

BLUE BIOTECHNOLOGY ALLIANCE
INTERNATIONAL CONFERENCE
11 - 14 AUGUST 2018 IN GREIFSWALD

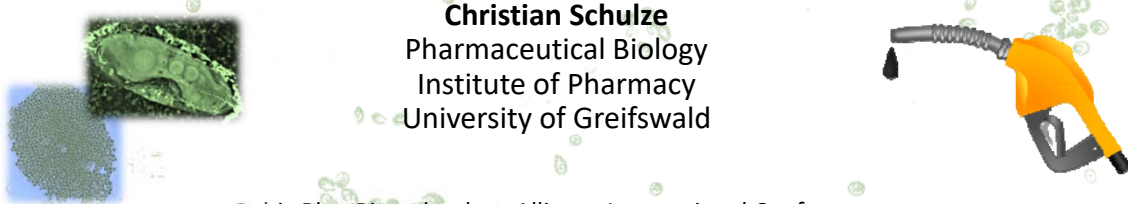
BLUE BIOTECHNOLOGY
IN THE BALTIC SEA REGION
From Science to Business

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Microalgae for Biofuels – Revolution or Reverie?

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Blue Biotechnology in the Baltic Sea Region – From Science to Business
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The slide features a background of green microalgae. On the left, there are two images: a microscopic view of a green microalga and a pile of dark green biomass. On the right, there is a yellow and black fuel nozzle. The University of Greifswald logo is in the top right corner.

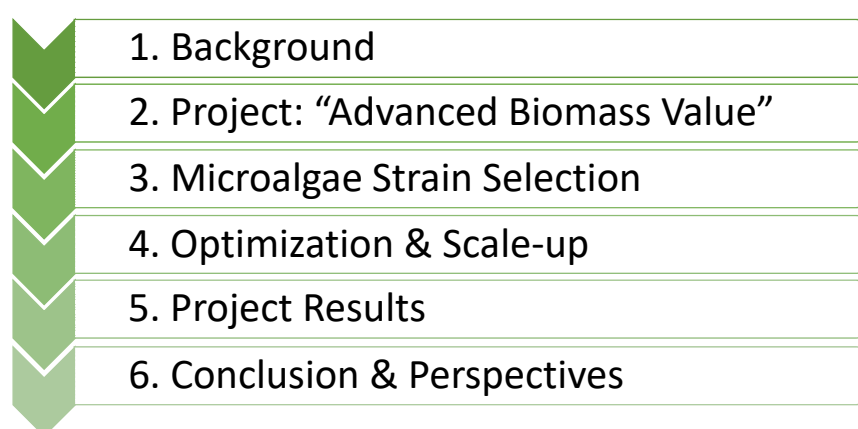
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3. Microalgae Strain Selection
4. Optimization & Scale-up
5. Project Results
6. Conclusion & Perspectives

Microalgae for Biofuels – Revolution or Reverie?

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The content list is presented as a vertical stack of six white rectangular boxes with rounded corners, each containing a number and a title. To the left of each box is a green arrow pointing downwards. The University of Greifswald logo is in the top right corner.



1. Background

- increasing human population + raised standard of living
 - exploding energy demand
- rising combustion of fossil fuels
 - rising CO₂ emission
- increasing atmospheric CO₂ concentration
 - green house effect, global warming, apocalypse
- CO₂-neutral energy sources needed:
 - renewable sources
 - wind, solar, water power: energy storage?
 - biofuels
 - conventional: environmental issues, limited agriculture land → food competition
 - **Microalgae?**



1. Background (2012)

Microalgae as a source for biofuels?

