RENEXPO® Western Balkans

ABG AlgaeBioGas

Algae – Wastewater – Biogas

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Agenda

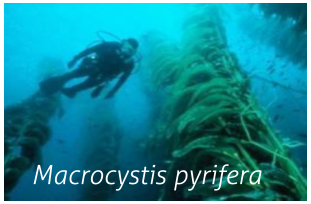
- Biogas in Slovenia
- Algae – Wastewater – Biogas
  - Introduction to algae
  - Algal-bacterial **treatment** of biogas digestate
  - Algae as biogas **feedstock**
- AlgaeBioGas project

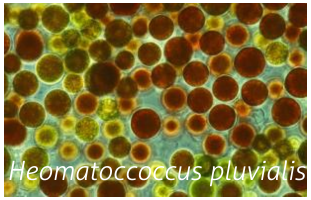
Biogas in Slovenia

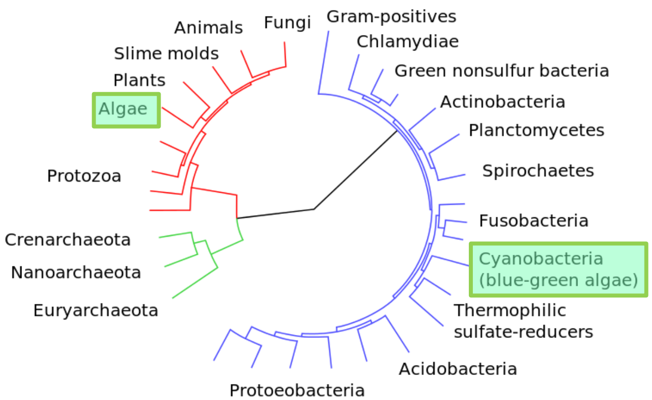
- 23 plants, 14 operational
- Size 0.3 – 5 MWe
- 2-3 food waste, 2 WW sludge, 9-10 agricultural
- Total power produced in 2014: 141 GWh
- Feed-in tariffs: ~160€/MWh (depends on size, substrate & heat used)
- No biomethane subsidies ➔ no gas enrichment

Algae

- aquatic organisms
- macroalgae, microalgae, cyanobacteria
- many species, poorly explored
- "plants" & products of the future
- photosynthesis
- huge potential







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Algal products

- Biofuels
- Bioplastics
- Biofertilizers
- Animal feed
- Food
- Omega-3 fatty acids
- Protein rich biomass
- Antioxidants
- Vitamins
- Cosmetics
- Nutriceuticals
- Custom made bioproducts (vaccines, antibodies, fine chemicals, …)








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Algal technology

How to grow, store, process and use algae.

Plants	Algae
agriculture, agronomy	algal technology
6000 years	60 years
seasonal crops	continuous harvesting
Storage	on demand
	better light & area efficiency
fertile arable land	water, degraded land, sea
fertilizer loss	no loss, reuse of growth media
chemical fertilizers	wastewater
water loss	closed systems

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Algal technology

- Biology: species, ingredients, growth conditions,
- Technology: nutrients, CO_2, light
- Economy: energy and cost efficiency
- Biorefinery: separation & down-stream processing






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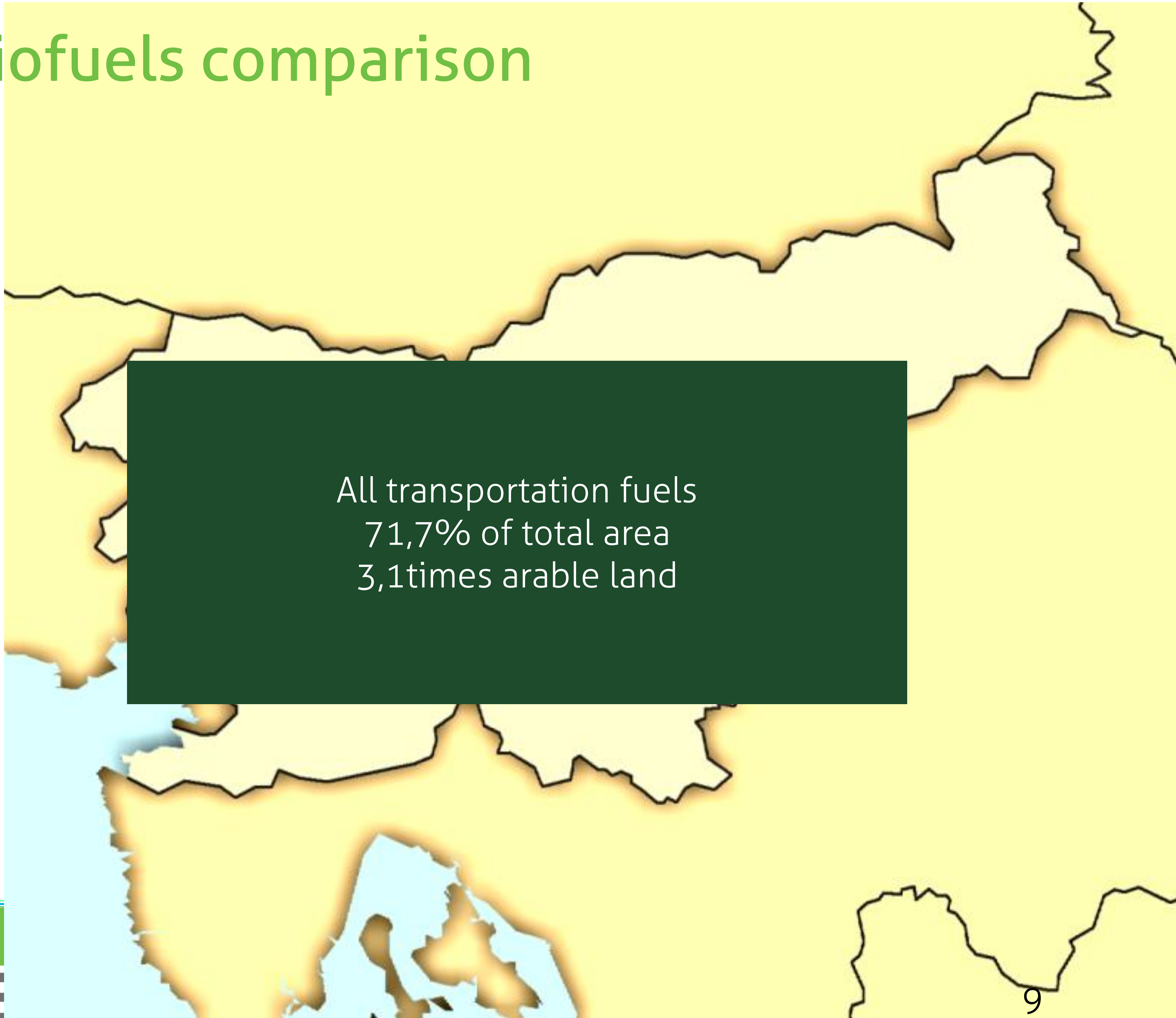
Algal fuels

