VALORGAS project – Collection and AD of Food Waste

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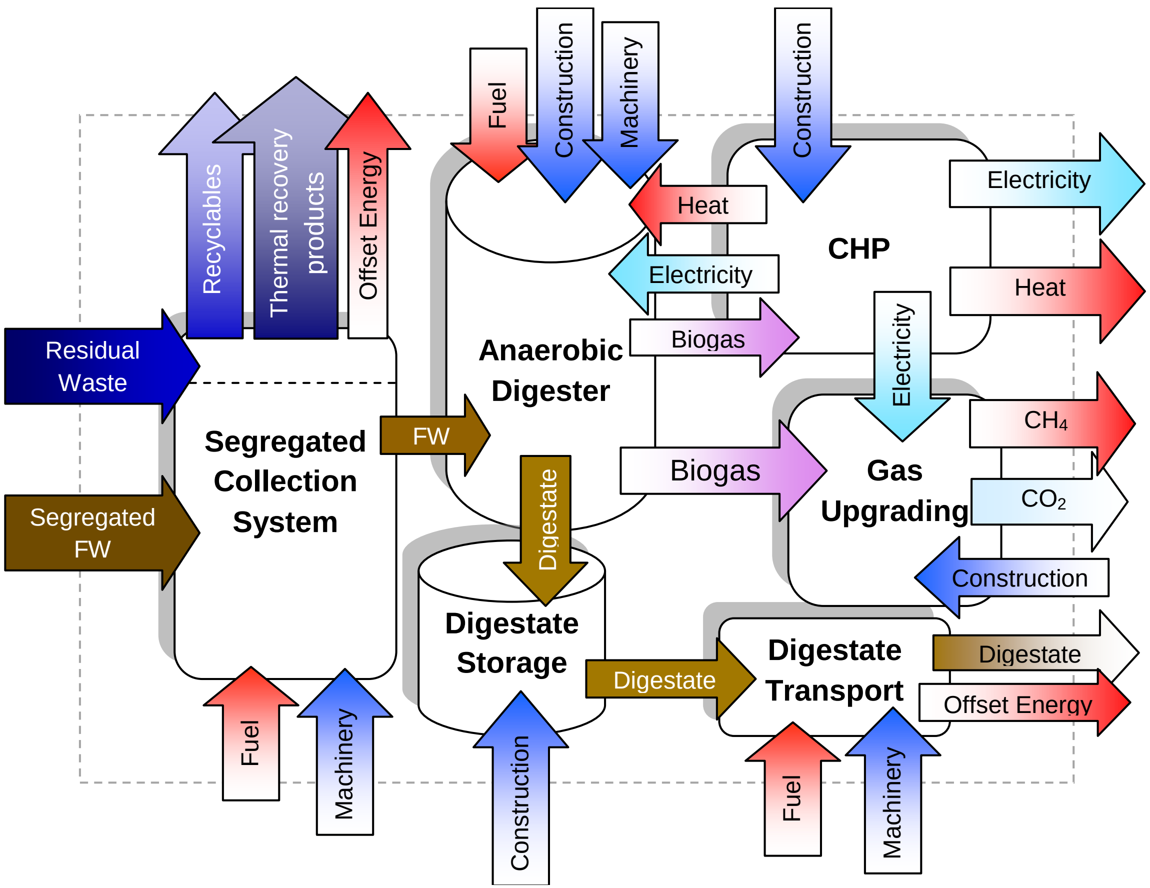
Valorisation of food waste to biogas - Project 241334

Sponsored by FP7 ENERGY.2009.3.2.2



13 partners in 6 countries
3.5 M€ from 2010 – 2013
Coordinator Soton

Aim:
To valorise the energy from food waste by anaerobic digestion (AD), with full evaluation of the associated whole-life energy balances from collection to product utilisation.

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FW recovery

- Allows efficient recovery of a second-generation fuel product with multiple end-uses
- Returns nutrients to agriculture, with associated economic, energy and carbon gains from offsetting of artificial fertilisers
- Reduces moisture content of residual waste, improving CV and efficiency of thermal recovery, and increasing the range of thermal technologies
- Increases potential for recovery of commodity grade recyclables

Today's presentation

- FW collection systems in Europe
  - Energy in FW collection
- FW characterisation
  - Compositional characteristics
  - Biochemical composition
  - Contaminants
- Anaerobic digestion of FW
- How it joins up

