The role of biogas and anaerobic digestion in the circular economy

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IEA Bioenergy Task 36 Workshop
Paris 10 Jan 2017

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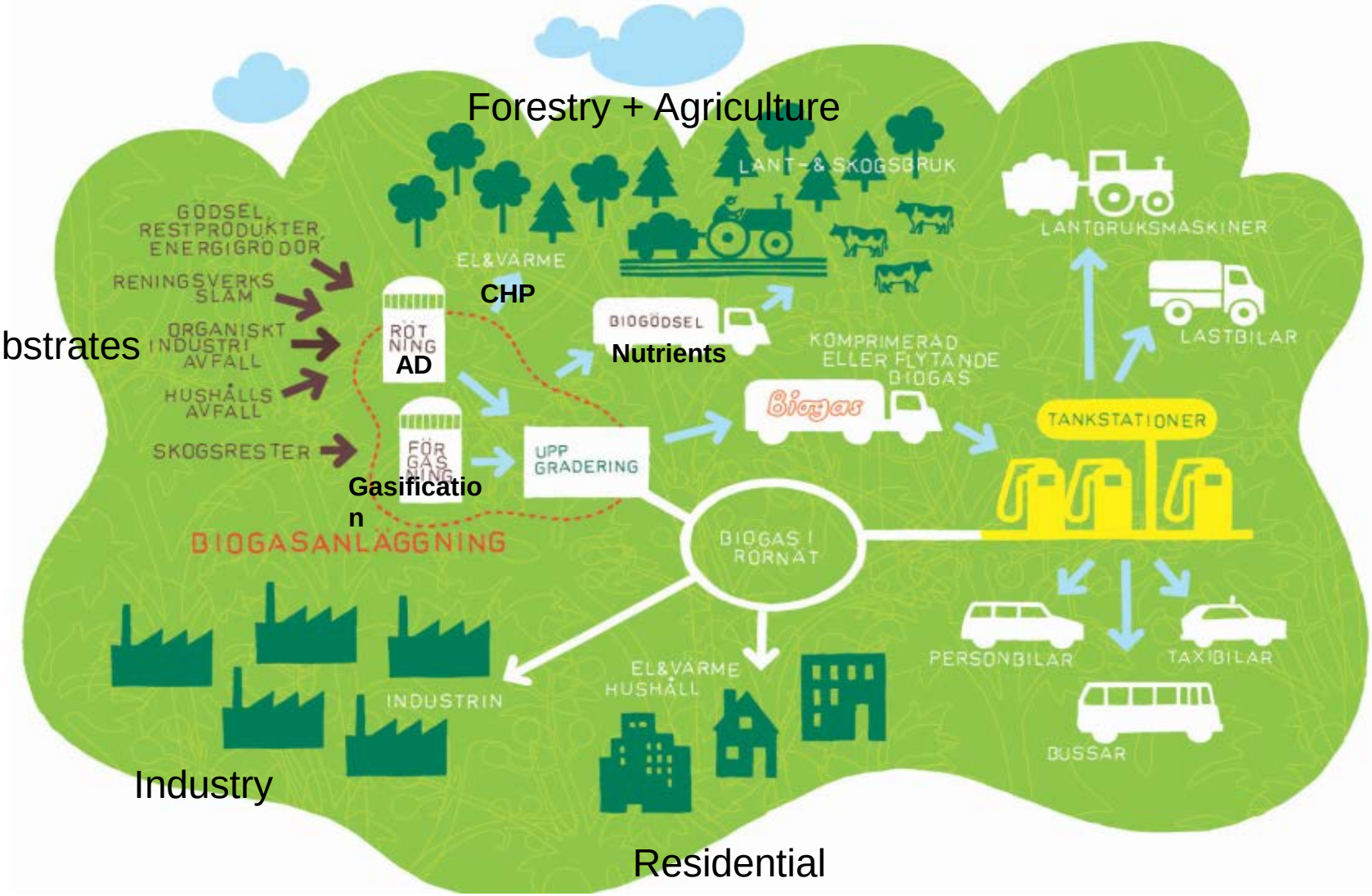
AD and biogas: Managing waste and nutrients while producing quality energy



Biomethane as transport fuel best use?

Not only lower emissions of CO_2 but also particles and SO_x and NO_x

Vehicle type	Present fuel	Liquid bio fuels	Electric	Hybrids	Biogas
Cars	Petrol/Diesel	Yes (%)	Yes	Yes	Yes (CBG)
Delievery trucks	Diesel	Yes (%)	No	Yes	Yes (CBG)
Urban busses	Diesel	Yes (%)	Yes (wired)	Yes	Yes (CBG)
Heavy trucks	Diesel	Yes (%)	No	No	Yes (LBG)
Train	Diesel/Electric	Yes (%)	Yes (wired)	No	Yes (LBG)
Ships	Diesel	Yes (%)	No	No	Yes (LBG)

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Biomethane potential

Waste, residual products and energy crops

Cities (urban)

Sewage sludge
Household organic waste
Industrial organic waste
Landfill gas

Agriculture

Manure
Residual products
Energy crops

Forestry

Residual products from forests and industry

The natural scavenger in all biorefinery schemes; dedicated biogas production show high substrate flexibility, and excellent conversion and area efficiency

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Lots of opportunities for growth!

- Large biogas potential, AD + gasification
- Commercially mature market production
  - Biogas production, lots of vehicle offers in all different segments, replaces natural gas in all its end-uses
- Dieselgate + The promise of future gas powertrains
  - Real emissions are lower (NO_2) and less hazardous (particles)
  - Future dedicated gas engines on par with diesel, 2nd gen dual fuel (methane diesel) launches in EU 2017
- A key technology of the circular economy and the future sustainable agricultural sector

