Factsheet
SYSTEMIC demonstration plant

Waterleau NewEnergy (Ypres, Belgium)

A short introduction to Waterleau

Waterleau NewEnergy is an environmental services company in the field of water, air and waste treatment. Waterleau NewEnergy runs an anaerobic digestion (AD) plant in Ypres (West Flanders, Belgium). The plant is operational since 2012 and can digest roughly 120 kilotonnes (kt) of feedstock per year at mesophilic conditions.

Table 1. Technical information of the biogas plant.

Characteristics	
Year of construction	2012
Maximum power output	3,2 MW_e
Digester volume	12 000 m^3
Digestion type	Mesophilic digestion

Drivers for nutrient recycling

The province of West Flanders is a nitrate vulnerable zone with intensive pig husbandry and a total animal manure production in terms of nitrogen (N) that exceeds the amount of manure that can be applied on agricultural land within legal limits. As a consequence, part of the produced manure and manure derived digestate has to be either exported or reduced in N content. Transport of manure or digestate is expensive, Waterleau NewEnergy has therefore implemented a nutrient recovery and reuse (NRR) system at the plant. The system reduces the total volume of streams that have to be transported and concentrates the nutrients by producing purified water.

Figure 1. Aerial photo of the demonstration plant Waterleau NewEnergy.

At Waterleau NewEnergy, digestate is upgraded into valuable biobased fertilisers:

- Dried solid fraction (SF) of digestate, which is mixed with part of the evaporator concentrate. The resulting blend is composted externally and thereafter exported to France;
- The remainder of evaporator concentrate is exported to the Netherlands;
- Condensed ammonia water is sold as reductant in the DeNOx system of a local incineration plant;
- Reverse osmosis (RO) permeate is reused as process water, as cooling water for the recovery of heat or it is discharged after polishing.

Feedstocks

The co-digestion capacity is 120 kt feedstock (organic substrate) per year. In 2020, the plant digested about 71 kt feedstock, of which 30% was animal manure (Table 2).

Table 2. Origin of Waterleau NewEnergy's digester feedstock (2020).

Type	Mass (kt)
Manure and solid fraction of manure	21
Sludge from industrial wastewater treatment plants and other biowastes	47.8
Glycerine and molasses	1.1
Total	**71**

Biogas production

In 2020 around 10 Mio Nm^3 of biogas were produced (Table 3). The biogas was converted by a Combined Heat and Power (CHP) installation into electrical (21,313 MWh) and thermal (22,800 MWh) energy.

Table 3. Biogas production and average biogas composition before purification for the year 2020.

Parameter	Amount
CH_4 (% v/v)	55
CO_2 (% v/v)	45
H_2S (ppm)	<200
O_2 (% v/v)	<1
Total biogas production (Nm^3)	10.3 Mio
Biogas per tonne of feedstock ($Nm^3\ t^{-1}$)	145

Horizon 2020

Waterleau NewEnergy (Ypres, Belgium)

Nutrient Recovery & Reuse (NRR) process

The feedstock is pre-heated to 40 °C and mixed to an optimal DM content before being pumped into the anaerobic digesters. The residence time in the digester is around 30 days and an additional 10 days in the post-digester. The produced digestate is hygienised (1 hour at 70 °C) and subsequently separated in a solid fraction (SF) and a liquid fraction (LF) of digestate by means of a decanter centrifuge. The SF of digestate is dried in a rotating disc dryer (Hydrogone® dryer) which can evaporate 1–1.8 t of water per hour. In this type of dryer there is no direct contact between hot air and the SF of digestate. Instead, the SF of digestate is mixed with discs filled with steam or hot oil. This reduces ammonia (NH_3) losses due to drying.

The exhaust air from the dryer is treated by an air scrubber, thereby producing air scrubber water. The LF of digestate, together with the air scrubber water and the evaporated water from the dryer flow to an aerobic treatment tank for lowering of the mixture's biochemical oxygen demand. The effluent subsequently flows to an evaporator which operates at 50-60 °C. NH_3 and water partially evaporate and are largely separated from each other based on volatility in the three consecutive stages of the evaporator. Condensation of these vapours in the condenser results in the following process streams: condensed ammonia water, process water and evaporator concentrate.

The condensed ammonia water is sold as reductant in the DeNOx system of a local incineration plant. The process water flows to an RO installation and the resulting permeate is either reused within the NRR system or discharged. The evaporator concentrate is partly mixed with the dried SF of digestate and subsequently composted and exported and partly exported directly.

