Nordic Biogas Model

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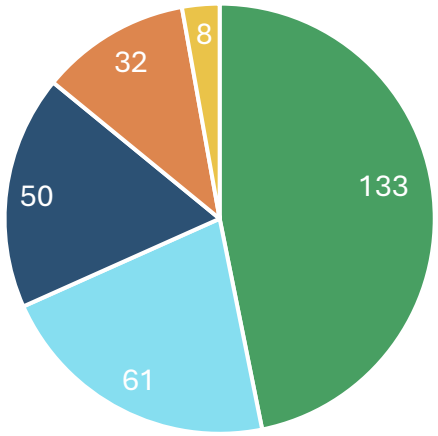
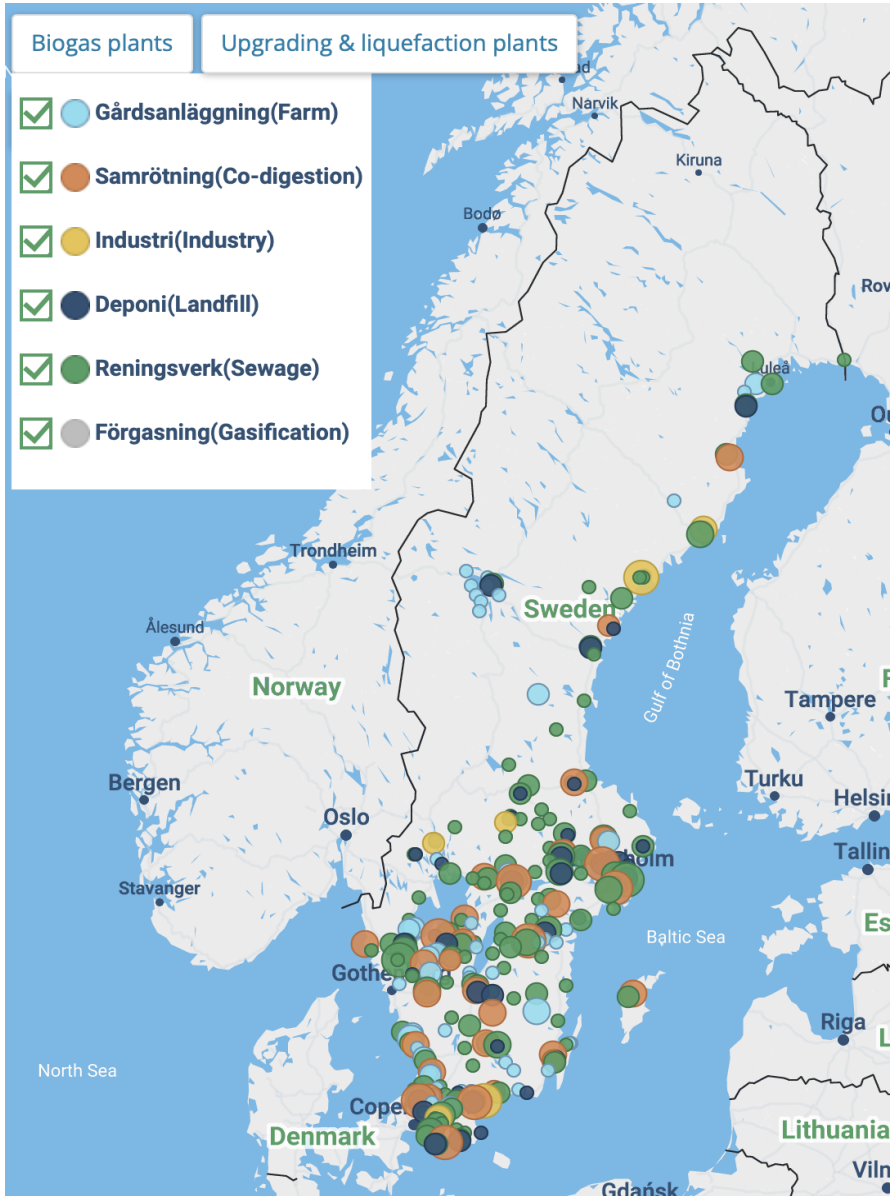
Biogas in Sweden

Biogas production

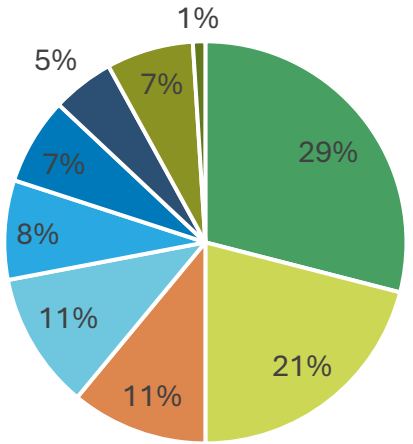
Number of biogas plants in 2022



- Wastewater treatment plants
- Farm plants
- Landfills
- Co-digestion plants
- Industrial wastewater treatment plants



Biogas production from substrates 2022



- Sewage
- Household waste
- Manure
- Others
- Food industry
- Animal waste (slaughter houses)
- Landfill
- Industrial plant (sewage)
- Energy crops