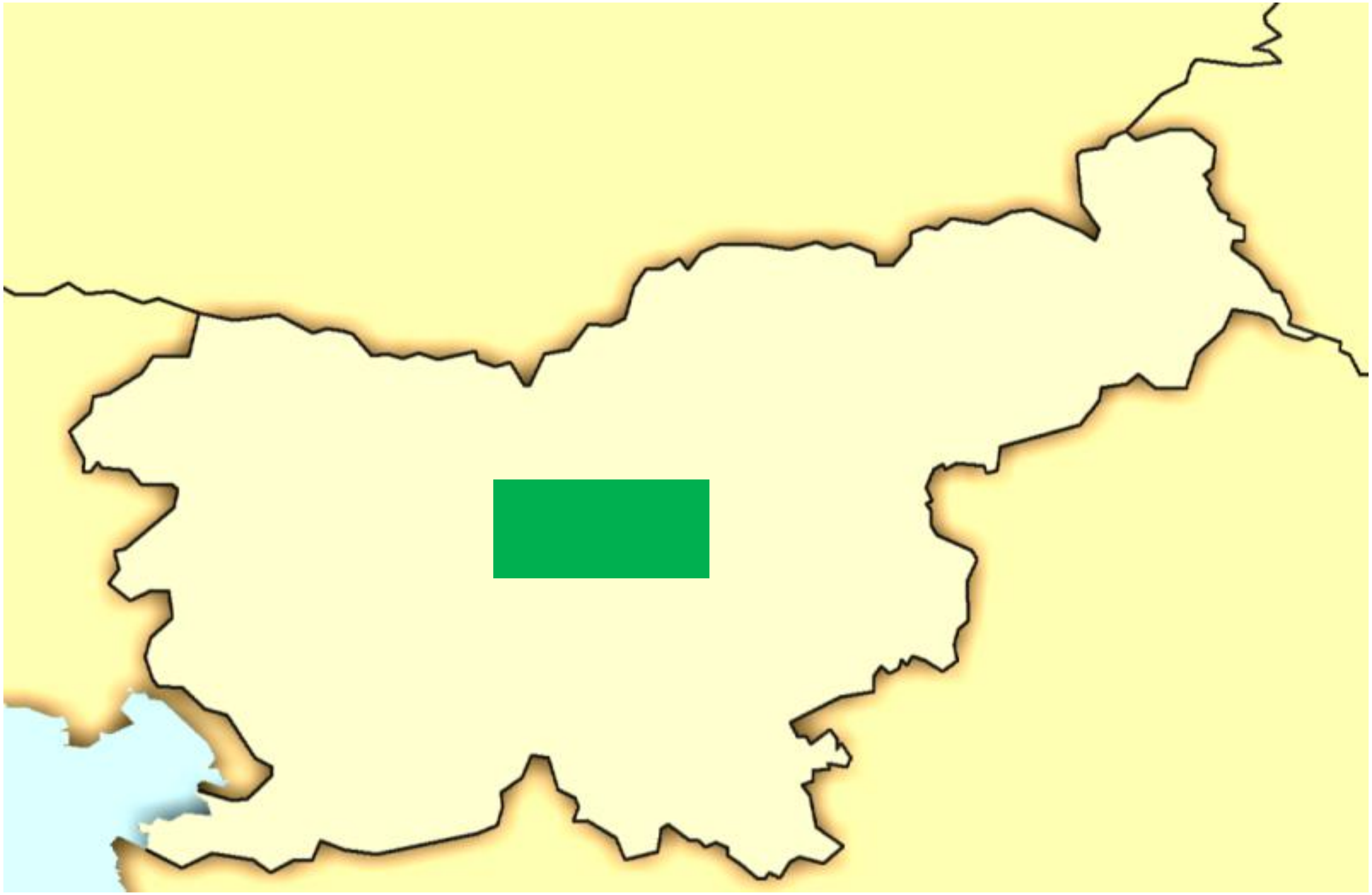
- Already using algal fuels (produced millions of years ago)
- Hydrocarbons: best energy carrier (mass, volume)
- Drop-in replacement (existing infrastructure)
- Alternatives not applicable everywhere (airliners, trucks, ships)

