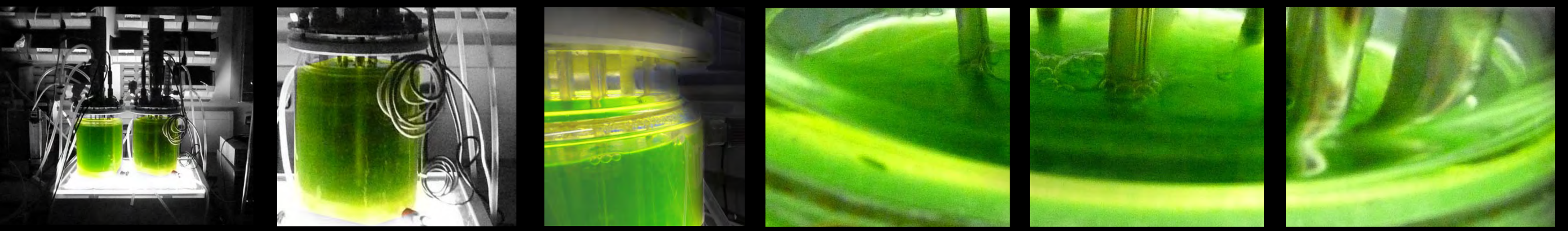
the algae house - algaetecture

Karuga Koinange - Chris Bowler - Daniela Krug
In collaboration with Cambridge Researchers & Engineers



algae?!

Algae is fast becoming the preferred source of bio-mass for use in the production of bio-diesel. Unlike conventional means of processing biomass crops however, a far cleaner, greener method is possible by way of hydrogen production. In the absence of sulphur they will switch from the production of oxygen as in normal photosynthesis, to the production of hydrogen. Capture of hydrogen, used in conjunction with a fuel cell, opens up the potential for a totally CO2 free route to end-use consumption of energy.

The team set out to investigate the potential for the micro-generation of algae within a domestic context through a process of experimental design.