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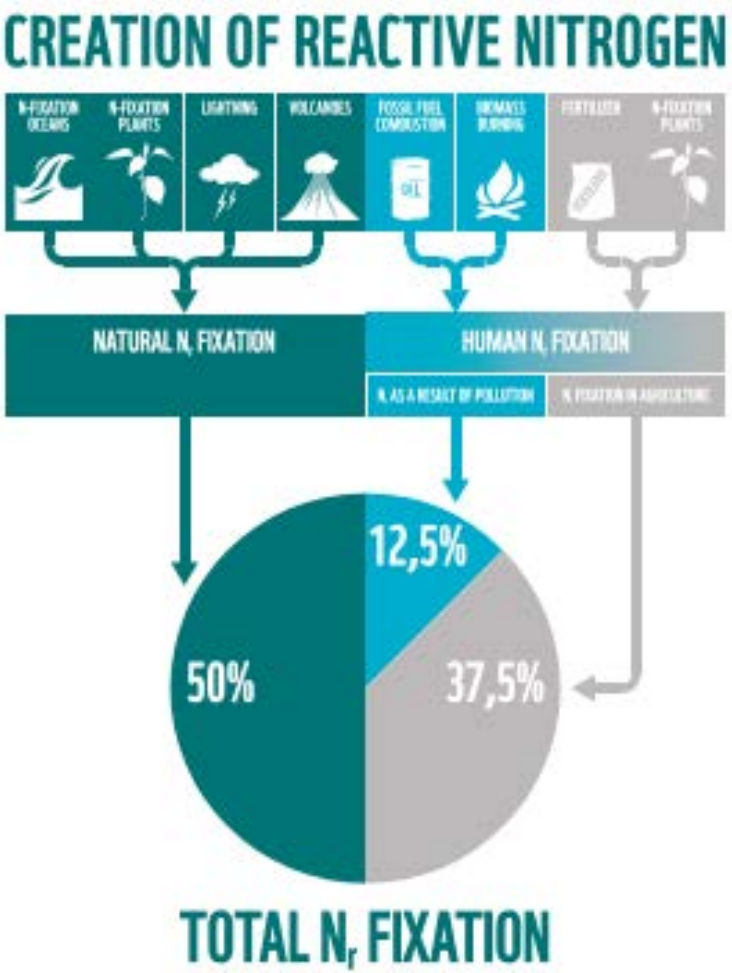
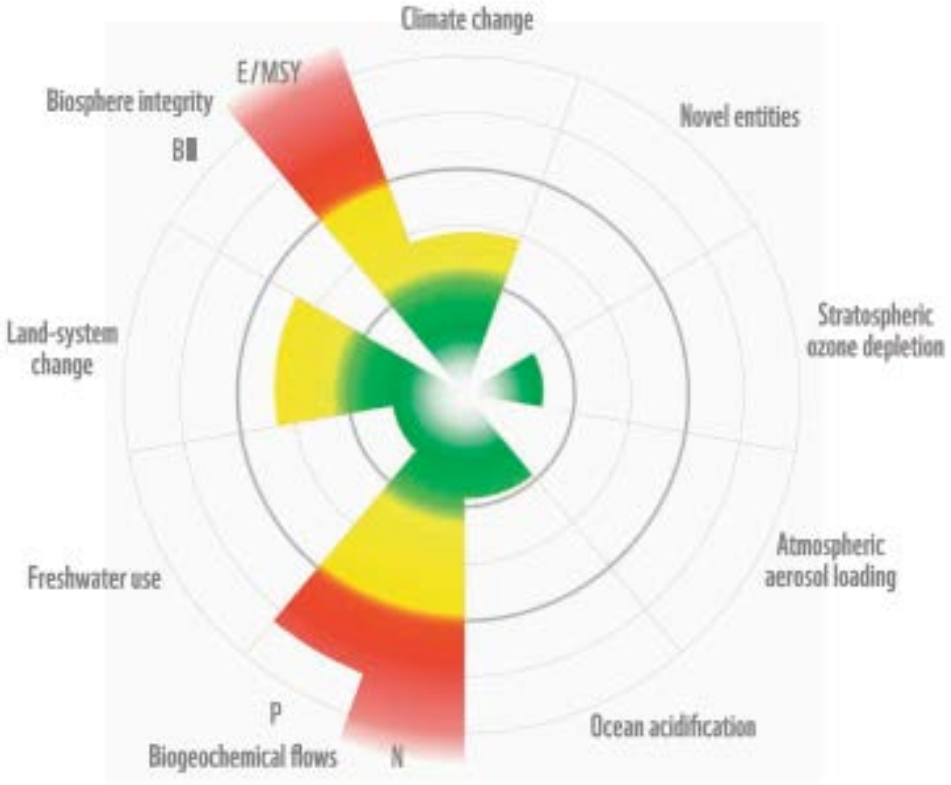
Nutrient accumulation worse problem than climate change





E/MSY Extinction rate (Extinctions per Millions Species-Years)
B Biodiversity Intactness Index
N Industrial and intentional biological fixation of N
P P flow from freshwater systems into the ocean (global) & P flow from fertilizers to erodible soils (regional)
Beyond zone of uncertainty (high risk)
In zone of uncertainty (increasing risk)
Below boundary (safe)

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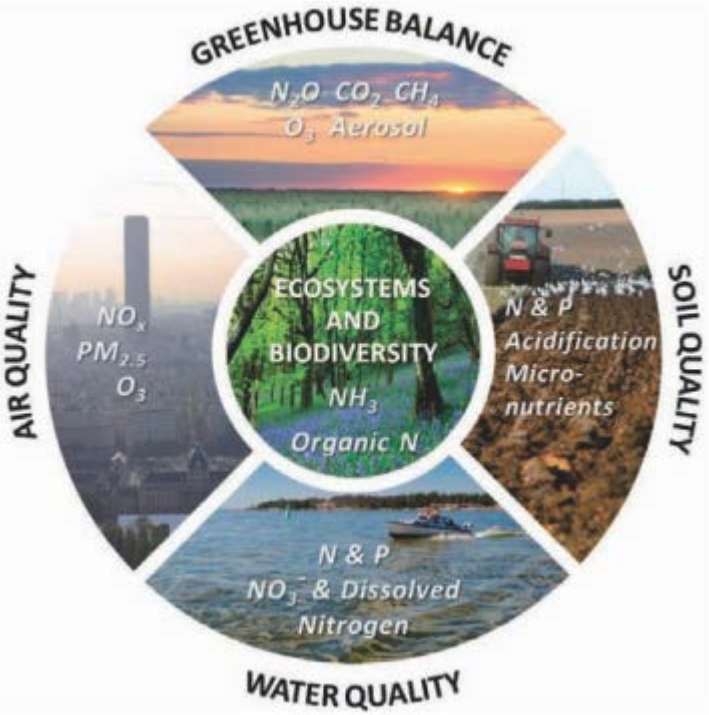
AD and Biogas alleviate key global threats

- Functions of AD and biogas:
  - Main scavenger tech for organic waste streams in industry and urban areas
  - Air quality and reduced NO_x formation
  - Improved nutrient management in agriculture
  - Aid for biological CCS schemes in agriculture, alleviates soil compaction
  - Renewable energy carrier
  - Renewable raw material (Carboxylic platform; CH_4, H_2)
  - Power balance services, grid injection
  - Sanitation (water quality, pathogen reduction)



