biogas
wind
photovoltaics
biomass
cogeneration

Asja Group | Biogas from wastes & by-products

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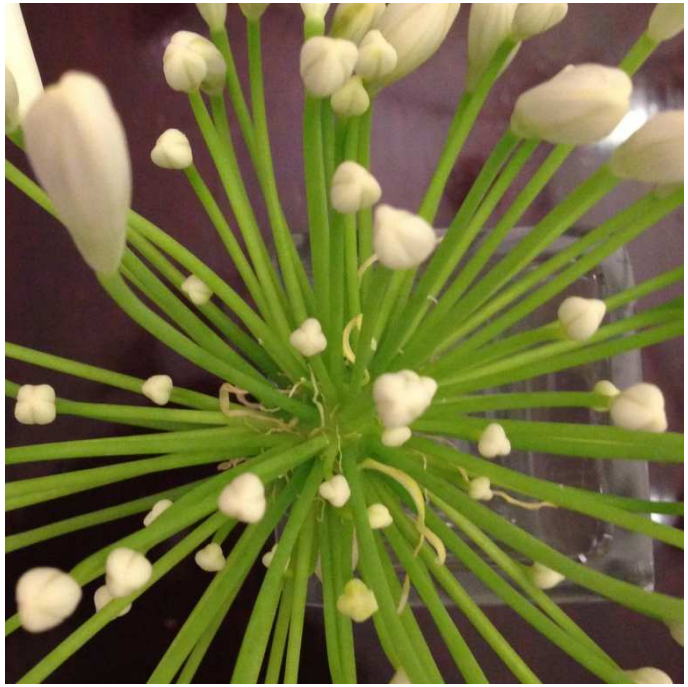


- **Biogas:** basic concepts
- **Anaerobic digestion:** basic concepts
- **How to produce biogas:** energy from wastes & by-product
- **How to use biogas:** cogeneration & upgrading
- **Types of anaerobic digestion plants**
- **Two cases of anaerobic digestion plant**

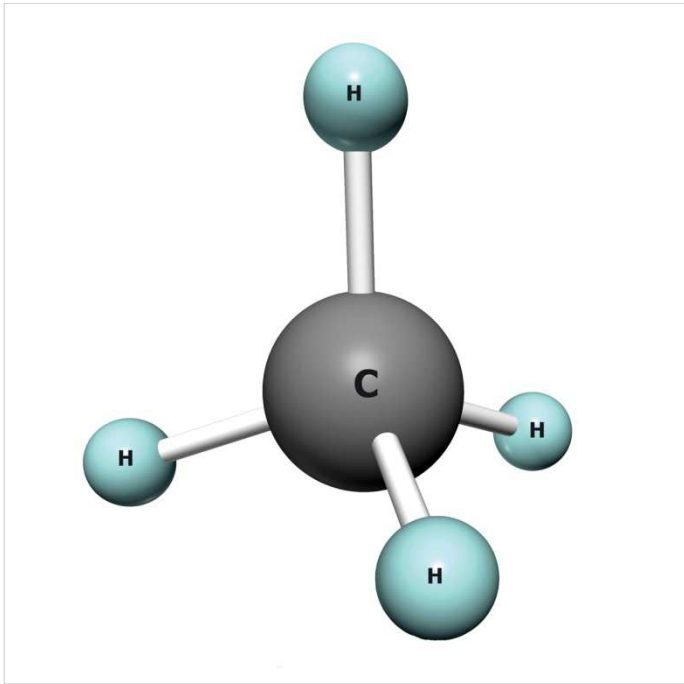
BIOGAS

BASIC CONCEPTS (I/II)

- Biogas is a **fuel gas** consisting of methane, carbon dioxide and small amounts of other gases and trace elements
- Biogas is produced by a **microbiological process** of decomposition of organic matter
- The process occurs in the **absence of oxygen** (O_2)
- The process is carried out by a wide range of **micro-organisms**
- The process occurs normally in many **natural environments** like forest litters and landfills
- It can be carried out under **controlled conditions** in airproof reactor tanks commonly named digesters

BIOGAS

BASIC CONCEPTS (II/II)



Chemical Components	Unit	Content	Usual value
Methane (CH_4)	%vol	50-80	60
Carbon dioxide(CO_2)	%vol	25-45	40
Oxygen (O_2)	%vol	0-1	<0.1
Nitrogen (N_2)	%vol	0-3	<0.3
Hydrogen (H_2)	ppm	0-3,000	<1,000
Water vapour (H_2O)	-	saturation	saturation
Ammonia (NH_3)	%vol	0-1	<0.1
Hydrogen disulfide (H_2S)	ppm	0-9,000	<300
Trace compounds	ppm	0-100	<10

ANAEROBIC DIGESTION
BASIC CONCEPTS (I/II)

ORGANIC SUBSTANCE
[VOS, TS, COD, TOC]

BIOGAS
[50-80%CH_4, 25-45%CO_2 and trace gases]

