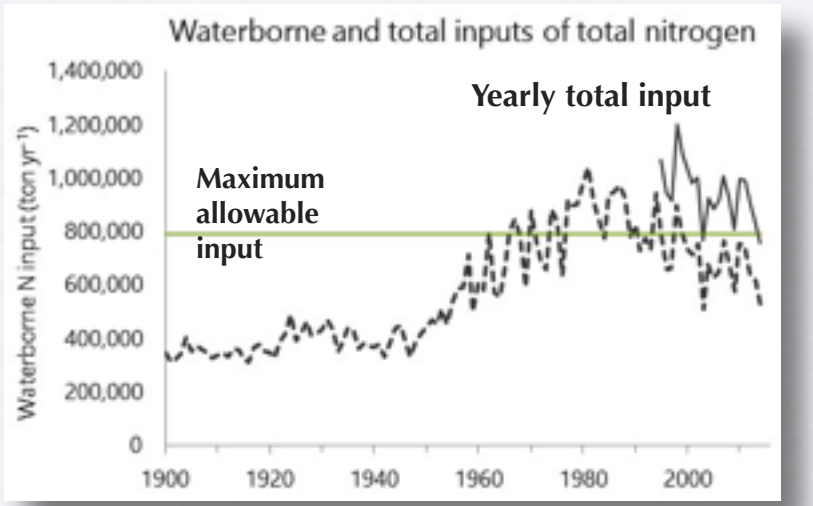
Seaweed
grown in the sea water

N-bioextraction
23.6 - 46.3 kg/tons dry

Nutrients emission supply

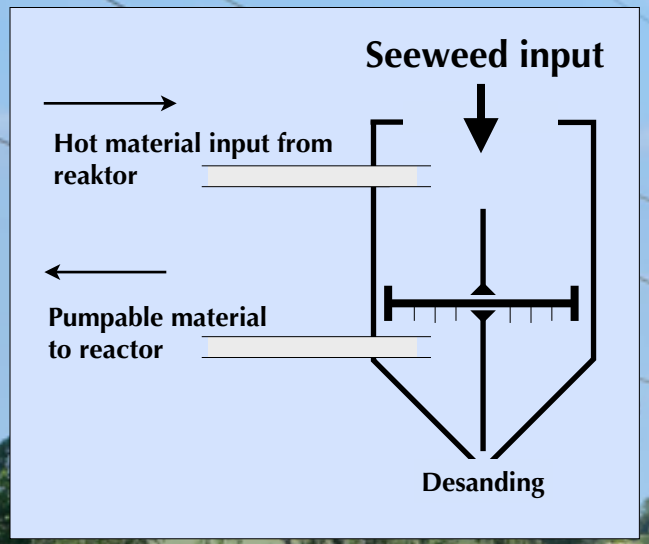
800,000-1,200,000 tons /year
Critical - more than 800,000 tons





Treatment at the biogas plant

[1] Seaweed is put in a tank with very strong stirrer.
[2] The stirrer separates sand and seaweed
[3] The sand is removed from the bottom of the tank.
[4] Seaweed is decomposed and diluted with additional material from the biogas reactor to make it pumpable and pumped into the biogas reactor