UNIVERSITY OF CAMBRIDGE

the algae house

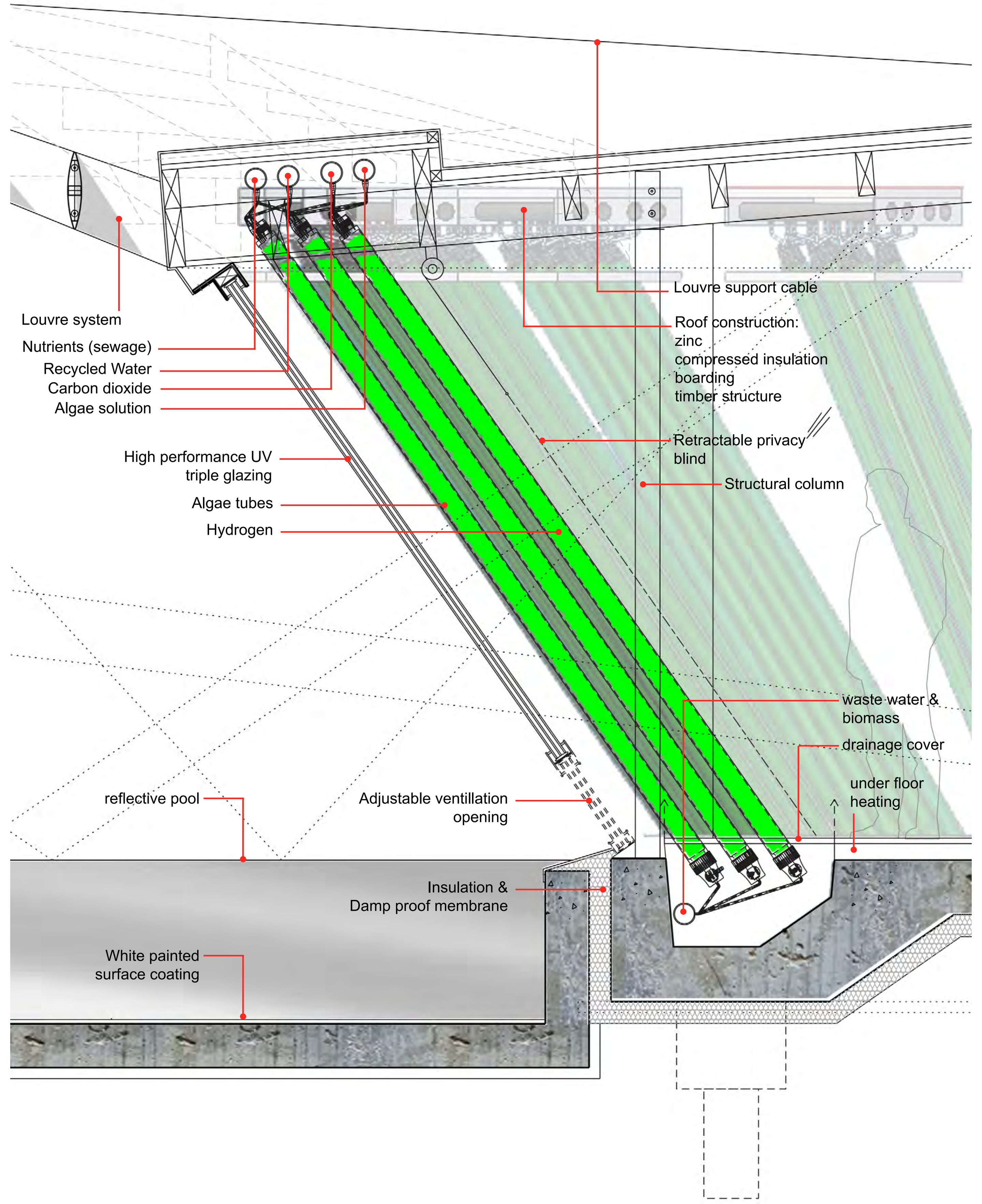
From early on in the design development it became clear that certain environmental constraints on successful cultivation were analogous to those required by humans. Specifically, these concerned issues to do with light and heat. Like people, algae thrive on exposure to high levels of solar insolation. However, the capture of gaseous hydrogen produced by the algae necessitated its housing in some form of sealed, transparent tank. Such tanks are highly prone to over-heating, killing the algae if rising to a temperature much above 30ºC. It became clear therefore that there existed the potential for the algae and domestic spaces of our 'Algae House' to enter **a symbiotic relationship**, whereby the one promoted the optimum environmental conditions for the other and vice versa. (This close relationship is even evident in the waste water recycling system whereby filtered brown water provides vital nutrients for the algae to grow).

The form of the façade was developed to achieve maximum solar insulation from the sun, whilst maintaining a stable temperature, so optimising the production of hydrogen. Through careful consideration of the algae tubes' altitude and azimuth orientation to the sun, and working in combination with a fixed louvre system, direct solar heat gain is allowed only during winter months and on spring and autumn mornings and evenings.

The shallow pool of water, or 'moat', located adjacent to the façade is intended to perform two functions. Firstly, the pool reflects low angle sun up to the overhanging algae façade, whilst absorbing more of the higher energy high angle mid-day summer sun. Secondly, as the major component of heat energy is transferred in the infrared band of the spectrum of light, the water usefully absorbs much of the heat from direct sunlight before reflecting it up to the algae.

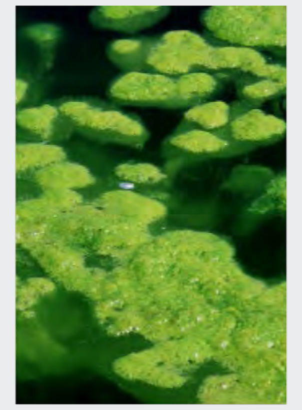
Calculating an estimate for the total amount of energy produced through the AlgaeHouse system was achieved through consultation with algae biochemical engineer and Cambridge PhD candidate Ben Taylor. Through this collaboration a tripartite energy extraction strategy was identified as realising the optimal potential from the algae. Indeed, algae are in fact unable to produce hydrogen for sustained periods of time and so, in the AlgaeHouse system, energy is also released through the extraction of lipids (oils) and bio-gas (through the processing of algae bio-mass in an anaerobic digester). To convert these oils and gas to useful electricity, rather than utilising the traditional 'dirty' technology of conversion through combustion, instead a catalytic-reactor based fuel processor converts the oils to hydrogen. This hydrogen, combined with that produced directly from the algae, is converted to electricity and heat in a hydrogen fuel cell. Based on the assumption that current trends in the genetic modification of algae continue towards the anticipated level of 15% efficiency in the conversion of light energy to hydrogen and given a volume of 2545 litres of algae solution, the house is estimated to produce 4100kWh per annum – enough to cover all energy demands of the occupants.

