



Cost of Production Analysis:

Hightech Glasshouse Production in Australia.



Agrology



This report was commissioned by the Western City & Aerotropolis Authority to assist in the development of the Western Sydney Airport Agribusiness Precinct.

The report has been prepared by Levi Nupponen for Agrology Pty Ltd.
December 2019.

Agrology Pty Ltd
ABN 42 620 084 988
agrology.com.au

Important notice – purpose of this report and restrictions on its use

Agrology Pty Ltd (“Consultant”) was engaged in the instruction of the Western City & Aerotropolis Authority (“Client”) to carry out a production cost analysis comparing greenhouse vegetable producers in Australia and world-leading examples.

The results of the Consultant’s work, including the assumptions and qualifications made in preparing this report, are set out in the Consultant’s report “Cost of Production Analysis: Hightech Glasshouse Production in Australia” (the “Report”). You should read the Report in its entirety including any disclaimers and attachments. A reference to the Report includes any part of the Report. No further work has been undertaken by the Consultant since the date of the Report to update it.

The Consultant has acted in accordance with the instructions of the Client in conducting its work and preparing the Report. Neither the Consultant nor its officers or related bodies corporate make any representation or warranty as to the accuracy, reliability or completeness of the information provided in this report. Neither the Report itself nor when read with any other document constitutes any recommendation to proceed or otherwise adopt the Project.

Liability in relation to other parties

Unless otherwise agreed in writing with the Consultant, access to the Report is made only on the following basis and in either accessing the Report or obtaining a copy of the Report the recipient agrees to the following terms:

- a. Subject to the provisions of this notice, the Report has been solely prepared for the Client and may not be used by any other party or relied upon by any other party without the prior written consent of the Consultant.
- b. The Consultant disclaims all liability in relation to any other party who seeks to rely upon the Report or any of its contents.
- c. The Consultant has prepared the Report solely for the benefit of the Client and has considered only the interests of the Client. The Consultant has not been engaged to act and has not acted, as an advisor to any other party. Accordingly, the Consultant makes no representations as to the appropriateness, accuracy or completeness of the Report for any other party’s purposes.
- d. No reliance may be placed upon the Report or any of its contents by any recipient of the Report for any purpose and any party receiving a copy of the Report must make and rely on their own enquiries in relation to the issues to which the Report relates, the contents of the Report and all matters arising from or relating to or in any way connected with the Report or its contents.
- e. No duty of care is owed by the Consultant to any recipient of the Report in respect of any use that the recipient may make of the Report.
- f. The Consultant disclaims all liability, and takes no responsibility, for any document issued by any other party in connection with the Report.
- g. To the fullest extent permitted by law, the recipient of the Report shall be liable for all claims, demands, actions, proceedings, costs, expenses, loss, damage and liability made against or brought against or incurred by the Consultant arising from or connected with the Report, the contents of the Report or the provision of the Report to the recipient.

Contents

1.	Executive Summary	6
1.1.	Key Recommendations	8
2.	Introduction	10
2.1.	Assumptions and Strategy Behind the Analysis	13
3.	Influencing Factors on the Cost of Production	16
3.1.	Climate Comparison	19
3.1.1.	Sunlight	22
3.1.2.	Temperature	23
3.1.3.	Water	25
3.2.	Production Equipment and Technology	27
3.3.	Access to Knowledge and Skilled Personnel	30
3.4.	Access to, and Cost of Labour	31
3.5.	Market Access and Competitiveness	32
4.	Cost of Production Analysis	36
4.1.	Overall Comparison: Australia vs the Netherlands	41
4.2.	Australia – Cost Summary	42
4.3.	Netherlands – Cost Summary	42
4.4.	Comparison of Major Operating Costs	44
4.5.	Comparison of Operating P&L	44

