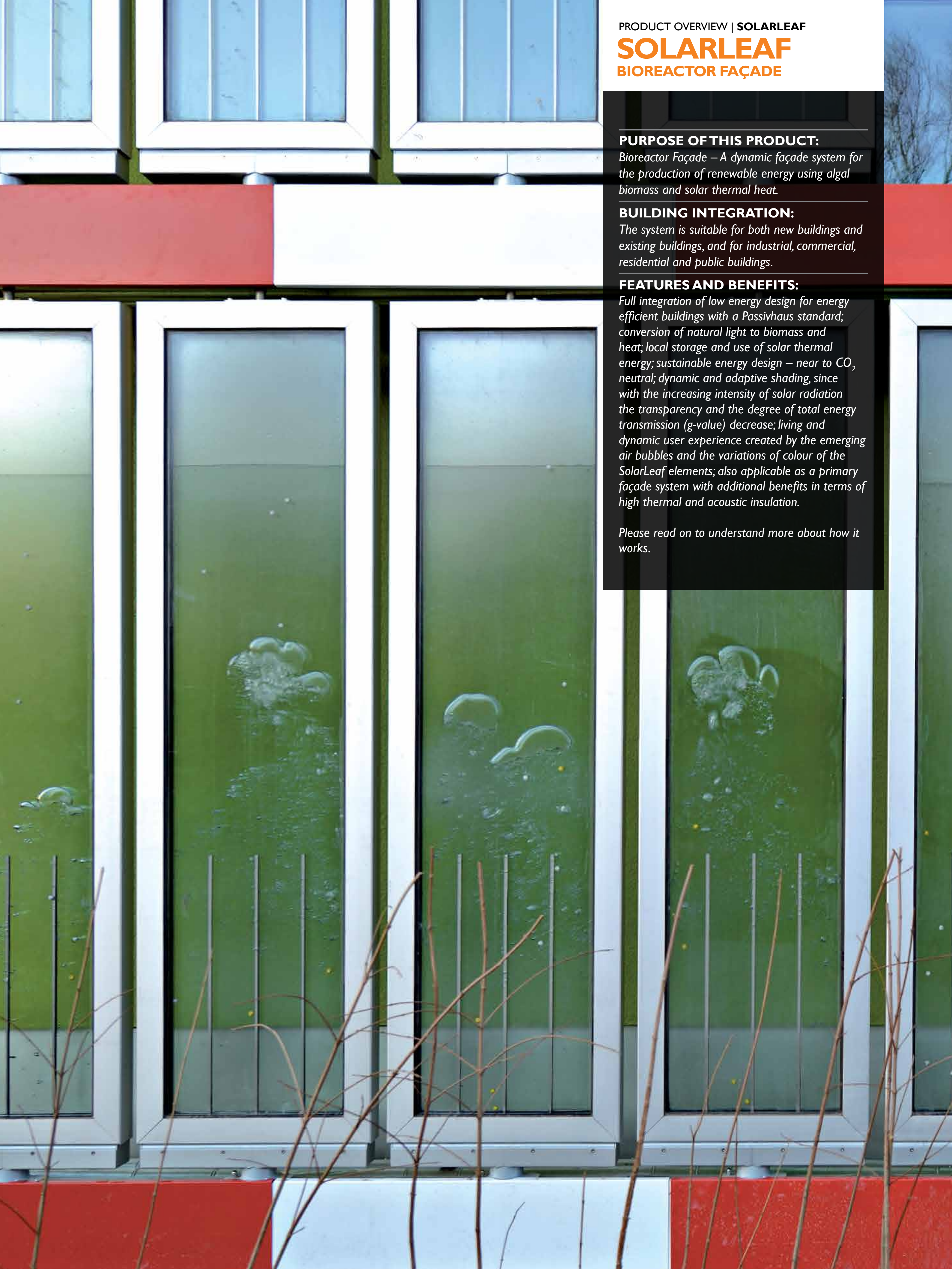
SOLARLEAF

BIOREACTOR FAÇADE



PURPOSE OF THIS PRODUCT:

Bioreactor Façade – A dynamic façade system for the production of renewable energy using algal biomass and solar thermal heat.