electric & thermal energy

biomethane

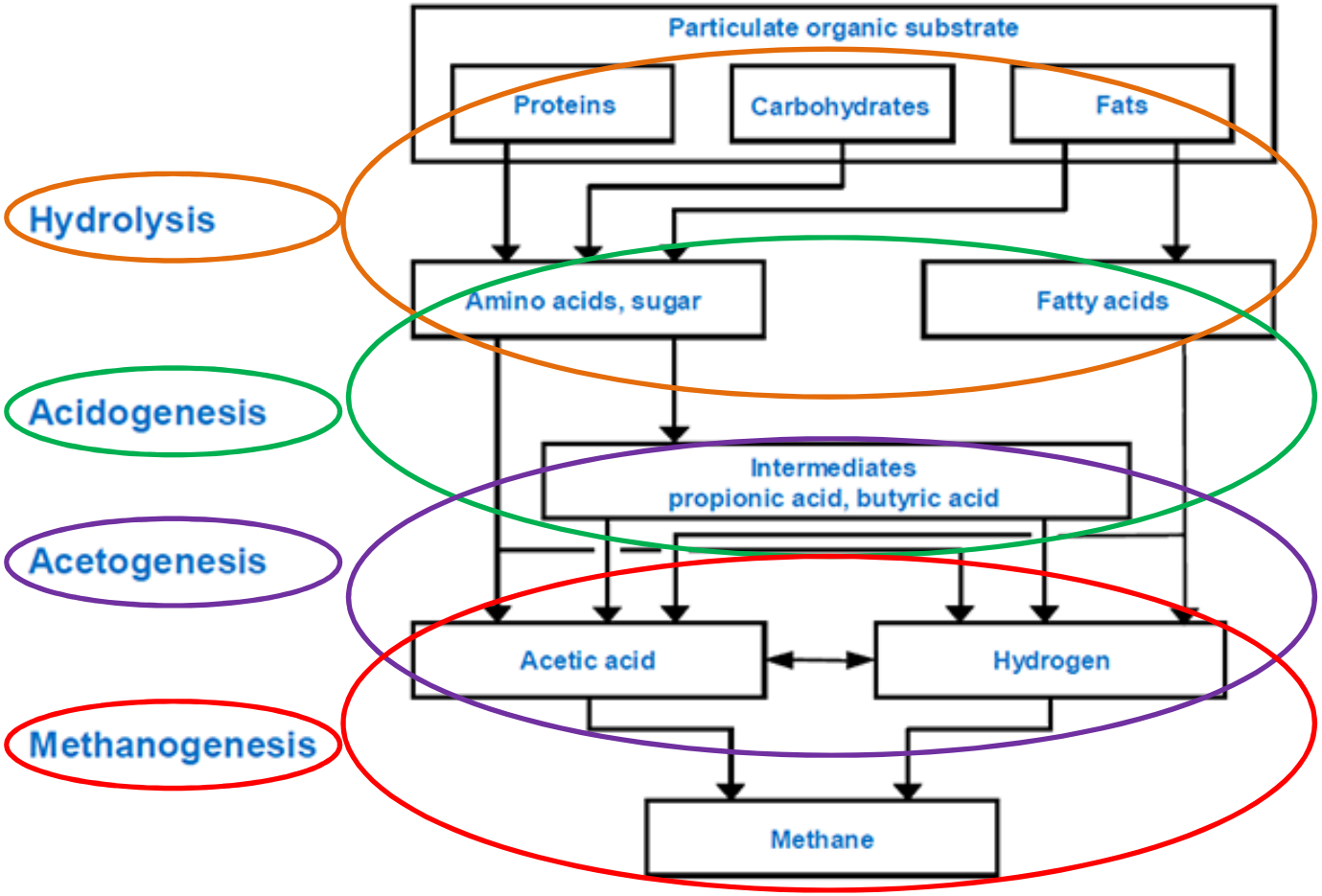
Anaerobic Digestion (AD) is a complex biological process in which different groups of microorganisms' work together and in sequence to break down biodegradable organic matter and produce CH_4, CO_2 as microbial by-products.

AD requires strict anaerobic conditions and evolve through 4 microbiological steps:

- **Hydrolysis**
- **Acidogenesis**
- **Acetogenesis**
- **Methanogenesis**

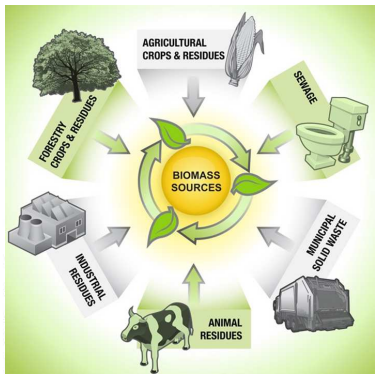
ANAEROBIC DIGESTION

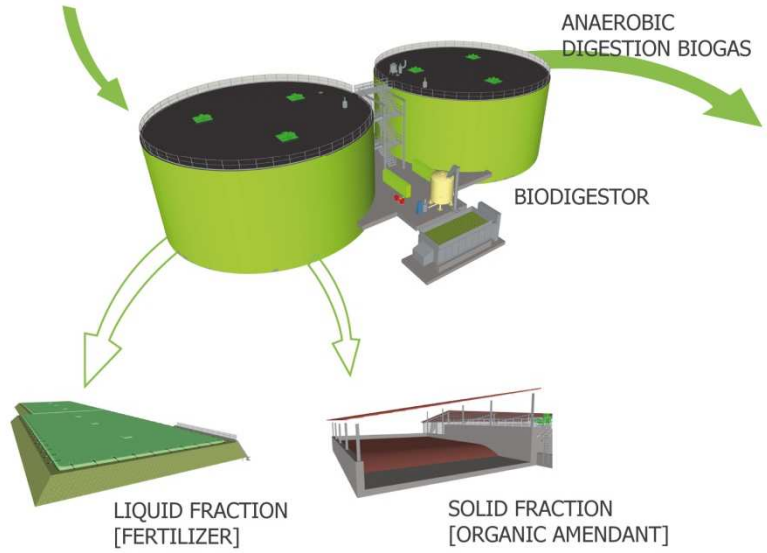
BASIC CONCEPTS (II/II)

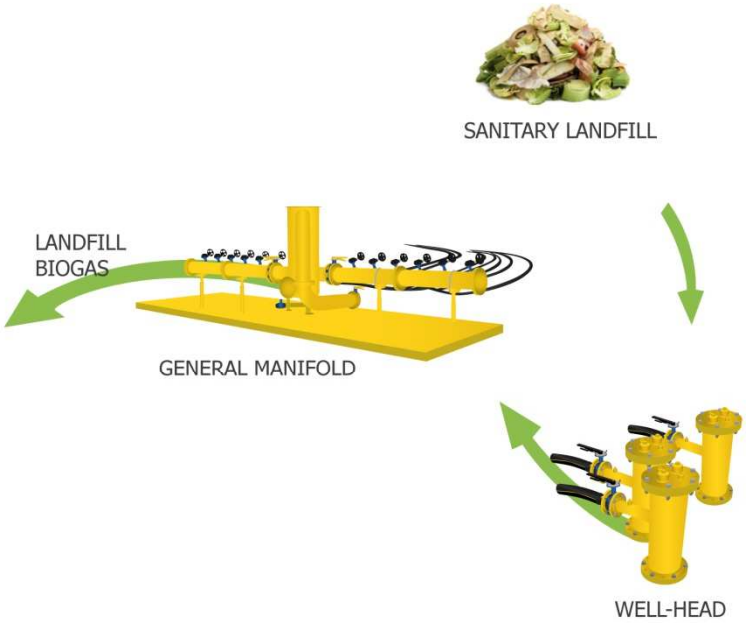


HOW TO PRODUCE BIOGAS

ENERGY FROM WASTES & BY-PRODUCT (I/II)