Biofuels comparison



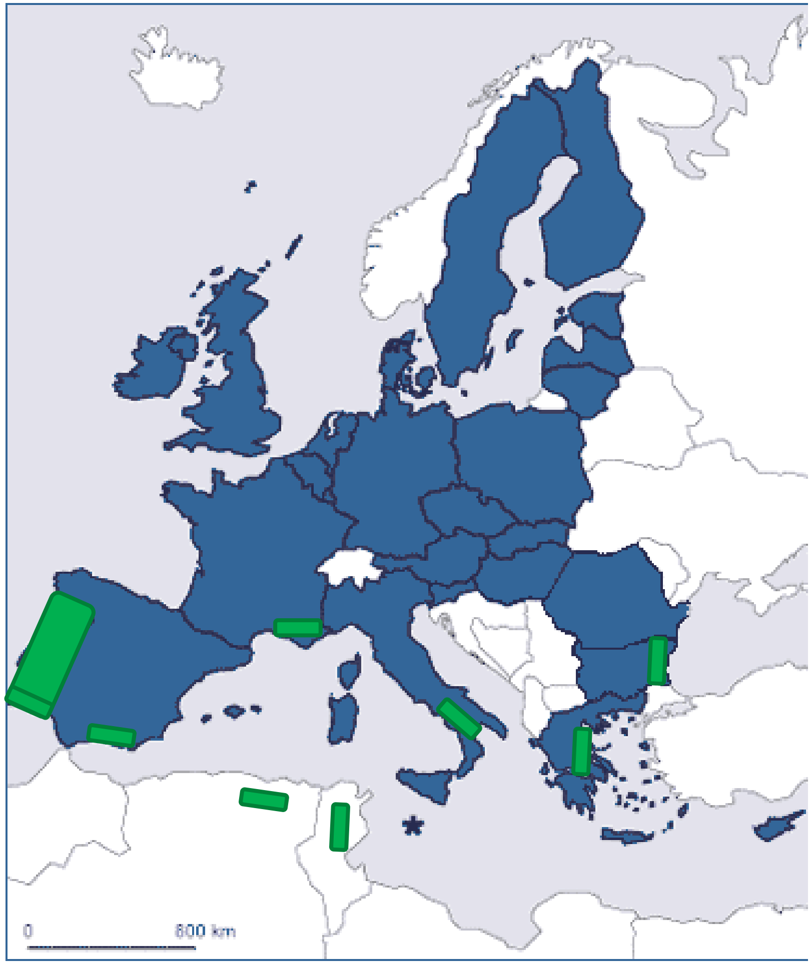
All transportation fuels
71,7% of total area
3,1times arable land

Algal fuels – all transportation fuels



Algal fuels produced in sea

All transportation fuels for EU



*Wijffels & Barbosa (2010) *An outlook on microalgal* biofuels. *Science.. 379: 796-799.)*

Algal fuel advantages

- Alternative to plant biofuels
- Non competitive tc ...od production
- Faster growth, b... ...elds
- No seasonal c...
- Better use ... ...ents
- Better u... ...ater
- Possible ... ...ne production
- Higher lipid content

but at cost 2-10€/L (today)

A biorefinery concept is required

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Other uses of algae (here & now)

- WW production ~15000 t/year
- Food (Chlorella, Spirulina)
- Nutriceuticals (asthaxantin, carotenes , Omega-3 PUFA)
- Fish and animal feed
- Biofertilizers
- Research

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AlgEn, algal technology centre

- Established 2010 in Ljubljana
- Four partners, many students
- Financing: FFFF & R&D (EU) grants
- Vision:
  - Develop
  - Partner
  - Integrate
  - Be ready
  - Play & have fun

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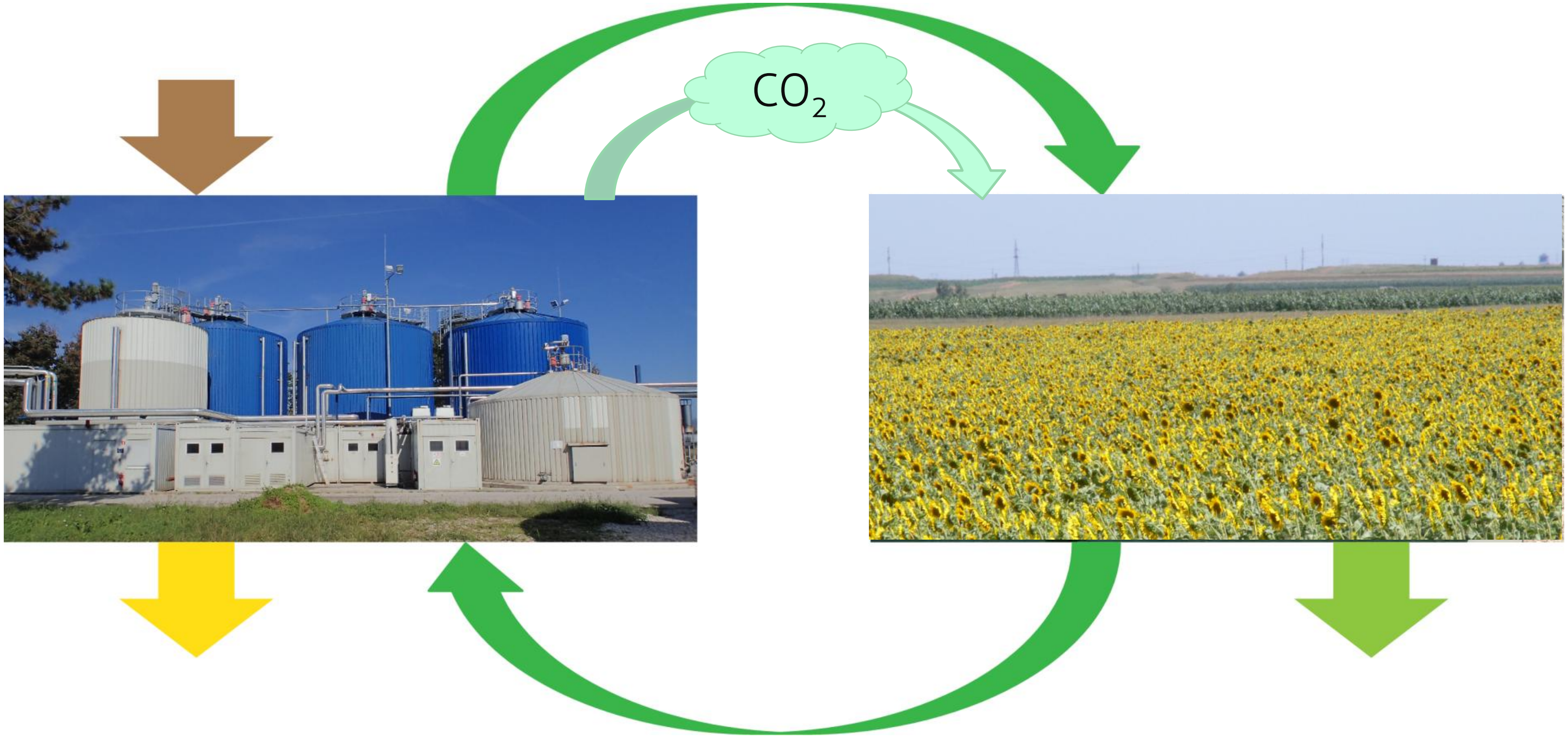
KOTO

