Visits from the United States
Prosperity from Sustainable Infrastructure and Energy
Sustainable energy - Biogas

AGRO BUSINESS PARK

Agro Business Park
Project Manager, Michael Støckler
Foulum, 19th. September 2019

Program of the visit:

- **9.30 Presentation of Agro Business Park, BGG**
- **10.30 Transport**
- **10.45 Aarhus University – biogas plant and upgrading**
- **11.50 Transport**
- **12.00 Lunch at Aarhus University canteen**
- **12.50 Transport**
- **13.00 Aarhus University – biorefining green biomass**
- **14.00 Departure to Copenhagen via Skanderborg**

Presentation of:

- **Agro Business Park**
  - **Inbiom (Innovation Network for Biomass)**
  - **DBN (Danish Biogas Network)**
- **Biogas production in Denmark**
- **Biogas Go Global**

Agro Business Park – Accelerator of technologies and companies within the bioeconomy

15 years of experience turning knowledge into business within the biobased economy (agriculture, food, bioenergy & environmental technologies) in unique facilities

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Agro Business Park anno 2019

25 employees in 4+ locations operating 3 start up environments

Creating growth and jobs via unique concept

Agro Business Park

Incubation	Innovation	Investment
- 62 start ups and SME´s in 3 own environment – both start ups and established companies within the agro sector	- 35 ongoing projects – both regional, national and international	- 8 active investments

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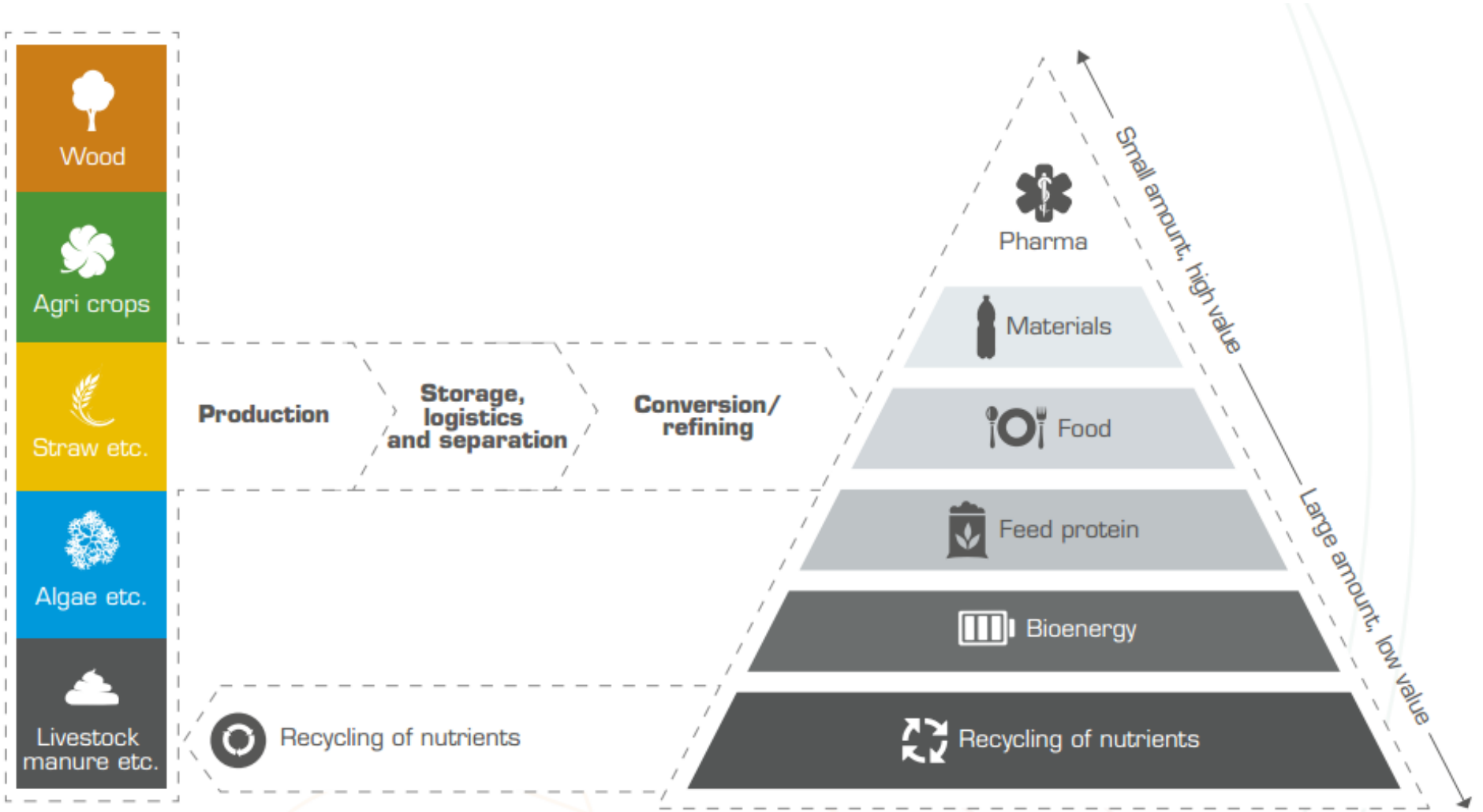
International activities

INBOM is your connection in the Danish bioenergy sector:

We can:

- Provide you with new knowledge from Denmark
- Help you find Danish technologies
- Identify potential business partners in Denmark
- Find relevant scientists and researchers depending on your interests
- Put together meeting programs
- Organize visits and tours to Danish biomass/bioenergy/biogas sites
- Provide market reports based on your specifications (Fee)

Our Focus: Bioeconomy - The New Black!



Access to Danish research in Biogas

The world's largest full scale biogas plant for research purposes Aarhus University Foulum in Central Denmark Region.

