AQUAFARM

Pordenone, 16-Feb-2018

ABG AlgaeBioGas

SaltGae algae to treat saline wastewater

Water2 REturn

Algae – Wastewater – Biogas

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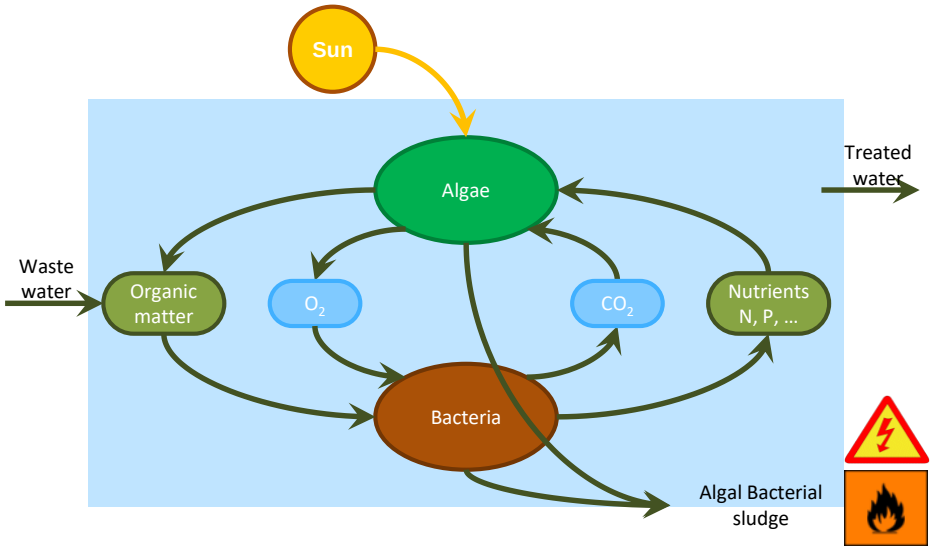
Agenda

- Algae – Wastewater – Biogas
  - Algal bacterial WW treatment
  - Biogas – recover energy from biomass
  - Biogas digestate
- Projects
  - AlgaeBioGas
  - Saltgae
  - Water2REturn
- How to start an Algae [– Biogas] project

Algal-bacterial WW treatment summary

- Oxygen producers
- Embeed more N, P
- Bind micro-pollutant
- Lower energy
- Less GHG release
- More resilent

