# the Aquaponics Solar Greenhouse

AquaponicsUk

# Contents

# 1. Introduction & Context

## Background

The aquaponics solar greenhouse represents the evolution of integrated farming into a complete multi-trophic food and energy system. Enclosed within an energy efficient building structure it maximises the use of natural resources to provide optimal growing conditions all year round.

Following more than two years of research and development, prototyping in Germany and receiving a “Greenius” Award in February 2013, Aquaponics UK in partnership with EBF Gmbh, proudly presents the “Aquaponics Solar Greenhouse” (ASG)....

The ASG is the product of a collaborative design, research and development partnership between Aquaponics UK and EBF in Germany. An international partnership working to create local solutions to global issues.

## Integrated food & energy systems

The time has come to think logically about how we will produce more food with less land and how to maximise use of our natural resources. The answer lies inevitably within nature, through mimicking natural ecosystems we can eliminate waste and create a stable and diverse system that is highly productive and efficient.The ASG is a perfect example, an energy efficient structure inspired by nature and a food system driven by natural ecosystem function...

## Producing more food

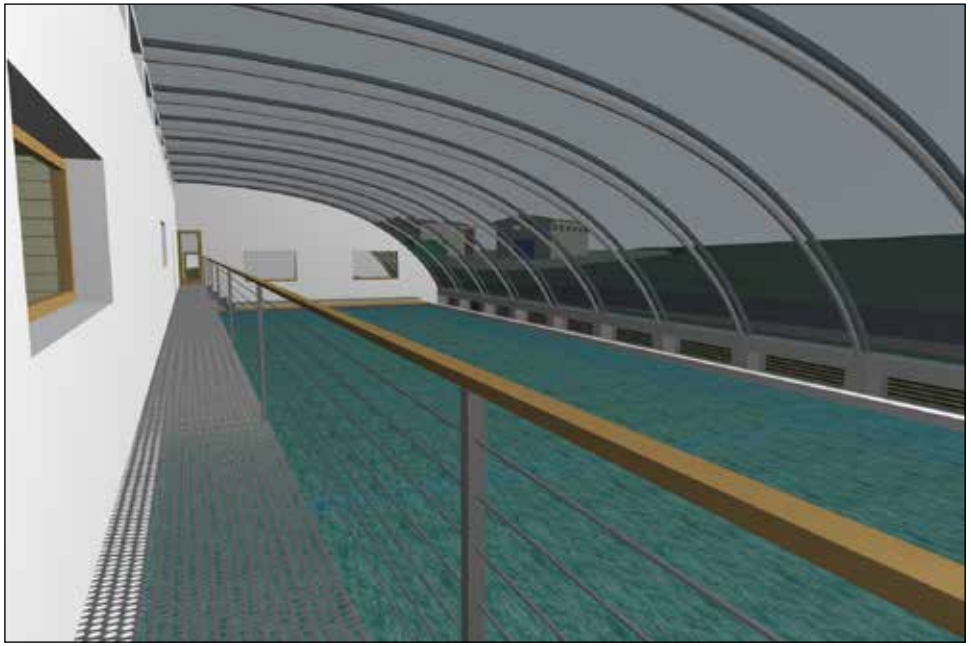
We face considerable challenges on a local, national and global level to feed our growing population. It is predicted we will need as much as 50% more food by 2030. In light of increasing demand for space especially in and around our growing urban centres, we need to produce more food on less land. We are also in need of technologies that make better use of resources, whether energy, water or so called ‘wastes’.
Through its innovative and joined up approach the Aquaponics Solar Greenhouse represents one solution; a sustainable, resource efficient, highly productive food system.