5.	Discussion on Major Costs	46
5.1.	Labour	49
5.1.1.	Pollination Labour	50
5.2.	Energy	52
5.2.1.	Heat	52
5.2.2.	Electrical	53
5.3.	Other Factors Besides Energy and Labour	54
6.	What Benefits can a Precinct Solution Deliver?	56
6.1.1.	Bio-Park Terneuzen: Medium-Scale Cross-Industry Integration	60
6.1.2.	Agriport A7: Mega Scale Purpose Built Greenfield Site	63
7.	Working Towards Parity – The IIPPH, a Solution for Australia	64
7.1.	Labour Costs	68
7.2.	Energy	68
7.3.	Other Costs	69
7.4.	The Overall Outcome	69
7.5.	Further Gains – The Potential for Yield Increase	72
8.	References	76
9.	Appendix 1 – Data Derived from KWIN Analysis	78



1 Executive Summary

Executive Summary

The [NSW Governments Integrated Intensive Production Hub \(IIPH\)](#) proposal envisages the development of a fresh food production precinct founded on the principles of circular economies located in the Western Sydney Aerotropolis. This precinct will enable sustainable and cost-effective large-scale greenhouse production of a wide variety of cropping species.

Whilst the activation of the IIPH will enable growers to produce food more sustainably and at a lower cost, it will also bring a challenge as to where this increased production should go. There is a limited opportunity to absorb such a large volume domestically given the current balance between supply and demand, therefore, a focus on export markets must be part of the overall strategy. This investigation was to determine the relative competitiveness of current Australian production systems on a global scale, and what the outcome may be if we activated the IIPH — could we be competitive enough to realise this export potential?

Our analysis showed that Australian growers are currently disadvantaged when compared to global market leaders, the Netherlands. Using an exemplary crop of greenhouse tomatoes, our analysis indicates a current cost of production for 1kilogram in Australia to be A\$1.60 verse A\$1.06 for the Netherlands (excluding land, depreciation, and interest), a cost difference of around 52%. Whilst this gap seems off-putting at first, there is much more to this figure, and a tangible opportunity to compete does exist.

The Netherlands has over 9,000hectares of greenhouse production, and over the past decade has proven the efficiencies of precinct-level solutions. Sites such as Agriport A7 have ~420 hectares of glasshouse linked to novel energy solutions and business hubs which enable growers to produce in the most efficient manner.

Meanwhile, in Australia, our total production area (of a modern greenhouse) is estimated at <300hectares, and all of these businesses are isolated and of only moderate scale (<40hectares sites). The result is that our cost of production is higher than it otherwise could be.

Some of the key benefits of precinct production include a reduction in energy prices, the possibility to improve access to labour and labour efficiencies, reduced transport costs and better distribution of fixed costs. When we modelled these potential gains, we were able to reduce the cost of production to A\$1.14, only 8% higher than the Dutch (excluding land, depreciation, and interest). The assumptions and output behind this can be found in [Table 9](#).

Australia will never be the lowest-cost producer, we can, however, offer a value proposition of high-quality product at competitive prices. This report demonstrates that at an operating cost level Australia can compete as a global food producer through solutions such as that offered by the IIPH. There is further work required around quantifying the cost of establishing such a precinct (and the benefits it will bring compared to individual sites), once these establishment costs are defined the full cost to business inclusive of depreciation, land and interest can also be applied.

The IIPH has the potential to reduce our cost of production to a level that would make Australian growers competitive on the international stage. It will provide employment opportunities for the residents of the Western Parkland City, and become a source of sustainable, cost-effective locally produced food.

We highlight that ongoing engagement with industry will be critical to ensure that the precincts disruptive effect is not detrimental to existing businesses. This engagement should form a collaborative approach between government and industry, focusing on the creation of new market opportunities, in so growing the 'size of the pie' rather than competing for a larger piece of what already exists.

1.1. Key Recommendations

To achieve the goal of developing a successful export-orientated production precinct we must deliver competitiveness via reducing the cost of production.

The following strategies can help achieve this goal, with the economic impact of implementation quantified in [Section 6](#) of this report.

1. REDUCE THE COST OF SITE ESTABLISHMENT

- a. Through precinct master planning sites can cost-effectively be serviced with utilities and transport solutions that in a remote location significantly add to site establishment costs.
- b. Enable a simplified development application (DA) and fire compliance processes. By creating an appropriate category in the Building Code of Australia (or a state-level workaround) we can remove ambiguity and reduce the costs and delays currently associated with this process.
- c. Large scale operation precinct-level investment will enable direct supply arrangements with manufacturers. This will bring economies of scale and direct purchasing power that will reduce the cost of technology.