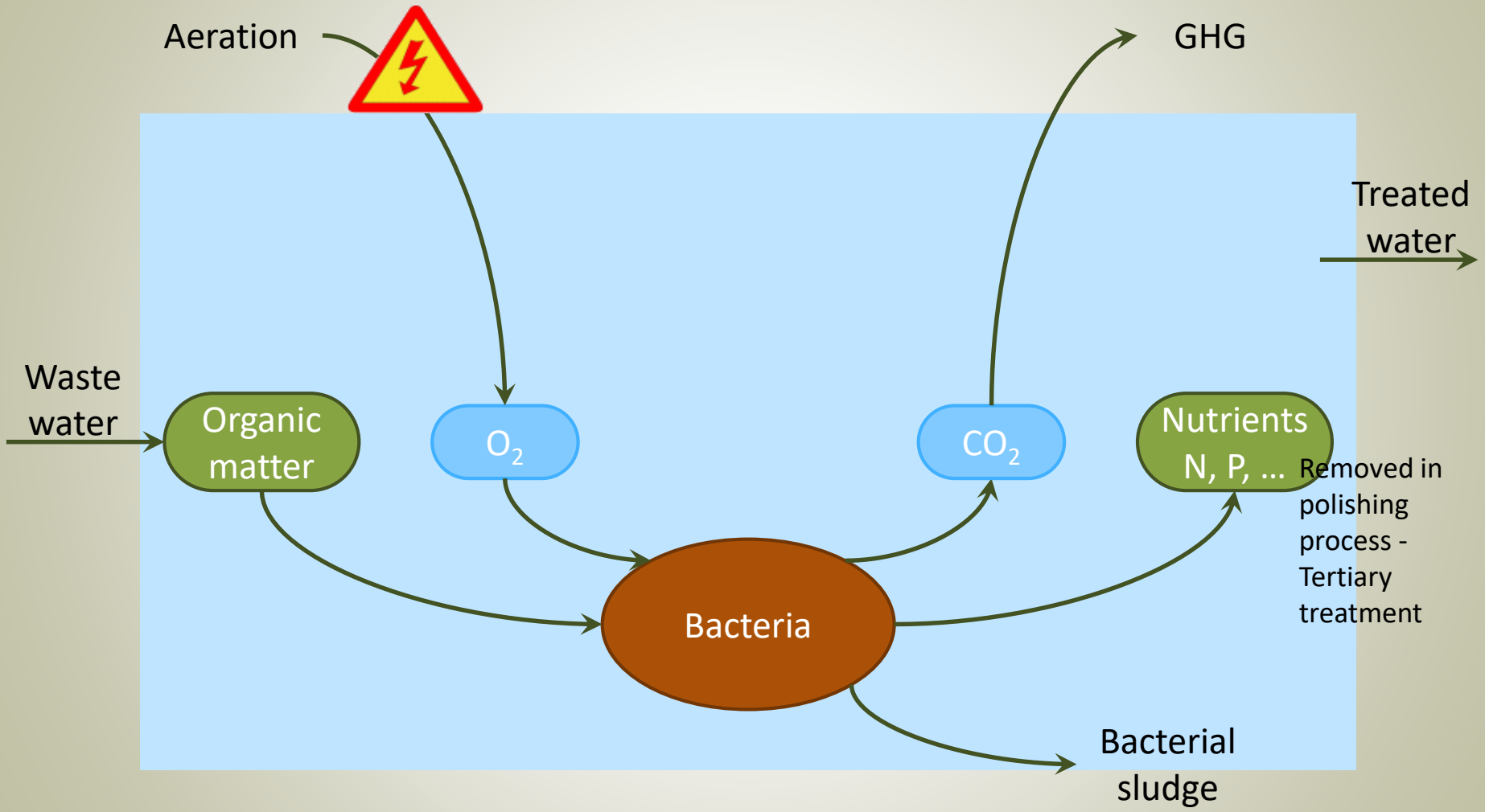


- High area demand
- Weather dependent

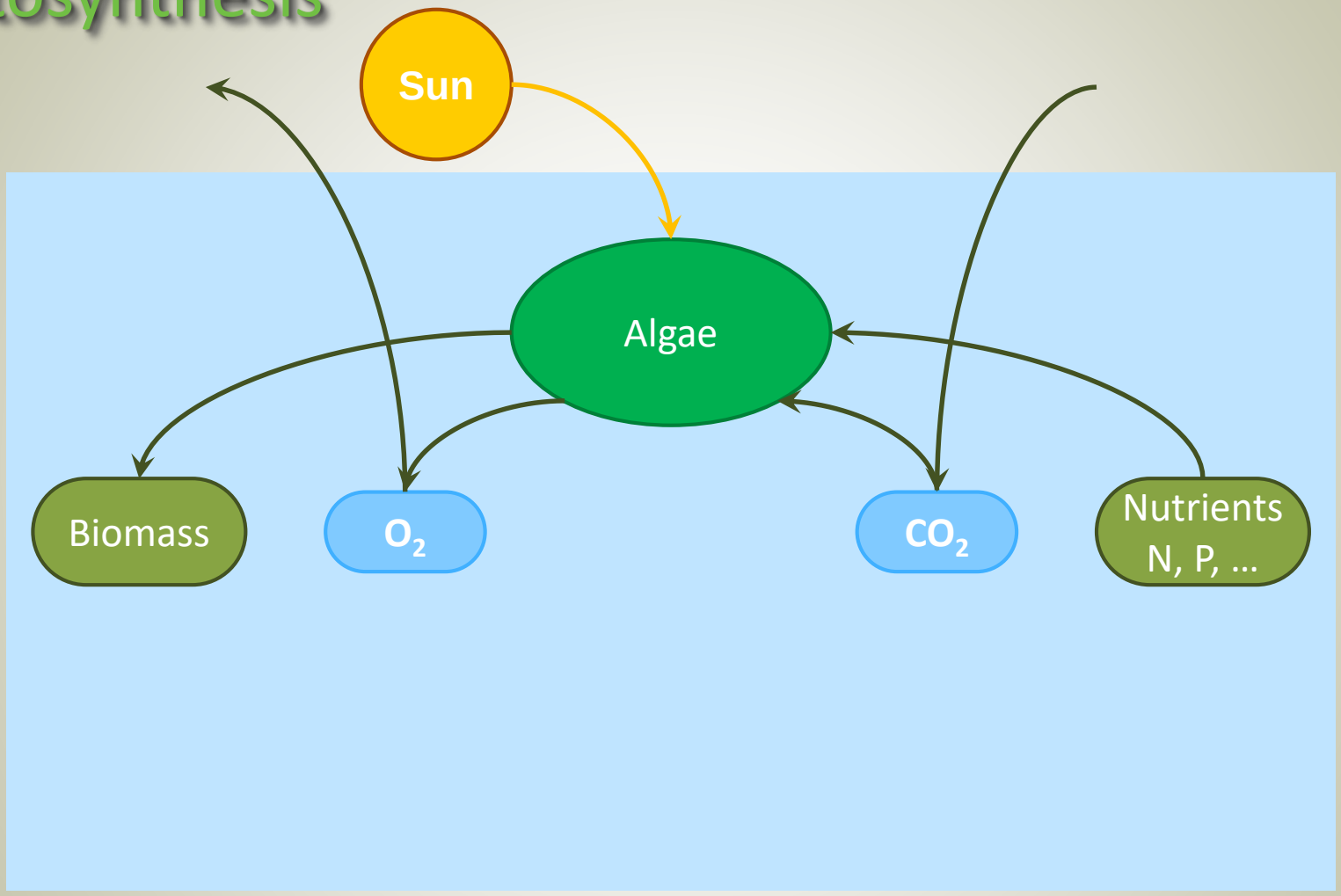
Wastewater

- Wastewater
  - organic compounds
  - nitrogen (mostly ammonia)
  - other nutrients (P)
  - micro pollutants (drugs, chemicals, heavy metals)
  - Chemical/Biological Oxygen Demand (COD/BOD)
- Algae & wastewater
  - Nature's method to treat wastewater
  - Technologically used for at least 60 years

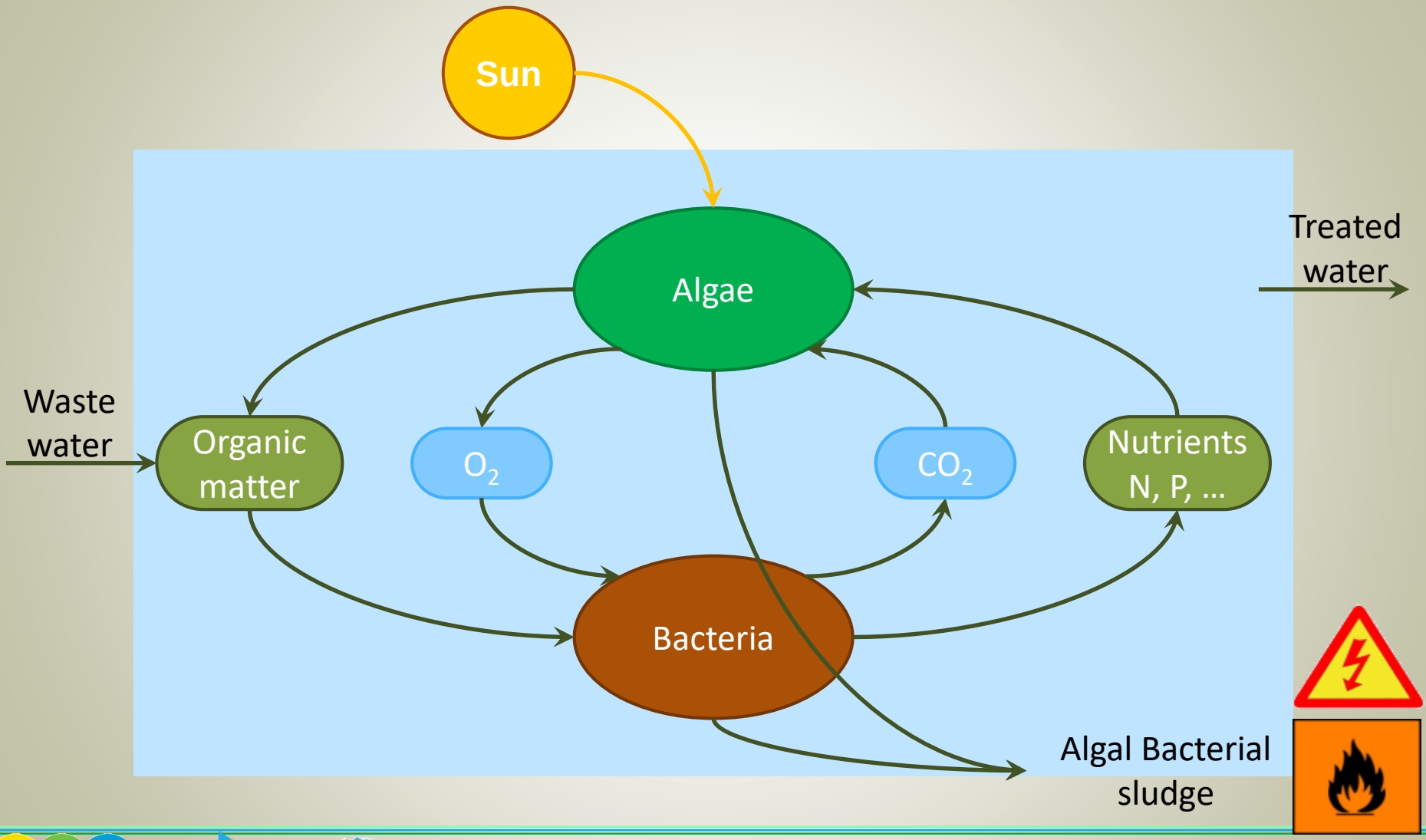
Algal bacterial process
Biological Aerobic Wastewater Treatment



Algal bacterial process
Photosynthesis



Algal Bacterial (ALBA) Wastewater Treatment



Algal Bacterial (ALBA) Wastewater Treatment

- lagoon treatment
- shifting objectives in the past (energy was “free”, no GHG paranoia)
- purpose of ALBA biomass
- algae : bacteria - C : N
- more diverse microbial community → less sensitive to sudden changes (antibiotics, biocides, salt, …)
- can use / recycle additional CO_2
- salty wastewater

A research topic of today

- no state of the art universal solutions
- algae bacterial community is unstable → needs to be tightly controlled
- WW may be dark – no light for algae – no oxygen for bacteria
- removal of heavy metals, accumulated toxic substances, salt, …
- should be independent of weather
- harvesting – sedimentation, DAF, …
- dark / light sections
- floc ecology, auto-flocculation