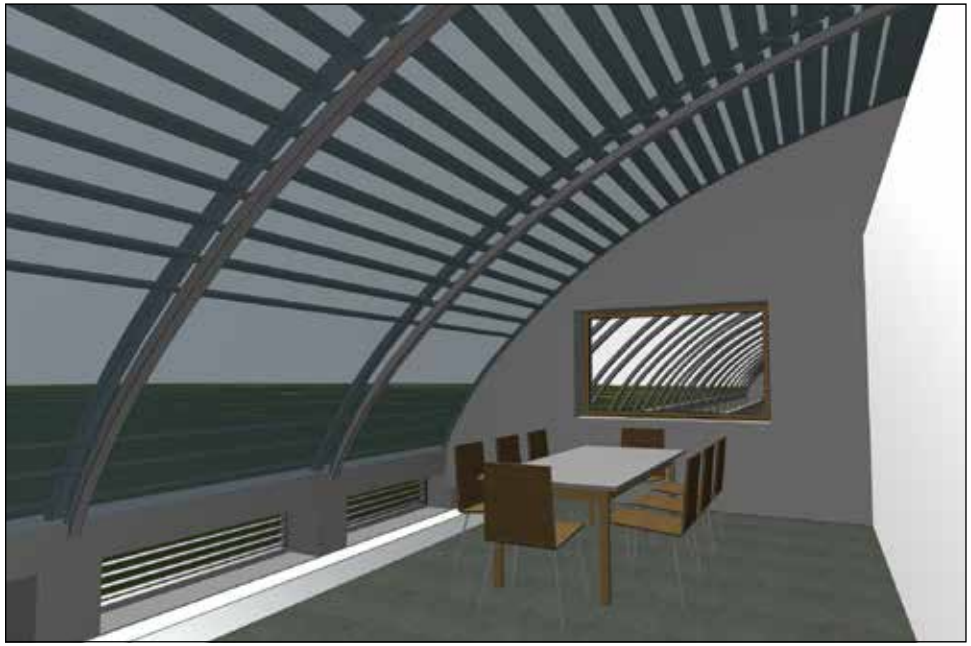
## Combining appropriate technology

The aquaponics solar greenhouse system encompasses a suite of geographically appropriate solutions to for growing at different latitudes. From multi-functional photovoltaics for shading to insulated thermal quilt systems preventing light pollution and minimising heat loss, the solar greenhouse can be adapted to suit.
Internally within the the greenhouse a number of complimentary farming systems are linked and integrated to produce a wide variety of outputs from the minimal inputs in a system where nothing is wasted...

This near closed loop system has the potential to be adopted in a wide range of contexts from commercial farming, to urban agriculture as well as an engagement tool for education, community cohesion and social mobility.

The aquaponics solar greenhouse poses a solution to producing more food, with less resources. Flexible and adaptable to different situations and production requirements this ecosystem approach represents the future of growing.





# 2. The Building Envelope

## Solar Greenhouse Design

Originally developed in 1930s China, the principle is a single slope, south facing greenhouse with thermal mass floor and east, west and north walls.
We have evolved this simple, logical design using state of the art materials and production technologies to create the next generation of greenhouse.
Excess solar energy is captured and stored within the thermal mass to cool the building when required and release energy into the growing space during colder periods. This maximises use of light and minimises temperature variation to provide optimal growing conditions year round as well as minimising energy requirements.

*Traditional Chinese solar greenhouse*

## ETFE covering

The greenhouse is covered in a revolutionary material called ETFE which has numerous advantages over glass, polythene and polycarbonate.
Most commonly associated with the Eden Project, ETFE is a material of the future and is being increasingly used for both horticultural & architectural structures.
Benefits include:

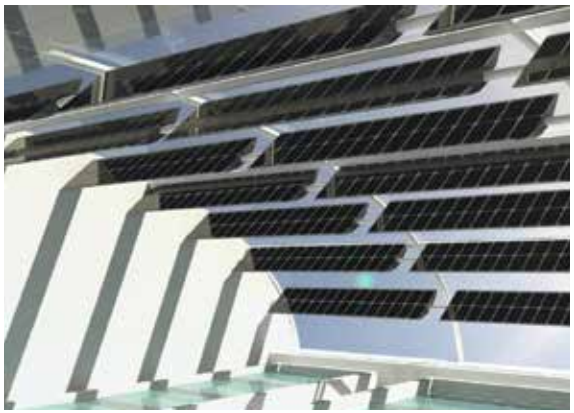
- Exceptional light transmittance,
- Incredible strength and durability
- Low frictional coefficient / self cleaning and anti-drip. Non-flammable
- 20+ year lifespan at which point it can be re-rolled and reused.
- Lightweight = minimum steel support

*F-Clean EFTE film (100 microns)*

## Multi-functional photovoltaics

Incorporated within the greenhouse is an innovative shading system that functions to produce electricity, shade the plants, and to heat & cool the air when required.

The low profile panels rotate to increase or decrease shading as required.
Housing the panels inside the greenhouses allows them to be coated in incredibly transparent 100µm thick ETFE as opposed to thick thick hail resistant glass. The long thin hollow panels allow air to be passed through, thus cooling the panel, further increasing their efficiency and also providing supplementary heat for growing.



