



SmartHort 2019

Vertical farming and horticulture: Horticulture 4.0

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Improving Production Systems

Intelligent Production Systems/ Derek Stewart





Horticulture 4.0? 2nd 3rd 4th 1st Mechanization, Mass production, Computer and **Cyber Physical** water power, steam assembly line, Systems automation electricity power

Global Challenge



Population of 8.3 billion by 2030 (UN)

Food 50% increase in demand (FAO)

Soil erosion & biodiversity loss

Freshwater 30% increase in demand (FAO) Land 120 million ha needed in developing countries crop production (FAO)

Energy

50% increase in

demand (EIA)



Probability of extreme weather events







Climate Change will hit the staple crops and then the consumer



IMPACTS OF CLIMATE CHANGE

By **2030**, nine out of 10 of the major crops will experience reduced or stagnant growth rates, while average prices will increase dramatically as a result, at least in part, due to climate change.





Global Food Companies & Climate Change

AHDB









AGRICULTURE





Percentage of our key agricultural ingredients sourced from more sustainable sources in 2016

Strawberry Fields Forever?





Anthracnose

Botrytis



One key pillar of this change, in almost every part of the world, is the mass adoption of indoor farming.





TODAY GROWING SOME CROPS IN SOME PLACES IS PROFITABLE AT INDUSTRIAL SCALE













Most indoor farming is **economically inefficient** due to the **high power costs**

Outside the developing world **labour costs** are prohibitive

Productivity is hampered by the inability to deliver totally controlled environment agriculture

Vertical farming brings a whole new set of challenges.





Stacking growing space requires power-hungry automation & mechanics

Monoculture operation requires tight, balanced environmental control

Power cost is driven even higher by the offset between lighting and ventilation

Lots of attention & investment but **profitability** remains elusive



So we've built revolutionary Power, Comms & Controlled Environment platforms.



50%LESS
POWERWe've solved the power problem.
Patented 3-phase Power & Communications platform to collapse energy costs,
using IOT to manage Lighting, Ventilation, Gases and Water (TCEA).

80%LESS
LABOURWe've solved the labour problem.Patented Tower Automation platform to manage stacks of growing trays,
handled by robots for germination and propagation.

2X-3X
YIELDWe've solved the productivity problem.
Using Artificial Intelligence our SaaS app lets growers find optimal growing
"recipes" using our platforms, including our patented Ventilation System.



Growth Tower Platform





Growth Tower Platform

Power & Comms platform enables real-time control of all tower variables via seamless cloud integration.



- Dynamic lighting utilised on each LED strip
- Flexing the lights per LED strip, per tray, per tower, whole farm
- Full closed-loop watering control
- Full closed-loop air sterilisation and conditioning control
- Humidity harvested from air
- CO_2 / O_2 continuously balanced
- Manual or Al-driven recipe creation
- Plants monitored for reaction to recipe changes
- Data capture direct to SaaS platform
- Exception detection and automatic re-set



- Manages Light, Temperature, Water/Nutrients & Gases
- Fully automated Growth Tray systems support all these variables
- 100% robotic handling
- Closed-loop water and air management
- In-tray Ventilation delivers <1°C variation across the crop
- Artificial Intelligence enables recipe experimentation and optimisation
- IOT enables remote monitoring and control of all systems
- Controls enabled at farm/tower/tray/LED strip level 24/7/365
- Designed to operate anywhere, globally







AHD





- Modular Design
- Built in Pairs of Towers
- 60 trays/300m² growing area per tower
- Robot Operated
- Picks
- Places
- Waters
- Inspects
- Samples
- Monitors



- Month 1 metrics (basil)
- 18-23 days to harvest weight vs 28-35 range for greenhouse
- 18 growth cycles per annum vs 12: 50% more
- 680g yield per punnet vs 450g industry standard: 50% greater
- = 225% Greater Yield Per Annum



Clear Product Strategy







Growth Station Platform



Clear Product Strategy





Growth Station Platform

Same core 'Power and Comms' platform enables real-time control of all station variables via seamless cloud integration



- Growth Stations have many of the tools developed within the Growth Towers
- Dynamic lighting utilised on each LED strip
- Flexing the lights per LED strip, per tray, per station, whole farm
- Direct ventilation per tray
- Allows single storey retro-fit
- Manual handling
- Manual or Al-driven recipe creation
- Plants monitored for reaction to recipe changes
- Data capture direct to SaaS platform

Fully IOT-enabled

No Cables. No Computers. No Capacitors.