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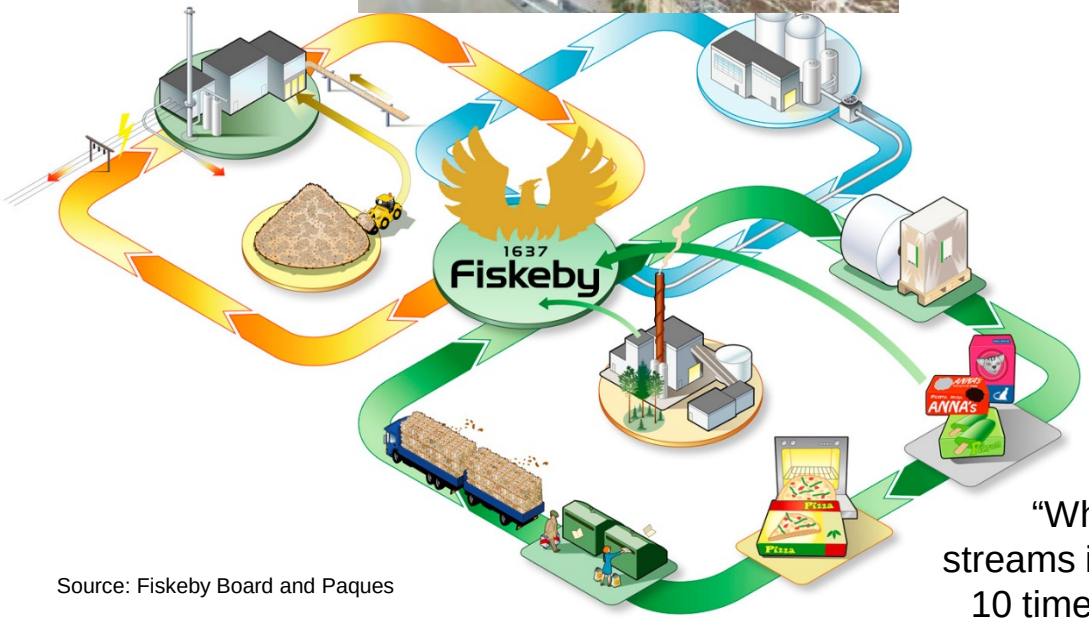
1 TWh biogas potential in Swedish paper and pulp mill effluents

UASB Technology taking care of effluent from recycled cardboard mill (Fiskeby Board). Considered end-use: Biogas powered infrared dryers



Source: Fiskeby Board and Paques

"Why spend energy to get rid of energy rich waste streams instead of spending a little bit of energy to gain 10 times as much?" Hans Kjellvander, Holmen Energi

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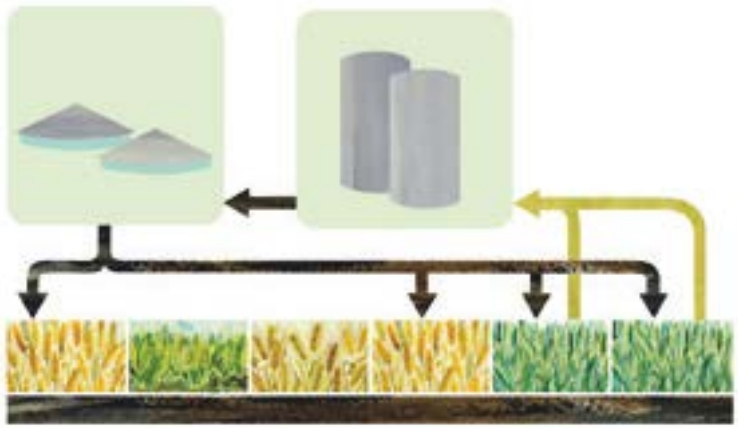
Using ley cropping to make arable land in Nordic countries into carbon sinks



S1

S2

Source: Presentation EBA Conference 2016, Bruce Dale

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Opportunities for double cropping in warmer climates

