Holistic perspectives on manure management

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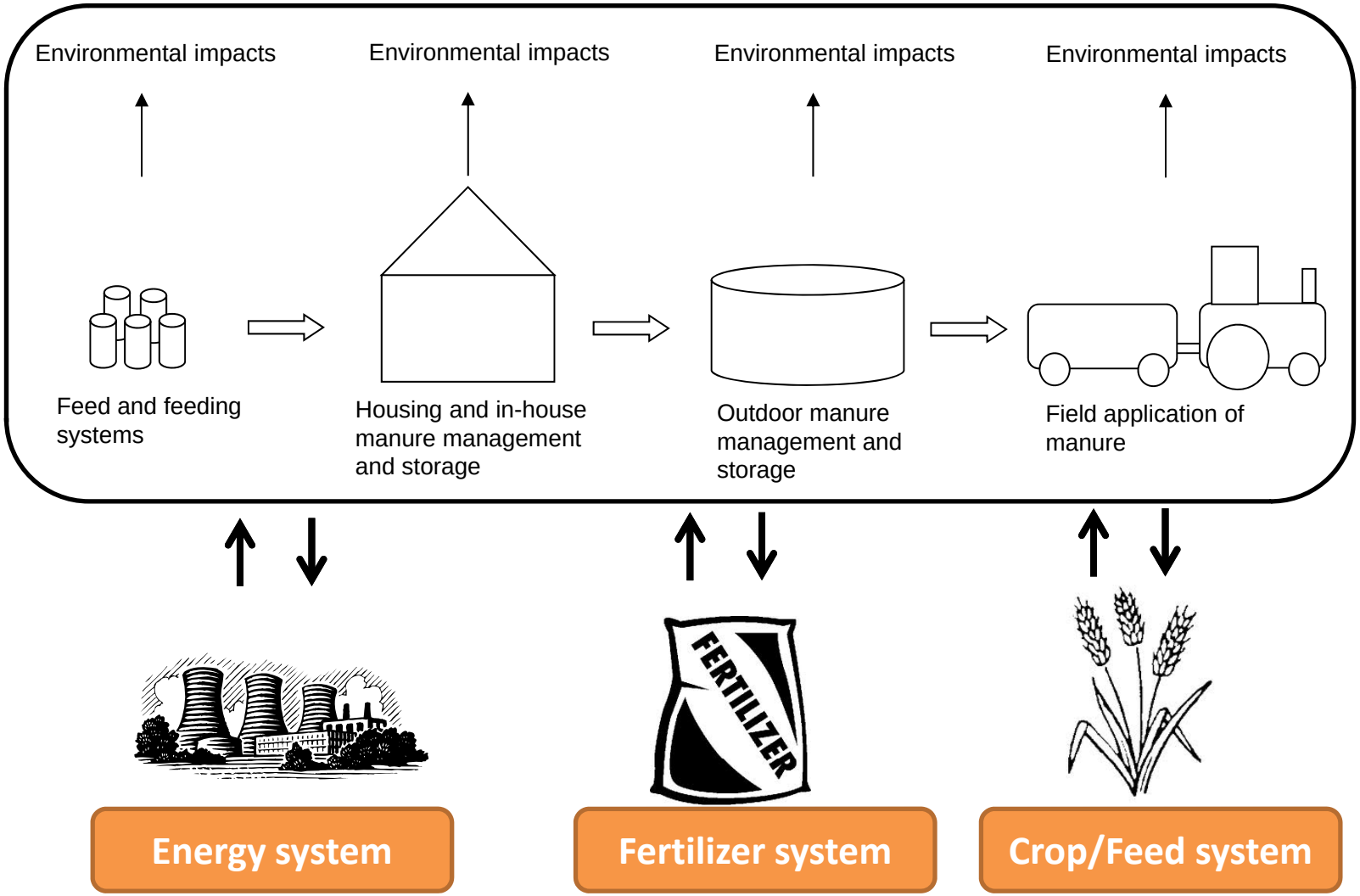
Greener Agriculture for a Bluer Baltic Sea 2013