*Multi-functional photovoltaic shading system*

## Passive heating & cooling

The Aquaponics Solar Greenhouse makes use of the natural air movements when heating and cooling.. When the greenhouse requires cooling air is drawn in through an underground earth to air heat exchanger into the cold trap, with warm air being vented out of the roof vents at the top of the north wall. When the greenhouse is in heating mode air can be recirculated through the thermal mass wall and underground collector to warm the recirculated air.

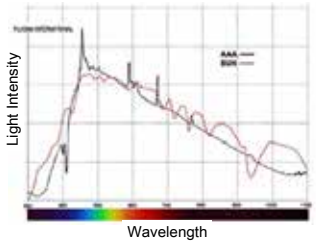
## Waste heat (biomass/CHP/AD)

Whilst the greenhouse is a relatively passive structure, supplementary heating may be required, either to grow warm water fast growing species such as tilapia and catfish and also for seasonal supplementary heating to ensure consistent year round growth and productivity. It is therefore proposed that the greenhouse is, where possible, coupled with a source of waste thermal energy.

Renewable energy applications such as biomass, combined heat and power and anaerobic digestion have all been identified as appropriate technologies for integration and solutions developed accordingly.

## Sulphur Plasma Lighting

In order to achieve consistent year round productivity supplementary artificial light is periodically required to ensure optimal growing conditions. The debate surrounding energy efficient horticultural lighting is a complex one, but the most significant and promising advancement is not through LEDs but with sulphur plasma, a light source that closely mirrors the suns spectrum and provides more lumens per watt than any the alternatives.




Working with the pioneers of the technology, sulphur plasma lighting has been integrated into the aquaponics solar greenhouse to maximize every single watt of energy required.

## Thermal Quilt

At night a thermal insulating curtain is automatically rolled down over the ETFE greenhouse front for two reasons, firstly to insulate the greenhouse and secondly to reflect light back into the growing space. The result is minimal energy loss and zero light pollution.

## Green roofing & landscaping

The north side of the solar greenhouse is a Passivhaus structure with a green (wildflower) -roof covering all but the greenhouse element of the structure. This removes the visual impact of the building structure from the northern aspect whilst enhancing local biodiversity through habitat creation and providing opportunity for livestock grazing.

## Rainwater Harvesting

The ETFE surface of the greenhouse will also function as a rainwater collector which will drain into a reservoir at ground level on the south side of greenhouse. This reservoir will be multi purpose, firstly to store water for use in the greenhouse and secondly to reflect light into the greenhouse from the southerly aspect.

# 3. Multi-trophic Ecosystem Farming

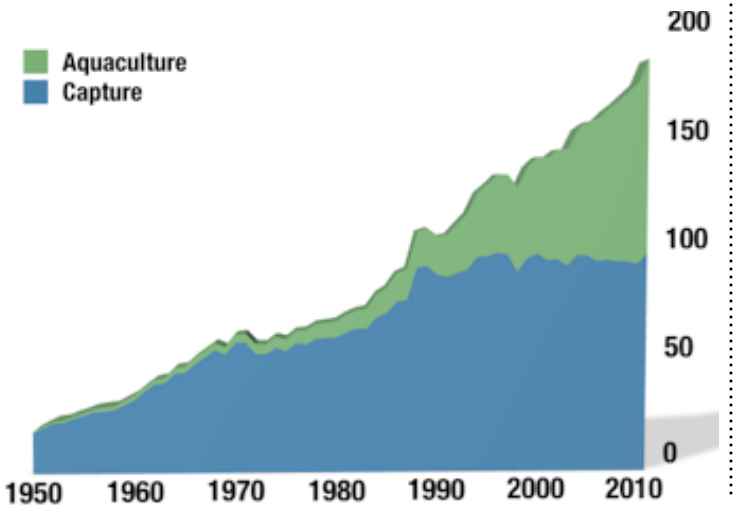
## Recirculating aquaculture systems

Fish is a vital food source, over 1 billion worldwide depend on it as their primary source of protein and it's health benefits are well documented. Natural stocks are dwindling due to overfishing and as such aquaculture is becoming increasingly important.

