Mass & Energy balances around full scale plants for food waste anaerobic digestion

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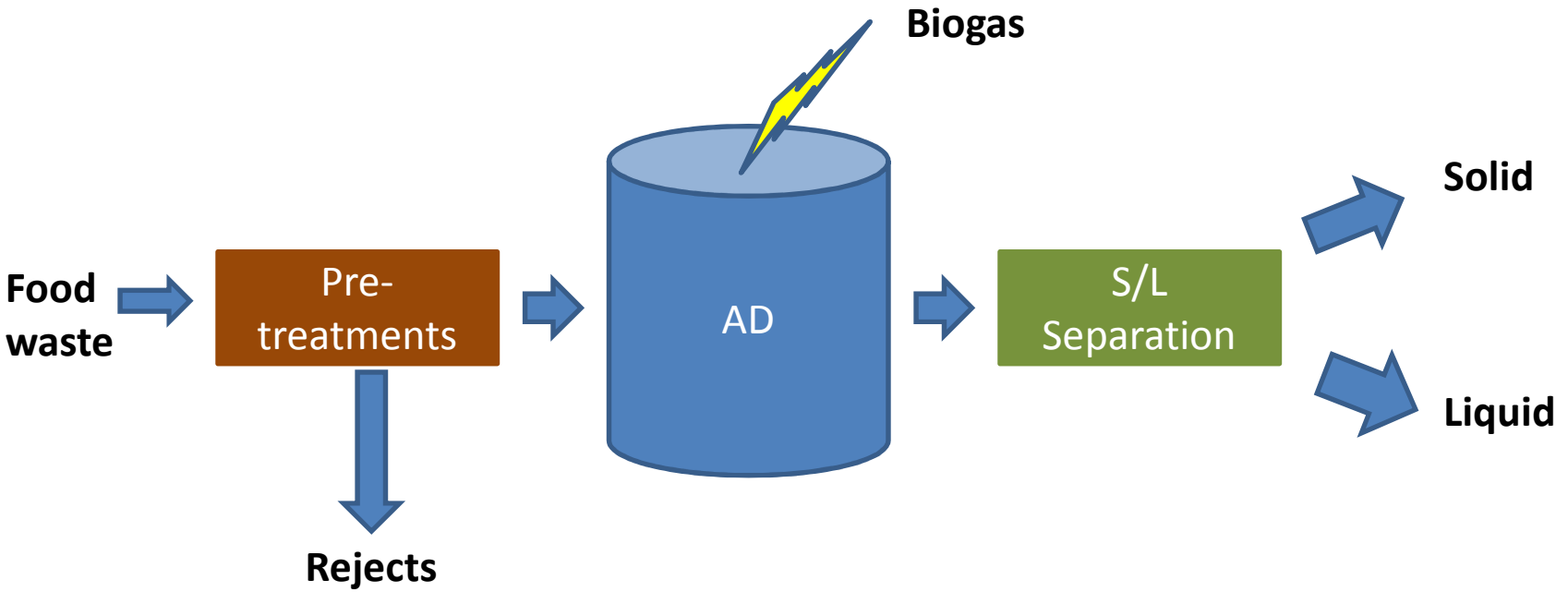
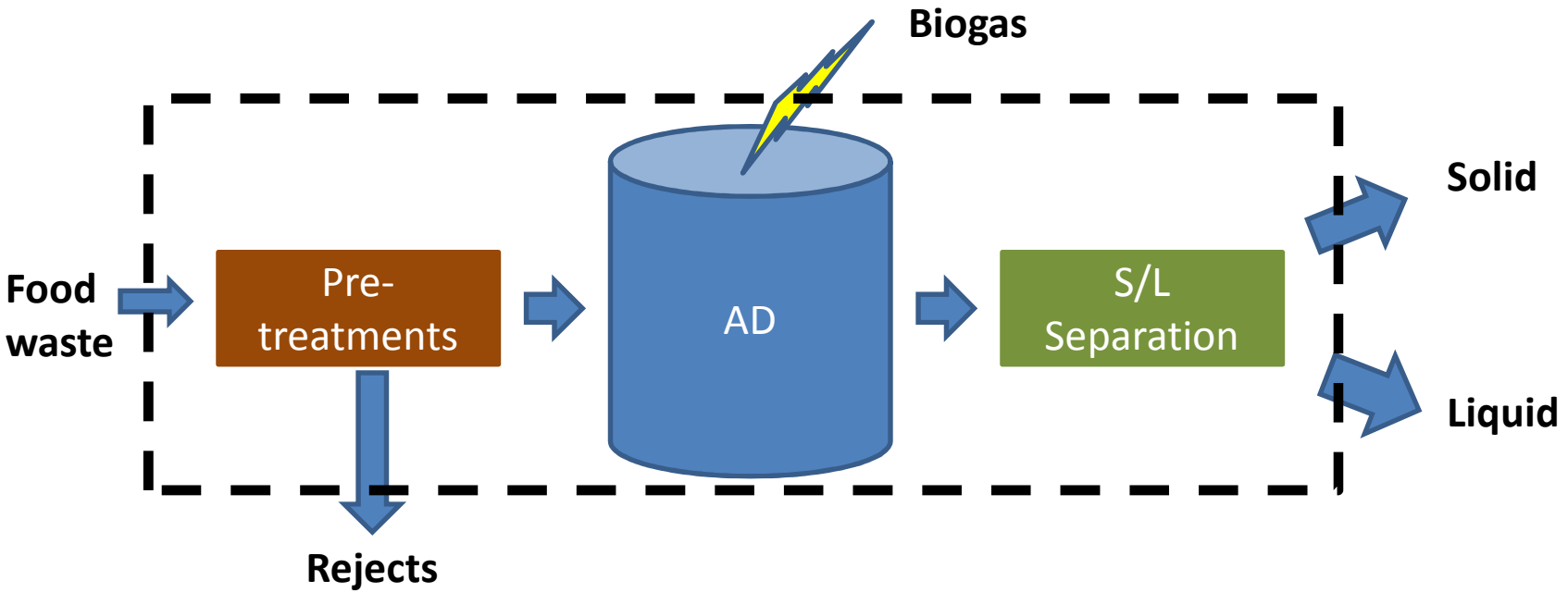
Valorgas (ENERGY-2009-3.2.2) workshop

Mass and energy balances around plants operating the mesophilic and thermophilic AD of food waste

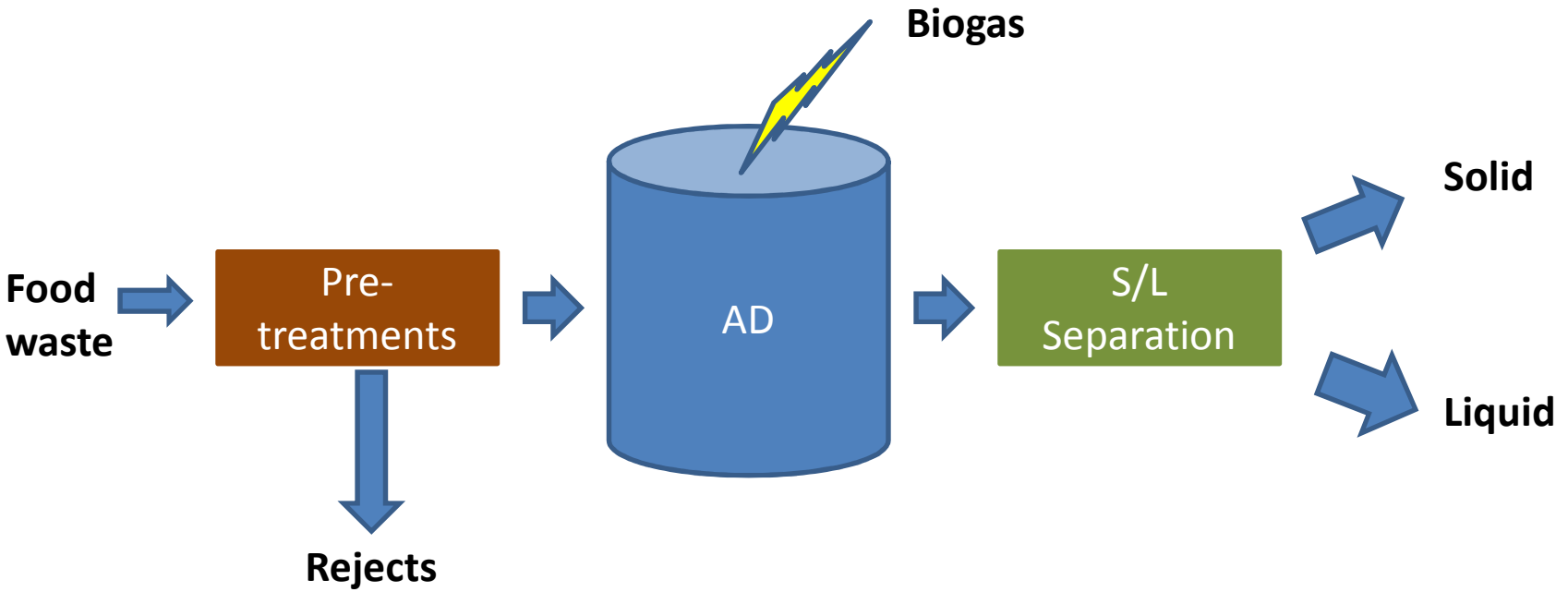
In the Valorgas project we are considering not only the global ….