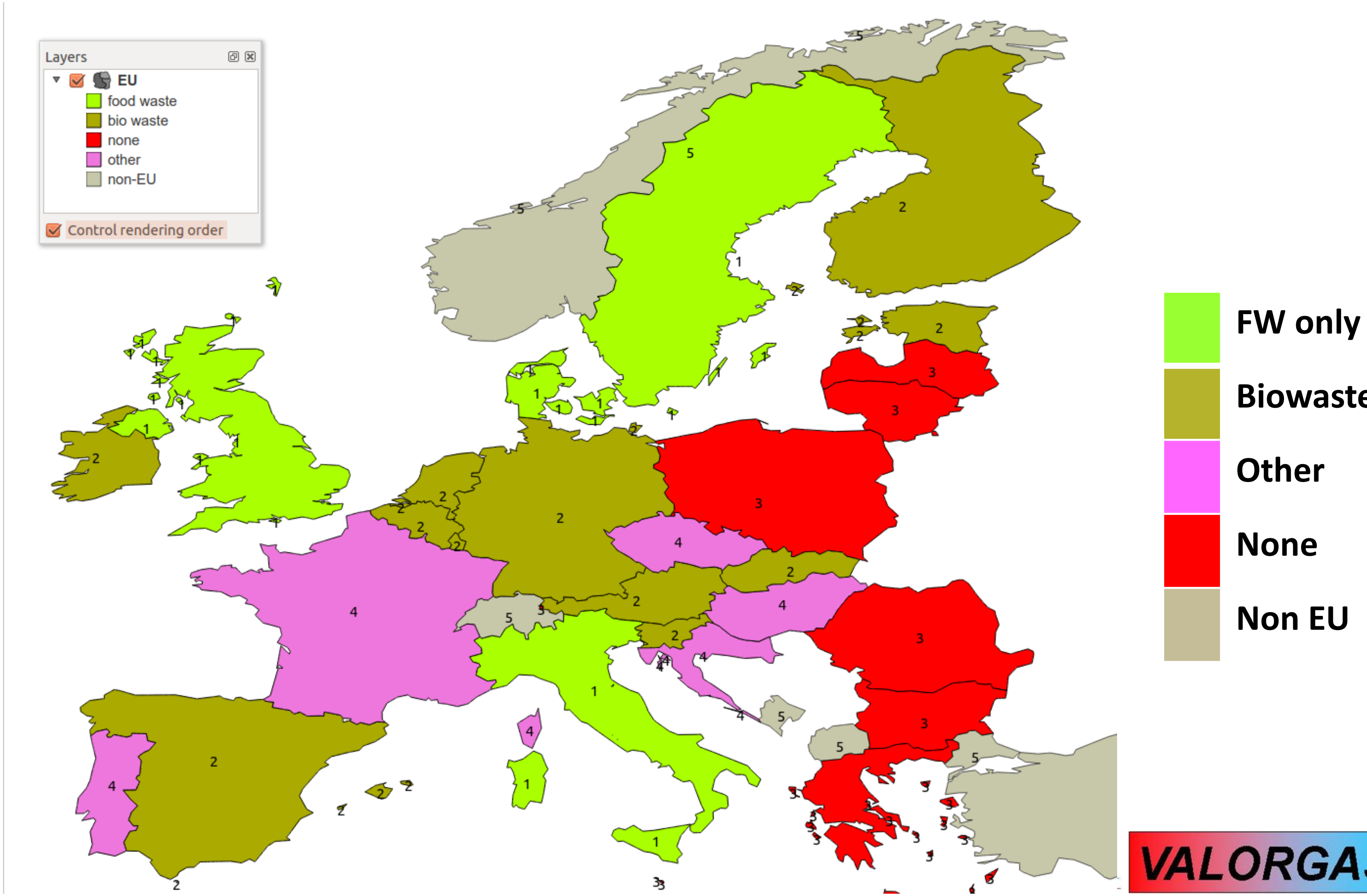
FW collection schemes in Europe

- Key factors that affect performance
  - Gross weight, contamination, participation, capture rate etc
- Questions
  - Who collects it?
  - How is this done?
  - What type of information is available and how easy is it to get?

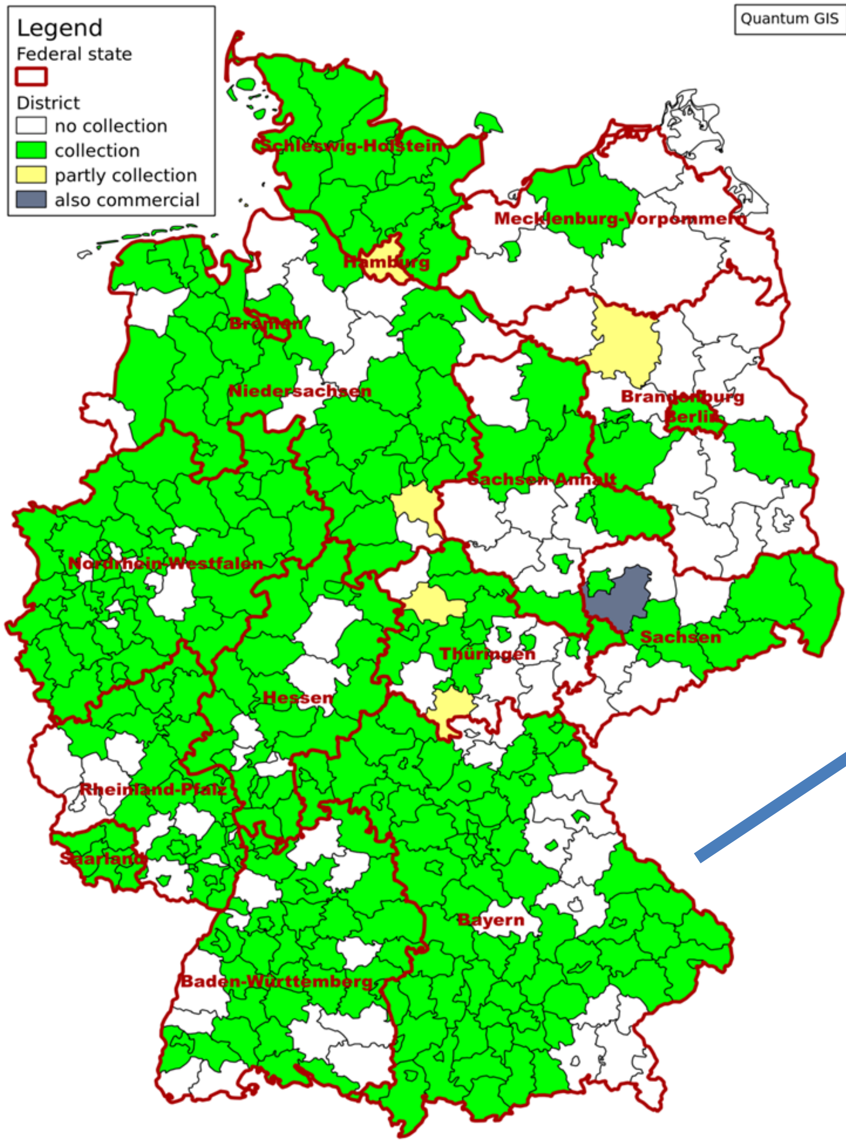
FW collection schemes in Europe

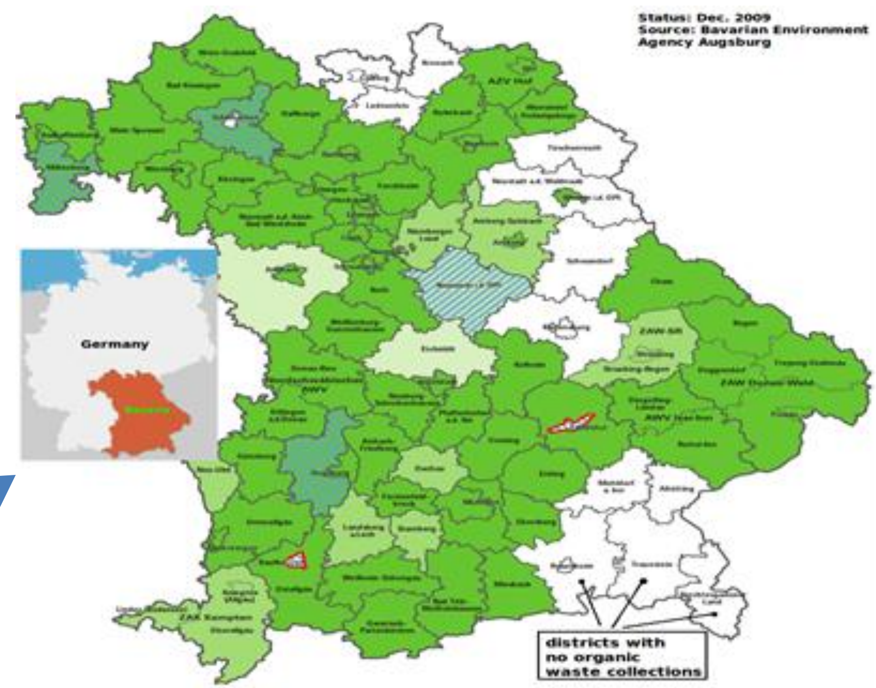
- Methodologies
  - quantitative compositional analysis, observational studies, public opinion surveys
- Web-based surveys
  - Organisations
  - Search terms
- Pilot
- Modifications
- QA