Biogas digestate

- Ideally: all organics consumed
- Ideal agricultural fertilizer



Biogas digestate

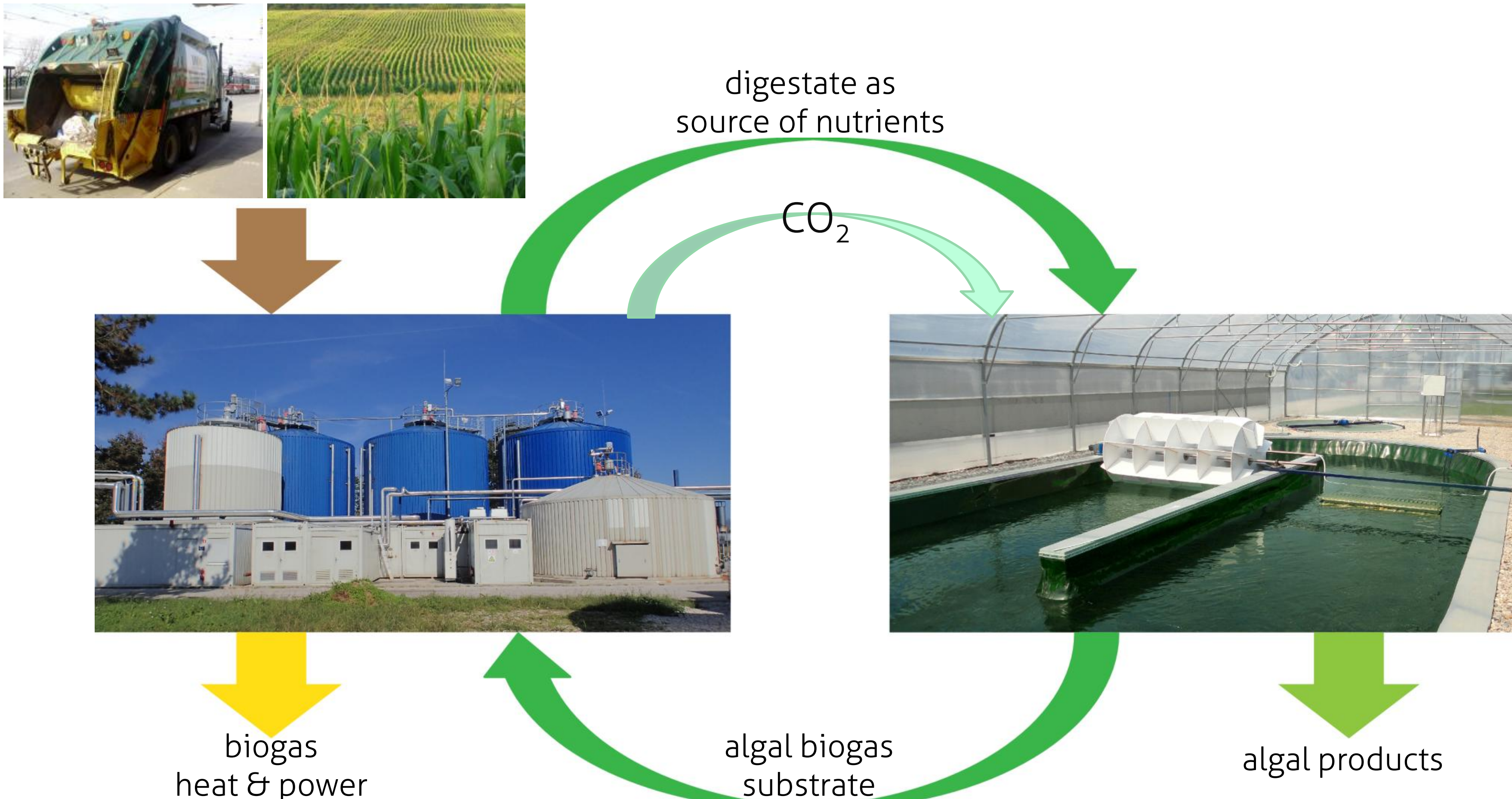
- In reality:
  - Very dilute (80-150 m^3/ha)
  - Logistics
    - Storage
    - Transportation
    - Machinery
  - Agro-technical problems
    - Liquid
    - Nutrient flushing from soil

- 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



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 wastewaer 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
- Now in Month 32/36:
  - Demonstration centre operational
  - Legislation analysis, LCA, business planning
  - Complementary technologies being tested
  - Technical development (controls, ponds)
  - Presentations & visits