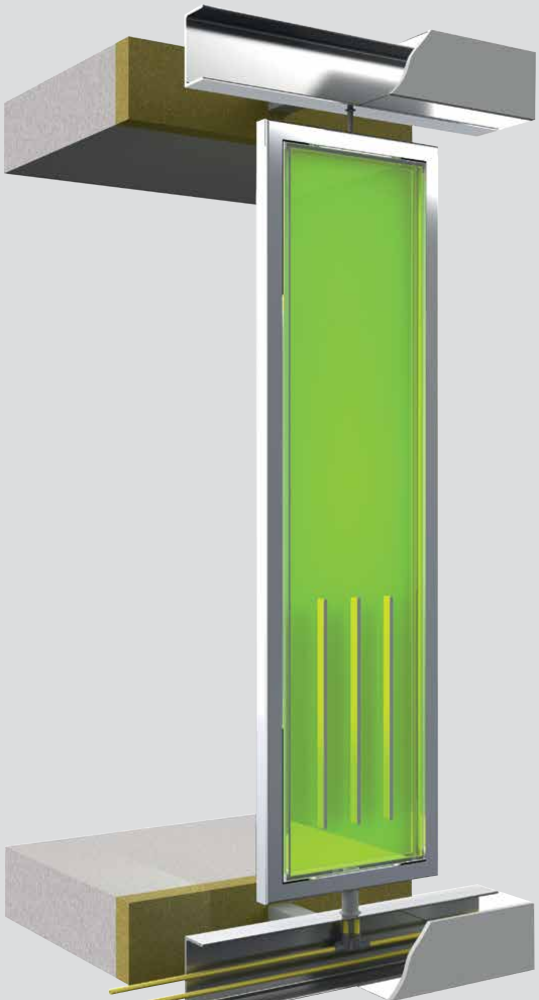
BUILDING INTEGRATION:

The system is suitable for both new buildings and existing buildings, and for industrial, commercial, residential and public buildings.

FEATURES AND BENEFITS:

Full integration of low energy design for energy efficient buildings with a Passivhaus standard; conversion of natural light to biomass and heat; local storage and use of solar thermal energy; sustainable energy design – near to CO_2 *neutral; dynamic and adaptive shading, since with the increasing intensity of solar radiation the transparency and the degree of total energy transmission (g-value) decrease; living and dynamic user experience created by the emerging air bubbles and the variations of colour of the SolarLeaf elements; also applicable as a primary façade system with additional benefits in terms of high thermal and acoustic insulation.*

Please read on to understand more about how it works.



The bioreactor façade – principal construction methodology of the SolarLeaf

SOLARLEAF – THE BIOREACTOR FAÇADE

The vertical glass louvres are filled with water containing nutrients which convert daylight and CO_2 to algal biomass through the bio-chemical process of photosynthesis; at the same time the water is heated up by solar-thermal effects. The biomass and heat generated by the façade elements are transported by a closed loop system to the plant room, where both forms of energy are exchanged by a separator and a heat exchanger respectively. The temperature levels of the heat generated can be increased by using a hot water pump for the supply of hot water and for heating the building. Excess heat can be stored by use of a geothermal system. The biomass has high energy content, and can therefore not only be used for generating energy but also processed and used by the food and pharmaceutical industries.

"The "SolarLeaf" bioreactor façade is pointing the way ahead for the future of the façade and low energy engineering for Green Buildings"

To be able to benefit from the synergies of the system, a holistic and comprehensive design approach is required right from the beginning. Our team of external consultants and experts can provide support at all stages of the design process.

From 2020 onwards, zero-energy houses will be obligatory in Germany and in some other European countries. Every new building will need to produce the same amount of energy as it consumes. In 2012, the energy generated by photovoltaic systems and solar thermal systems in Germany provided 1.5% of the total energy supply, while biomass as a renewable energy source provided 8%. The advantage of biomass compared to photovoltaic is that it is a form of solar energy that can be easily stored and therefore doesn't require expensive storage technologies like batteries. The bioreactor façade is the first building integrated system to generate biomass.

The conversion of light to heat is a well known physical process used in solar thermal design. In contrast, the conversion of light to biomass is a biochemical process facilitated by microscopically small algae, called microalgae. Microalgae, like other higher level plants, use sunlight for the photosynthetic process and this is linked to the process of conversion of CO_2 to organic matter. In fact, microalgae are much more efficient in the conversion of light to biomass than higher-level plants, because they consist only of single cells, each of which is capable of photosynthesis. Microalgae can divide themselves up to two times a day and thus increase their biomass by a factor of four. Their biomass contains 23-27 kJ of energy per gram dry weight. This biomass can be used as raw material for cosmetic and pharmaceutical products or is used for animal food or dietary supplements. By varying the cell density in the culture medium the transparency can be varied between 10 and 80%.

HOW DOES SOLARLEAF WORK?

When used as a secondary façade the bioreactor elements form a rainscreen system of the outer layer of a double-skin façade. The vertical elements have a size of 2.5m x 0.7m and can span across a full storey if required. In addition they can rotate along its vertical axis to track the position of the sun. When fully closed the SolarLeaf forms a continuous outer skin providing a thermal buffer.