Wastewater as nutrient source

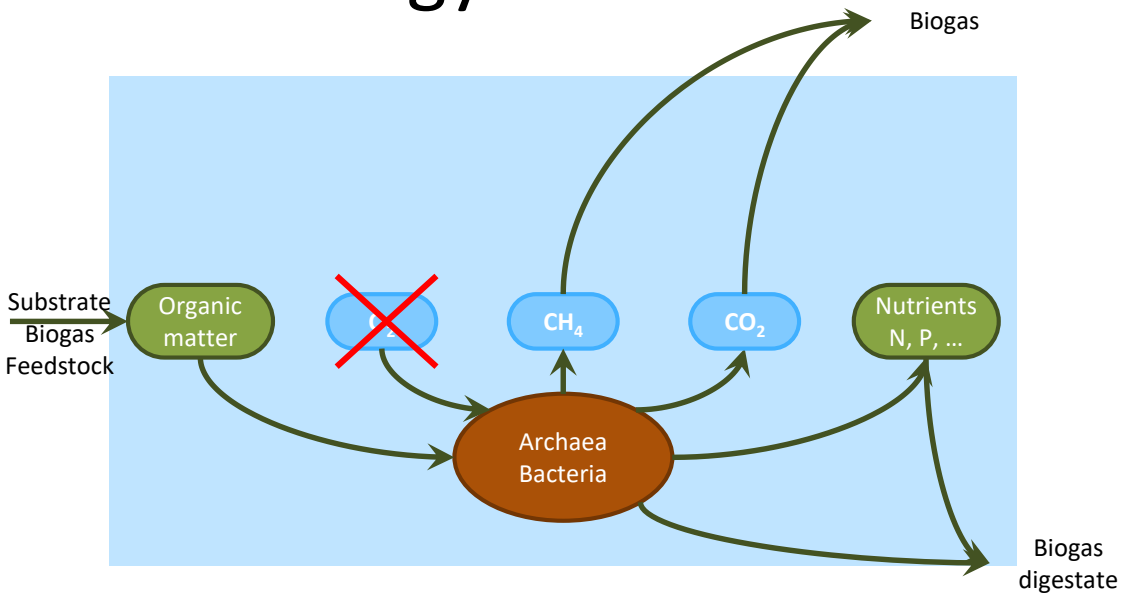
- Negative price of nutrients
- Essential for any large scale low cost products

Wastewater as resource

- **Algae & biogas – basic technology for energy and nutrient recuperation from wastewater**
- 1 m^3 municipal wastewater contains 7 kWh
- We use 0.5 – 1 kWh to treat it

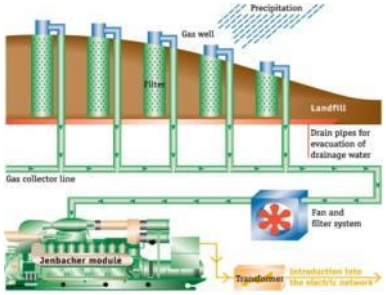
Biogas

- Anaerobic digestion
  - Anaerobic bacteria (Archaea) converting organic matter to methane (and H_2, CO_2, H_2S, …)
- A waste treatment technology



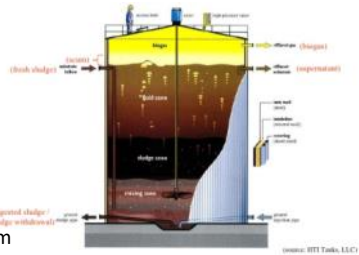
Biogas flavours

- Landfill gas
- Wastewater sludge
- Bio waste
- Wastewater (anaerobic treatment)
- Agricultural waste
- Energy crops



LSI group

www.acs-environment.com



HTI tanks

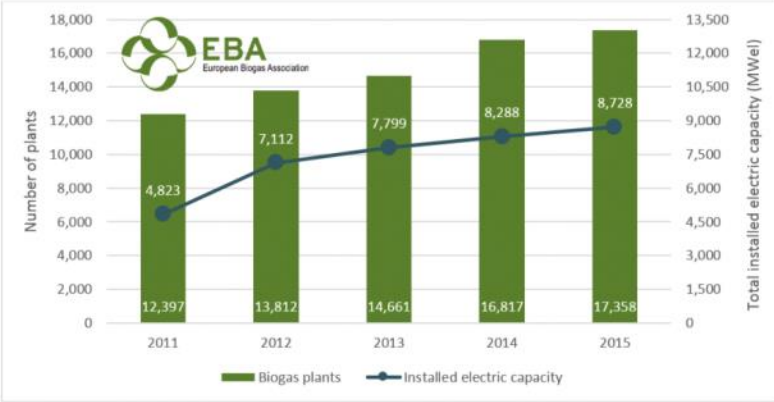
EurObserv'ER 2013

- Different technology levels
- Mesophilyc / thermophilic
- CHP / heat / biomethane

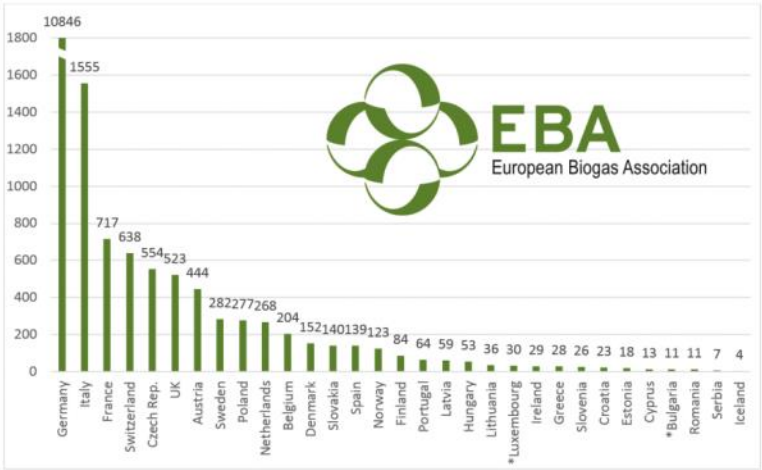
Biogas in EU

- EU 17358 (end 2015)

- Legislation & subsidies
  - Gas grid ↔ CHP
  - Waste ↔ energy crops
  - Access to power grid
  - Renewable energy tarrifs
  - Nitrogen vulnerable zones