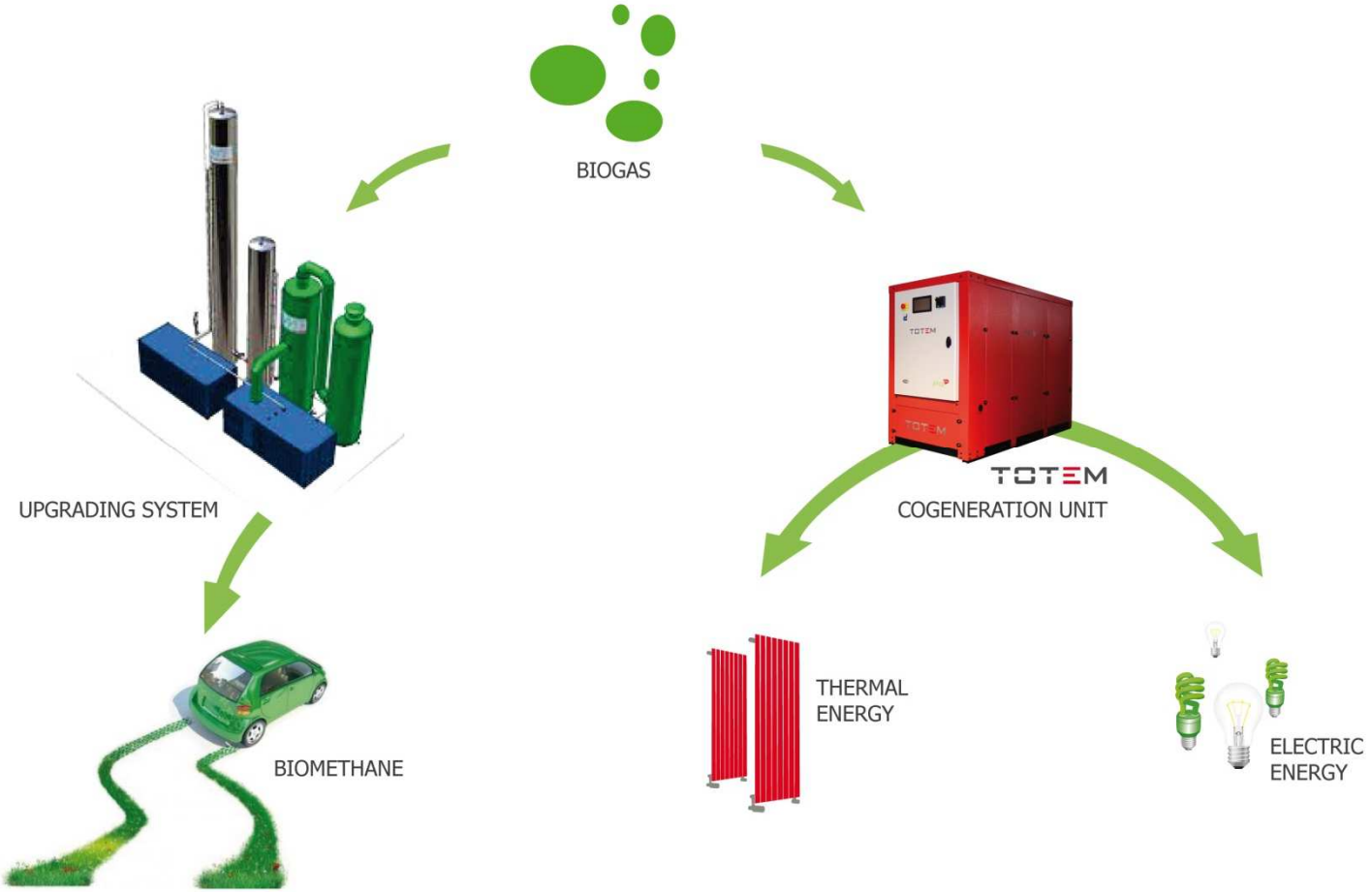






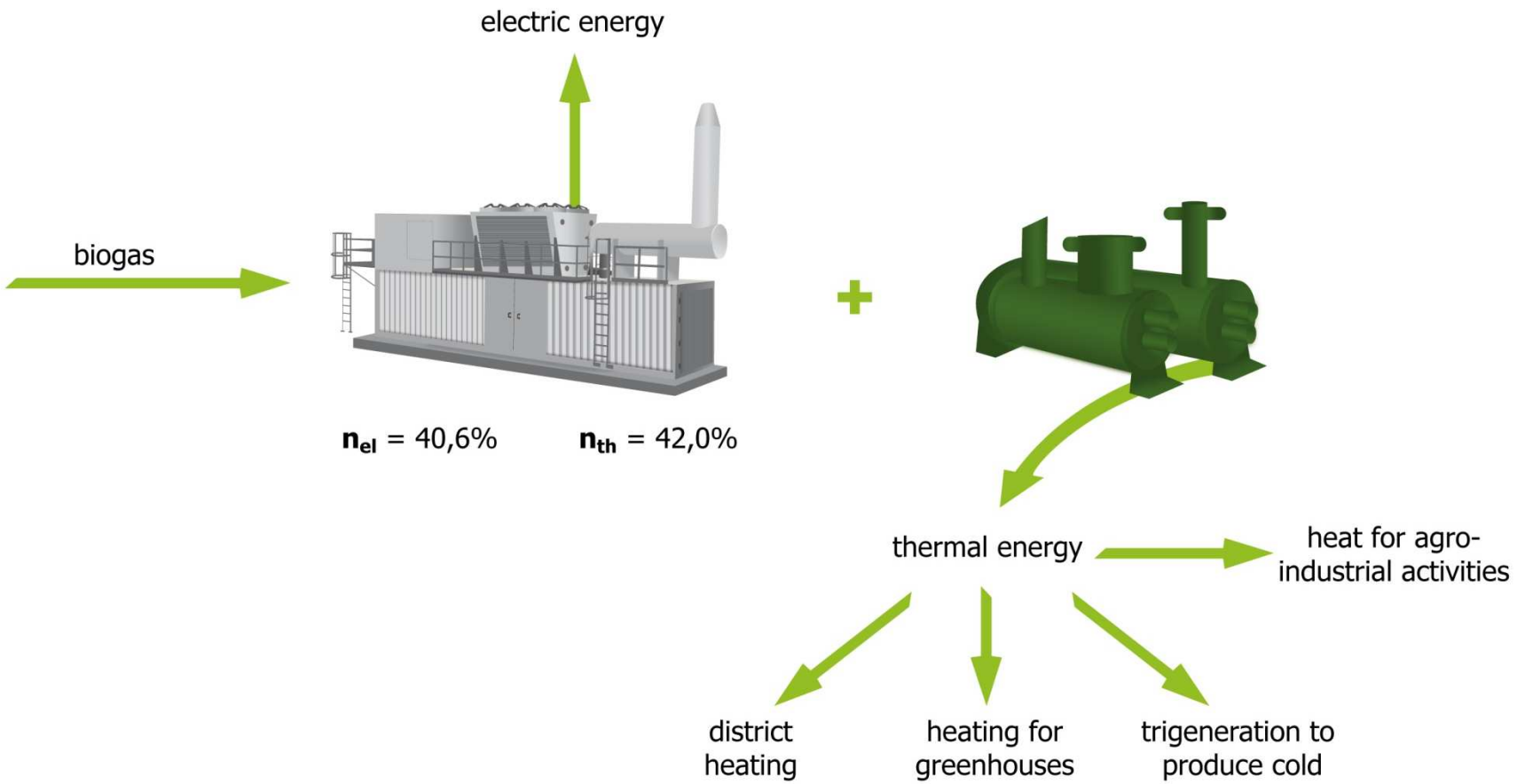
HOW TO USE BIOGAS

ENERGY FROM WASTES & BY-PRODUCT



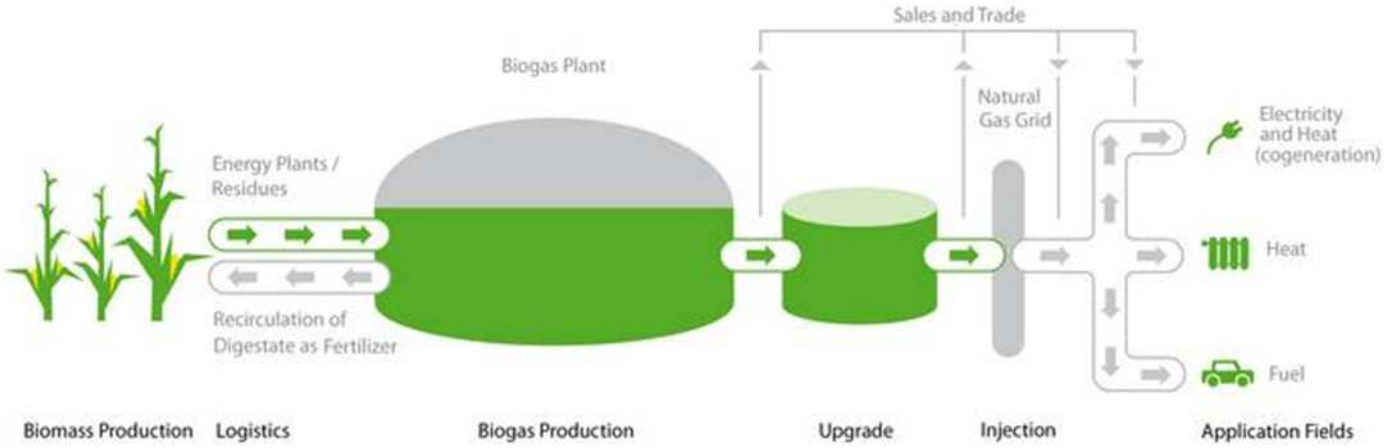
COGENERATION (CHP)

ENERGY FROM WASTES & BY-PRODUCT



BIOGAS UPGRADING

ENERGY FROM WASTES & BY-PRODUCT (I/III)



BIOGAS UPGRADING

ENERGY FROM WASTES & BY-PRODUCT (II/III)

BIOGAS

CH_4=50-80%
CO_2=25-45%
N_2 + O_2 < 1%
H_2S =50–5.000 ppm
H_2O = saturated

PURIFICATION & UPGRADING

BIOMETHANE

CH_4=97-98%
CO_2=1-2%
O_2 < 0,4%
H_2S < 1 ppm
H_2O < 1 ppm

Biogas Upgrading to high energy biomethane is a technology based on the separation of CH_4 from CO_2 and trace elements.

The final products are:

- **Biomethane:** substitute natural gas used for grid injection and/or as vehicle fuel
- **Offgas:** CO_2 enriched gas that can be employed for industrial purposes