15 liters → 1200 m3 reactor available for:

- Testing new type of biomasses for biogas production
- Developing new pre-treatment- technologies
- Biogas upgrading tests

AARHUS UNIVERSITY

Opportunities to cooperate through various types of funding

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Ministry of Higher Education and Science – Denmark

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INNOVATION NETWORK FOR BIOMASS

Denmark – Incentives for biogas production

The current development in the Danish biogas production has been achieved through a set of incentives in the environmental-, agricultural- and energy regulation, including:

- Dedicated governmental support schemes
- Taxes on consumption of fossil fuels
- Restricted use of fertilizer/manure on fields
- Ban on organic waste on land fill since 1998
- Fees for waste treatment
- Dialogue and joint efforts with key stakeholders through follow-up programs and a Biogas Taskforce
- Support for research, development and demonstration of new technologies
- Limit on the use of energy crops in biogas production

Energistyrelsen – Danish Energy Agency

Denmark – Governmental support schemes

The following uses of biogas receive support as stated in the table below:

- Production of electricity
- Upgraded biogas delivered to the natural gas grid or cleaned biogas delivered to a town gas grid
- Use of biogas for process purposes in the industry
- Use of biogas as a transport fuel
- Use of biogas for heating purposes

Energistyrelsen – Danish Energy Agency

Denmark - Biogas subsidy scheme in Denmark

Biogas subsidy scheme in Denmark from 2012	**General subsidy**	**Bonus regulated in relation to the natural gas price**	**Bonus, that is phased out in 2020**	**Total subsidy**
	USD/GJ	USD/GJ	USD/GJ	USD/GJ
Upgrading	12,14	3,99	1,54	17,67
Process	5,99	3,99	1,54	11,52
Transport	5,99	3,99	1,54	11,52
Heat	0,00	3,99	1,54	5,53
	USD/kWh	USD/kWh	USD/kWh	USD/kWh
Electricity				
Fixed price incl electricity price	0,122	0,040	0,015	0,177
Fixed Premium on top of electricity price	0,066	0,040	0,015	0,122

Energistyrelsen – Danish Energy Agency

Danish regulation

Replacement of mineral fertilizer with digestate requires that the digestate can be handled and used in an efficient and safe way.

In Denmark the Ministry of Environment and Food are responsible for the regulation of the use of manure as fertilizer and for implementing relevant EU legislation. The most important regulation is:

- A statutory order regulating manure management from livestock production
- A statutory order regulating the use of fertilizers by agriculture and on plant cover
- A statutory order regulating the use of organic waste as fertilizer on farmland
- The use of residues from animals e.g. slaughter houses is regulated by Danish Veterinary and Food administration

Danish regulation

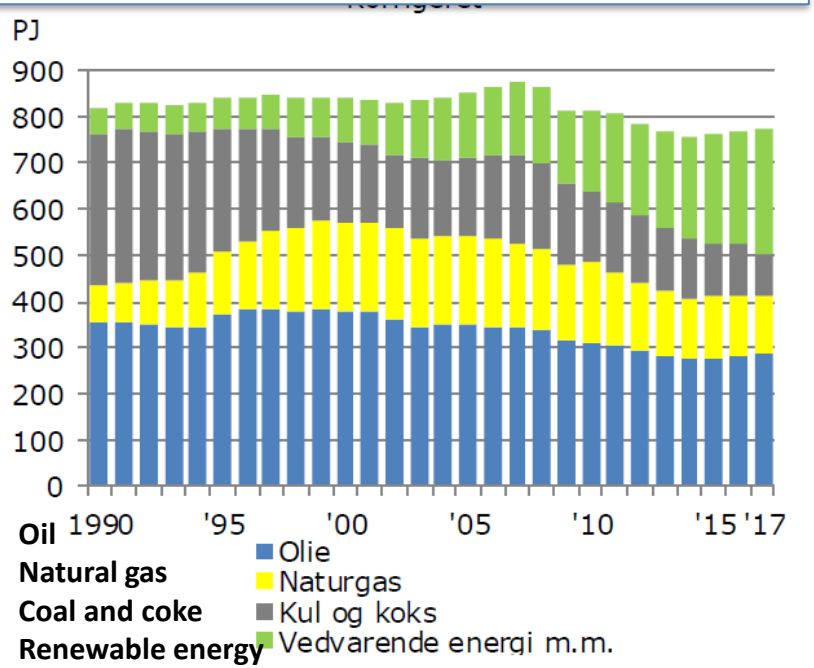
Important elements in this regulation are:

- Livestock manure is allowed to be used untreated on agricultural land.
- Manure and slurry must be stored in tight and covered storage tanks (9 months).
- Nutrients in manure and slurry must be used as fertilizers on crop land.
- Ceilings limit the quantities of N and P per hectare that can legally be applied to agricultural land.
- If a farm has more manure than can be legally applied on the farms own land, there must be a written agreement that the excess manure is allocated to another farm, a biogas plant or an incineration plant.
- Application of liquid fertilizer or degassed biomass must take place with certain technologies in order to avoid odor and emissions
- Application of liquid fertilizer or degassed biomass must take place just before and in the growing season in order to use the nutrients efficiently and avoid leakages

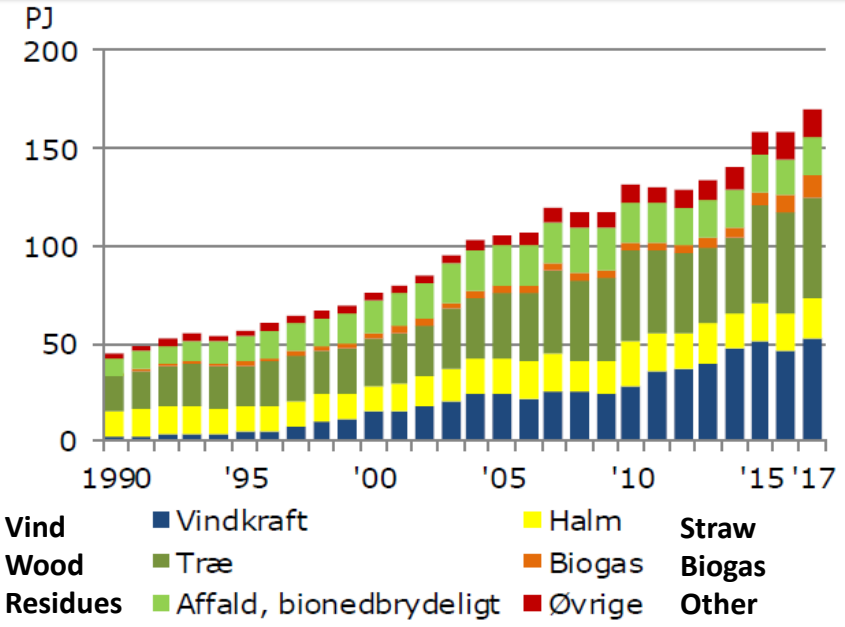
Certain types of organic waste can be applied to farm land without permission, other types need permission. Both have to apply limits for heavy metals, environmentally harmful substances and physical impurities.