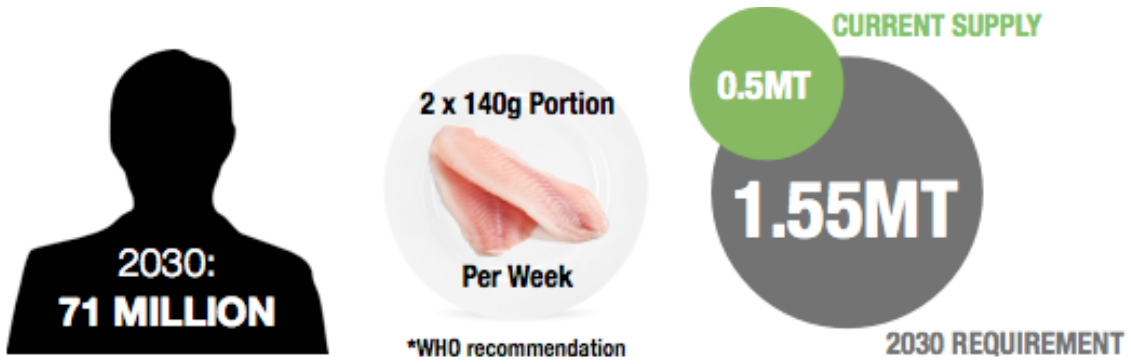
Fish farming now accounts for 48% of all food fish supply, it is the fastest growing food producing industry in the world and one of the most efficient methods of producing protein. However this rapid growth has not come without environmental criticism particularly relating to resource use and biological and environmental pollution.

Recirculating aquaculture, where water is filtered and reused within a land based, closed system, is a major advancement. This has helped to eliminate some of these issues however there is still an emission of wastes. In aquaponics nutrients and heat are recovered in the production of a high valuable secondary crop. Less water and energy is required to produce greater and more varied outputs thus production is more economically and environmentally sustainable.

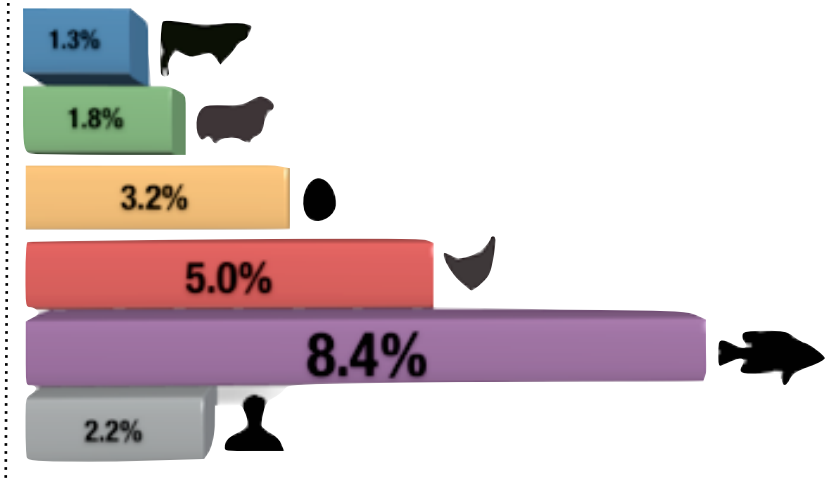
*Capture versus Aquaculture - Million Tonnes*




*Capture versus Aquaculture - Million Tonnes*




*Average Annual Production/Population Increase 1970 - 2008*



## Organic hydroponics

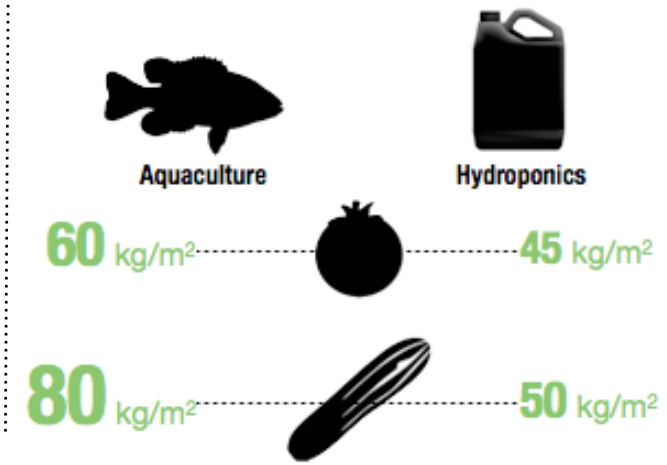
Hydroponics is the growing of plants without soil, plants are grown in an inert media and are provided with dissolved nutrients via the irrigation water. Conventional hydroponic nutrients are generally petroleum derived synthetic compounds. These are provided to plants under very sterile and controlled conditions to optimise growth whilst producing a uniform output of the desired crop. In an 'organic' aquaponics system, nutrients are derived naturally from the fish 'wastes' and the plants become a high value, harvestable filter.