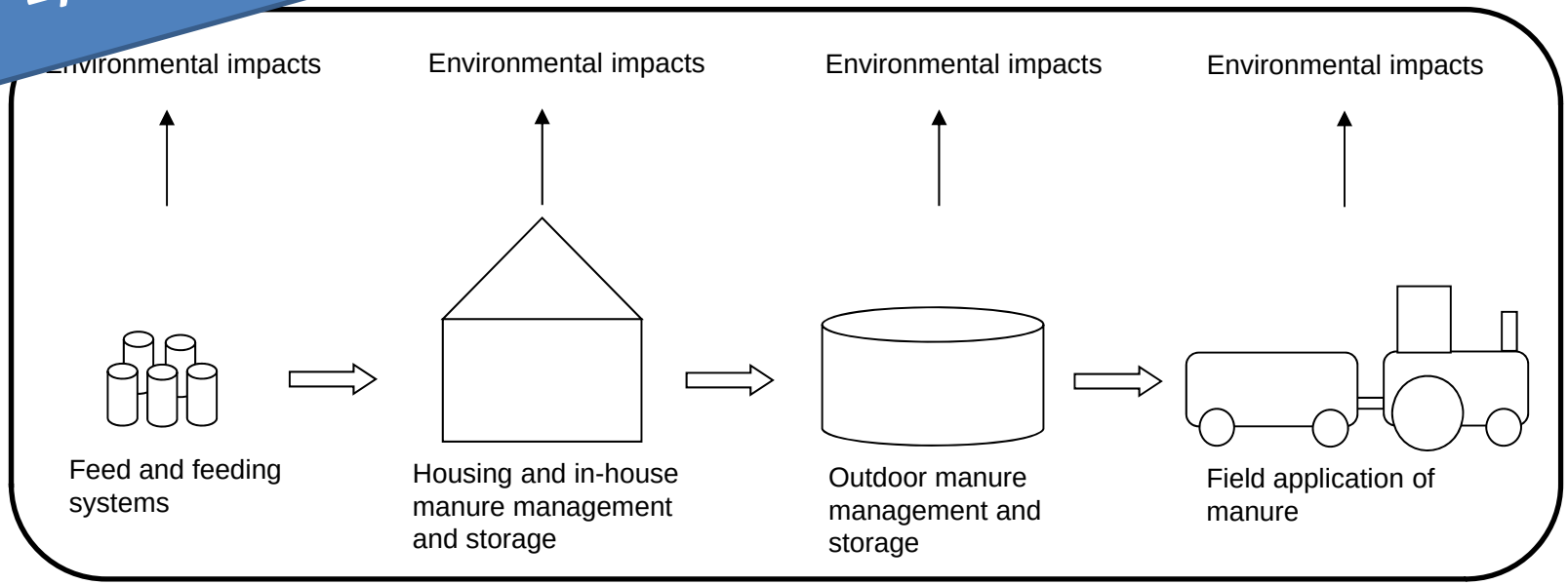
The project is partly financed by the European Union (European Regional Development Fund)

