BIOSOLAR
CENTer
A co-operation of GICON® Group and
Anhalt University of Applied Science

GICON®

Cultivation of Microalgae

Photobioreactor-Systems

From test tube to
modular production facility

Foto: Mario Salisch, Hochschule Anhalt

Mixing tank at the microalgae photobioreactor plant, Anhalt University of Applied Sciences, Köthen (Germany)

Dr. Reiner Haseloff (Governor of Sachsen-Anhalt) during the 2013 opening ceremony of the Biosolar Center in Köthen.

HUGO JUNKERS PREIS
FÜR FORSCHUNG UND INNOVATION AUS SACHSEN-ANHALT

In 2013, the Biosolar Center attained 3rd place in the Hugo-Junkers-Award as 'most innovative alliance'

GICON - Grossmann Ingenieur Consult GmbH was established in 1994 as a privately owned, independent company. Since then, GICON has grown into an internationally-recognized group of companies with 350 employees and 150 contract associates. Offices throughout Germany as well as in various locations in Europe, Asia, North and South America support GICON's global customer base.

GICON provides a wide range of products and services. Based on the client's need, GICON's employees are able to form interdisciplinary teams within the GICON Group. This approach ensures complimentary competencies and synergistic effects, providing the client with solutions and services from a single source.

In addition to experience and expertise, GICON also stands for innovation and technology development. Collaboration between Anhalt University of Applied Sciences and GICON led to the establishment of the Central Germany Biosolar Center in Köthen.

High quality pilot systems, modern labs and dedicated staff who implement new ideas in close collaboration with the university, ensure continuous development and quality improvement of existing products and processes.

In 2013, the Central Germany Biosolar Center was awarded the Hugo Junkers Prize, an award from the State of Saxony-Anhalt for the 'Most Innovative Alliance' between academia and industry.

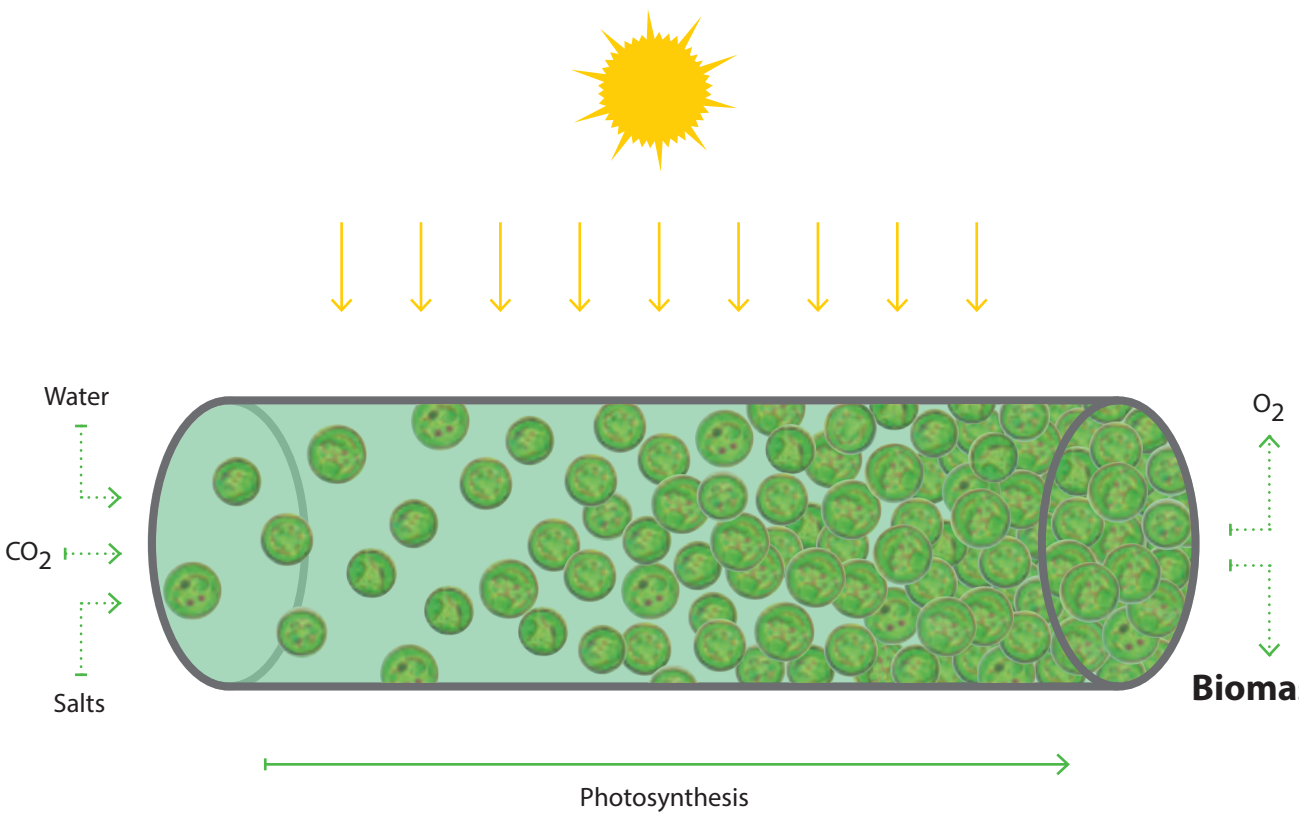
Services in the field of photobioreactor systems by the GICON Group/Biosolar Center:

- System design
- Permitting
- Plant engineering and construction supervision
- Technology developement
- Efficiency improvement
- Micro algae screening, biomass production and material analytics

MICROALGAE

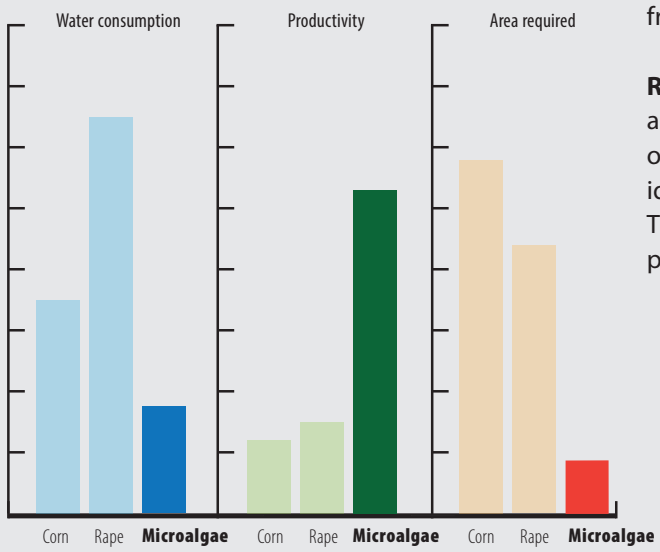
HOPE OF A BIOBASED FUTURE

- Mostly eukaryotic microorganisms as found in water, which perform photosynthesis
- High **biodiversity**: over 500,000 algae species worldwide; only 20 used technologically
- Important **primary producer**: producing 1/3 of the world's biomass and 50% of atmospheric oxygen
- Higher **biomass** production compared to complex plants
- **Year-round** availability
- Reduced **demand** for macronutrients
- **Total** biomass can be used



THE ADVANTAGES OF MICROALGAE:

Resource-efficient: algae can be cultivated in **fresh, brackish** or **sea water**. Algae cultivation is characterized by **low surface area usage and low water consumption**. Arable areas for food production are therefore not used.