Survey results



Survey results





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Survey results

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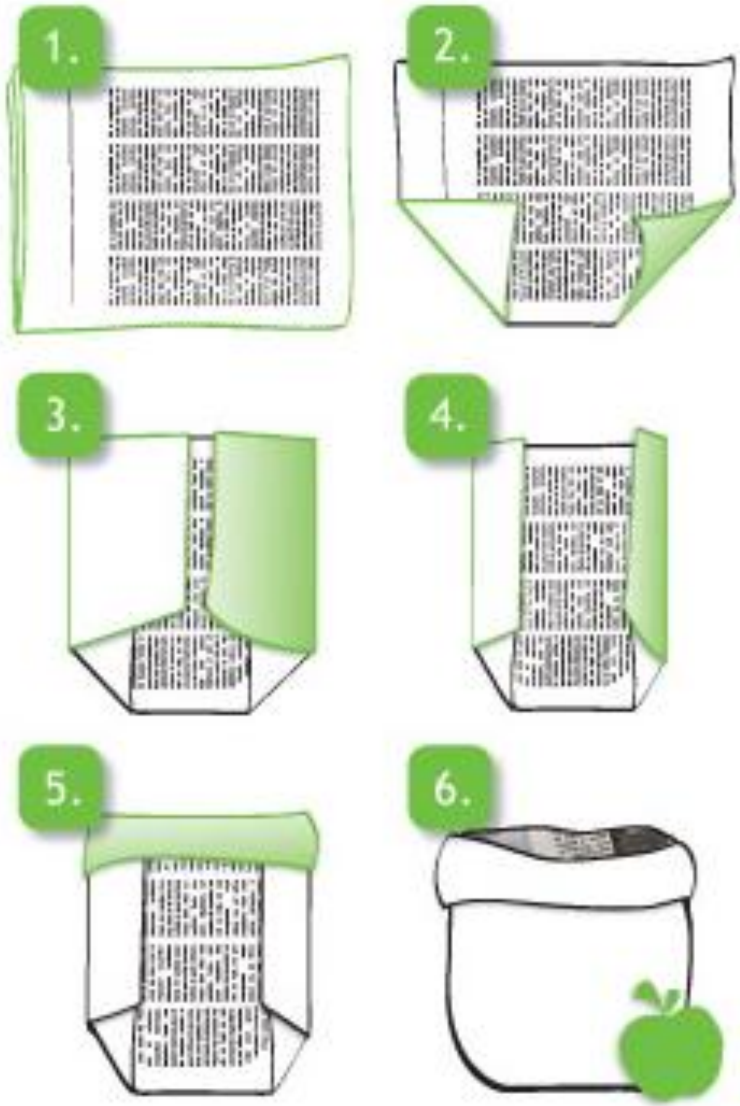
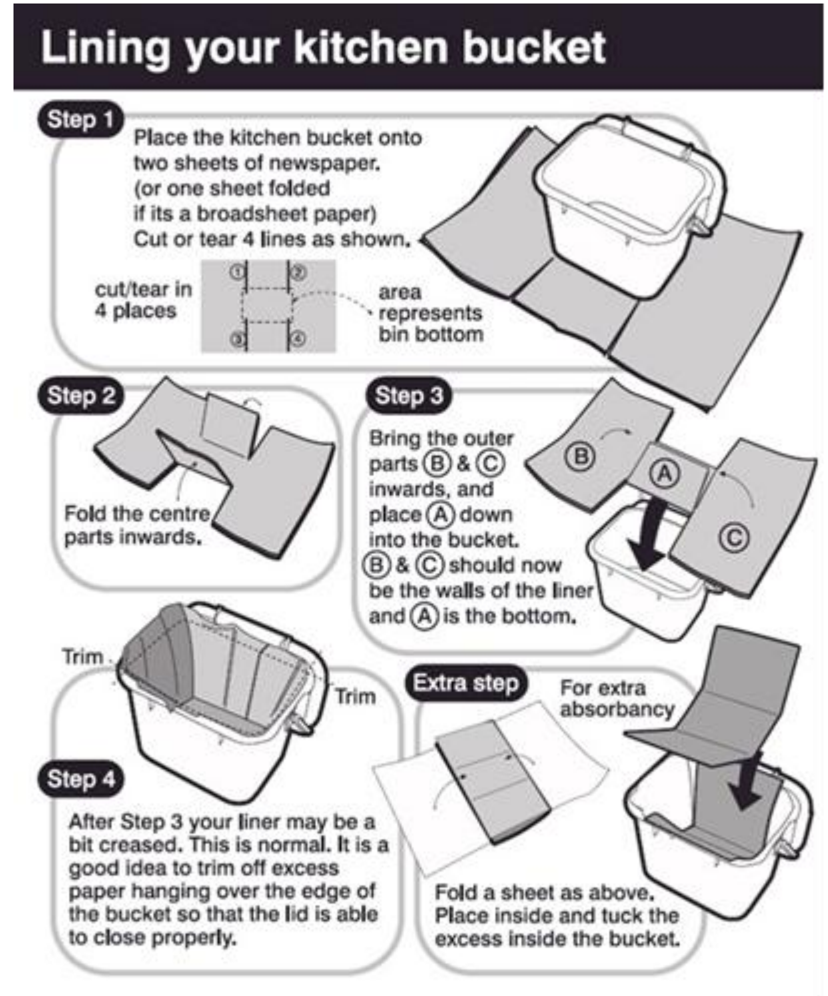
Survey results





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Survey results

Survey results

Survey results

Survey results

- 3 types but merge
  - critical for plant design and operation
- Container size a significant factor
  - plastic bags
- Inconsistent definitions
- Good practice information
- Methodology

FW Collection

- Energy out > Energy in ☺
- Energy out < Energy in ☹
- Multiple factors
  - Climate, population size and density, vehicle type, working hours, collection frequency, participation rate, segregation efficiency: no information

   

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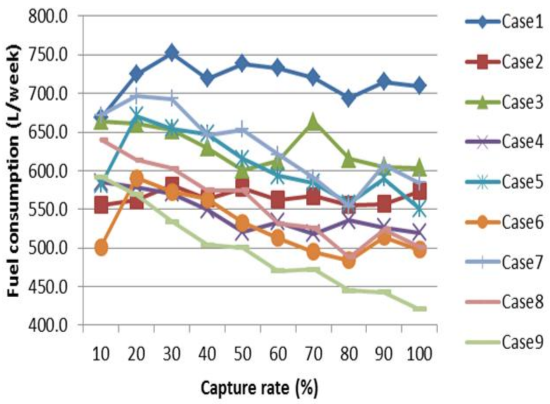
Mechanistic model

- Input
  - No. of households, housing density, FW generation rate, participation rate, collection frequency etc
- Select
  - Vehicle type, crew size, no. of bins etc
- Outputs
  - fuel consumption, collection hours (staff time), no. of vehicles required

Mechanistic model

- Fuel savings of 25% and more
- Insights on vehicle design
  - – pod better than split



Scoping tool

- Best: weekly food waste collection with AWC of recyclable and residual waste by compartmentalised vehicle
- Worst: weekly separate collection of recyclables, residual and food waste by single-compartment RCV

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FW composition

- Approaches
  - Compositional characterisation
  - Physico-chemical analyses
- Composition – categories?
  - WRAP and other studies
  - Partner systems