Source: Swedish Energy Agency/Swedish Gas Association

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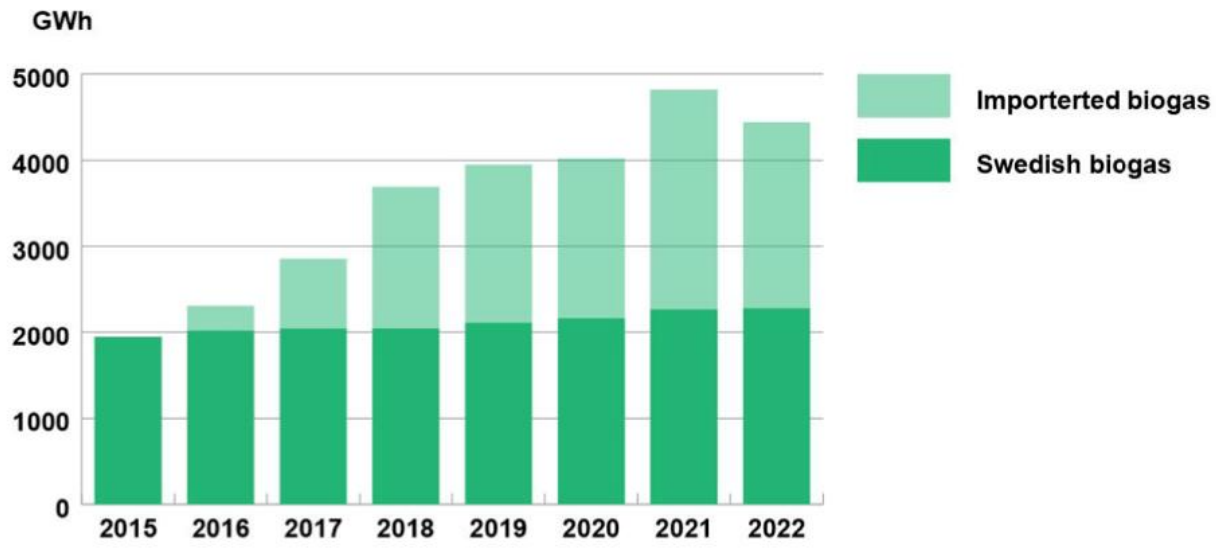
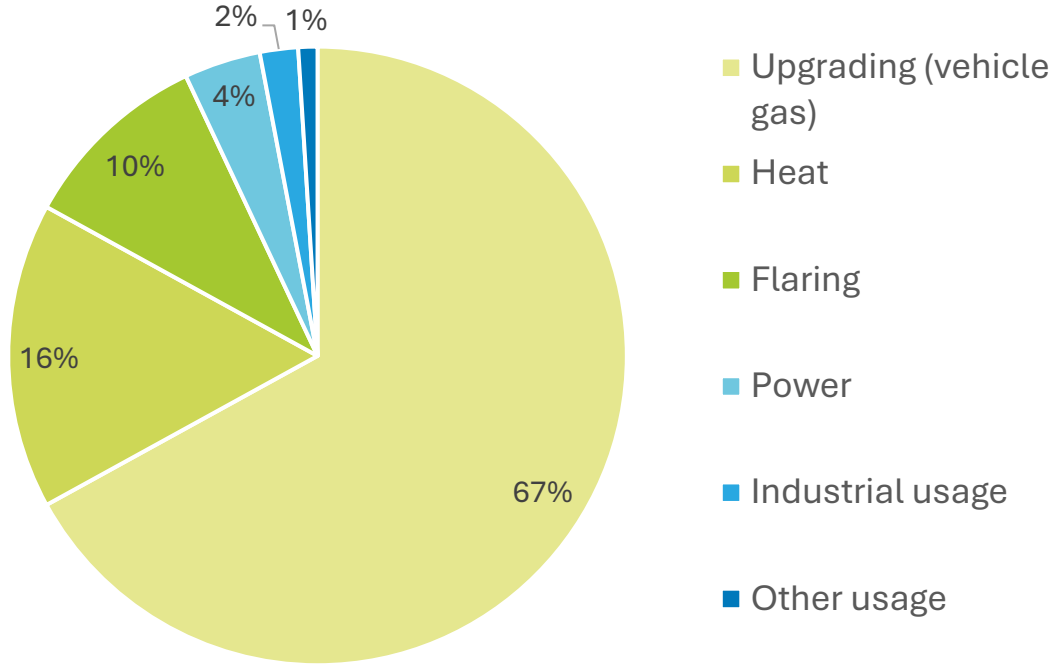
Biogas use

Total biogas use (GWh) in Sweden 2015-2022.



Biogas usage 2022



Source: Swedish Energy Agency/Swedish Gas Association

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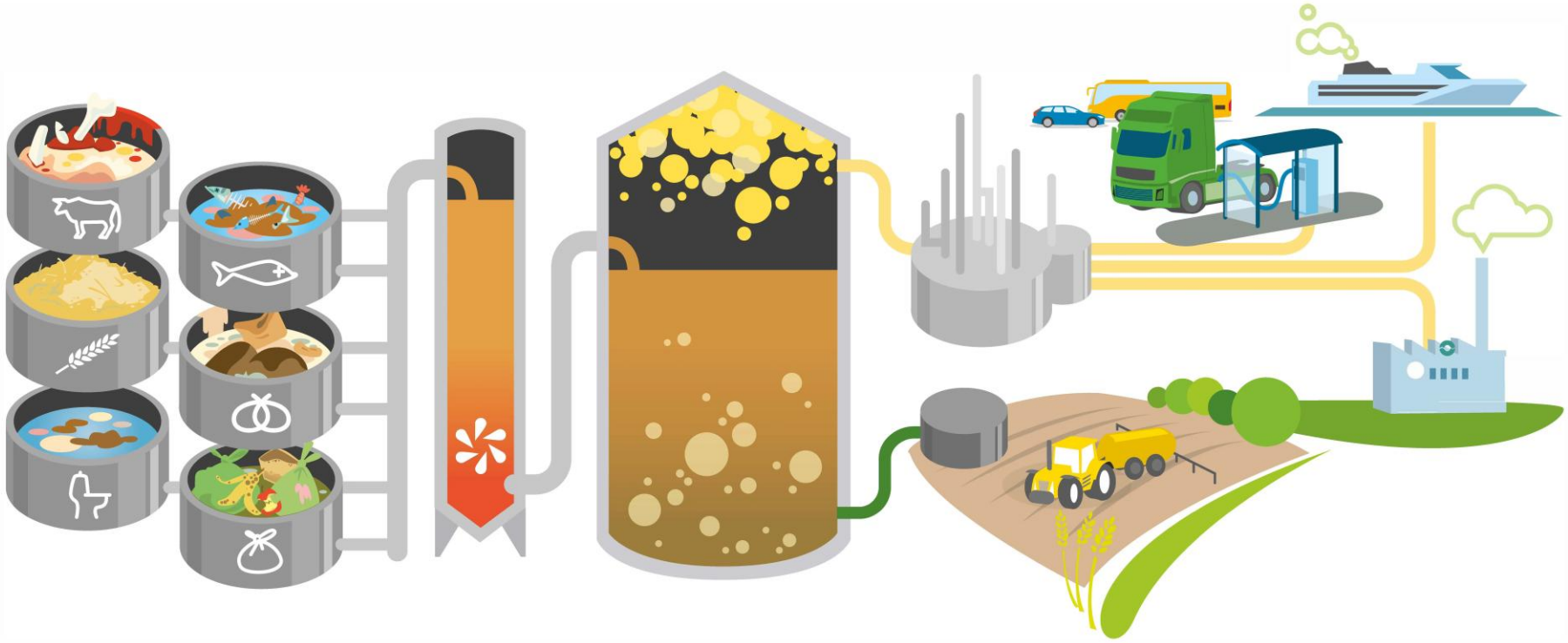
Nordic Biogas Model

