SYDDANSK UNIVERSITET

Inputs from WP5 – LCA of biogas and energy crops

Presented by : Lorie Hamelin

CEESA Project

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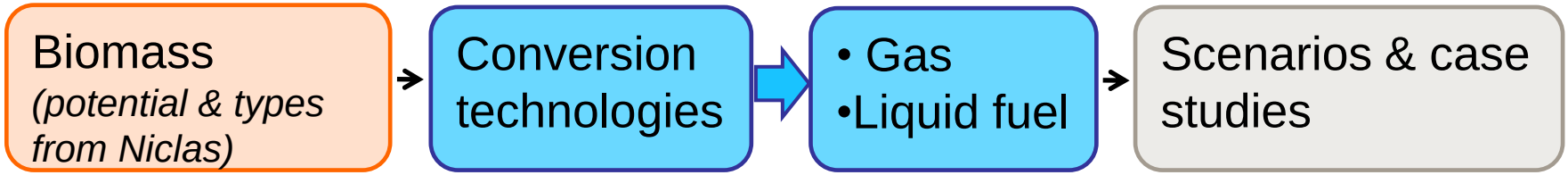
Overview

Providing "missing" data (1) in order to assess the environmental consequences (2) of the different CEESA scenarios to be considered



Var.	•Agr. biomass;	•All biomass types	
Data type	•Flow of substances *(C, N, etc.)* •Boundary conditions *(LUC, marginals)*	•Efficiencies •Process data •LHV	
Who	SDU	DTU	SDU/DTU

Outline

- **Biogas from BAT in Denmark from separated slurry**
  - Presentation of the project and results overview
- **Direct land use changes (LCA of energy crops)**
  - Overview and status
- **Activities and expected deliverables for 2010**

Biogas from separated slurry *- context*

- **Biogas from slurry only (through separated slurry):**
  - Using more of the slurry produced in Denmark for biogas production;
  - Limited availability of the C-source materials that are actually co-digested with the slurry.

Biogas from separated slurry *- context*

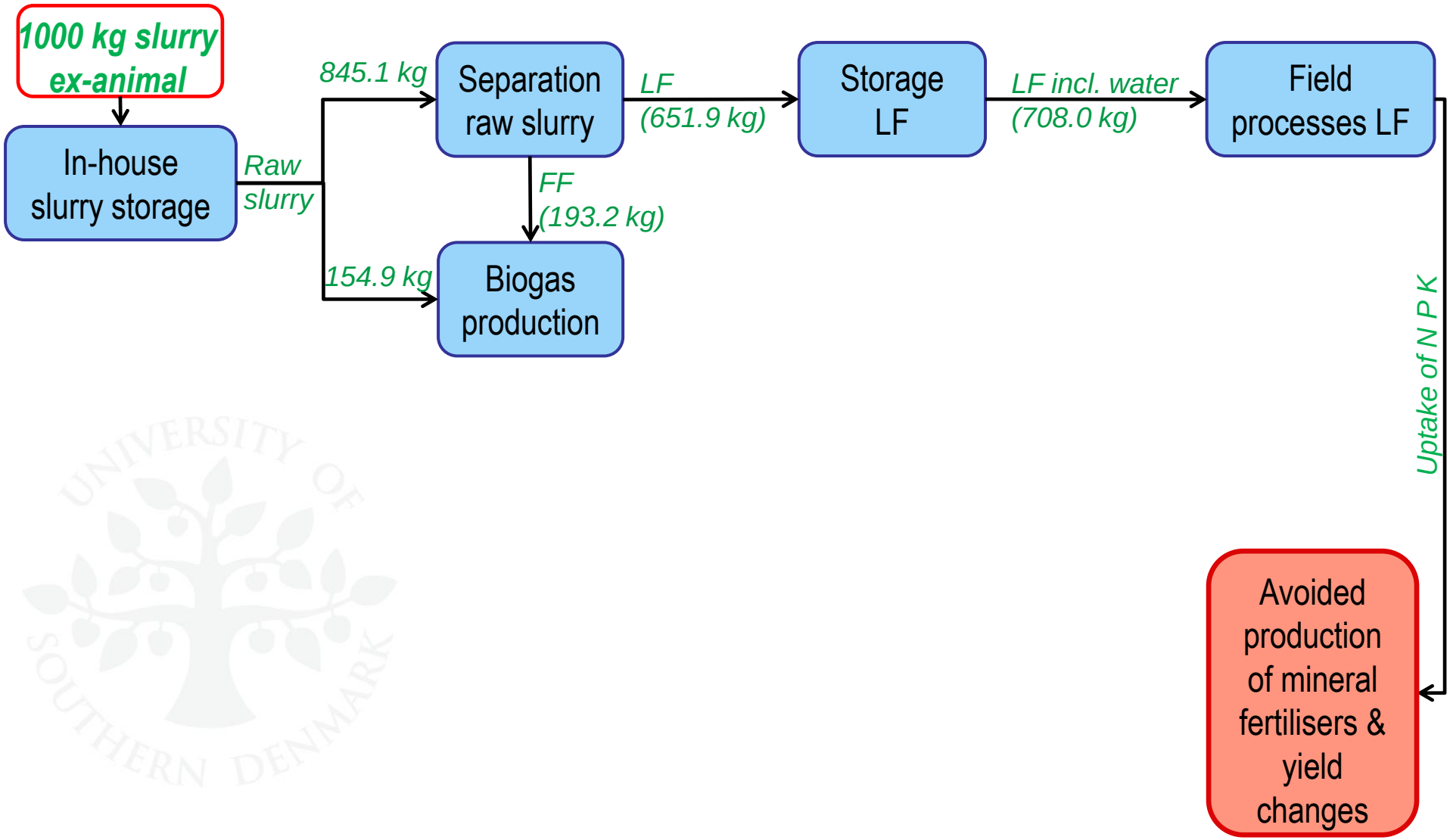
- **4 scenarios assessed with slurry as the sole C source :**