Biogasdoneright™

Produces Food and Low Carbon Energy

Large Scale

Increased Soil Organic Carbon

Improved Farm Economics

Widely Applicable Nutrient Recycle

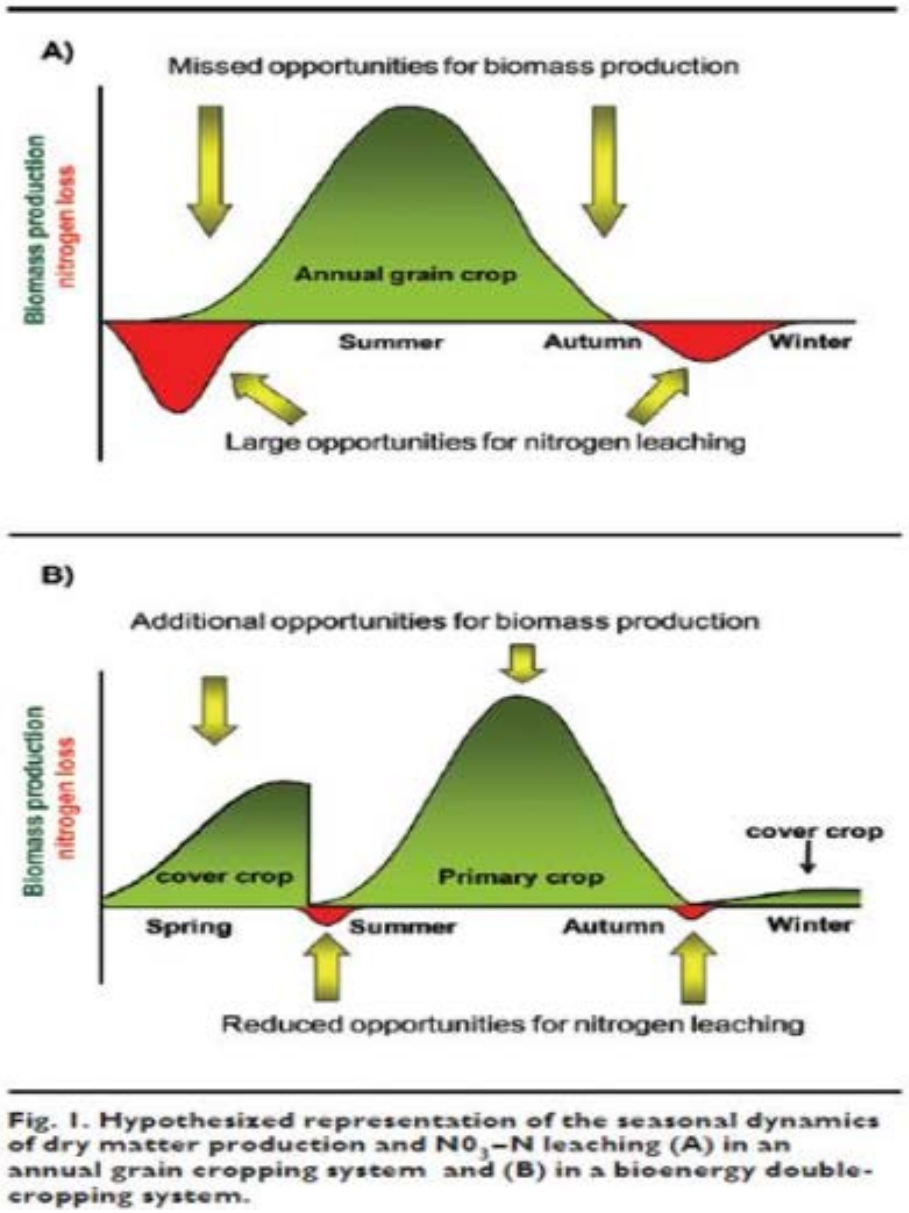

Fig. 1. Hypothesized representation of the seasonal dynamics of dry matter production and NO_3–N leaching (A) in an annual grain cropping system and (B) in a bioenergy double-cropping system.

Source: Presentation EBA Conference 2016, Bruce Dale

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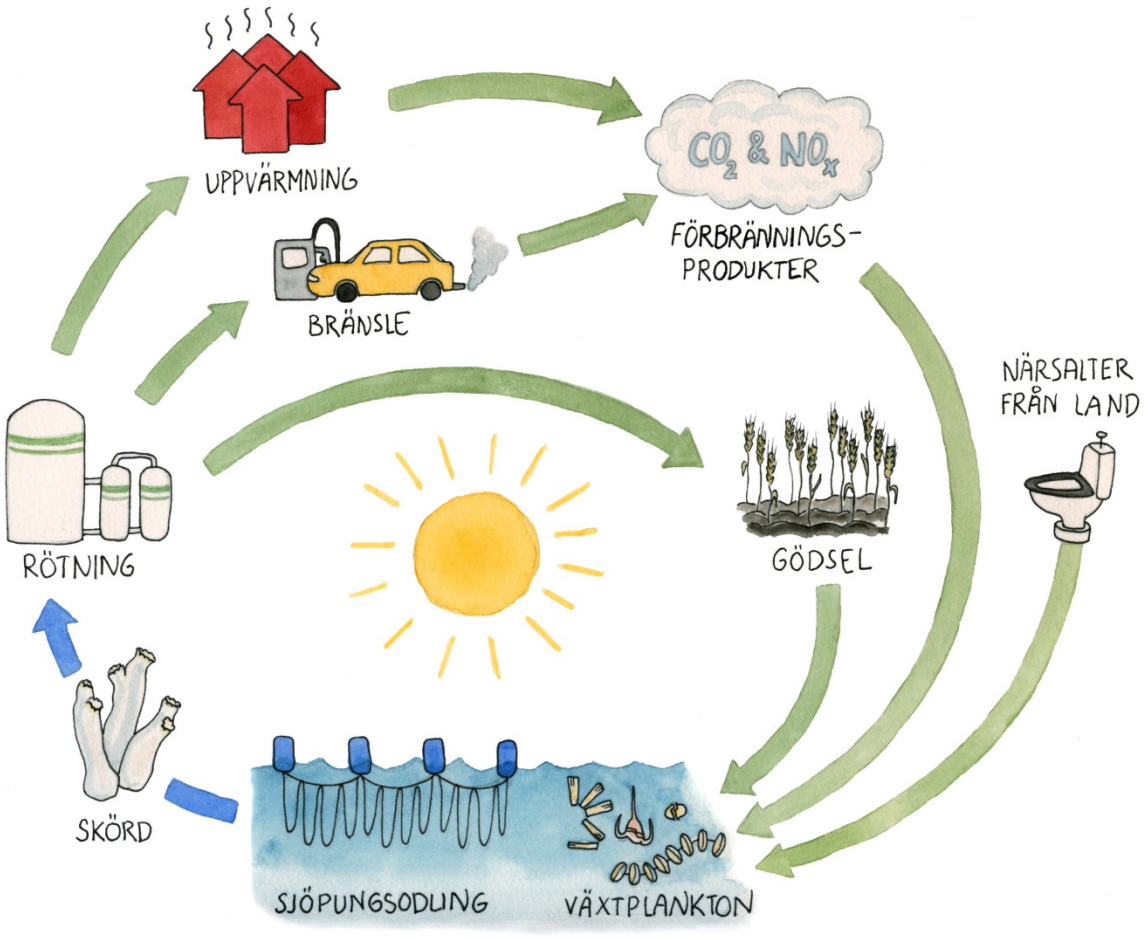
650 MWh/ha potential from Ascidian* farms in coastal sea areas removing 26 ton N/ha



* (Sea squirt, Ciona intestinalis)
http://www.mynewsdesk.com/se/pressreleases/23-miljoner-till-foernyelsebar-energi-foer-ett-renare-hav-1128630

