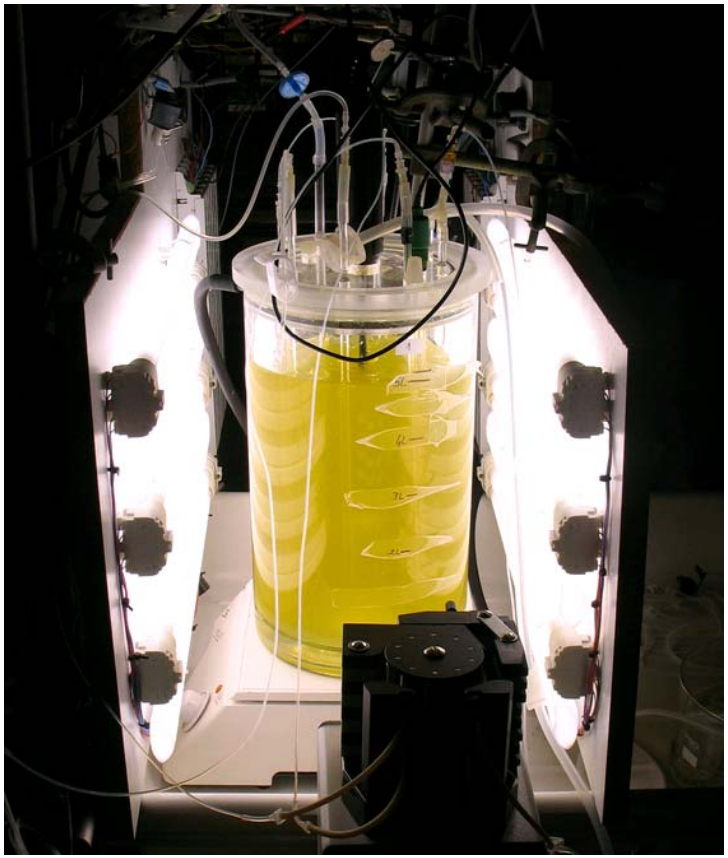
3 years of active research on microalagal biofuel in Europe : achievements and hurdles



Bruno SIALVE
(Naskeo Environnement)
&
Olivier BERNARD
(INRIA)

Shamash

SYMBIOSE

3 years of active research on microalagal biofuel in Europe : achievements and hurdles

- Projects in Europe
- Overview of French projects
- Focus on Shamash and Symbiose projects : objectives and some results
- Conclusion : achievements and hurdles

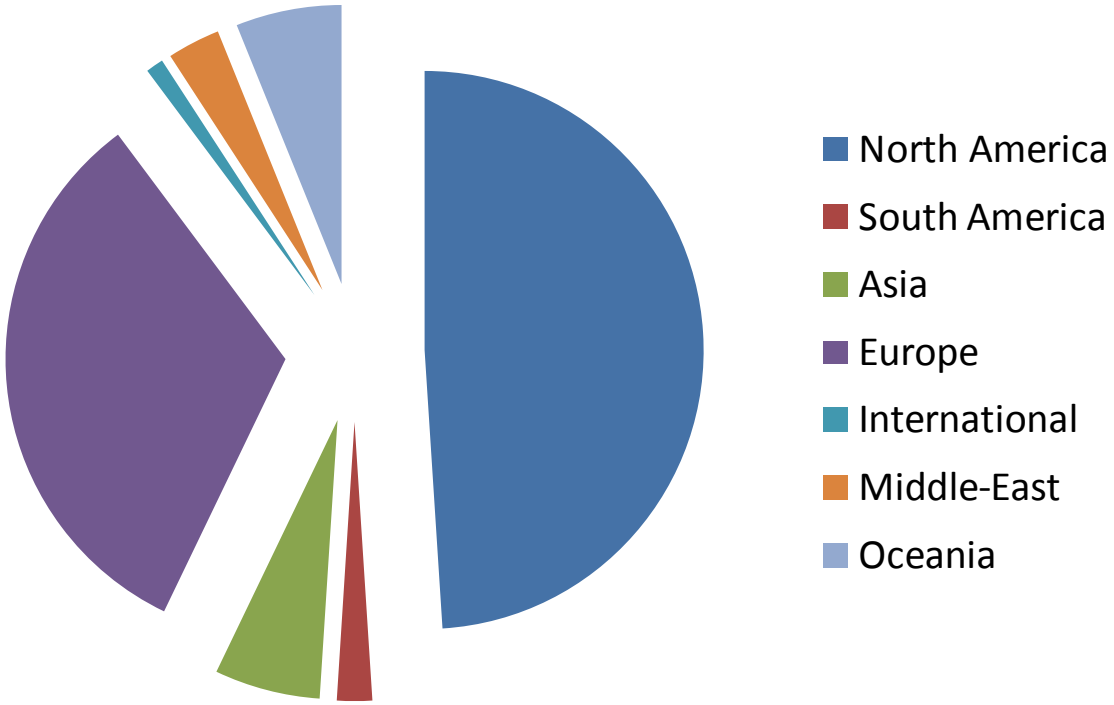
1 Microalgae for energy in Europe

Study based on data from the Internet (« project » websites and reports)

