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AD in an integrated farming environment

Dr Andrew Salter

Anaerobic Digestion and Biogas Association
National Exhibition Centre, 07 July 2010

AD 4 RD

- Integrated Systems for Farm Diversification into Energy Production by Anaerobic Digestion
- Rural Economy and Land Use (RELU)
- University of Southampton
  - School of Civil Engineering & the Environment
  - School of Biology
- University of Reading,
  - Centre for Agricultural Strategy
- http://www.AD4RD.soton.ac.uk

AD 4 RD

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- Research areas include:
  - Policy and practice
  - Social implications/perspectives
  - Economics
  - Environmental impacts
  - Energy and GHG emissions

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Crops for AD

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AD - feedstocks and outputs

- AD creates two products
  - Biogas = energy
  - Digestate = bio-fertiliser

- Can change the amounts/balance of both of these by changing the materials fed in to the digester

Crops for bio-fuel (energy) production

- for bio-diesel
  - oilseed rape
  - sunflower
  - linseed
  - soya
  - Peanut
  - Jatropha
- for bio-ethanol
  - wheat
  - sugar beet
  - maize
  - sugar cane
  - *lignocellulosic material*
- for biogas
  - crops
  - agricultural wastes
  - green waste

Potential crops for biogas -

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- Barley
- Cabbage
- Carrot
- Cauliflower
- Clover
- Elephant grass
- Flax
- Fodder beet
- Giant knotweed
- Hemp
- Horse bean
- Jerusalem artichoke
- Kale
- Lucerne
- Lupin
- Maize
- Marrow kale
- Meadow foxtail
- Miscanthus
- Mustard
- Nettle
- Oats
- Pea
- Potato
- Oilseed rape
- Reed canary grass
- Rhubarb
- Ryegrass
- Sorghum
- Sugar beet
- Triticale
- Turnip
- Verge cuttings
- Vetch
- Wheat

Methane yields

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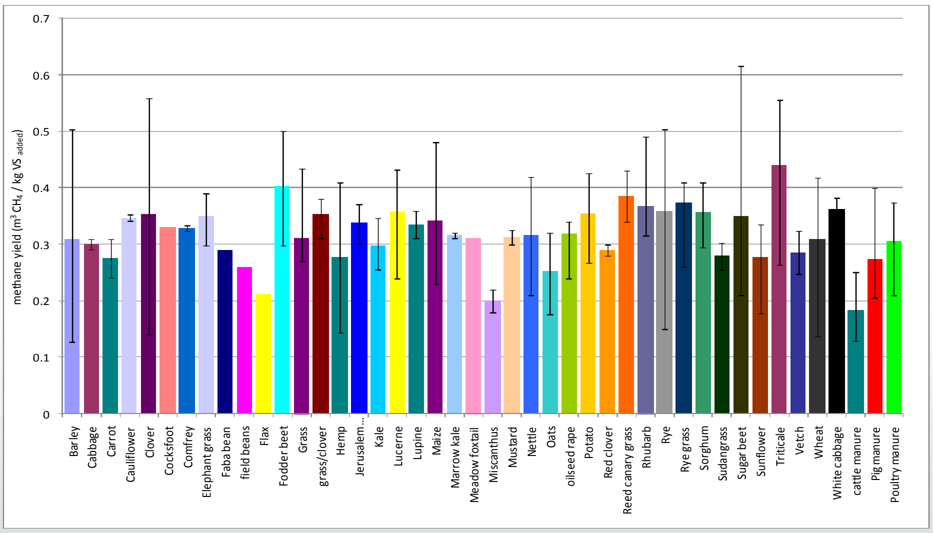