Energy consumption in Denmark

Gross energy consumption by fuel in DK



The production of renewable energy by energy products



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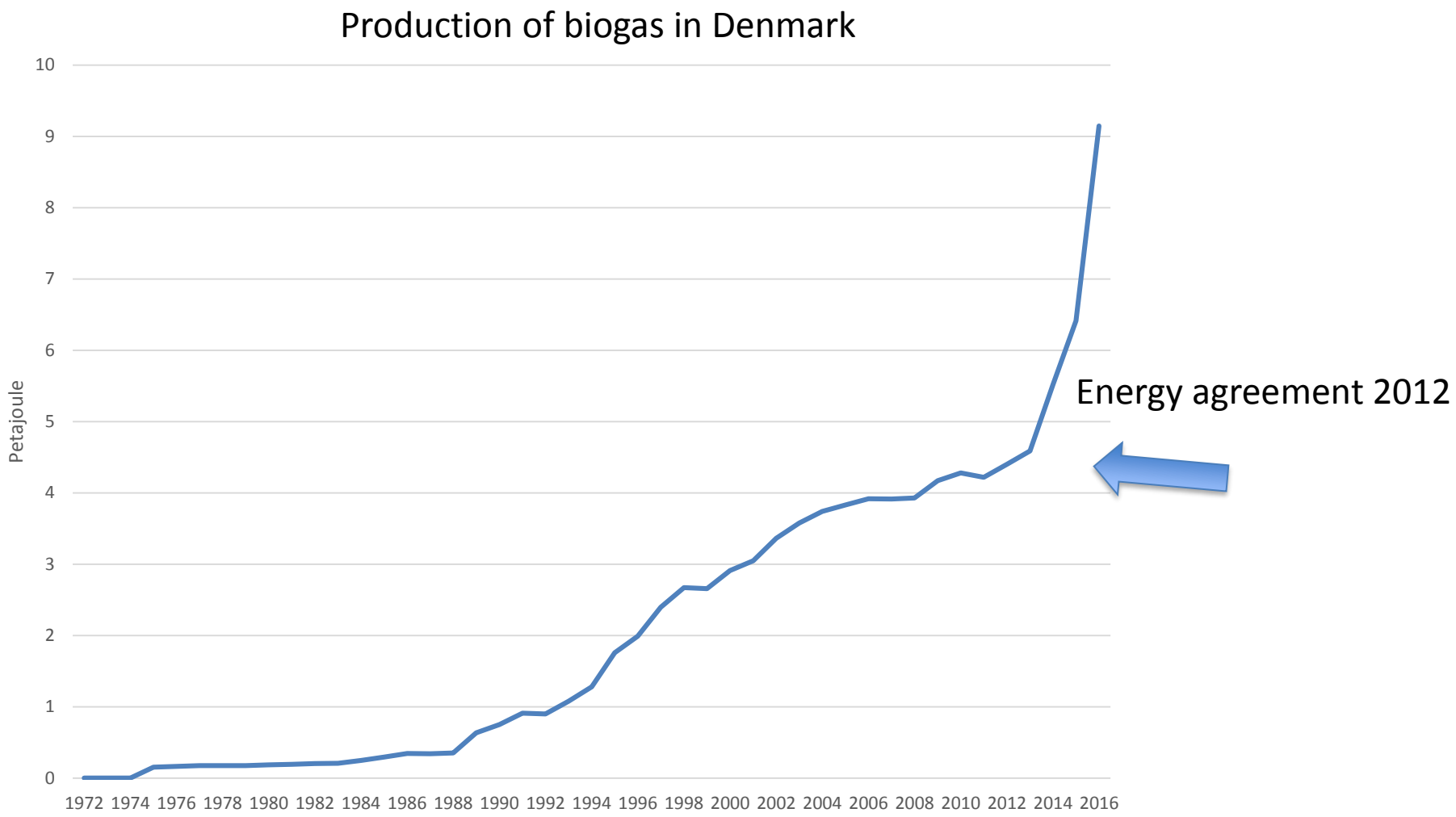
Biogas development in Denmark