- Activity = project involved in producing energy from microalgae (Lab, company…)
- A project is defined as working in (one or several tasks):
  - Algae (selection, caracterisation…)
  - Culture
  - Molecule(s) extraction
  - Energetic valorisation
- **104 « activities » identified**

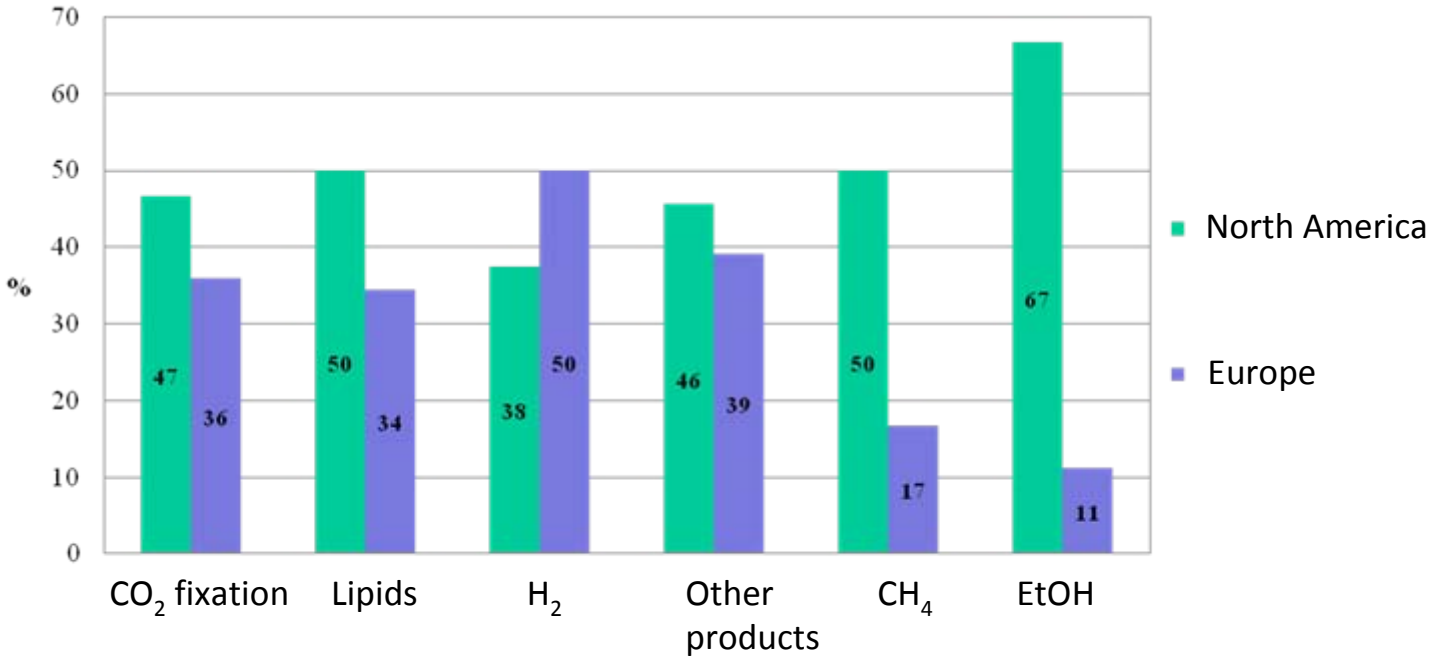
1 Microalgae for energy in Europe

- 104 identified « activities » in the field of energy from microalgae

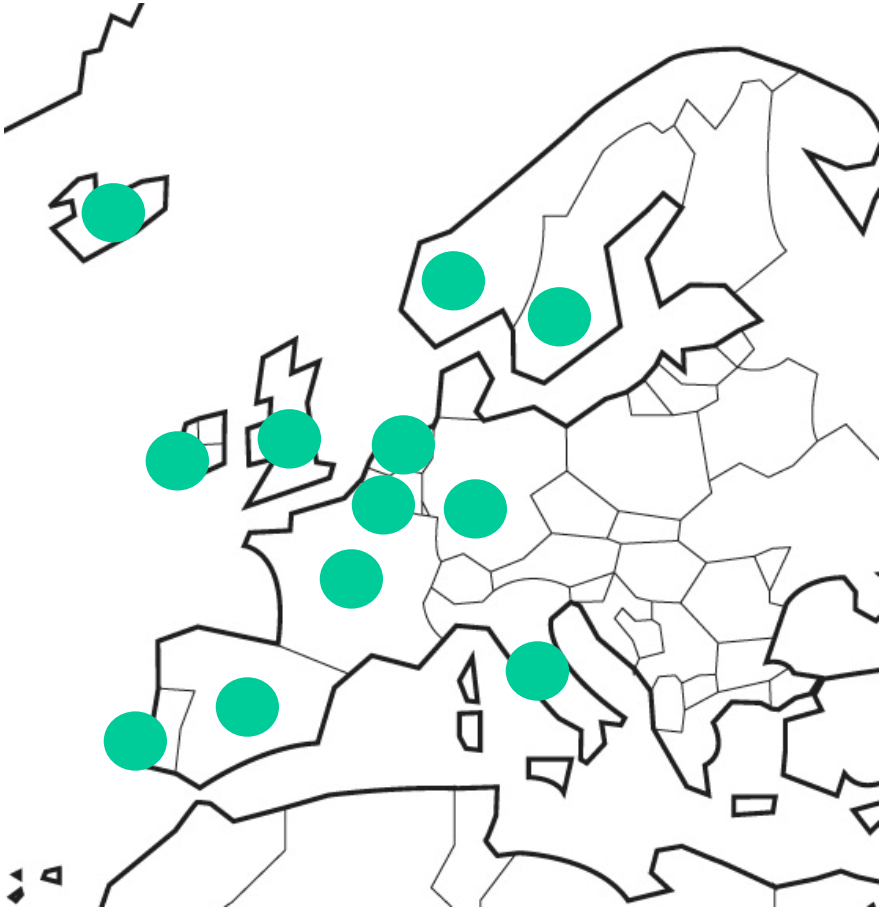


