

Integrated systems for farm diversification into  
energy production by anaerobic digestion:  
implications for rural development, land use &  
the environment

# Agroenergetics, crop species & energy balances

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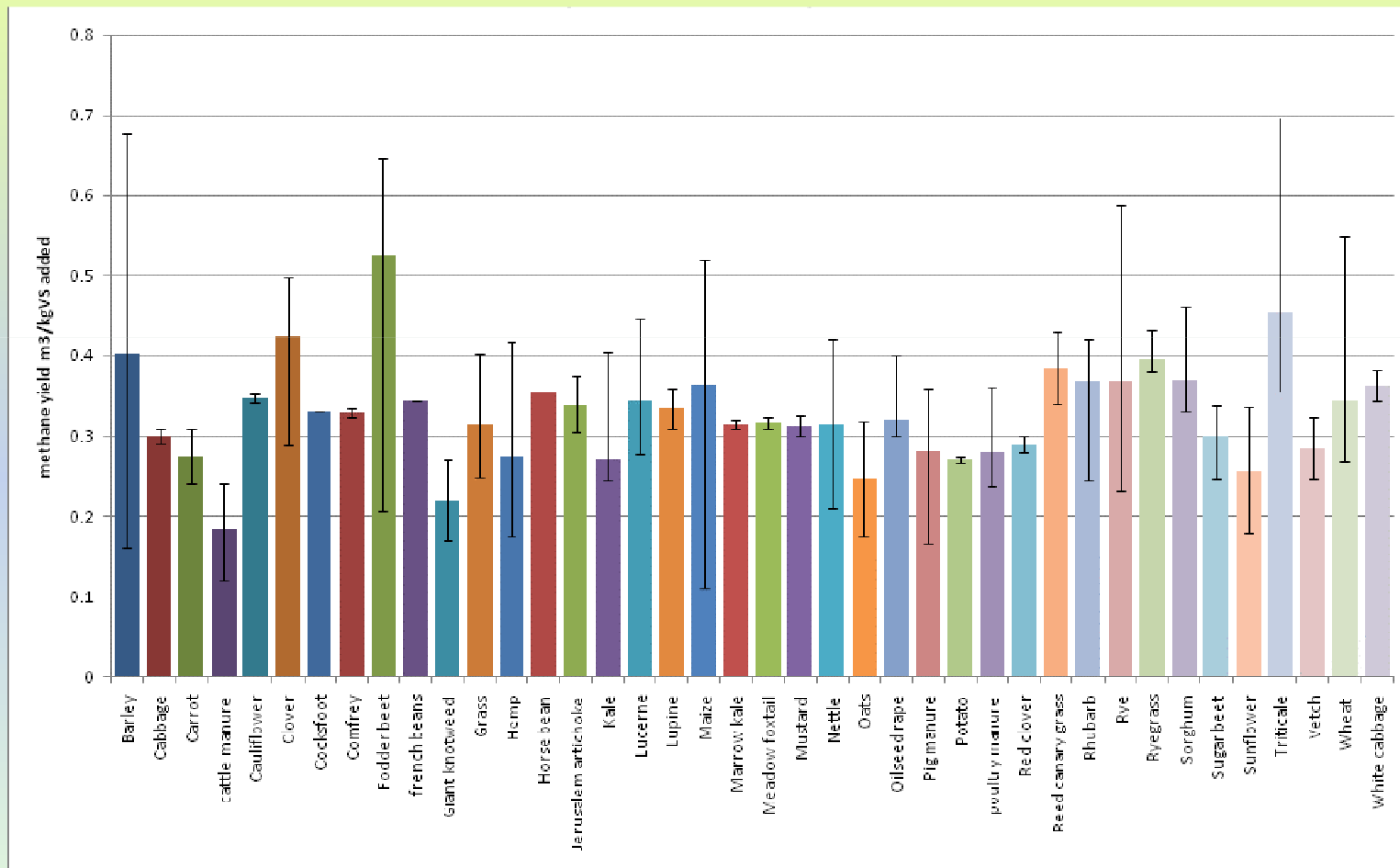
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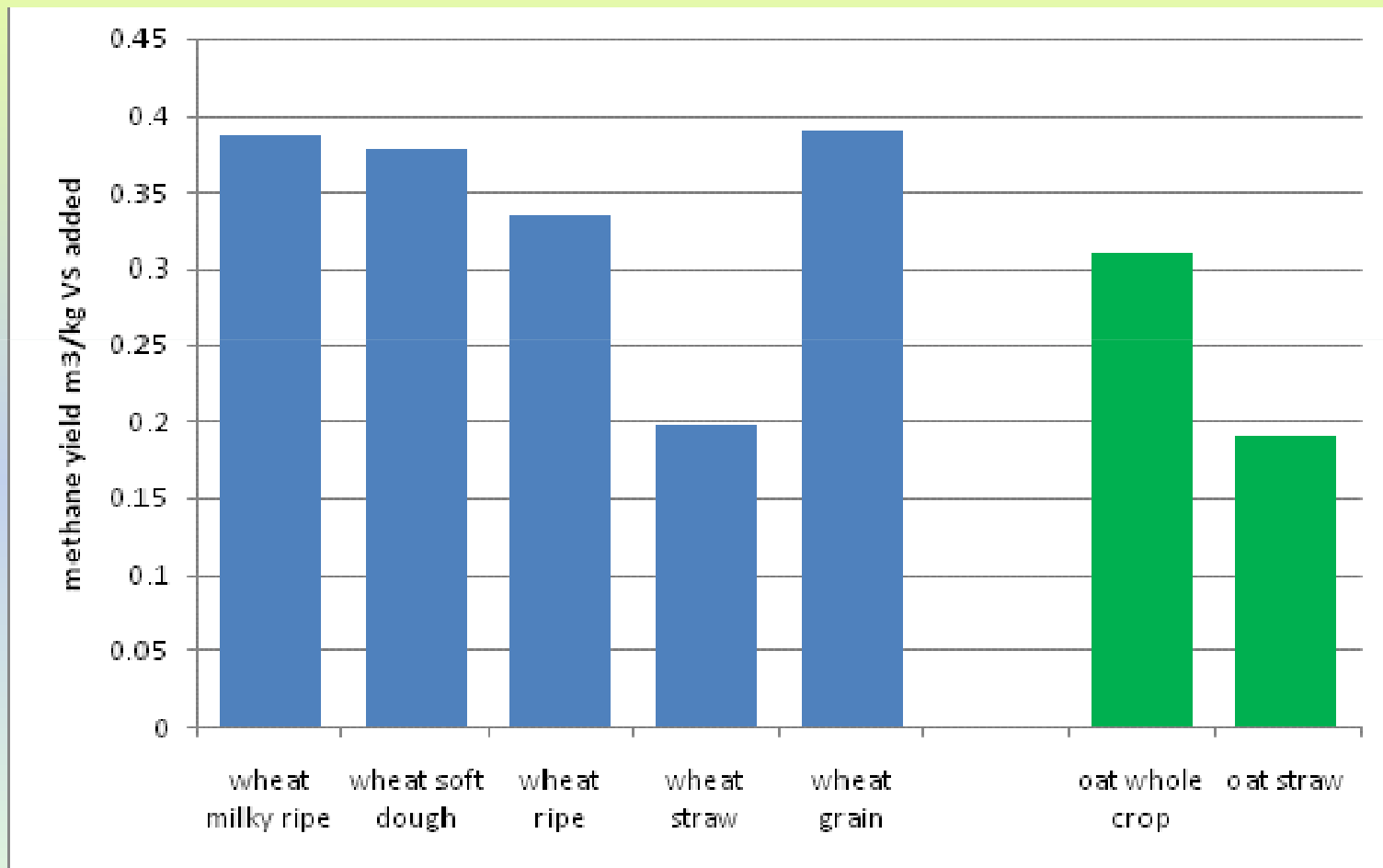
# Outline of work