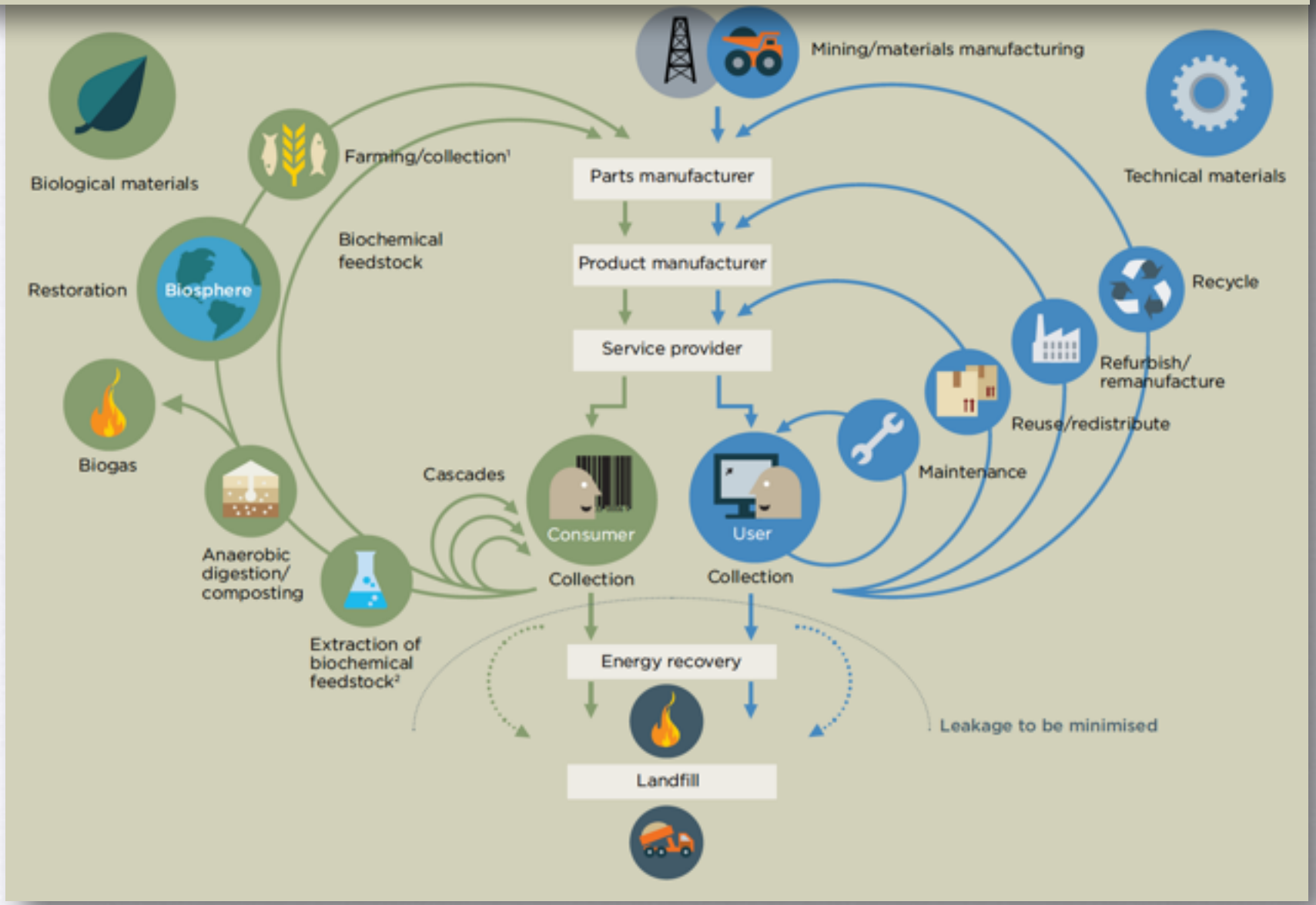


Collection of seaweed

The same day - after ....