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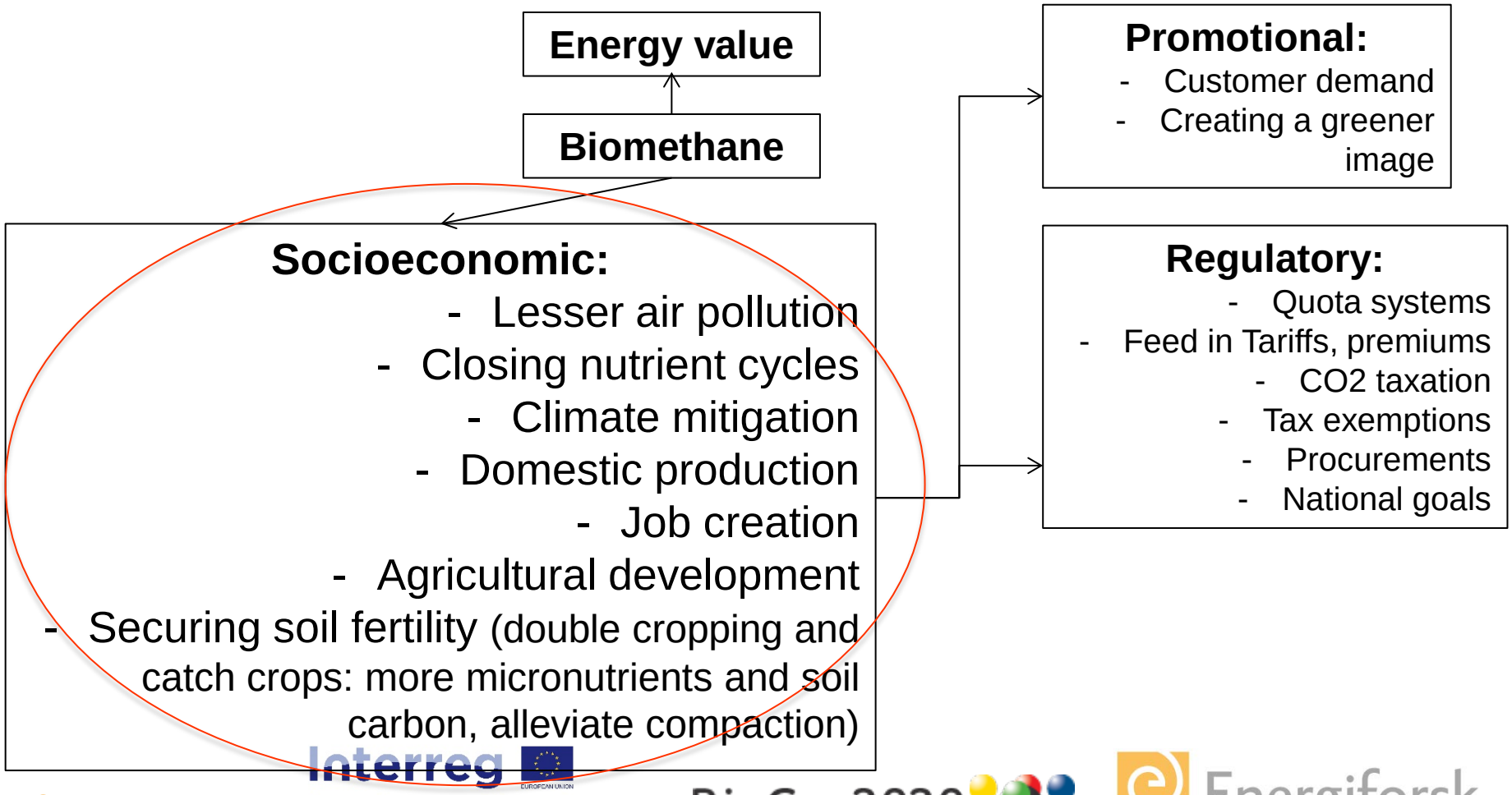
So AD and biogas brings positive externalities - do we value them enough?



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Why is it not already happening?

- No or inadequate recognition of socio-economic services rendered
- Production capital intensive with low profit margins
- Market actor inadequacies
  - Complex and heterogenous value chain
  - Marginal segment for many involved actors, e.g. gas industry and vehicle manufacturers
  - Lack of commercial competence
- Public perception and acceptance
- Bioenergy credibility is suffering (energy crops, forestry)
- Biomethane: Electric powertrain preferences, e.g. city bus segment
- The need for long-term policy environments

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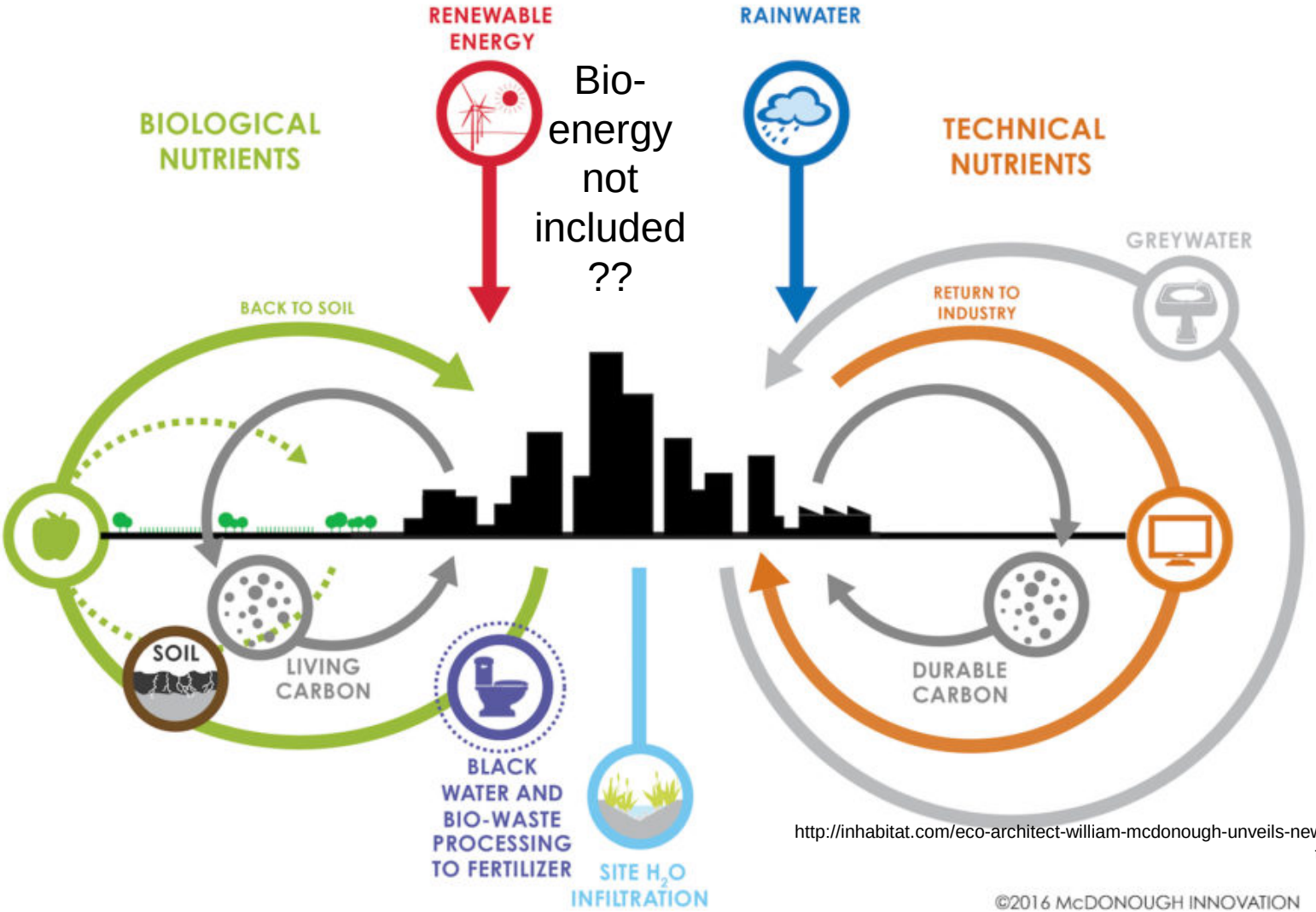
The future?



http://inhabitat.com/eco-architect-william-mcdonough-unveils-new-language-to-end-the-war-on-carbon/

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Sustainability of bioenergy questioned

- ILUC – Indirect land use change, the reason behind the 7 % cap food based biofuels in EU
- The “carbon debt” issue (gasification!)
  - Long pay-back time for forest-based bioenergy
  - But: Intensified forest management show that BOTH forest growth and increased gross fellings are possible, inclusive of solid biofuels outtake
- Current state of mind:
  - Policies disappearing
  - Lack of trust – is this really the solution for the future?
- Crucial to turn this around in time for post 2020 regulations of biofuels and renewable energy!