Compositional characterisation

WRAP revised (2009)	WRAP original (2008)	VALORSUL	VALORGAS	Greenfinch
1 Fresh vegetables and salads 3 Fresh fruit 8 Processed vegetables and salad 14 Processed fruit	7 Vegetables 5 Fruit 6 Salads	1 Vegetables 13 Fruit 3 Salads	1 1a Fruit and vegetable waste 1b Fruit and vegetables (whole) 1c Large stones, seeds and fibrous materials	1 Fruit & veg peelings 2 Fruit & veg whole 17 Seeds & stones
10 Staple foods	4 Dried foods/powders	8 Dried foods/powders	2 Pasta/rice/flour/cereals	3 Pasta/rice/flour 9 Cereal
4 Bakery	1 Bakery	10 Bakery	3 Bread and bakery	4 Bread and bakery
6 Meat and fish	2 Meat and fish	9 Meat and fish 32 Special - bones	4 4a Meat and fish 4b Bones	5 Meat and fish 6 Bones
7 Dairy and eggs	3 Dairy	7 Dairy	5 5a Dairy 5b Egg shells	8 Dairy 7 Eggs
2 Drinks	9 Drinks	4 Drinks	6 Drinks	10 Tea bags & coffee
13 Confectionery and snacks 11 Cake and desserts	8 Confectionery and snacks 11 Desserts	5 Snacks	7 7a Confectionery and snacks 7b Desserts	11 Sweets & desserts
9 Condiments, sauces, herbs and spices 5 Meals (homemade and pre-prepared)	10 Condiments, sauces, herbs and spices 12 Mixed foods	12 Condiments, sauces, herbs and spices 6 Mixed meals	8 8a Condiments 8b Mixed meals	16 Mixed meals
15 Other 12 Oil and fat	13 Other	11 Other food	9 Other food	12 Other food material
			10 Biodegradable bags	14 Biodegradable bags
		2 Garden waste	11 Garden waste	13 Non food biodegradable w
		14 Paper 15 Cardboard - packaging 16 Cardboard - non packaging	12 Paper and card	
		17 Plastic - film bags 18 Plastic - bottles 19 Plastic - polystyrene 20 Plastic - other 23 Ferrous metals 24 Non ferrous metals 21 Glass - packaging 22 Glass - non packaging 25 Composites 26 Textiles 27 Sanitary textiles 28 Combustibles - wood 29 Combustibles - other 30 Incombustibles 31 Special - packaged organics 33 Special - other	13 13a Plastic containers 13b Plastic film (non-biodegradable) 13d Metals 13e Glass 13f Miscellaneous	

Compositional characterisation

- VALORGAS partners
  - Finland, Portugal, Italy, UK
- Multiple studies in UK

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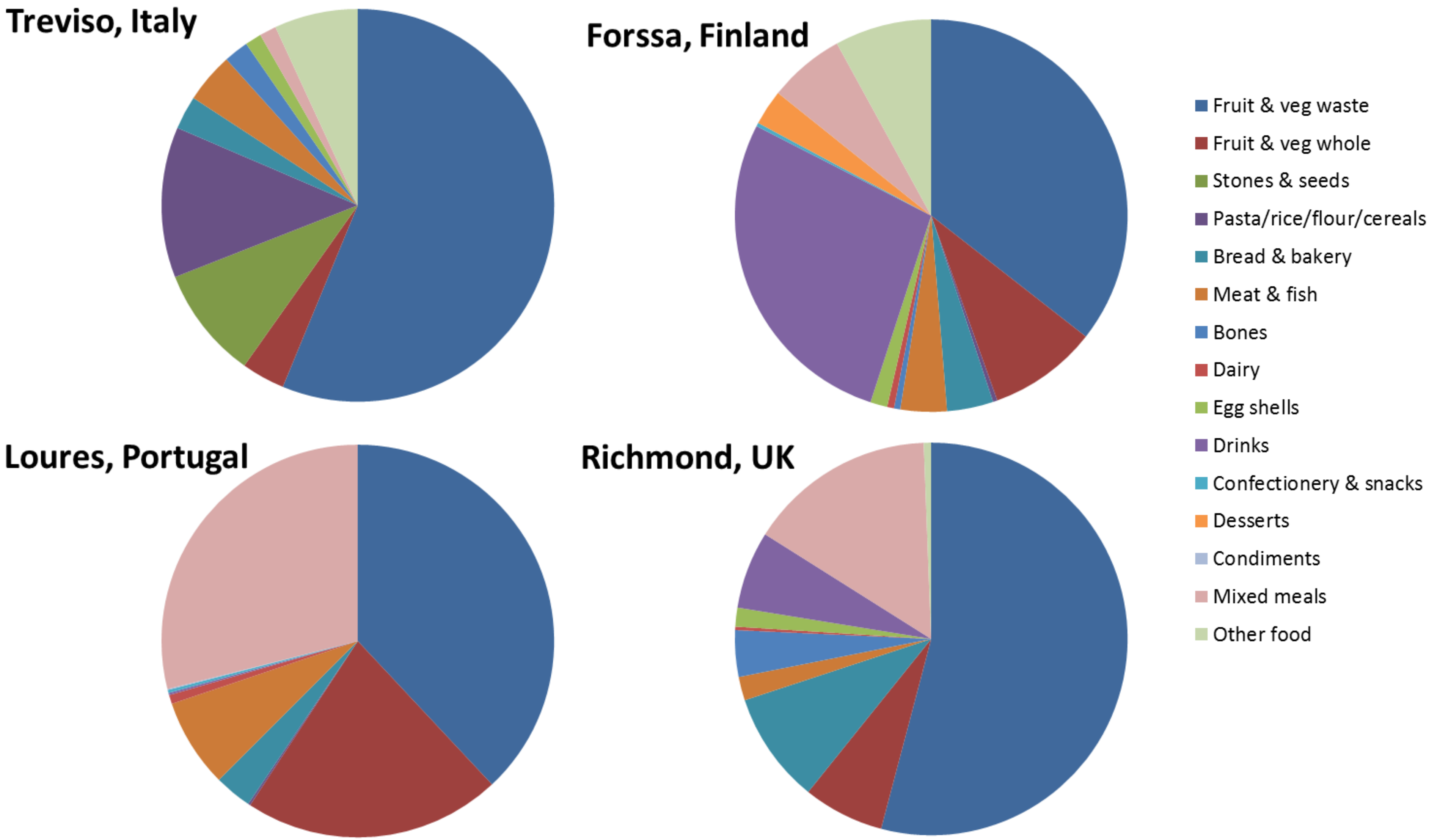
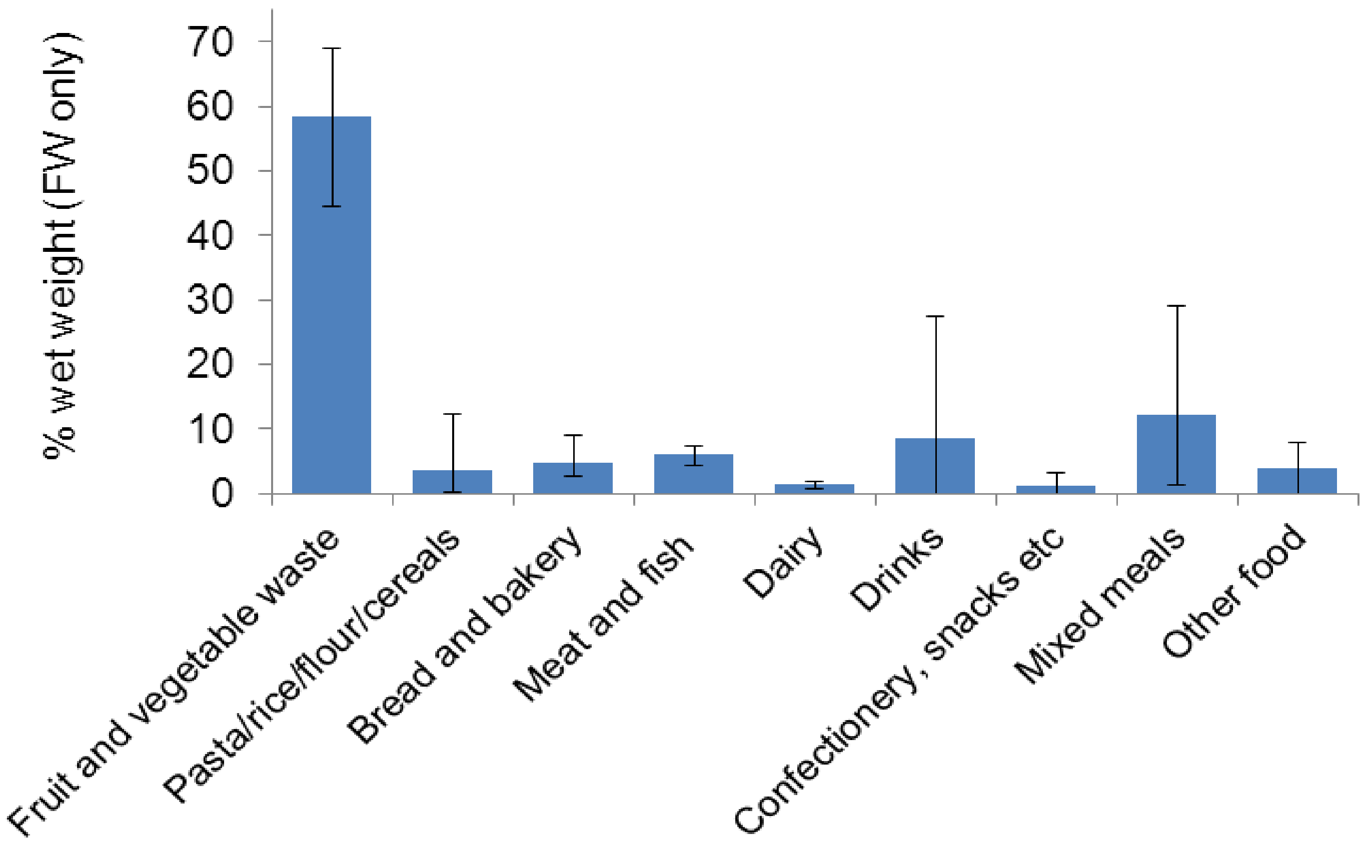
Compositional characterisation