- Crop species
  - growth stages
- Energy models
  - emissions

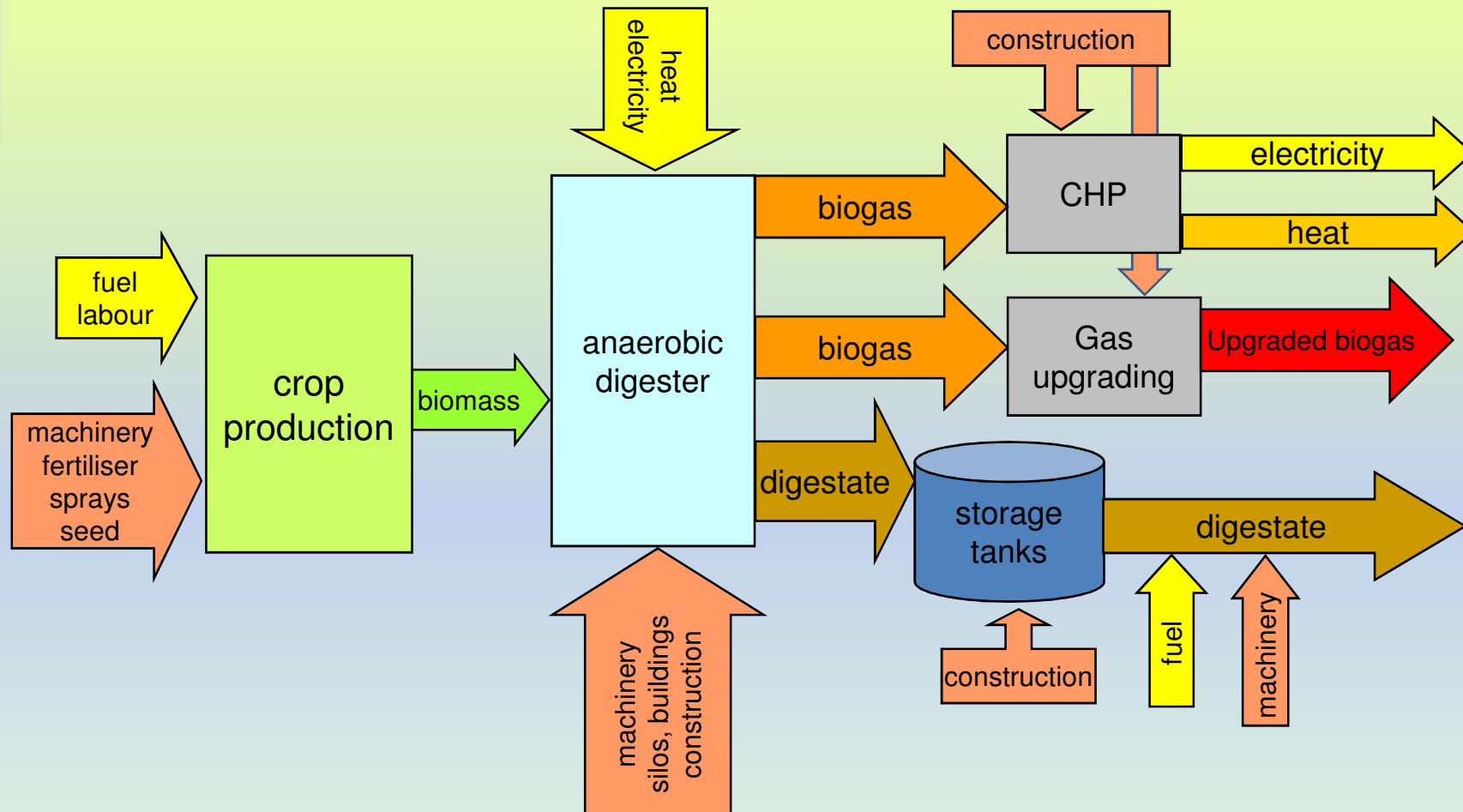
# Methane yields - feedstocks



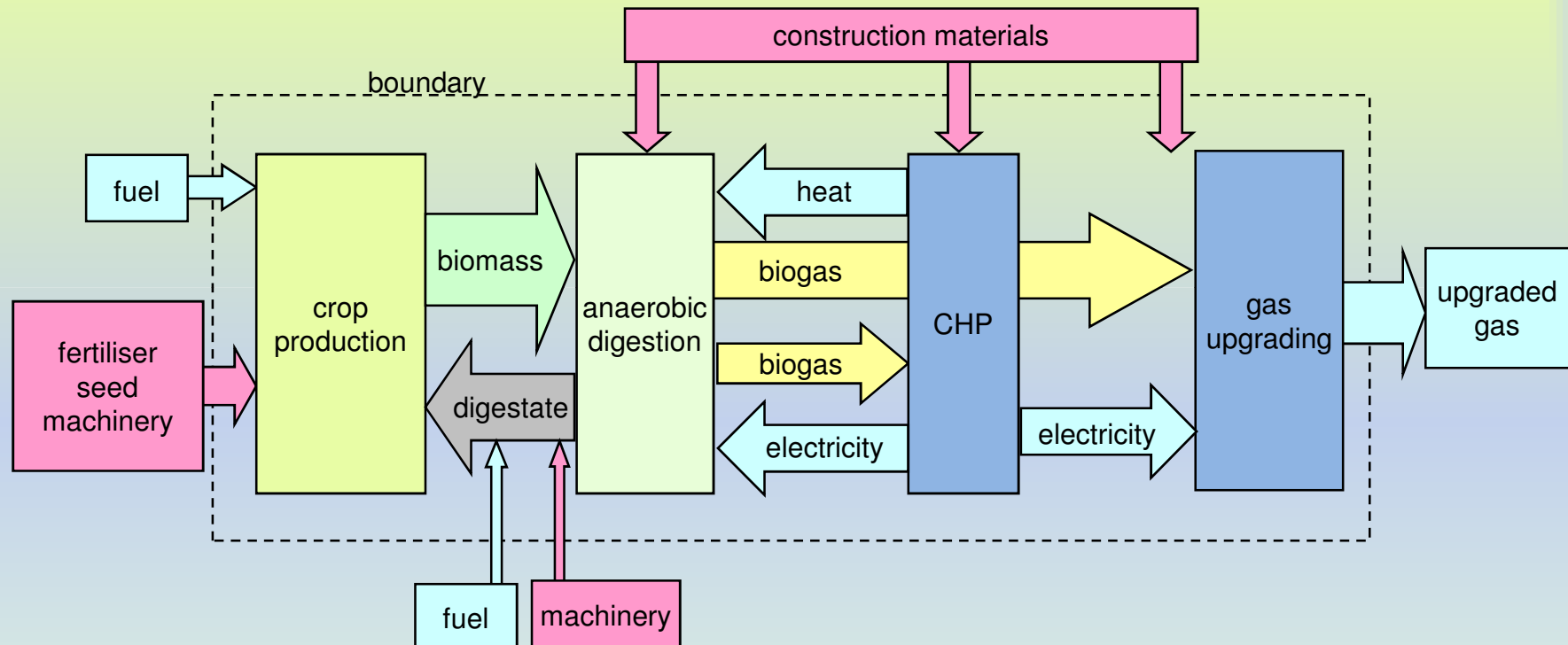
# Methane yields – growth stage



# Energy models -the digestion 'system'



# Energy balances



# Energy balances

## Scenario 6

crop		maize	whole crop triticale	fodder beet	sunflower	lupin	perennial ryegrass	timothy grass	lucerne
crop production	GJ/yr	4231	4662	5377	4664	9636	9841	7128	5808
crop transport	GJ/yr	274	282	525	274	952	552	471	493
digester embodied energy	GJ/yr	2109	2109	2109	2109	2109	2109	2109	2109
digestate transport & spreading	GJ/yr	430	432	1009	414	1126	786	701	749
<b>total deficit</b>	<b>TJ/yr</b>	<b>7.0</b>	<b>7.5</b>	<b>9.0</b>	<b>7.5</b>	<b>13.8</b>	<b>13.3</b>	<b>10.4</b>	<b>9.2</b>
CH <sub>4</sub> (in biogas)	10 <sup>6</sup> m <sup>3</sup> /yr	1.94	1.94	1.78	1.66	1.78	1.94	1.89	1.89
CH <sub>4</sub> required for CHP	10 <sup>6</sup> m <sup>3</sup> /yr	0.38	0.38	0.41	0.33	0.41	0.41	0.39	0.40
<b>surplus</b>									
CH <sub>4</sub> in upgraded biogas	10 <sup>6</sup> m <sup>3</sup> /yr	1.57	1.57	1.37	1.34	1.37	1.53	1.49	1.49
energy value	TJ/yr	55.9	55.9	48.9	47.7	48.8	54.7	53.3	53.2