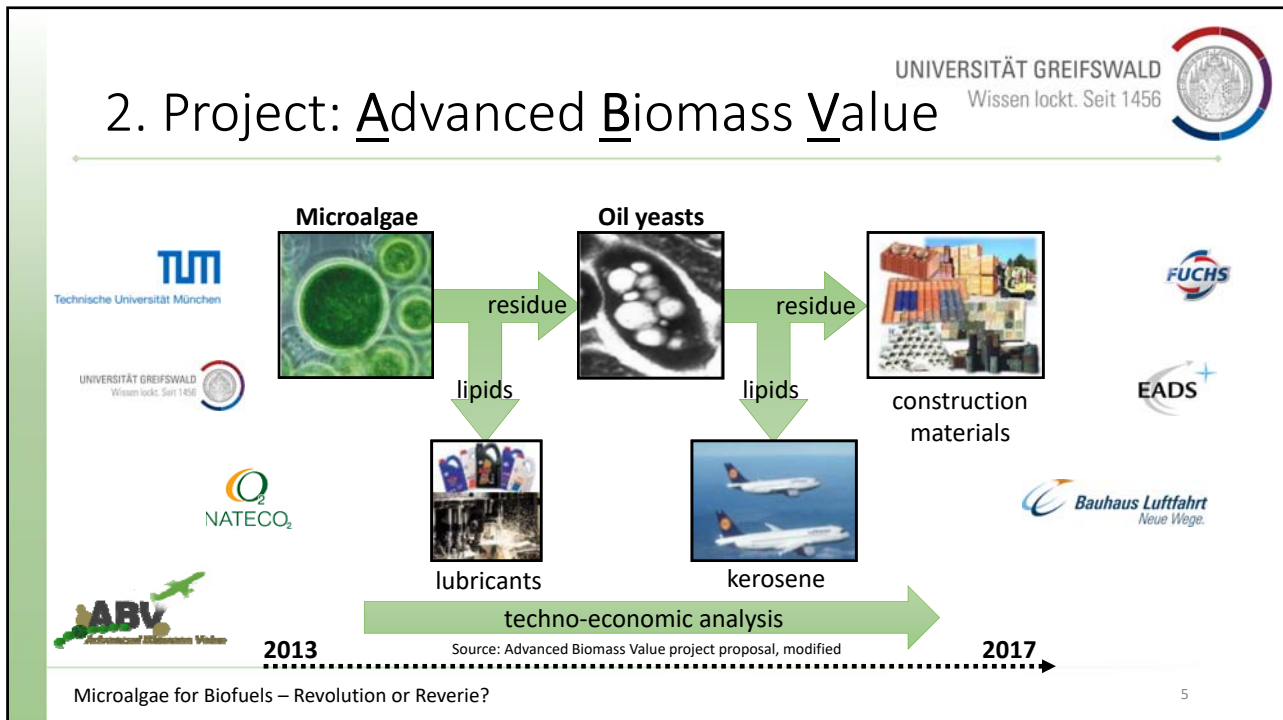
pros

- high growth rates (up to 100× higher compared to land plants?)
- cultivation on barren land/urban areas: no competition to food production

challenges

- cultivation & harvesting expensive
- low product yield & incomplete biomass utilization





2. Project: Advanced Biomass Value

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Some **characteristics** of the ABV-Project

- whole biomass utilization
- lipid extraction by supercritical CO₂

Aims of the ABV-Project

- identification of fast-growing algae strain
- microalgal growth optimization
 - increased lipid & carbohydrate yield
 - reduced cultivation costs
- techno-economical analysis of the whole concept

Why scCO₂?

- solvent characteristic like n-hexane
- no organic solvents
- easy solvent regeneration

NATECO₂

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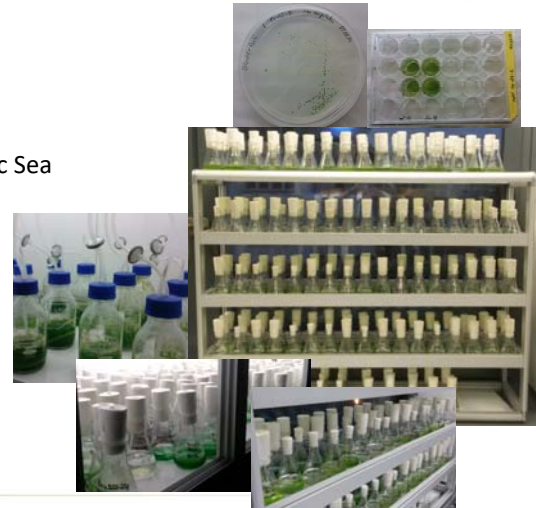
3. Microalgal strain selection