Number of biogas plants and total installed capacity in Europe 2011 - 2015

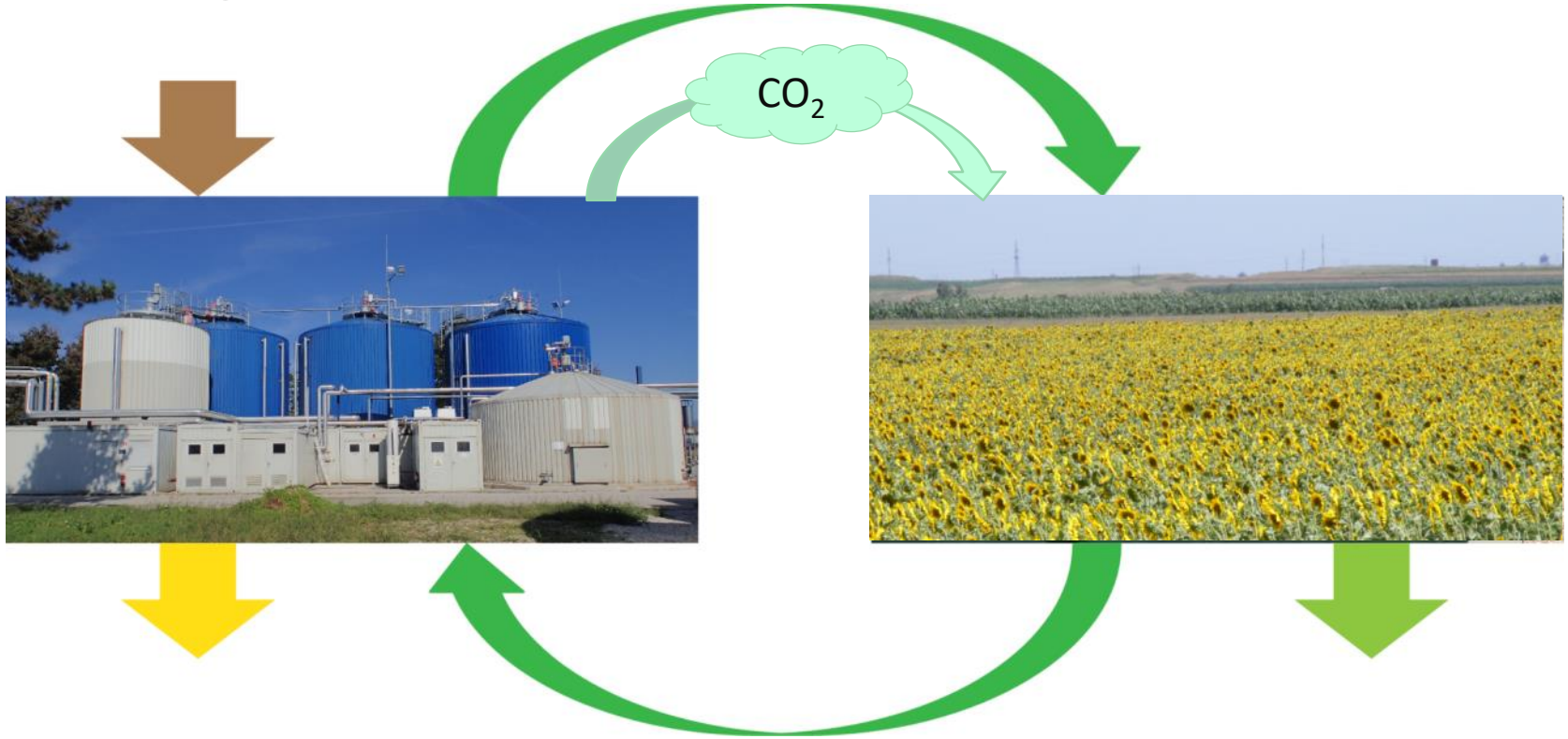


17,358 biogas plants in Europe (31/12/2015)
Total installed capacity of 8,728

- **Biogas is the most efficient biofuel**

Biogas digestate

- Ideally: all organics consumed
- Ideal agricultural fertilizer



Biogas digestate

- In reality:
  - Very dilute (80-150 m^3/ha)
  - Logistics
    - Storage
    - Transportation
    - Machinery
  - Agro-technical problems
    - Liquid
    - Nutrient flushing from soil
- Separation to liquid and solid phase
  - Solid – like ordinary fertilizer
  - Liquid – wastewater, with only limited application to soil
- Waste, end-of-waste directive, control & monitoring

Liquid biogas digestate

- One of the hard-to-treat substances
- COD 8000 – 50000 mg O_2/L
- Classical WW processing (3 – 20 €/m^3)
  - Energy consuming conversion or organics and nutrients to CO_2 and N_2
  - Loss of energy and nutrients
- Alternatives:
  - Drying
  - Ultrafiltering
  - Reverse osmosis
  - …
- Algal treatment

AlgaeBioGas Basic Cycle

digestate as
source of nutrients

CO_2

biogas
heat & power

algal biogas
substrate

algal products

Algae as biogas substrate

- Hard to digest
- C : N ratio (high C substrate should be added)
- Pre-treatment required
  - Heating, enzymatic, fungal, bacterial, ultrasonification, pressure shock, …
- Thermophilic process optimal
- If done properly biogas productivity comes close to corn silage (based on dry weight)
- Depends on species & composition
- Cannot be cost effective unless grown on wastewater or digestate

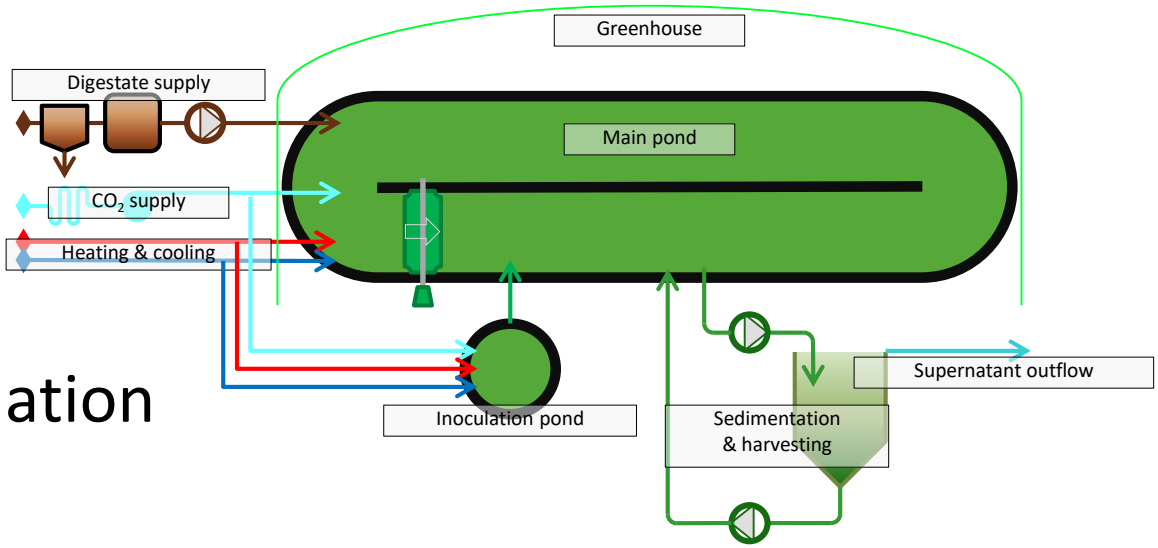
AlgaeBioGas Project

- **Algal treatment of biogas digestate and feedstock production**
- An Eco-Innovation project (CIP-EIP-Eco-Innovation-2012)
- Pilot and market replication project
- Two partners:
  - AlgEn, algal technology centre,
  - KOTO, biogas operator, animal waste treatment facility both in Ljubljana, Slovenia

AlgaeBioGas Objectives

- Objectives:
  - Demonstration centre design, construction, operation
  - Prepare technology for replication
  - Market development activities
- Finished in 2016
  - Demonstration centre operational (100m^2)
  - Running for 3.5 years
  - Legislation analysis, LCA, business planning
  - Complementary technologies were tested
  - Technical development (controls, ponds)
  - Presentations & visits
  - Technology ready for Early Adopters

Subsystems

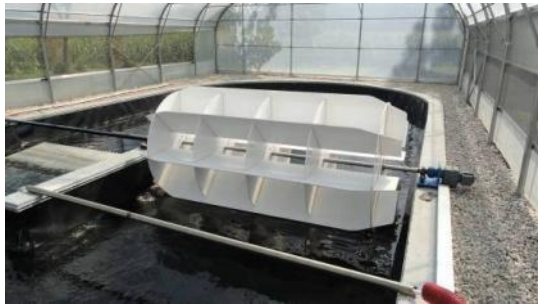


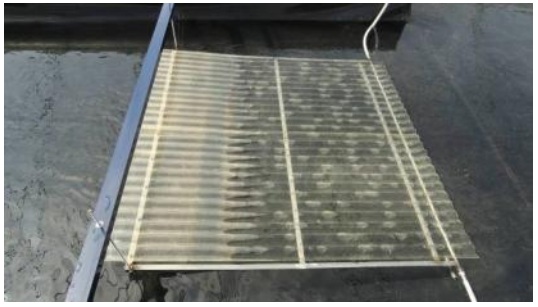
- Ponds: main & inoculation
- Mixing equipment
- Greenhouse
- Heating & cooling
- Exhaust gas supply (cooling, purification)
- Digestate supply (separation, anaerobic filter, storage)
- Sedimenter / clarifier & recycling
- DAF
- Control system