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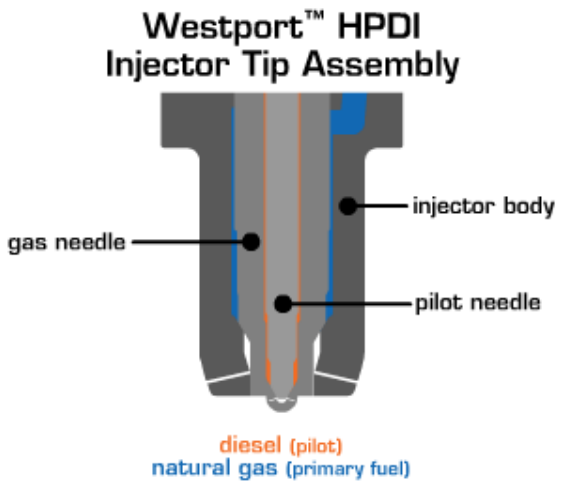
The future gas engine with diesel-like performance

- Current commercial trends:
  - Scania Euro VI dedicated otto gas engine 340 hp: Sweet spot 40% efficiency, only 7% fuel penalty mixed driving. Rumours about >400hp version!
  - Westport HPDI 2.0: dual-fuel direct injection with diesel-like performance, Volvo launch predicted to late 2017



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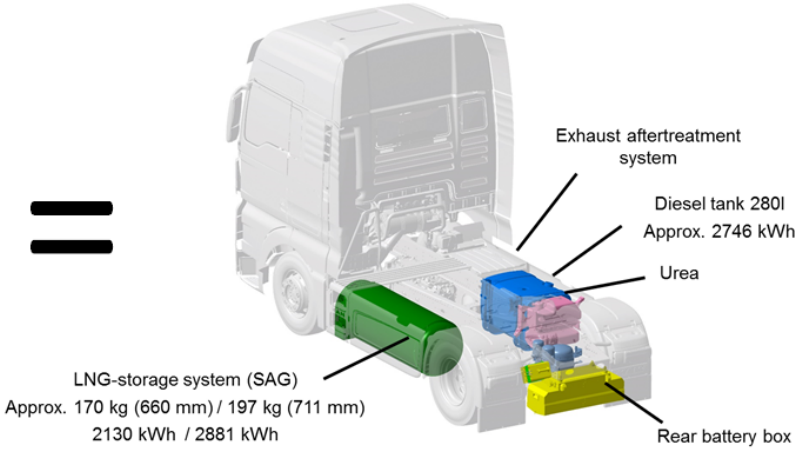
HDGAS – MAN, IVECO and Volvo working together on more efficient methane HDVs



Three HDGAS engine concepts:
Volvo - A high pressure gas direct injection diesel engine
Iveco - A low pressure direct injection spark ignited engine
MAN - A low pressure port injected dual fuel engine

LNG tank

LNG DualFuel demo truck
TRL Level 6/7

Source: www.hdgas.eu

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Diesel-like gas engines feasible?

- Current gas engines in essence non-optimized conversions of conventional engines – research shows potential!
  - Improved low load performance and increased max. power close to the dilution limit through high turbulence pistons, EGR, turbocharging, higher compression and model based control (M Kaiadi 2011)
  - Increasing dilution limit further: Fuelled prechamber tech delivered 47.5% efficiency at 10 bar IMEPg with low NOx (no optimization) – results not dependent on engine scale! Lack of funding for further studies! (A. Shah 2015)
  - Stratified lean burn DI (18 bar) 28 % more efficient compared to stoichiometric, mixing limitations creates soot and need further work on hardware optimization (M. Melaika 2016)

- But: It all hinges upon the gas quality delivered!
  - Controlling trace compounds, biomethane can deliver

Biogas and AD in the circular economy

Thank you for the opportunity!

Questions?

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Final remarks

- The complex research showing the environmental and socioeconomic sustainability benefits of bioenergy need to be disseminated AND demonstrated!
- Public-private partnerships and long-term policies are key in building a biomethane powered NGV market!
  - Cost adaptive but long-term policy environment, preferrably % market size!
  - The whole value-chain need to be involved from the beginning!
  - Future efficient gas powertrains calls for cooperation between gas industry and vehicle manufacturers!
- More commercial competence building needed!
- Need to Customer oriented approach, making gas powered transport more “sexy”
- In the background: Reduction of OPEX and CAPEX through continued technology improvement and increased understanding of the AD biology regarding the technology of the process – harvesting and storage issues in both agriculture and aquaculture important areas