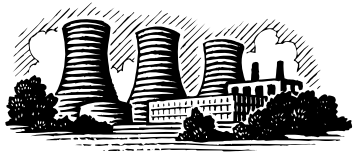
Whole system approach



Wh system oach

1) Address the whole chain



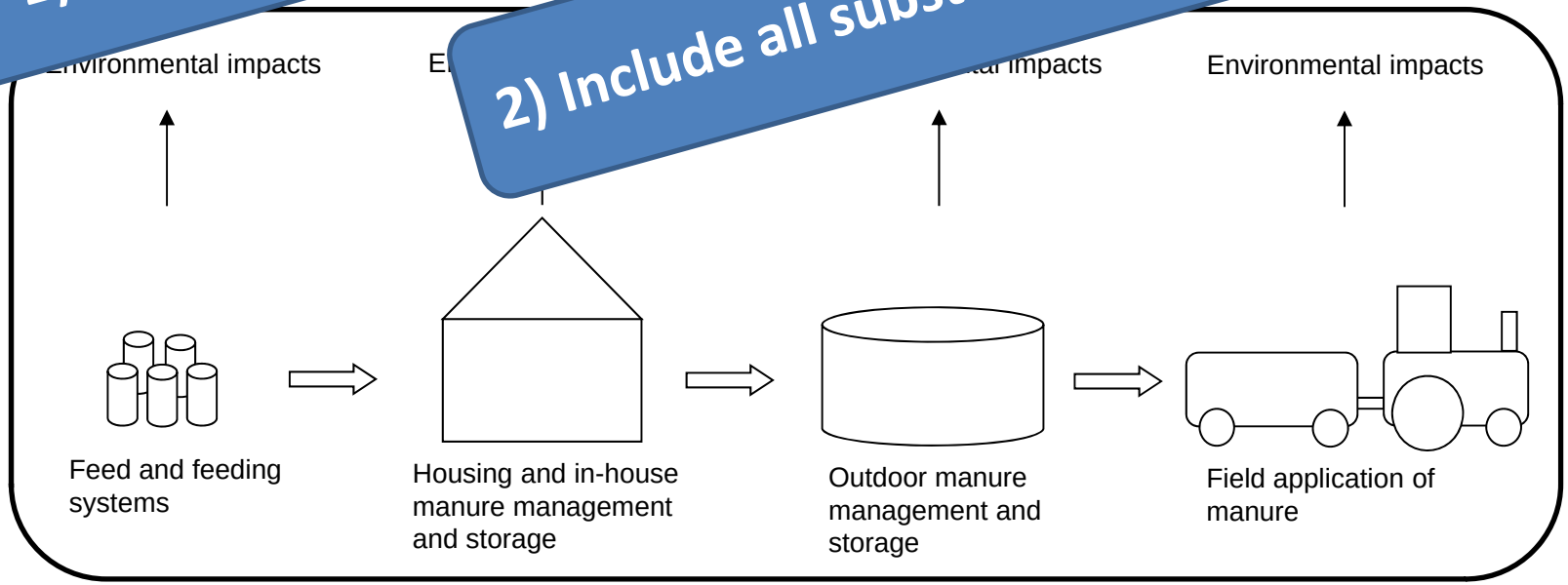


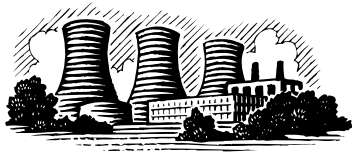
Energy system | **Fertilizer system** | **Crop/Feed system**

Wh system oach

1) Address the whole chain

2) Include all substances affected





Energy system

Fertilizer system

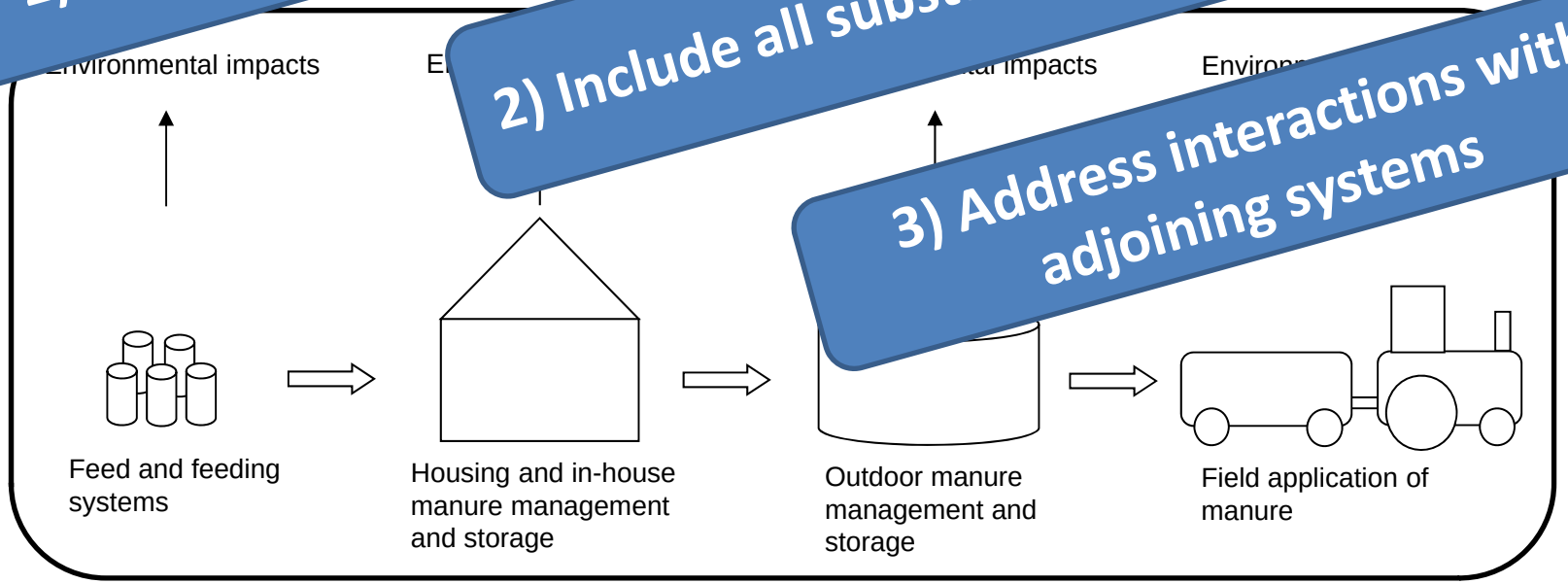
Crop/Feed system

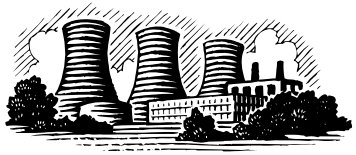
Wh system
oach

1) Address the whole chain

2) Include all substances affected

3) Address interactions with adjoining systems





Energy system

Fertilizer system

Crop/Feed system

Environmentally ideal

- **What defines “environmentally ideal”?**
- **Must be quantified in a future perspective:**
  - **Decisions are taken TODAY, and will generate consequences in the FUTURE**