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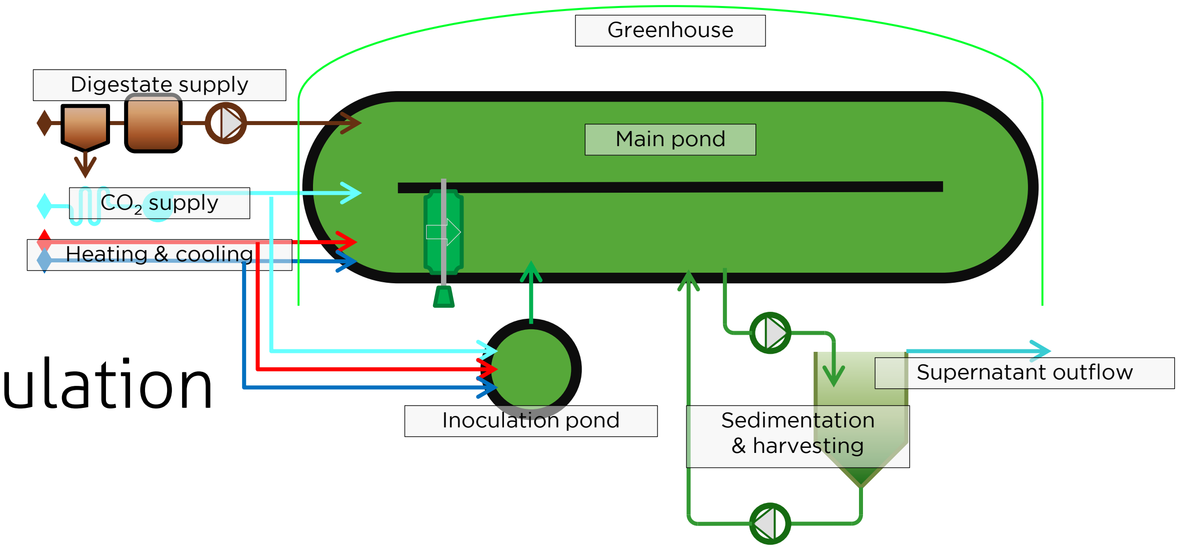
Subsystems



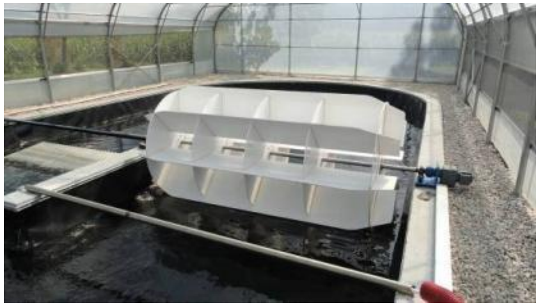
- Ponds: main & inoculation
- Mixing equipment
- Greenhouse
- Heating & cooling
- Exhaust gas supply (cooling, purification)
- Digestate supply (separation, anaerobic filter, storage)
- Sedimenter / clarifier & recycling
- Switching to DAF
- Control system

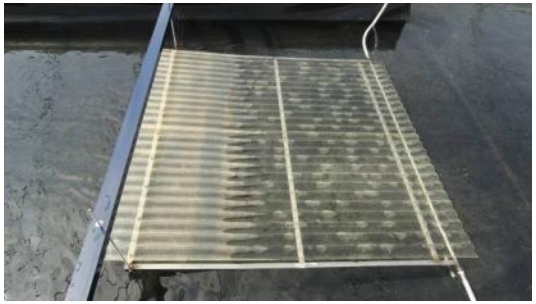
Location


Biogas plant
AlgaeBioGas
Biofilter
CHP
Gas motor
Heat exchanger
WWT plant
Digestate
separation
Image © 2014 DigitalGlobe

Greenhouse, ponds, mixing, CO_2



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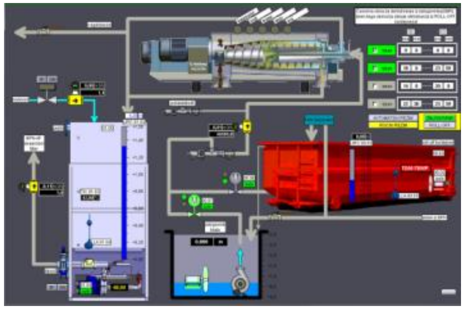
Digestate preparation



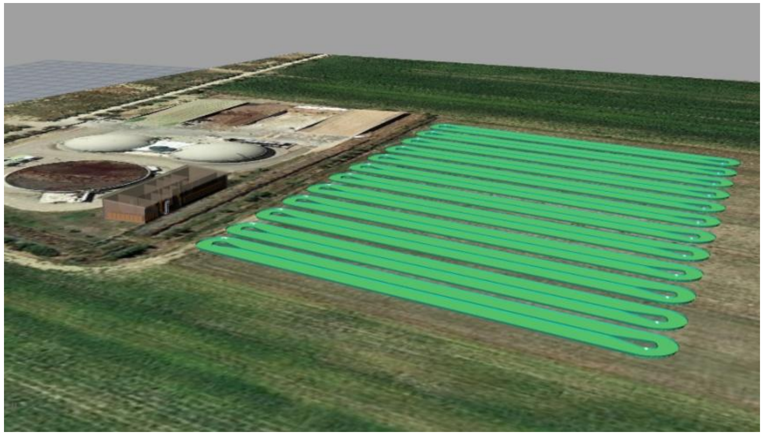

Control & instrumentation



Observed performance (digestate treatment)

- Model **biogas CHP with 1 MWe**
- to recycle major part of nutrients
  - area 3 - 5 ha
  - 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

Future



- Installation #2 in Italy (0.5 ha)
- Complementary technologies:
  - Digestate pre-treatment
  - Auto(bio)flocculation, DAF
  - ALBA biomass pre-treatment for biogas
  - Animal feed trials (fish, chicken)
- Technical & manufacturing
  - More cost-effective ponds
  - Better performance & more control
- **Partners**: sales & implementation service