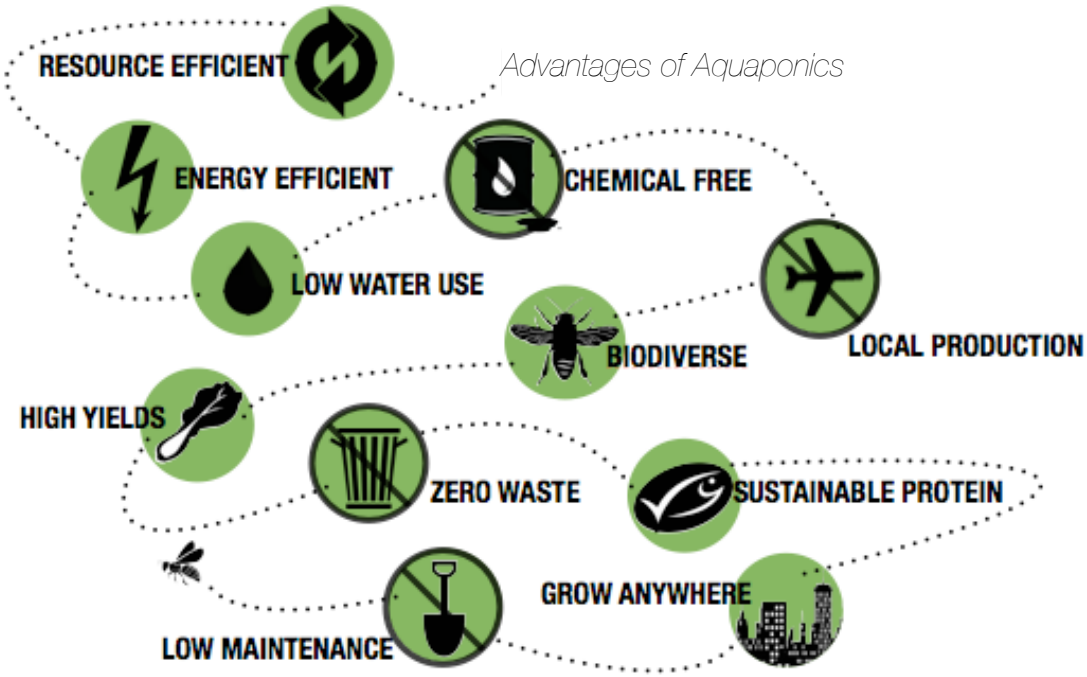
Integrated pest management is adopted to ensure pesticide free crops and it is well proven that this organic approach can be equally if not more productive as the inorganic one.

## Waste streaming

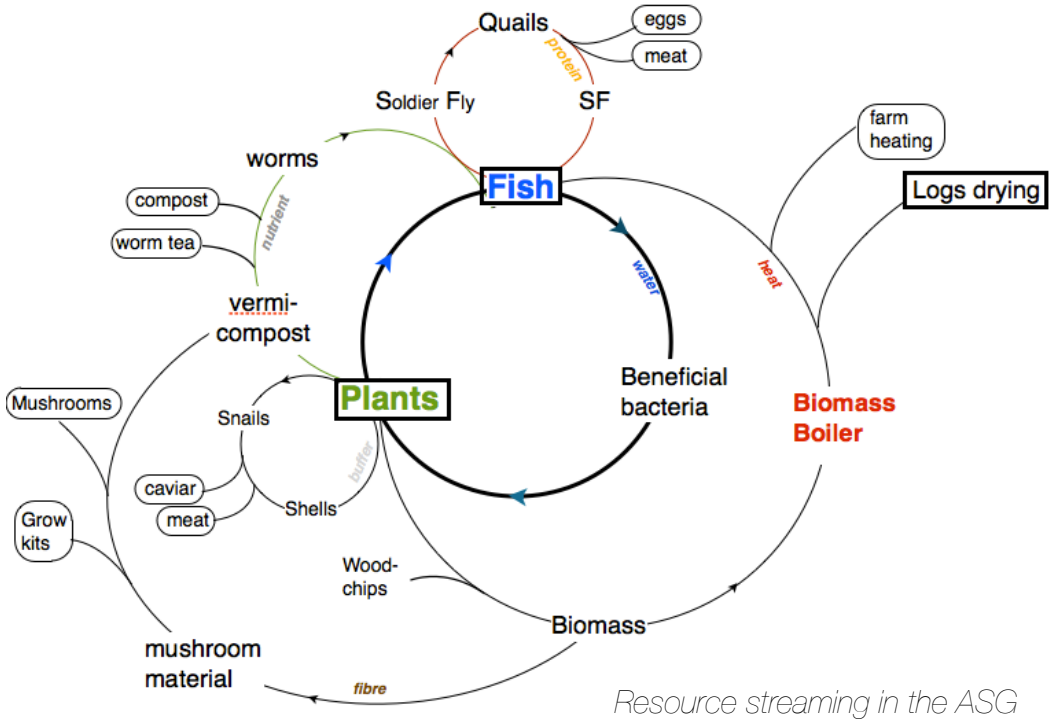
Through the integration of insects, molluscs and crustacea into this multi-trophic production system we are able to turn every conceivable waste into a added value from the system.
Insect and plant based on-farm feed production is at the core of this sustainable and self reliant food system.

