Aquaponics: A closed-loop food production method

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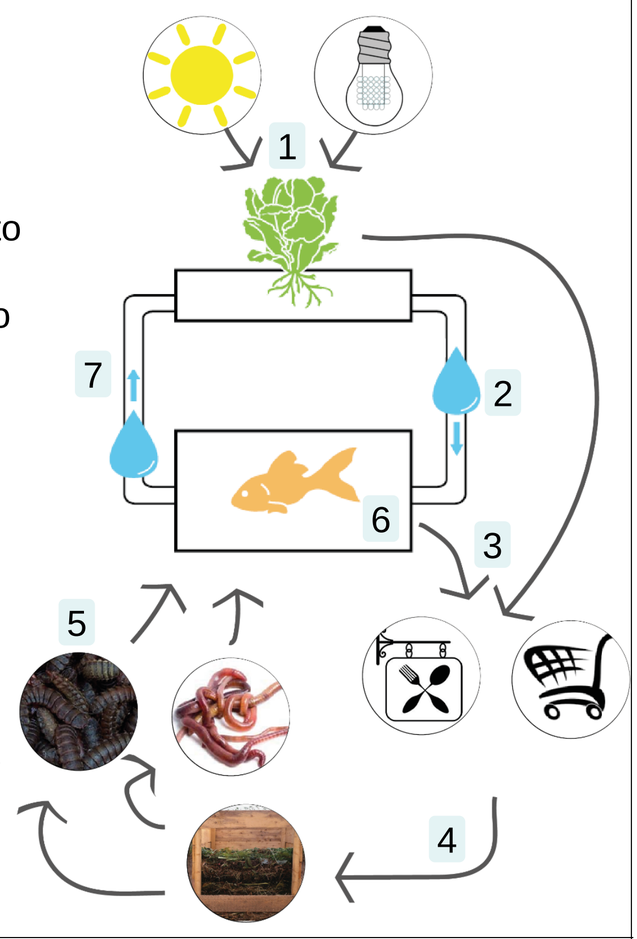
INTRODUCTION

The focus of this project is to develop a low-carbon sustainable aquaponics facility. Aquaponics is a food production system that combines fish farming (aquaculture) with soilless crop farming (hydroponics).

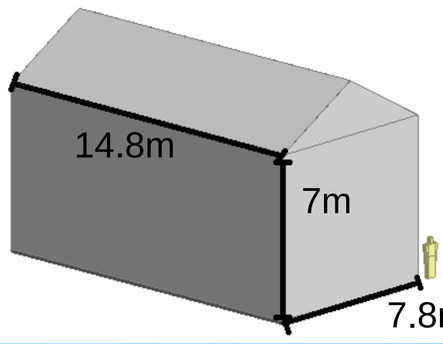
Aquaponics cycle:

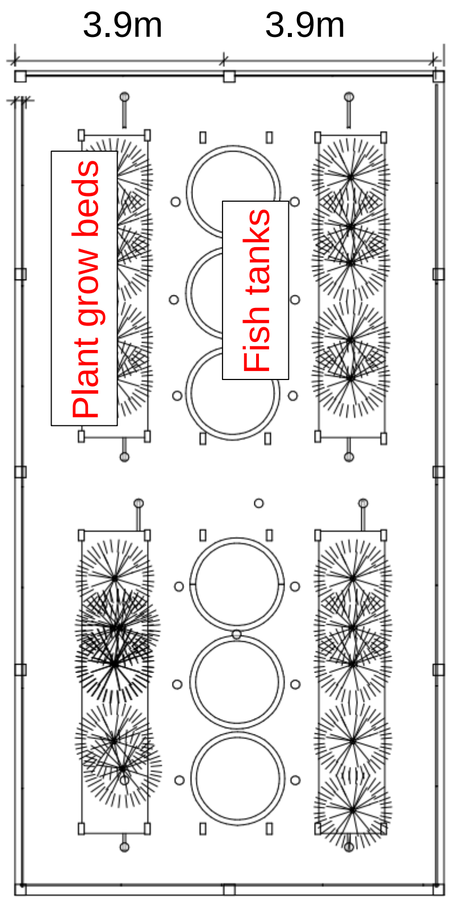
1) Sunlight and LEDs provide energy for plant photosynthesis
2) Water filtered by plants is sent to fish tanks
3) Plant and fish produce is sold to local restaurants and shops
4) Food waste is composted by restaurants and residents
5) Black soldier fly larvae and worms feed on compostable material
6) Fish are fed black soldier fly larvae and worms and their ammonia-rich excrement is converted into nitrates by bacteria
7) Nutrient-rich water is pumped into the plant grow beds