Future

- An H2020 project Saltgae: Demonstration project to prove the techno-economic feasibility of using algae to treat saline wastewater from the food industry (in negotiation phase)
- Demonstration site for treating tannery wastewater

Thank you for your attention

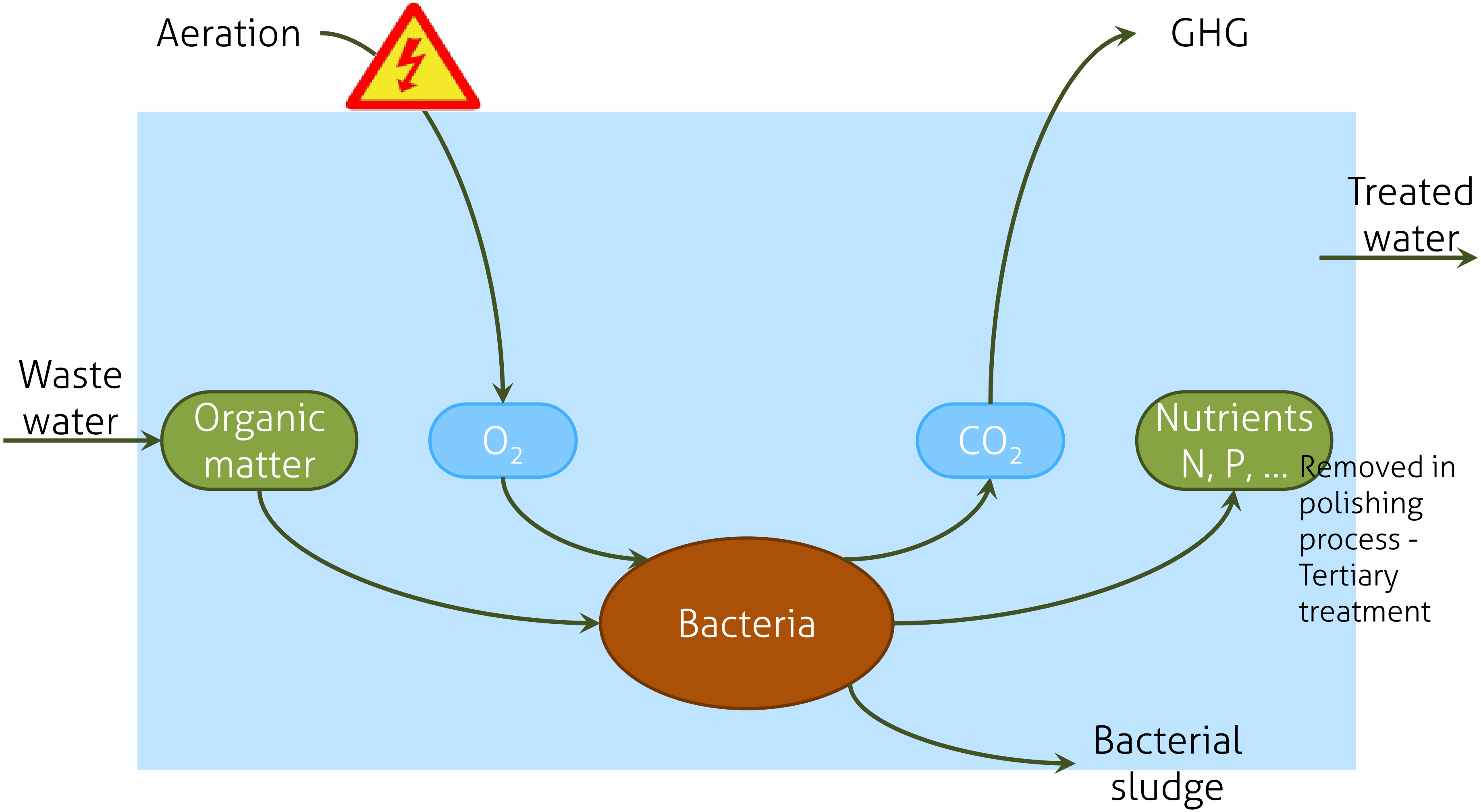
- Questions?

- Welcome to the visit the ABG AlgaeBioGas demonstration centre.