1 Microalgae for energy in Europe

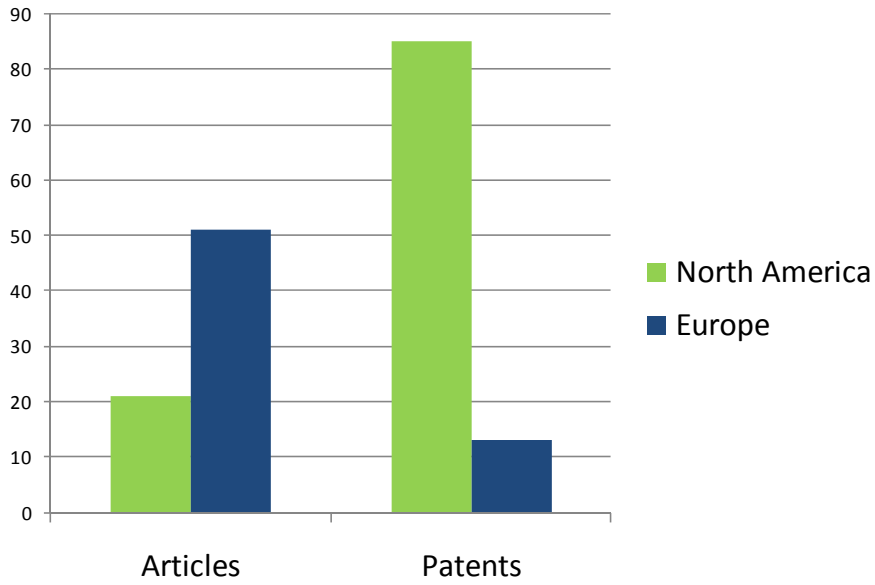
- Energy production from microalgal biomass



1 Microalgae for energy in Europe



- Most European countries involved
- 60 % < 2006
- 56% Main activity



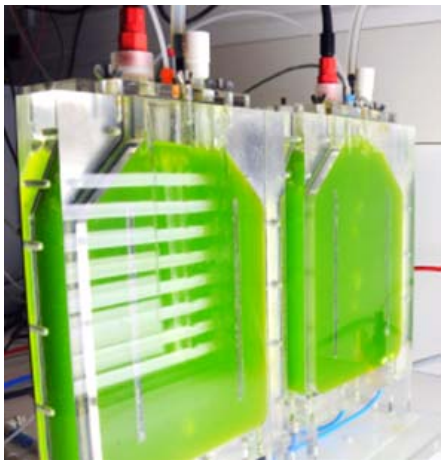
2 Microalgae for energy in France

- Shamash (INRIA)
- Symbiose (Naskeo)
- Algomics (CEA)
- Biosolis (GEPEA)
- Fermentalg (SA)
- Winseafuel (Biocar) (Macroalgae)
- ….