Compositional characterisation



Compositional characterisation



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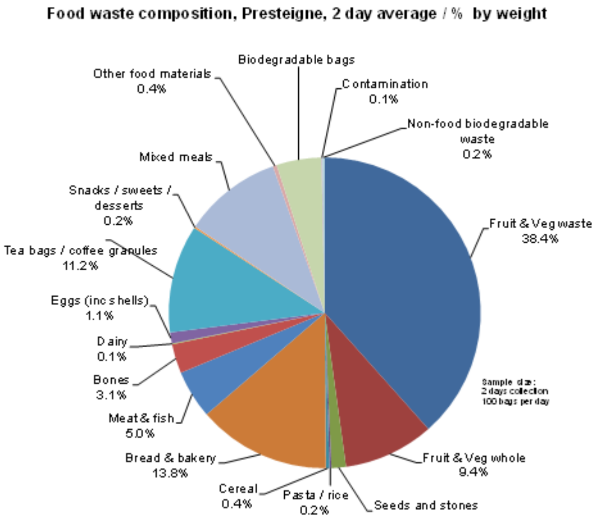
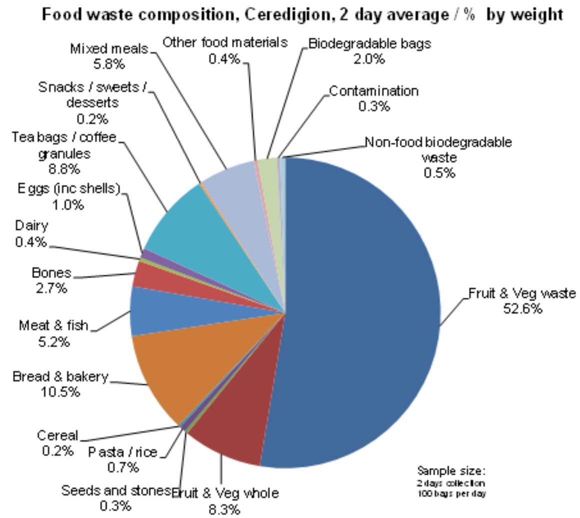
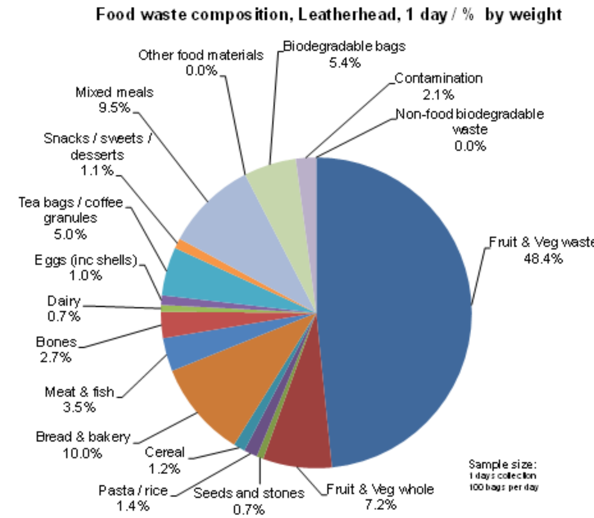
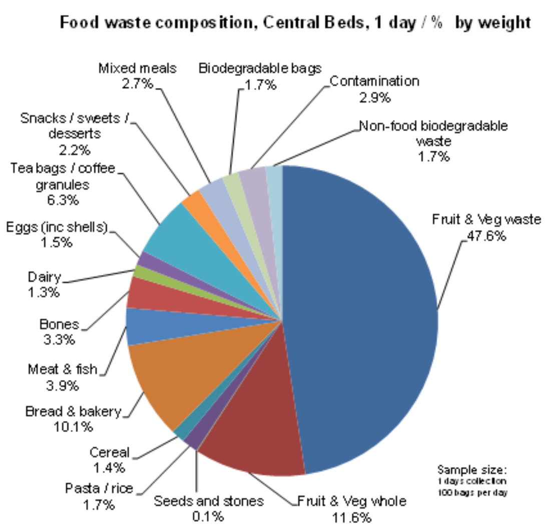
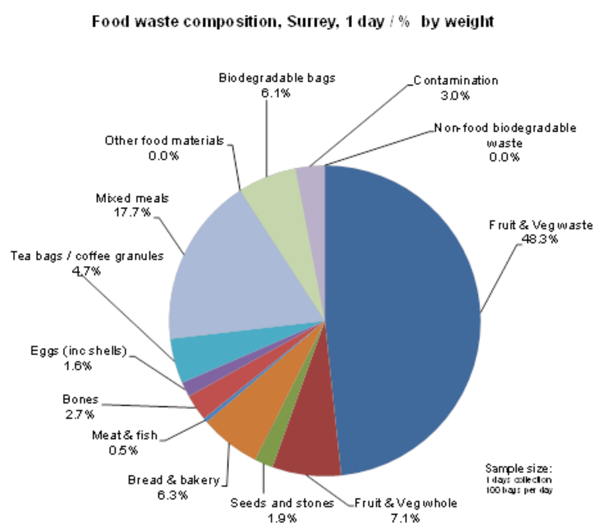
Compositional characterisation