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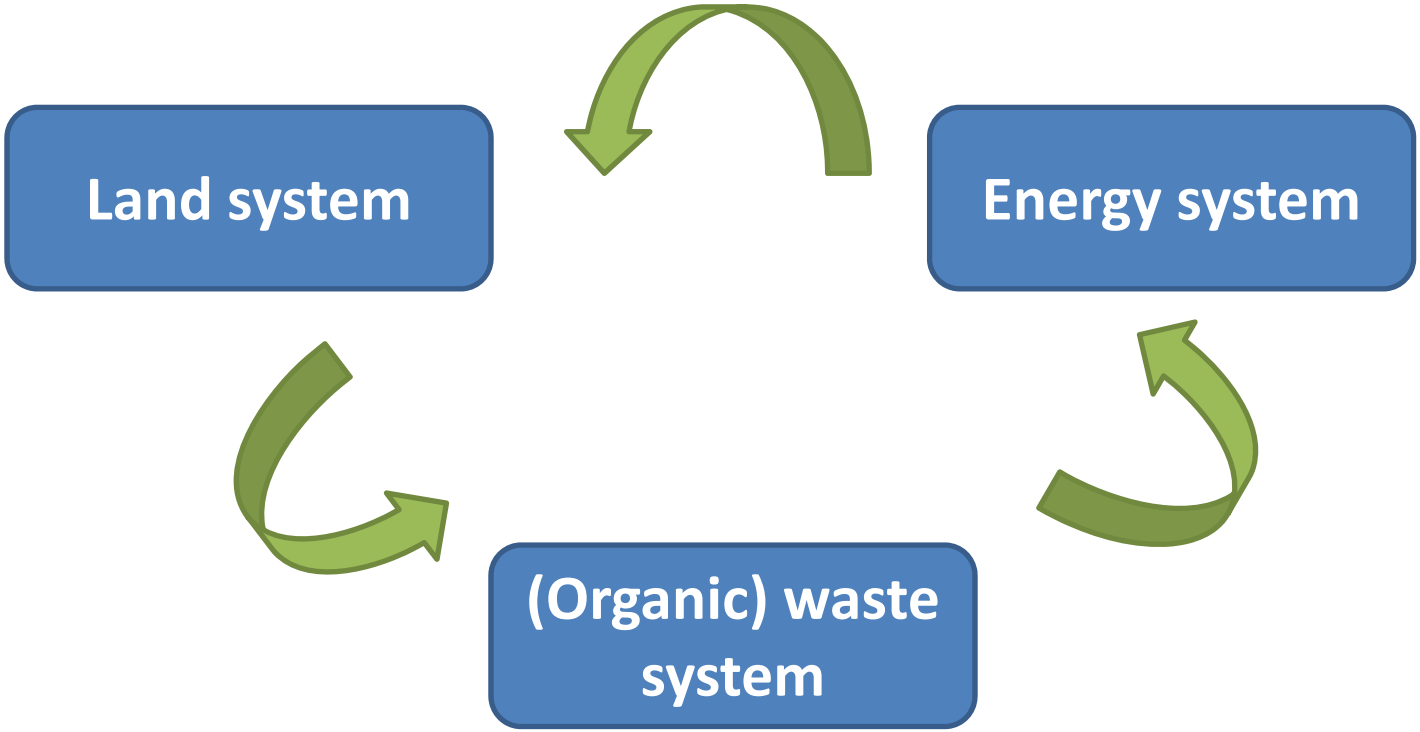
Background conditions for possible futures

- More people to feed?
- More meat in the menu?
- Organic food / feed / meat demand & animal welfare?
- Increased demand for land-dependant bioenergy ?
- Uncertain prospects for yield increase
  - Accessibility of fertilizers in key regions
  - P status?
  - Pollinator status and biodiversity?
  - Climate change impacts ?
  - What would be the dominant driver (N-based, technology?)

System Integration



1) The land system

Agriculture & Forestry

- The global view on proportions

Comparison of food and energy

All harvested biomass "today" (year 2000)	≈ 230 EJ/year
Fossil energy consumption today	≈ 450 EJ/year
Biomass for full fossil substitution today	≈ 680 EJ/year

→ we need ≈ 3 times as much biomass as what is harvested "today" for full fossil substitution by biomass

Can agricultural yield increases reduce the gap?

Yield increase in agriculture	≈ 1.2% per year
Global demand increase for cereals/veg. oil/ sugar	≈ 1.4/4.4/1.8% per year

Conclusion: Demand is rising faster than yield, so expansion unavoidable!

Baltic Sea Region Programme 2007-2013

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Global land constraints

13 Gha of land area on Earth:

- 4.89 Gha agricultural land
  - 1.53 Gha arable land;
  - 3.36 Gha permanent meadows and pastures
- 4.04 Gha forest
  - 3.76 Gha natural forest;
  - 0.28 Gha plantations
- 4.09 Gha other land
  - 2.50 Gha uncultivable (tundra, ice, desert);
  - 1.59 Gha rest (built-up land, savannah, etc.)

(FAOSTAT, retrieved in 2012; FAO 2010; Kampman et al. 2008; Kok et al. 2008)

Global land constraints

- How much of the 3.76 + 3.36 + 0.28 Gha is suitable for agricultural cultivation?

Theoretical!