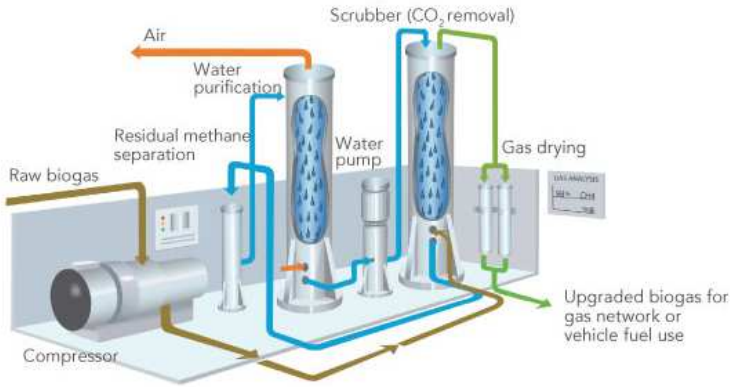
Technologies are built on unit operations based on principles of

- **absorption (PWS, PSA)**
- **permeation (membrane separation)**
- **criogenic separation**

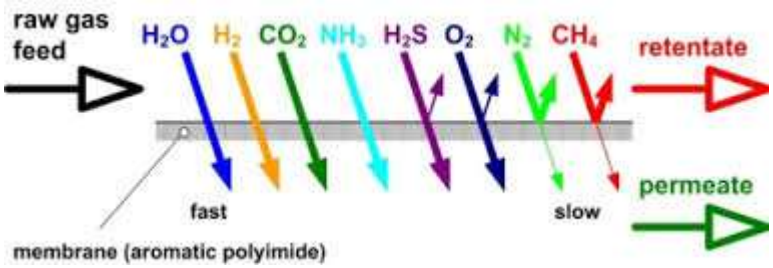
BIOGAS UPGRADING

ENERGY FROM WASTES & BY-PRODUCT (III/III)

Water scrubbing /Solvent scrubbing



Membrane separation



ORGANIC MATERIALS FOR BIOGAS PRODUCTION






- Organic fraction of municipal solid wastes
- Straw
- Tomato skins
- Potato & beet wastes
- Whey milk
- Grape marks & lees
- Olive pomace & olive mill waste waters
- Livestock manures (bovine, ovine, poultry farms)
- Coffee wastes (coffee ground, coffee out of specification)
- Bakery & cereal wastes
- Corn
- Sorghum
- Triticale (a hybrid between rye and wheat)

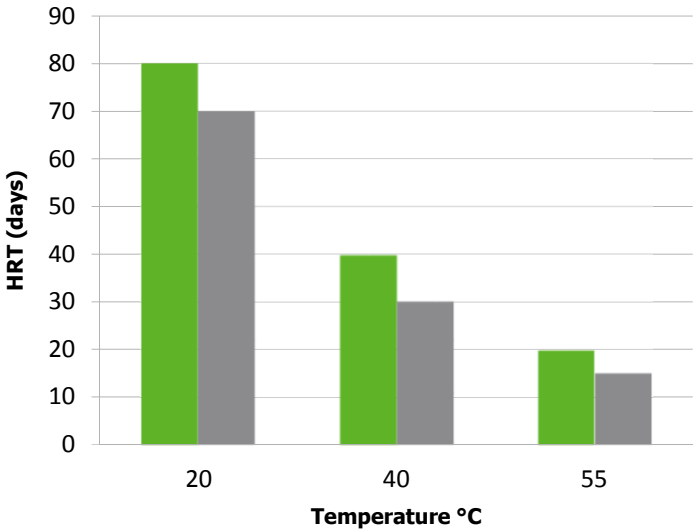
BIOGAS POTENTIAL OF DIFFERENT SUBSTRATES

