

Vertical farming

1. EXECUTIVE SUMMARY

- 1.1. Vertical farming, which is a form of Controlled Environment Agriculture (CEA), is gaining significant investment worldwide. It offers the ability to grow crops such as leafy greens, salads, herbs and cannabis, in a highly productive environment by stacking modular hydroponic grow beds vertically and using specifically programmed LED lights. It is seen as an innovative way to use industrial spaces to grow food close to (or within) urban centres and a viable way for existing agricultural businesses to diversify.
- 1.2. The growing process is energy intensive, requiring significant amounts of electrical energy to power the LED lights. It is vital that CEA is powered by renewable energy in order to make a contribution to a net-zero agricultural sector. CEA farms can programme energy consumption to demand electrical energy at off-peak times. CEA can produce crops that would otherwise have to be imported, reducing the carbon footprint of produce whilst also increasing food-security for the Island.
- 1.3. Vertical farming represents an interesting opportunity in the Isle of Man, particularly where robotic automisation and software R&D may represent areas of growth for the economy. Although the domestic carbon account will not benefit from reducing the scale of imports of fresh greens into the Isle of Man (though certainly, reducing 'food-miles' will benefit the global carbon footprint of the food purchased), food-security among certain produce and economic benefits are apparent.

2. FOOD PRODUCTION – THE GLOBAL CHALLENGE

- 2.1. The World Health Organisation (WHO) estimates that among the global population (7.5 billion people) one-third is well-fed, one-third are under-fed and one-third is starving. By 2050, the total figure is forecast to increase to 9 billion. Food production will have to increase 60% from today's production levels in order to feed all of the human population. Considering that many of the world's agricultural systems are strained and severely degraded under the intensity with which they are cultivated and the dependence of current practice on fossil-fuel derived chemicals, the challenge is immense. These issues are compounded by the anticipation that most of the population growth will occur in cities and megacities, which require food products to be imported at great environmental (CO₂e) cost (assuming that freight is dependent upon fossil fuel combustion).
- 2.2. The great challenge of the 21st century is for the global civilisation to survive its own expansion and find solutions to live within the limits of the planet. There is no single solution, but disruptive technology and innovation are certainly key characteristics of the change required. Sonny Ramaswamy, Director of the National Institute of Food

and Agriculture at the USDA, said “indoor farming will play a significant role in easing food shortages of greens and vegetables”. We share this vision and anticipate indoor farming will play a significant role within small island nations that have vulnerable supply-chains, such as the Isle of Man. “Urban Farming is the future of agriculture” (Futurism, Jan 2018).

3. FOOD SECURITY – THE MANX CHALLENGE

- 3.1. The British Retail Consortium has recently highlighted how vulnerable the UK’s food supply is in the wake of Brexit, particularly if trade flow is disrupted with a no-deal scenario, especially considering “Fruit and Vegetables” has the largest trade deficit in the UK. By extension, any difficulty encountered on a UK-EU border would be compounded on imports into the Isle of Man. This is particularly true for fresh produce, including salads, leafy greens, herbs, vegetables and fruit, 70% of which is imported into the UK from the EU and other countries (mainly the middle-East and Africa). The import figure for the Isle of Man is estimated to be over 95%. Notwithstanding the existential ecological challenge of global food production, as discussed above, heavy reliance on food imports represents a real economic and societal risk. Increasing food security in the Isle of Man will be critical to the Island’s economy in the 21st century. With the right innovative direction and investment, the Isle of Man could address some supply-chain risks associated with the crop types that vertical farming lends itself to.



Figure 1. Geoffrey Boot, MHK (Minister for DEFA) showing the impacts of supply disruption to Isle of Man fresh produce,

4. ISLE OF MAN FOOD & DRINK

- 4.1. The Department for Environment Food & Agriculture (DEFA) launched the 'Food Matters' strategy in 2015, which is a 10 year strategy that identifies "sustainable growth, a diverse range of products, increased competitiveness and profitability for the sector as key to its success, with particular focus on industry collaborations and strengthening the supply chain". The ambition for the Isle of Man food sector in 2025 is to have:
- Flourishing businesses reliably supplying locally-produced staple and artisanal products
 - Profitably exporting and contributing to a local food culture
- 4.2. Likewise, the IOM Government's Vision 2020 document identifies the £75 million "distinctive local food and drink" as a key sector to promote economic growth, aiming to grow to £125 million.
- 4.3. The Food Matters strategy clearly states that local production of food is better for the Manx environment in terms of waste and food-miles, as well as highlighting provenance and traceability as crucial aspects of Manx food. Most importantly, the vision of the future in the strategy highlights:
- Food security
 - Adding value to the Manx economy
 - Increasing employment opportunities
 - Supporting the health and well-being of Manx residents and visitors.