2. DEVELOP AFFORDABLE ENERGY SOLUTIONS

- a. Enable affordable energy solutions that are comparable to what Dutch growers pay on a cost unit basis. This should be a combined strategic solution that implements circular economy principles and links across industries. Furthermore, these types of approaches also generate significant benefits to the surrounding communities.
- b. Enable scalable infrastructure to support the development of innovative energy solutions. Precinct level production offers a scale that makes complex modern energy solutions viable that would otherwise be out of reach for individual operators and sites.

Note:

Due to the complex nature and specificities of an individual site, we have removed the capital outlay and depreciation cost from this analysis and have focused on operational costs only. We suggest that a detailed study is carried out to further quantify these costs and help in the following planning and implementation phases for the precinct.

3. IMPROVE LABOUR EFFICIENCIES AND REDUCE THE COST PER HOUR

- a. Connect and activate the workforce of southwestern Sydney with growers. Enable access to an efficient and much more cost-effective workforce than is possible in most regional settings.
- b. Labour efficiency programs should be developed. These would be underpinned by both applied technology (automation and labour management software) and cultural changes in our business models (worker incentivisation programs etc).
- c. Pollination labour has a direct cost of over \$0.09/kg and further indirect costs associated with lower fruit quality (grading and seconds) and lower yields. A biological or mechanical solution must be developed and requires a collaborative approach between industry, academia and Government.

4. ACCESS TO KNOWLEDGE AND SKILLED PERSONNEL

- a. Enable industry-based research centres for the development of local solutions and support networks to enable the application and continued development of all the previously identified recommendations.
- b. Develop training and career pathways for the future workforce required to operate these facilities.

5. MARKET ACCESS

- a. The above recommendation will amount to nothing if we do not activate market access agreements with target countries.
- b. Market access agreements should be based on the economic opportunity for the keys cropping species and destination markets.
- c. Market access must be underpinned by workable biosecurity protocol.
- d. Development of 'Brand Australia' should be run in parallel to optimise value capture for producers.

2 Introduction



The purpose of this paper was to undertake an analysis comparing Australia’s economic competitiveness in the global commodities of greenhouse vegetable production. The paper is an initial investigation using a single exemplary benchmark crop-tomatoes.

Although we recommend further detailed work to quantify other crop species, this data is indicative of the output of the trends we would find in these studies.

Punching above its weight

The tiny Netherlands has become an agricultural powerhouse – the second largest global exporter of food by dollar value after the U.S. – with only a fraction of the land available to other countries. How has it achieved this? By using the world’s most efficient agricultural technologies.

Harvesting impressive yields

Over the past three decades, the Dutch tomato industry has become the world leader in yield, producing more tomatoes per square mile than anywhere else in the world.

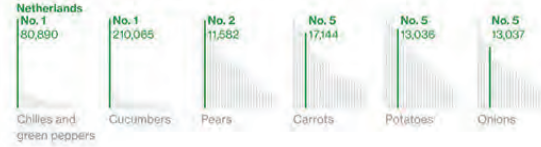
Yield
No. 1 globally
144,352 tons
per square mile

Area harvested
for tomatoes
No. 95 globally
6.9 square miles

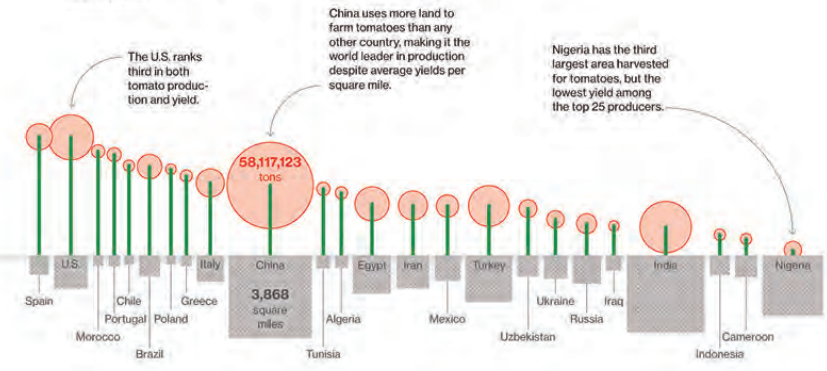
Netherlands

The Netherlands enjoys high yields in multiple staple crops in addition to tomatoes.