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Effect of harvest date

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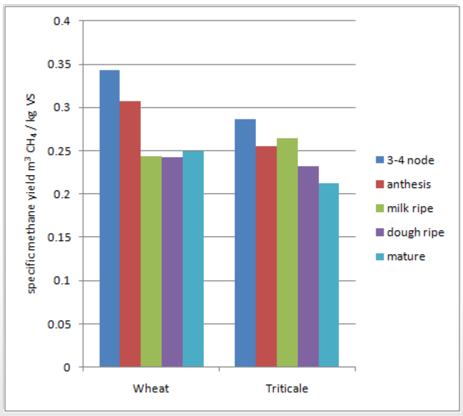

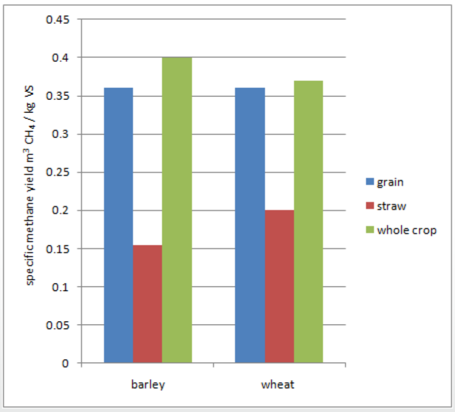

Amon, T., Amon, B., Kryvoruchko, V., Machmüller, A., Hopfner-sixt, K., Bodiroza, V., Hrbek, R., Friedel, J., Pötsch, E., Wagentristl, H., Schreiner, M. & Zollitsch, W. (2007) Methane production through anaerobic digestion of various energy crops grown in sustainable crop rotations. *Bioresource Technology*, *98*, *3204-3212.*

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Environmental impacts

Dr Donna Clarke

University of Southampton
School of Biological Sciences

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Environmental & Ecological Impacts

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Aims

- Assess potential impacts on biodiversity of diversification into farm energy production through AD (i.e. dedicated energy crops)
- Develop conceptual model / framework to identify impacts for management & mitigation

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Environmental impact assessment

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RISK SCORED ON		Potential impact on invertebrates & weeds				
		Regulating		Supporting		
Management Practice		Pest Control	Pollination	Soil Formation	Nutrient Cycling	Primary Production
Cultivation						
Tillage	"tillage"	+1.0	-1.0	-2	-2	-2
	Inversion ploughing	-3	-2	-3	-3	-2
	Minimal tillage	+1.5	+1.5	+1	+1	+2
	Direct Drilling	+1	?+1	+1	+1	-1/+1
	Cultivation Score					
Crop Production						
Nutrient input	Mineral fertilizer	-2	-2.0	-2.5	-2.5	-2.5
	Slurry / organic	+1.5?	+1	+2	+2	+1.5
	Digestate	?	?	?	?	?
	Production Score					
Crop Protection						
Weed control	Mechanical	-1	-2.0	-1.5	-1.5	-2
	Herbicides	-2	-3	-2	-2	-3
control	Pesticides	-2	-3	-2	-2	-3
	fungicides	?	?	Neg	neg	?
	Protection Score					
Pre / Post Cropping						
	Stubble removed	-2.5	-2.5	-2.0	-2.0	-3
	Stubble retained	+2.5	+2.5	+2.0	+2.0	+3
	Incorporation	?	?	+1.5	+1.5	+2
	Spring sowing	Pos	Pos	Pos	pos	+3
	Winter sowing	?	?	?	?	-3
	Pre/Post Cropping Score					
Other Management Practices						
Intensive grassland	- cutting (>1/yr)	+0.5?	-2.0	?	?	-2
	- grazing (high intensity)	-1.5	-1.5	?	?	-2
	- fertiliser applications	-2	-1.5?	-2.5	-2.5	-3
Other	Unimproved grassland	**Pos**	+2.5	Pos	pos	+3
	Permanent grassland (>5 yrs)	**Pos**	neg?	Pos	pos	+2
	Switch from hay to silage	+1	-2.5	Neg	neg	-2.5
	Other Practices Score					
	OVERALL RISK SCORE					