Algae and people may not present themselves as obvious bedfellows, but through this project we hope to have shown that the integration of algae as an energy generator within a house is not only feasible, but that co-habitation can result in a self-sustainable symbiotic system and open up many exciting architectural possibilities for 'green living'.



why tubed algae?

What are the benefits of cultivating algae in a closed-system, closely integrated with the architectural form of a house, as opposed to a natural pond based open system?

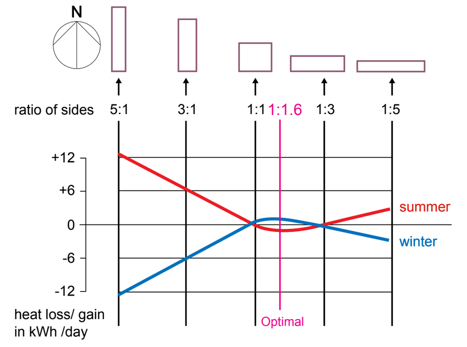


Open system - Pond	Closed system - Algae Tubes
X Invasive	✓ Non-invasive
X Surface growth	✓ Cylindrical shape allows for even distribution of light
X Evaporation	✓ Closed system - no evaporation
X Difficult to harvest	✓ Simple to harvest
X Daily/ seasonal temperature cycles	✓ Controlled enviornment
X Difficult to control	X Expensive
✓ Inexpensive	

urban-rural algaetecture

The geometries and solar system developed in *AlgaeHouse* are adaptable to an increased urban density and scale.

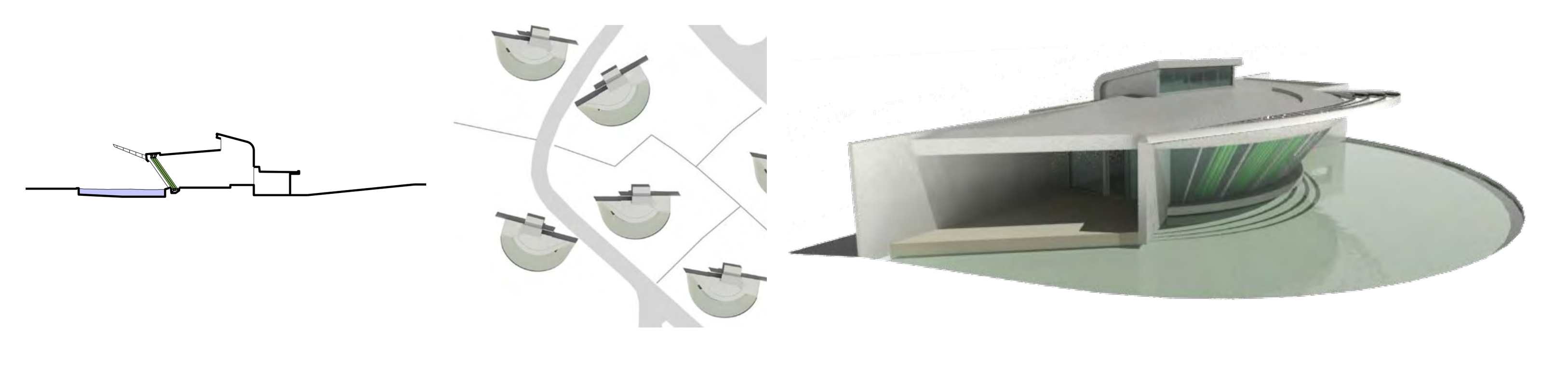
'AlgaeHouse'