Raw manure + solid fraction from slurry separation

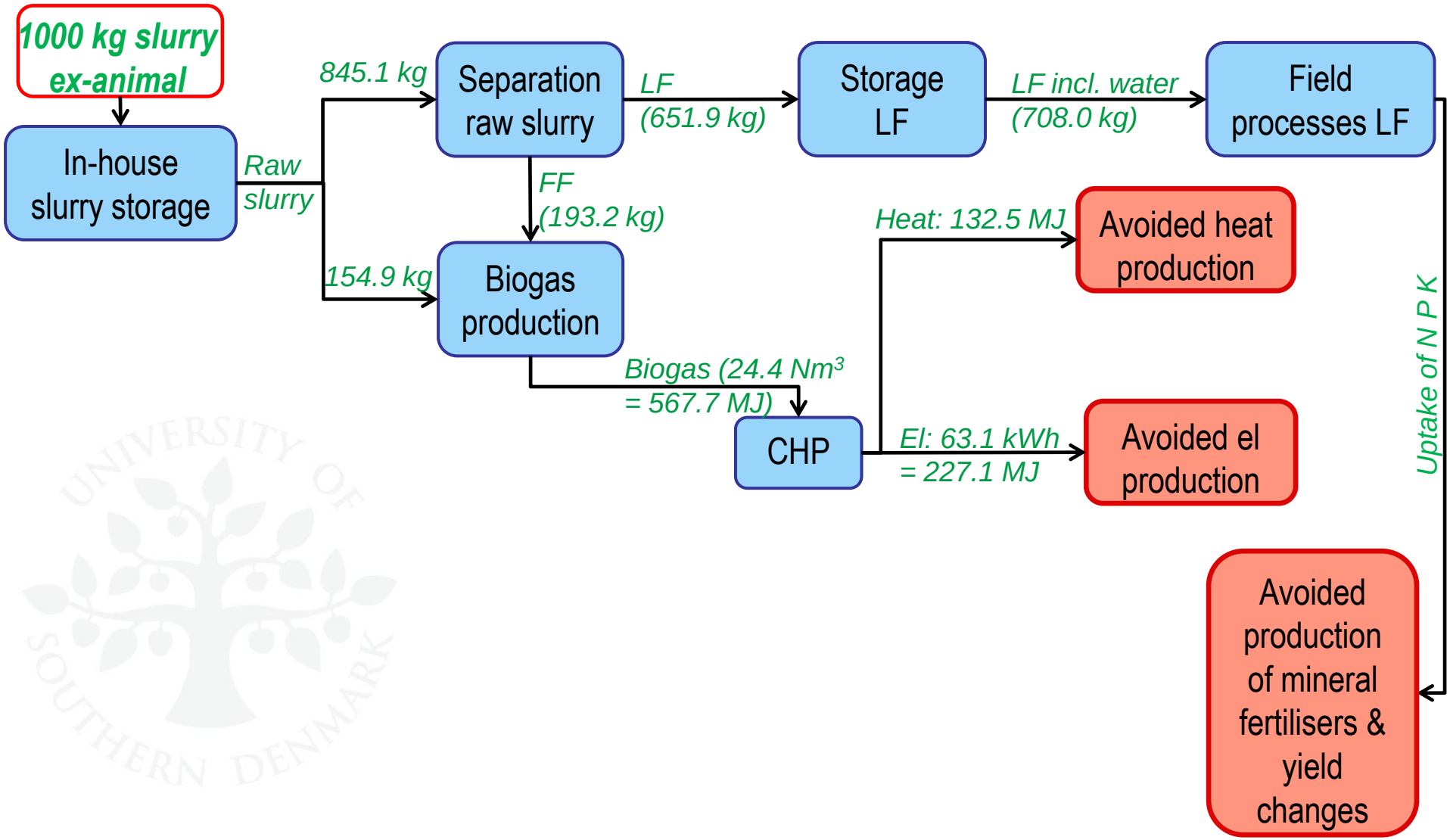
  - Chemical-mechanical separation (pig) + raw pig slurry
  - Chemical-mechanical separation (cow) + raw cow slurry
  - Mechanical separation (pig) + raw pig slurry
  - Fibre pellets (pig) + raw pig slurry