Top 25 producers by yield, 2014 in tons per square mile



Top 25 tomato producers, 2014 ranked by yield



Dutch tomato growers are recognised as the most efficient in the world.

Figure 1

Source: National Geographic Magazine, 2017.

2.1. Assumptions and Strategy Behind the Analysis

The Netherlands are undoubtedly the most efficient producers of greenhouse vegetables utilising high tech facilities such as modern, climate-controlled glasshouses. An exemplary crop is that of tomatoes, representing ~20% of the total ~9,000ha hectares of Dutch glasshouse production (WUR, 2018). The Dutch tomato industry has become the world leader in yield, producing more tomatoes per given area than anywhere else on earth (National Geographic Magazine, 2017), making it an ideal benchmark crop for our study.

We have set out to run a comparative analysis of typical Australian producer vs data for production costs in the Netherlands. The core assumptions and data sources were utilised as shown in Table 1.

Please note that rounding has been applied to some numbers in this report for presentation purposes.

Core assumptions used in this analysis

Table 1

Data	Data Source	Comments
Crop	Tomatoes — large (~150gram) truss/cluster tomato.	The leading greenhouse vegetable crop in both the Netherlands and Australia.
Dutch Production cost	The “KWIN” WUR 2018. Wageningen University and Research. Quantitative information on Dutch greenhouse horticulture 2016 – 2017. English version.	All information pertaining to the cost of production in the Netherlands is sourced from the KWIN unless otherwise specified.
Australian Production cost	Anonymous – due to commercial sensitivity we cannot divulge the source of Australian data.	Multiple large-scale greenhouse operations in Australia have been interviewed and operating budgets have been analysed. Costs are indicative of corporate farms, not owner-operators who tend to run leaner cost structures.
Production (Kg/m²)	WUR 2018. Wageningen University and Research. Quantitative information on Dutch greenhouse horticulture 2016 – 2017. English version. Industry contacts (Growers) in the Netherlands and Australia.	There is a potentially wide range dependant on technology, grower and variety choices. We would estimate annual average production of ~65kg/m² however we note that yields exceeding 70kg/m² are achieved in summer crop cycles. WUR 2018 lists 70kg/m² for all their analysis, and this has been applied across both data sets, with the acknowledgment that this represents the better operators in both regions.
Structure type	Conventional Dutch Venlo glasshouse with energy screens.	The most common glasshouse in both Australia and the Netherlands is a conventional Dutch Venlo system with energy screens. We acknowledge there is a shift towards semi-closed in some regions of Australia and this must be considered in future analysis.
Pollination Cost	<ul style="list-style-type: none">• Australian growers• Zonda Beneficial’s, New Zealand• Koppert Biological Systems, The Netherlands	Bumblebees in Europe and New Zealand. We chose the most traditional method of pollination in Australia – hand pollination with vibrating wands. Some growers utilise cheaper alternatives that are arguably less effective.
Currency conversion	EU (€) : AUD (\$) 1.0 : 1.60	Conversion rate determined from recent history at the date of analysis.
Interest rates, land value and depreciation.	Not applied in this instance due to variability between projects and sites.	Financing rates, land values, total CapEx and depreciation are highly complex topics and often site/business specific so have been omitted from the financial analysis output. We do discuss both CapEx and depreciation in detail within the body of the report.



3 Influencing Factors on the Cost of Production

There are several considerations that should be taken into account when we compare markets for greenhouse production systems.

Whilst this list is potentially expansive, we have narrowed it down to five key areas that will impact the comparative cost of production in modern protected cropping systems:

- 1. Local climatic conditions;
- 2. Types of production equipment and technology;
- 3. Access to knowledge and skilled personnel;
- 4. Access to, and cost of labour; and
- 5. Market access and competitiveness.

It is important that we understand the comparative differences in the two regions and what impact they are having on the cost of production. This section of the report (Section 3) serves to highlight and expand upon the major factors influencing the cost of production.