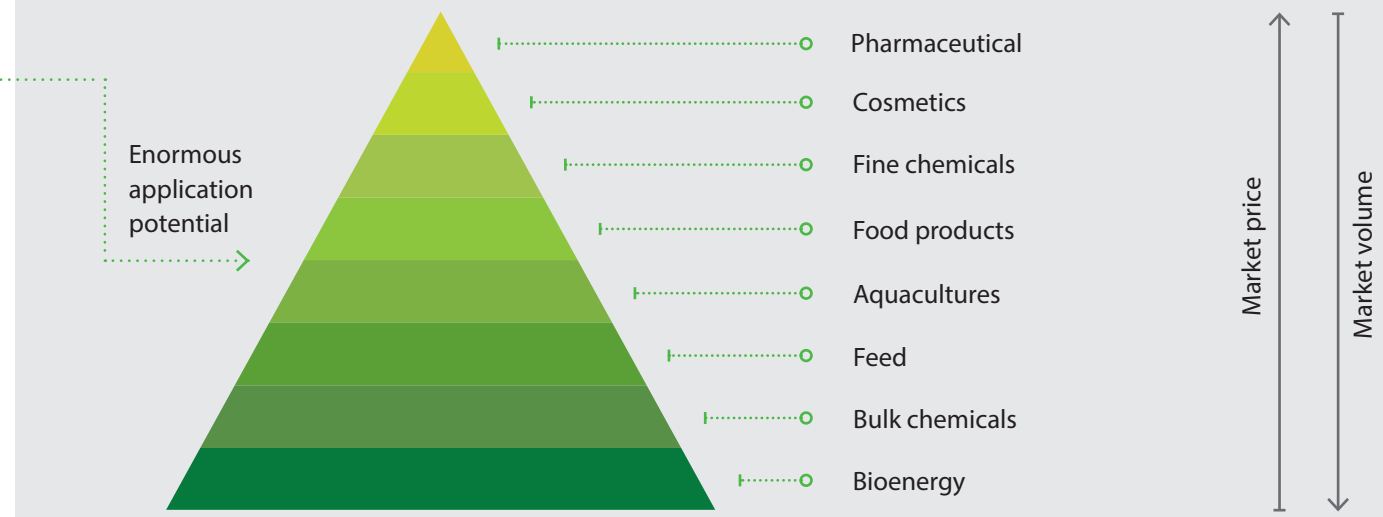


CO_2 - fixation - microalgae use CO_2 as carbon source and produce oxygen and biomass.

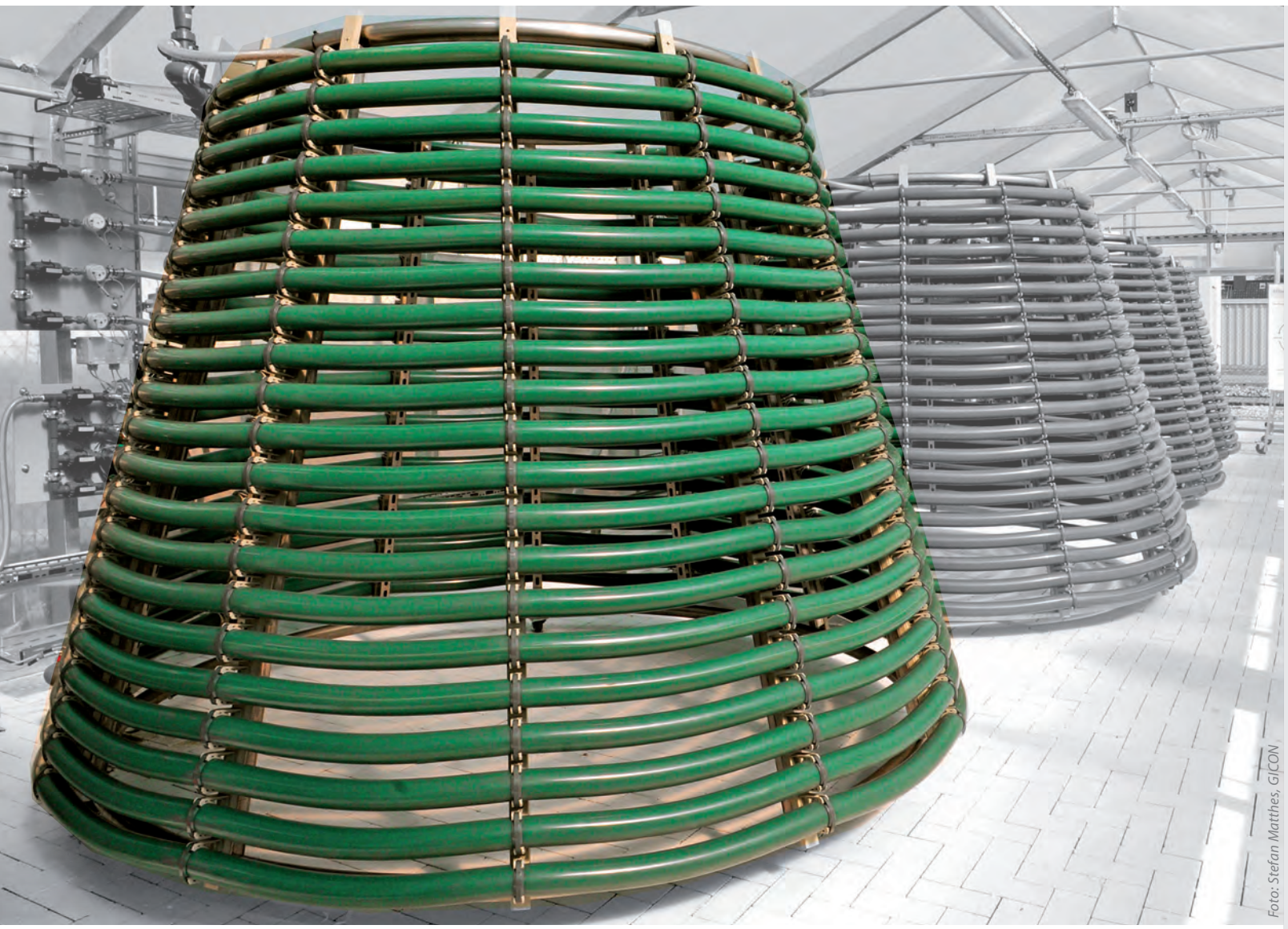
Energy efficiency - 5-10 times better conversion of the absorbed solar energy into biomass compared to terrestrial plants. Microalgae utilize more energy from the sun and grow more efficiently.