Nordic model for biogas: 3 main concepts

- **Waste hygienisation & management**
- **Renewable energy recovery**
- **Renewable nutrient recovery**

- **Focus on increasing valorization**
- Use organic wastes, wastewater, or low-grade biomass
- Upgrade to biomethane (compressed or liquified)
- Use, or upgrade to use digestate as a biofertilizer
- Moving toward carbon capture and utilization, CCU



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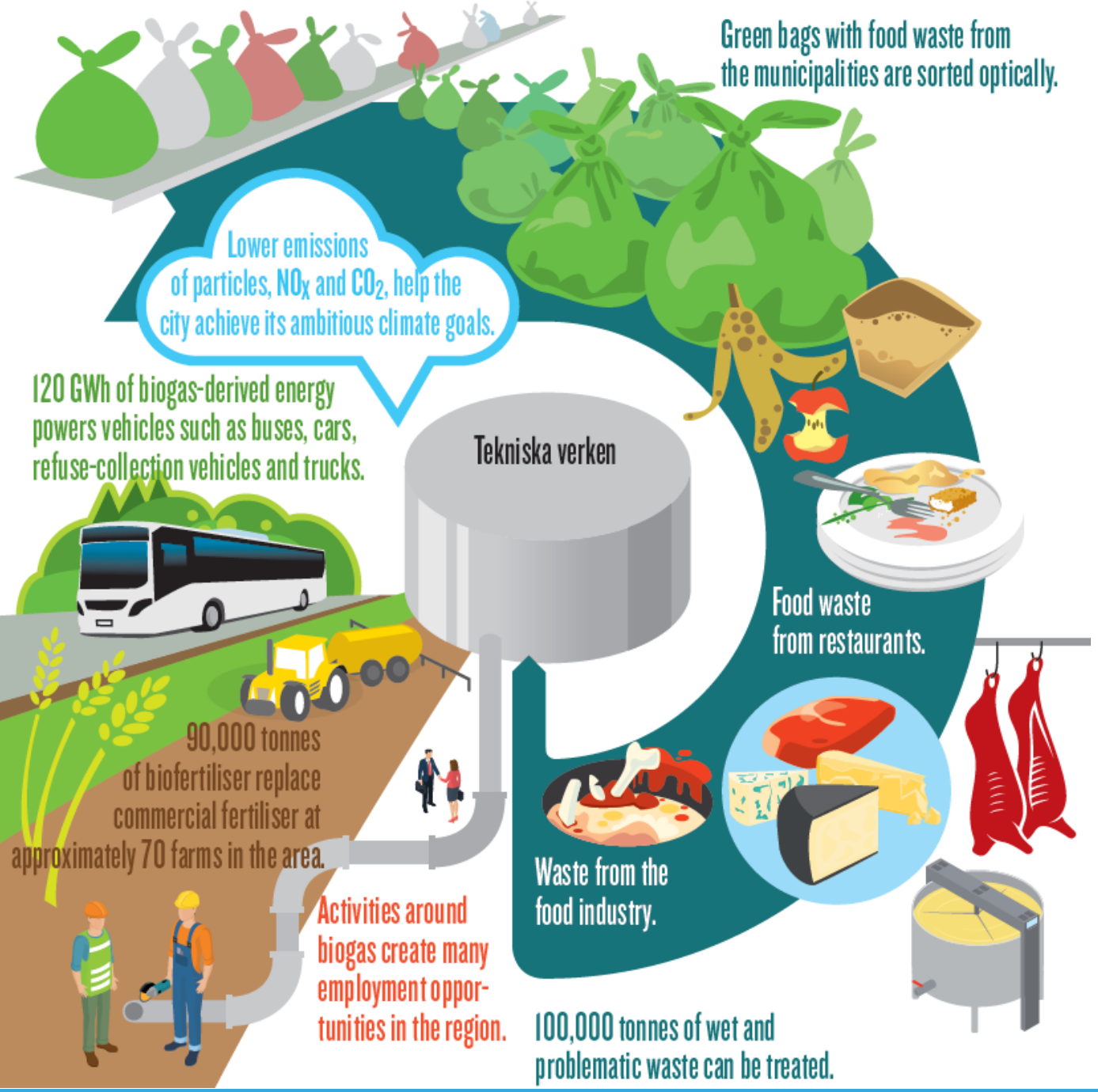
Linköping – waste to value