- Radical cost savings: power, installation, maintenance
- Supports LED dimming, pulsing and colour-mixing
- No loss of efficiency
- Power factor $\approx 1 @$ dimming range 100%-15%
- Almost no harmonics: balanced phases
- Giving significantly greater productivity: yield, quality, consistency
- Communications makes every device addressable / IOT-enabled
- Enables remote control of every device
- Data capture enables "growth recipe" optimisation







DISRUPTIVE. PATENTED. DEFENSIBLE.







• Growth Station Controller

app:

• Easy to use with little or no

training

- Direct control of the lights
- User can build arbitrarily complex sequences of lighting

IGS Portal web interface:

- Richer functionality
- Facility management
- Supports both production and

experimentation







Machine Learning Platform Road Map

24/7 real-time data from 1,000's of data points, measuring everything from soil moisture to regional power conditions.

IGS leverages a scalable, high performance AI platform architected for large volume spatio-temporal data (IOT, stress sensing, imagery analysis, etc.) to optimize operational efficiency, crop profiles and even supply chain demand management.

Real-Time Operations	Growth Recipes	Supply Chain
Monitoring data (environmental, lighting, watering, HVAC)	Dynamic Recipes : all growing attributes can be planned for each crop family and variety	 Forecast customer demand based on actual historical to predict optimal crop management and planting schedules* Leverage across 100s or 1000's of geographically disparate vertical systems and markets*
Operational data (timing of all events, tasks scheduled and actioned)	 Recipe Timing: can be run on different trays, at same or staggered timing. A time machine for scientists and market flexibility for production Rapid Experimentation correlated to target outputs (taste, growth cycle, shelf-life, etc) by controlling all TCEA inputs 100's of experiments per tower 	
Comparing planned events vs actual events vs risk		
Predictive maintenance enabled throughout		Empower large scale growers to flex crop capacities seamlessly*
Managing overall lighting, ventilation, irrigation, operational efficiency		
Ontimising power consumption and growing conditions		
Flexing with the grid to deliver demand side response*	Optimising growth cycles, nutrient content and specific taste profiles*	
		* work in progress



Cost Reduction = Key To Market Growth



MATCHING MARKET DEMAND

Consumer pull *not* technology push Price is the key

Premiums must provide value Quality: Taste, Nutrition, Food Safety Consistency

Retailer benefits Less wastage Fresher Fewer food miles

Long Day Veg – all year round

- Crops use predominantly blue and red parts of the light spectrum
- Get fundamental, natural, changes in plant growth and phytochemistry (flavour, storage properties, nutrient density; growth rate; ripeness) by altering the ratios, timing and duration of different wavelengths





Making Indoor Ag Profitable

IGS' unique technology drives costs down and yield up, further than any competing system



Reduce Power costs with Photon Optimisation Smart Power Management

Reduce Labour costs by Automating Scaling

Tech & plant science will deliver Higher yields Better quality

Greater consistency



Total Control environment agriculture



• Higher plant densities; higher nutrient density; faster growth and more crops per annum

•GROWING LOCALLY, GLOBALLY

- Producing beside the market collapses food miles, cutting costs
- Increases food security, by reducing dependency on imports
- 'Farm to fork' within hours every day, 365 days of the year, increasing both freshness and shelf life, reducing storage

•BETTER QUALITY

 Product appearance, nutritional qualities and taste are improved and remain consistent year round

- Disease-free growing eliminates the need for pesticides
- Semi-hydroponic techniques eliminate the need for washing, reducing contamination

SAVING NATURAL RESOURCES

 Small footprint allowing production close to endmarkets

- Highly efficient growing media and temperature management reduces water consumption by more than 90% with minimal effluent
- Large reduction in wastage compared to conventional production

DECLINING COST

•Driven by the collapsing cost of LEDs and improving electrical efficiency

•Compression of the value chain reduces number of participants taking a margin

•Production matched to consumer demand, reducing wastage

•Integrated automation reduces labour



Conclusions

- Food Security is becoming a crucial issue.
- The treats of climate change and extremes are evident and increasing.
- A game change is required in food and crop product production
- The emergent vertical farming system <u>IS</u> that game change
- VF can both produce food (and products) and be used to breed climate resilient varieties for conventional agriculture.
- The system software, energy management and light control makes sustainable profitable production assured.



ADVANCED PLANT GROWTH CENTRE









Deliver increased commercial, economic and environmental benefits to the agricultural, food and drink sectors in the UK and Internationally by innovative use of precision controlled environment technologies.