Rich in ingredients and materials - micro-algae have a high protein and lipid content and possess a wealth of **valuable ingredients**, such as pigments, carotenoids, vitamins, essential fatty acids and much more. Thus, they prove to be **multi-talented** with enormous potential.

PRODUCT PYRAMID



THE GICON®-PBR (PHOTOBIOREACTOR)



GICON®-PBR at the Biosolar Center, Anhalt University of Applied Sciences, Köthen (Germany).

A stable and resource-conserving production of microalgae biomass requires a cultivation system with a high degree of effectiveness and controllability. Process management within the ideal growth area of microalgae entails a moderate temperature control with an effective supply of sunlight. This is reliably provided by the flexible, double-wall tube system with its integrated temperature control closed circuit. The innovative GICON®-PBR is the first system to combine the main requirements for photobioreactor systems, offering stable growth, also due to its biomimetic shape of a pine tree. For this reason, the GICON®-PBR was recognized as 'Innovation of the Month' (May 2012) by the German Center for Research & Innovation in New York.

German Center for Research and Innovation – New York

Germany
Land of Ideas

GICON® PBR DESIGN – ADOPTED FROM NATURE

The reactor consists, based on required specification, of a number of truncated cone-shaped basic structures which function as mounting brackets for the flexible double-wall tube system. The biomimetic design is reminiscent of a pine tree (pine tree light collector module, PLM). A photobioreactor plant consists of several PLMs in a 'sylvan array'.

ADAPTIVE GEOMETRY

The geometry of the GICON-PBR ensures optimal light supply throughout the day. Depending on the geographical latitude, the reactor design is initially adapted with respect to the structure's angle and the reactor height in order to achieve the most effective light input.