- Ramankutty et al. (2002): 2.3 Gha additional
- IIASA*: 0.7 to 1.2 additional Gha
- EEA*: up to 0.4 additional Gha

* *In*: RFA (2008)

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Global land constraints

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The available additional cultivable cropland is LIMITED!

Theoretical!

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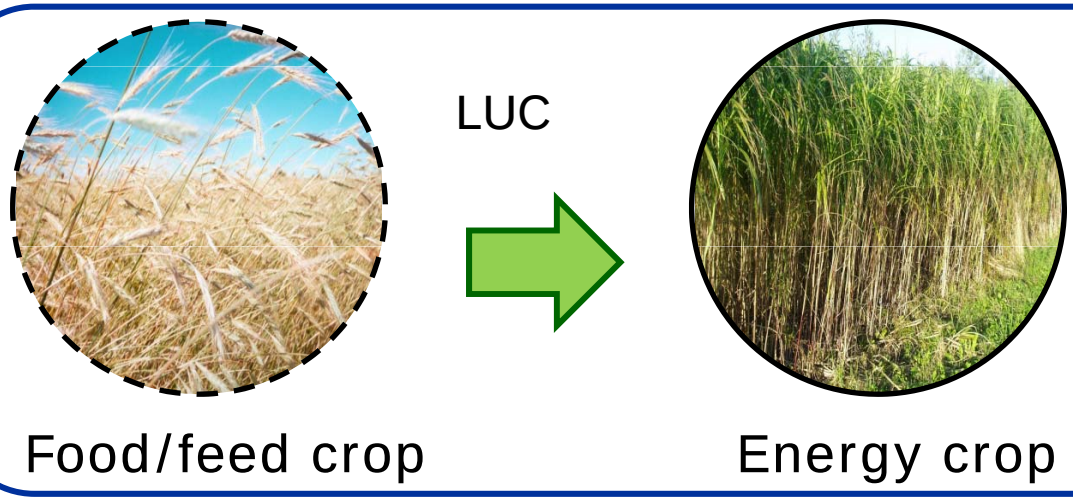
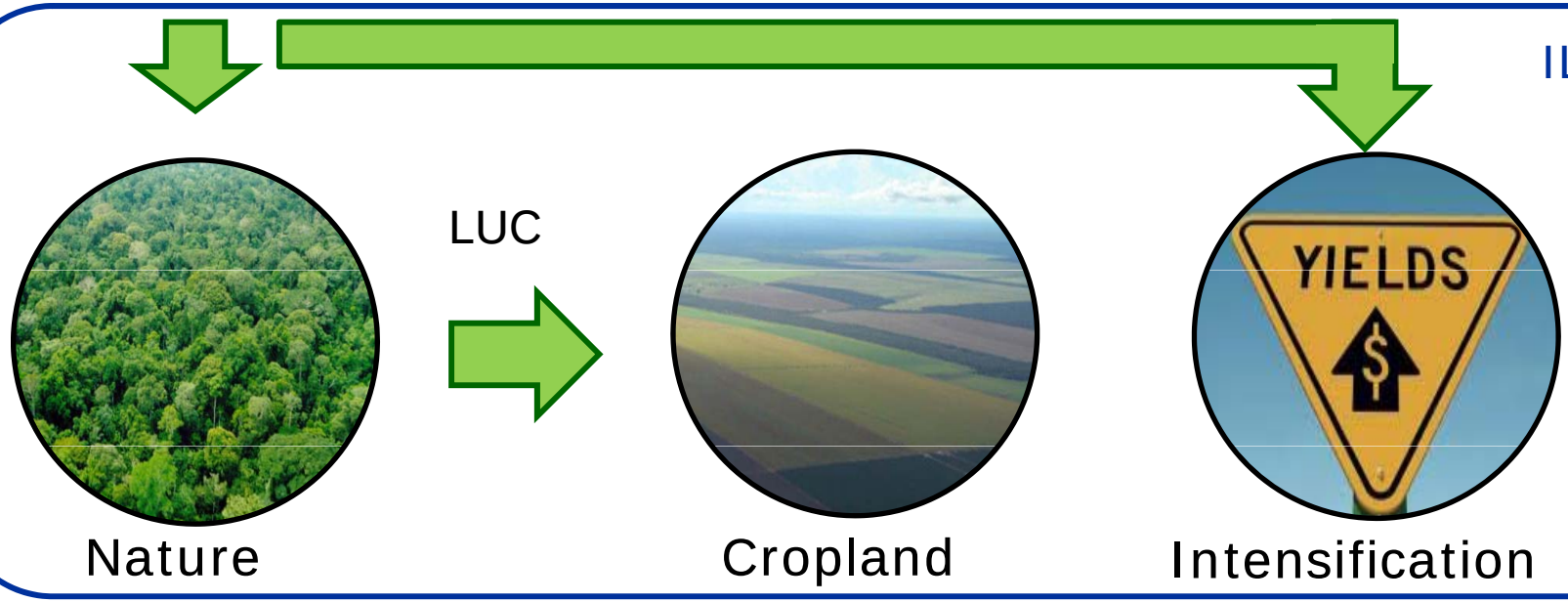
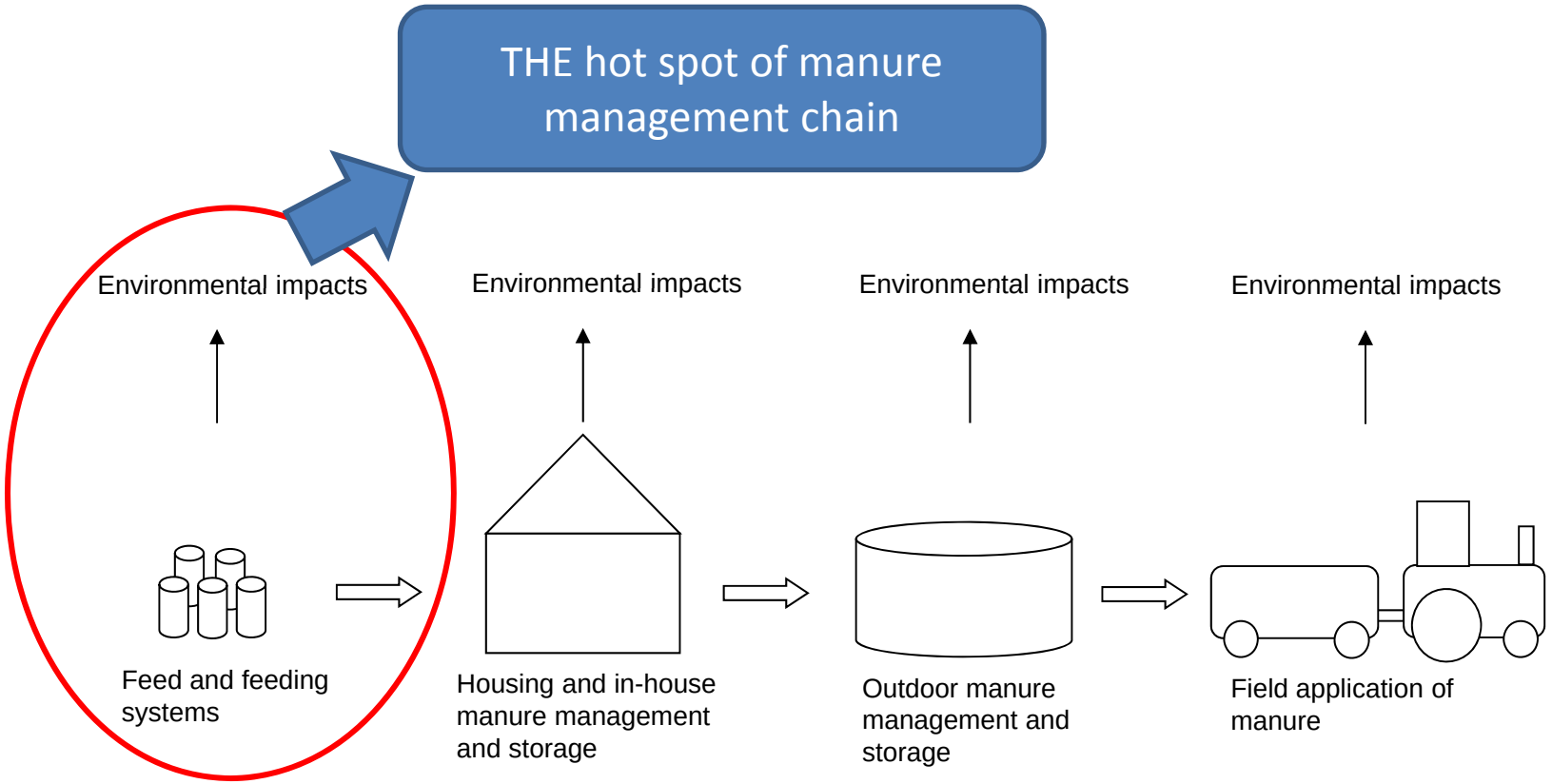
Land use changes