Biomass	Methane yeld [%]	Biogas yeld [m^3/t fw]
Organic fraction of MSW	60	130 - 180
Liquid Cattle manure	60	25
Liquid Pig manure	65	28
Distilled grains	61	40
Poultry manure	60	45
Cattle manure	60	60
Pig manure	60	80
Beet	53	88
Sweet sorghum	54	108
Forage beet	51	111
Grass silage	54	172
Corn silage	52	202

TYPE OF ANAEROBIC DIGESTION PLANT

Parameter	Application
Temperature	Psychrophilic
	Mesophilic
	Thermophilic
Total solid content	Wet
	Semi dry
	Dry
Configuration	Single-stage (phase)
	Two-stages (phases)

TEMPERATURE



- Psychrophilic digestion below 25°C
- Mesophilic digestion 25°C - 45°C
- Thermophilic digestion 45°C - 70°C

TOTAL SOLIDS

- Wet digestion TS<10%
- Semi dry digestion TS=10% - 25%
- Dry digestion TS=25% - 40%

CONFIGURATION

- Single-stage digestion system consists of only one tank or reactor. All the 4 anaerobic digestion microbiological steps occur in the same reactor.
- Two-stage digestion system consist of at least two separate tanks or reactors. In this case Hydrolysis occurs in a separate reactor with respect to acidogenesys, acetogenesys and methanogenesys.

WET ANAEROBIC DIGESTION

AGRICULTURAL AND AGROINDUSTRIAL RESIDUES

WET ANAEROBIC DIGESTION

- Biomasses characterized by a total solid content lower than 10%
- Codigestion with liquid biomasses (total solids <3-4%)
- Continuous and automatic feeding system
- Continuous stirring thank reactor (CSTR)
- Mesophylic anaerobic digestion (35 - 45 °C)
- Biogas storage into gasometric cup
- Integrated biogas sulphur removal
- Continuous monitoring of process parameters
- Direct use of digestate as a soil liquid or solid fertilizer

DRY ANAEROBIC DIGESTION

ORGANIC FRACTION OF MUNICIPAL SOLID WASTES

DRY ANAEROBIC DIGESTION

- Biomasses characterized by high total solid content (30-40%)
- Continuous or batch feeding system
- Plug and flow reactor or batch reactor
- Thermophilic anaerobic digestion (55 °C)
- Continuous monitoring of process parameters
- Integrated or external biogas sulphur removal
- Digestate need to be treated before land application

APPLICATIONS

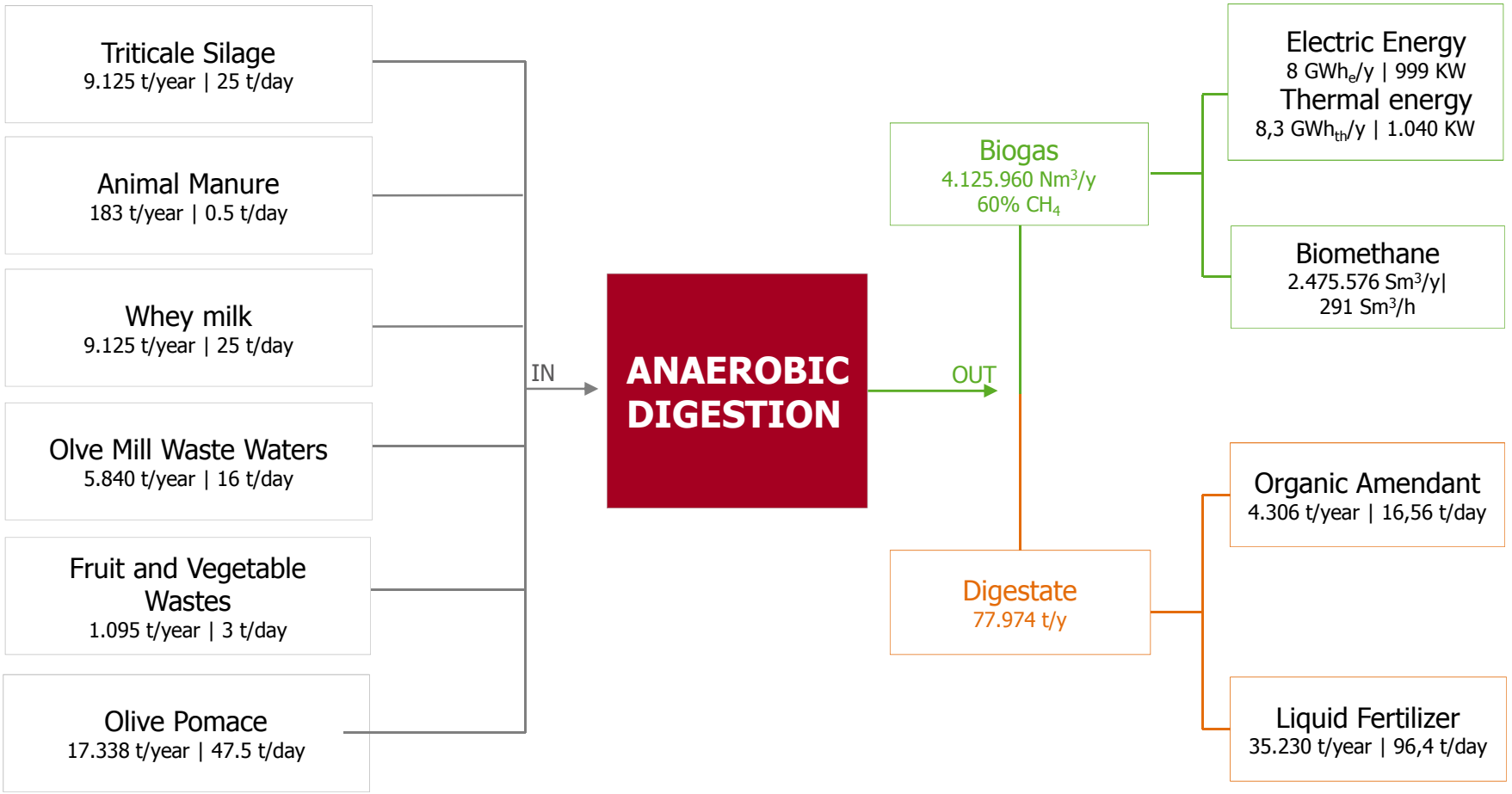
TWO CASES OF ANAEROBIC DIGESTION PLANT

biogas plant from Organic Fraction Municipal Solid Waste (OFMSW)