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- > 70 species tested under standard laboratory conditions
 - fresh- and seawater species
 - Chlorophyta, Rhodophyta, and other
 - origin: strain collections, new isolates e.g. from Baltic Sea

- best-growing species:
 - *Monoraphidium* spp.
 - *Chlorella* spp.
 - *Desmodesmus* spp.
 - *Scenedesmus* spp.
 - ***Scenedesmus obtusiusculus A189*** ($0.05 \text{ g L}^{-1} \text{ d}^{-1}$)
→ used for optimization experiments



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4. Optimization & Scale-up

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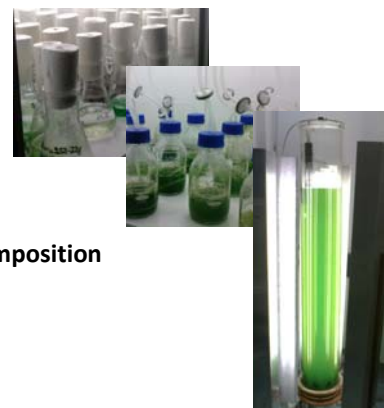


A) Optimization of growth conditions for increased biomass yield

- pH (6-11)
- temperature (15-38°C)
- light supply ($50\text{-}2000 \mu\text{mol Photons m}^{-2} \text{ s}^{-1}$)
- reactor design & size (bubble column, flat plate; 0.05 L - 400 L)

B) Medium optimization for cost reduction & improved biochemical composition

- identification of essential nutrients
- identification of optimal nutrient concentrations
- usage of cost-saving water sources as medium basis
 - Artificial Brackish Water, Baltic Sea Water, Peene River Water



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4. Optimization & Scale-up

A) Optimization of growth conditions for increased biomass yield

→ up to $2 \text{ g L}^{-1} \text{ d}^{-1}$

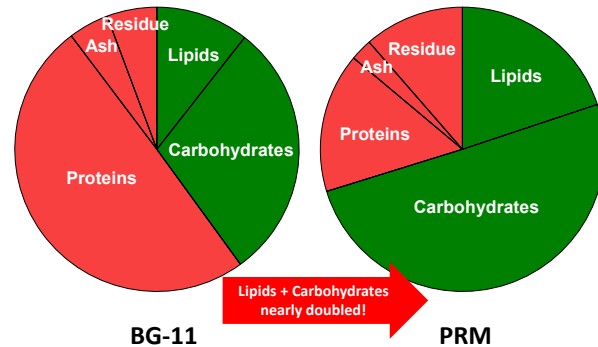
B) Medium optimization for cost reduction

Component [g L^{-1}]	BG-11	ABWM [#]	PRM ^{##}
NaNO_3	1.5	0.375	0.375
K_2HPO_4	0.031	0.031	0.031
$\text{C}_6\text{H}_8\text{O}_7 \times n\text{Fe} \times n\text{NH}_3$	0.006	0.0006	0.0006
$\text{MgSO}_4 \times 7\text{H}_2\text{O}$	0.075	0	0
$\text{CaCl}_2 \times 2\text{H}_2\text{O}$	0.03576	0	0
$\text{C}_6\text{H}_8\text{O}_7$	0.006	0	0
Na_2EDTA	0.001	0	0
Na_2CO_3	0.02	0	0
trace element solution	1 mL	0	0
purified water	1 L	1 L	0
artificial sea salt	0	5.0	0
Peene River water	0	0	1 L

[#]: ABW = Artificial Brackish Water Medium

^{##}: Peene River Medium

& improved biochemical composition



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5. Project Results



Biofuels from Microalgae...