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Conventional Winter Wheat

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RISK SCORED ON		Potential impact on invertebrates & weeds				
		Regulating		Supporting		
Management Practice		Pest Control	Pollination	Soil Formation	Nutrient Cycling	Primary Production
Cultivation						
Tillage	"tillage"	+1.0	-1.0	-2	-2	-2
	Inversion ploughing	-3	-2	-3	-3	-2
	Minimal tillage	+1.5	+1.5	+1	+1	+2
	Direct Drilling	+1	?+1	+1	+1	-1/+1
	Cultivation Score	-3	-2	-3	-3	-2
Crop Production						
Nutrient input	Mineral fertilizer	-2	-2.0	-2.5	-2.5	-2.5
	Slurry / organic	+1.5?	+1	+2	+2	+1.5
	Digestate	?	?	?	?	?
	Production Score	-2	-2	-2.5	-2.5	-2.5
Crop Protection						
Weed control	Mechanical	-1	-2.0	-1.5	-1.5	-2
	Herbicides	-2	-3	-2	-2	-3
control	Pesticides	-2	-3	-2	-2	-3
	fungicides	0	0	Neg	0	0
	Protection Score	-4	-6	-4	-4	-6
Pre/Post Cropping						
	Stubble removed	-2.5	-2.5	-2.0	-2.0	-3
	Stubble retained	+2.5	+2.5	+2.0	+2.0	+3
	Incorporation	?	?	+1.5	+1.5	+2
	Pre/Post Cropping Score	+2.5	+2.5	+2	+2	+3
Other Management Practices						
Intensive grassland	- cutting (>1/yr)	+0.5?	-2.0	?	?	-2
	- grazing (high intensity)	-1.5	-1.5	?	?	-2
	- fertiliser applications	-2	-1.5?	-2.5	-2.5	-3
Other	Unimproved grassland	Pos	+2.5	Pos	pos	+3
	Permanent grassland (>5 yrs)	Pos	neg?	Pos	pos	+2
	Switch from hay to silage	+1	-2.5	Neg	neg	-2.5
	Other Practices Score					
	OVERALL RISK SCORE	-6.5	-7.5	-7.5	-7.5	-7.5

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Organic grassland

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RISK SCORED ON		Potential impact on invertebrates & weeds				
		Regulating		Supporting		
Management Practice		Pest Control	Pollination	Soil Formation	Nutrient Cycling	Primary Production
Cultivation						
Tillage	"tillage"	+1.0	-1.0	-2	-2	-2
	Inversion ploughing	-3	-2	-3	-3	-2
	Minimal tillage	+1.5	+1.5	+1	+1	+2
	Direct Drilling	+1	?+1	+1	+1	-1/+1
	Cultivation Score					
Crop Production						
Nutrient input	Mineral fertilizer	-2	-2.0	-2.5	-2.5	-2.5
	Slurry / organic	+1.5	+1	+2	+2	+1.5
	Digestate	?	?	?	?	?
	Production Score	+1.5	1	+2	+2	+1.5
Crop Protection						
Weed control	Mechanical	-1	-2.0	-1.5	-1.5	-2
	Herbicides	-2	-3	-2	-2	-3
control	Pesticides	-2	-3	-2	-2	-3
	fungicides	?	?	Neg	neg	?
	Protection Score					
Pre/Post Cropping						
	Stubble removed	-2.5	-2.5	-2.0	-2.0	-3
	Stubble retained	+2.5	+2.5	+2.0	+2.0	+3
	Incorporation	?	?	+1.5	+1.5	+2
	Pre/Post Cropping Score					
Other Management Practices						
Intensive grassland	- cutting (>1/yr)	+0.5?	-2.0	-1	0	-2
	- grazing (high intensity)	-1.5	-1.5	?	?	-2
	- fertiliser applications	-2	-1.5?	-2.5	-2.5	-3
Other	Unimproved grassland	Pos	+2.5	Pos	pos	+3
	Permanent grassland (>5 yrs)	+1	-1	+1	+1	+2
	Switch from hay to silage	+1	-2.5	Neg	neg	-2.5
	Other Practices Score	+1.5	-3	0	+1	0
	OVERALL RISK SCORE	+3	-2	+2	+3	+1.5