- **All compared to a reference slurry management scenario.**

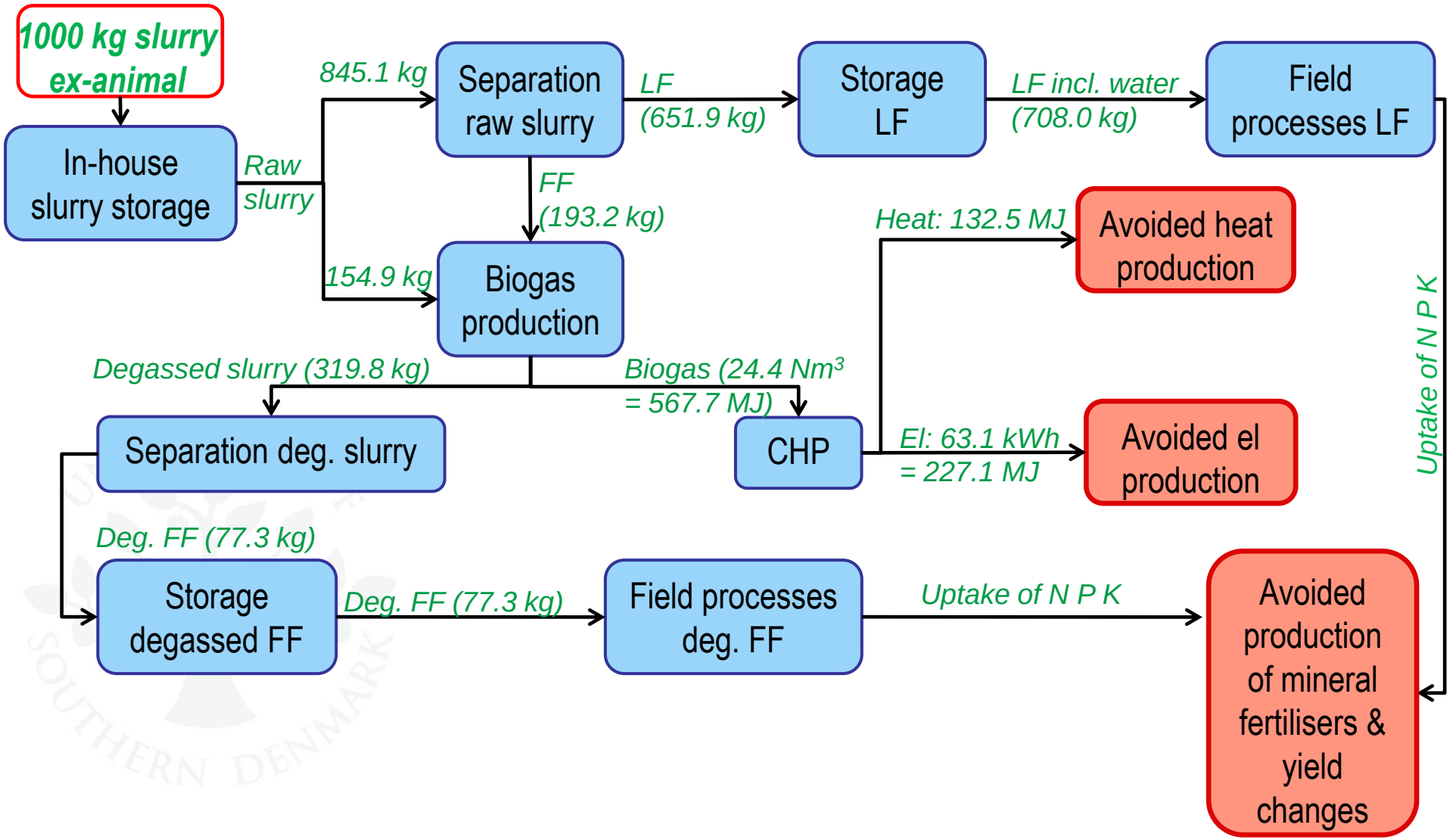
Biogas from separated slurry – *overview*