*Aquaculture Vs Hydroponics*




*Advantages of Aquaponics*




*Resource streaming in the ASG*

## Fish Production

Each Aquaponics Solar greenhouse has the potential to produce over 10 tonnes of fresh fish per year.
Due to the flexibility of the culture system, a wide variety of different species can be grown; ranging from warm water species such as tilapia, catfish and barramundi to more temperate species such as perch, carp, zander and sturgeon.
A fish nursery is also incorporated to grow fry to fingerlings before on-growing.

## Plant Production

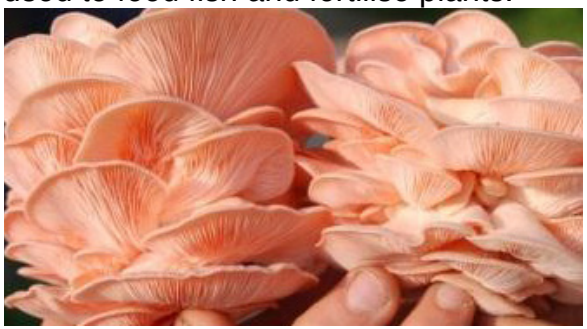
The greenhouse growing area is predominantly designed for floating raft culture, with fast crop rotations of between 4-6 weeks.
Seedlings are propagated in a purpose built propagation room before being planted onto rafts and floated down the raft tank in 4-6 weekly stages before being harvested and moved to the processing room for packaging.
Over 34 tonnes of fresh vegetables can be produced in the system per year.

## Quails, Snails & Prawns

A variety of additional high value crops are produced from the wastes of the fish-plant system. Quails are grown and fed from black soldier flies produced from the fish wastes, and the fish are fed worms produced from plant wastes as well as soldier flies from the quails.
Giant freshwater prawns or red-claw crayfish are grown under the floating rafts and mushrooms, snails and compost are additional by-products.

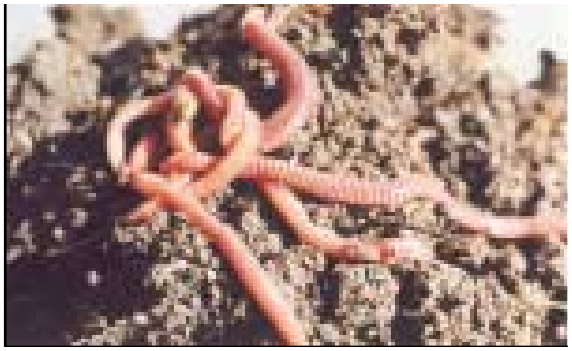
## Mushroom Production

Mushroom culture and aquaponics are an ideal fit. The light, humid greenhouse conditions are ideally suited to fruiting gourmet mushrooms and like fish, mushrooms produce CO2 and consume oxygen making an ideal synthesis with plant production. Nutrients from agricultural and municipal wastes (such as coffee) can be recycled into a high value, protein and nutrient rich product. The spent substrate can be further recycled as a highly fertile feedstock for worm and other insect production the products of which can be used to feed fish and fertilise plants.