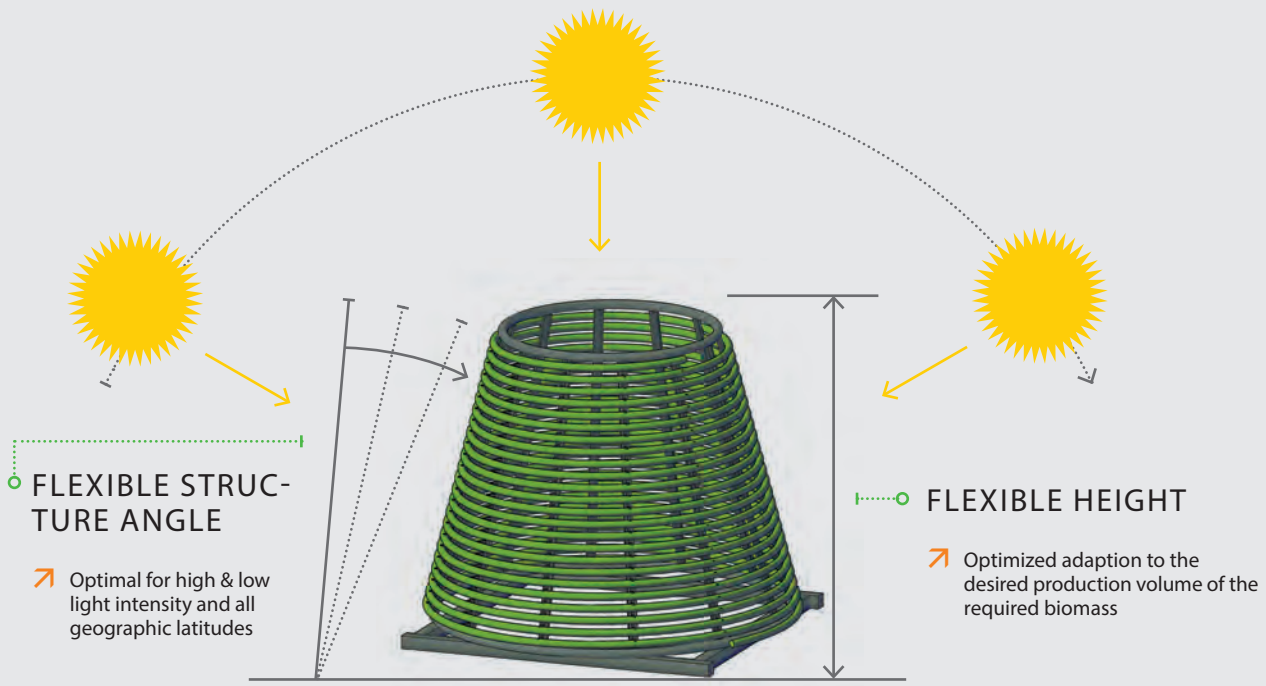


Foto: Stefan Matthes, GICON

THE PLATFORM TECHNOLOGY

TAILORED SOLUTIONS FOR INDIVIDUAL NEEDS

The GICON® PBR is designed for use as a stand-alone small reactor, as a pilot plant for research and development, and as a basic module for large-scale industrial reactors. By combining individual modules, reactor systems of any scale are accessible. The systems are tailor-made to meet the client's requirements. Thus, they guarantee a continuous production of high-quality, defined algae biomass.

The uniform design, based on the tubular collector system, enables integration into further biotechnological processes (e.g. material coupling with biogas plants).

Features of the GICON® PBR

- suitable for indoor and outdoor use depending on equipment
- optimal temperature control of the microalgae suspension in the outdoor temperature range of 10 - 35 °C
- short-term culture maintenance even at outside temperatures of 0 °C or 40 °C
- multi-purpose character for variable production of a wide range of freshwater and marine algae species
- sensor equipment according to client requirements (min. pH, temperature; optional: PhAR/global radiation, optical density, O2/CO2 concentration, pressure, volume flow liquid/gaseous)
- cleaning during operation by pulsation and/or pigging
- 10-year warranty on durability of the hose material

GICON® CHRISTMAS TREE FOR SMALL-SCALE PRODUCTION

- Ideal for small scale production for screening purposes
- phototrophic up to 50 kg/a Chlorella vulgaris in Central Europe
- high crop stability even with mixotrophic operation
- Optional equipment: lighting, temperature control module, saturated steam disinfection

Key data:
Photoactive volume: approx. 400 l
Total volume: approx. 600 l
Max. Volume flow: 6 m³/h
Electr. connected load: 2 kW
Max. Heating/cooling capacity: 15 kW
Installation area: approx. 11 m²
Prices on request

GICON® OCTAGON AS A SCALABLE UNIT FOR INDUSTRIAL PRODUCTION

- basic module for large-scale phototrophic and mixotrophic production of various varieties of microalgae
- phototrophic e.g. up to 500 kg/a Chlorella vulgaris in Central Europe
- arbitrarily scalable
- optional equipment: lighting, temperature control module
- optional stainless-steel version for special applications
- optional: client-specific process development and commissioning of the reactor

Key data:
Photoactive volume: approx. 3200 l
Electr. connected load: 5 kW
Total volume: approx. 5000 l
Max. Heating/cooling capacity: 100 kW
Max. Volume flow: 40 m³/h
Installation area: approx. 125 m²
Price on request

THE DOUBLE-WALL TUBE

ADVANTAGES OF THE DOUBLE-WALL TUBE SYSTEM

ECONOMIC VIABILITY

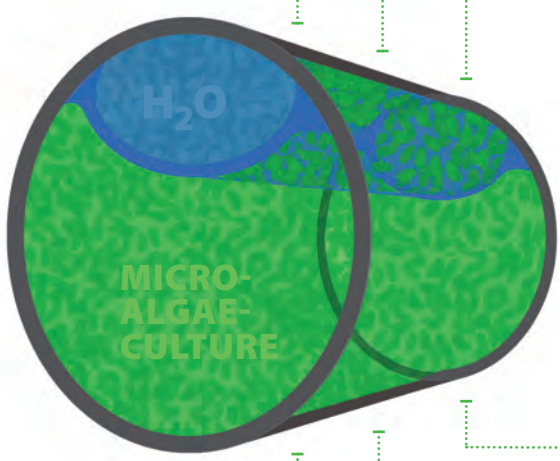
- Length of the systems can be scaled as required (extrusion)
- Connecting elements and connectors are not required
- Extra long life

TRANSPARENCY

- Optimal at 400 – 760 nm

RADIATION RESISTANCE

- Silicone does not lead to discoloration and has a lifetime of up to ten years
- Material can be exposed to electromagnetic radiation in high doses