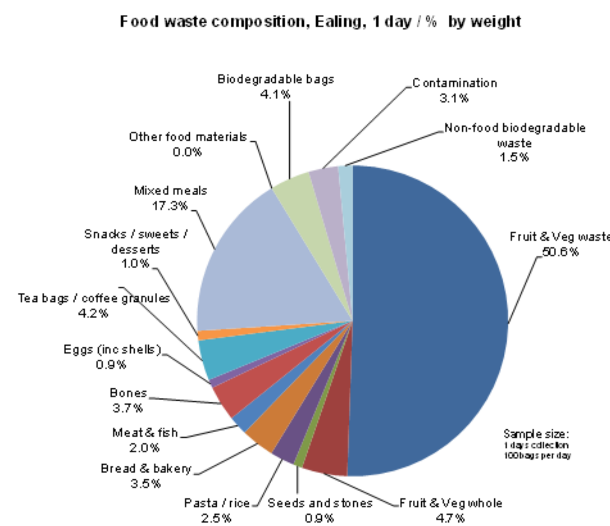












Physico-chemical analysis

		UK					Finland	Italy		Portugal		
		Luton [a]	Hackney [a]	Ludlow [a]	Eastleigh	Eastleigh	Forssa	Treviso	Treviso	Lisbon raw waste	Lisbon to digester	Lisbon to digester
		(Lab 2)	(Lab 2)	(Lab 2)	(Lab 2)	(Lab 1)	(Lab 1)	(Lab 1)	(Lab 3)	(Lab 3)	(Lab 1)	(Lab 3)
Fundamental characteristics for anaerobic digestion												
pH		5.12 ± 0.01	5.18 ± 0.01	4.71 ± 0.01	5.02 ± 0.01	5.70	5.34	6.16				
TS	% WW [b]	23.70 ± 0.06	25.74 ± 0.18	23.74 ± 0.08	25.89 ± 0.01	28.62 ± 0.07	27.02 ± 0.12	27.47 ± 0.03	24.43 ±4.57	33.80		[illegible]
VS	% WW	21.84 ± 0.10	23.47 ± 0.31	21.71 ± 0.09	24.00 ± 0.03	26.83 ± 0.16	24.91 ± 0.05	23.60 ± 0.09	20.16 ± 3.75	27.60		
VS	%TS	91.28 ± 0.20	91.17 ± 0.91	91.44 ± 0.39	92.70 ± 0.12	94.18 ± 0.42	92.26 ± 0.26	86.60 ± 0.40	83.32 ± 5.87	81.7		
TOC	%TS	51.2 ± 1.2	51.3 ± 0.2	48.3 ± 1.0	48.76 ± 0.87							
TKN		3.12 ± 0.01	3.13 ± 0.03	3.42 ± 0.04	2.91 ± 0.05	2.74 ± 0.05	2.39 ± 0.04	2.55 ± 0.03	2.84 ± 0.76	1.5	6.93 ± 0.07	4.30
TKN	$g\ kg^{-1}$ WW	7.39 ± 0.02	8.06 ± 0.08	8.12 ± 0.09	7.53 ± 0.13	7.84 ± 0.16	6.45 ± 0.1	7.02 ± 0.1	7.19 ± 2.06	5.1	4.37 ± 0.05	2.72
CV	$kJ\ g^{-1}$ TS	21.43 ± 0.12	21.64 ± 0.11	20.66 ± 0.18	20.97 ± 0.02	21.32 ± 0.08	21.39 ± 0.11	20.50 ± 0.01			25.23 ± 0.26	
Biochemical composition												
Lipids	$g\ kg^{-1}$ VS	148 ± 4	157 ± 2	151 ± 1	149 ± 1	152 ± 2	156 ± 0.5	202 ± 0.5			314 ± 0.4	
Crude protein	$g\ kg^{-1}$ VS	213 ± 1	213 ± 2	235 ± 3	197 ± 4	183 ± 4	162 ± 0.4	186 ± 3				
Nutrients												
TKN (N)	$g\ kg^{-1}$ TS	31.2 ± 0.1	31.3 ± 0.3	34.2 ± 0.4	29.1 ± 0.5	27.4 ± 0.5	23.9 ± 0.4	25.5 ± 0.3	28.44 ± 7.62	15		
TP (P)	$g\ kg^{-1}$ TS	4.87 ± 0.08	6.41 ± 0.12	5.41 ± 0.32	2.82 ± 0.13	2.94 ± 0.01	2.73 ± 0.05	3.47 ± 0.06	3.26 ± 1.54	5.0		
TK (K)	$g\ kg^{-1}$ TS	12.3 ± 0.1	12.9 ± 0.6	14.3 ± 0.8	8.59 ± 0.27	11.2 ± 0.2	10.0 ± 0.2	10.0 ± 0.1				
Elemental analysis												
N	%TS	3.12 ± 0.01	3.13 ± 0.03	3.42 ± 0.04	2.91 ± 0.05	2.80 ± 0.02	2.46 ± 0.03	2.58 ± 0.05			5.72 ± 0	
C	%TS	51.2 ± 1.2	51.3 ± 0.2	48.3 ± 1.0	48.8 ± 0.9	50.6 ± 0.2	49.4 ± 0.04	47.2 ± 0.01			54.8 ± 0.1	
H	%TS	6.56 ± 0.04	6.67 ± 0.13	5.53 ± 0.63	6.37 ± 0.19							
S	%TS	0.21 ± 0.00	0.23 ± 0.03	0.15 ± 0.01								
O	%TS	30.7 ± 1.2	29.8 ± 0.4	34.3 ± 2.5	34.7 ± 0.9							

[a] Samples analysed as part of the Defra funded project WR1208 (Banks et al., 2011)   [b] WW = wet weight