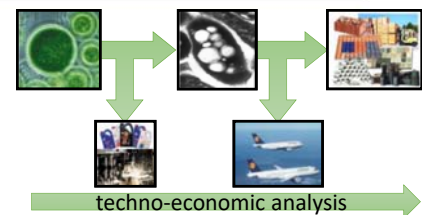
$2 \text{ g L}^{-1} \text{ d}^{-1}$, 20 % Lipids, 50 % Carbohydrates

• resulting productivity:

- cultivation Central Europe: $48 \text{ t algae oil} + 22 \text{ toe ha}^{-1} \text{ a}^{-1}$
(Corn: $6 \text{ toe ha}^{-1} \text{ a}^{-1}$)

- European fuel demand: $800,000,000 \text{ toe a}^{-1}$
- surface requirement: $115,000 \text{ km}^2 \cong 1/3 \text{ area of Germany}$

- (Corn: $1,300,000 \text{ km}^2 \cong \text{area of France} + \text{Germany} + \text{Poland}$)



... – The Revolution?

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5. Project Results



Biofuels from Microalgae...

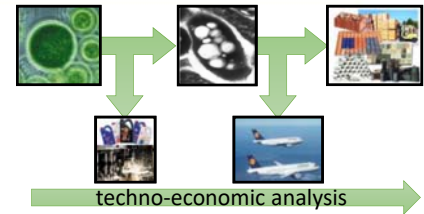
- techno-economic analysis results:

A) production costs:

product	algae-based [€ L ⁻¹]	petroleum-based [€ L ⁻¹]
kerosene	18	0.4
diesel	20	0.5
oil/lubricants	21	1

B) CO₂ balance:

product	algae-based [g MJ ⁻¹]	petroleum-based [g MJ ⁻¹]
kerosene	270	85



... – A Reverie?
... – A Nightmare?

5. Project Results



Weaknesses of microalgae

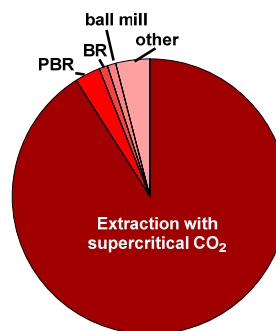
- low cell density (< 0,5 % m/m DW)
→ harvesting & drying
- lipid storage
→ cell disruption
 - mechanic, enzymatic, chemical
- extraction step necessary
 - organic solvents, supercritical CO₂

→ 14 € L⁻¹ for extraction only!

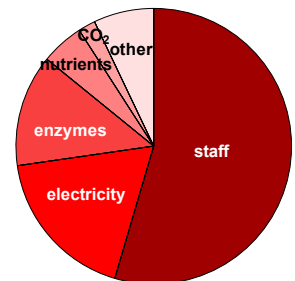
product	algae-based [€ L ⁻¹]	petroleum-based [€ L ⁻¹]
kerosene	18 – 14 = 4	0.4

→ ×10! →

Economic analysis of the ABV project



investment



consumables & personnel

6. Conclusion & Prospects

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from today's perspective:

Microalgae for Biofuels

–
a **Reverie** rather than the Revolution!

nevertheless: Microalgae still promising!

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6. Conclusion & Prospects

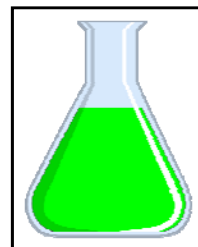
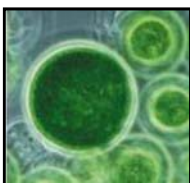
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Challenges to be solved

- new harvesting methods
- economically feasible extraction techniques

Further development of bio refinery concept?!



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Acknowledgements

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- Thanks to...
 - organization committee for invitation
 - project partners for support & data
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 - Pharmaceutical Biology team for assistance



Thank you for your attention!



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