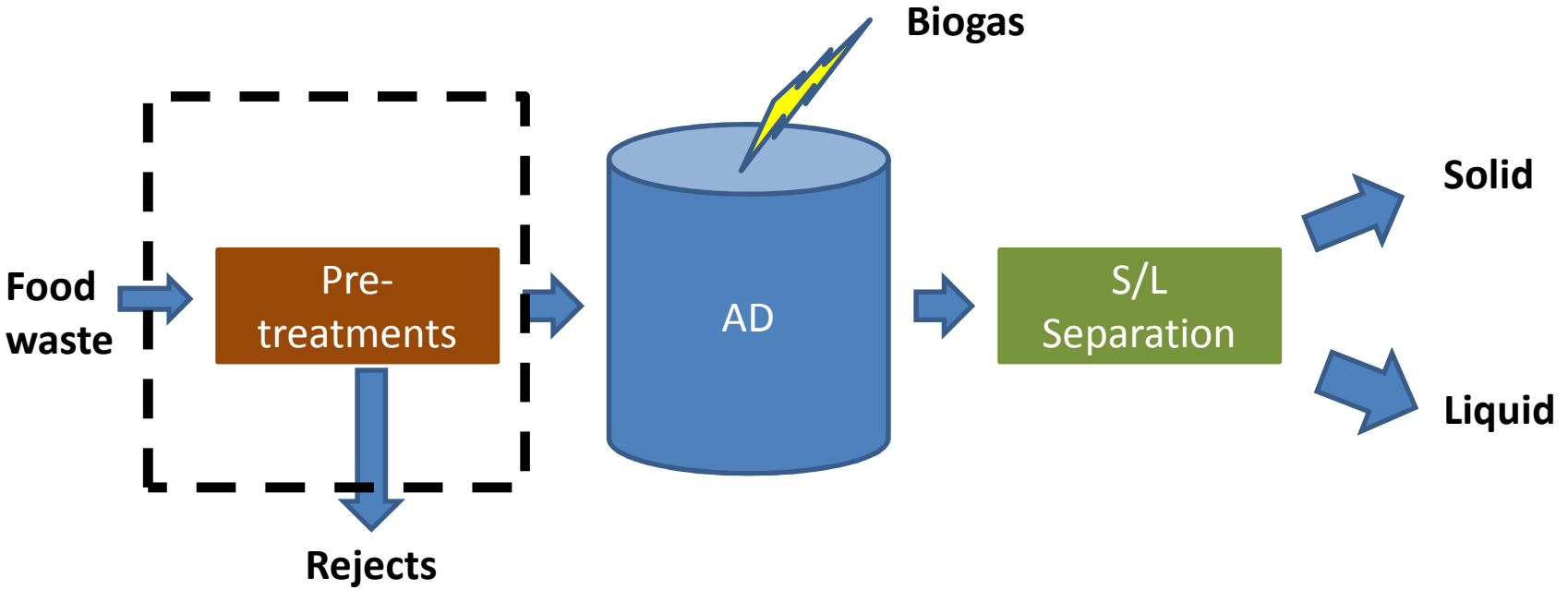


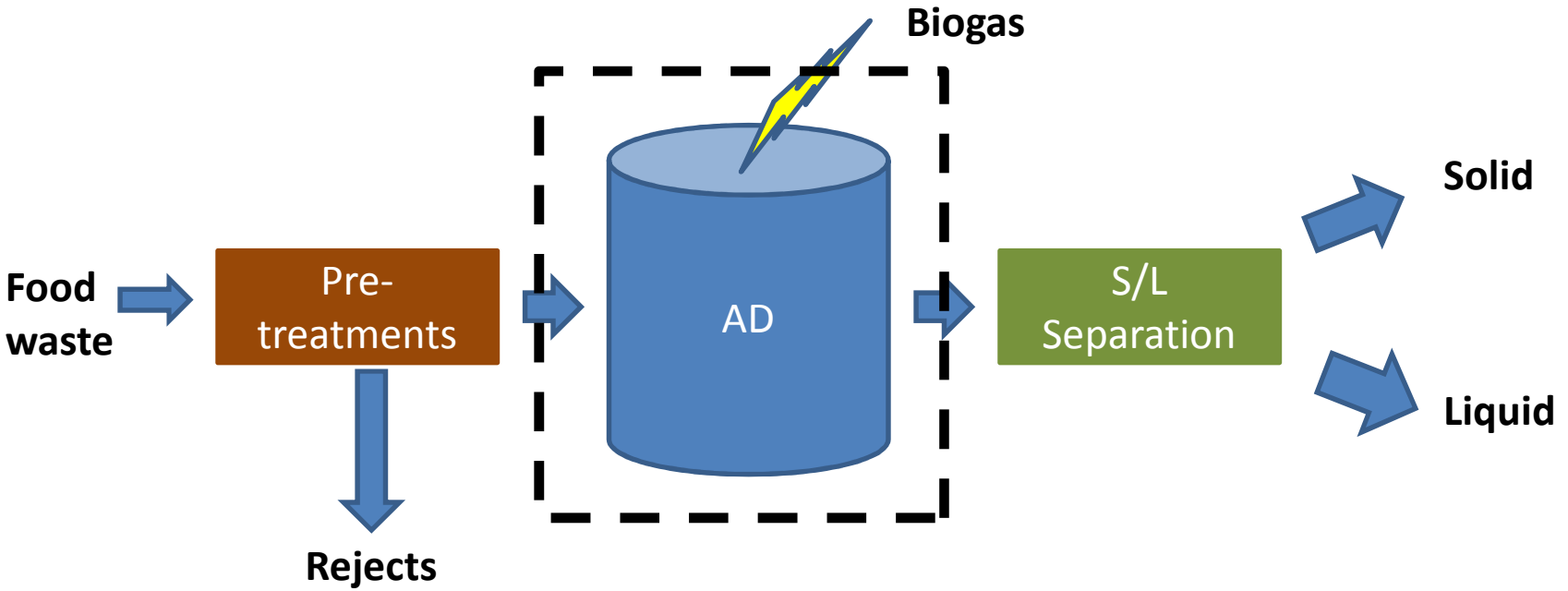
…. mass and energy balance, but also ……



… the balance for single parts of the train of processes for food waste treatment ….