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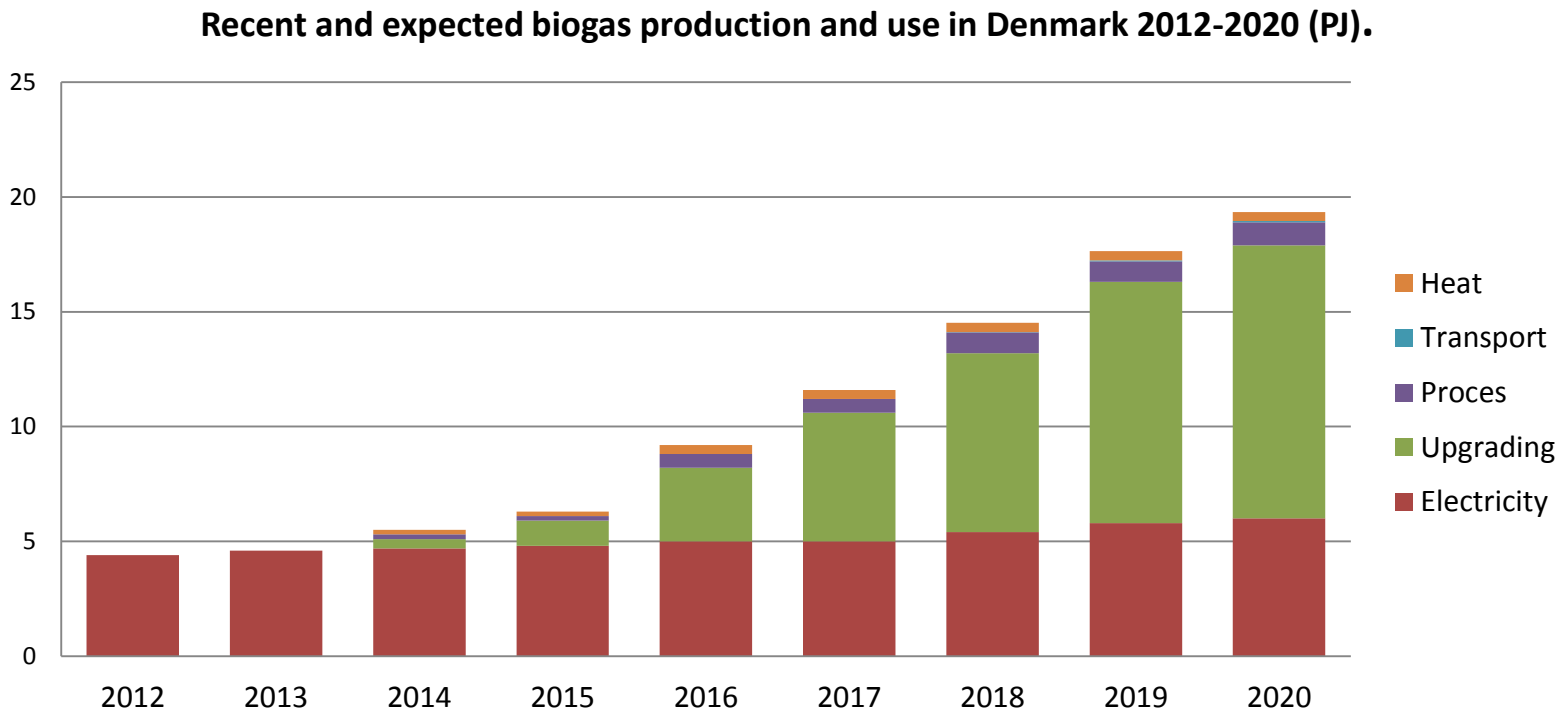
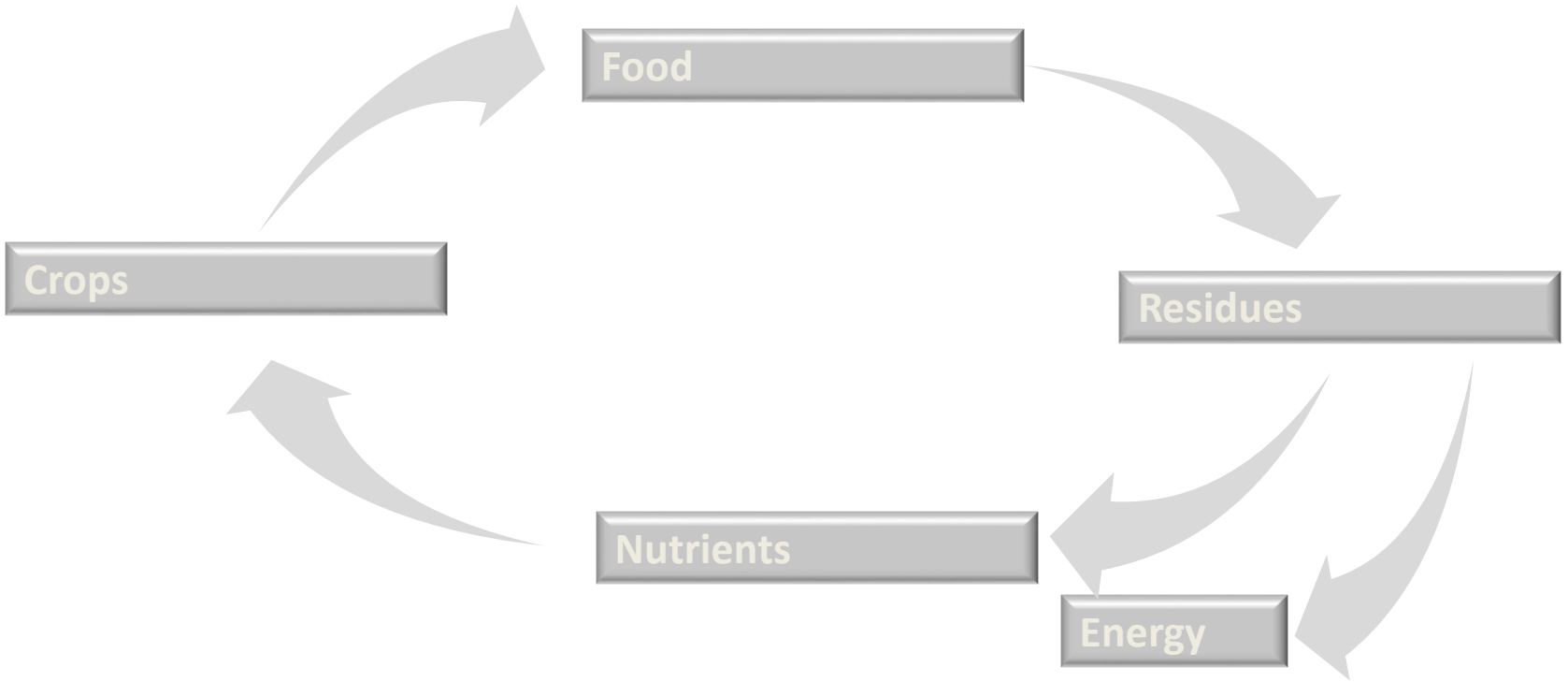
Denmark - biogas



Currently 32 biogas plants are producing biomethane in Denmark and in 2018, 7.2 PJ (or 1993 GWh biomethane) was produced.

Biogas is circular economy

- **Residues from households, agriculture and industry are recycled**
- **The organic content of the biomass (C) is converted to high-value biogas**
- **Nutrients (N, P, K) are recycled**
- **The manure is converted into a better fertilizer product**



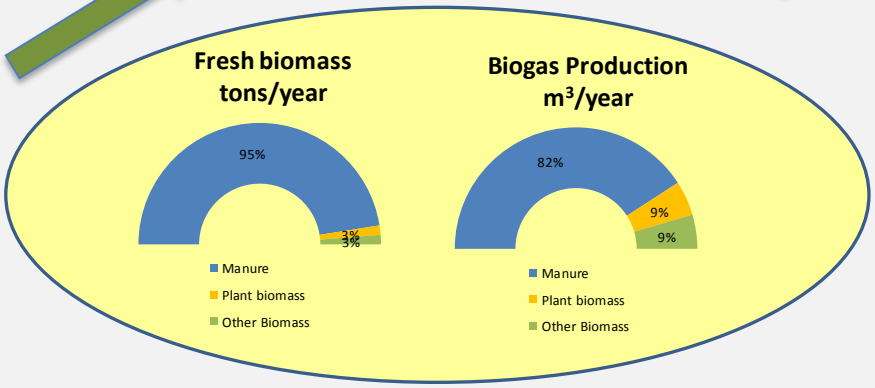
Optimizing biogas production with co-digestion
Modeling and prediction

Teoretical yield

Organic material	Process	Yield		
		ml biogas/g	ml CH4/g	CH4 %
Cellulosis	$(C_6H_{10}O_5)n + n\ H_2O$ -- $3nCH_4 + 3nCO_2$	830	415	50,0
Protein	$2C_5H_7NO_2 + 8H_2O$ -- $5CH_4 + 3CO_2 + 2(NH_4)(HCO_3)$	793	504	63,6
Fat	$C_{57}H_{104}O_6 + 28H_2O$ -- $40CH_4 + 17CO_2$	1444	1014	70,2