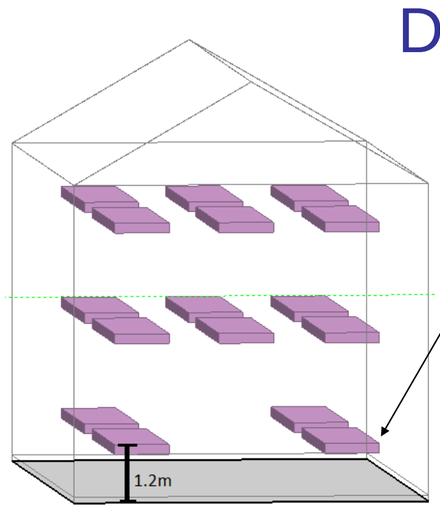
GREENHOUSE CHARACTERISTICS

The greenhouse designed is based on Love *et al*. (2015). As the embodied carbon of timber is less than that of steel, timber is used for the structure. Acetylated timber is used as this type of timber resists size changes due to humidity.

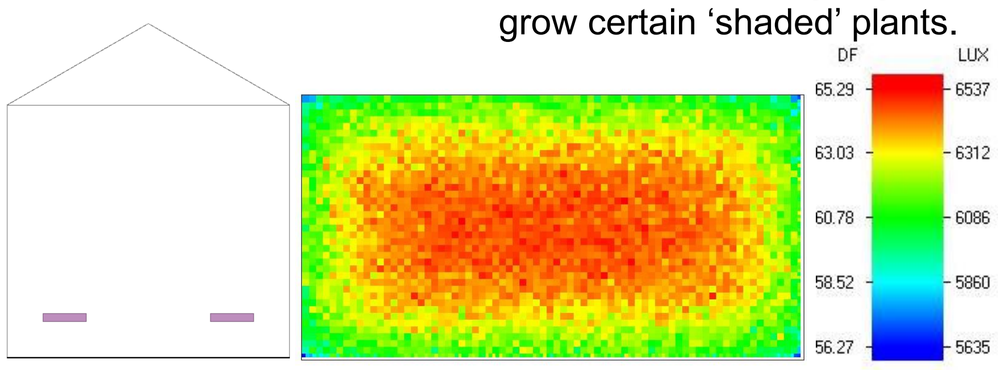


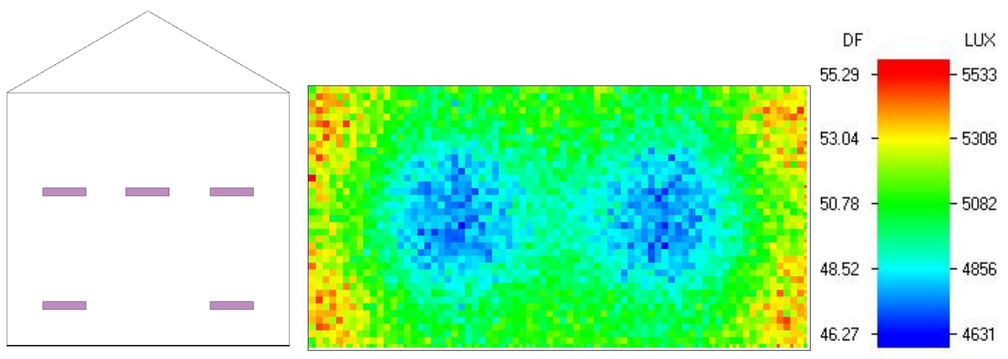


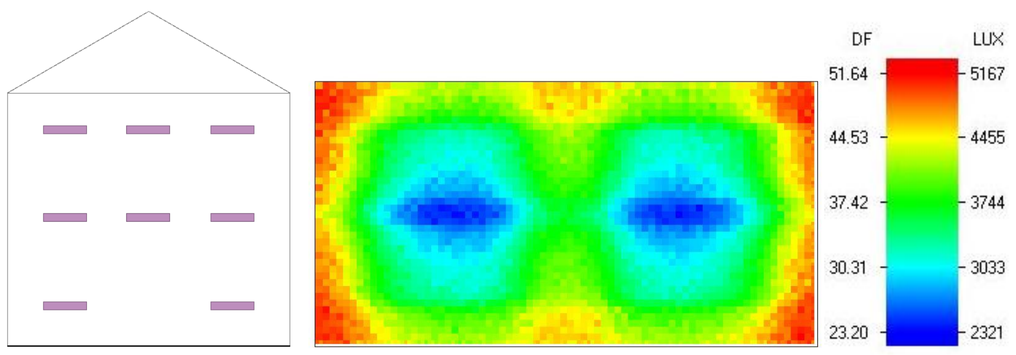