biogas plant from agricultural products agro-industrial by-products

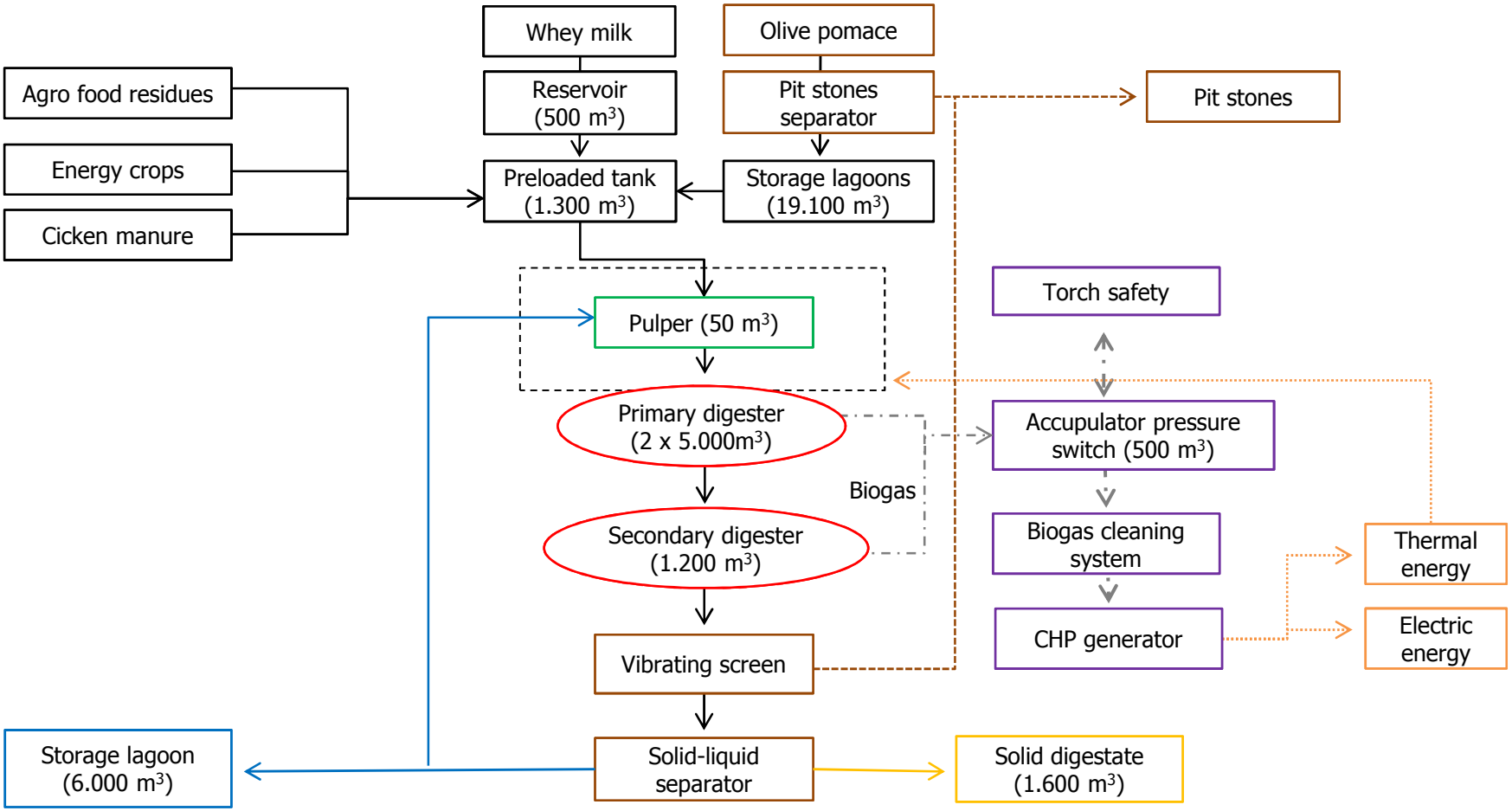
AGRO-INDUSTRIAL BY-PRODUCTS BIOGAS PLANT

MASS BALANCE



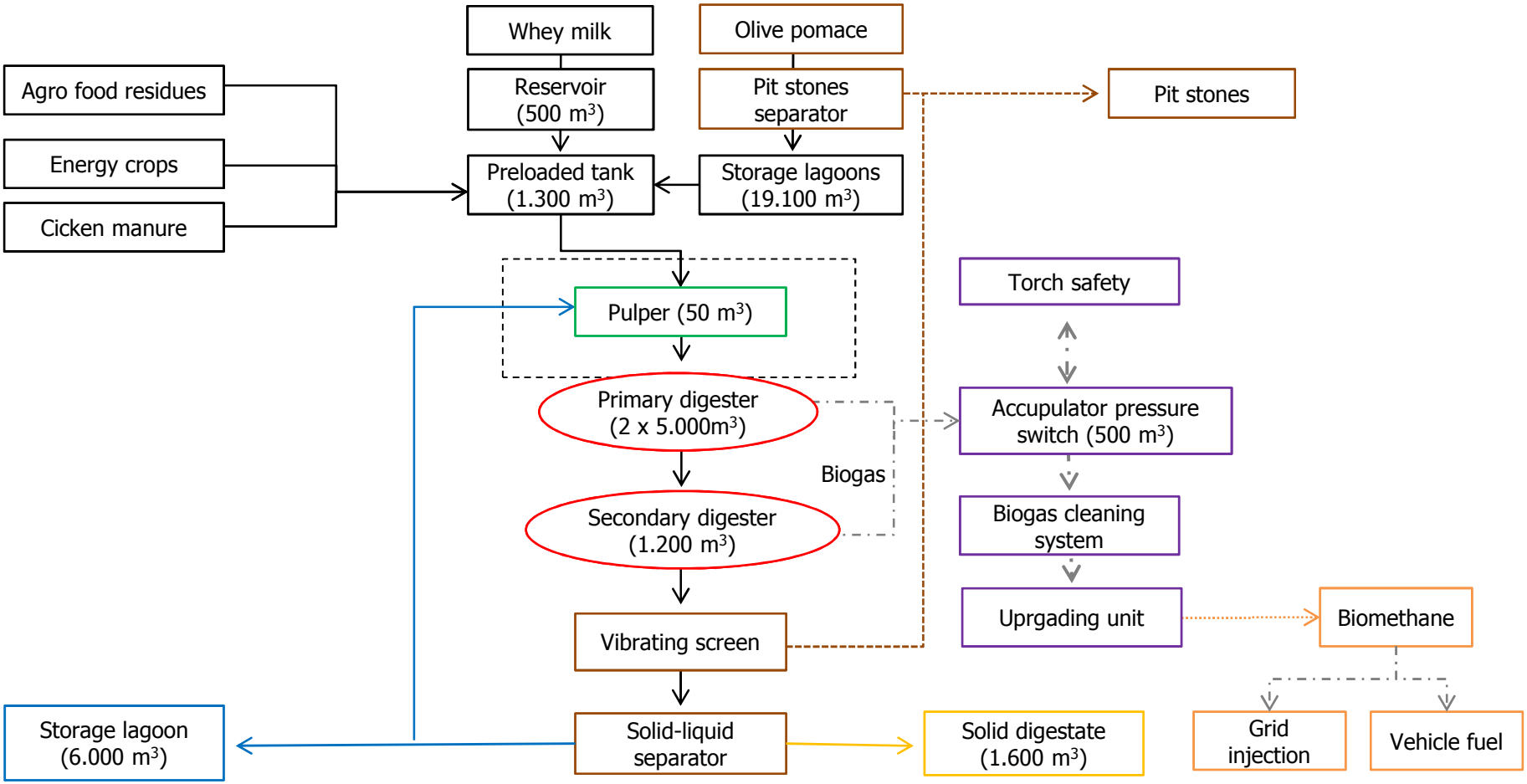
AGRO-INDUSTRIAL BY-PRODUCTS BIOGAS PLANT