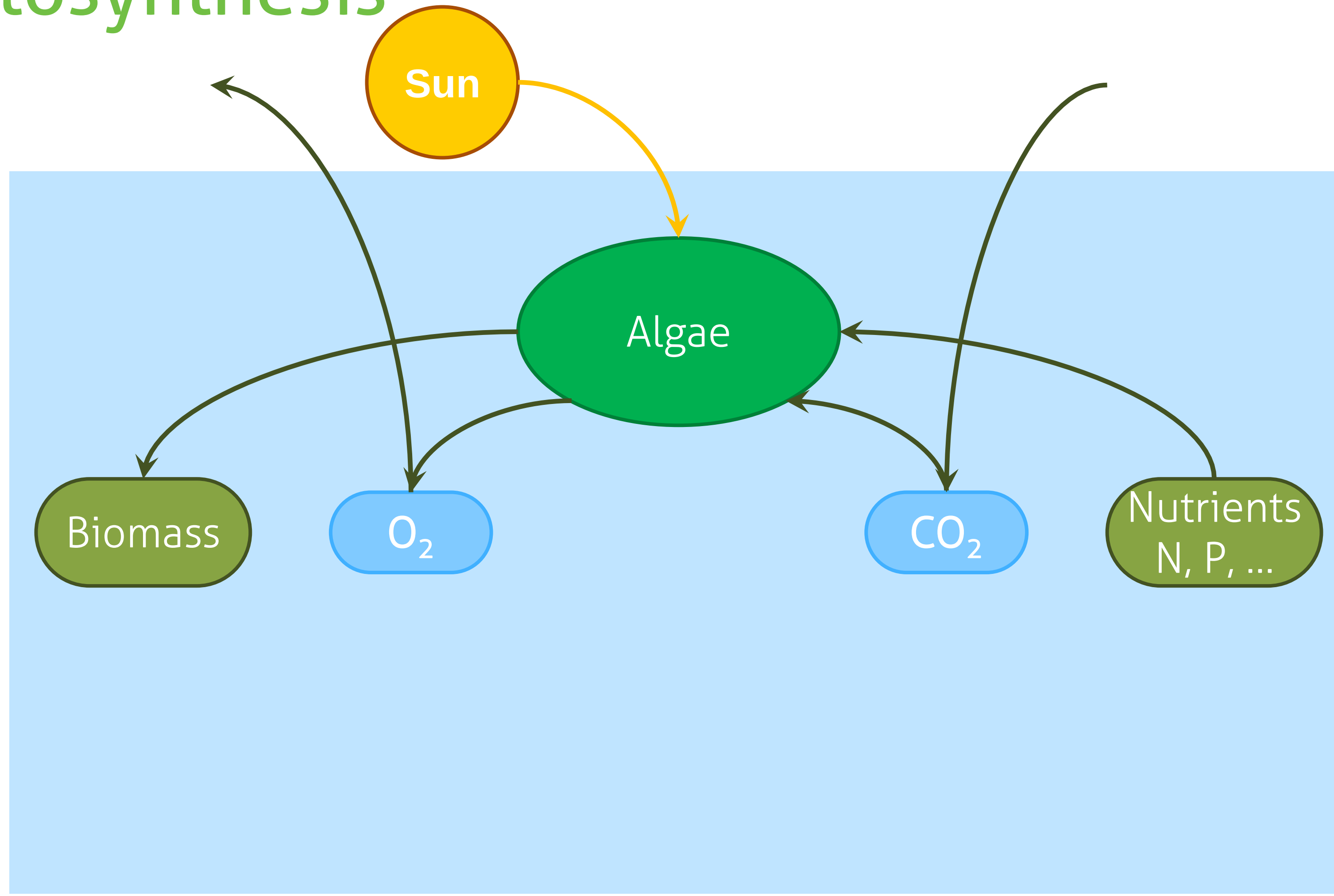
Wastewater

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

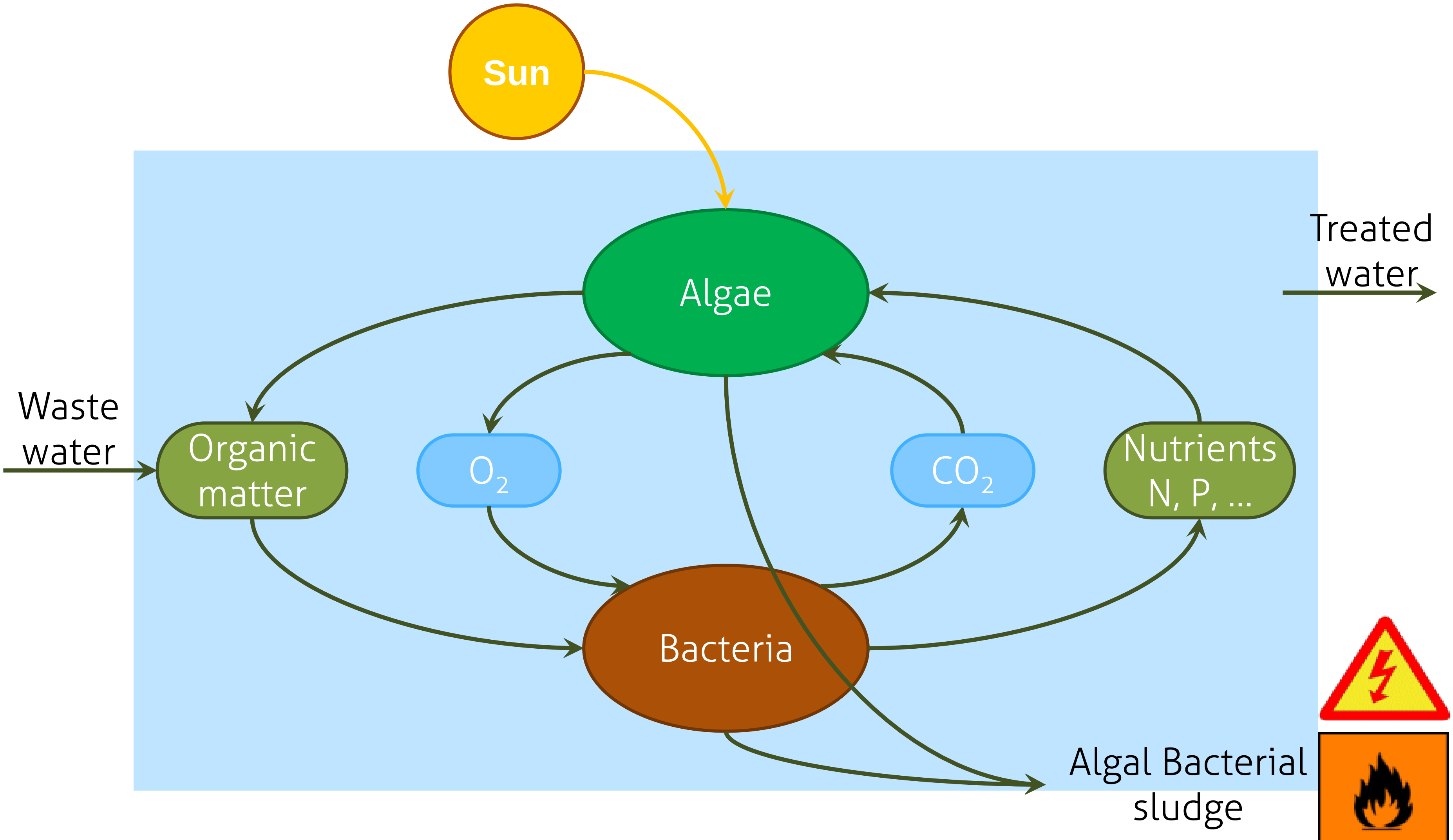
Algal bacterial process
Biological Aerobic Wastewater Treatment