The biogas plant

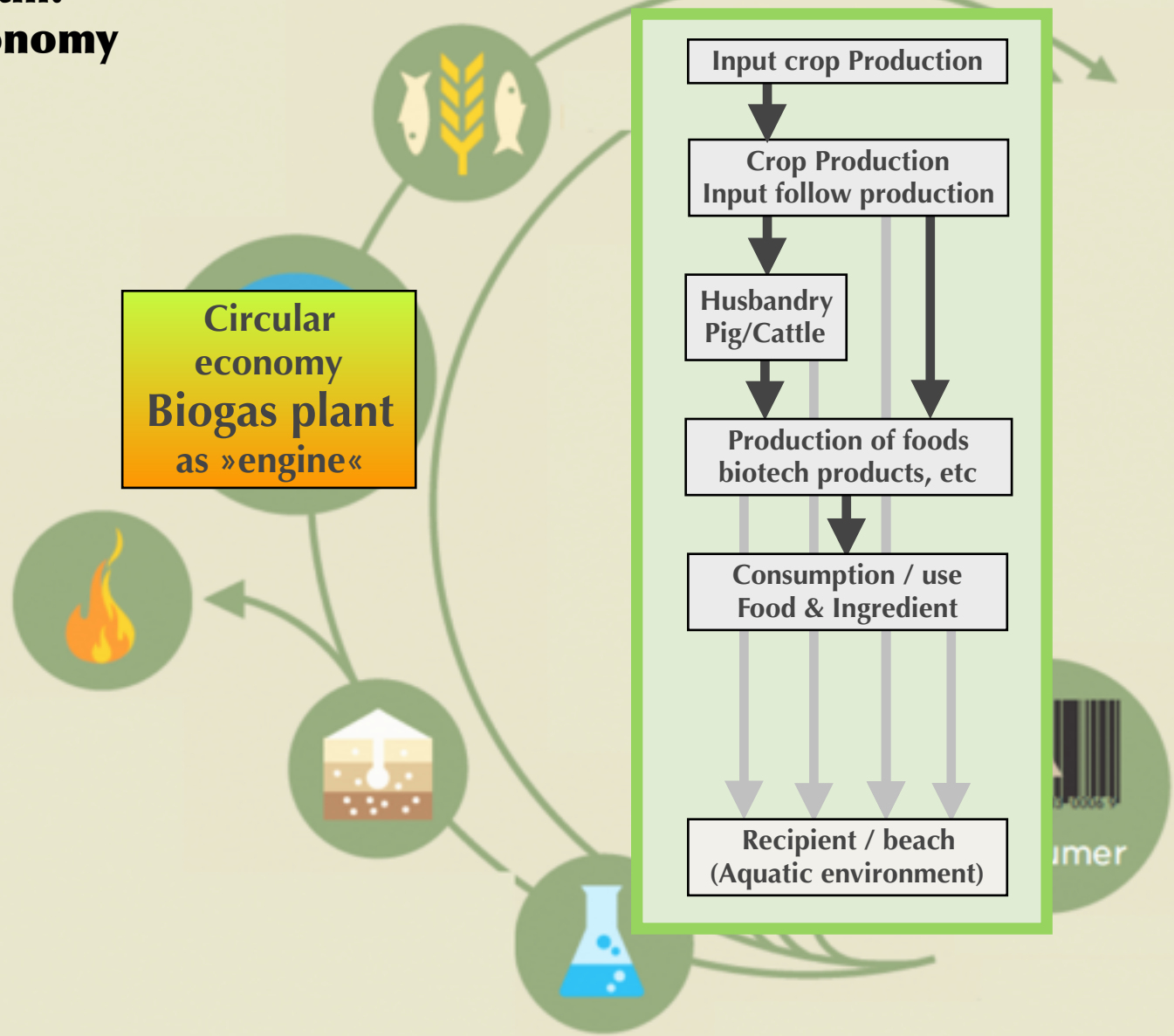
The circular economy



The biogas plant

The circular economy