POWER 999 kW | P&I



AGRO-INDUSTRIAL BY-PRODUCTS BIOGAS PLANT

Biomethane production| P&I



AGRO-INDUSTRIAL BY-PRODUCTS BIOGAS PLANT

OPERATIONAL PARAMETERS

- Organic loading rate (OLR) = 3 KgSV/$m^3_{reactor}$ d
- Hydraulic retention time (HRT) = 40 days
- Operational temperature (T) = 40 °C
- Total solids (TS) = 11% fresh weight
- Specific gas production (SGP) = 96 Nm^3/t F.W.

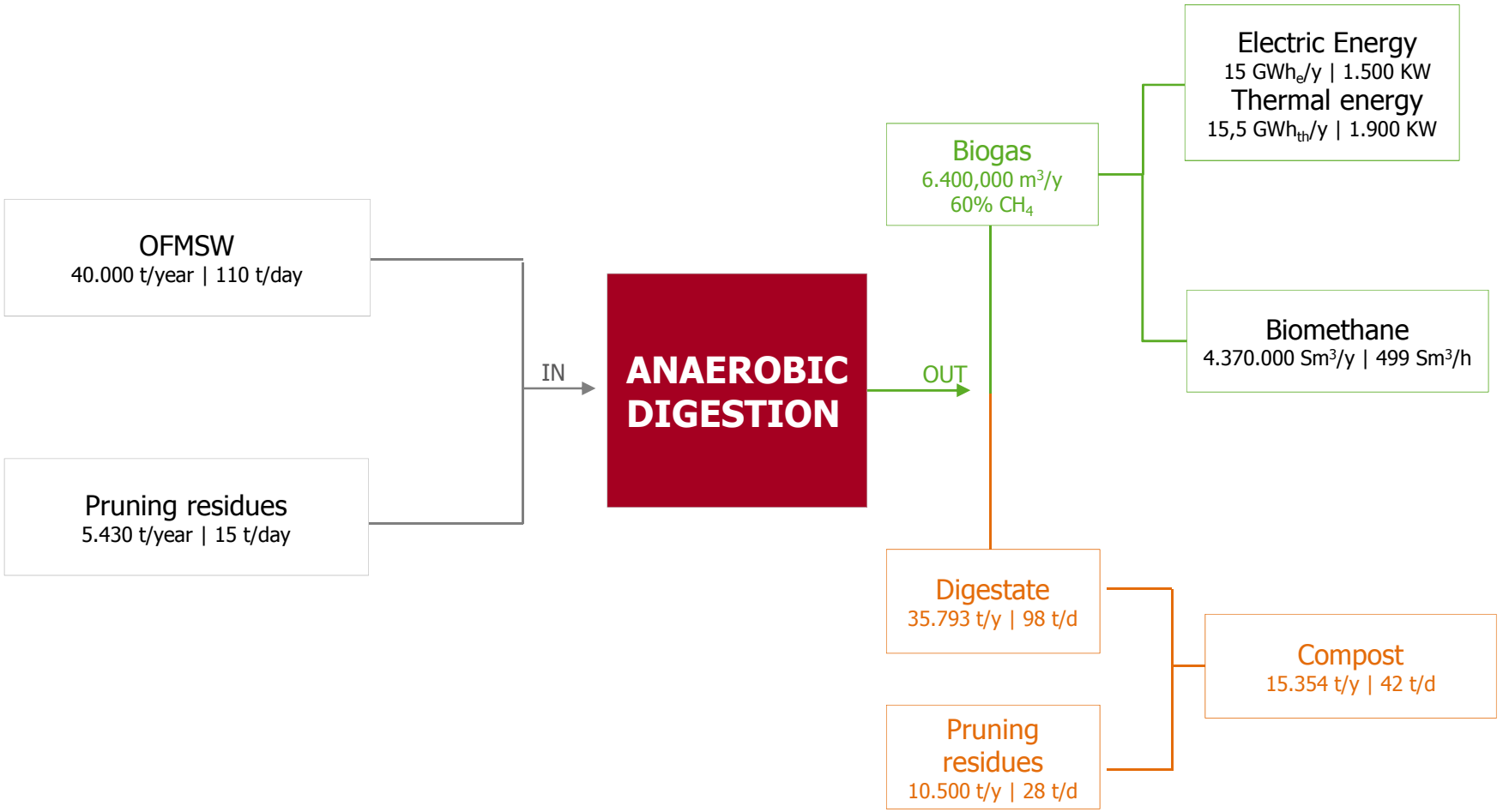
WET AGRO-INDUSTRIAL BY-PRODUCTS BIOGAS PLANT

LAYOUT

WET OFMSW BIOGAS PLANT
LAYOUT