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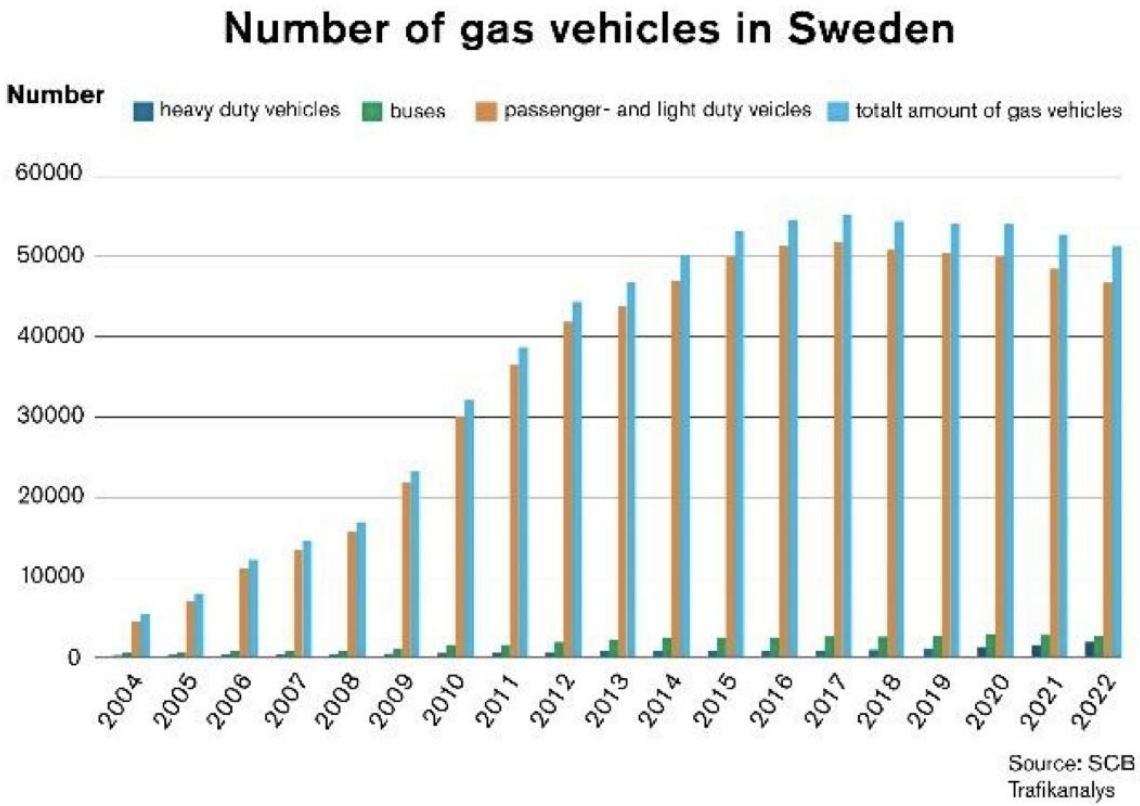
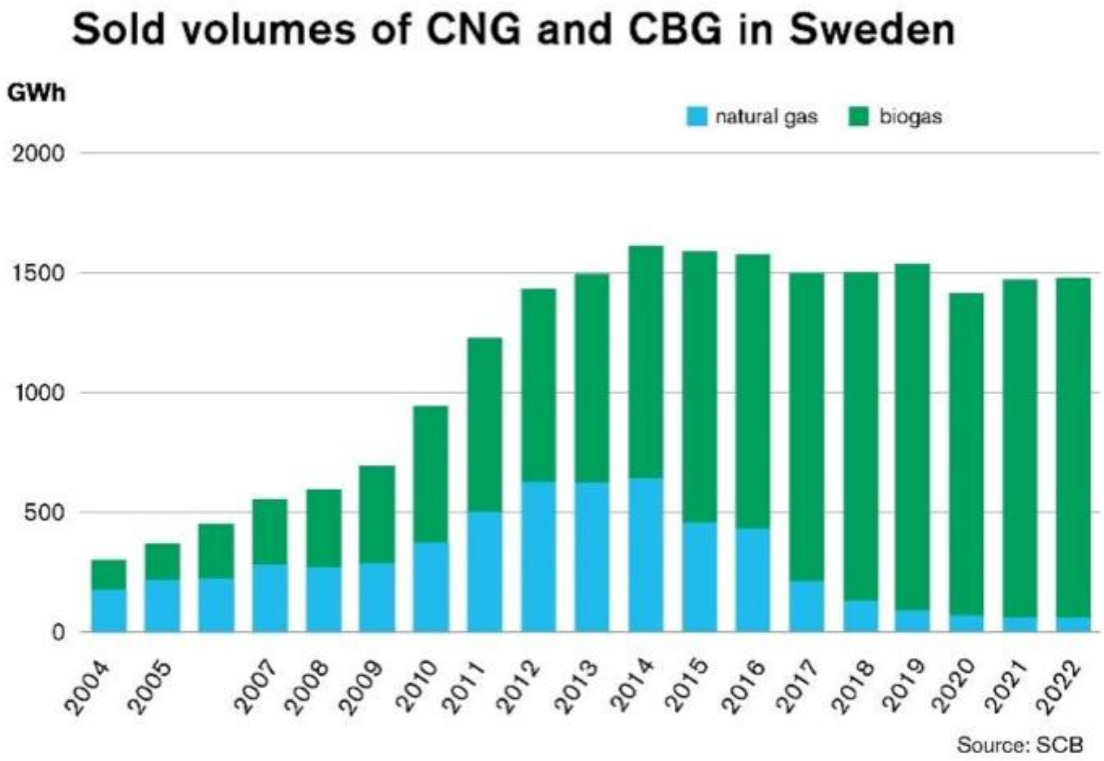
Renewable energy recovery