THERMAL RESISTANCE

- Stable up to 150 ° C
- Steam sterilization possible

FOOD CONTACT SUITABILITY

- Physiological compatibility with regard to use in the food and feed sectors

CHEMICAL RESISTANCE

- Use of salt water for cultivation and temperature control

CLEANING / MAINTENANCE

- Simple mechanical cleaning technology
- Cleaning possible during the production process (no downtime)
- Silicone material is reparable

ENVIRONMENTAL SUSTAINABILITY

- Flame retardant and easily recyclable

DOUBLE-WALL SYSTEM ENSURES OPTIMUM TEMPERATURE CONTROL

The core of the GICON® photobioreactor is the flexible tubular silicone tube system. It is the result of the successful cooperation between GICON and Wacker Chemie AG. In conjunction with the shape of the reactor, a tube was developed which due to its highly transparent ELASTOSIL® silicone rubber and innovative double wall system provides a very convincing a solution.

The new, geometrically variable design of the double wall tube system protects the algae from extreme temperature fluctuations. This enables accurate temperature control of the cultures.
The choice of the reactor material also has a positive effect on productivity. Due to the material, the adhesion of microalgae to the reactor wall - the so-called biofouling - is significantly reduced.

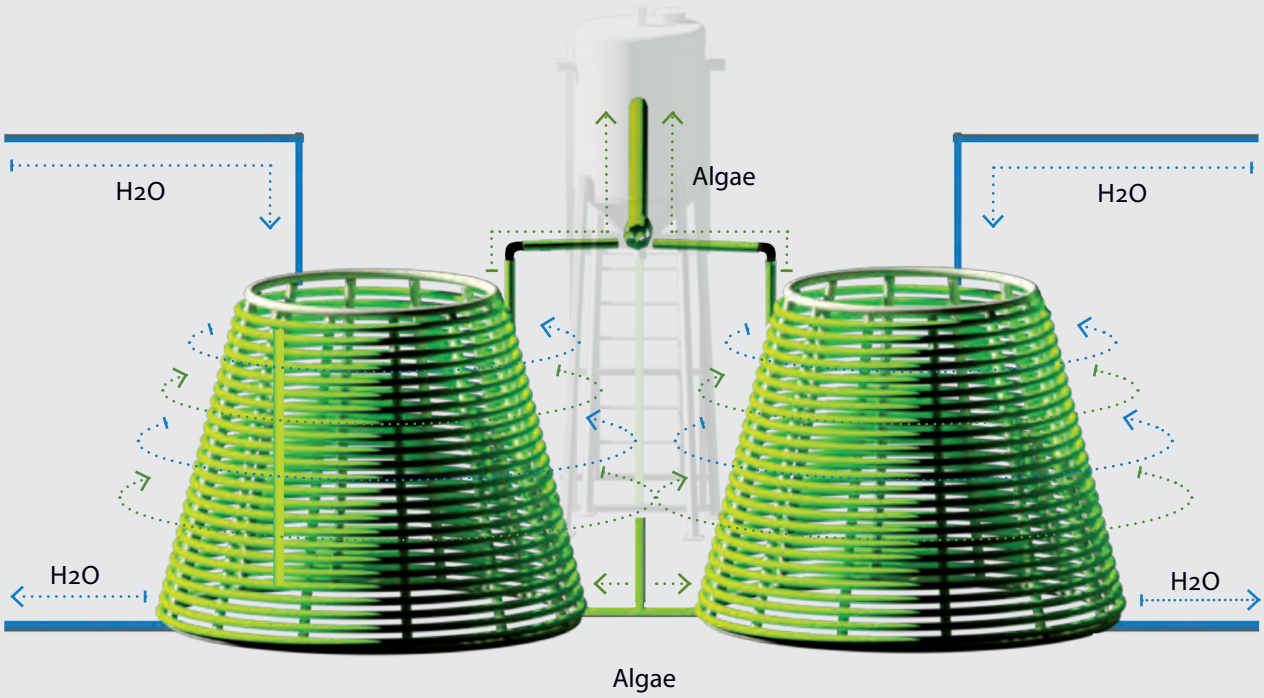
At the same time, tests have shown that the produced biomass has a quality suitable for use in food and feeds.

Due to the outstanding advantages of the newly developed system and the transport-friendly properties, the reactor can be used for cultivation of photoactive microorganisms; independent of temperatures and ambient conditions.