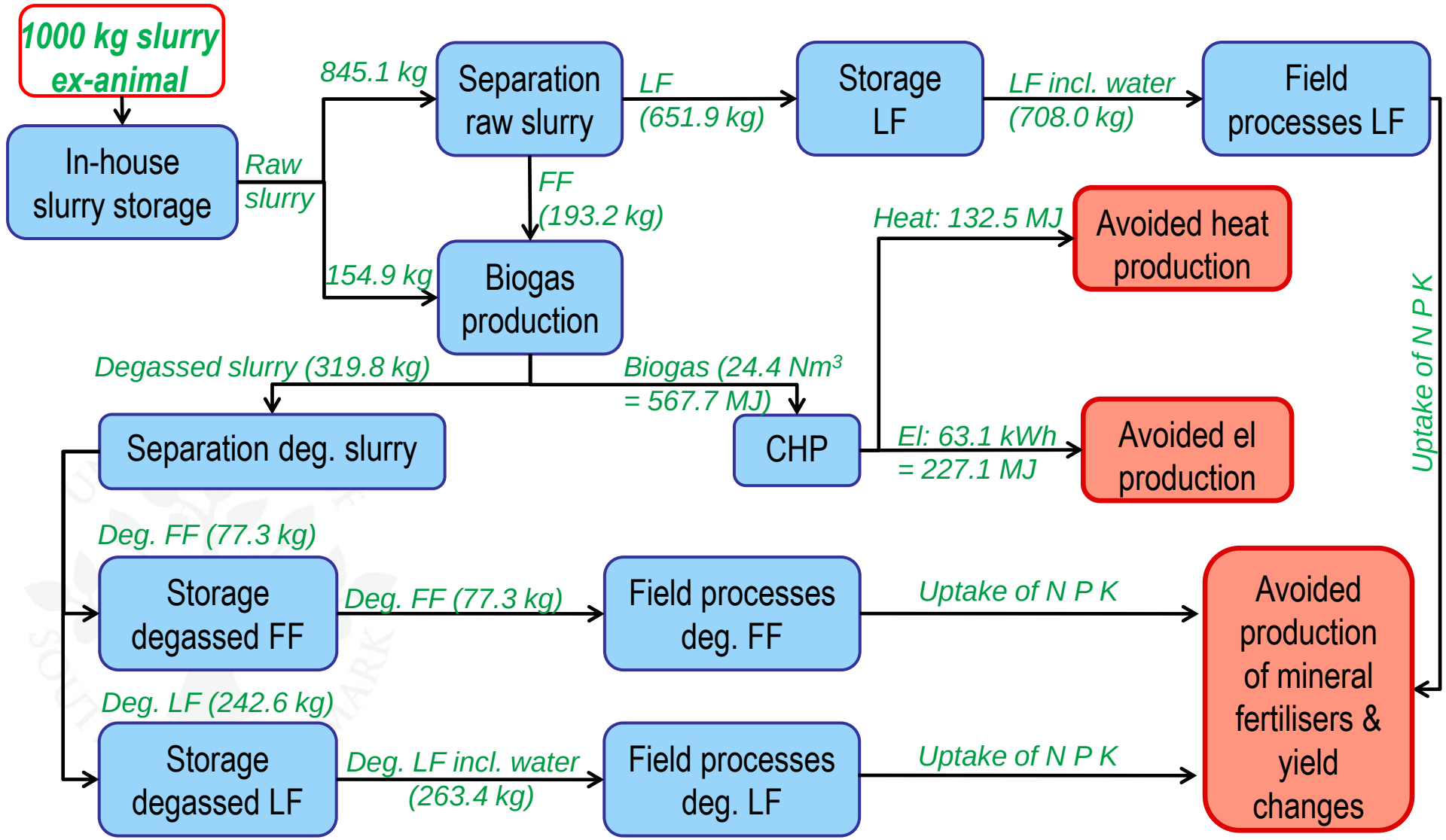
Biogas from separated slurry – *overview*