Land: why is it important?

- **Tropical deforestation ≈ 20 % of annual CO2 emisssions** (Gibbs et al., 2008)



2) The energy system

Closing the C gap

- the role of hydrogen for the Danish case

Step 1: Producing H_2 from water electrolysis

$$2\,H_2O_{(l)} \rightarrow 2\,H_{2(g)} + O_{2(g)}$$

Hydrogen for hydrogenation & CCR

- letting wind power replace land use by upgrading and recycling biogenic-C

1) Hydrogenation

Gasify the biomass into a syngas, and use the produced H_2 to upgrade the biomass energetic value

2) Carbone capture and recycling (CCR)

Use the produced H_2 and combine it with the CO_2 output of biomass combustion plants, to produce methane, methanol, or any C-based chemicals and materials.

Closing the carbon gap

- upgrading biomass and recycling carbon

Hydrogenation to methane:

biomass		hydrogen			methane		water
$C_6(H_2O)_5$	+	$12\ H_2$	$\longrightarrow$		$6\ CH_4$	+	$5\ H_2O$
2.8 MJ		2.9 MJ			4.8 MJ		

Hydrogenation to diesel:

biomass		hydrogen			diesel		water
$C_6(H_2O)_5$	+	$5.75\ H_2$	$\longrightarrow$		$½\ C_{12}H_{23}$	+	$5\ H_2O$
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CCR to methane:

carbon dioxide		hydrogen			methane		water
$6\ CO_2$	+	$24\ H_2$		→	$6\ CH_4$	+	$12\ H_2O$
0 MJ		5.8 MJ			4.8 MJ		

CCR to diesel:

carbon dioxide		hydrogen			diesel		water
$6\ CO_2$	+	$17.75\ H_2$		→	$½\ C_{12}H_{23}$	+	$5\ H_2O$
0 MJ		4.3 MJ			3.6 MJ		

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This surplus H_2 could also be used for **fertilizer production**, instead of natural gas

This surplus H_2 could also be used to **synthetize amino acids**, which would reduce the land demand for "protein" crop.

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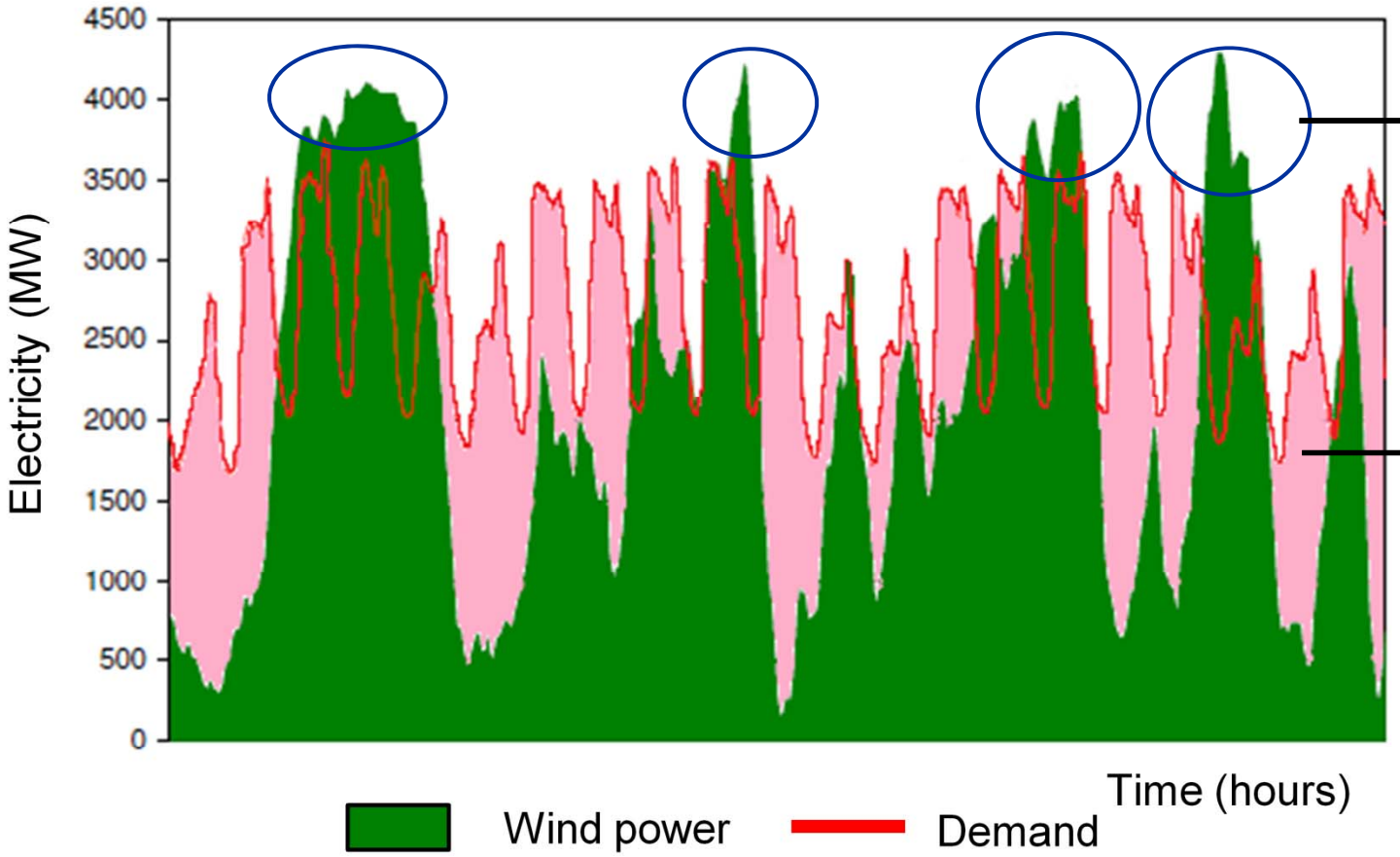
We want gas



Circles: surplus wind

In pink: wind not enough

Electricity produced from wind power vs demand. Modelled as 2008 capacity + 3000 MW (to represent 2020), for January (744 hours). Adapted from Hansen (2011).