In Section 4 of this report, we will show the analysis output of the overall cost of production and further details on the economic implications.

Note:

- Bleiswijk is a village in the centre of the growing region in the district known as the Westland.
- In the following discussion we refer to climatic data as per:
 - In the graphic comparisons the months for the Netherlands have been opposed (i.e. July = January) to align and allow direct comparison between Northern and Southern Hemisphere seasons.
 - Data for Australia is derived from BOM, years 1990-2018. (BOM, 2019).
<http://www.bom.gov.au/climate/data/>
 - Data for the Netherlands was sourced from the KWIN (WUR, 2018) and NASA climate data, years 1990–2018. (NASA, 2019).
<https://power.larc.nasa.gov/data-access-viewer/>

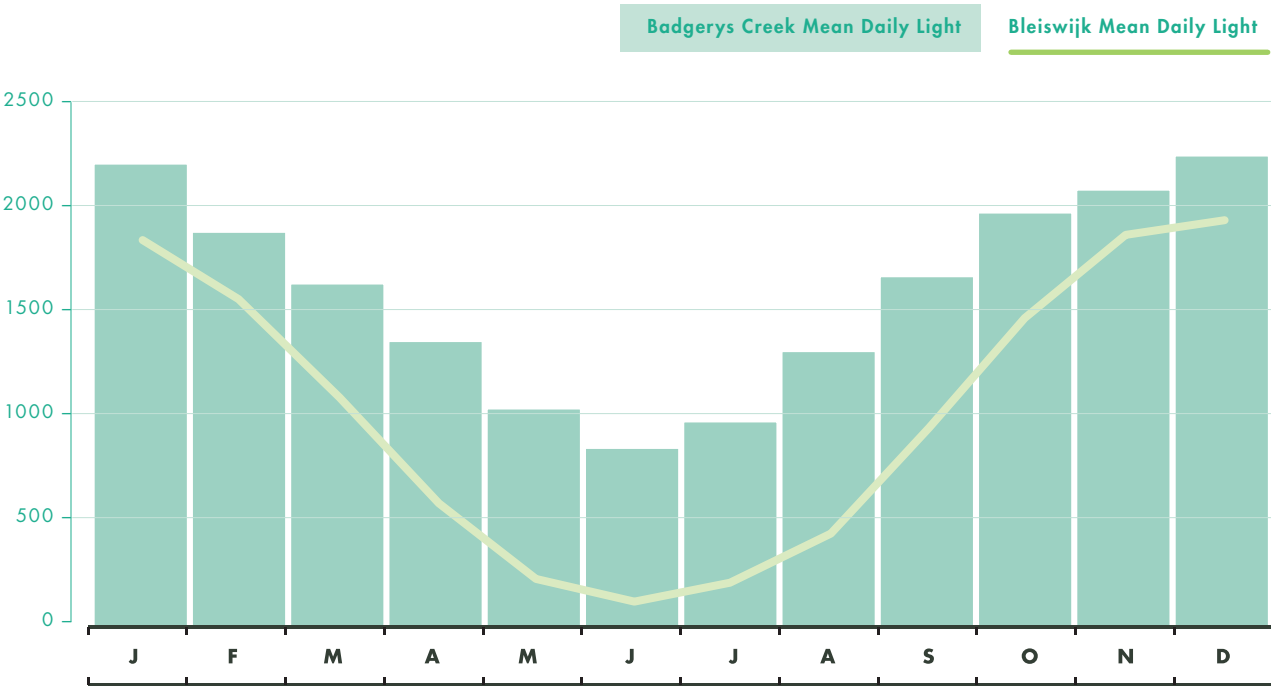
3.1. Climate Comparison

The Westland District represents the main growing region of the Netherlands and lies around the 52nd latitude, whilst the identified region in Badgerys creek resides around the –33rd latitude. These global-scale variations will significantly influence the climate. Unsurprisingly the climate of the two regions is quite different and can significantly influence the cost of both building and operating a facility.