Each SolarLeaf element features a multiple glass assembly, designed to meet the latest performance criteria of modern façade engineering. The two inner layers form an 18mm wide cavity with a capacity of 24 litres for the circulation of water and growth of algae. For safety and thermal insulation the photobioreactor is clad on both sides with laminated safety glass.

Compressed air is introduced to the bottom of each bioreactor at certain time intervals. The gas emerges as large air bubbles and generates an upstream water flow and turbulence to stimulate the intake of CO_2 and light by the algae. At the same time, the inner surfaces of the panels are washed by the mixture of water and air that is visible to the naked eye. The flat photobioreactors are thus very efficient for algal growth and need minimal maintenance. All servicing pipes for the inflow and outflow of the culture medium and the air are integrated into the substructure of the SolarLeaf elements. At the BIQ pilot project in Hamburg 32 elements are combined into a closed loop system and connected to the plant room.

A central building management system controls all the processes necessary to operate the bioreactor façade and to fully integrate it with the energy management system of the building. This includes the control of the algal cell density and the temperature in the culture medium.

The heat obtained from the façade has a temperature of about 40°C and is either used directly to heat water or is stored in the ground by use of a geothermal system. The system can be operated all year long.

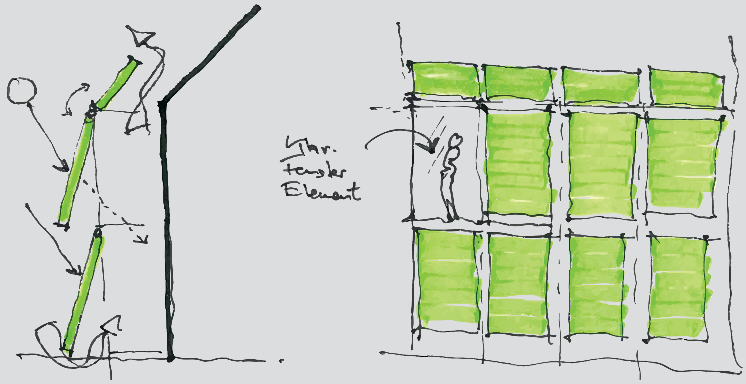
The efficiency of the conversion of light to biomass is 10% and to heat 38%. For comparison, photovoltaic systems have an efficiency of 12-15% and solar thermal systems 60-65%.

So the bioreactor façade is competitive relative to these other technologies. In addition, bioreactor façades remove CO_2 from flue gas at quantities equivalent to the build-up of biomass and thus reduce the CO_2 emissions from buildings and help to improve the overall CO_2 balance.

Strategic Science Consult GmbH

Colt International GmbH – www.coltgroup.com
ARUP Deutschland GmbH – www.arup.com
SSC Strategic Science Consult GmbH – www.ssc-hamburg.de

www.colt-info.de/solarleaf.html



"Napkin" sketch showing the design for building integration of bioreactors being used as a secondary skin of a building

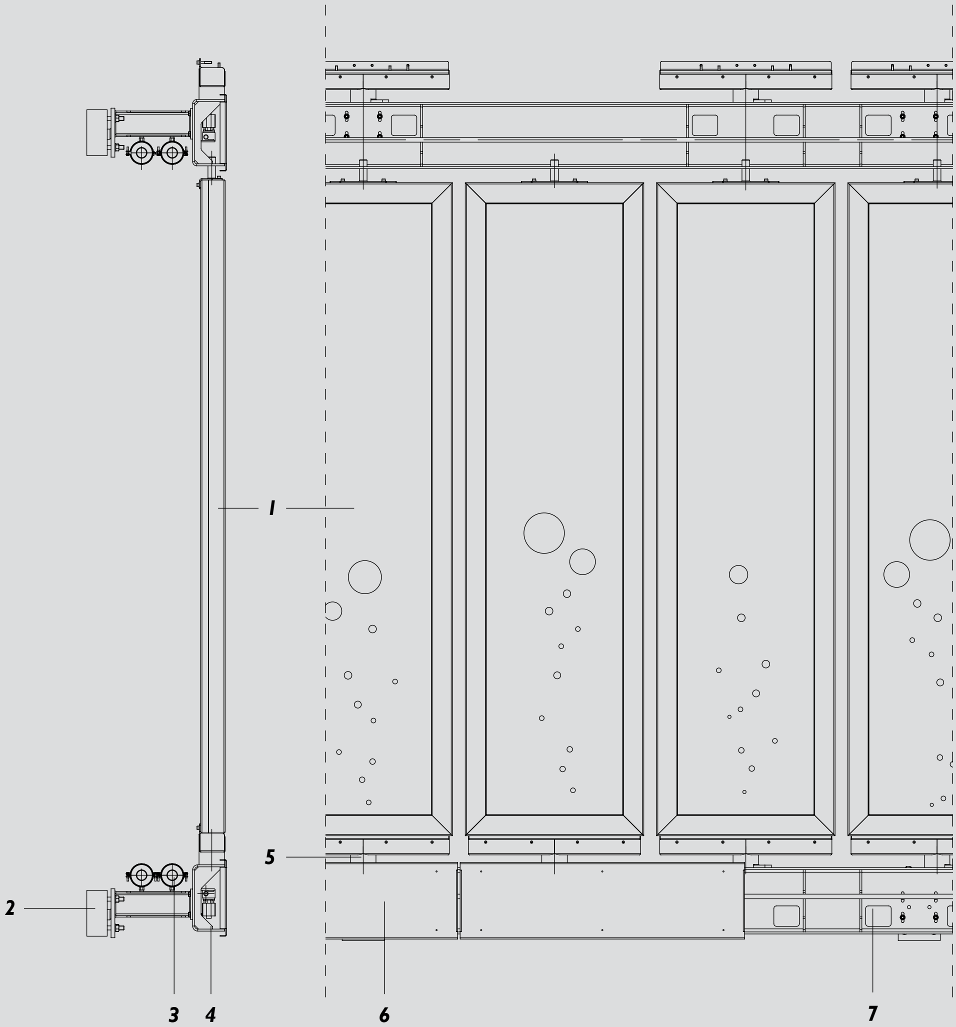
In April 2013 the first ever bioreactor façade was showcased at the BIQ House during the International Building Exhibition (IBA) in Hamburg, featuring 129 SolarLeaf elements covering 200 m².