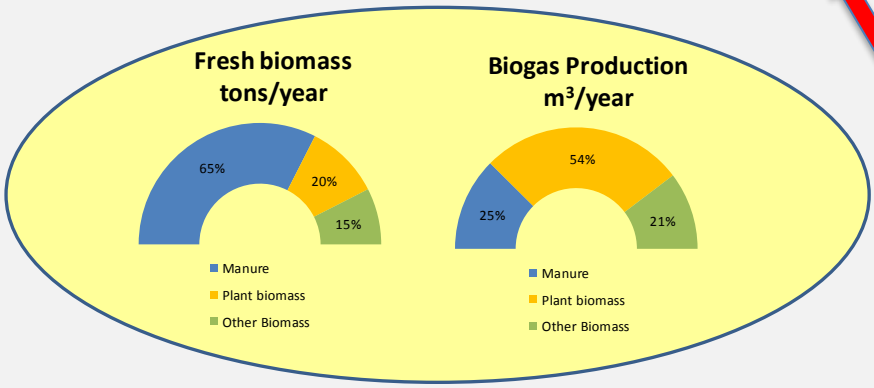
Biomasse and biogas production

Biomasse	Tons pr. år	Methan M³ / år	Biogas Udbytte M³/t	Raw biogas M³ / år
Manure	95.000	1.454.561	15	2.488.906
Plant biomass	2.500	164.571	66	281.599
Other biomass	2.500	161.569	65	276.462
Annual supply	100.000	1.780.702	18	3.046.966



Biomasse and biogas production

Biomasse	Tons pr. år	Methan M³ / år	Biogas Udbytte M³/t	Raw biogas M³ / år
Manure	65.000	1.167.829	18	1.998.277
Plant biomass	20.000	2.554.025	128	4.370.202
Other biomass	15.000	969.415	65	1.658.770
Annual supply	100.000	4.691.269	47	8.027.249



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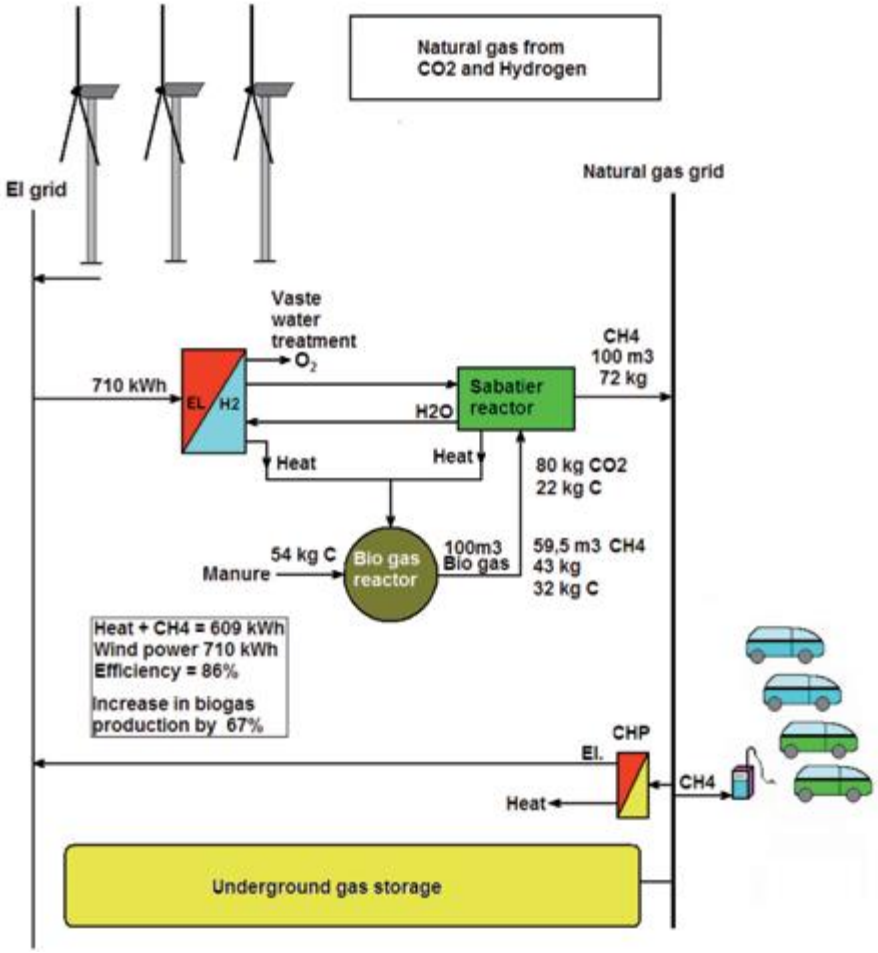
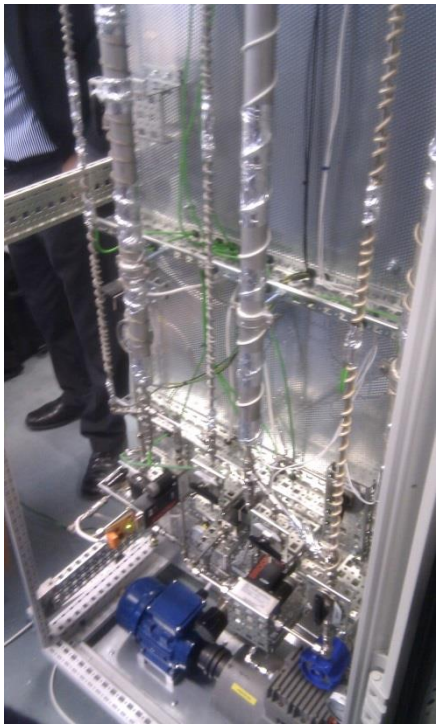
Improving biogas concepts

Co-digestion is important because:

- It must be ensured that there is sufficient biomass
- Nutrient composition is ensured
- Biogas potential is optimized
- The biogas process is stabilized
- Nutrients are recycled and reused

Upgrading biogas and methane-production using CO_2 and power from windmills





Danish Biogas

Danish companies have many years of experience in establishing and operating biogas production

Danish companies can supply:

- Know how and advice
- Delivery of equipment
- Delivery of complete installations and plants
- Cooperation on planning
- Design and dimension of plants
- Cooperation on execution
- Cooperation on operations

Danish Biogas

Danish companies can provide:

- Turn Key biogas plants
- Turn Key upgrading facilities
- Turn Key pre-treatment facilities
- Gas motor installations - CHP
- Gas cooling installations
- Storage facilities

Biogas farm scale

Madsen Bioenergy

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GrønGas Vrå, treating manure, deap litter and residues