Biogas
Food waste
Pre-treatments
AD
S/L Separation
Solid
Liquid
Rejects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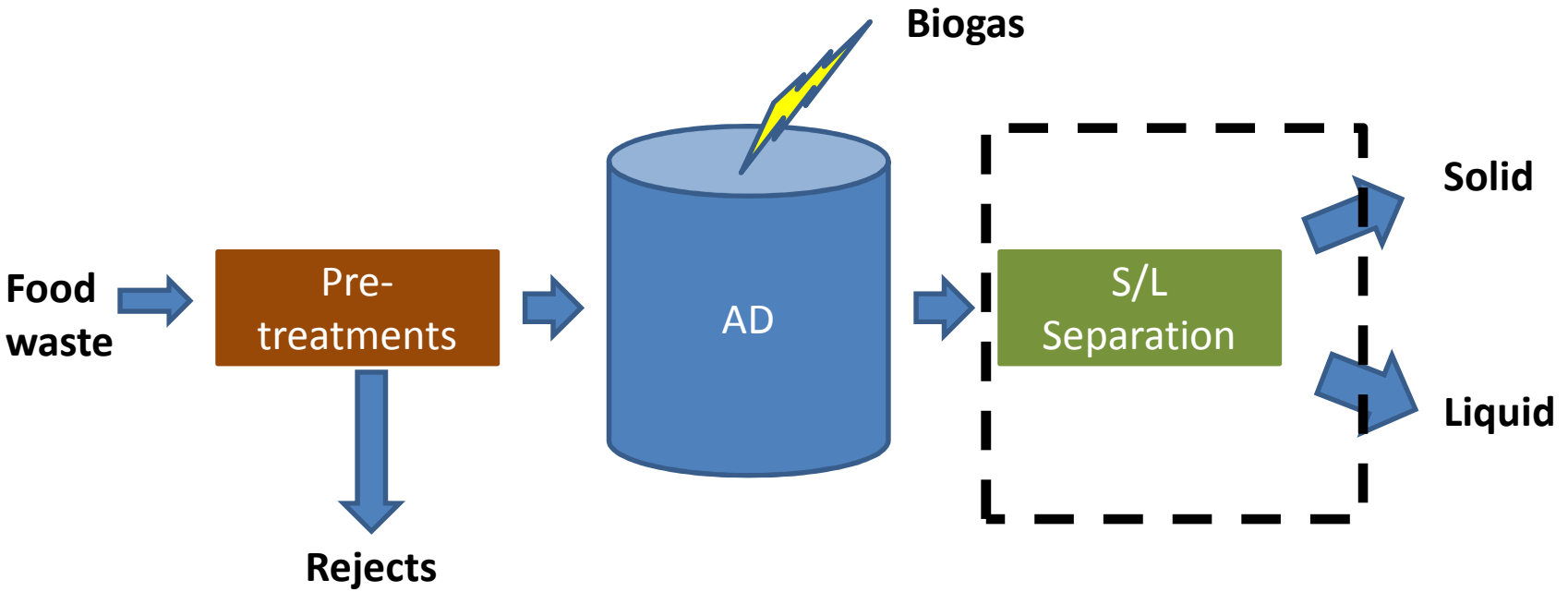
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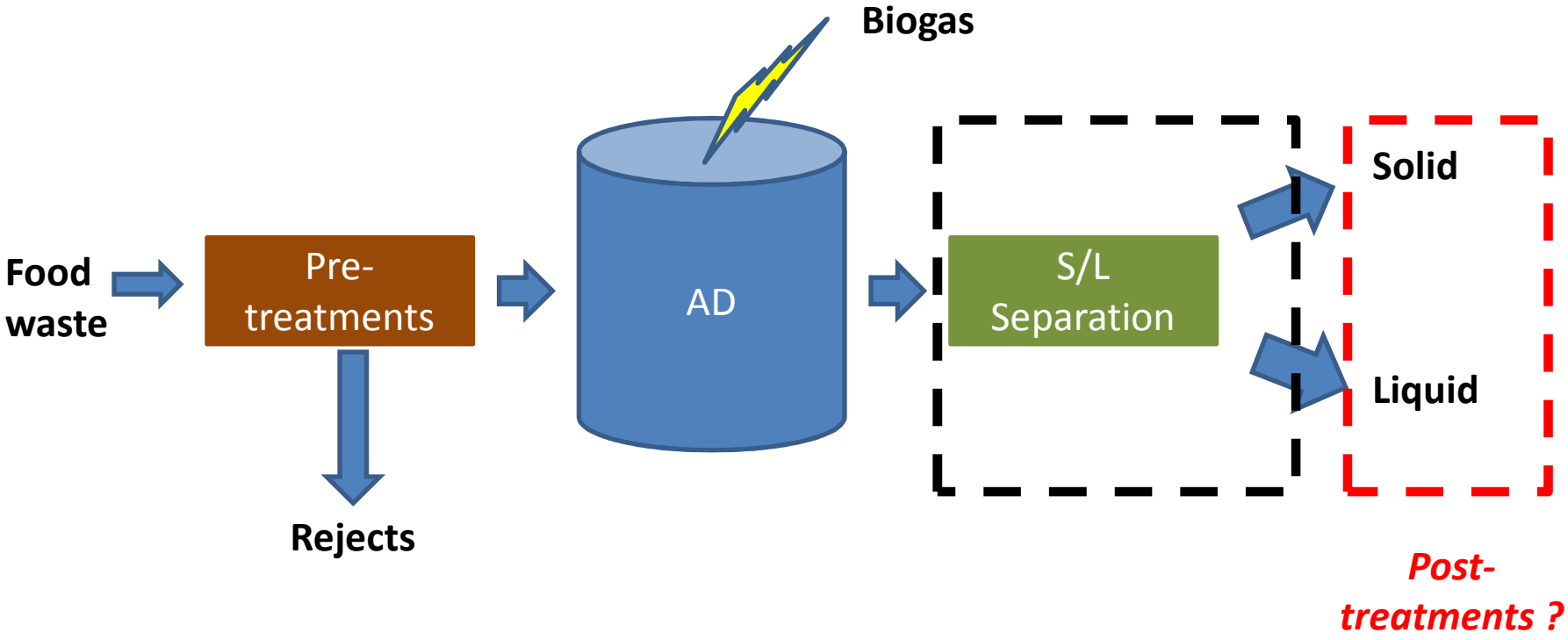

Biogas
Food waste
Pre-treatments
AD
S/L Separation
Solid
Liquid
Rejects
Post-treatments ?

We decided, together with the plant managers at Valorsul (P) and Biogen Greenfinch (UK), to collect data on samples from the following points (wherever possible)

And determine the following parameters (minimal set)

Solid/liquid streams

Parameter	Abbreviation	Units
Flowrate,	Q	kg day^{-1}
Total solids	TS	g kg^{-1} or % on wet weight
Total volatile solids	TVS	g kg^{-1} ,%TS
Total COD	TCOD	gO_2 $kgTS^{-1}$
Total Kjeldahl Nitrogen	TKN (as N)	g $kgTS^{-1}$
Total phosphorous	TP (as P)	g $kgTS^{-1}$

Biogas

Parameter	Abbreviation	Units
Flowrate,	Q	Nm^3 day^{-1}
Mass flowrate		kg day^{-1}
CH4 content	CH4	%
CO2 content	CO2	%

Then, also the energetic balance, as a global figure, and for different parts of the treatment plants, will be determined considering:

a) the heat and power production from biogas

b) the overall power consumption of the plant (kWh per day)

c) the heat and power supply from nets (if any)

On the other hand, the specific energy consumption for any single unit (e.g., pre-treatment – and its parts, if possible - , digester, solid/liquid separation ....) is of fundamental interest for the study and comparison of different processes/technologies/substrates.

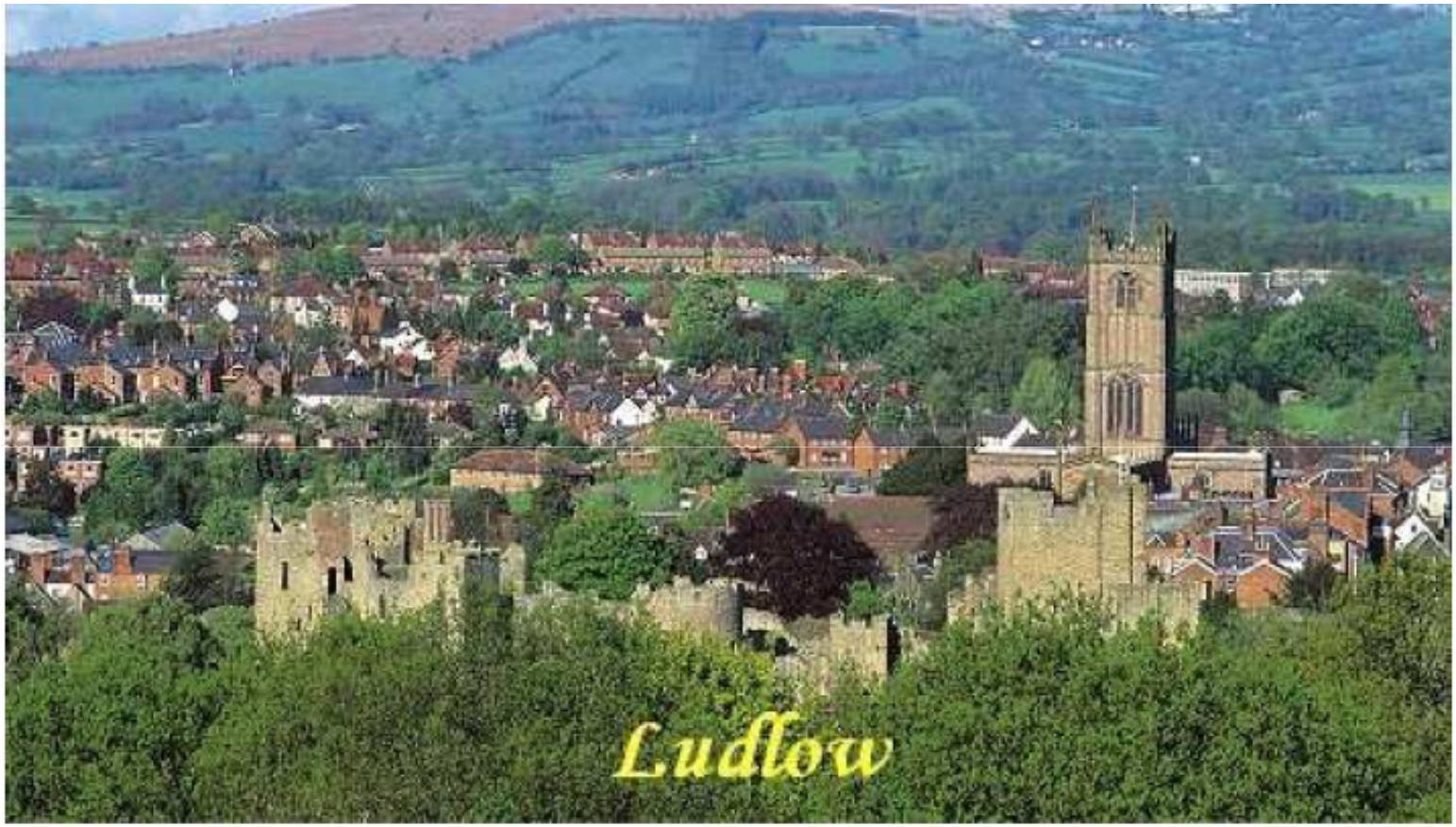
Two different treatment plants are considered in the research project

a) **The Biogen Greenfinch plant in Ludlow (UK) - MESOPHILIC AD of food waste from separate collection**

b) **The Valorsul plant in Almadora-Lisbon (P) – THERMOPHILIC AD of both food waste from separate collection and residues from restaurants /markets**

Biogen Greenfinch plant in Ludlow (UK)