Biogas as a fuel

Gas vehicle market in Sweden





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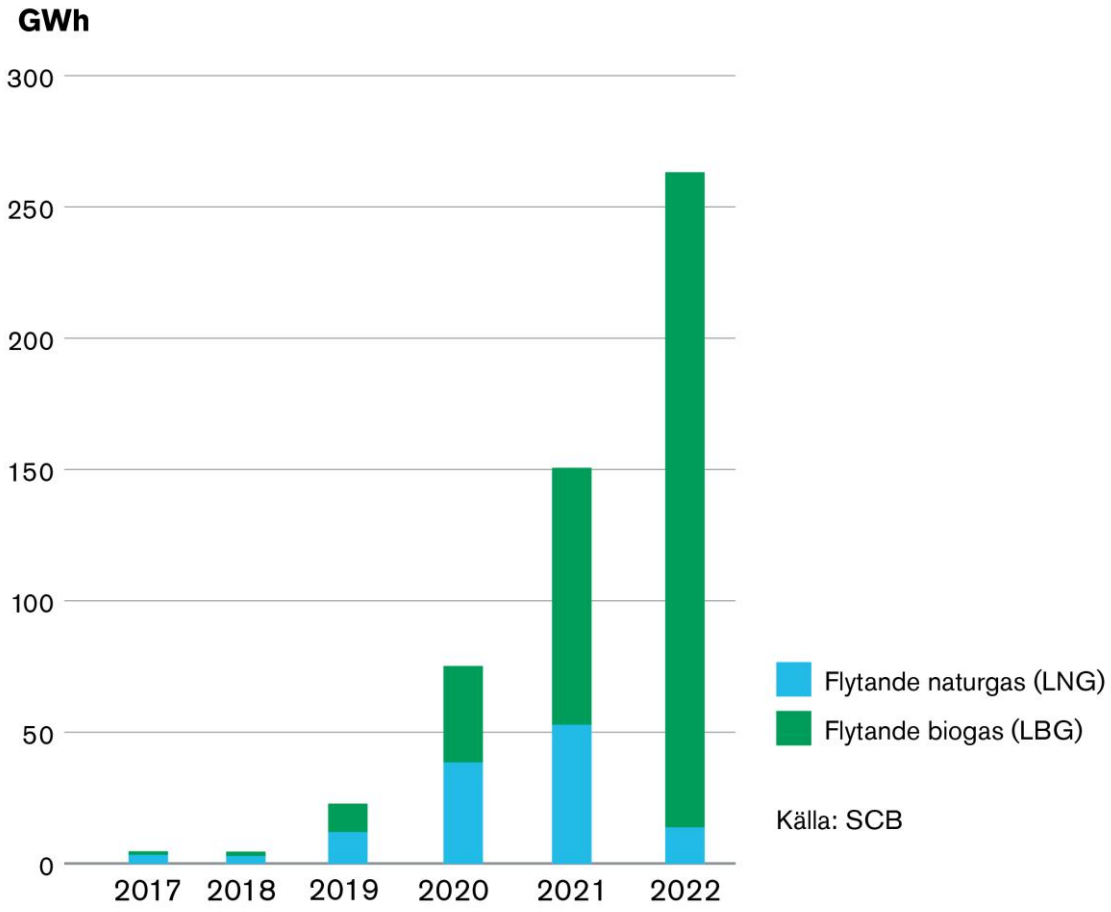
Biogas as a fuel

LNG vs LBG in Sweden



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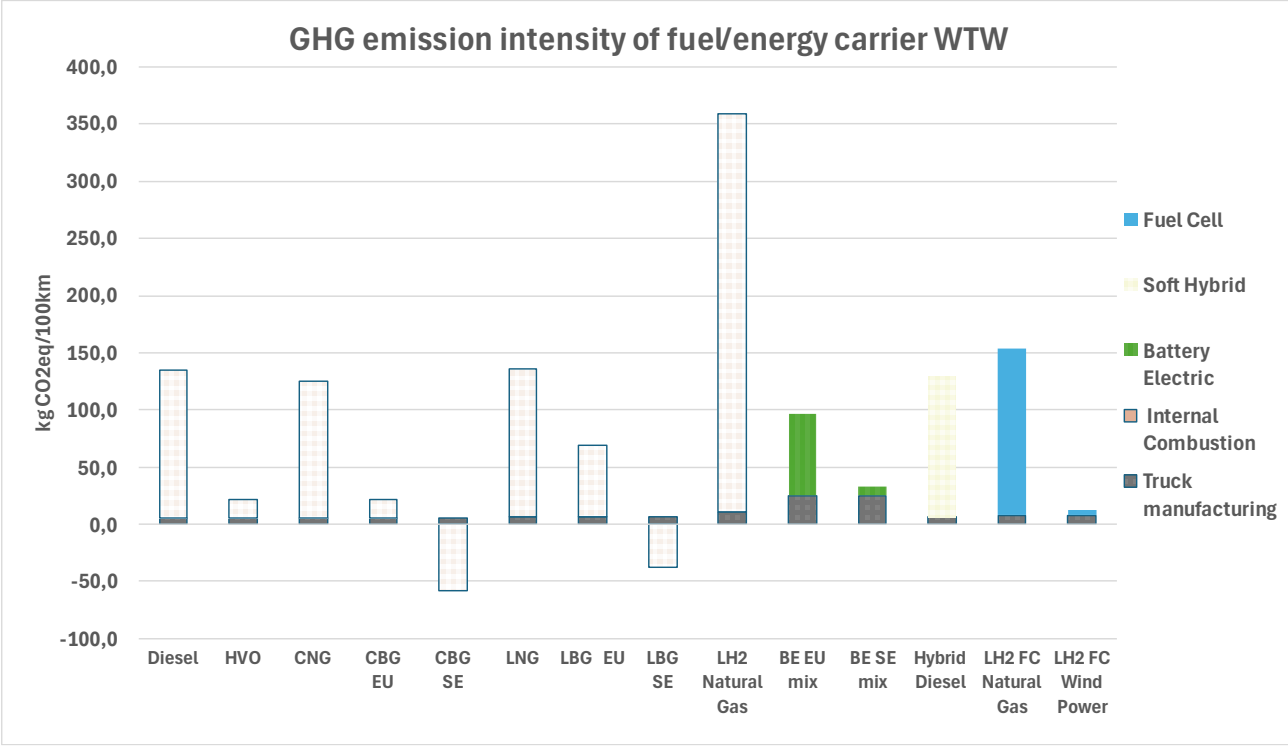
Biogas as a fuel