Greenhouse, ponds, mixing, CO_2

ABG AlgaeBioGas






ABG W2R AQUAFARM algen algal technology centre

Digestate preparation

ABG AlgaeBioGas

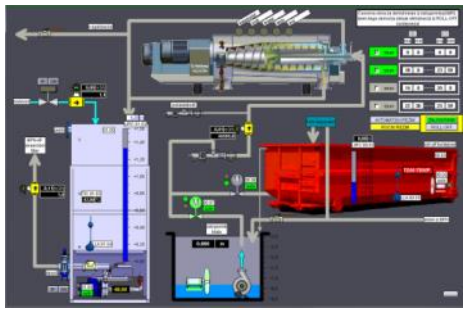
Control & instrumentation

ABG AlgaeBioGas



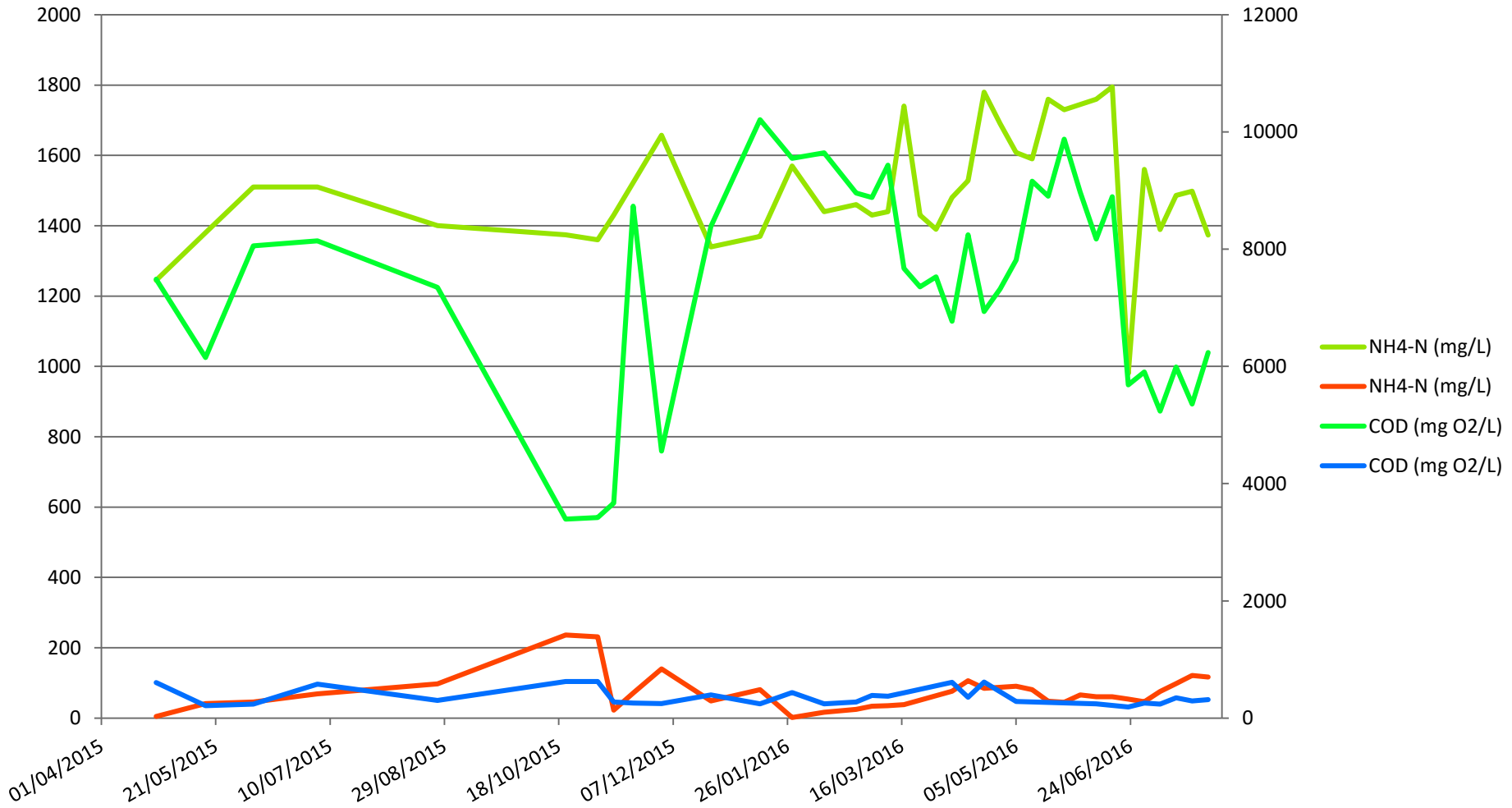







ABG W2R AQUAFARM algen algal technology centre

Observed performance



Full scale estimate

- Model **biogas CHP with 1 MW_e**
- Digestate treatment: to recycle major part of nutrients
  - area 2 - 5 ha ponds
  - volume 3000 – 17000 m^3
  - 60 – 200 t algae bacterial biomass p.a.
  - use approx the same amount of waste paper pulp (or other carbon rich substrate)
  - replacing 120 – 400 t dry mass of corn = 360 – 1200 t of corn silage
  - replacing 8 – 26 ha of corn fields