5. CONTROLLED ENVIRONMENT AGRICULTURE (CEA) TECHNOLOGY

- 5.1. CEA aims to control all of the fundamental abiotic variables that facilitate efficient plant growth, including the supply of growing media, nutrients, water, temperature, CO₂ and light. Hydroponics is the cultivation of plants in a precisely dosed nutrient-solution.
- 5.2. Whilst these growing systems have been around for decades, technological innovations and cost-reduction in LED lighting have meant that efficient production is now commercially viable for indoor growing. Vertical farming, which utilise the volumetric space of an indoor environment to its fullest potential using racks and/or towers, is an emerging industry that is expected to disrupt the food supply chain by bringing growers into urban areas as well as to populations with low food-security, such as the Isle of Man.
- 5.3. Globally, the indoor vertical farming industry is expected to be worth \$13 billion by 2024. The Isle of Man represents a small, but opportune market for this technology.

- 5.4. Highly optimised CEA systems can produce the equivalent of 42 acres of outdoor farmland in just 0.6 acres of indoor space. The products will be pesticide free and herbicide free (though these inputs are minimal in the Island's agricultural industry, see agriculture work package) as well as being less exposed to crop failures from disease.
- 5.5. They will be of a higher quality and, if powered by renewable energy sources, have a smaller carbon footprint than imported goods due to the reduction in food miles, as well as having an extended shelf life with the possibility of reach farm to fork in less than 4 hours. Importantly for the Isle of Man, the produce will be supplied year-round, with no trade flow disruption from gale force winds in the Irish Sea. Moreover, CEA represents an opportunity to overcome the seasonal fluctuations in the availability of locally grown produce using conventional techniques.

6. PRODUCTS

Herbs

- 6.1. Fresh and potted herbs both represent profitable markets in the Isle of Man. With the exception of seasonally available fresh herbs from Manx organic suppliers, available in Shoprite, imported herbs are supplied wholesale (to businesses throughout the Island) and retail (Shoprite) by Robinsons. Tesco, M&S and Co-op have their own imported supply of herbs.
- 6.2. Herbs are grown most successfully and efficiently in vertical-plane systems, such as ZipGrow. The Lamiaceae family tends to show the most impressive results. Each herb variety will require unique environmental inputs (pH, nitrogen, light etc.) but, through calculated compromise, a single system can satisfy the needs of multiple varieties.



Figure 2. Sweet Basil (*Ocimum basilicum*) growing on a vertical-plane ZipGrow system (left). Zipfarm (daytime) (right).

- 6.3. Varieties that would be able to be supplied would include:
- Basil (Sweet/Genovese, Thai Basil, Lemon Basil, Dwarf Basil)
 - Oregano, Mint, Chives, Fennel, Coriander, Parsley, Rosemary

- 6.4. Cut herbs products would be supplied in 25g clamshell packaging for the retail market, and 500g bags for wholesale markets. More details on environmental preferences of herbs, production estimates and price assumptions can be found in the appendix.
- 6.5. Potted herbs is a market that requires more research on the Island. Biodegradable pots (i.e. those being trialled at Shellworks) would present an opportunity for this market to expand significantly.

Microgreens

- 6.6. Microgreens are essentially seedlings. They're grown just like the seedlings are for herbs, but much more densely, and on an open-faced media. They are harvested when they're still very young and tender (around 10 – 15 days), often before they've grown true leaves.
- 6.7. The market for microgreens has been identified as a profitable venture by the Vertical Farming Forum, more so than greens or herbs. These crops are adored by chefs and regular consumers alike, being versatile, nutritious and aesthetically impressive. They are therefore easy to sell:
- Their value is very apparent, and you can use them in almost any dish.
 - Microgreens are very healthy—studies show that microgreens can carry up to 14 times as much nutrition as mature crops.
 - They're easy to deliver and get to customers fast.
 - Microgreens are very low cost to grow (quick yields).
 - You can get a high margin.
- 6.8. Microgreens are grown in F&D horizontal-plane systems. Several UK suppliers of these systems have already been approached and this crop is incorporated into the business model based on assumptions on production and price. Currently, the only microgreens available on-Island are those imported to Tesco and M&S, as well as one clamshell product (40g) from Staarvey farm (available in Shoprite). The market opportunity for year-round Manx microgreens is present.

- 7.2. Agtech investment continues to grow year to year, with 2018 financings exceeding those of 2017. Total capital invested in 2018 is \$1.6 billion across 209 deals in agtech, with median deal sizes rising to \$10 million. The median deal size for Indoor Ag in 2018 was \$1.7 million.
- 7.3. In the UK, the most representative comparison to a commercial vertical farming company is Growing Underground (GU). GU are based in London and produce high-quality microgreens in a retrofitted WW2 air-raid shelter, 100ft below Clapham junction. They have a commercially scaled model that produces ~ 200 tonnes of microgreens per month using GrowStack[®] technology. They supply M&S, Tesco, Planet Organic, Waitrose and Farmdrop within the greater London area. After initial trials, they ran a successful crowdfunding campaign and raised £700,000 capital to expand their production.
- 7.4. In the U.S. and Canada, several large-scale indoor farms have been successful. Most recently, Plenty[™] merged with Bright Agrotech and secured \$200 million investment from Softbank, with the aim to set up a large indoor growing facility in the San Francisco Bay area. The technology they use is ZipGrow towers, but instead of 8' towers that are available online to purchase, they have scaled the system up to 30' towers.