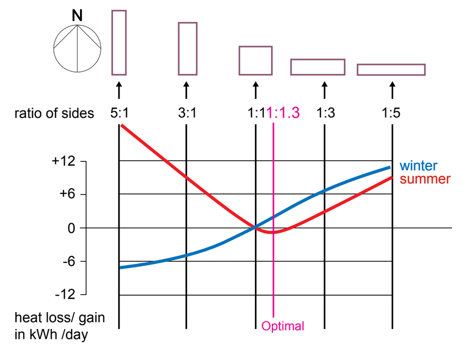
Moderate climate

Algae strain used;
Chlamydomonas reinhardtii
Favour moderate conditions

6 dwellings per hectare
= approx. 24600 kWh per annum per hectare



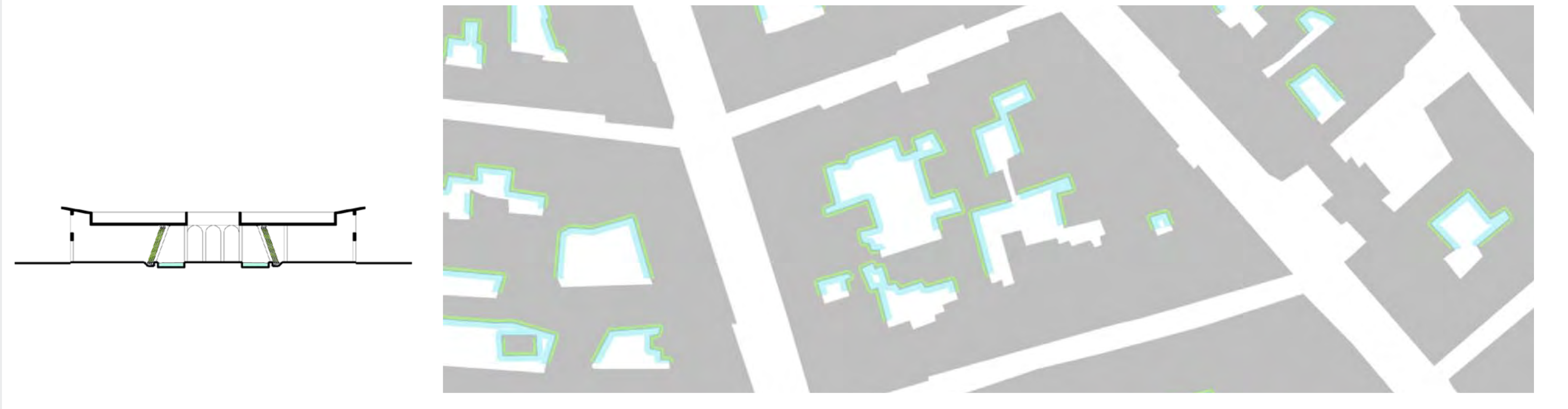
'AlgaeCourtyard'



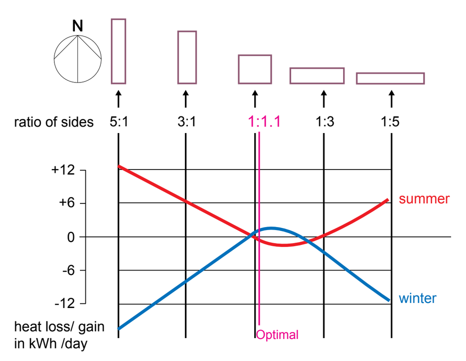
Hot, arid climate

Algae Strain used;
Scenedesmus obliquus
Tolerant of hot, arid conditions

25 dwellings per hectare
= approx. 65000 kWh per annum per hectare



'AlgaeTower'



Cool climate

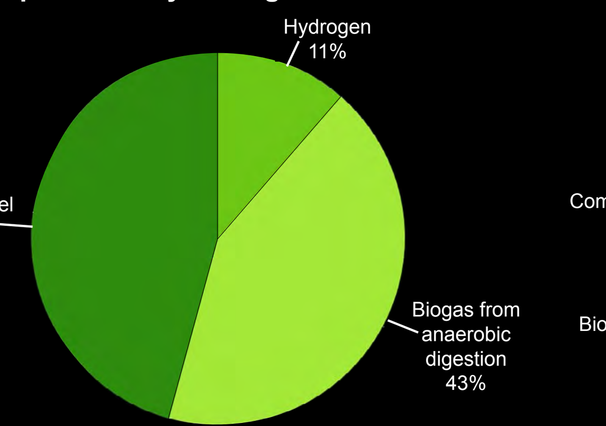
Algae strain used;
Chlamydomonas f-9
Marine (saltwater) tolerant

100 dwellings per hectare
= approx. 300000 kWh per annum per hectare

...energy flows

SUPPLY

A total of 4059 kWh/ annum produced by the Algae facade



DEMAND

Breakdown of energy