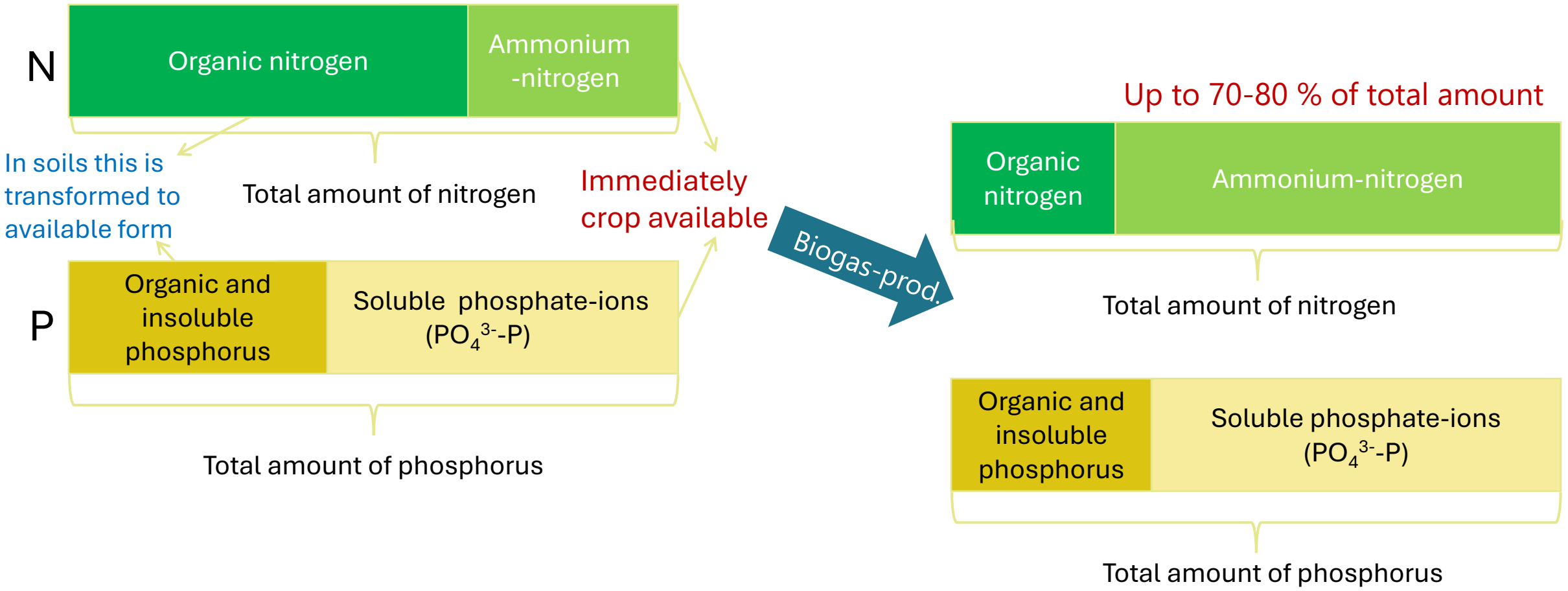
Multi-criteria comparison of Heavy-duty transportation



Powertrain type	*Internal Combustion*							*Hybrid*	*Battery*	*Fuel cell*
Fuel/energy carrier type	Diesel	HVO	CNG	LNG	CBG SE	LBG SE	LH2 Wind	Diesel	SE mix	LH2 Wind
Maturity of technology	VG ***	VG ***	VG ***	VG ***	VG ***	VG ***	VP ***	VG ***	P - G **	VP ***
Range	G ***	G ***	S - G ***	G ***	S - G ***	G ***	VP - VG *	G ***	VP - S **	VP - VG **
Fuelling/charging efficiency	G ***	G ***	G ***	G ***	G ***	G ***	S - G **	G ***	VP - G **	S - G **
Operating flexibility	VG ***	VG ***	VG ***	G ***	VG ***	G ***	S **	VG **	VP ***	S **
Infrastructure availability	VG ***	VG ***	G **	G **	G **	G **	VP ***	VG ***	P **	VP ***
CAPEX	G ***	G ***	S ***	S ***	S ***	S ***	VP *	G **	VP **	VP *
OPEX	P ***	VP ***	P ***	P ***	S ***	S ***	VP *	S **	VG **	VP *
Security of supply and cost stability	VP ***	VP ***	P **	P **	S ***	S ***	VP *	VP ***	P *	VP *
GHG emission savings	VP ***	VG **	VP ***	VP ***	VG ***	VG ***	VG **	VP ***	VG ***	VG **
Primary energy efficiency	VG ***	VG ***	G ***	G ***	P ***	P ***	VP ***	VG ***	VG ***	VP ***
Air quality impact	P-S **	P-S **	G **	G **	G **	G **	G *	P-S **	G-VG **	VG **
Land or aquatic environmental impact	VP ***	VP **	VP ***	VP ***	G **	G **	S *	VP ***	S **	S *
Political support	VP ***	S **	P **	P **	S **	S **	G **	VP ***	G ***	G **
Sociotechnical systems services	S ***	S ***	S ***	S ***	VG ***	VG ***	S **	S ***	VP-VG ***	S **
Working environment of the driver	VP ***	VP ***	S **	S **	S **	S **	S *	VP ***	VG **	VG *