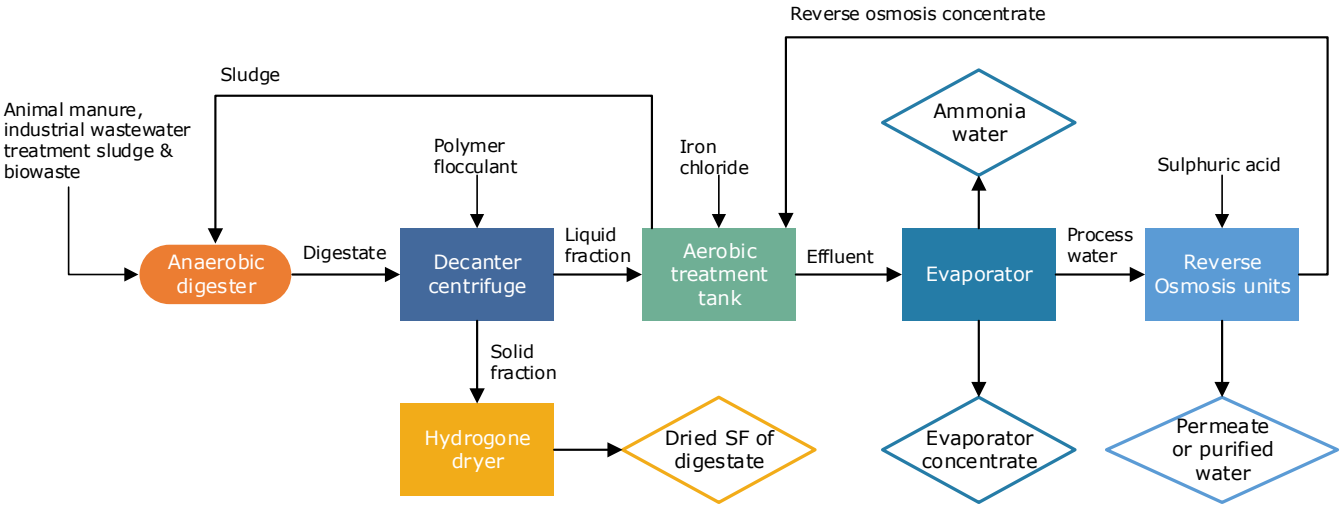

Figure 2. Simplified process flow diagram of Waterleau NewEnergy's current nutrient recovery and reuse system.

Status of construction

The biogas plant was built in 2006 and included the digesters and the current NRR system, except the RO installation. In 2013, the hygienisation tanks were moved from upstream to downstream of the digesters. In 2017, the RO installation was constructed to allow polishing of the process water produced by the evaporator.

Waterleau NewEnergy currently seeks a method to dewater the evaporator concentrate with the excess heat produced by the CHP installation. An alternative is acquiring additional dried SF of digestate of other biogas plants to allow mixing of all evaporator concentrate with dried SF of digestate.

This project has received funding from the European Union's H2020 research and innovation programme under the grant agreement No: 730400. SYSTEMIC started 1 June 2017 and ran for four years.

Horizon 2020

Waterleau NewEnergy (Ypres, Belgium)

Products and market

The SF of digestate is dried and composted in Flanders. This product has a positive effect on the dry matter (DM) content and structure of the compost. The proximity of WNE to many composting companies and the French border reduces transport costs, and the product containing concentrated nutrients is well accepted in northern France.

The evaporator and RO produce permeate or purified water, condensed ammonia water and an evaporator concentrate. Condensed ammonia water is not suitable as fertiliser, because of its high pH (>10) and therefore also high risk of NH_3 volatilisation and crop burning. The product is sold to a Belgian waste incineration plant and used as reductant for the DeNOx exhaust gas treatment system. The evaporator concentrate with high potassium (K) concentration is traded as fertilizer to the Netherlands. Alternatively, it is mixed with the dried SF of digestate and exported to France.

Table 5. Composition of the ingoing digestate and produced end products at Waterleau NewEnergy (June 2020 – December 2020).

	Digestate	Dried solid fraction of digestate	Evaporator concentrate	Ammonia water	Purified water
Dry matter (g kg^{-1})	57	904	187	-	-
Organic matter (g kg^{-1})	33	637	91	-	-
Total N (g kg^{-1})	6.5	29	13	96	0.63
Total P (g kg^{-1})	1.0	24	2.1	0.0005	0.000024
Total K (g kg^{-1})	3.9	15	22	0.00055	0.000073
Total S (g kg^{-1})	0.93	10	11	0.5	0.0022

Economic benefits

Long distance transport of digestate from the province of West Flanders to nutrient demanding regions is costly. The implemented NRR system enables Waterleau NewEnergy to concentrate nutrients in certain end products and to reduce the total volume of digestate and its end products that need to be transported, thereby saving costs for transport. Overall, per tonne of processed digestate, between €11–16 of disposal costs are saved by the current NRR system compared to conventional disposal of unseparated digestate

Table 6. Estimated disposal costs for the end products produced at Waterleau NewEnergy for the current NRR system and for the scenario without NRR system for the year 2020.