Focus on Shamash project

Shamash

Lipid biofuel production from microalgae



2006-2010

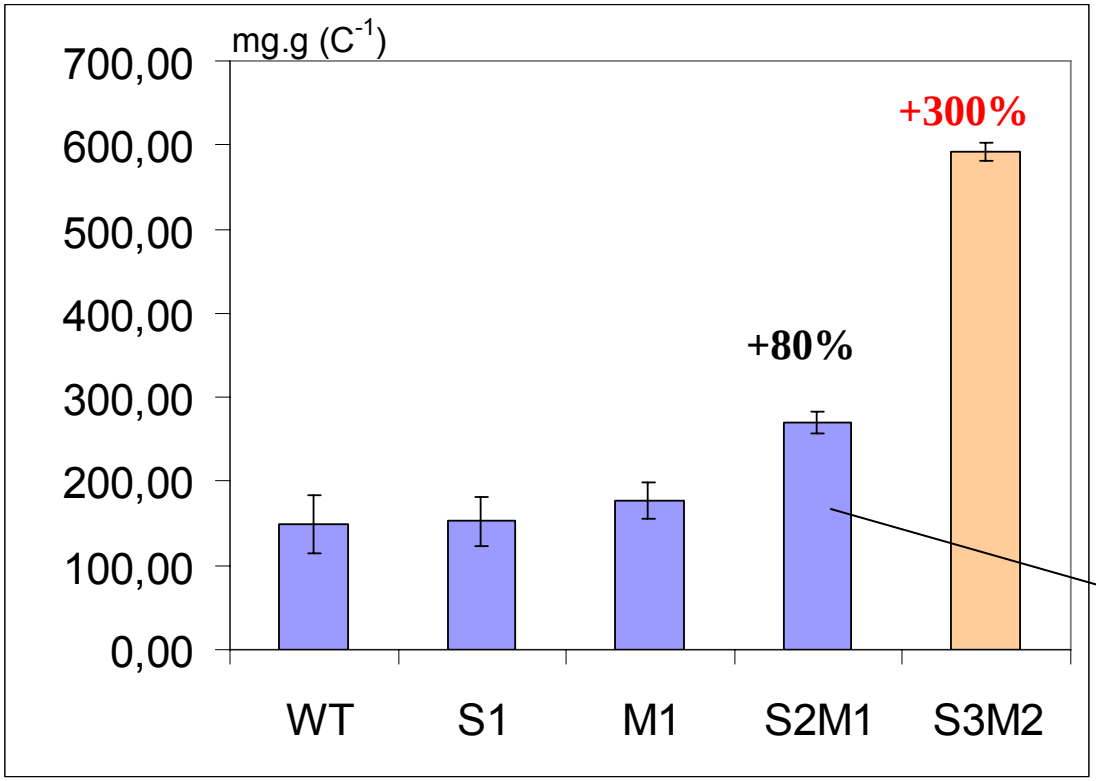
8 Partners

Coordination: Olivier BERNARD

Budget : 3 Millions €
Founded by the National Research Agency

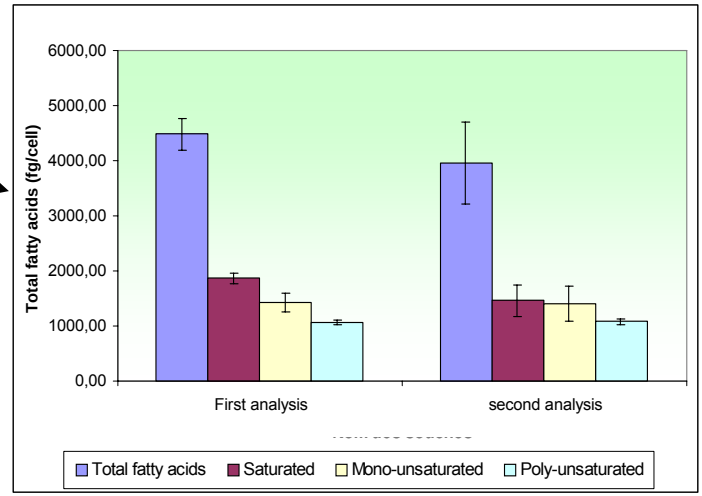
3 Focus on Shamash project : achievements