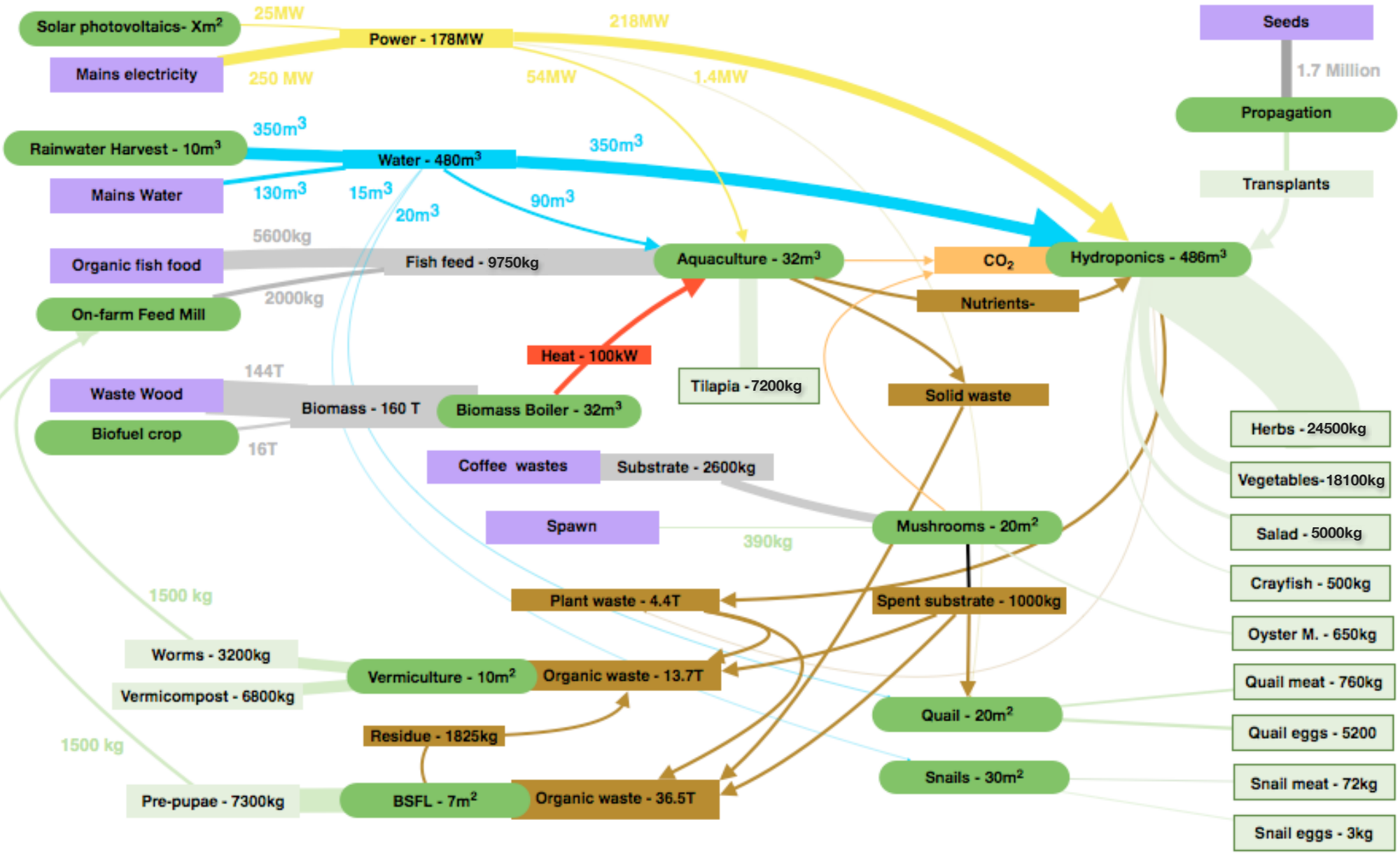
## Black Soldier Fly Larvae

BSF larvae are amazing convertors of organic waste, they will consume and digest almost any form of putrescent waste, including meat, dairy products and manure, reducing the mass of waste by 50% and nutrient content by up to 75%. Protein and nutrients are assimilated as larval biomass creating a high quality animal feedstuff. Not only this but mature larvae migrate from the feeding ground effectively harvesting themselves! And the residual material can be used as a vermiculture feed or soil amendment.

## Vermiculture

There are numerous synergies with aquaponics and vermiculture. Plant roots and off-cuts can be used as feedstock for worms and the worms themselves are a source of protein for fish feed. Vermi-castings, leachate and teas have a rich microbial diversity and contain substances beneficial for plant growth. Vermicompost is a highly fertile, organic compost and aerated compost teas suppress plant disease and pests and can also be used as a nutrient rich foliar feed.