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Environmental impact scores

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	Regulating		Supporting		
	Pest Control	Pollination	Soil Formation	Nutrient Cycling	Primary Production
Winter Wheat (conventional)	-6.5	-7.5	-7.5	-7.5	-7.5
Oilseed rape (conventional)	-6.5	-6.5	-7.5	-7.5	-7.5
Maize	-6.5	-7.5	-7.5	-7.5	-7.5
Grass (3 cut silage)	-3.5	-3.5	-2.5	-2.5	-5
Spring Wheat (conventional)	-4	-6	-6.5	-6.5	-5.5
Winter Wheat (organic)	+1	+1.5	+1	+1	+2.5
Grass (organic)	+2	-1	+2	+2	-0.5

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Economics

Philip Jones

University of Reading

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Economic potentials

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- Optimise net margin for whole farm
  - Linear programming
  - Compare inputs, outputs and costs for a range of farm enterprises
- Example
  - Cereal farm model
  - Based on East of England
  - Farm size 312 ha (average of FBS)

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Reference scenario

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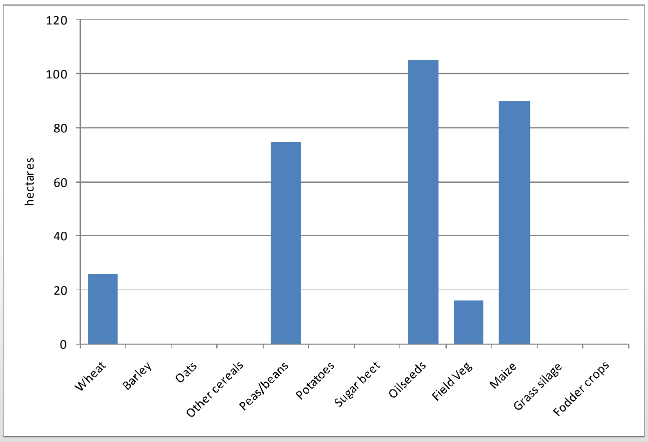
- Based on 2009 prices



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Introducing AD

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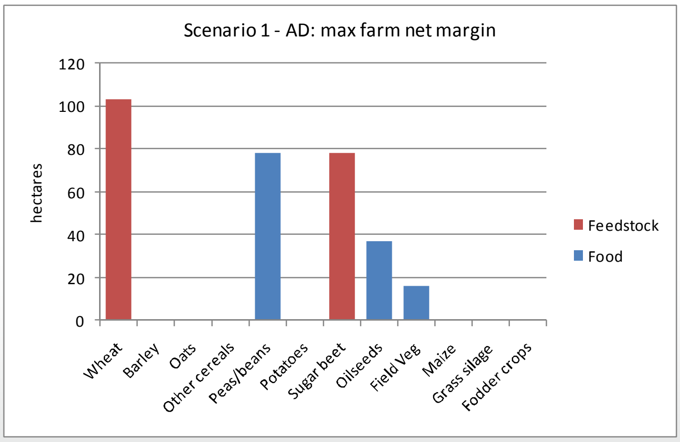

nutrient imports	Reference run (kg)	Scenario 1 (kg)	Percentage change
Nitrogen (N)	39,796	18,387	-53.8
Potassium (k)	24,185	9,768	-59.6
Phosphorous (P)	15,467	9,359	-39.5

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Changing the electricity value