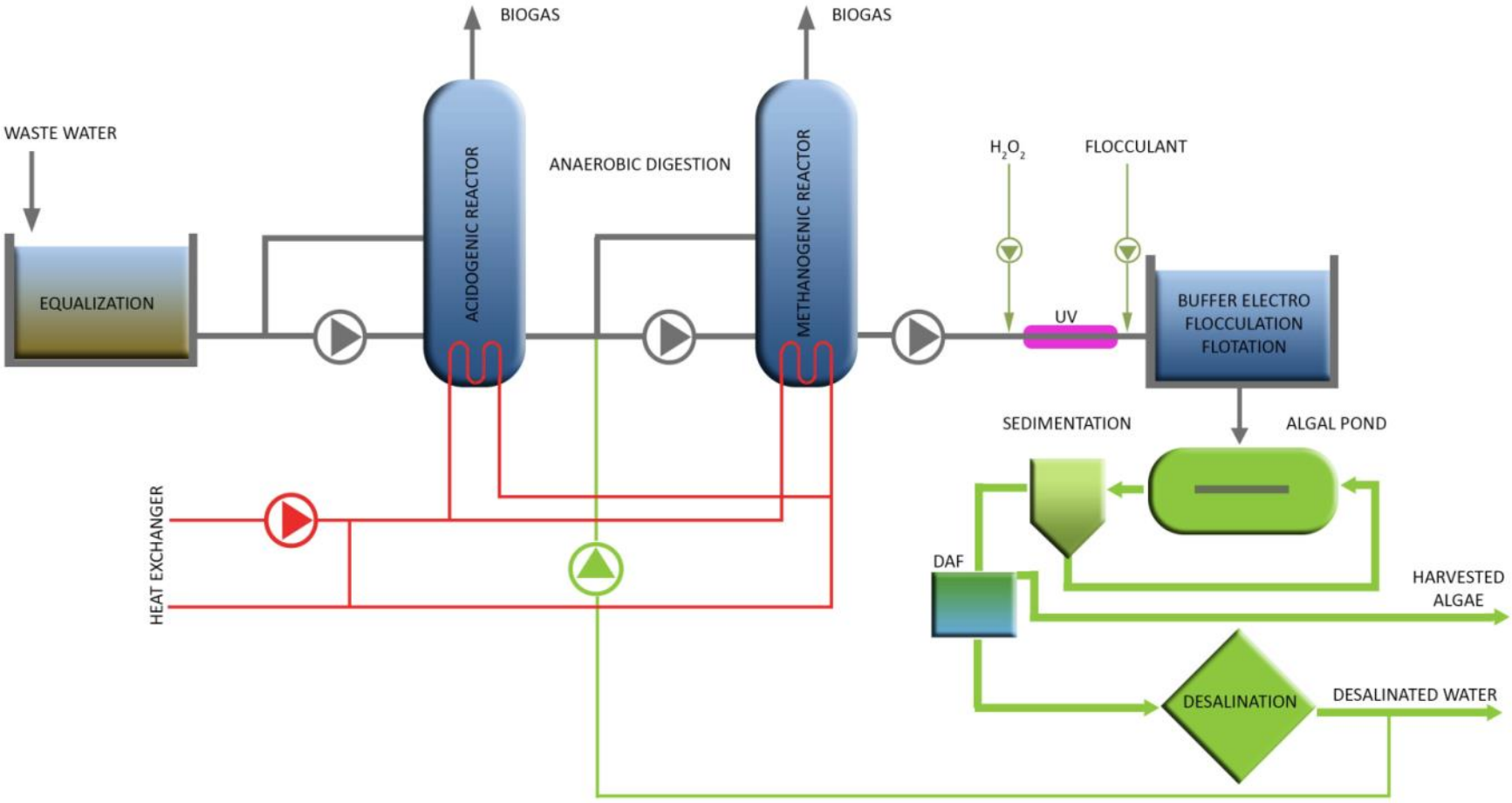
Saltgae

SaltGae
algae to treat saline wastewater

- Demonstration project to prove the techno-economic feasibility of using algae to treat saline wastewater from the food industry
- Innovative Action Horizon 2020 project
- Started in June 2016
- Three demo sites - starting now
  - Camporosso, Italy (dairy ww)
  - Ljubljana, Slovenia (tannery / hide warehouse ww)
  - Arava, Israel (fishery ww)

General process

SaltGae
algae to treat saline wastewater



Project structure

SaltGae
algae to treat saline wastewater

Sludge Valorisation	High salinity Anaerobic Digestion Pre-treatment	Support Services
Effluents Valorisation	Desalination: electrodialysis, reverse osmosis Efficient pumping and RO energy recovery	Life-Cycle Assesment Business evaluation Stakeholder's platform Dissemination Exploitation
Biomass Valorisation	Extraction & separation Animal feed Adhesives & Coatings Fillers & pastes (3D printing)	
Algal Ponds	Algal ponds optimization Algal-bacterial treatment Process modelling Harvesting, Ultrafiltration (RO)	
Demo Sites	Camporosso Italy: WW from dairy industry – edible products, batch Ljubljana Slovenia: WW from hide warehouse (tannery) – AD, algae, RO Arava Israel: WW from fishery, spirulina & dunaliella production	

Partners

SaltGae
algae to treat saline wastewater

inspiralia
algen algal technology centre
Arava Development Co.
Archimede Ricerche Srl
Bibo Aqua
FOOD+i CLUSTER
DCU
European Desalination Society
enco engineering & consulting
EUBIA
EXTRACTIS
PTP SCIENCE PARK
iBET Instituto de Biologia Experimental e Tecnológico
INSTM
KOTO
NOVA id FCT Associação para a Inovação e Desenvolvimento da FCT
OFFICINE MECCANICHE SANFILIPPO s.r.l.
OXIDINE Water Technology
PRODUMIX
RISE

ABG
W2R
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Gallery

SaltGae
algae to treat saline wastewater





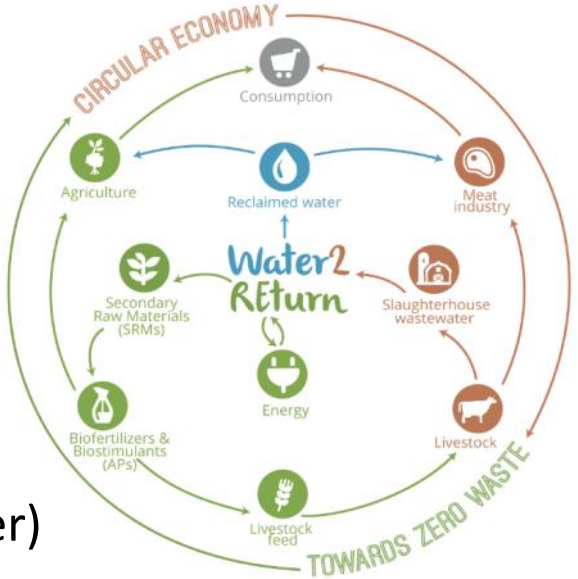



Water2REturn

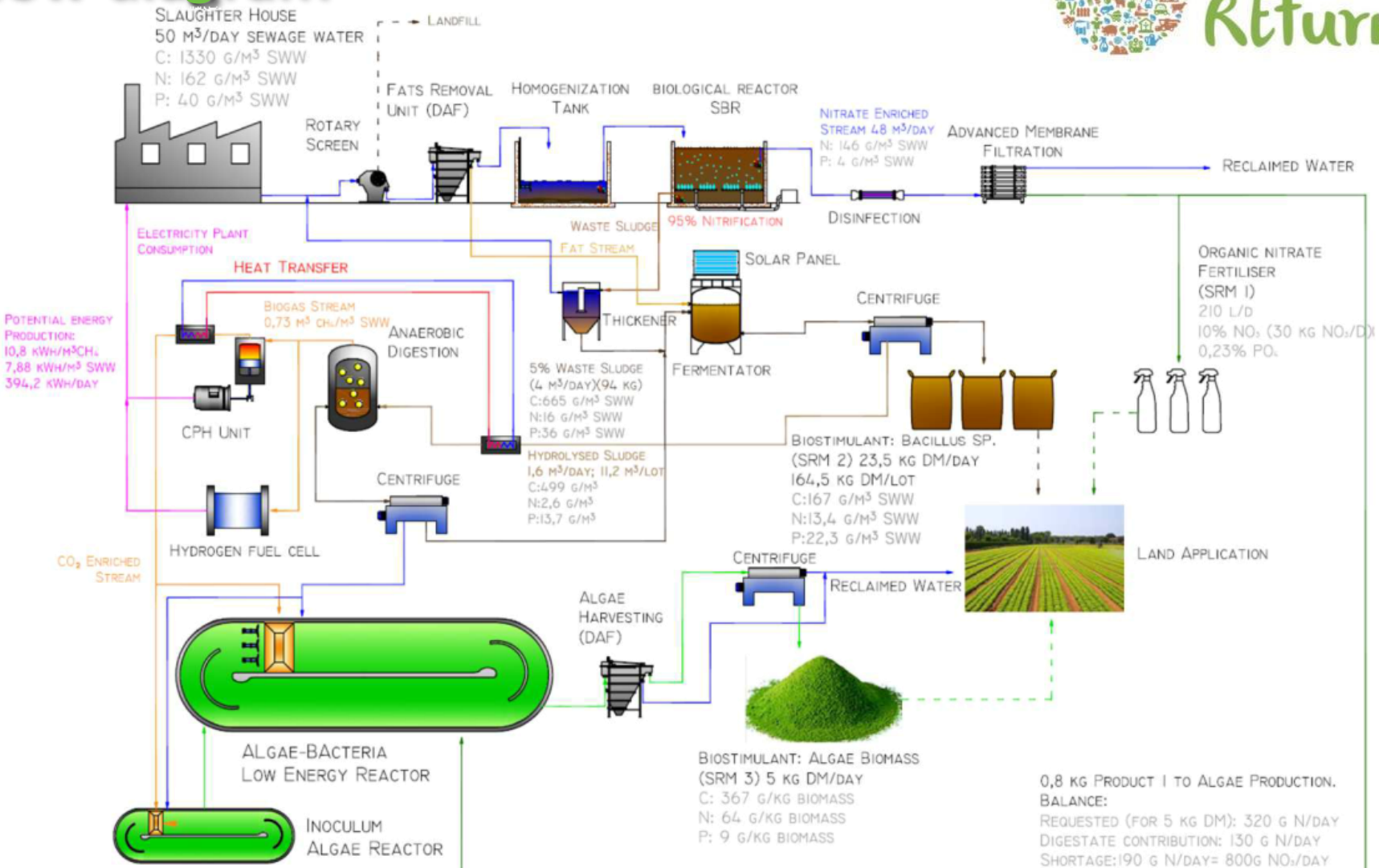
- REcovery and REcycling of nutrients TURNing wasteWATER into added-value products for a circular economy in agriculture
- Innovative Action Horizon 2020 project
- Started in July 2017
- Demo site - starting November 2018
  - Matadero del Sur, Seville, Spain