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 additional CO_2

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 - how long oxygenation lasts?
- floc ecology, auto-flocculation

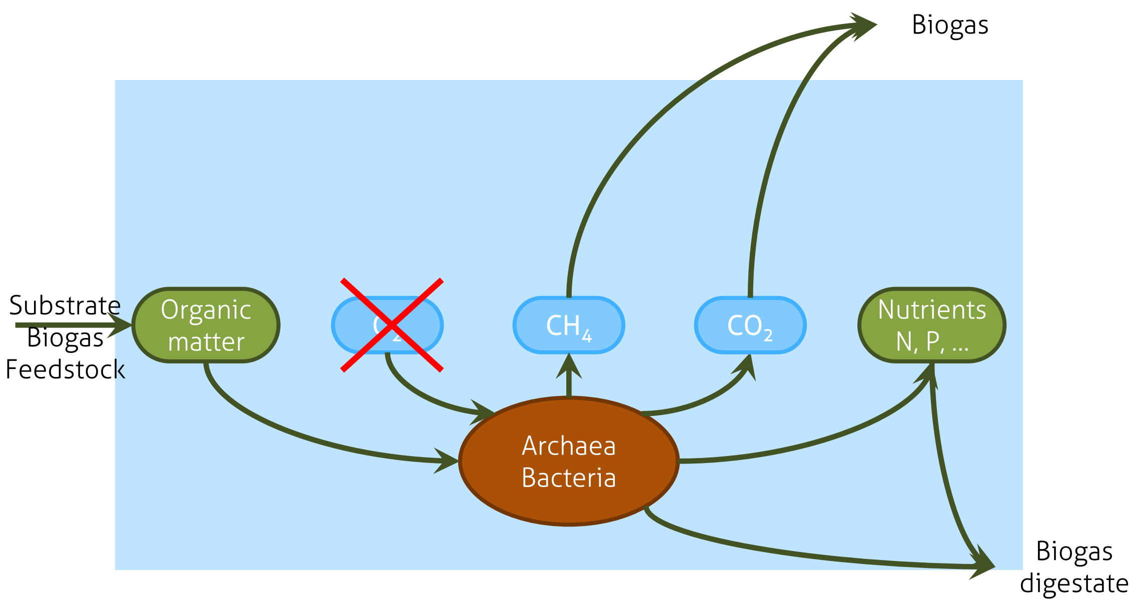
Wastewater as nutrient source

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

- Algae & biogas – basic technology for energy and nutrient recuperation from wastewater

Biogas

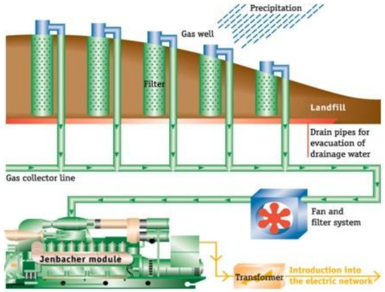
- Anaerobic digestion
  - Anaerobic bacteria (Archaea) converting organic matter to methane (and H_2, CO_2, H_2S, ...)
- A waste treatment technology



Biogas flavours

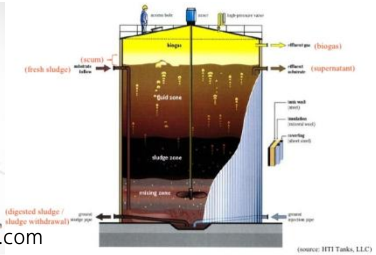
- Landfill gas
- Wastewater sludge
- Bio waste
- Wastewater (anaerobic treatment)
- Agricultural waste
- Energy crops

- Biogas is the most efficient biofuel



LSI group


www.acs-environment.com


HTI tanks

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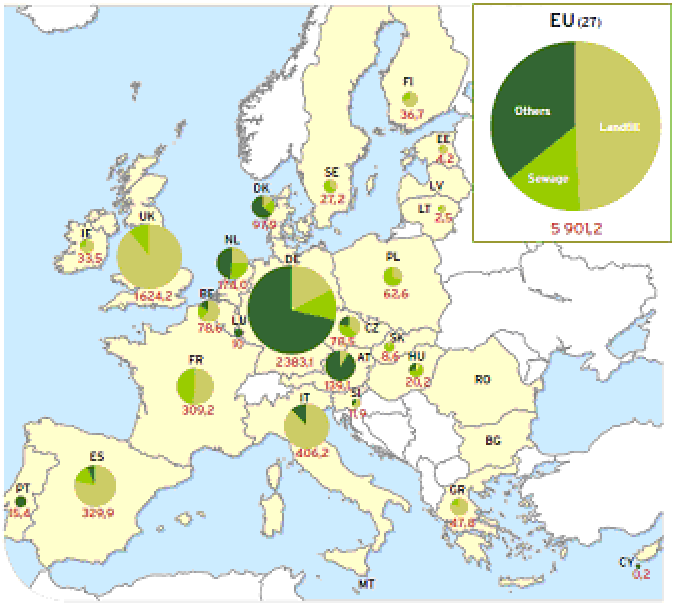
Biogas plants

- Different technology levels
- Mesophilyc / thermophilic
- Biogas use
  - Heat
  - Combined heat and power (CHP)
  - Gas networks (enriched biogas)
- Legislation & subsidies
  - Gas grid ↔ CHP
  - Waste ↔ energy crops
  - Access to power grid
  - Nitrogen vulnerable zones



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