Courtesy of Paolo Pavan



Courtesy of Michael Chesshire

Kerbside bins ready for collection in Ludlow

Kitchen caddy, corn starch bags & kerbside bin

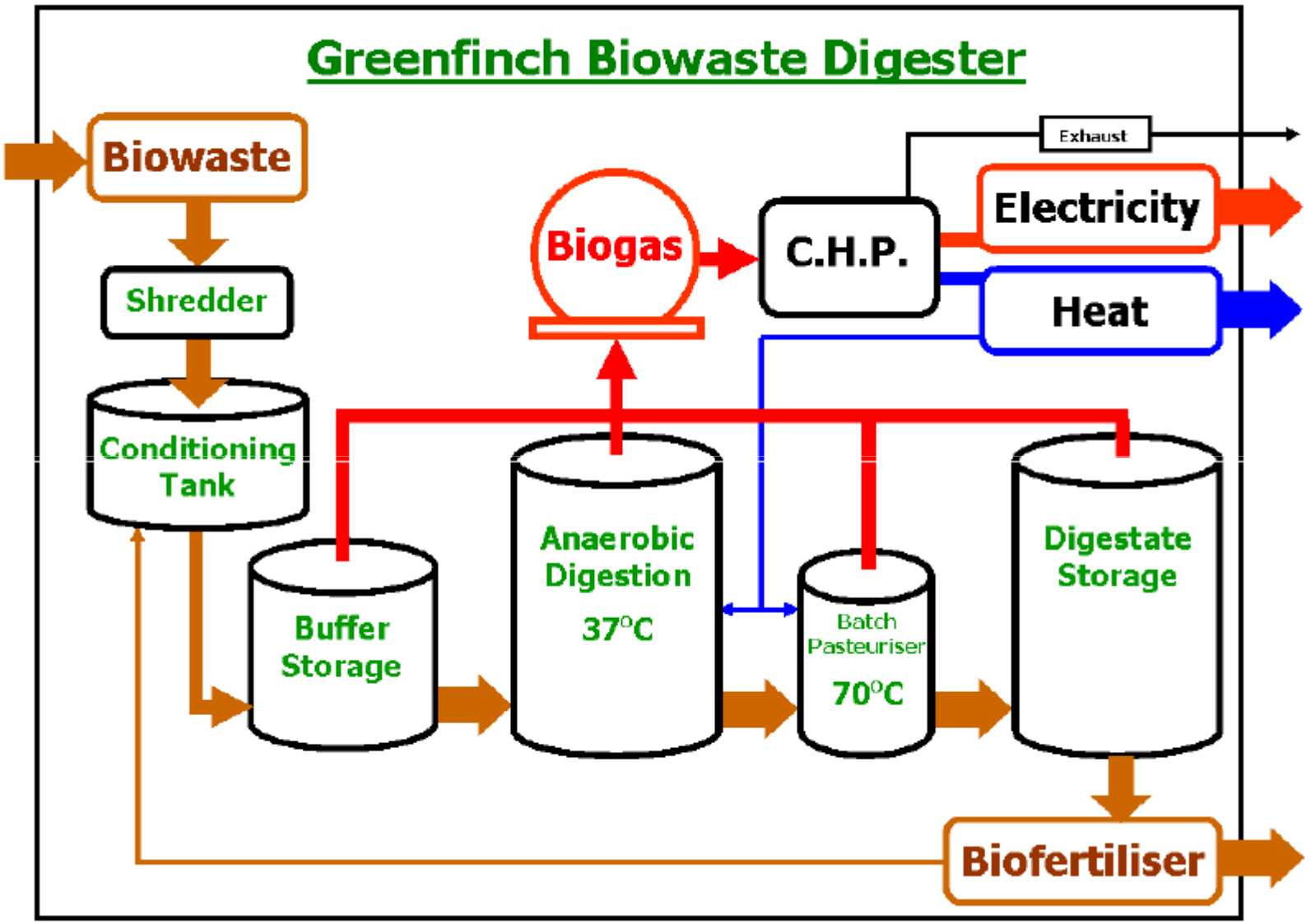
Courtesy of Michael Chesshire

Electric collection vehicle

Courtesy of Michael Chesshire

Ludlow biodigester under construction

Courtesy of Michael Chesshire


Greenfinch Biowaste Digester
Biowaste
Shredder
Conditioning Tank
Buffer Storage
Anaerobic Digestion
37°C
Biogas
C.H.P.
Exhaust
Electricity
Heat
Batch Pasteuriser
70°C
Digestate Storage
Biofertiliser

Food waste in reception hall

Courtesy of Michael Chesshire

Shredded food waste

Courtesy of Michael Chesshire

Ludlow food waste digester

Courtesy of Michael Chesshire

Liquid biofertiliser

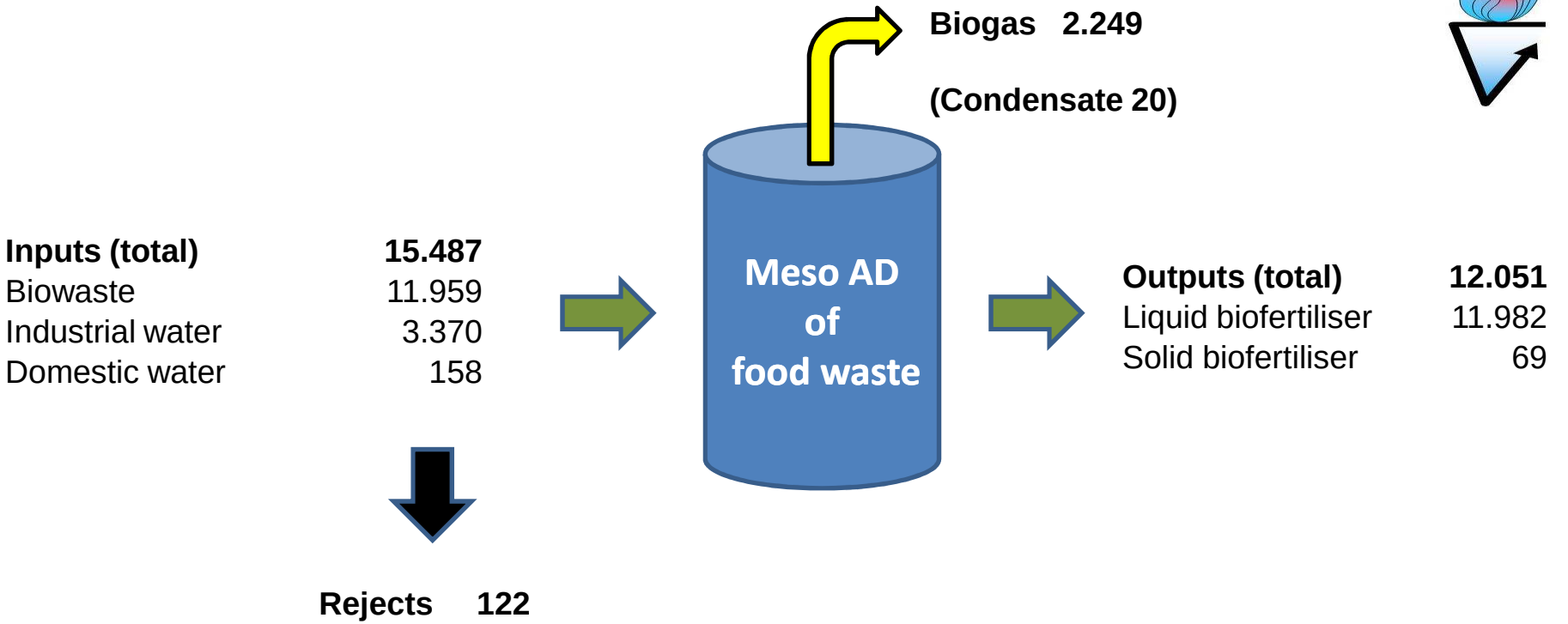
Courtesy of Michael Chesshire

Solid biofertiliser

Courtesy of Michael Chesshire

MASS BALANCE

Preliminary figures from Greenfinch (tonnes/year)



Inputs (total)	15.487
Biowaste	11.959
Industrial water	3.370
Domestic water	158

Outputs (total)	12.051
Liquid biofertiliser	11.982
Solid biofertiliser	69

Key figures

Specific biogas production **160** Nm^3/tonne or **0.65** Nm^3/kgVS

VS removal up to 84%

ENERGY BALANCE

The average yearly data for Biogen Greenfinch in Ludlow (UK) are

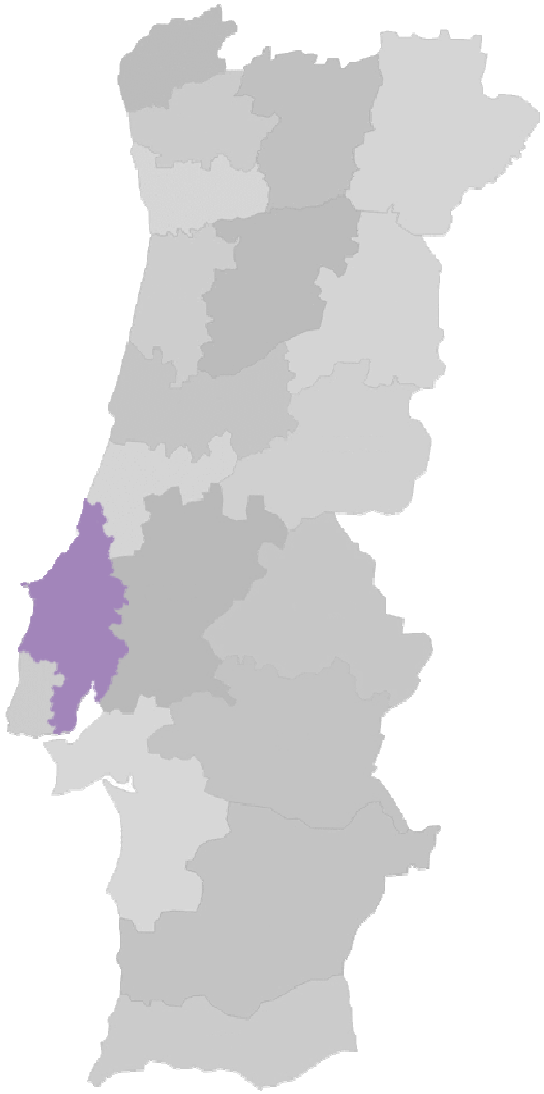
Electricity Generated	2.329	MWh	
Parasitic	782	MWh	*90% digester mix & CHP*
Imported Electricity	211	MWh	*10% fans and S/L separation*
Net Electricity Output	1.547	MWh	