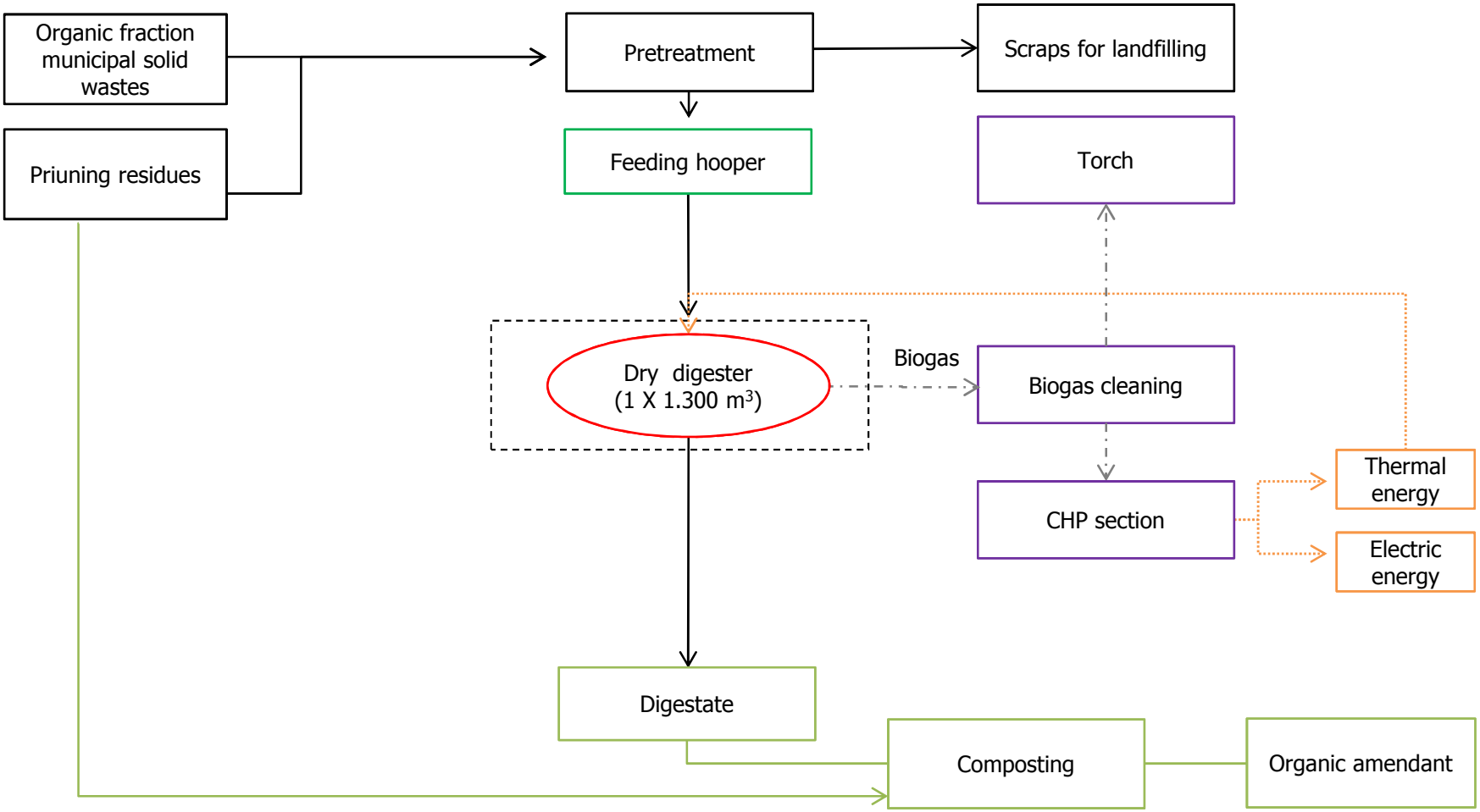
DRY OFMSW BIOGAS PLANT

MASS BALANCE



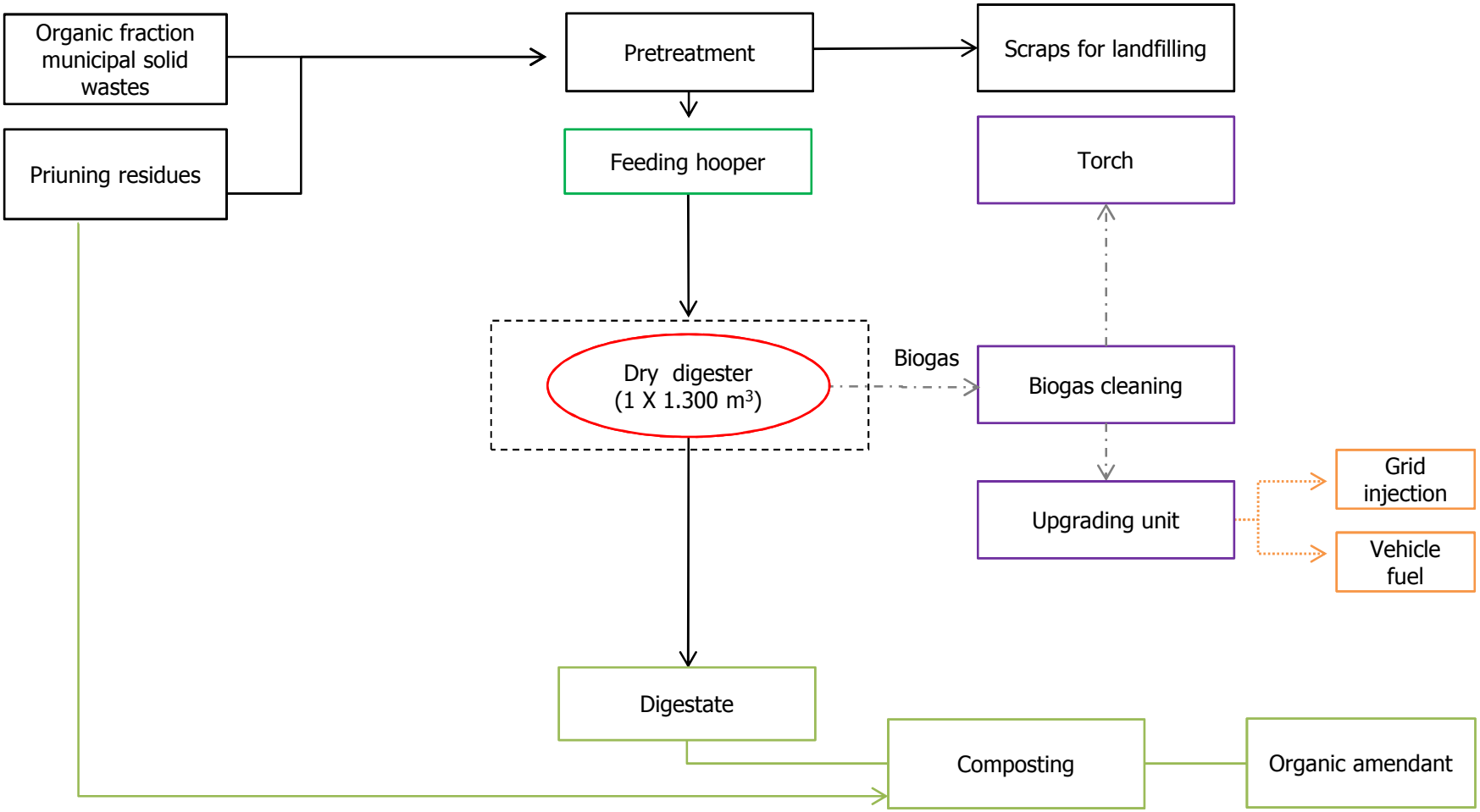
DRY OFMSW BIOGAS PLANT

Cogeneration| P&I



DRY OFMSW BIOGAS PLANT

Biomethane production| P&I



OFMSW BIOGAS PLANT
OPERATIONAL PARAMETERS

- Organic loading rate (OLR) = 10 KgSV/$m^3_{reactor}$ d
- Hydraulic retention time (HRT) = 25 days
- Operational temperature (T) = 55 °C
- Total solids (TS) = 30% fresh weight
- Specific gas production (SGP) = 160 Nm^3/t F.W.

OFMSW BIOGAS PLANT
LAYOUT