THE „BIQ“ PILOT PROJECT IN HAMBURG

The BIQ House is part of the International Building Exhibition (IBA) 2013 in Hamburg. It has a bioreactor façade which is expected to produce biomass of 30 kWh/m² p.a. and heat energy of 150 kWh/m² p.a. In total the façade will reduce the CO_2 emissions of the building by six tons p.a. and in addition eliminate 2.5 tons of CO_2 p.a. The building is specifically designed to achieve synergies between the façade and the other systems (e.g. the building technology, energy and heat distribution and water circulation systems) as well as to minimize CO_2 emissions.

In the plant room (see picture below) the heat is removed from the culture medium by a heat exchanger and either directly used in the building or stored.

The generated biomass is harvested by a separator from the culture medium automatically. Besides controlling all parameters affecting the bio-chemical processes, the building automation system can alter the orientation of the elements towards the sun so as to control the production of biomass and heat as well as the shading and sound absorbing capacities. A Rockwell SPS system manages the whole process.



1 SolarLeaf external louvre
2 Brackets with thermal breaks for the transfer of loads to the primary substructure
3 Pipework for the medium to enter and leave
4 Sub-frame, rolled steel U-section
5 Pivot fixing allowing rotation
6 Metal cladding
7 Supply of pressurised air, controlled by magnetic valves

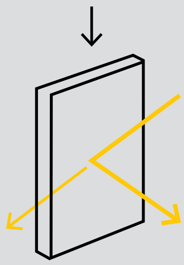
SOLARLEAF IN OVERVIEW

A Solarleaf bioreactor façade:
- produces high value biomass (10% ECS*)
- produces solar thermal heat (38% ECS*)
- provides dynamic shading
- increases the thermal and acoustic performance

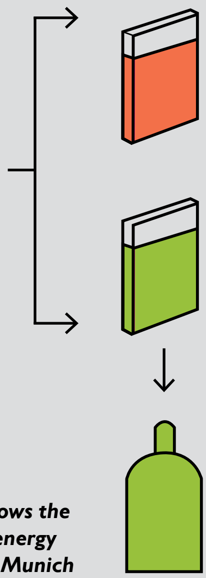
Optimal conditions for building integration:
- Production of a constant flue gas or source of carbon
- Production of heat throughout the year
- Ideal for south facing façades (>200 m²)

** ECS = energy conversion efficiency ratio, which indicates the percentage of the incoming light energy converted to biomass or heat.*

Global radiation, Munich
1150 kWh/m²a



550 kWh/m²a
50% loss due to orientation, exposure and reflection



Heat 40%
220 kWh/m² p.a.
CO_2 reduction
0,04 t/m² p.a.

Biomass 8-10%
50 kWh/m² p.a.
CO_2 reduction
0,015 t/m² p.a.

Biogas 80%
40 kWh/m² p.a.
CO_2 reduction
0,014 t/m² p.a.

The illustration on the right shows the results of a calculation of the energy yield of a bioreactor façade in Munich (Germany).