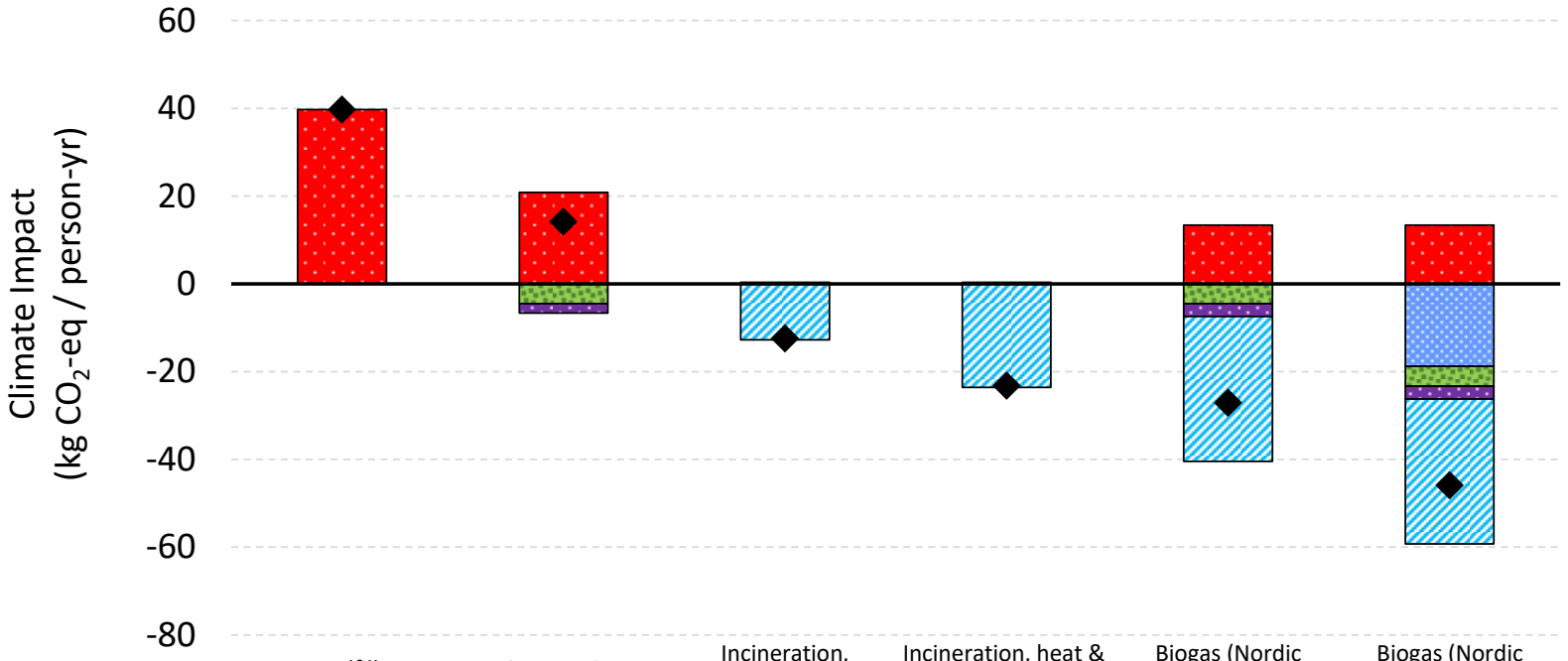
Renewable nutrient recovery

All nutrients in the feedstock remains in the digestate /biofertilizers but are more available for the crop



Slide from Åke Nordberg, Swedish University of Agricultural Sciences, Uppsala

Climate Impact in a theoretical 1 million city by waste handling pathways



	Landfill	Composting	Incineration, electricity	Incineration, heat & electricity	Biogas (Nordic model)	Biogas (Nordic model with CCU)
Production	39.7	20.8	0.4	0.4	13.4	13.4
Fuel or energy substitution	0	0	-12.8	-23.6	-33.0	-33.0
Fertiliser substitution	0	-2.2	0	0	-3.0	-3.0
Soil carbon storage	0	-4.5	0	0	-4.5	-4.5
Carbon capture and use	0	0	0	0	0	-18.8
Net impact	39.7	14.2	-12.4	-23.2	-27.1	-45.9

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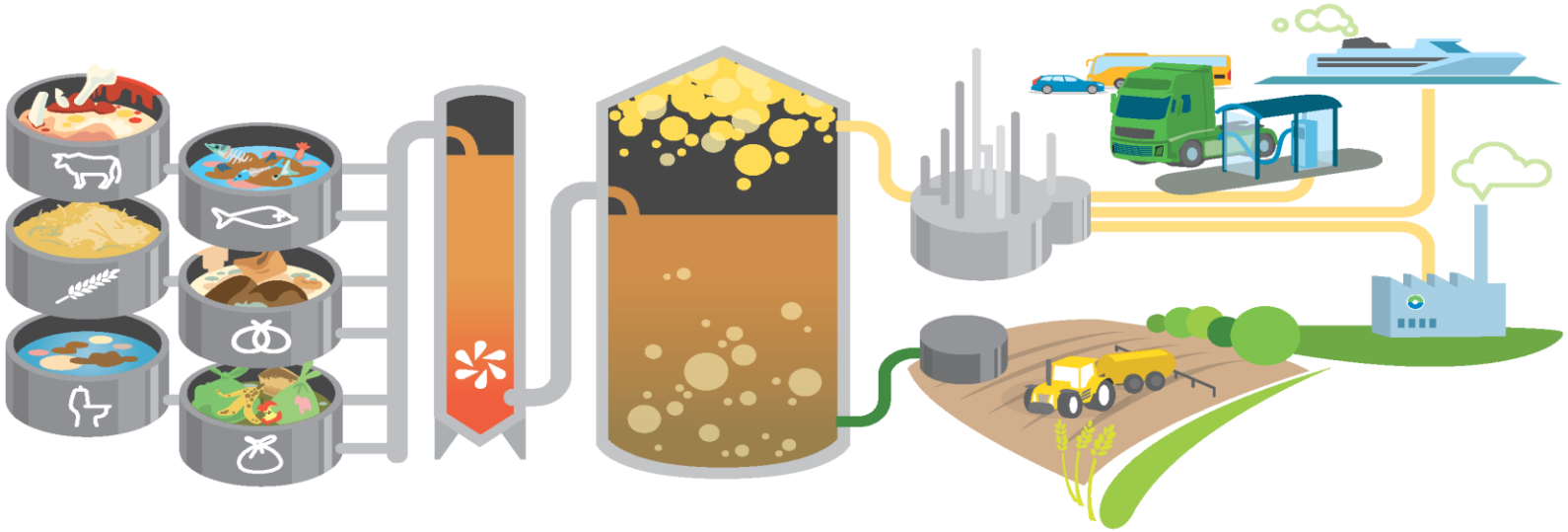
Effects of NBM application