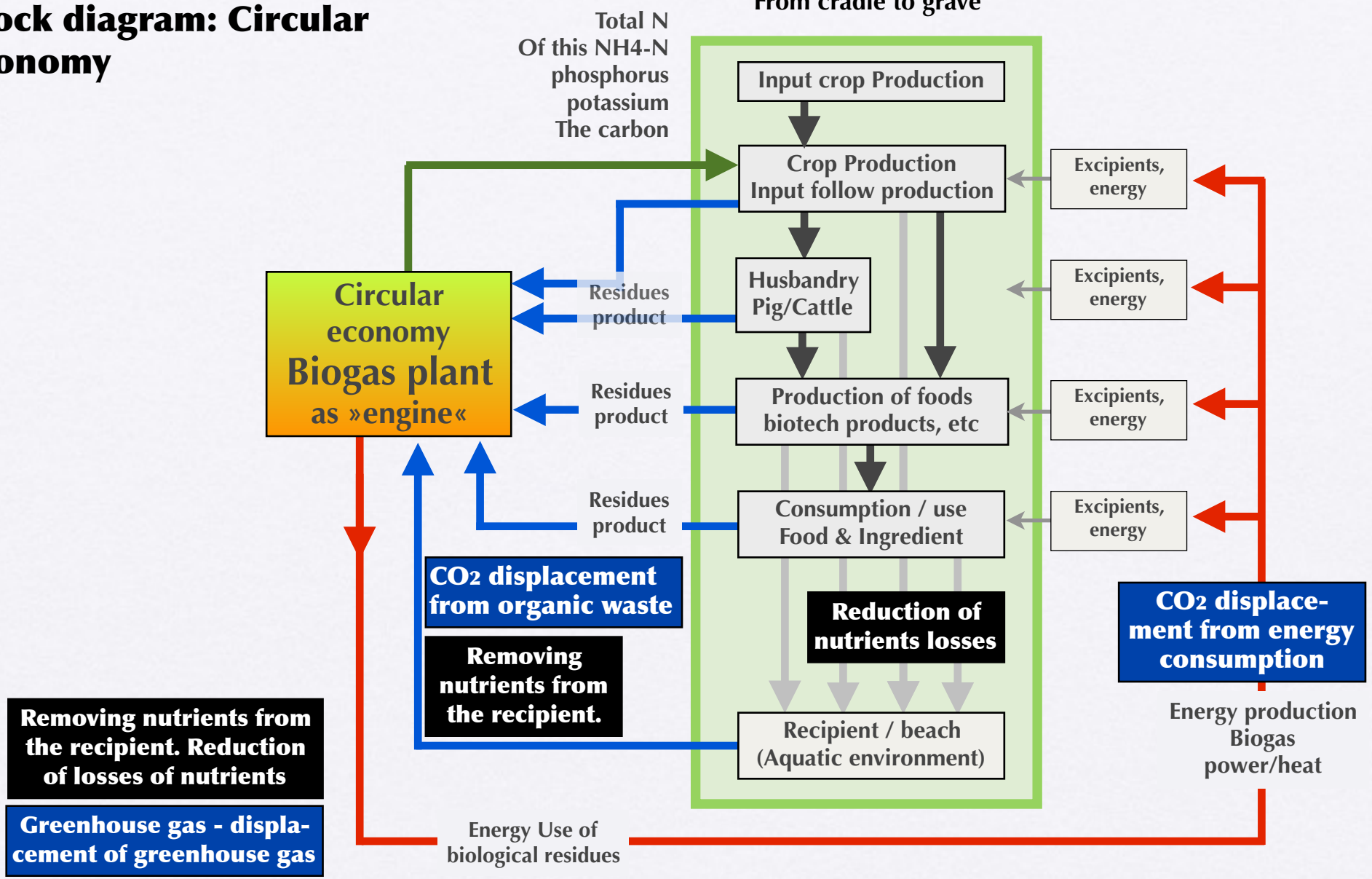
Block diagram: Circular economy



The biogas plant

The circular economy

Block diagram: Circular economy