Generated	194	kWh/tonne
Consumed	23	kWh/tonne
Energy Index (Gen/Cons)	**8,5**	

Valorsul treatment plant in Lisbon Metro area (P) - thermophilic treatment of households and restaurants food waste

Courtesy of Paolo Pavan


ESTAÇÃO DE TRATAMENTO
E VALORIZAÇÃO ORGÂNICA
O PRESENTE PROJECTO
CO-FINANCIADO PELA UNIÃO EUROPEIA,
CONTRIBUI PARA A REDUÇÃO DAS DISPARIDADES SOCIAIS
E ECONÓMICAS ENTRE OS CIDADAOS DA UNIÃO.
UNIÃO EUROPEIA
Fundo de Coesão



19 Municipalities

3378 km²

1,5 million inhabitants

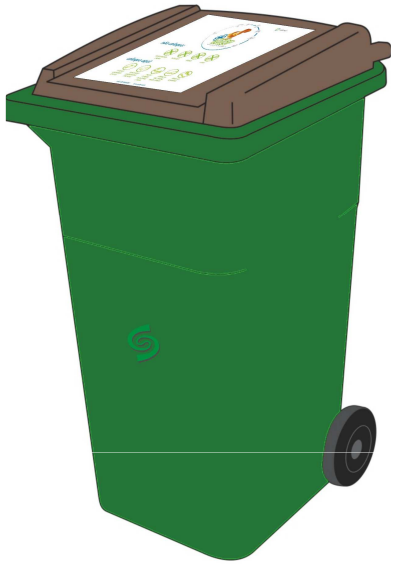
1 million tons of MSW per year

20% of Portugal MSW

Collection from large producers (restaurants, canteens, supermarkets ….)

Organic waste selective collection programme, exclusively for hotels, restaurants, canteens and other large producers

Incentives to participation



- Free periodic bio-waste container washes
- Free information support
- Free training from +valor agents
- +Valor network membership
- Programme Certification
- Technical support for complaints, information and requests (phone line and internet)

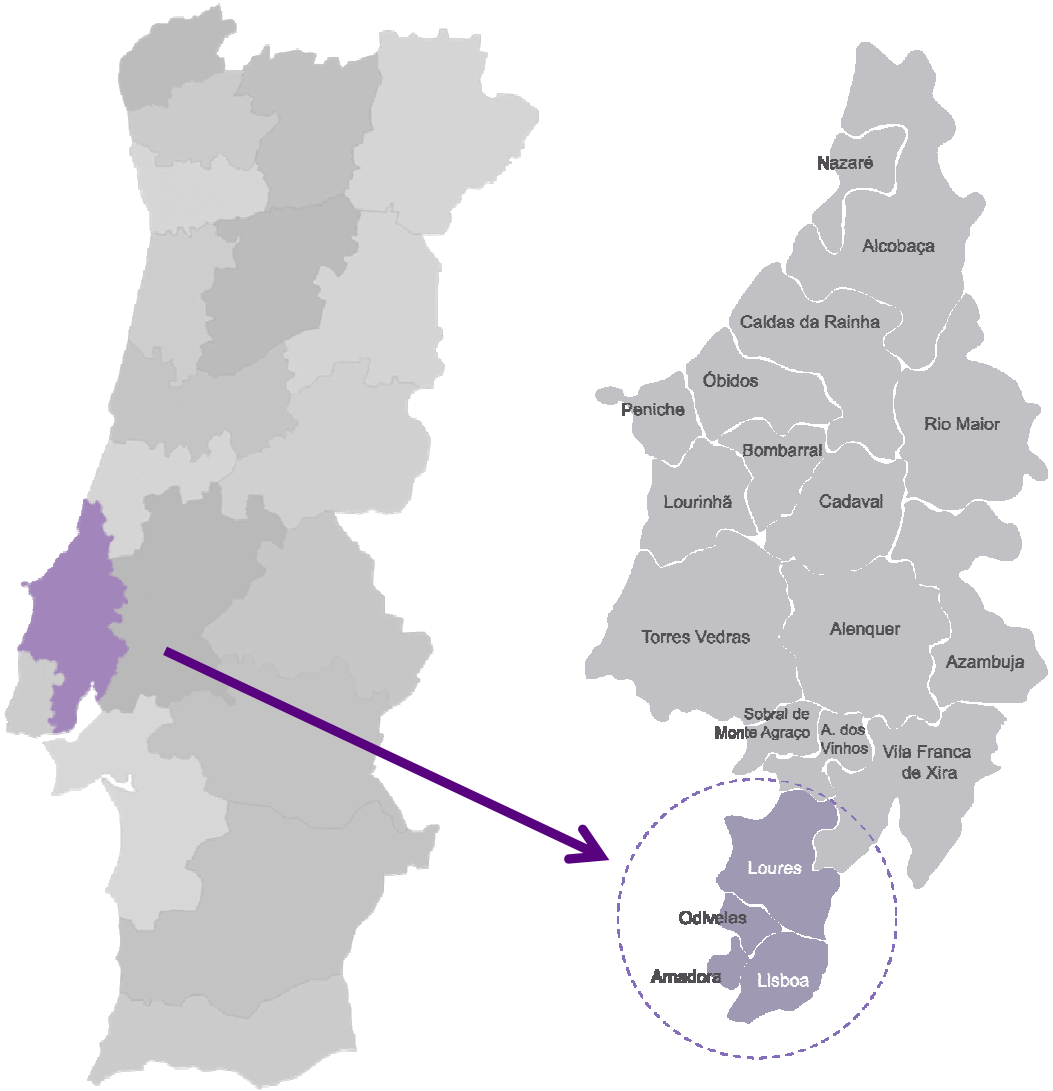
Obligatory

- Solid Waste
  - food waste
  - fruit
  - vegetables
  - meat
  - fish
  - eggs
  - cakes
  - snacks
  - tea bags
  - paper napkins

Forbidden

- Liquid waste
- Packages
- Glasses, cups, knifes, forks, spoons
- Plastic bags
- Cigarette ends
- Textiles

Source of OFMSW and type of collection



2547 collection points for large producers

- Lisbon 1229
- Amadora 149
- Loures / Odivelas 550

1988 household collection points in 3 locations in Loures added in 2010

[b] circuit: defined route a vehicle travels to collect from X waste organic producers