Water2REturn

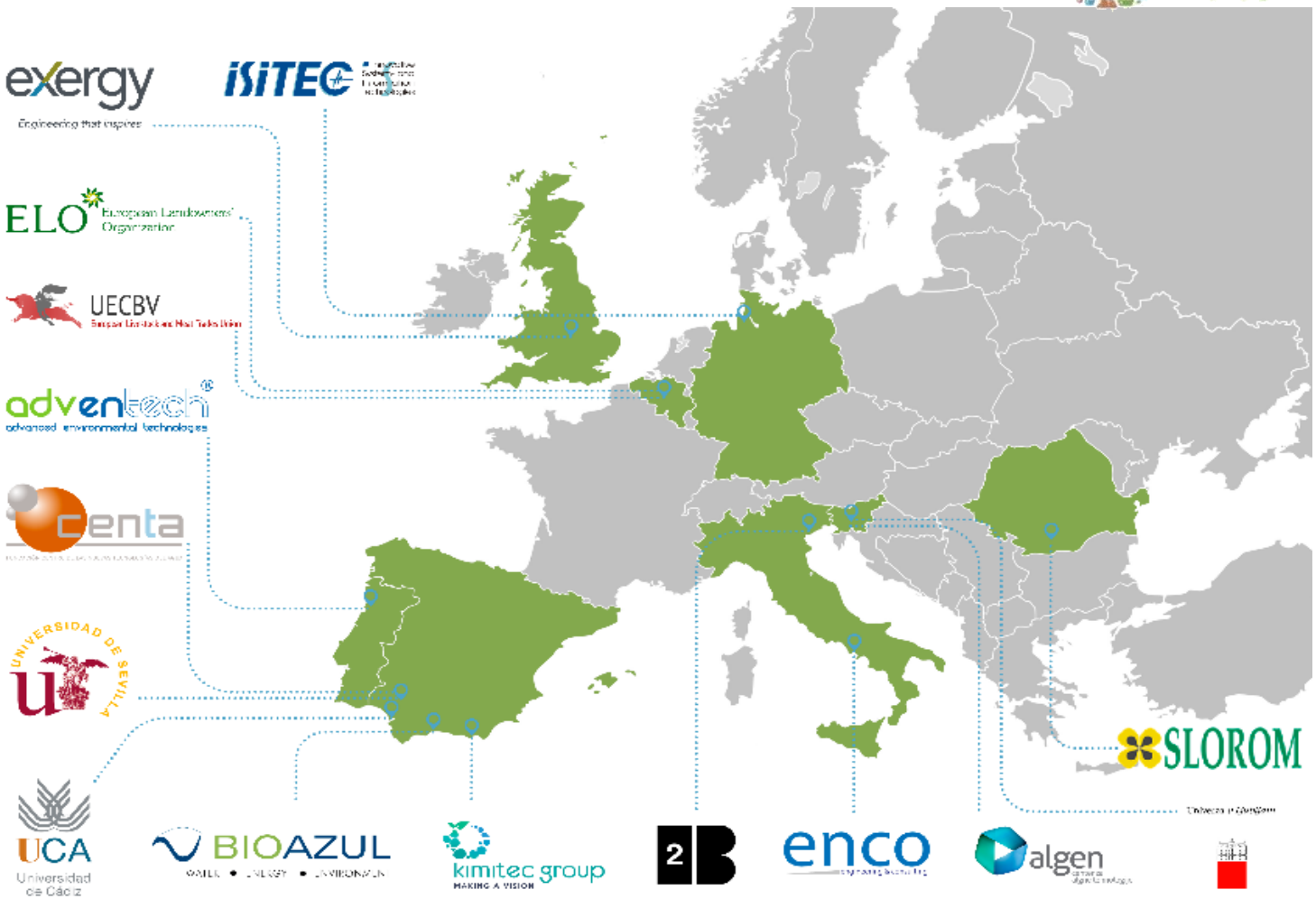
- full-scale demonstration process to treat slaughterhouse wastewater
  - viable
  - cross-sectoral
  - integrated
- novel combination of biochemical and physical technologies and processes in cascade
- positive balance in energy footprint
- extraction of valuable agronomic products
  - Nitrate and phosphate concentrate (organic fertiliser)
  - hydrolysed sludge (biostimulant)
  - algal biomass (biostimulant)