WACKER

RESOURCE-EFFICIENT TEMPERATURE CONTROL OF THE GICON®-PBR

Integrated closed circuit in double-wall system



PROOF OF CONCEPT

YEAR-ROUND OUTDOOR CULTIVATION IN CENTRAL GERMANY

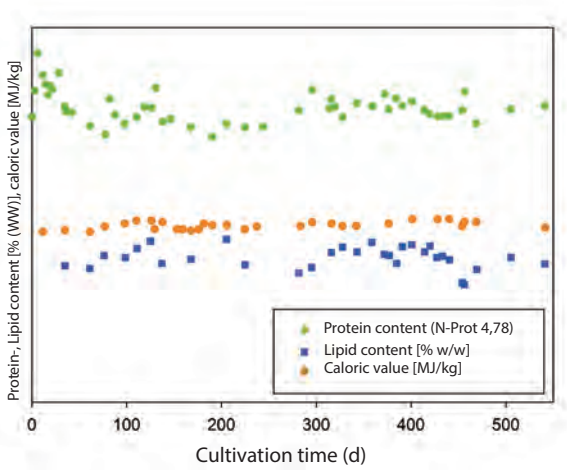
The Central German Biosolar Center's team has succeeded in not only stably cultivating a microalgae culture but also with high yield - for two years without interruption and adding fresh biomass from the laboratory. Productivity in the vegetative period averaged 0.3 grams and peak values of up to 0.75 grams per liter / day. These are unprecedented results for a Central European location. A defined and consistent composition of the biomass has been achieved.

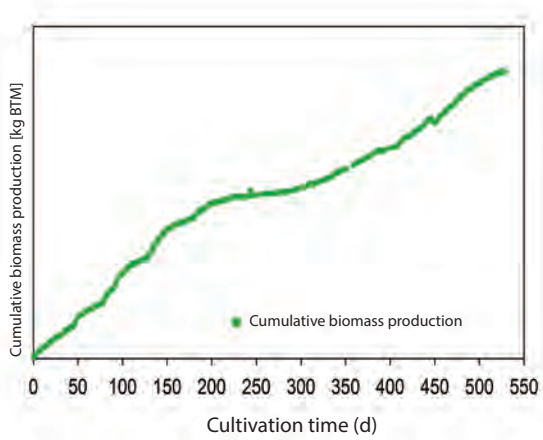
A milestone of GICON® innovation on the way to large-scale application

An important factor in long-term cultivation is the tubular double-wall system. Even at high outside temperatures and a global radiation of 900 watts per square meter, a stable growth rate can be achieved. Utilizing the integrated and closed temperature circuit, the radiating heat can be controlled at a resource - efficient, low water consumption level.

Dr. Stefan Matthes,
GICON®-Department Head Biosolar:
„The heat exchange properties of the system are not at capacity even at high temperatures of 35 to 40 ° Celsius. This allows us to control the heat in the module, even at hotter temperatures all year round. This shows us that we have created the basic prerequisites for the use of photobioreactor technology in all parts of the world and, for example, paved the way for the production of food and other products in desert regions!"

Prof. Dr. Carola Griehl,
Department Head Algae Biotechnology, Anhalt University:
„The GICON®-PBR has been running trouble-free for two years now. This enables us to produce up to 15 kg of algae biomass per month in Köthen with the biomimemic 'pine trees'."





Source: adjusted per Matthes, S. Matthes, S. et al., 2015. Reliable production of microalgae biomass using a novel microalgae platform. Journal of Applied Phycology, 27(5), pp.1755–1762.

REFERENCES

KLÖTZE | GERMANY (2000)

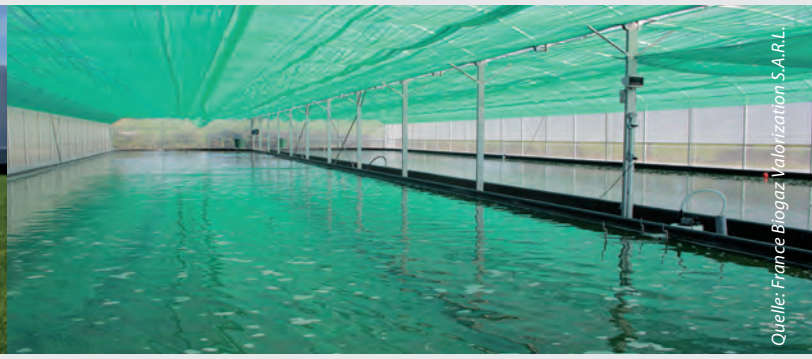
Due to their modular construction consisting of several reactors, the microalgae systems can be extended as required. Employees of GICON®'s Bitterfeld-Wolfen branch have, then still as employees of Bisantech Nuova, planned and installed the world's first and largest tubular production facility for micro-algae in Germany (Saxony-Anhalt) with 20 photobioreactors and around 700,000 liters of utilization volume on a 1.2 hectares area for the client.
The biological connection was realized in cooperation with IGV GmbH Potsdam Rehbrücke. Based on the experience of this project, GICON® has developed its PBR and thus improved algae cultivation.