Without NRR system	**t y^{-1}**	**€ y^{-1}**	**€ t^{-1} digestate**
Digestate	65 000	975 000 – 1 300 000	15 – 20
With NRR system	**t y^{-1}**	**€ y^{-1}**	**€ t^{-1} digestate**
Evaporator concentrate (30%) + dried solid fraction of digestate (100%)	2 500 + 3 000	0	0
Evaporator concentrate (70%)	5 833	244 986	3.8
Condensed ammonia water	724	7 240	0.11
Total		258 610	3.9

This project has received funding from the European Union's H2020 research and innovation programme under the grant agreement No: 730400. SYSTEMIC started 1 June 2017 and ran for four years.

Horizon 2020

Waterleau NewEnergy (Ypres, Belgium)

Monitoring data: total mass flows

Total mass flows (Figure 3) were calculated for the NRR system of Waterleau NewEnergy for the period June – October 2020. This was done to evaluate the overall performance of the plant and the separation efficiencies of the individual process units.

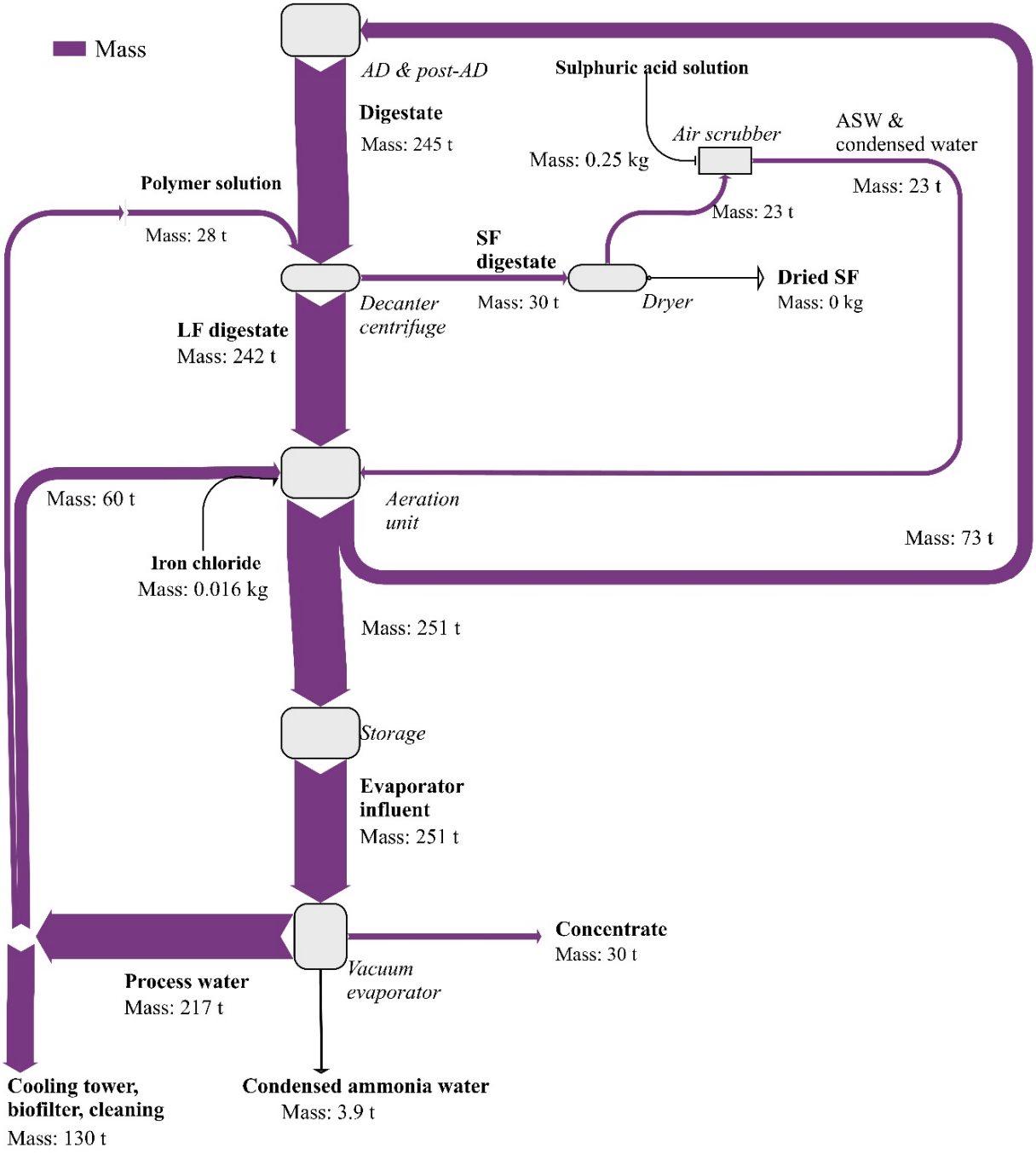

Figure 3. Total mass flows of the nutrient recovery and reuse system at Waterleau NewEnergy in tonnes (t) per day.

This project has received funding from the European Union's H2020 research and innovation programme under the grant agreement No: 730400. SYSTEMIC started 1 June 2017 and ran for four years.

Horizon 2020

Monitoring data: nutrient mass flows

Nutrient mass flows (Figure 4) were calculated for the NRR system of Waterleau NewEnergy for the period June – October 2020. This was done to evaluate the overall performance of the plant and the separation efficiencies of the individual process units.

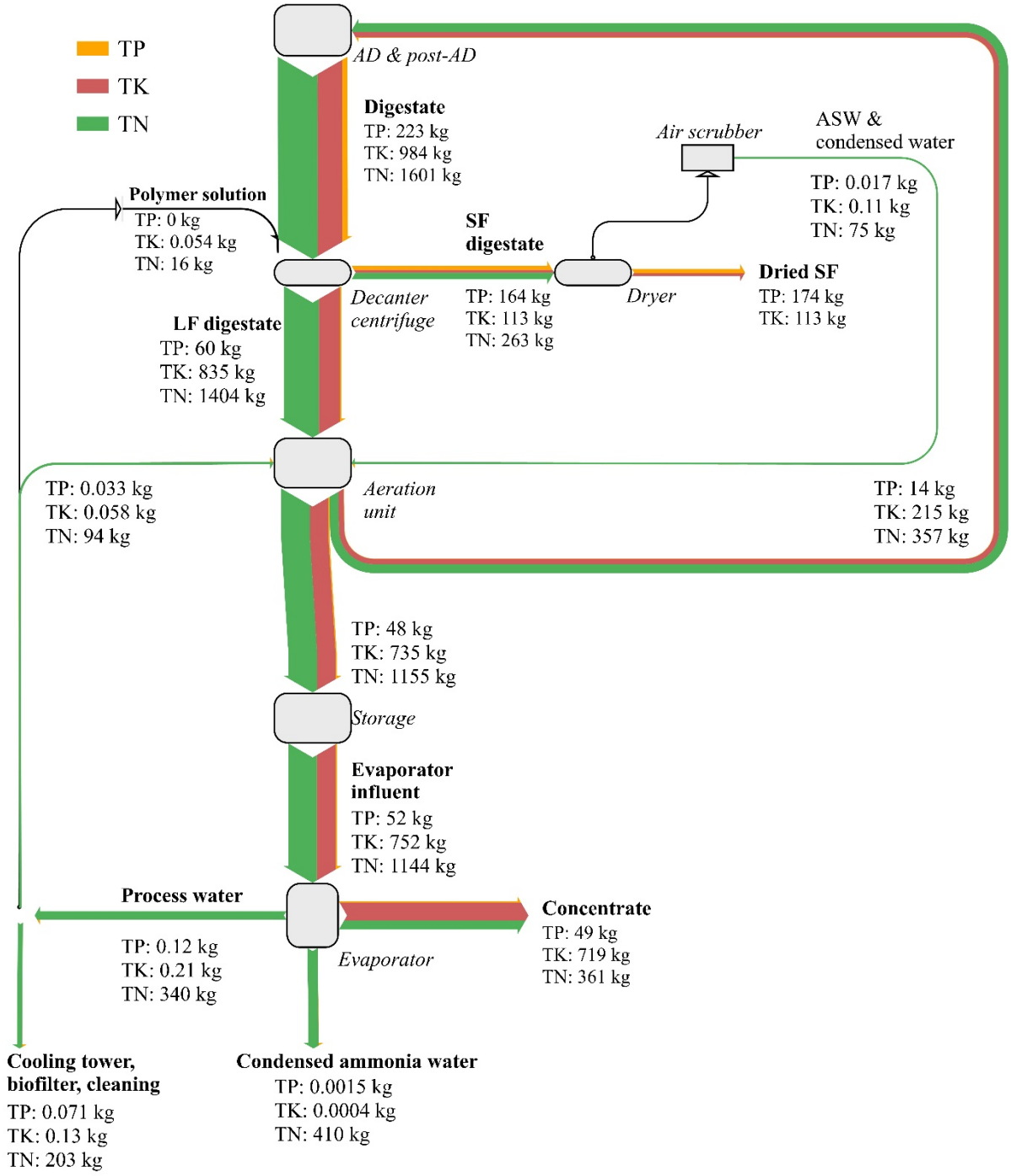

Figure 5. Total nitrogen (TN), total phosphorus (TP) and total potassium (TK) mass flows of the nutrient recovery and reuse system at Waterleau NewEnergy in kilograms (kg) per day.