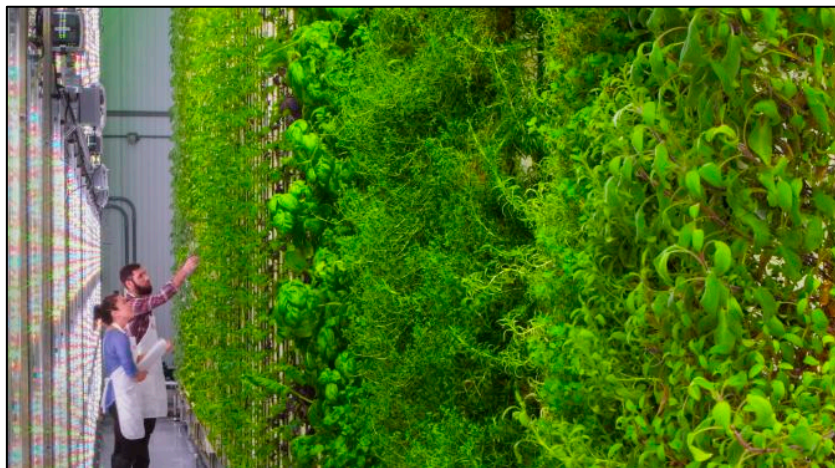


Figure 5. Plenty. Scaled up ZipTowers being used to grow herbs and greens in the San Francisco Bay area.

- 7.5. This industry is still in its infancy but there are examples throughout the world of successful indoor vertical farming, mostly concentrated in urban areas selling to high-end retail markets. The global market for indoor agriculture is forecast to be worth \$13 billion by 2024.

8. THE ISLE OF MAN OPPORTUNITY

- 8.1. Vertical farming represents an interesting opportunity in the Isle of Man, particularly where robotic automisation and software R&D may represent areas of growth for the economy. Favourable corporate tax incentives, a dynamic regulatory and legislative environment, electrical energy stability together with an isolated and well-positioned

local produce market with respected provenance, make the Island well positioned to invest in this sector with both food-production and IP / Research incentives.

- 8.2. Although the domestic carbon account will not benefit from reducing the scale of imports of fresh greens into the Isle of Man (though certainly, reducing 'food-miles' will benefit the global carbon footprint of the food purchased), food-security among certain produce and economic benefits are apparent. If carbon audits were to consider scope 3 (imported GHG emissions), then emissions reductions are possible, provided renewable energy is used to power the CEA installations.
- 8.3. The Government could encourage this sunrise industry by offering an efficient planning process to use industrial and brown-field sites for vertical farming. Further, DEFA could include a specific section within the Agriculture & Fisheries Grant Scheme to encourage start-up development.
- 8.4. Whilst CEA is energy intensive (Al-Chalabi, 2015), in the form of electrical demand to power the LED grow lights and climate-control systems, there is an opportunity to develop this industry in parallel with the increased capacity and supply of renewable (carbon-neutral) electrical energy. With the eventual transition of electrical generation and supply to renewable energy sources, vertical farming offers an opportunity to reduce the CO₂ footprint of produce (grown in CEA) when conventional techniques are restricted by seasonal parameters and imports continue to rely on fossil-fuelled freight transport.
- 8.5. Finally, there is an opportunity to use CEA as a grid balancing industry. A system that produces ~ 45t greens per year requires approx. 0.5 MWh per day. The growth of the plants is optimised by the LED lights emitting certain frequencies of light for a period of 16 hours per day. Since the timing of this day/night modality is entirely controlled by the operation, it could be used as a grid-balancing mechanism whereby the lights operate overnight and up to mid-day, when electrical demand in the rest of the economy is low (off-peak).

9. CARBON BENEFIT

- 9.1. Not quantified

10. ECONOMIC BENEFIT

- 10.1. Not quantified

11. RECOMMENDATIONS

- 11.1. Manx agricultural practice & policy must align with the overarching carbon objective of achieving net-neutrality by, or before, 2050.

- 11.2. CEA must be appraised on a case-by-case scenario to evaluate carbon benefits, as the industrial process is energy intensive. CEA must run on renewable energy if it is to become part of the carbon solution.
- 11.3. Renewable energy supplied CEA must look to develop crops and varieties that are imported and seasonally restricted by conventional organic techniques on-Island, in order to have the greatest carbon negative effect and improvements to food security.
- 11.4. CEA proposals that claim to be carbon-efficient compared to conventional techniques and/or imports should conduct a carbon-based life-cycle-analysis (LCA) of the industrial operation.

12. REFERENCES

Al-Chalabi, M., 2015. Vertical farming: skyscraper sustainability?. *Sustainable Cities and Society*, Volume 18, pp. 74-77.