LUX LEVELS AT DIFFERENT GROWBED DENSITIES

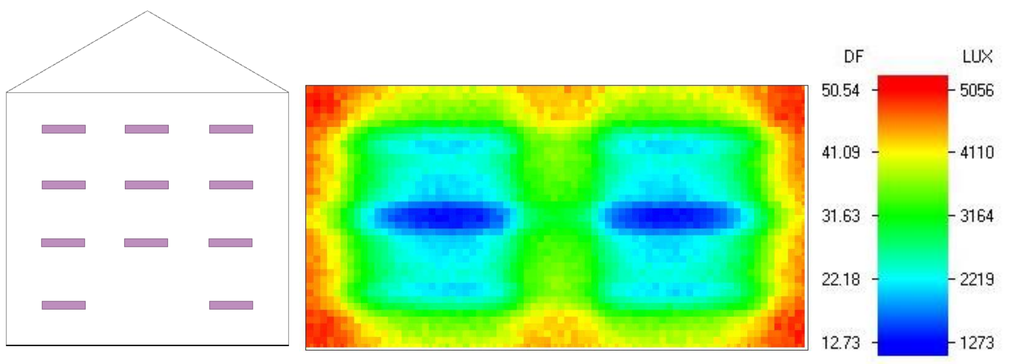


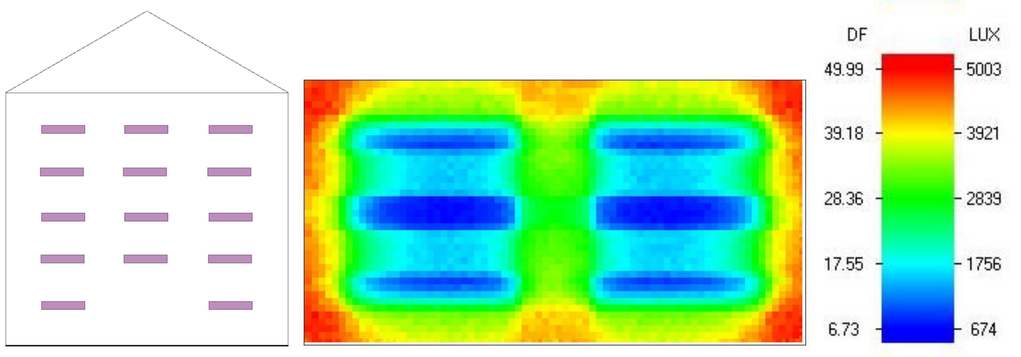
Shading is a problem in vertical farming. The lux level at the lowest growbed (1.2m) was measured using different vertical densities of growbeds. Analysis shows that as growbed density increases, lux levels decrease uniformly within the growbed area. Using 3 rows of growbeds would ensure enough light to grow certain ‘shaded’ plants.