Flow diagram



Partners


exergy
Engineering that inspires
iSITEC
ELO
European Landowners' Organization
UECBV
advantech
advanced environmental technologies
centa
UNIVERSIDAD DE SEVILLA
UCA
Universidad de Cádiz
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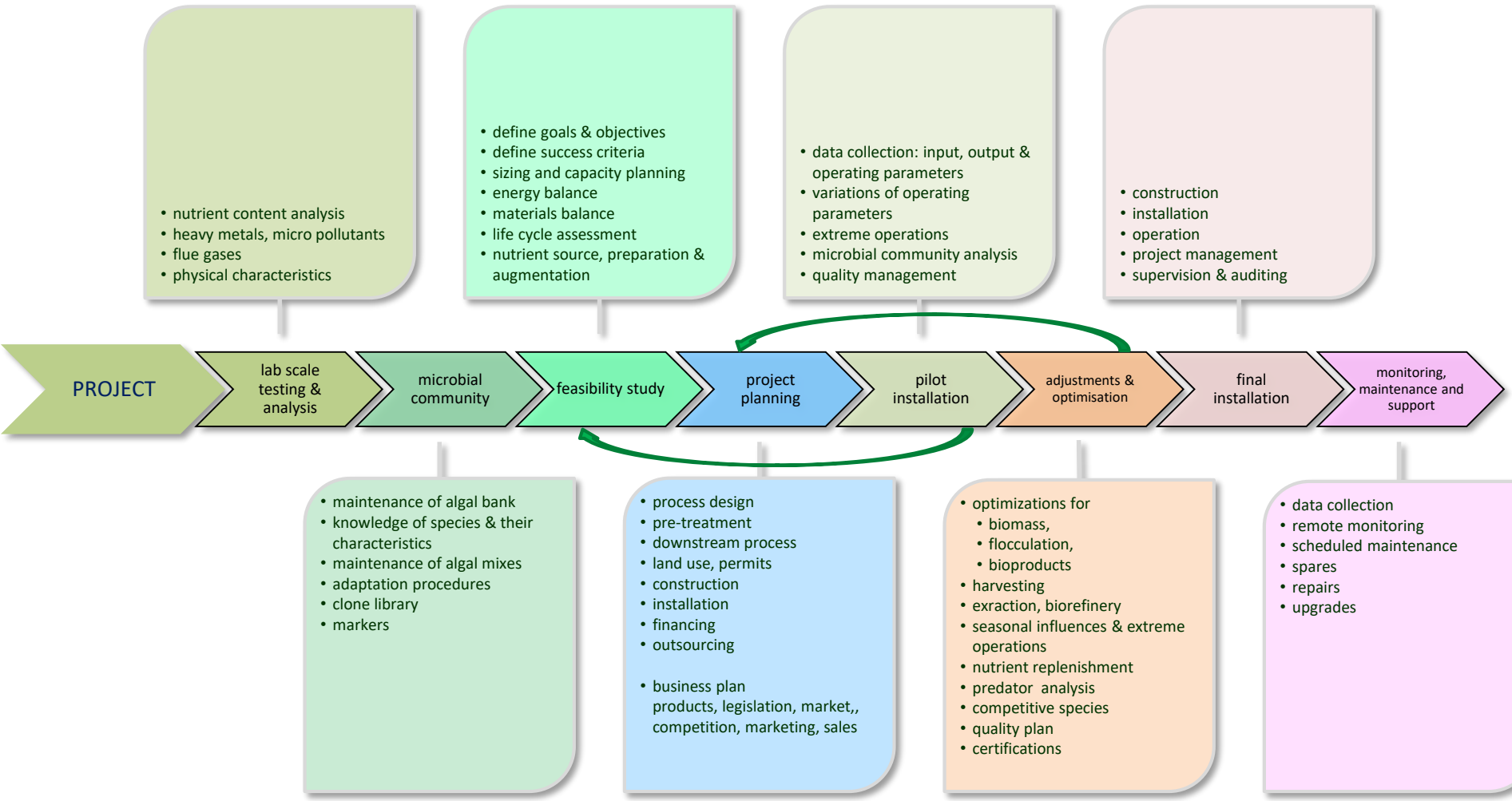
kimitec group
MAKING A VISION
2B
enco
algen
SLOROM

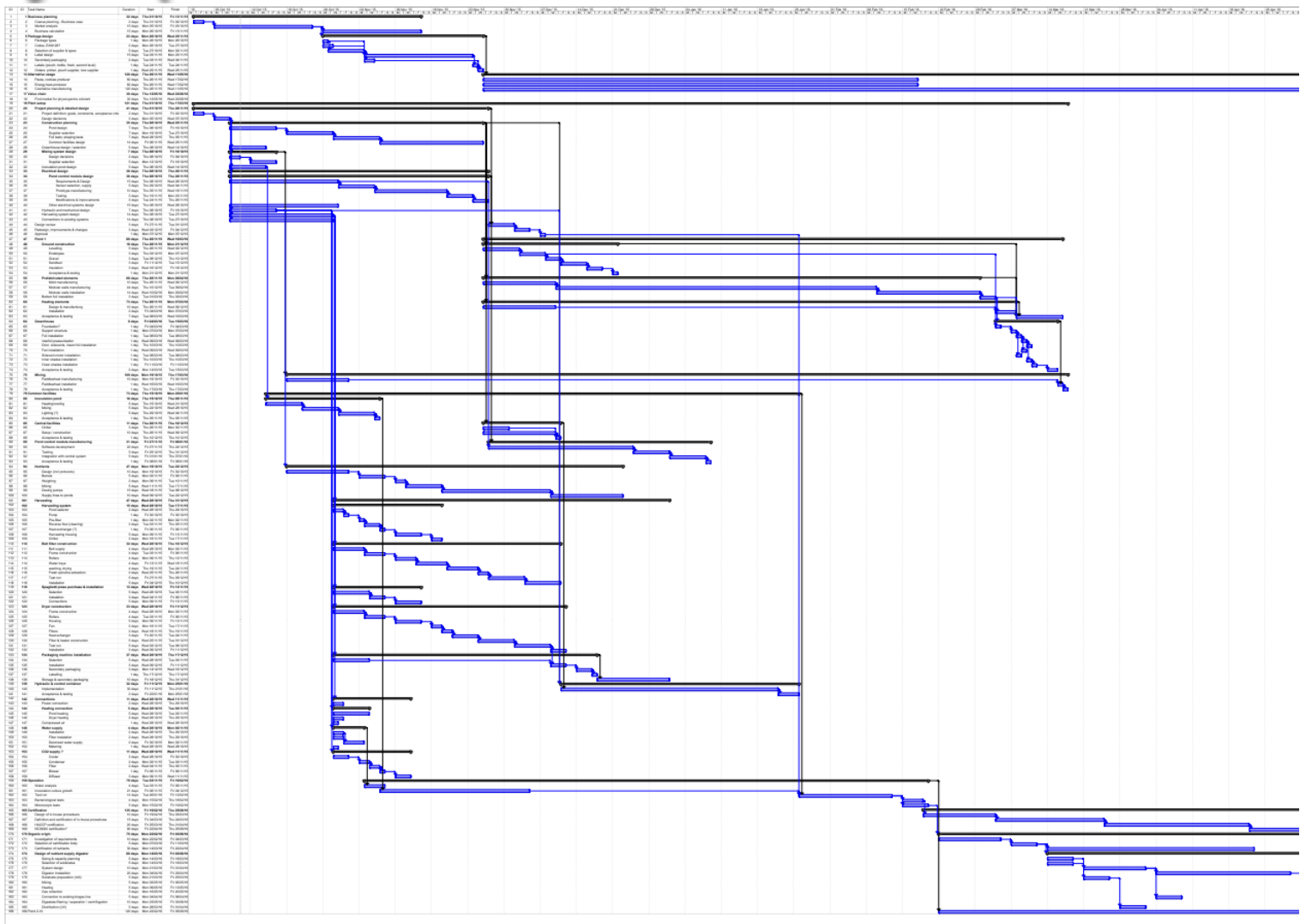
How do I start an algae project, first steps

- What you have
  - water, space, nutrients, heat
- What you want
  - pains, challenges, products, market
- Are you an **early adopter**?
- Do basic balances, do it twice and repeat it
- Learn from mistakes of others
- Do not reinvent the wheel
- Be flexible & adapt

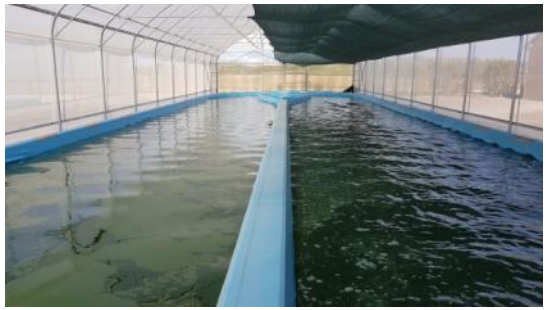
Your Project



A project plan



This has started as an AlgaeBioGas project



Thank you for your attention

- Questions?

- Welcome to visit the  demo centre.