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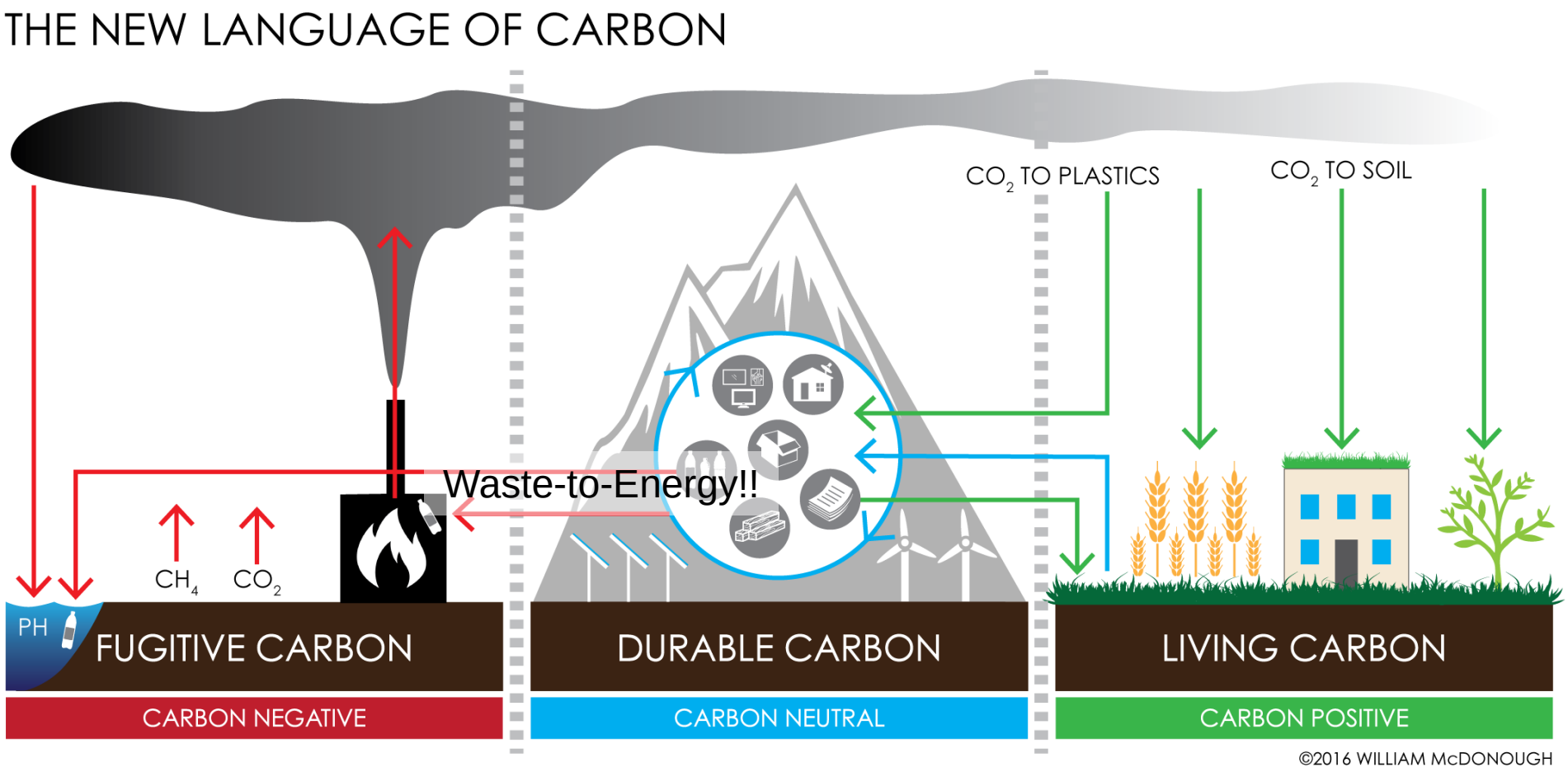
Why biomethane in transports?

Only fully oil dependent sector in Sweden! (92 %)*

- **Full utilization of energy with solutions available now**
  - Inevitable heat losses in CHP utilization, wind & sun better alternatives
  - Commercially available solutions for oil dependent transports of all types (LDV, MDV, HDV, short, medium and long-distant), with performance on par with diesel soon to come!
  - Natural gas and biomethane: freely intermixed and interchangeable
  - Evident co-distribution and backup synergies (backup for market fluctuations, process failure) allow for 100 % utilization of your biomethane and earlier market buildup
- **Promotional value compensates for added costs**
  - Steadily increasing the renewable share gives true greening

* Industry – 25 % fossil fuels (oil, coal,natural gas)
Households – 10 % fossil fuels (oil)
Source: Energiläget 2014, Swedish Energy Agency

The future?



http://www.mcdonough.com/new-language-carbon/

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THE NEW LANGUAGE OF CARBON

Too much carbon in the atmosphere is damaging. Instead, it should be retained in durable forms such as plastic and wood or in living organisms. Recycling materials and nurturing the soil ensure that carbon ends up in the right places in the right amounts.

FUGITIVE CARBON

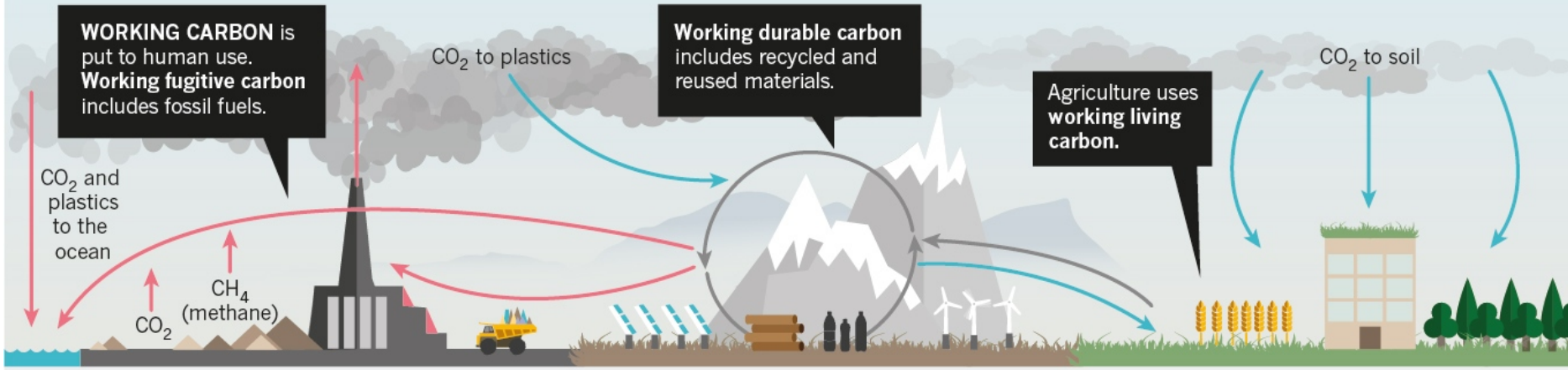
Has ended up somewhere unwanted and can be toxic. It includes carbon dioxide released into the atmosphere by burning fossil fuels, 'waste to energy' plants, methane leaks, deforestation, much industrial agriculture and urban development. Plastic in the ocean is fugitive carbon.

DURABLE CARBON

Locked in stable solids such as coal and limestone, or in recyclable polymers that are used and reused. It ranges from reusable fibre, such as paper and cloth, to building and infrastructure elements that can last for generations and then be reused.

LIVING CARBON

Organic, flowing in biological cycles, providing fresh food, healthy forests and fertile soil. It is something we want to cultivate and grow. Soil includes living carbon in the form of fungi, microbes, humus, legumes and grasses.



MANAGEMENT STRATEGIES

CARBON NEGATIVE

Actions that pollute the land, water and atmosphere with various forms of carbon. For example, releasing methane into the atmosphere or plastic waste into the ocean is carbon negative.