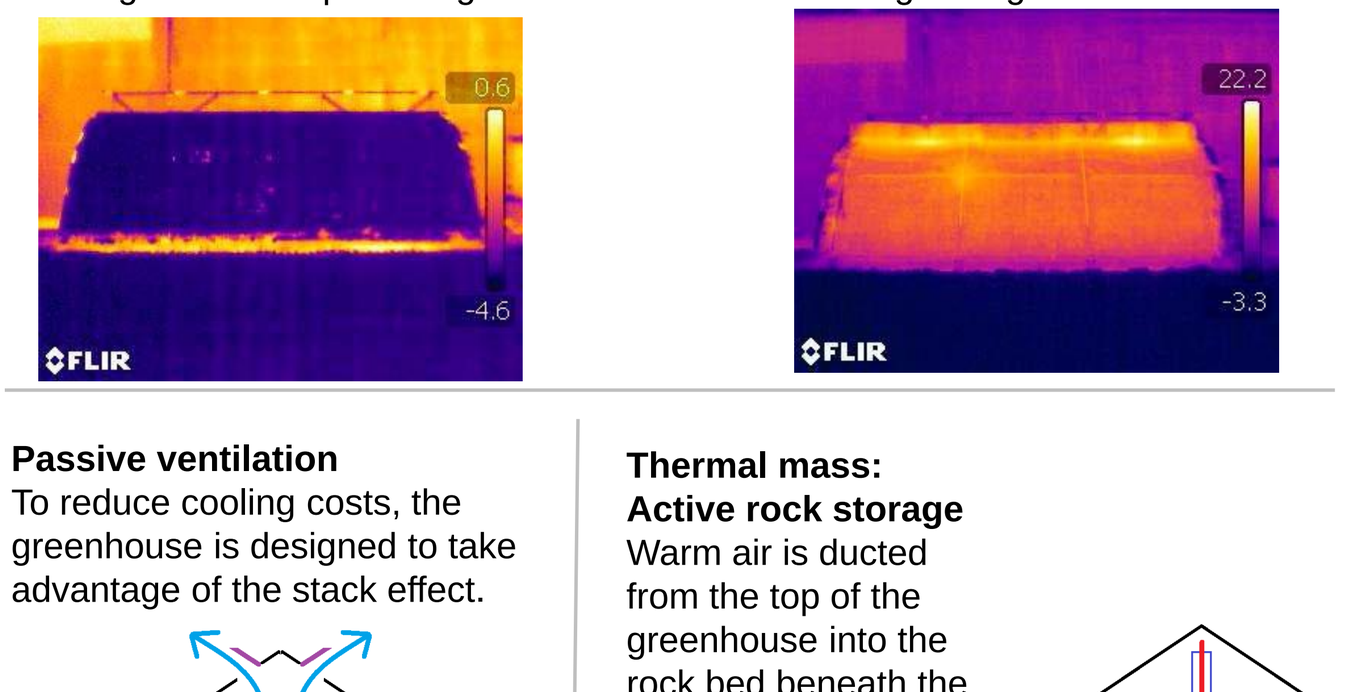








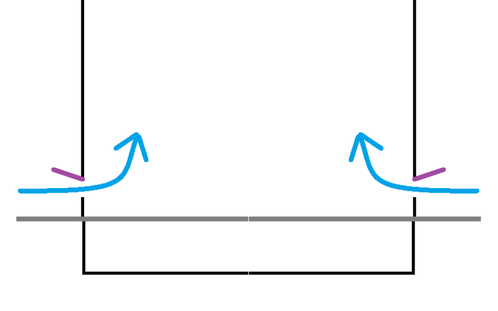
GREENHOUSE STRATEGIES

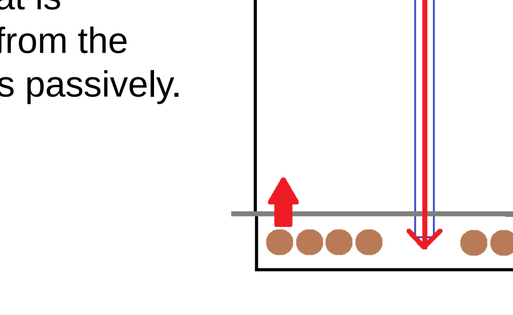


Various strategies were used to ensure the greenhouse remained within 20-27 ºC. Some of these strategies (outlined below) were modelled in DesignBuilder to investigate the temperature and energy use of the building.

Thermal quilt

Utilising a thermal quilt at night reduces heat loss through the glass exterior.





Passive ventilation

To reduce cooling costs, the greenhouse is designed to take advantage of the stack effect.

Thermal mass: Active rock storage

Warm air is ducted from the top of the greenhouse into the rock bed beneath the greenhouse to be stored. At night, when the greenhouse cools, heat is supplied from the rock mass passively.