Biogas from separated slurry – *overview*



Biogas from separated slurry – *overview*



Biogas from separated slurry – *process*

- **Separation technology: decanter centrifuge + polymer (GEA Westfalia)**
  - Efficiency for DM: 87.2 % remains in the FF *(based on experimental data from manufacturer)*
- **Biogas process:**

Parameter	Value
Biogas Composition: CH_4 CO_2	 65 % 35 %
Biogas density	1.158 kg/Nm^3 biogas
Engine efficiency: Heat El	 46 % 40 %
LHV biogas	6.46 kWh/Nm^3 biogas (23.26 MJ/Nm^3 biogas)
Process conditions	Mesophilic T (~37°C); 2 steps digestion;

Biogas from separated slurry – *proces*

- **CH_4 yield per input type (Nm^3 CH_4/ton VS)**

Input type	CH_4 yield (Nm^3 CH_4/ton VS)	kg VS per kg DM
Raw pig slurry	319	0.80
Raw (dairy) cow slurry	231	0.80
Sep. solids (mec-chem)	319	0.80
Sep. solids (mec)	187	0.80
Corn silage	378	0.962
Grass silage	363	0.898
Grain wheat	352	0.982
Grain rye	352	0.980
Glycerin	475	0.950

- **Biogas yield in the 4 scenarios considered in this project: 43.14; 43.36; 45.31 and 70.1 Nm^3 biogas per ton input mixture**