Mutation/selection of *Isochrysis affinis galbana*

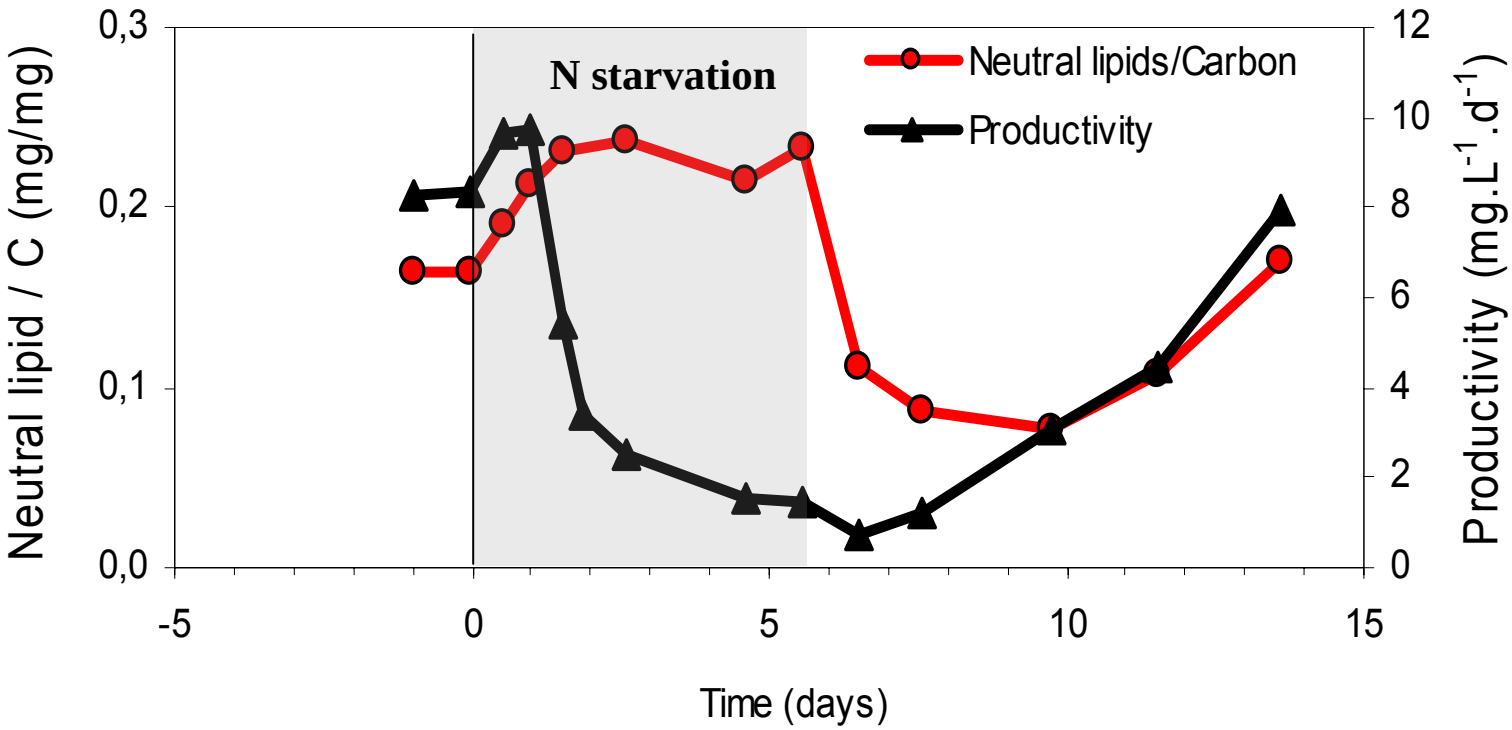


The selection-mutation process leads to a 300 % increase of total fatty acids produced

Stability of the new strain



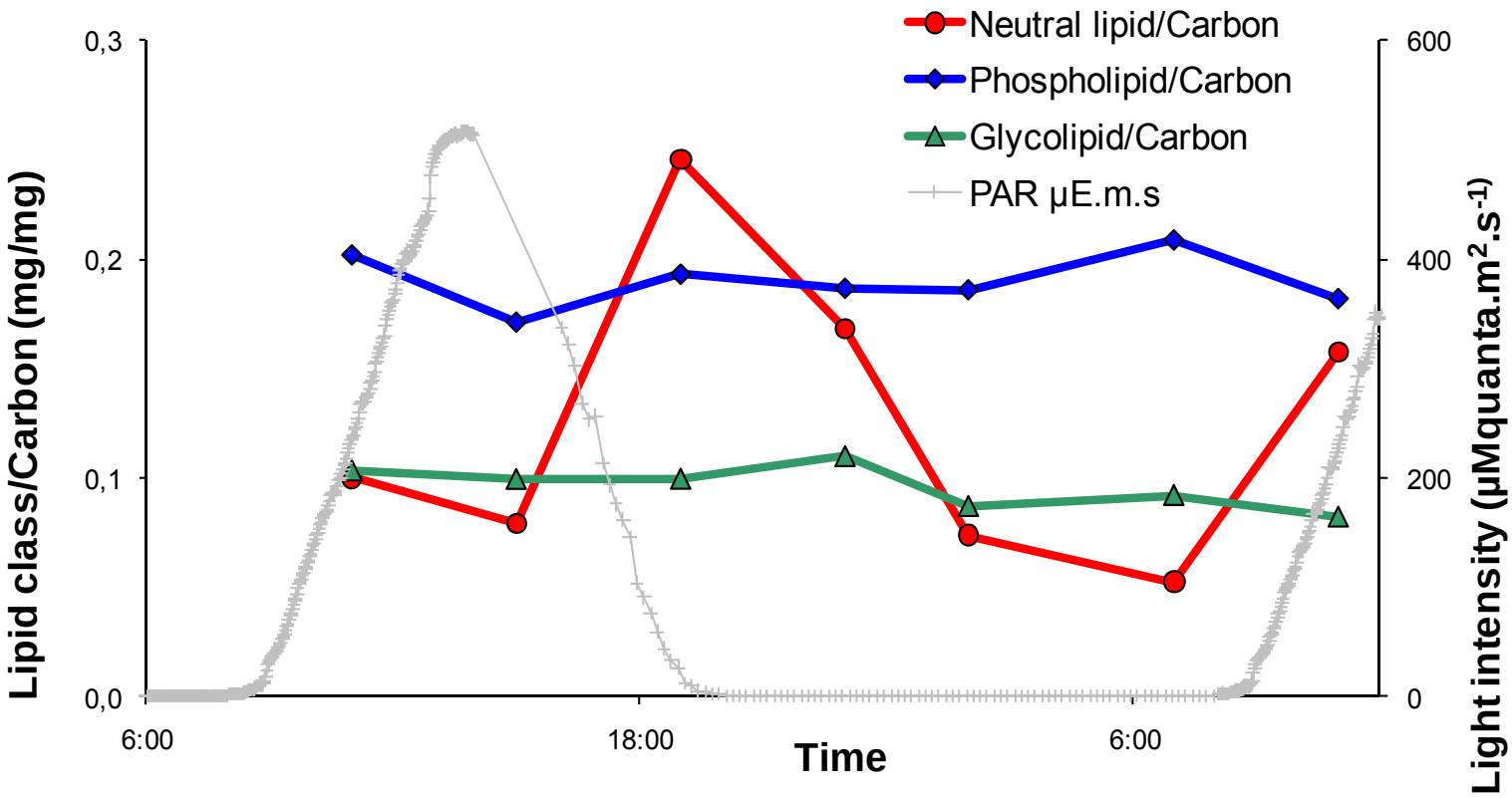
3 Focus on Shamash project : achievements