This project has received funding from the European Union's H2020 research and innovation programme under the grant agreement No: 730400. SYSTEMIC started 1 June 2017 and ran for four years.

Horizon 2020

Waterleau NewEnergy (Ypres, Belgium)

Monitoring data: energy balance

In 2020 the plant generated 21,313 MWh of electricity, of which 32% was consumed by the NRR system. More specifically, 14% by the evaporator, 10% by the dryer, 5.8% by the aerobic treatment tank, 1.2% by the decanter centrifuges, 0.93% by the hygienisation tanks and 0.4% by the RO installation. All produced heat was used on-site by the hygienisation tanks (12%), dryer (31%) and evaporator (56%).

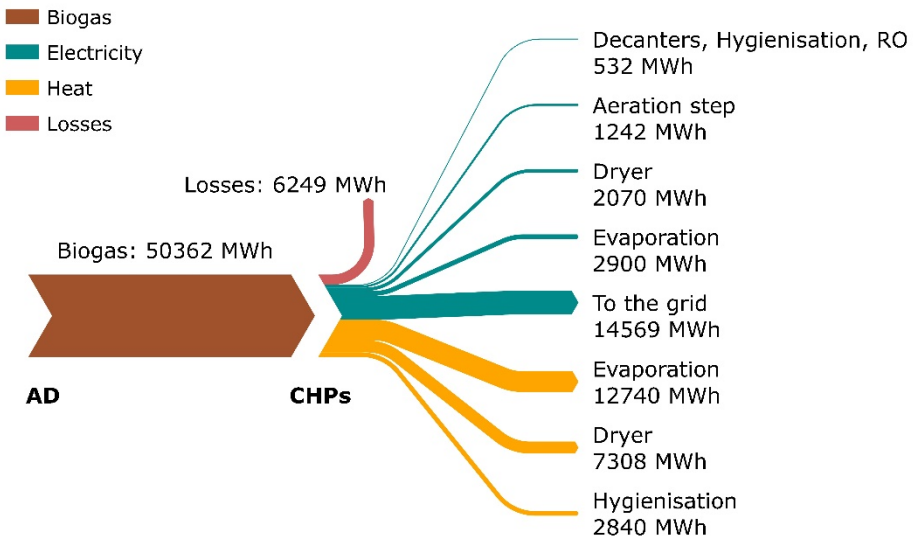

Figure 6. Energy balance of the anaerobic digestion (AD) and nutrient recovery and reuse system at Waterleau NewEnergy for the year 2020.

Key Performance Indicators (KPIs)

Economic KPIs are simple tools to gain insight into a company's economic performance:

KPI_1: EBIT (Earnings Before Interest and Taxes) margin as % of revenues.
KPI_2: EBITA (Earnings Before, Interest, Taxes and Amortisation) margin as % of revenues.
KPI_3: Substrate (financial) productivity → total gross revenues per tonne of feedstock.
KPI_4: Biogas (financial) productivity → net revenues of biogas (energy / green certificates) per cubic meter of biogas delivered.
KPI_5: Digestate (financial) productivity → net costs/revenues generated by digestate per tonne of feedstock.

Table 7. Economic KPIs of Waterleau NewEnergy's plant.

KPI	
EBIT margin	8%
EBITA margin	19%
Substrate financial productivity	€62 / tonne feedstock
Biogas financial productivity	€0.33 / Nm^3 biogas
Digestate financial productivity	€-7.1 / tonne feedstock

The plant has a relatively high substrate financial productivity and a relatively low digestate financial productivity compared to the other SYSTEMIC demonstration plants. Digestate financial productivity is relatively low because of the costs for processing of the digestate and disposal of the end products.

More information on the economic KPI analysis is available in deliverable D2.4: *'Final report on the development and application of economic key performance indicators (KPIs)'.*

This project has received funding from the European Union's H2020 research and innovation programme under the grant agreement No: 730400. SYSTEMIC started 1 June 2017 and ran for four years.

Horizon 2020