Biogas from separated slurry – *proces*

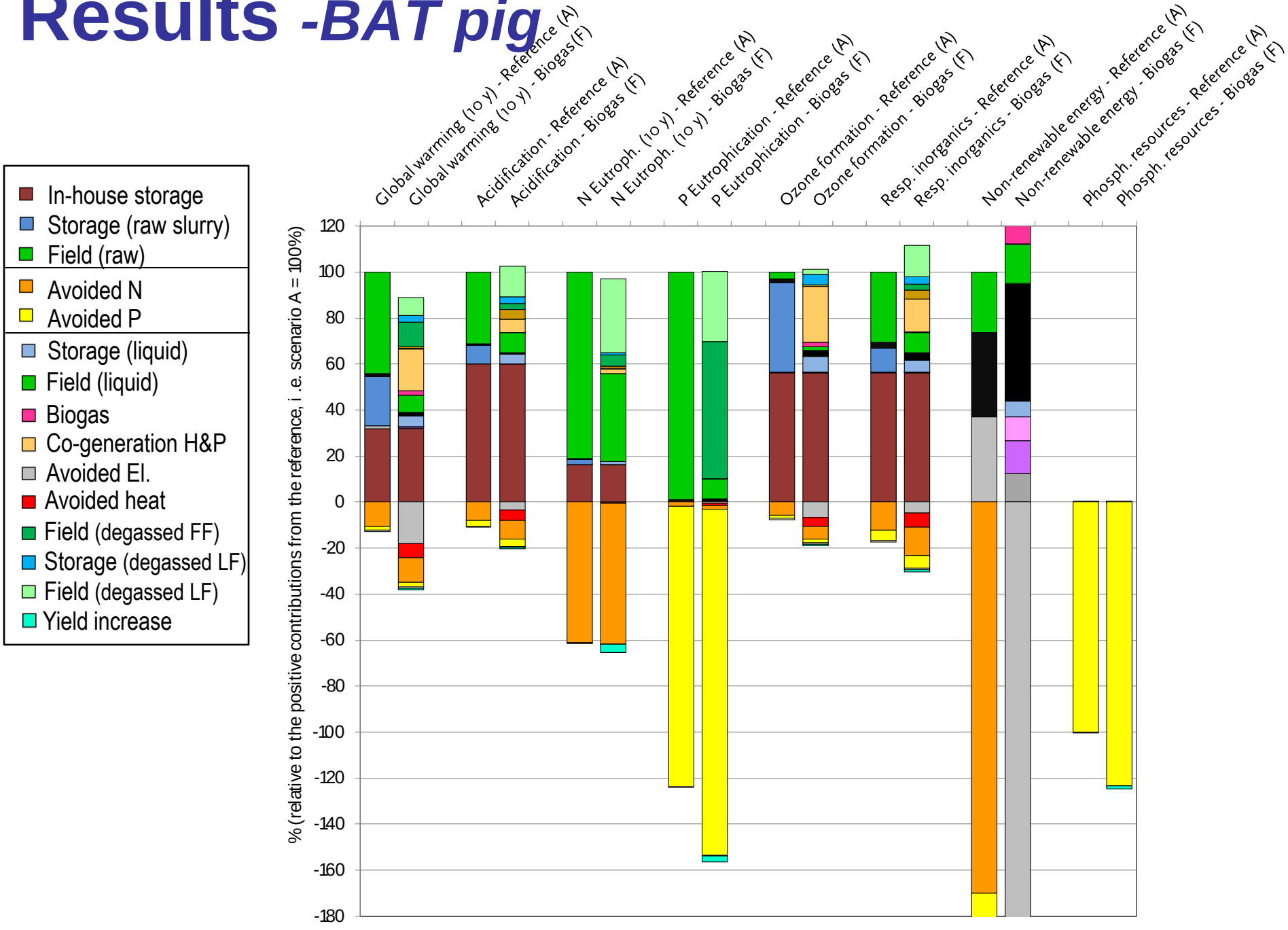
- **Electricity consumption during the process (ana. diges)**

Electricity consumption as a % of the net production	This project for BAT-pig (kWh/Nm³ biogas)	Literature (kWh/Nm³ biogas)
5 – 10 (used : 5 %)	0.129 (with eff. el. of 40 %)	0.09 – 0.132