Treat 300,000 tons/year, produce 9 mio. m^3/CH_4

New products and value streams
From Biowaste to Food Ingredients

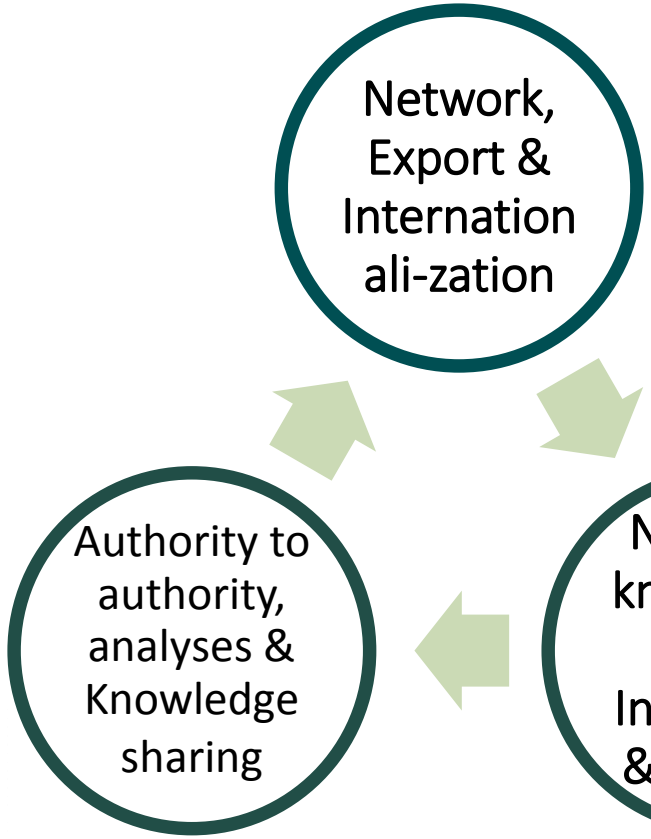
Danish CO2 from agriculture becomes bubbles in your soda

Nature Energy and Strandmøllen A/S have entered into a partnership under which excess CO2 from the world's largest biogas plant in Esbjerg will be recycled as, for example, bubbles in your soda. Under the partnership, Strandmøllen will have easy access to necessary CO2, which is otherwise in short supply throughout Europe, and, in addition, CO2 emissions from the biogas plant will be reduced by 70% compared with an ordinary biogas plant.

STRANDMØLLEN

NGF nature energy

Biogas Go Global
A triple helix approach (2018-2021)



WASTE, RECYCLING AND BIOGAS ADVISORY

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Energistyrelsen
Danish Energy Agency

Project Management/initiator

INDUSTRIENS FOND
FREMMER DANSK KONKURRENCEEVNE
The Danish Industry Foundation

Biogas Go Global
A triple helix approach (2018-2021)

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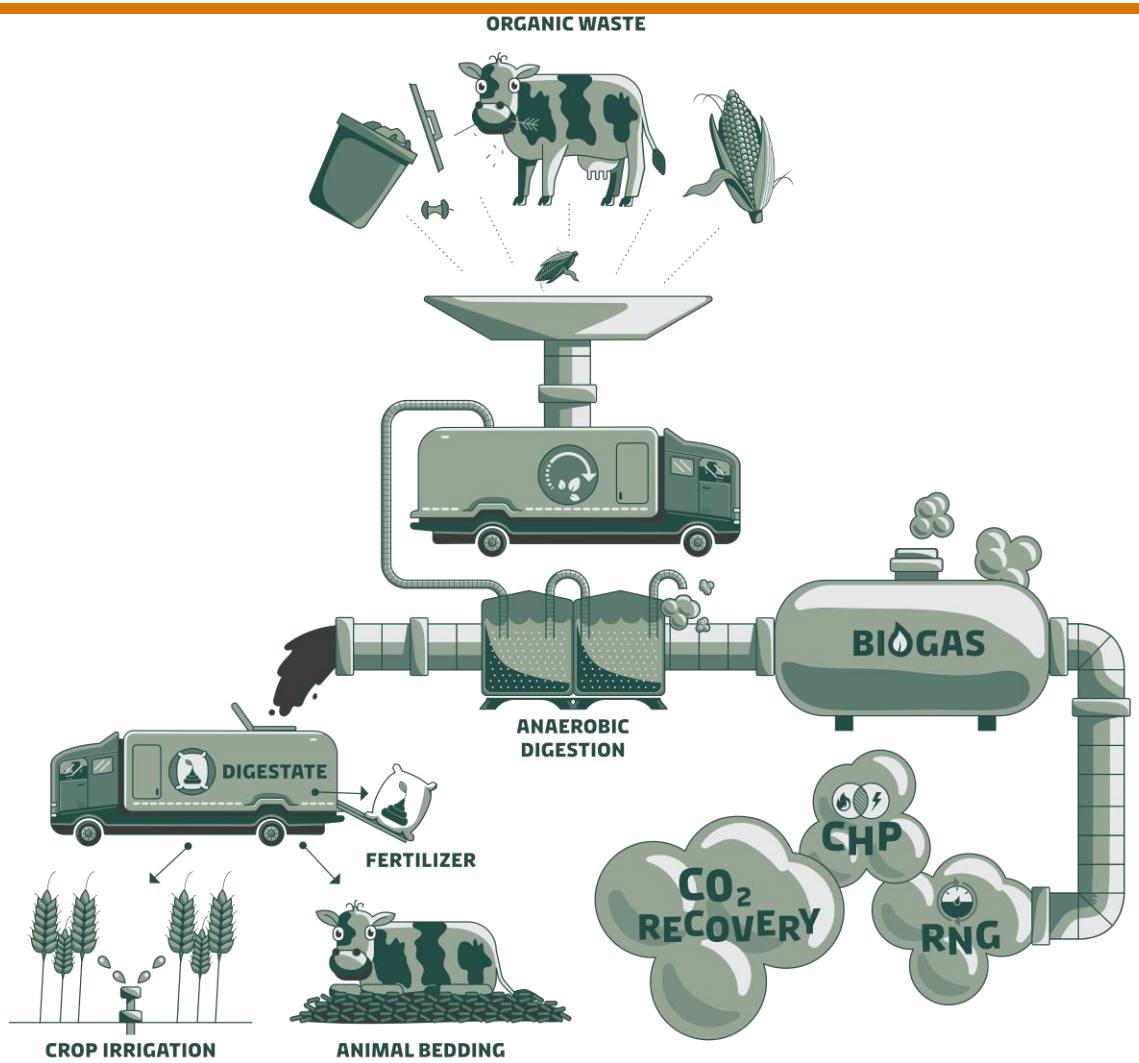