► Neutral lipids are highly accumulated during nitrate starvation (**+ 44 %**) and consumed after N re-supply

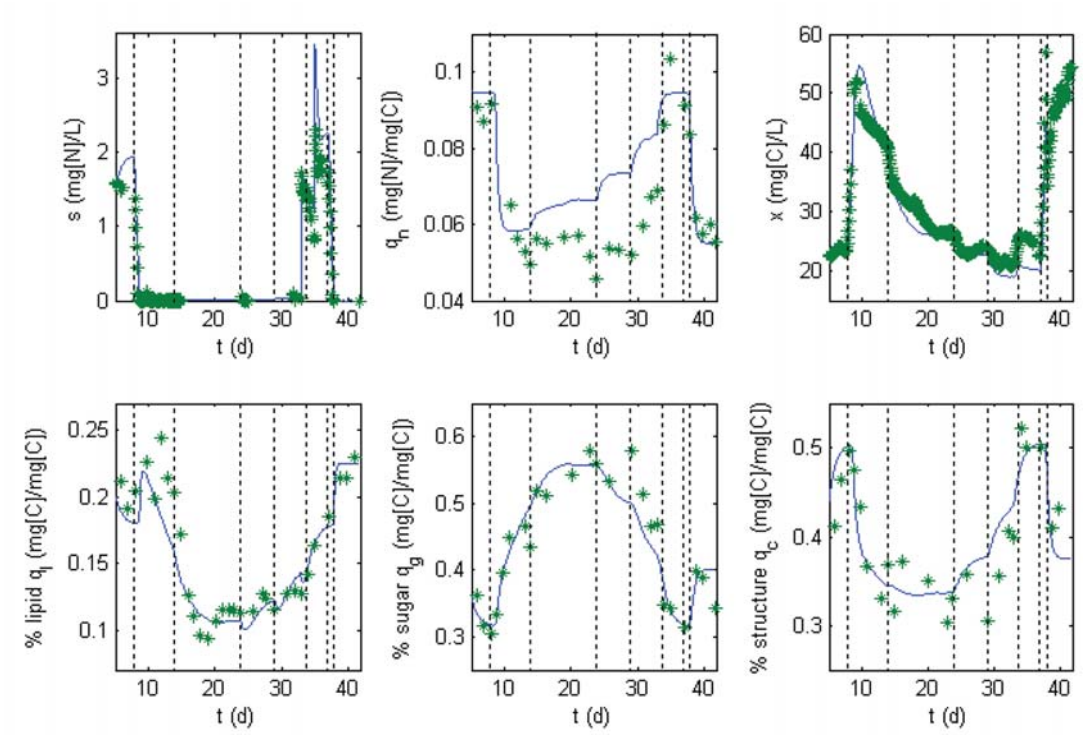
► But, the **productivity** (mg neutral lipid.L^{-1}.D^{-1}) is enhanced by **only 15 %** during a short and transient time period

3 Focus on Shamash project : achievements



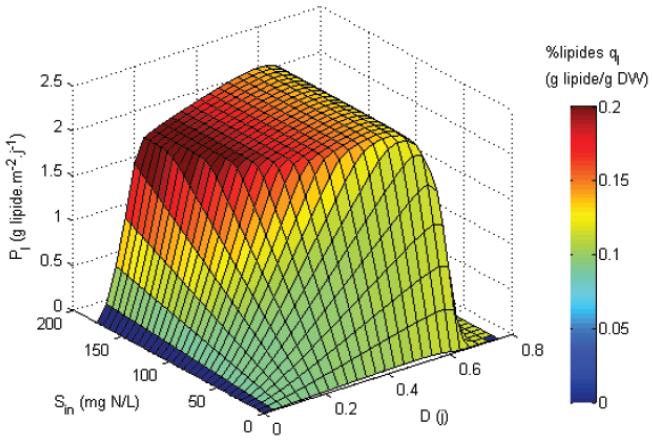
- Phospholipid and glycolipid quota are not affected by L/D cycle.
- Neutral lipids are accumulated during light period and consumed during the night.