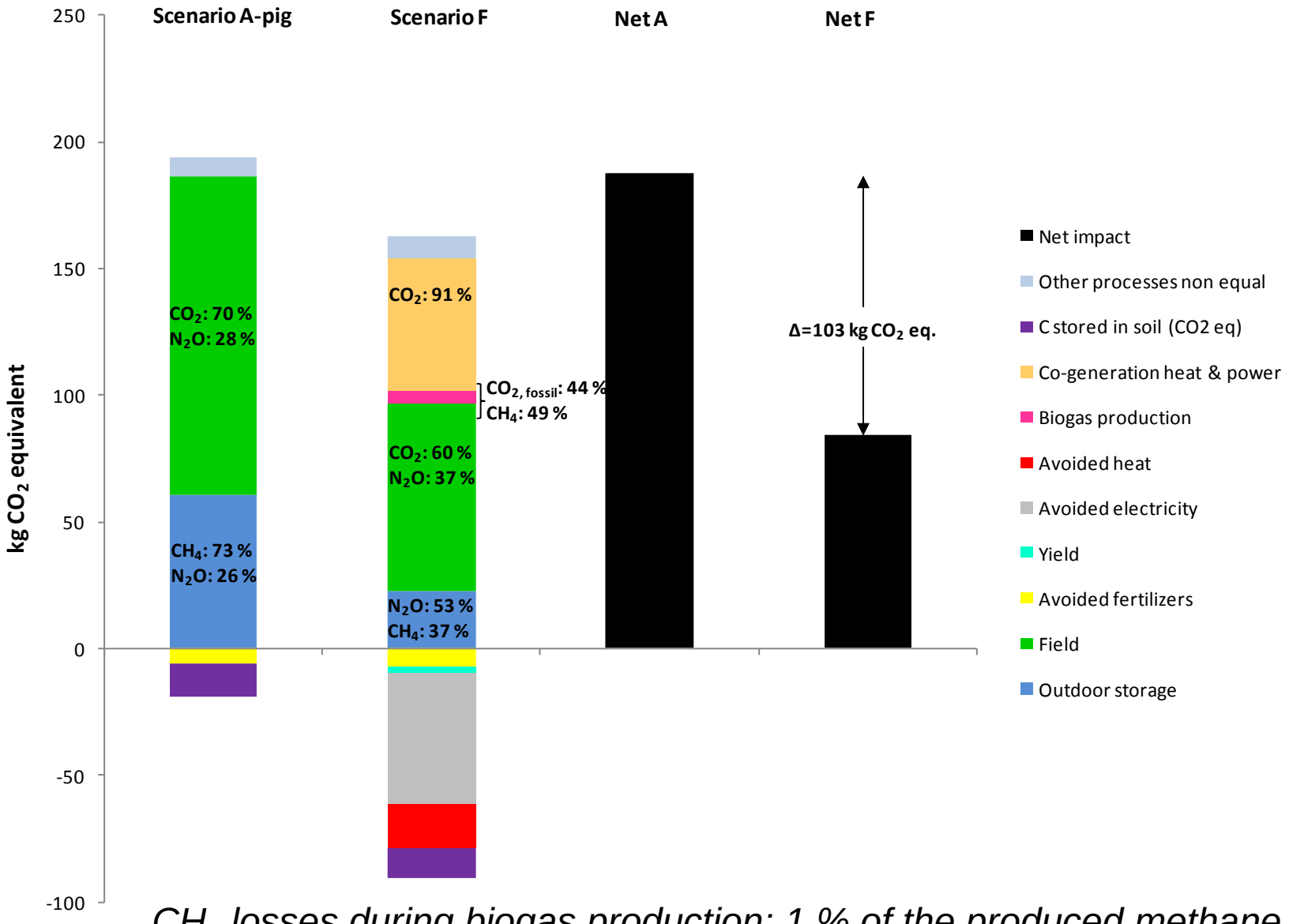
- **Heat consumption during the process (ana. diges) : based on heating the mixture from 8°C to 37°C.**

Specific heat (kJ/kg * °C)		This project for BAT-pig (MJ/Nm³ biogas)	Remark
DM	3.00	1.649 (0.458 kWh / Nm³ biogas) (~ 15 % of the heat produced)	•Insulated plant; •Δ T could be less (15-20°C in plant equipped with heat exchangers)
water	4.20		