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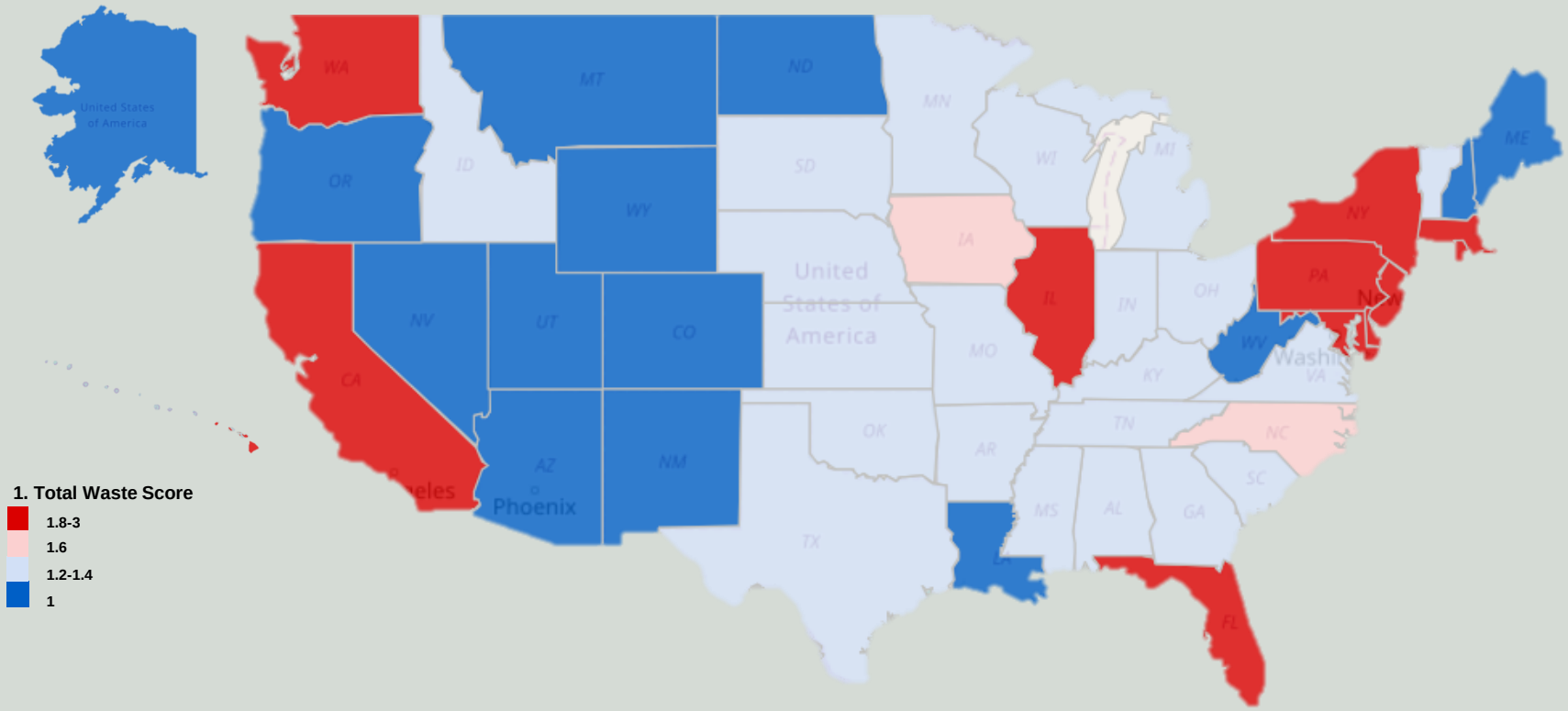
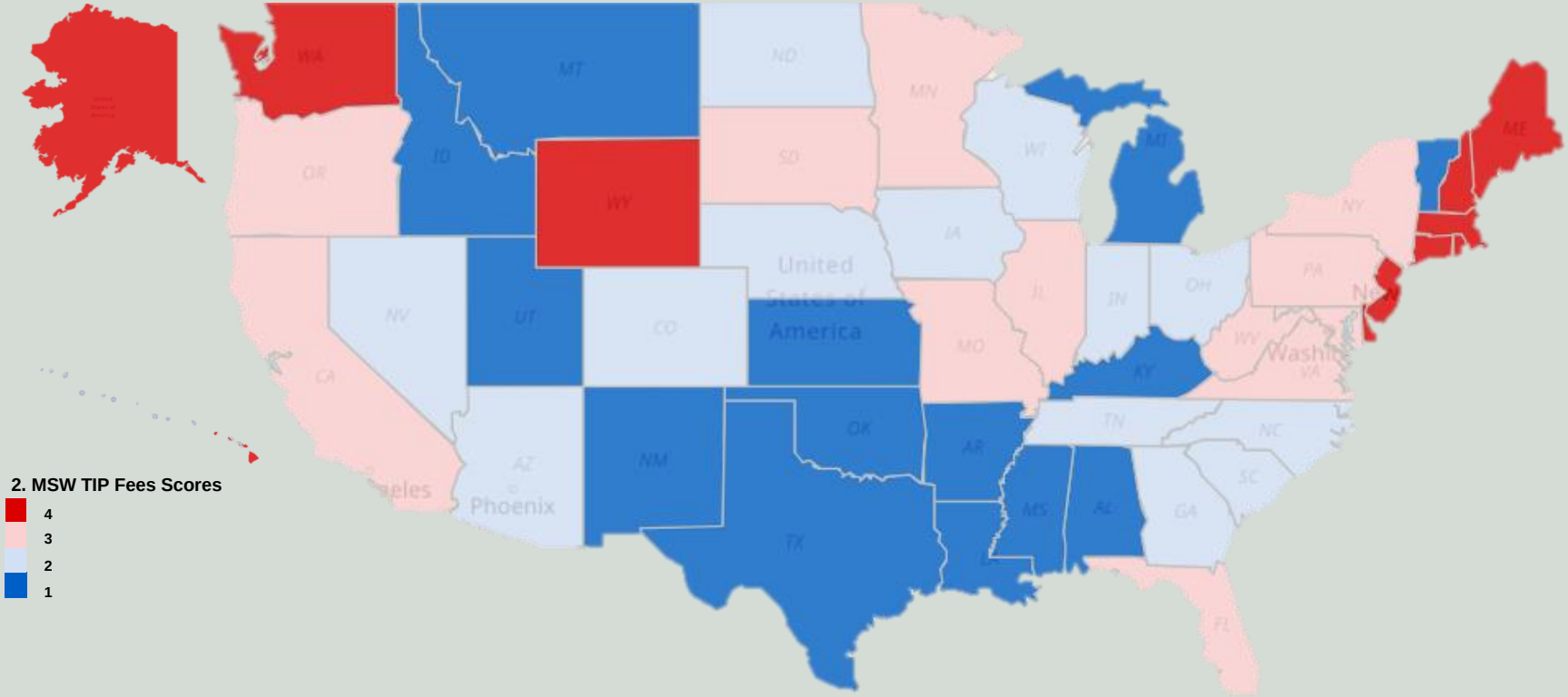
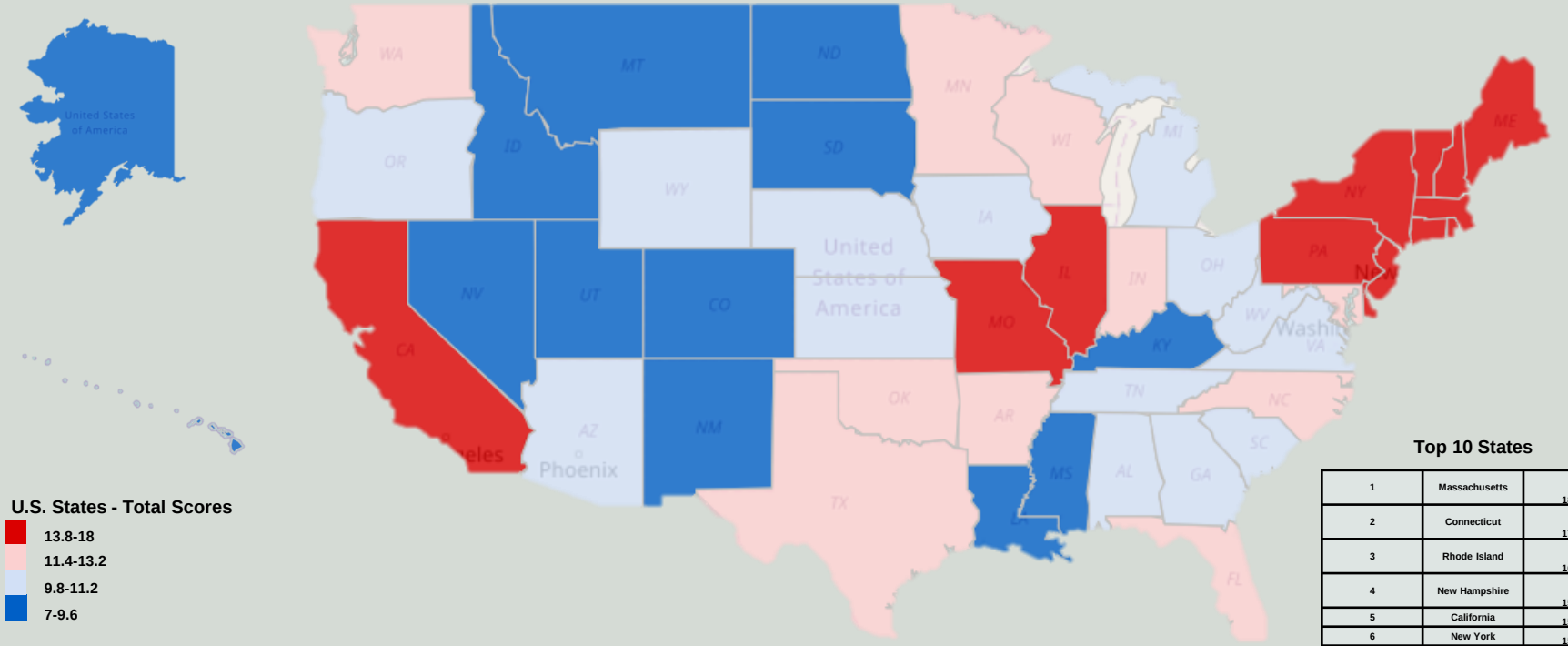
1. Food and livestock waste – united states