22-27%

23-30%

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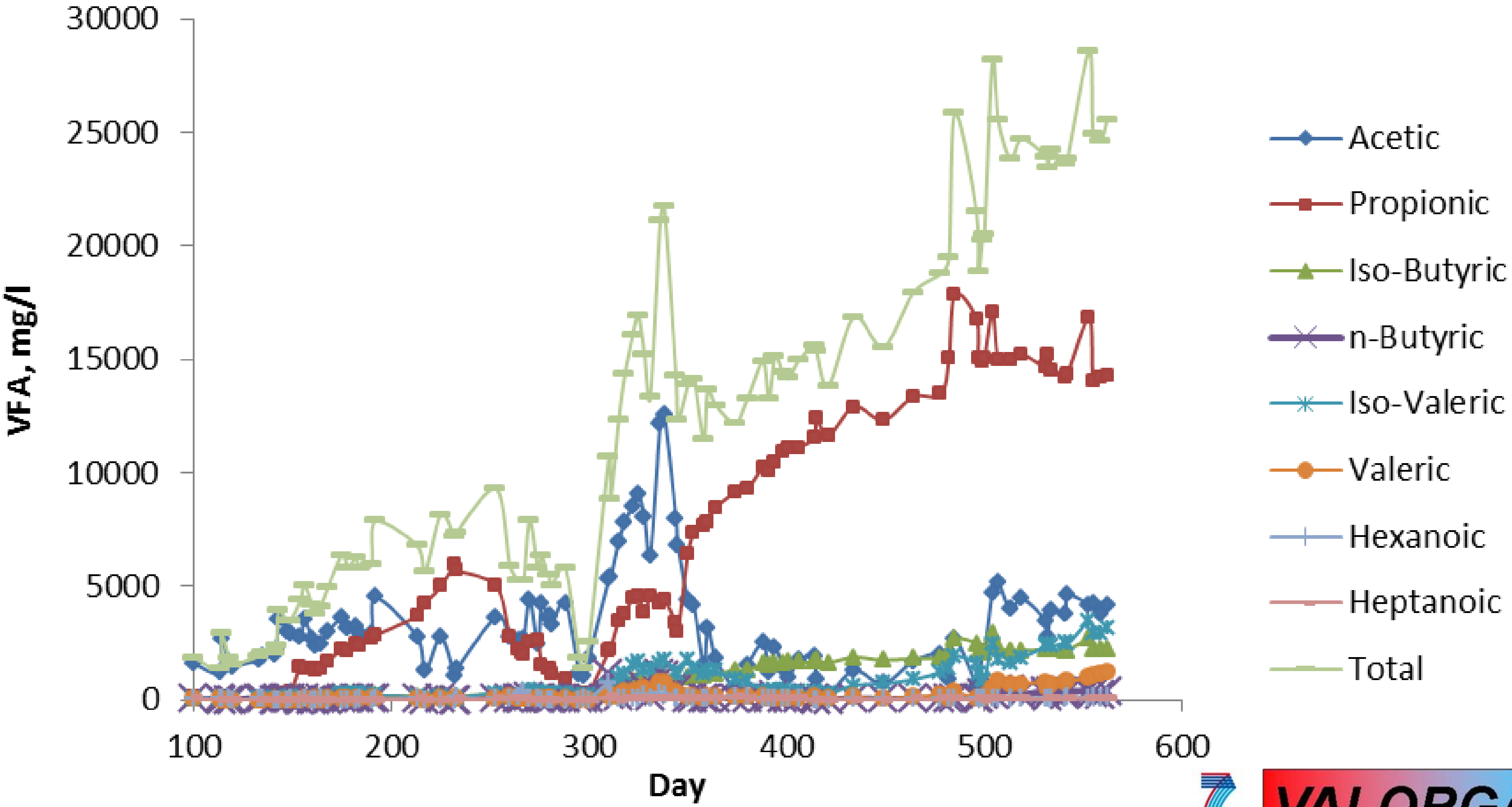
Overall characterisation

- Similar

  …but may be changing?

AD of Food waste

- Early problems associated with this feedstock



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AD of Food waste

- … now resolved at mesophilic temperatures
  - hypothesis on metabolic pathway and role of hydrogenotrophic methanogens proven
- Laboratory-scale reactors running at up to 7 kg VS m^{-3} day^{-1}, compared to < 2 kg VS m^{-3} day^{-1}
- Robust under varying loading

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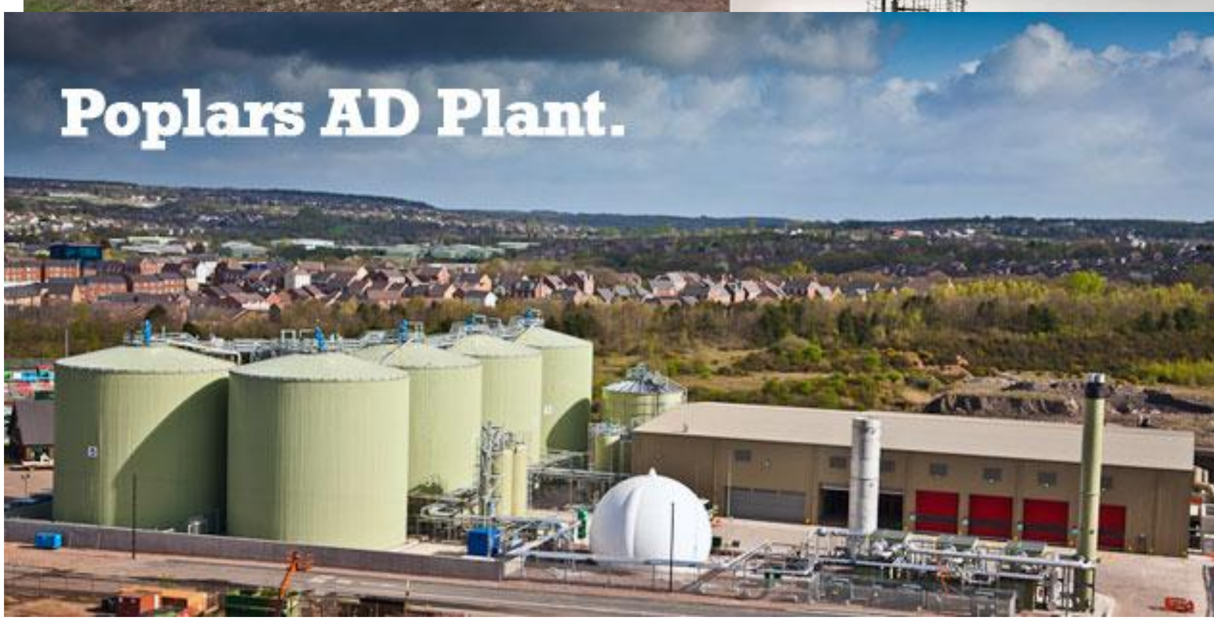
AD of Food waste