AD Plant


Composting
Digesters and
gas holder
Reception and
pre-treatment
Water treatmen

AD Plant


Composting
Digesters and
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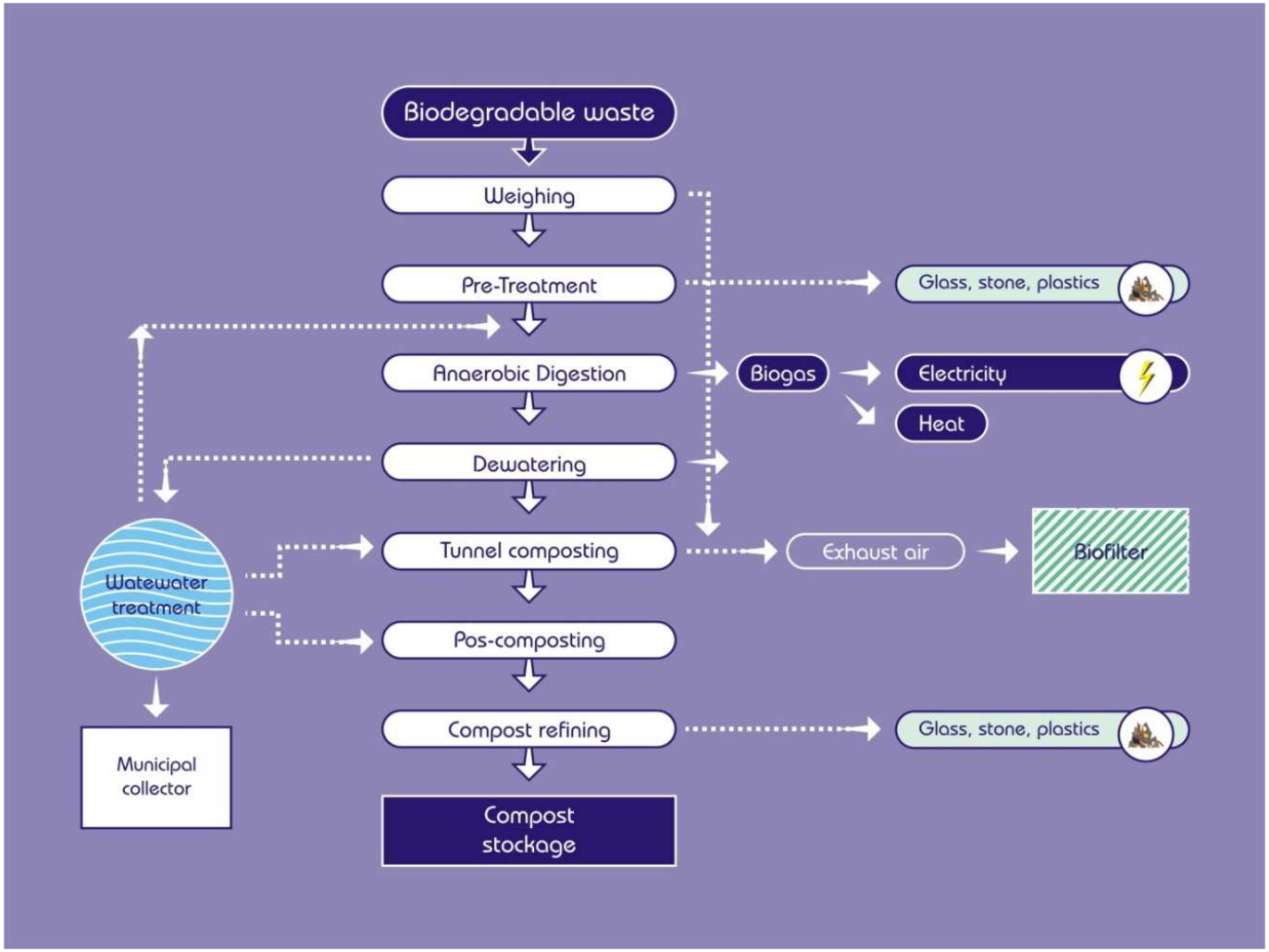

Biodegradable waste
Weighing
Pre-Treatment
Glass, stone, plastics
Anaerobic Digestion
Biogas
Electricity
Heat
Dewatering
Tunnel composting
Exhaust air
Biofilter
Watewater treatment
Pos-composting
Compost refining
Glass, stone, plastics
Municipal collector
Compost stockage

Collected bags from restaurants and canteens

Courtesy of Paolo Pavan

Up to 18% contaminants in large producers waste….

Courtesy of Paolo Pavan

“Inert” output of the trommel screen

Courtesy of Paolo Pavan

Manual sorting

Courtesy of Paolo Pavan

Wet rafination for heavy (glass, stones…) and light (plastic) inerts by means of a hydro-pulper

Hydro-pulper (Linde)

Courtesy of Paolo Pavan

Hydropulper (internal view)

From BTA website

Inert material from the pulper (bottom) ….

Courtesy of Paolo Pavan

“Compost” (or compost-like ?) from digestate

Courtesy of Paolo Pavan

Compost from digestate

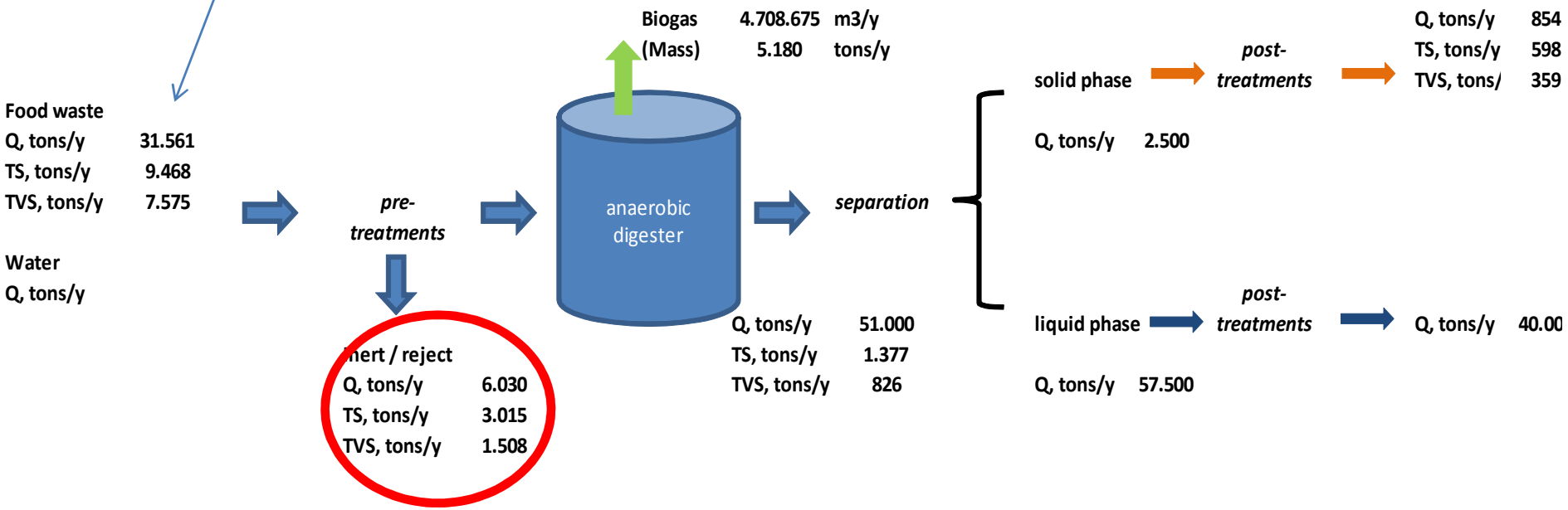
Courtesy of Paolo Pavan

Compost from digestate (after polishing)

Courtesy of Paolo Pavan

Preliminary figures from Valorsul (tonnes/year)

21,000 tons/y from households
10,000 tons/y from large producers



Key figures

Specific biogas production **149** Nm^3/tonne or **0.62** Nm^3/kgVS

Removal efficiency 80% (on VS)