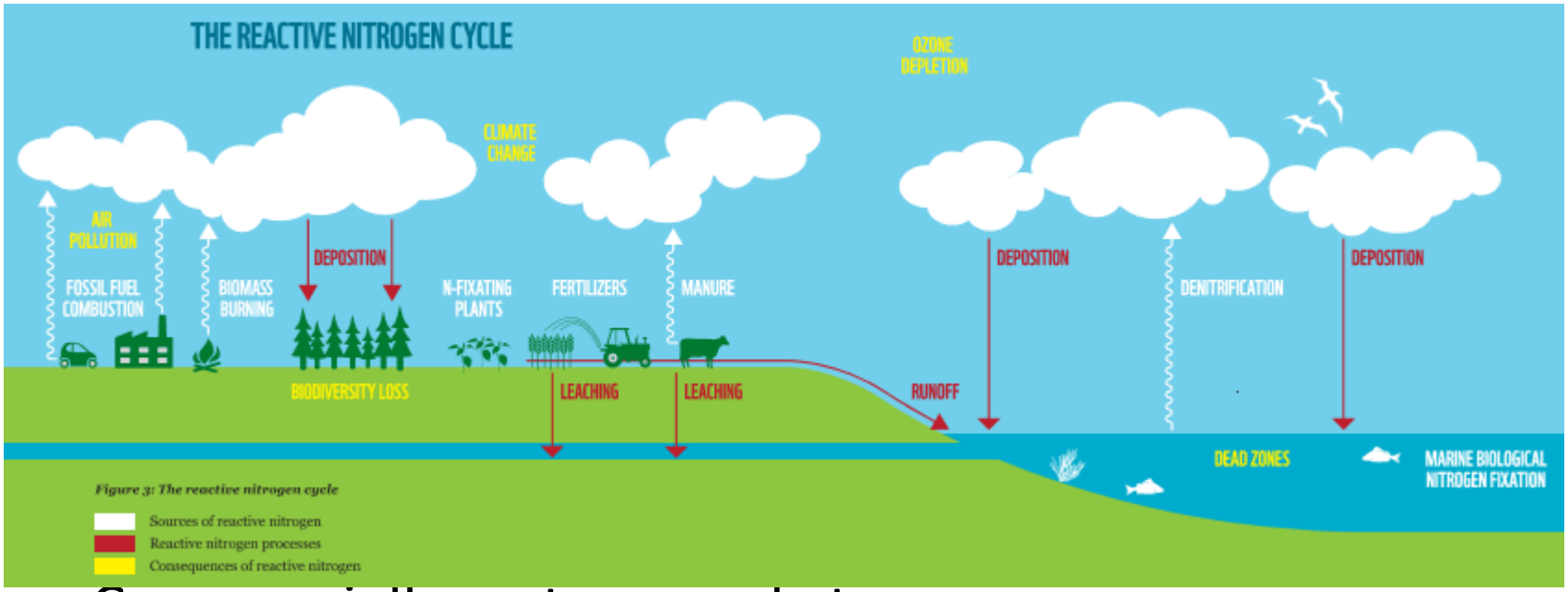
CARBON NEUTRAL

Actions that transform or maintain carbon in durable earthbound forms and cycles for use across generations; or renewable energy such as solar, wind and hydropower that do not release carbon.

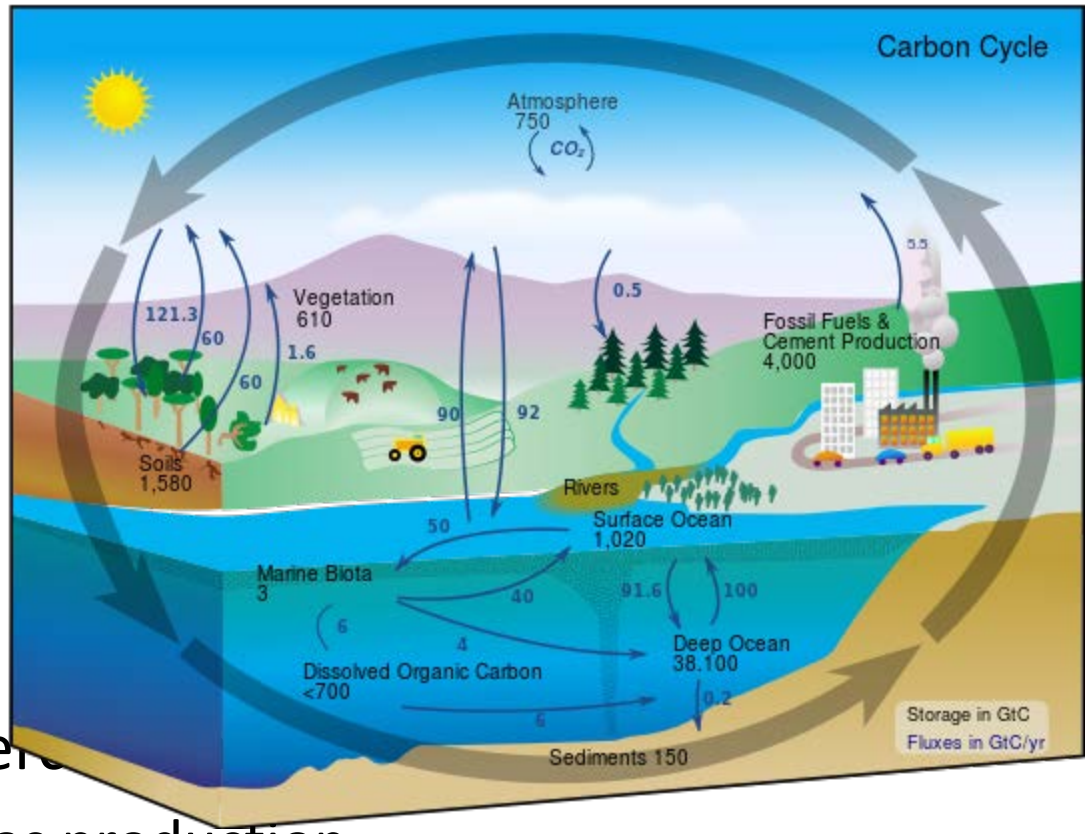
CARBON POSITIVE

Actions that convert atmospheric carbon to forms that enhance soil nutrition or to durable forms such as polymers and solid aggregates. Also includes the recycling of carbon into soil nutrients from organic materials, food waste, compostable polymers and sewage.

http://www.nature.com/news/carbon-is-not-the-enemy-1.20970



- Commercially mature market
  - Biogas production



- Comme
  - Biogas production

This carbon cycle diagram shows the storage and annual exchange of carbo
the atmosphere, hydrosphere and geosphere in gigatons - or billions of tons - of Ca
Burning fossil fuels by people adds about 5.5 GtC of carbon per year into the a
Wikicommons Fis

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