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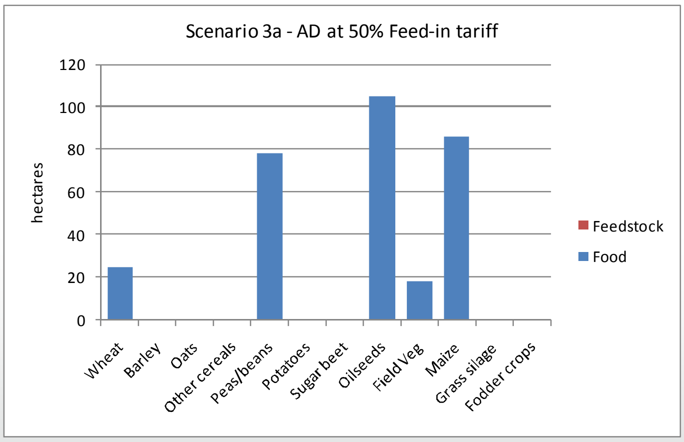

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Imported feedstock

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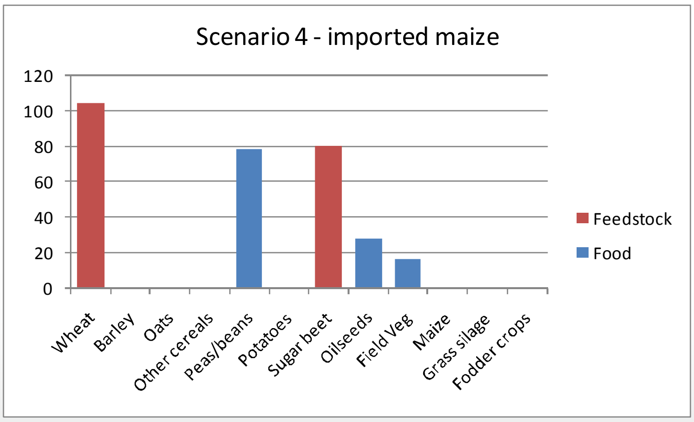

	Scenario 1 (kg)	Scenario 4 (importation of feedstocks) (kg)	Percentage change
Nitrogen (N)	18,387	0	-100
Potassium (k)	9,768	0	-100
Phosphorous (P)	9,359	3104	-68.2

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Reducing farm GHGs

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Sources of GHGs

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- Arable farms
  - Mineral fertilisers
  - Diesel fuel use
- Dairy farms
  - Manure management
  - Mineral fertilisers
  - Diesel fuel use

GHG emissions - arable

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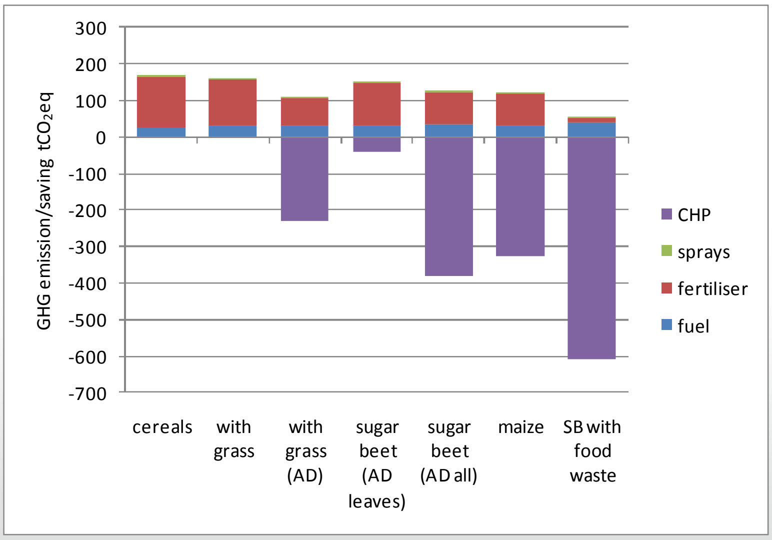