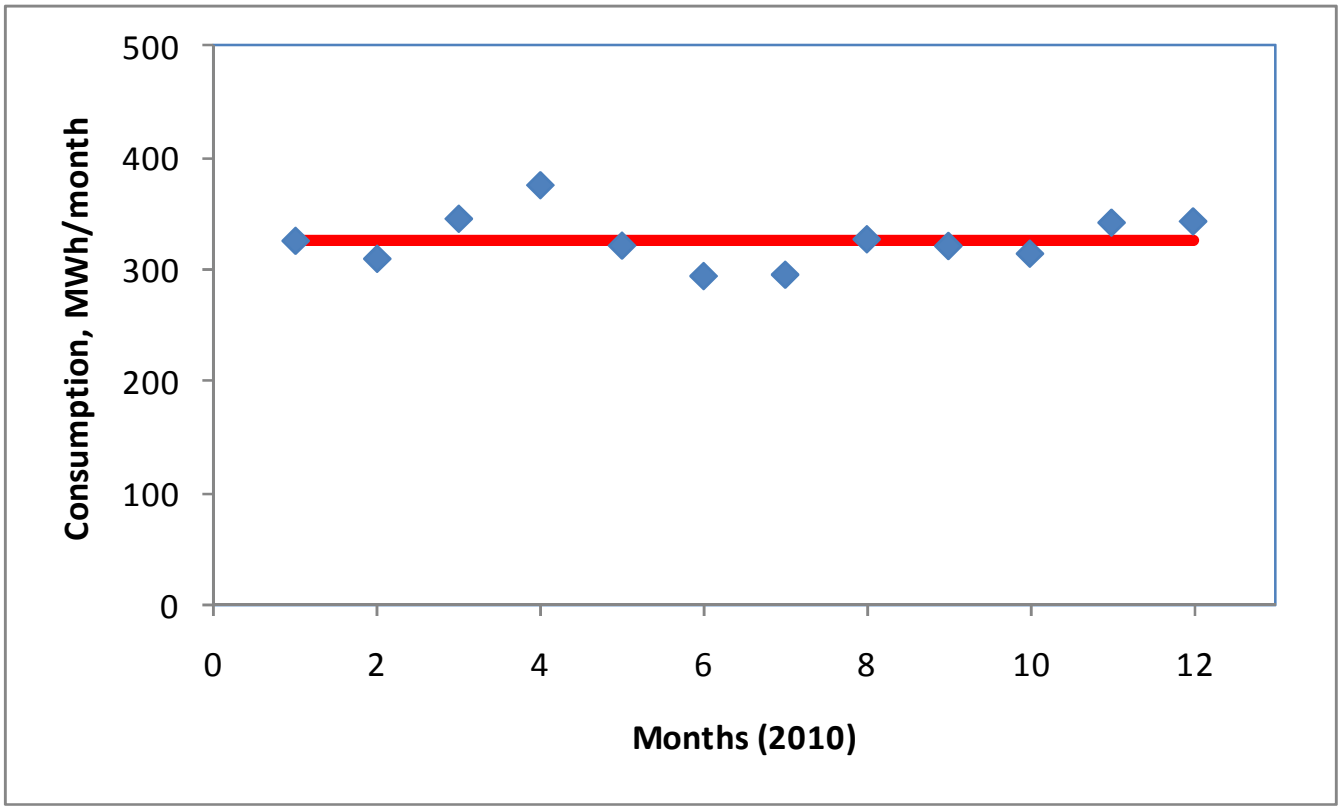
ENERGY BALANCES

The average yearly data for Valorsul in Lisbon (P) are

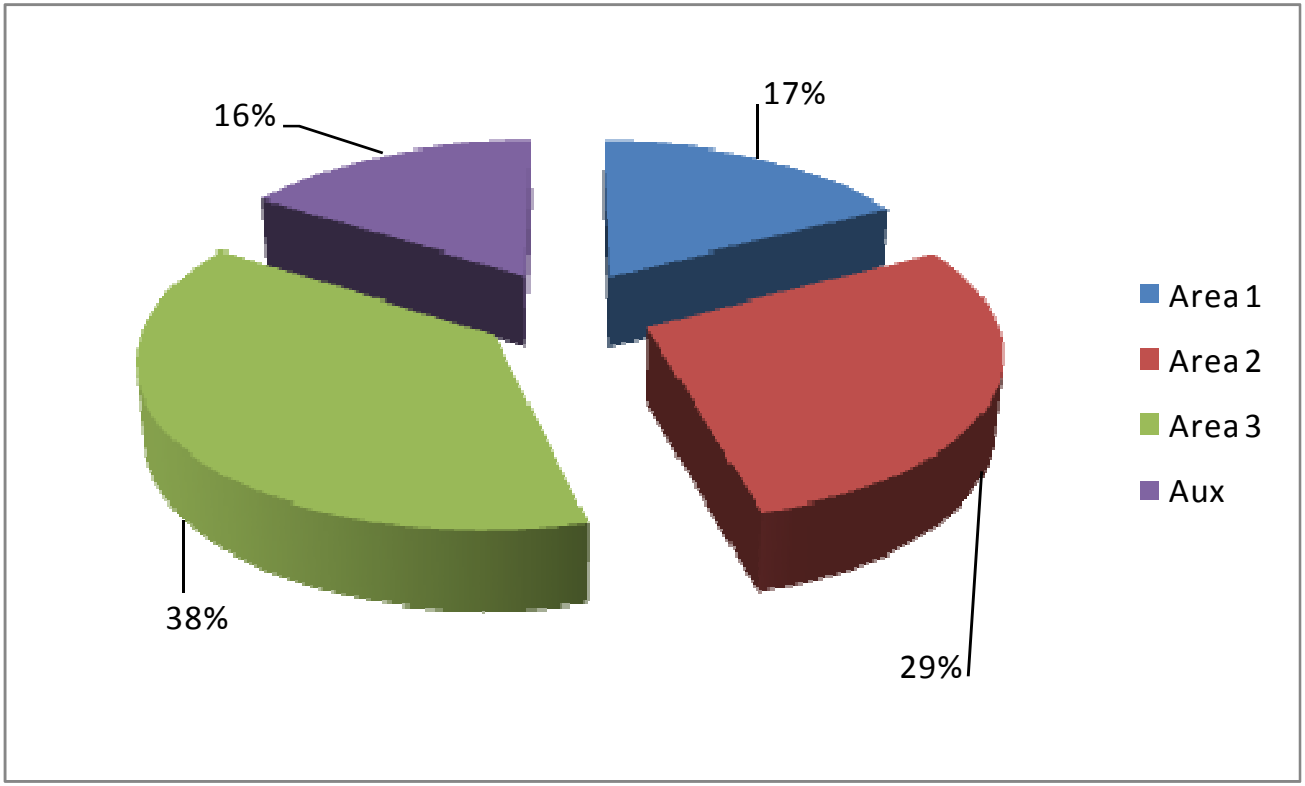
Generated (specific)	160 kWh/tonne
Consumed (specific)	110 kWh/tonne
Energy Index	**1.5**

ENERGY BALANCES

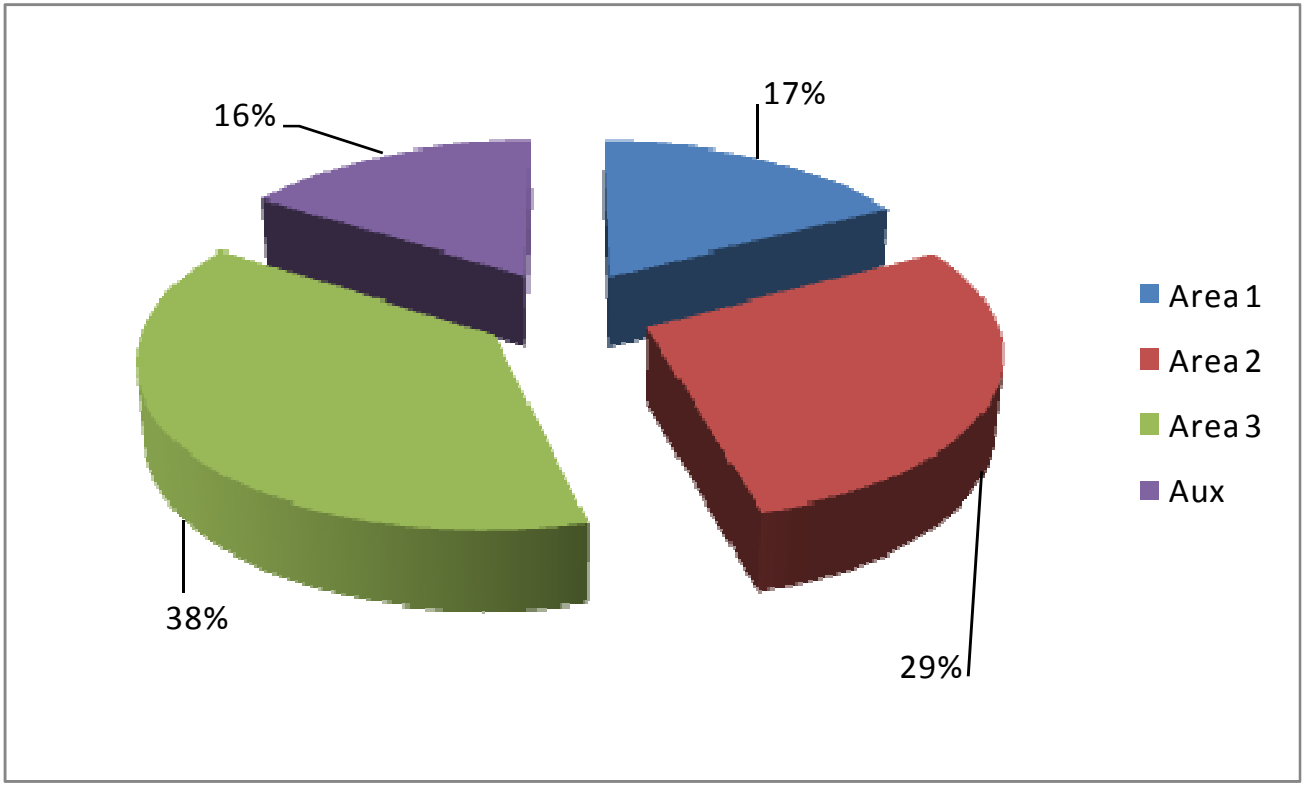
The average consumption at Valorsul in 2010 was some 326 MWh per month for the treatment of some 2,500 tonnes of biowaste per month.



Consumptions are related to different areas of the plant and a real break down of the figure is difficult.



Consumptions are related to different areas of the plant and a real break down o
the figure is difficult.
In general, considering average data:
Area 1 (related to biowaste pre-treatments) accounted for some 56 MWh/month