Manure-Biogas: what we know

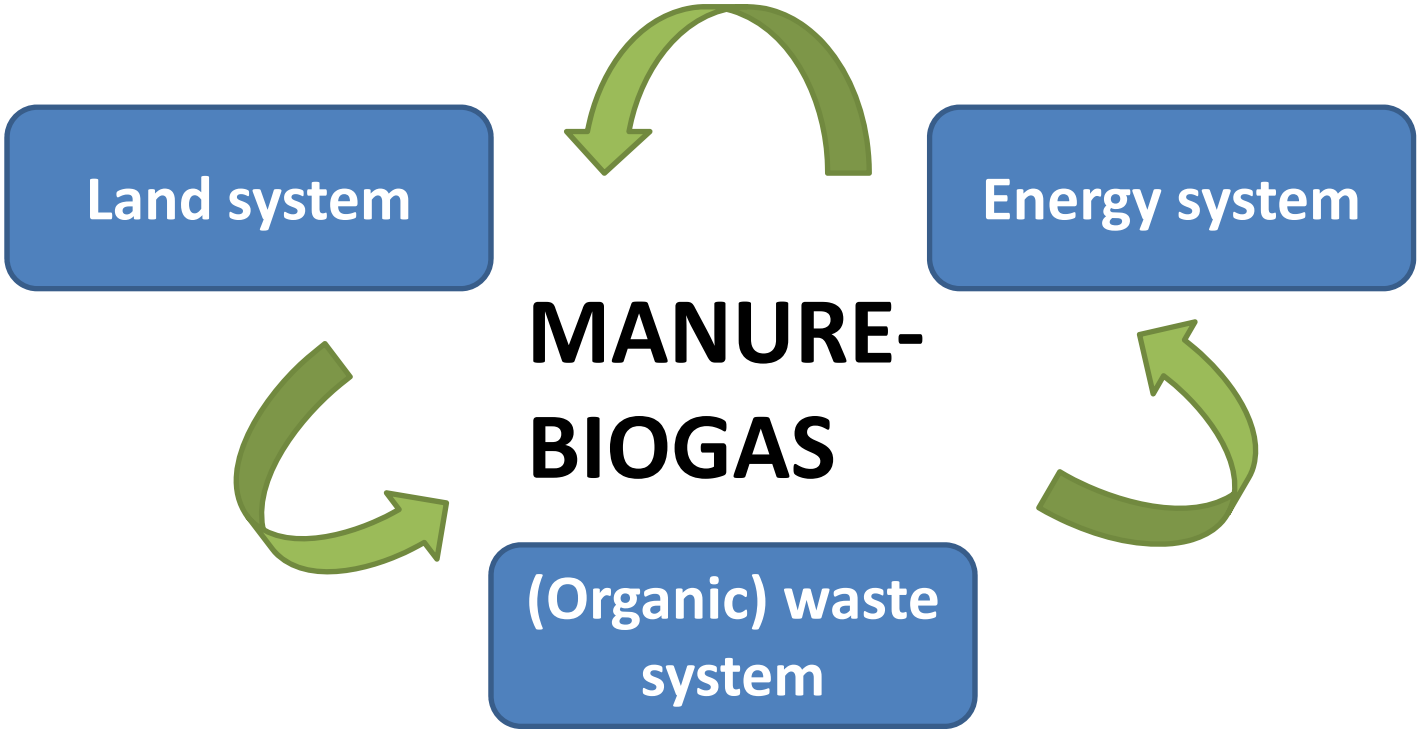
- **Tremendous benefits from avoiding reference manure management**
- **Ideal for nutrient and C recycling**
- **Organic material without a feed value should be prioritized for biogas**

Conclusive remarks & perspectives (I)

- **Importance of system perspective for long-term decisions that are taken NOW**
- **Any strategy allowing to minimize land use is likely to be of high interest for an "environmentally ideal" future.**

Conclusive remarks & perspectives (II)

- **Biogas: appears to be a key link to future "environmentally ideal" manure management, waste management and renewable energy systems**



Questions & Discussions

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www.balticmanure.eu

All results of Baltic Manure, including LCA results, to be found on the Baltic Manure website!!

All quoted references can be provided upon request

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