<b>energy balance</b>	<b>TJ/yr</b>	<b>48.8</b>	<b>48.4</b>	<b>39.9</b>	<b>40.3</b>	<b>35.0</b>	<b>41.4</b>	<b>42.9</b>	<b>44.0</b>
<b>energy ratio (out/in)</b>		<b>7.9</b>	<b>7.5</b>	<b>5.4</b>	<b>6.4</b>	<b>3.5</b>	<b>4.1</b>	<b>5.1</b>	<b>5.8</b>
energy in diesel equivalent	10 <sup>6</sup> l/yr	1.56	1.56	1.37	1.33	1.36	1.53	1.49	1.49

# Greenhouse gas emissions

Greenhouse gas emissions from the production and use of transport fuels, biofuels and other bioliquids shall be calculated as:

$$E = eec + el + ep + etd + eu - eccs - eccr - eee,$$

Where:

*E = total emissions from the use of the fuel;*

*eec = emissions from the extraction or cultivation of raw materials;*

*el = annualised emissions from carbon stock changes caused by land use change;*

*ep = emissions from processing;*

*etd = emissions from transport and distribution;*

*eu = emissions from the fuel in use;*

*eccs = emission savings from carbon capture and sequestration;*

*eccr = emission savings from carbon capture and replacement; and*

*eee = emission savings from excess electricity from cogeneration.*

Emissions from the manufacture of machinery and equipment shall not be taken into account.