Consumptions are related to different areas of the plant and a real break down o
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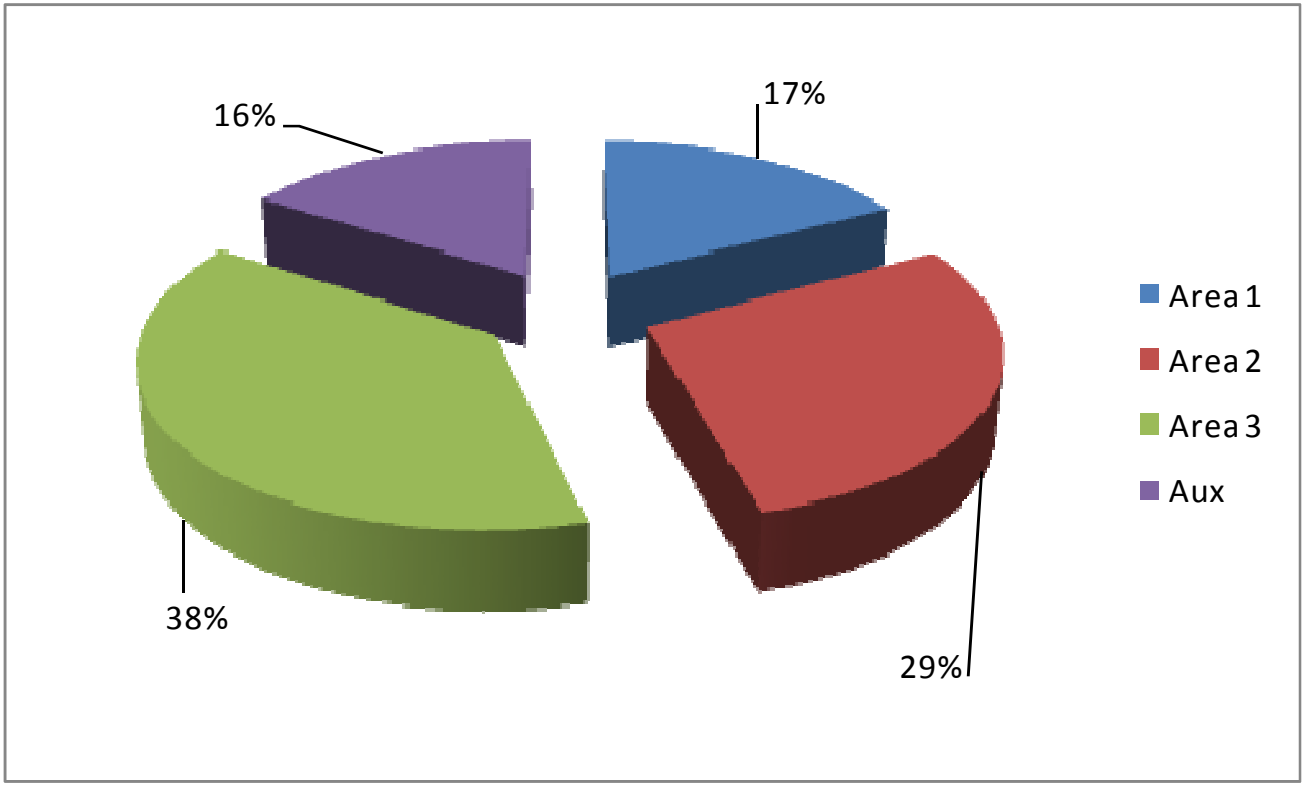
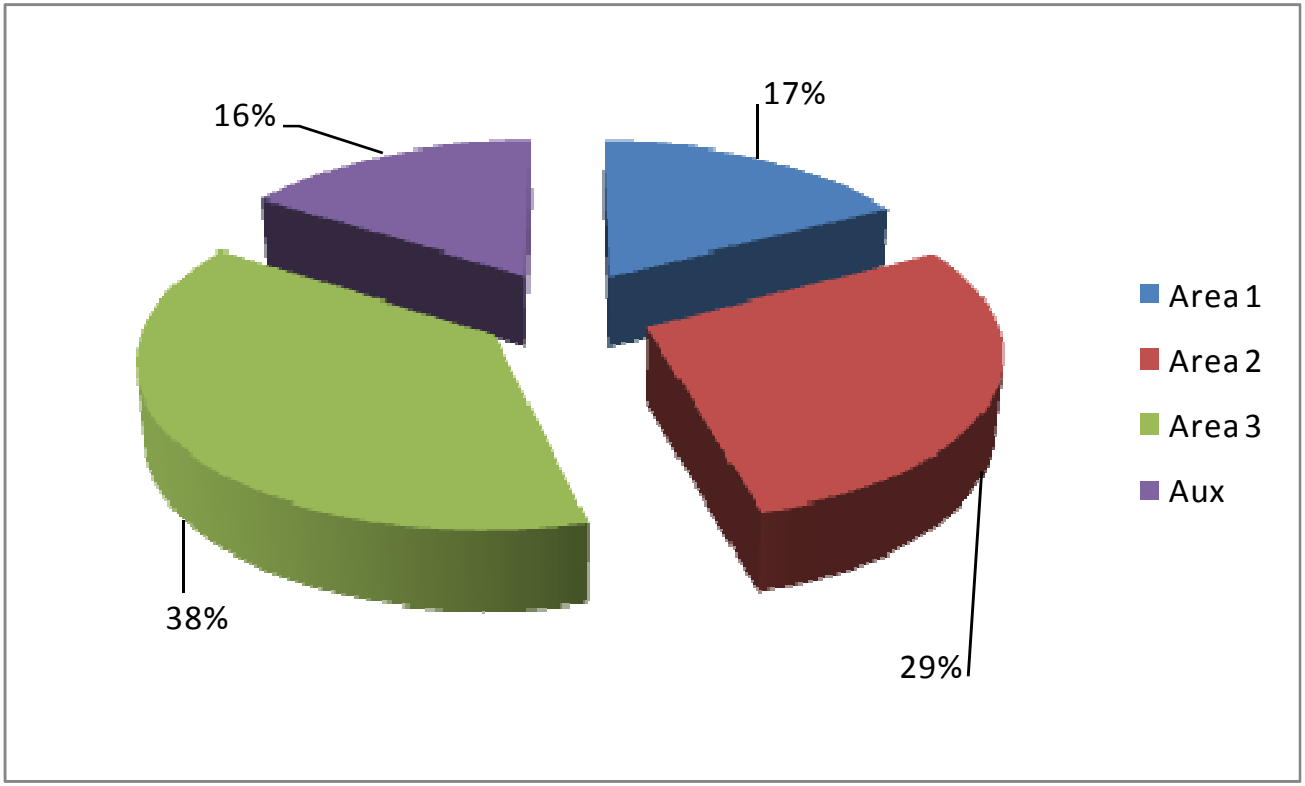
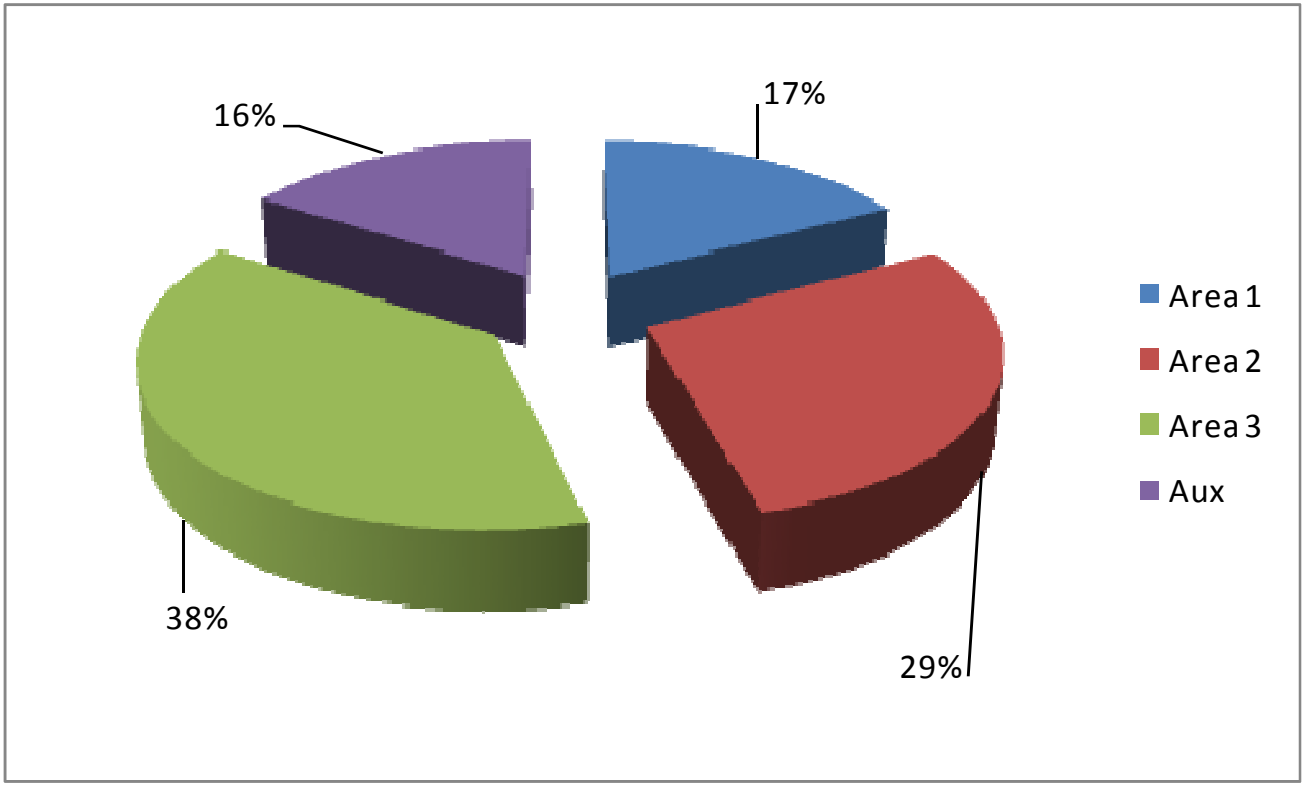
In general, considering average data:
Area 2 (related to the digester and the CHP unit) accounted for 94 MWh/month



Consumptions are related to different areas of the plant and a real break down o
the figure is difficult.
In general, considering average data
Area 3 (related to S/L separation, composting+exhaust air treatment, and WWTP)
accounted for some 125 MWh/month



Consumptions are related to different areas of the plant and a real break down of the figure is difficult.
In general, considering average data
Auxiliary consumptions accounted for some 52 MWh/month.



Take home message

The food waste quality does matter !!!