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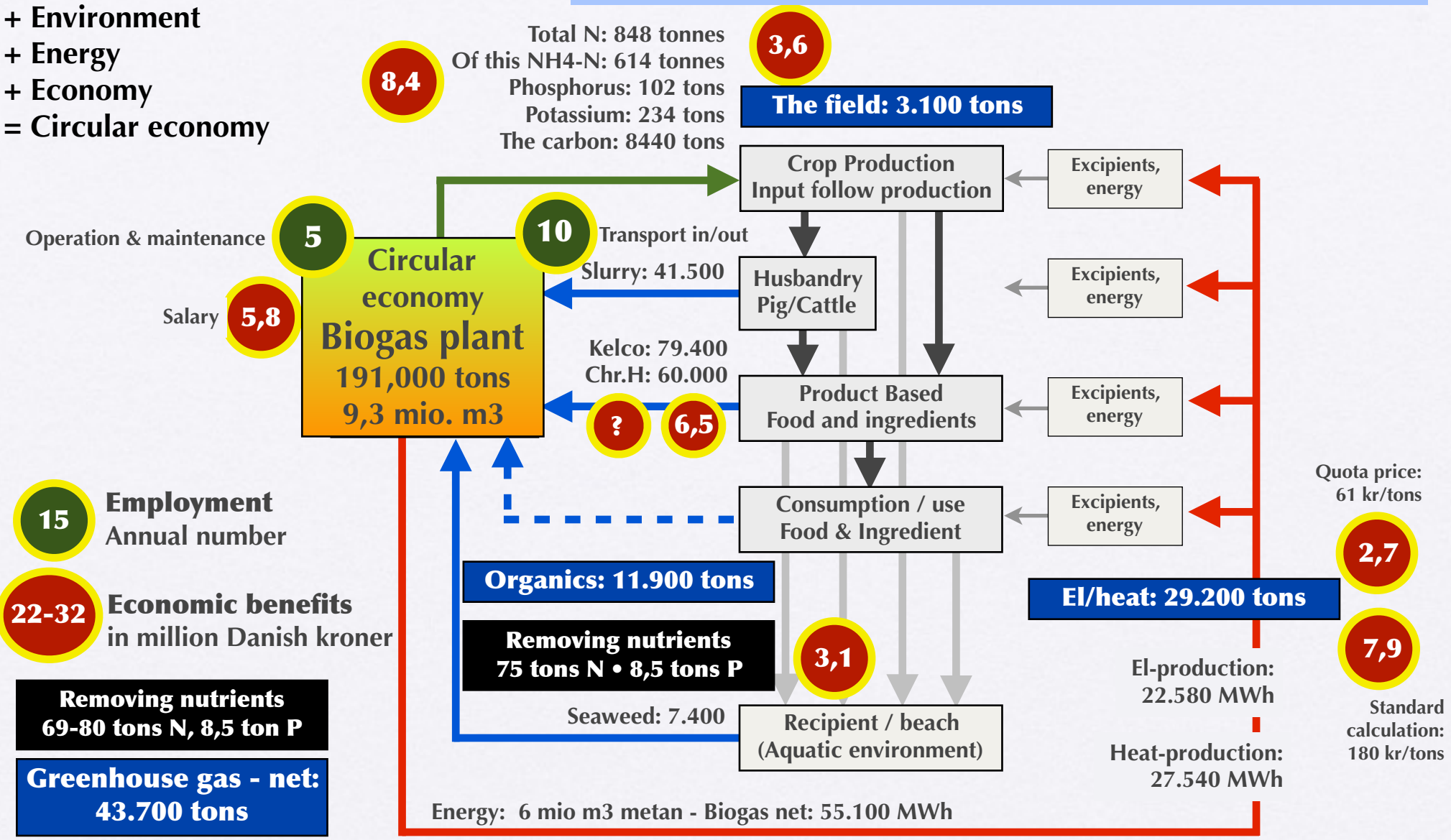
The biogas plant