Nordic biogas model

Waste management

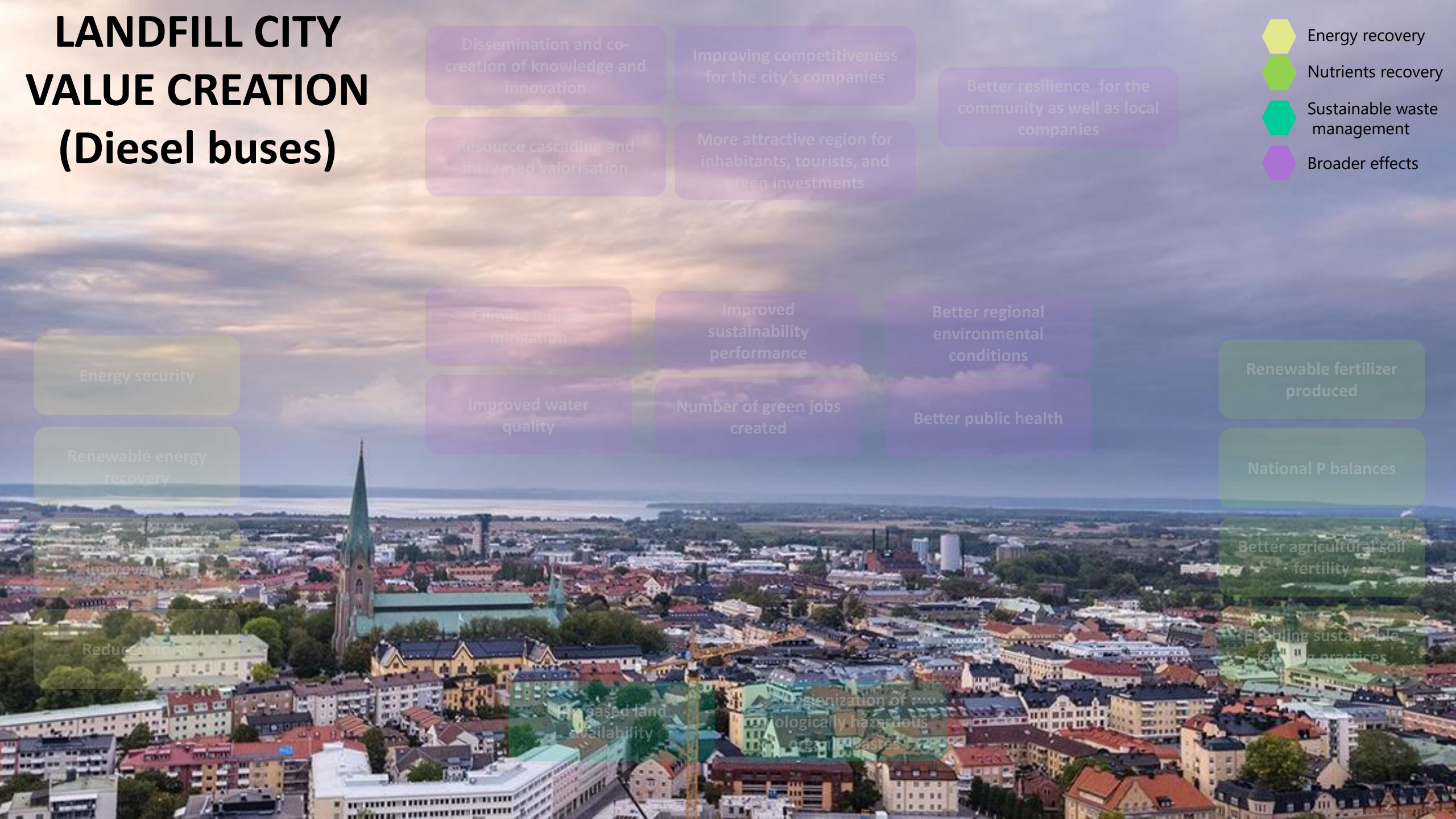
Renewable energy

Renewable nutrients

Biogas solutions can adress them all, at the same time

- Air pollution
- Urbanisation and congestion
- Climate change
- Soil health and fertility
- Amount of waste grows
- Not enough jobs
- Water pollution
- Fossil energy dependency
- Energy security

LANDFILL CITY VALUE CREATION (Diesel buses)



COMPOST CITY VALUE CREATION (Diesel buses)

Energy recovery
Nutrients recovery
Sustainable waste management
Broader effects

Dissemination and co-creation of knowledge and innovation

Improving competitiveness for the city's companies

Better resilience for the community as well as local companies

Resource cascading and increased valorisation

More attractive region for inhabitants, tourists, and green investments

Climate impact mitigation

Improved sustainability performance

Better regional environmental conditions

Energy security

Improved water quality

Number of green jobs created

Better public health

Renewable energy recovery

Improvement

Reduced nutrient

Renewable fertilizer produced

National phosphorous balances

Better agricultural soil health and fertility

Enabling sustainable farming practices

Increased land availability

Hygienization of biologically hazardous organic wastes

INCINERATION CITY VALUE CREATION (electric buses)

Dissemination and co-creation of knowledge and innovation

Improving competitiveness for the city's companies

Better resilience for the community as well as local companies

Resource cascading and increased valorisation

More attractive region for inhabitants, tourists, and green investments

- Energy recovery
- Nutrients recovery
- Sustainable waste management
- Broader effects

Climate impact mitigation

Improved sustainability performance

Better regional environmental conditions

Energy security

Improved water quality

Number of green jobs created

Better public health

Renewable fertilizer produced

Renewable energy recovery

National P balances

Local air quality improvement

Better agricultural soil fertility

Reduced noise

Enabling sustainable fertilising practices

Increased land availability

Hygienization of biologically hazardous organic wastes

BIOGAS CITY VALUE CREATION (Gas buses)

Dissemination and co-creation of knowledge and innovation

Improving competitiveness for the city's companies

Better resilience for the community as well as local companies

Resource cascading and increased valorisation

More attractive region for inhabitants, tourists, and green investments

Energy recovery

Nutrients recovery

Sustainable waste management

Broader effects

Climate impact mitigation

Improved sustainability performance

Better regional environmental conditions

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Energy security

Renewable energy recovery

Local air quality improvement

Reduced noise

Renewable fertilizer produced

National phosphorous balances

Better agricultural soil health and fertility

Enabling sustainable farming practices

Increased land availability

Hygienization of biologically hazardous organic wastes

Thank you for listening!