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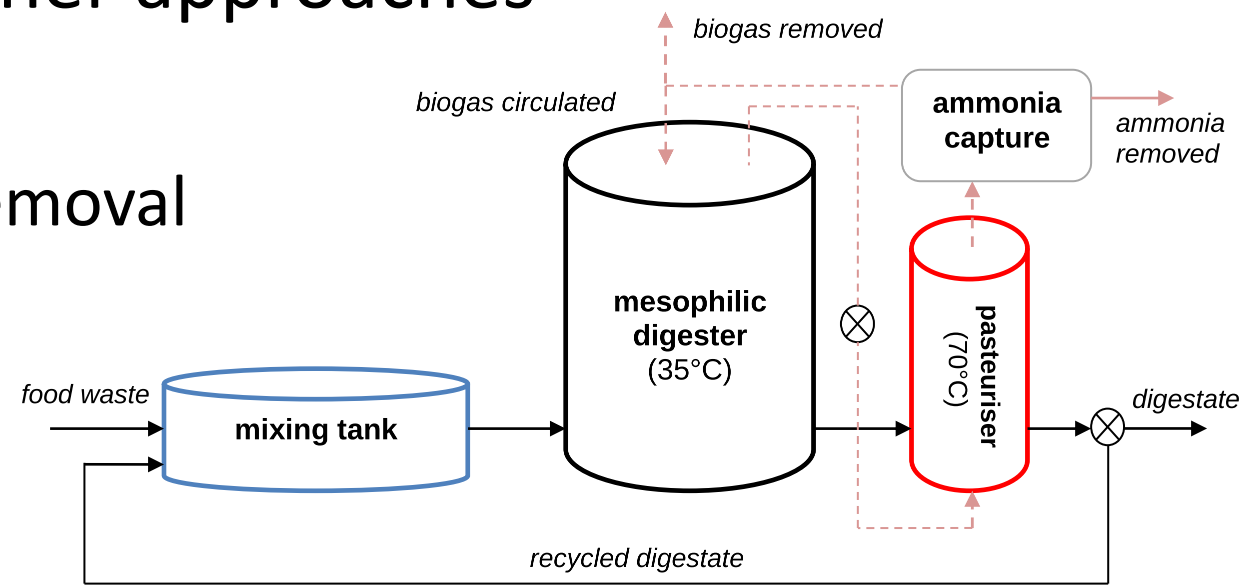
AD of Food waste

- … still unclear in thermophilic conditions
  - different metabolic pathways and micro-organisms, increased ammonia toxicity
- Looking at other approaches
  - Dilution
  - Ammonia removal



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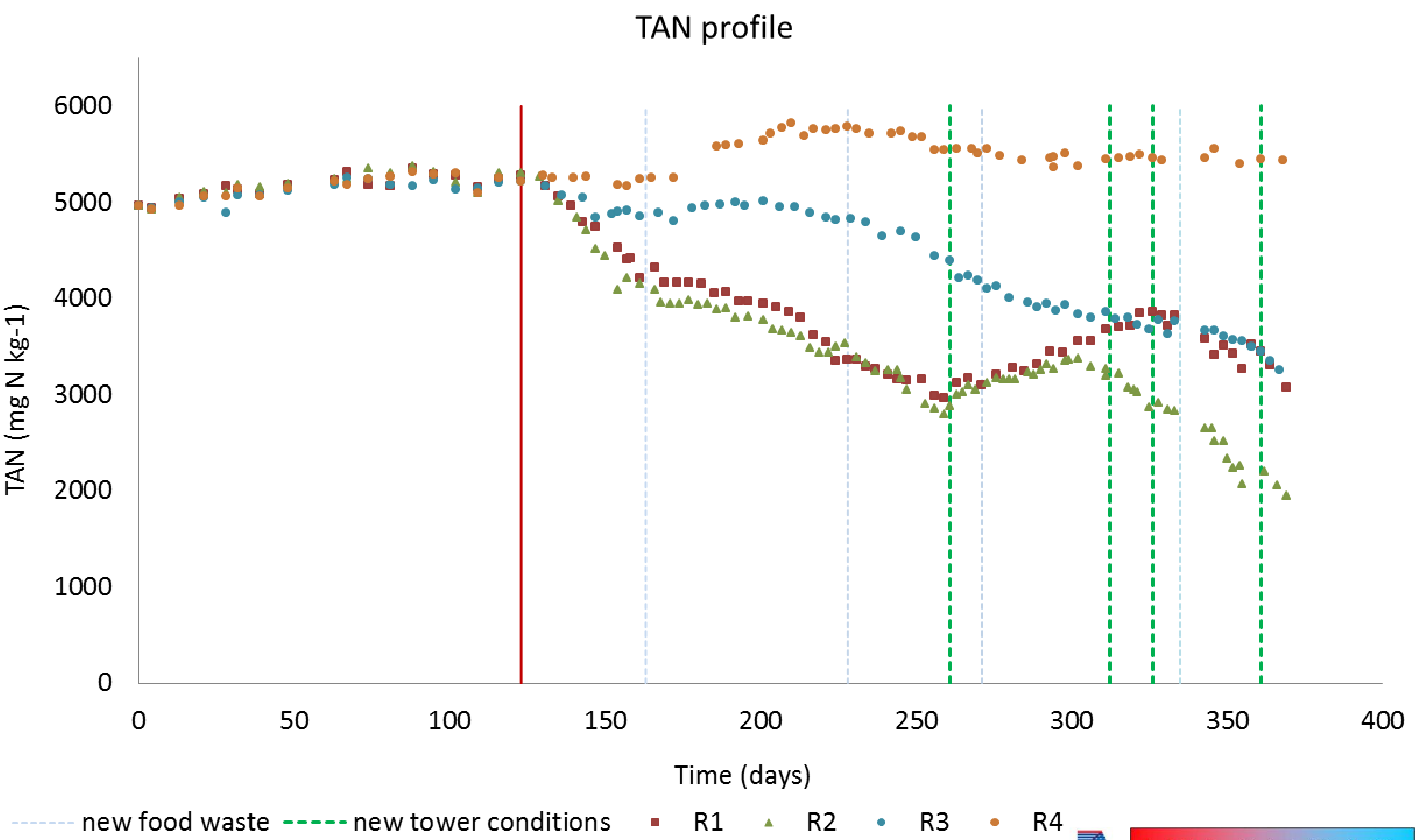
Ammonia removal



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Ammonia removal

- Potential solution for thermophilic operation
- Opens up possibility of 'designer digestates'
- Application to other feedstocks

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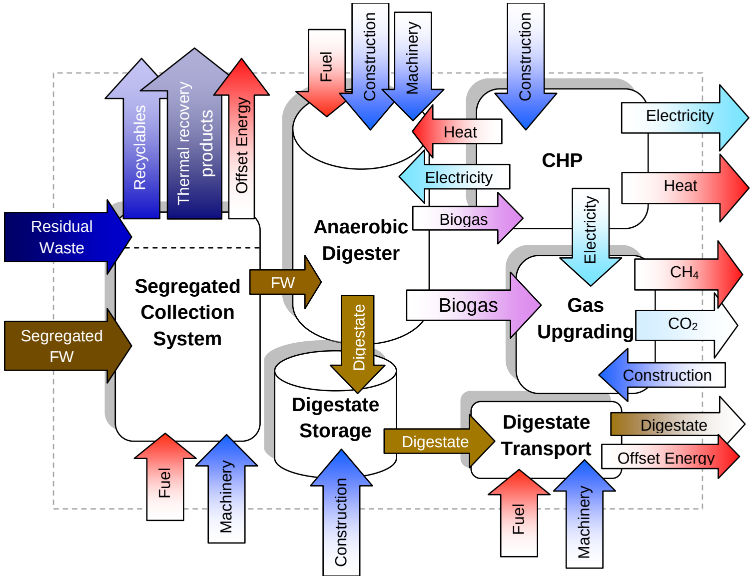
Overall view

- Other activities
  - gas upgrading, use in transport, case studies, residuals
- Energy balance approach
  - energy - carbon - nutrient
  - 'join up the bits'
  - complex versus simple
  - consequences of decisions



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Thank you!

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