Quelle: Roquette Klötze GmbH & Co. KG

World's first and largest tubular production facility for micro-algae in Klötze, planned and built by GICON.

TREIZE-VENTS | FRANCE (2014)

The potential of biogas plants for the cultivation of microalgae use - this goal has been implemented by GICON® in an installation in Treize-Vents in the west of France. A 190 kW plant directs the surplus heat into two raceway ponds, in which algae are cultivated. The heat supply stimulates the growth of microalgae. The resulting algae biomass is used, among other things, as an admixture for animal feed.



Quelle: France Biogaz Valorization S.A.R.L.

190kW biogas plant in Treize-Vents with two raceway ponds for microalgae cultivation.

RESEARCH & DEVELOPMENT

BIOSOLAR
CENTER

A co-operation of GICON® Group and
Anhalt University of Applied Science

In 2011, GICON founded the Biosolar Center in cooperation with Anhalt University of Applied Sciences in Köthen. The innovative research center team's objective is to develop internationally competitive solutions in the field of biosolar technology.

Microalgae cultivation using bubble column reactor in the laboratory.

PRODUCT RANGE:

- Complete or partial systems for industrial production
- Stand-alone small-scale plants for agriculture and aquaculture
- Coupled plants for algae technology and biogas production using the biorefinery principle
- Tailor-made concepts for our customers

With the excellent laboratory and technical equipment, highly qualified employees and a very good research infrastructure, the Biosolar Center can offer a service-oriented service spectrum.

SERVICES:

- PBR based design and plant planning
- Microalgae screening
- Biomass production
- Valuable substances analytics
- Algae screening in the laboratory and outdoors
- Services for the operation of microalgae systems
- Rearing stage for pilot plant and production facilities
- Microalgae cultivation and application for the feed industry

CONTACT

Prof. Dr. Carola Griehl, Anhalt University of Applied Sciences, *Department Head Algae Biotechnology*
carola.griehl@hs-anhalt.de

Dr. Stefan Matthes, GICON®
Department Head Biosolar, GICON®
s.matthes@gicon.de

GICON'S RESEARCH PARTNERS IN THE FIELD OF BIOSOLAR

An integral part of the research and development work are our partners from science and industry. Since its inception, GICON has invested a significant portion of its profits in research and development of new processes, products and services. The consequent implementation of this concept has produced numerous patents.

Hochschule Anhalt
Anhalt University of Applied Sciences

↗ Long-term cooperation for further development of the GICON®-PBR; in addition, there is a cooperation agreement within the framework of the Biosolar Center.

WACKER

↗ Successful industrial cooperation for the investigation of a silicone based tube system. Patent cooperation for development of a tube based photobioreactor.

HOCHSCHULE WISMAR
UNIVERSITY OF APPLIED SCIENCES
TECHNOLOGY, BUSINESS AND DESIGN

↗ Since 2016 cooperation with the objective of the industrial development of the photobioreactor system. Development, construction and testing with ESG Edelstahl- und Umwelttechnik Stralsund GmbH.

b-tu
Brandenburgische Technische Universität Cottbus - Senftenberg

INBIA
Institut für Bioenergieträger und innovative Abfallverwertung GmbH

↗ Expertise partnership with the INBIA Institute at Brandenburg University of Technology Cottbus for the core process engineering development to couple microalgae technology with the 2-stage GICON® biogas process.

IMP PAN GDAŃSK

↗ Since 2015 cooperation in the field of simulation and testing of phase change storage for energy optimization in microalgae cultivation.

GICON®

Biosolar Center
A cooperation of GICON Group and Anhalt University of Applied Sciences

GICON®-GROSSMANN INGENIEUR CONSULT GMBH
Tiergartenstrasse 48 I 01219 Dresden I Germany I Phone +49 351 47878-0 I Fax +49 351 47878-78
Bitterfeld-Wolfen Branch
Greppiner Strasse 6 I 06766 Bitterfeld-Wolfen, OT Wolfen I Germany I Phone +49 3494 667025-0 I Fax +49 3494 667025-9

CONTACT
Dr. Stefan Matthes, s.matthes@gicon.de
Dr. Martin Ecke, m.ecke@gicon.de

www.gicon.de

Cover Photo: Mario Salisch, Anhalt University of Applied Sciences