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GHG emissions - dairy

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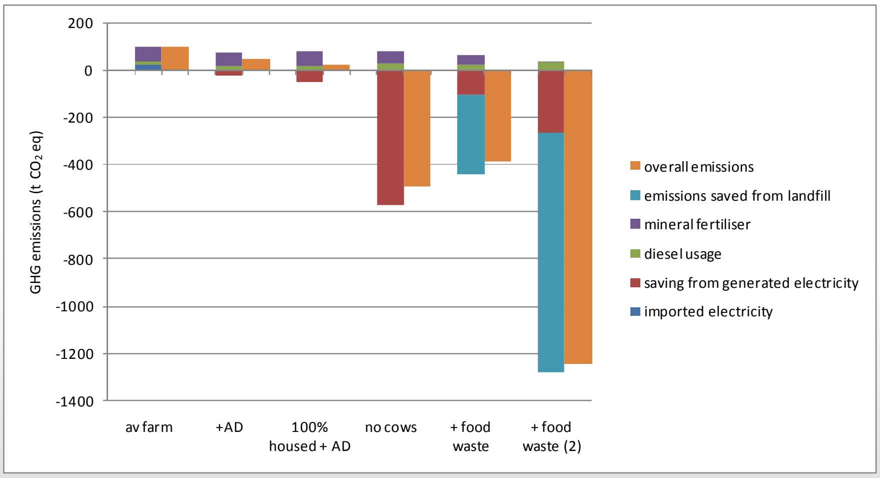

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An integrated approach

Integrated farming approach

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- Can combine food and energy production.
  - Utilise break crops for energy and environment
- Reduce mineral fertiliser use with digestate and legume crops
  - legume (clover) before wheat to capture nitrogen, can be digested and used as feedstock
- Use crop residues as a resource for energy production and then nutrients

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Farm integration

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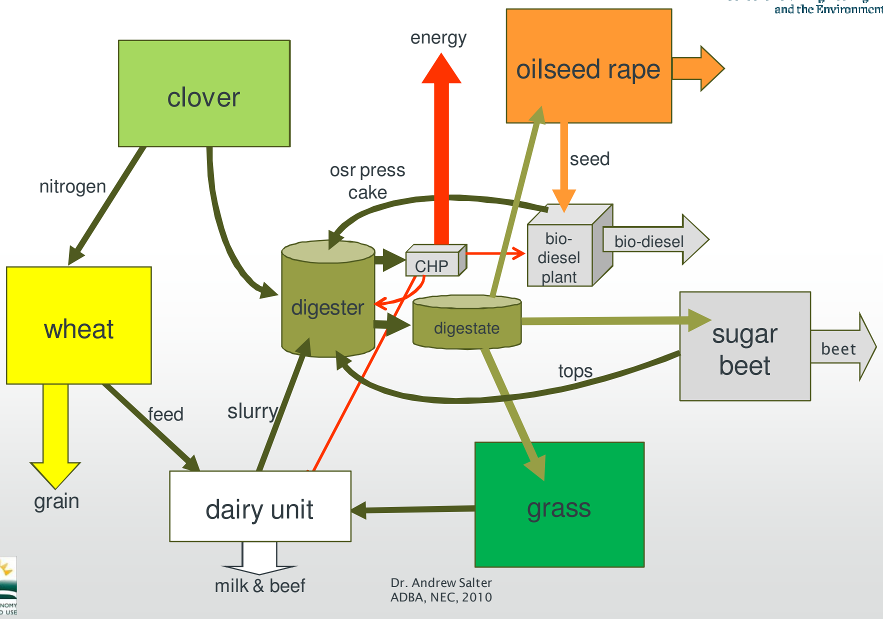

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An integrated example

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Conclusions

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- Many different crops can be used as feedstock depending on the circumstances
  - Grass - multiple harvest dates
  - Whole crop cereals – earlier than Maize and range of possible harvest dates
  - Headlands and margins
  - Rotation systems
- Alternative cropping systems help to maximise yield and minimise use of artificial fertiliser
  - Reduce costs
  - Reduce GHG emissions

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Thank you

This research is funded by UK Research Councils under the Rural Economy and Land Use Programme (RELU)

More information can be found at:

http://www.AD4RD.soton.ac.uk

http://www.cropgen.soton.ac.uk

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