Results -*BAT pig*



Results *-BAT pig*



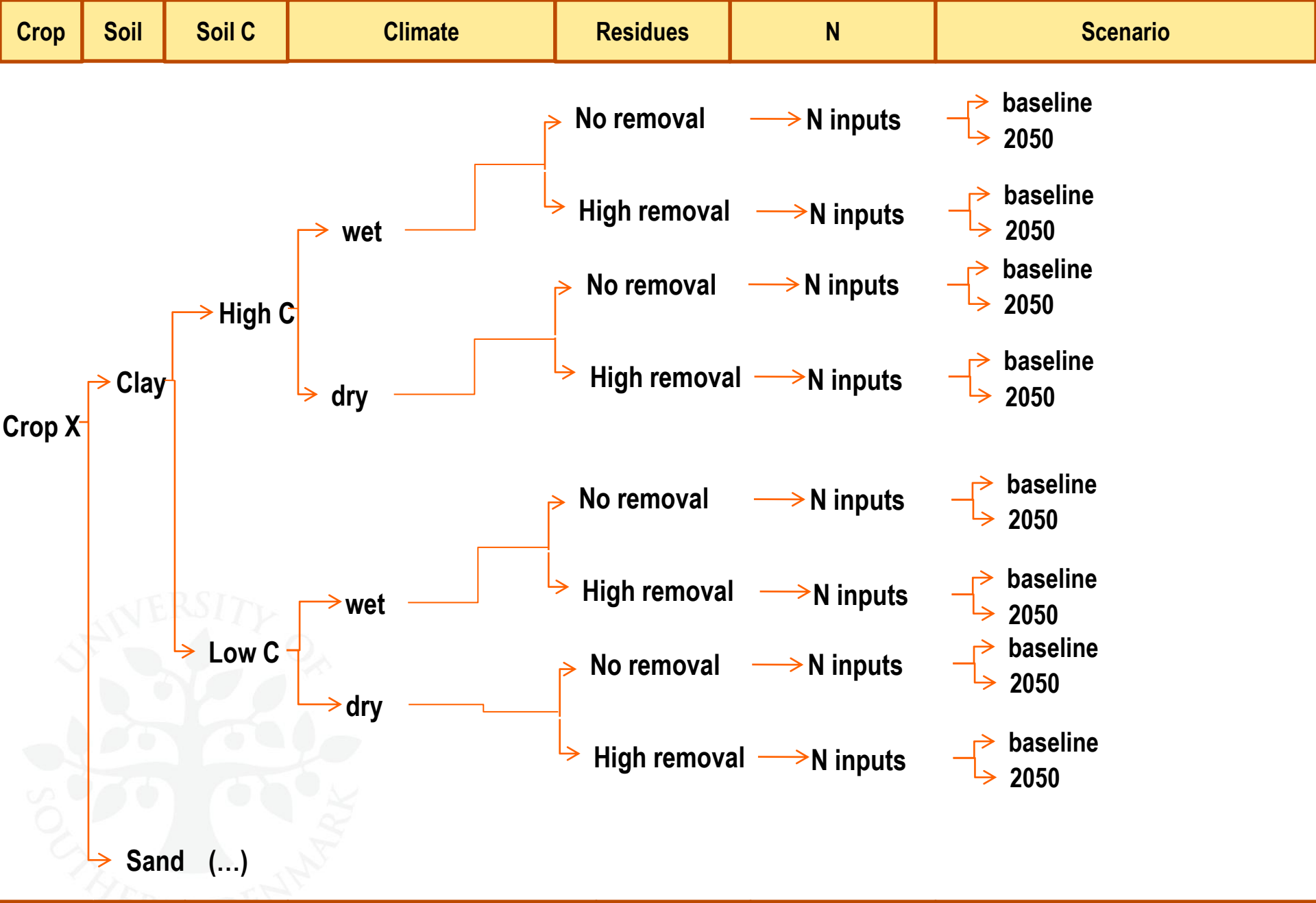
CH_4 losses during biogas production: 1 % of the produced methane

Biogas from separated slurry *-What we*

- **Biogas from separated slurry: importance of an efficient VS (or DM) separation technology**
- **Importance of including C-binding in the analysis**
- **Yield increase does not mean so much**
- **Possibility of high separation efficiency without PAM (polymer) is to be investigated.**

LCA of energy crops in Denmark

- **9 energy crops selected:**
  - Winter wheat
  - Willow
  - Miscanthus (autumn & spring harvest)
  - Maize silage
  - Sugar beet
  - Rye grass
  - Spring barley (alone & combined with a catch crop)
- **Boundaries: From soil cultivation to harvest (storage)**



Levels	2	2	2	2	1	2

TOTAL combinations per crop= 2 x 2 x 2 x 2 x 1 x 2 = 32 (x9 crops)

LCA of energy crops in Denmark

- **Reference flow : 1 ha**
- **Output, for all combinations:**
  - Substances flows
    - *C (including CO_2 due to soil C changes. Changes in soil C considered for both 20 and 100 years horizon)*
    - N (NH_3, N_2O, N leaching, N_2, NO_x)
    - Others (P, other nutrients)
  - DM harvested and associated energy content
  - Nutritional value (when this applies)
- **In collaboration with DJF (data and models)**

LCA of energy crops in Denmark

- **Conditions for 2050**
  - Yield 2050 to be taken from the Climate Commission
  - Slurry input (for fertilisation) is digested slurry
  - Temperature / Precipitation:
    - IPCC SRES (A1B?)

Next steps – *iLUC response*

- **For 1 ha turned to energy crop production in Denmark, what is the response in terms of indirect land use changes?**
  - What is the Danish crop displaced and what is the market response to that?
  - What is the ultimate crop affected and where in the world is it cultivated?
    - How much of the response lies into expansion vs intensification?
    - Substitution ratio: what is the supply elasticity of crops in the food market?

Next steps – *case studies*

- **High bio vs high wind**
  - How much land do we save and where?
- **Prioritizing the use of saved land (under high wind) in Denmark:**
  - Food vs Energy crop vs Nature
- **Biogas**
  - Different ways to boost slurry biogas…what's best?

Questions?
Comments?