2. MSW Tip FeeS – United states



Nationwide suitability analysis



U.S. States - Total Scores

- 13.8-18
- 11.4-13.2
- 9.8-11.2
- 7-9.6

Top 10 States

1	Massachusetts	18.00
2	Connecticut	17.60
3	Rhode Island	16.20
4	New Hampshire	15.60
5	California	15.20
6	New York	15.20
7	Pennsylvania	15.20
8	Illinois	15.00
9	Maine	14.60
10	Missouri	14.40

Biogas Go Global
A triple helix approach (2018-2021)

We are looking for partners in US for cooperation in the biogas sector.

- Government to government cooperation and exchange
- Universities and knowledge institutions
- Companies
- Project developers

all contacts are welcome

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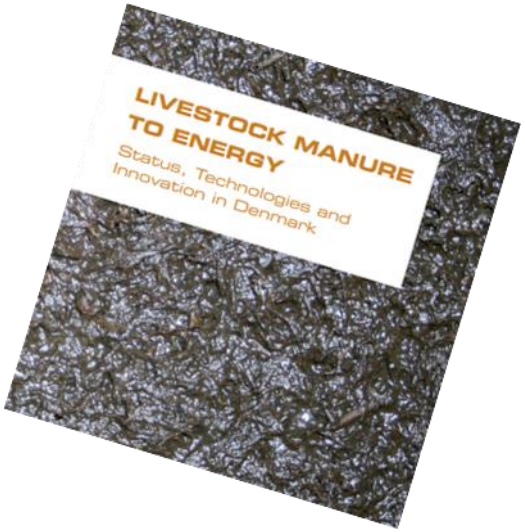
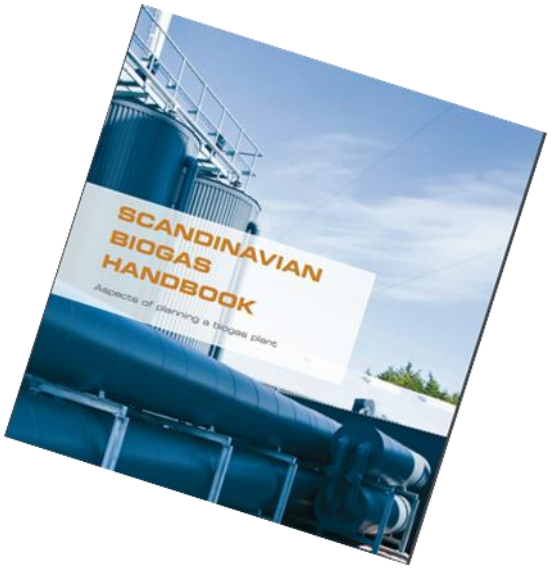
A triple helix approach (2018-2021)





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Biogas is fantastic !

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Thank you for your attention!