Solrød Biogas

+ Environment
+ Energy
+ Economy
= Circular economy

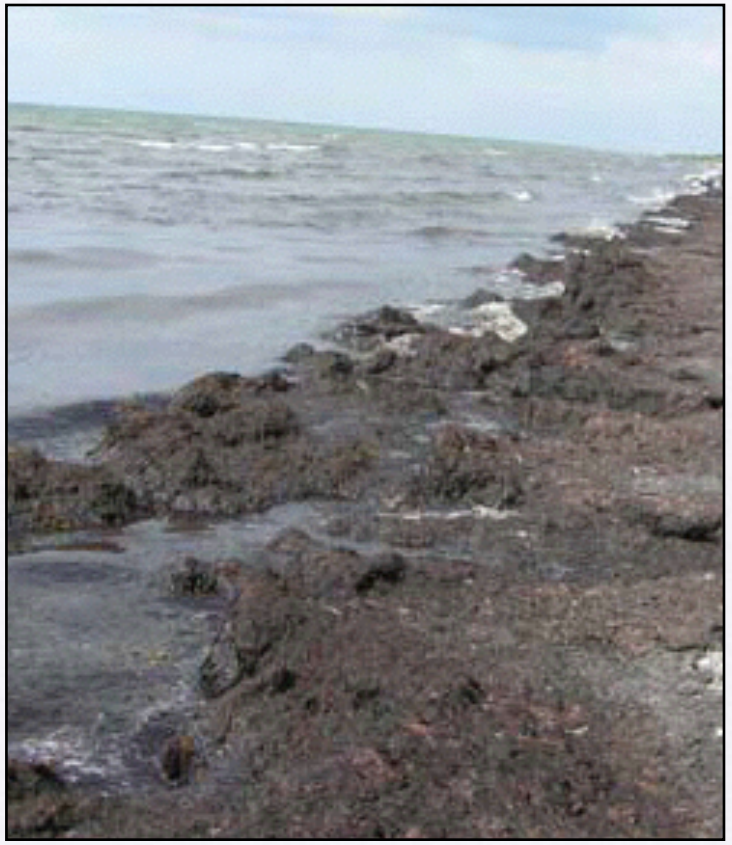
Turnover (sales) in the facility: 35 million kr
Figures from 2018 accounting



The biogas plant

Benefit of the biogas plant

Win-win situation



First of all: Production of renewable energy

Local benefits form the biogas plant:

- **Odors:** Solve problems with odors from seaweed & algae by removing the seaweed and use it in a biogas plant
- **Climate:** Contribution to solve the climate problem: Using seaweed and organic waste from Kelco in a biogas plant will contribute to reduce the use of fossil fuels in the energy consumption in the area
- **Nutrients:** Contributing to solve problems with marine pollution. Removing the seaweed of the Køge Bay will diminish the load of nutrients, which today is a major problem of the aquatic environment
- **Fertilizer:** Contribute to useful nutrients. The residues from the gas plant will be used for fertilizer to replace chemical fertilizer.

Company benefits form the biogas plant:

- Two of the involved companies will benefit from use of more renewable energy, because of the restrictions caused by CO_2 allowances and energy taxation
- And all companies will of course also benefit from community reputation from their contribution to mitigate the greenhouse gasses

The biogas plant

Comparison: Compared to same net production

Sammenligning

Solrød Biogas ≈ Coalfired powerstation Amagerværket, Hofor Copenhagen

Solrød Biogas		Coal power Hofor Amagerværket	
Input energy:	53.100 MWh	Input energi:	109.400 MWh
Production:	50.040 MWh	Production:	50.040 MWh
Efficiency:	94%	Efficiency:	46%
Raw materials:	waste/residues	Raw materials:	coal
Water consumption:	0 tons	Water consumption:	31.120 tons
Residues:	185.000 tons	Residues:	2.070 tons
in dry matter:	14.800 tons	in dry matter:	1.160 tons
Used as fertilizer:	100%	Used in cement (fly ash):	55%
Greenhouse gas:	÷ 43.700 tons	Greenhouse gas:	24.340 tons
Recycled carbon:	8.440 tons	Recycled carbon:	0 tons
Recycled nutrient:	1.180 tons	Recycled nutrient:	0 tons
Externality costs:*	**+ 1,1 mio $**	Externality costs:*	**÷ 4,1 mio $**

*) Water, landfilled waste and greenhouse gases

Washington visit to Solrød Biogas

Solrød Biogas A/S

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Thank you for your attention