*Input/Output and Resource Streaming*

Processes | External Inputs | Internally produced input | Outputs

AquaponicsUk

# 4. Inputs, Outputs & Productivity

## Inputs / year


130 m


9750 kg fish food


250 MW electricity


144 tonnes waste wood


1.3 million plant seeds


18,000 fish fry

## Outputs / year


47600 kg plants
(herbs, salad and vegetables)


7200 kg tilapia, catfish, perch, zander
sturgeon, barramundi or carp


500 kg freshwater prawns or
red-claw crayfish


650 kg mushrooms


750 kg quail/chicken meat


5200 quails eggs


70 kg snail meat


3 kg snail caviar


7300 kg black soldier fly larvae


3200 kg worms


8600 kg compost & potash

# 5. The Future of Growing

## Environmental benefits:

- Zero waste - all by-products are reused on site for further production
- Increased biodiversity through habitat creation
- No pesticides or chemical fertilisers.
- Efficient use of water, no abstraction from natural water bodies
- Can be located close to market to minimise transport related emissions, year round supply also reduces requirement for air freighting
- Reduces requirement for wild-caught and unsustainably farmed/fished sea-food
- High welfare conditions - low fish densities viable due to diversification
- Low life cycle impact - constructed from ecological materials where possible, minimal inputs of resources and energy for operation and the majority of components can be recycled at decommissioning.
- Does not require fertile land or deplete soil nutrients
- High yielding, less land required for production
- Promotes ecosystem approach to farming to a wide audience base

## Economic benefits:

- Inputs requirements are reduced by integrating systems.
- Passive structure minimises energy requirement
- Economic risk is reduced through diversification. Growers are less vulnerable to crop disease/pests and market volatility
- Proximity to market means a exceptionally fresh and high value product allowing access to niche markets, including direct sales
- High growth rates and fast turnover allow fast reaction to market change and enables growers to to plant to order
- Easily integrated into farm diversification and renewable energy strategies thus reaping benefits of associated financial incentives
- Capital costs will decrease as more units are constructed and components become ‘off the shelf’ products, systems can be scaled to suit.
- The unit is potentially self-sufficient and unaffected by rising oil prices
- Consistent, year round production of high value, varied produce
- Land requirements are low due to high yields

## Socio-cultural benefits:

- Provides direct employment, and skill development through training courses
- Construction of the ASG provides business for local manufacturers, builders and contractors.
- Establishes a direct connection between consumers and communities with how food is grown.
- Adds to social capital and community resilience and profile
- Can improve Uk food security and reduce reliance on imports
- Can improve health of communities via access to affordable, healthy food.
- Improves local environment both aesthetically and also biologically through increased biodiversity
- Aids community cohesion bringing people together around food.
- Provides opportunity for additional community facilities such as on-site retail of produce from the farm and local suppliers
- Processing and value adding can be passed on to local businesses further boosting the local economy and stimulating entrepreneurship.

## The Aquaponic Solar Greenhouse

represents a sustainable solution to producing high quality food, year round in temperate climates.
Its ability to maximise resources and integrate complimentary farming systems, provides a sustainable and multi-trophic solution to our food security challenges.
The oil dependency of our current food system is of great concern and with peak oil starting to cause rapid price increases, the decoupling of oil from our food system is vital if we are to be resilient going forewords.
Given the significance of the food and energy challenges we face in the near future, we need to address these issues and create food and energy systems that meet the needs of local people, that are flexible enough to grow different crops in different contexts, all year round.

## Localised Commercial Production

It is widely predicted that localised food production will be at the heart of our future green economy. The Aquaponics Solar greenhouse provides a modular, highly profitable food system producing a range of high value crops direct to local consumers.

## Community Supported Agriculture

Encouragingly we have seen a rise in community driven initiatives targeted at producing food, increase resilience and bringing communities together around food. The Aquaponics Solar Greenhouse provides an integrated solution that engages people with different skills to take responsibility, to work together, and to be rewarded with a multitude of high value outputs.

## Prisons & Probationary Services

Following some of our early work with ex-offenders and the probationary services, it has long since been the desire to create a multi-dimensional model for use as engaging space to produce food, but more importantly to propagate new skills and opportunities for a fresh start.
Replicating the model both within the prison environment and “on the outside” to create continuity of work and spin-off business startup opportunities.

## Schools & Colleges

As a learning environment, the Aquaponics Solar Greenhouse provides an unparalleled experience. All elements of science and technology are played out in a single building.

The ASG represents a cost effective investment for educational centres firstly from the production of healthy food, but secondly the less quantifiable but equally valuable engagement of learners within this multi-trophic ecosystem.

Contact us...

hello@aquaponics.org.uk