Developping numerical models



Numerical model for photobioreactor experiments with I.galbana

Productivity predictions



B.Sialve & O.Bernard

Focus on Symbiose project

Symbiose
Microalgae to methane production

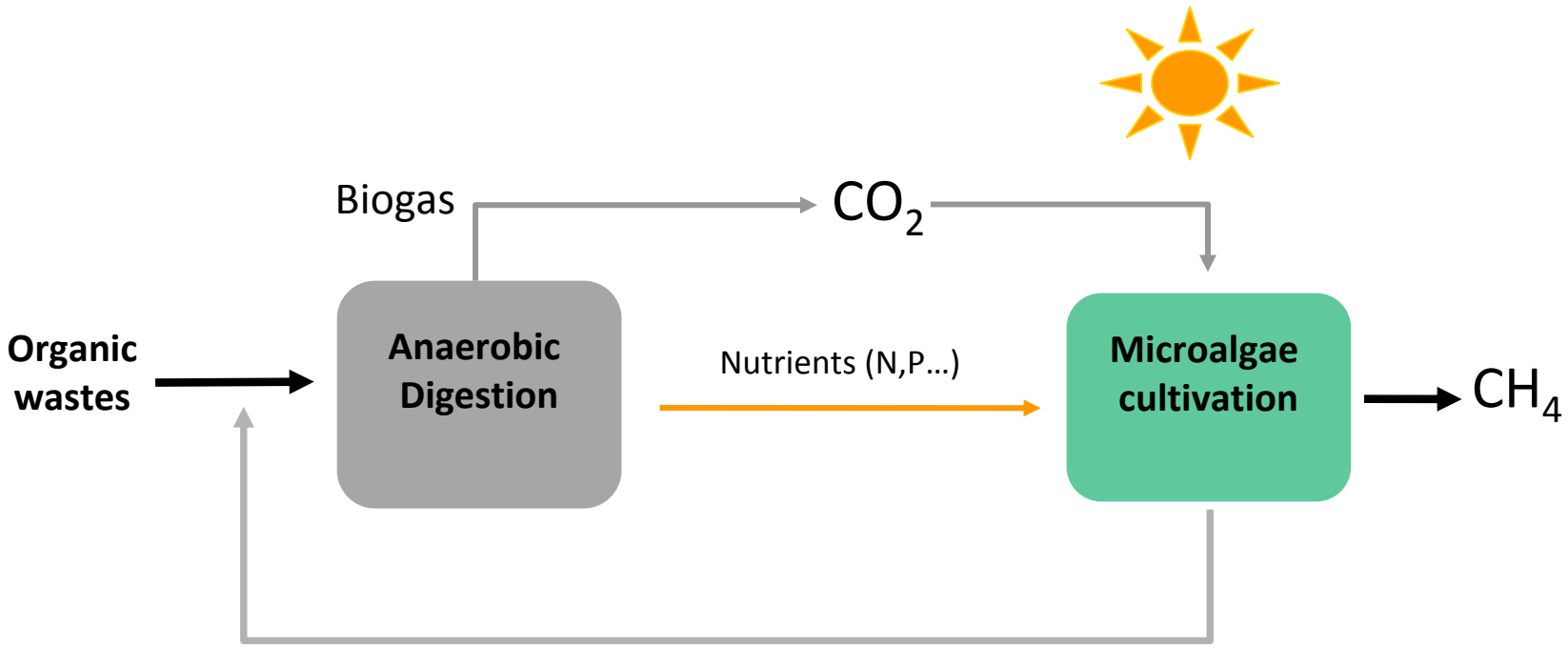
2009-2011

5 Partners

Coordination: Bruno SIALVE

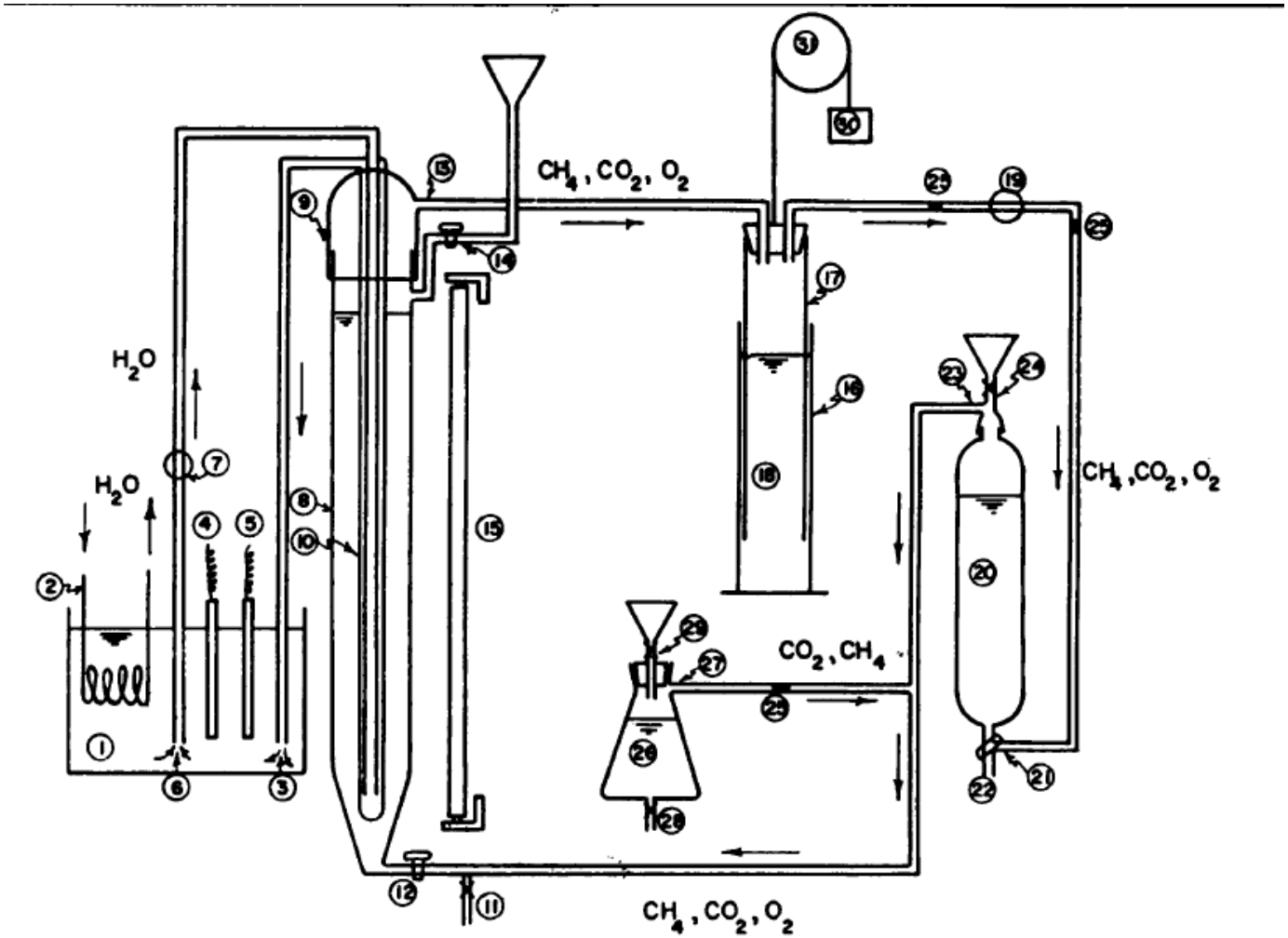
Budget : 2,5 Millions €
Founded by the National Research Agency

3 Focus on Symbiose project



- Flue gas and Organic waste treatment
- Need for external inputs decreased
- Solar energy recovery

3 Focus on Symbiose project



Goeluke & Oswald (1959)

3 Focus on Symbiose project

Reactor	Substrate	T (°C)	HRT (d)	Loading rate	Methane productivity L CH_4 g VS^{-1}	CH_4 (% vol)	References
Batch 11 L	Algae sludge (*Chlorella – Scenedesmus*)	35-50	3-30	1.44 – 2.89	0.17 – 0.32	62 - 64	(Golueke et al., 1957)
	Algal biomass	35	28	1	0.42	72	(Chen, 1987)
	Spirulina	35	28	0.91	0.32 – 0.31		
	Dunaliella	35	28	0.91	0.44-0.45		
CSTR 2-5 L	*Tretraselmis* (fresh)	35	14	2	0.31	72-74	(Asinari Di San Marzano et al., 1982)
	Tretraselmis (dry)	35	14	2	0.26	72-74	
	Tretraselmis (dry) + NaCl 35g/L	35	14	2	0.25	72-74	
Batch 5 L	*Chlorella vulgaris*	28-31	64	-	0.31-0.35[a]	68-75	(Sanchez and Travieso, 1993)
Semi continous (daily fed) 10 L	*Spirulina maxima*	35	33	0.97	0.26	68-72	(Samson and LeDuy, 1982)
Fed Batch 2 L	*Spirulina maxima*	15-52	5-40	20-100	0.25-0.34	46-76	(Samson and LeDuy, 1986)
CSTR 4L	*Chlorella-Scenesmus*	35	10	2-6	0.09-0.136	69	(Yen and Brune, 2007)

[a]estimated from data given in L CH4.gCOD-1 using a COD/VS ratio of 1.5xx

- Methane productivity: 0.2-0.5 L CH_4/g VS (~0.2 – 0.5 g oil/g d.w.)

3 Focus on Symbiose project

- Main identified limitations in AD
  - High proteins content (NH_3 issue)
  - Cell wall resistance and cell survival
  - Sodium toxicity for marine species

- Solutions
  - Selection of adapted species
  - Increase C/N Ratio (codigestion or metabolic strategy)
  - Biomass pretreatments

(Sialve et al, Biotechnology Advances 2009)

3 Focus on Symbiose project

- First Steps

  - Ecosystems (microalgae + bacteria) showed good responses in AD effluents assimilation
  - Recycling effluents can decrease 70 % of nitrogen inputs
  - Methane potentials are in the upper range
  - LCA demonstrate the strong environmental impact of extraction, harvest, and nutrients supply (microalgae to lipids)[1]

[1]Lardon et al. Environmental Science and Technology (2009)

Conclusion : hurdles for biofuel production

■ **Technical challenges:**

- Study more realistic conditions (temperature, light…)
- Biomass harvesting and lipid extraction: energetic cost!
- Manage the (huge) fluxes of nitrogen and phosphorus
- At the same time produce biofuel, mitigate CO_2 , process wastewater and recover some high added value compounds

■ **Strategic:**

- LCA will guide researches and orient towards sustainability
- Need for pilot/industrial scale culture units
- Need for investments
- Lack of qualified experts !

Thank you for your attention !

http://www-sop.inria.fr/comore/shamash

http:// www.anr-symbiose.org