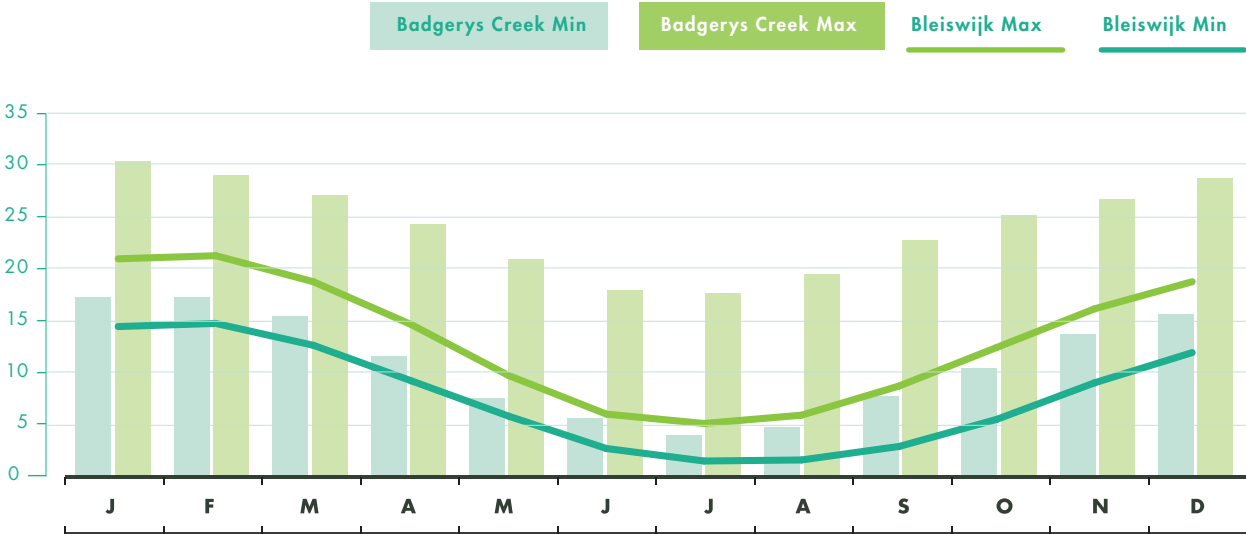
A comparative summary of the two regions has been provided in Table 2. We further discuss the impact of these differences below. Data has been sourced from the Australian Bureau of Meteorology (BOM), the KWIN and NASA.

Variable	Badgerys Creek	Bleiswijk
Annual solar radiation (J/cm2)	565,765	383,158
Lowest light month and average daily radiation (J/cm2/day)	June 868	December 196
Highest light month and average daily radiation (J/cm2/day)	December 2,262	June 1,965
Day length – peak summer	>14 hours	>16 hours
Day length – peak winter	~10 hours	<8 hours
Average Minimum Temp	10.8°C	7.6°C
Average Maximum Temp	24.0°C	13.2°C
Annual rainfall	678mm	877mm

Table 2
Climate comparison of the Netherlands versus Badgerys Creek.



Comparison of average daily light levels*.
Figure 2



Mean minimum and maximum temperatures.
Figure 3

Comparison of average minimum and maximum temperatures*.
*Months for the Netherlands have been opposed (i.e. July = January) to allow direct comparison between Northern and Southern Hemisphere seasons.

Month	Badgerys Creek	Bleiswijk*
January	2,225 J=cm²	1,913 J=cm²
February	1,902	1,638
March	1,646	1,136
April	1,372	615
May	1,056	293
June	868	172
July	996	262
August	1,327	465
September	1,687	963
October	1,986	1515
November	2,102	1907
December	2,262	1963

Figure 2 – Data
Mean daily light

Month	Badgerys Creek	Bleiswijk*
January	17.1 – 30.1°C	14.4 – 20.9°C
February	17.1 – 28.8	14.7 – 21.2
March	15.3 – 26.9	12.6 – 18.7
April	11.5 – 24.1	9.2 – 14.6
May	7.5 – 20.8	5.8 – 9.7
June	5.6 – 17.8	2.7 – 6.0
July	4.0 – 17.5	1.5 – 5.1
August	4.7 – 19.3	1.6 – 5.9
September	7.7 – 22.6	2.9 – 8.7
October	10.4 – 25	5.5 – 12.4
November	13.6 – 26.5	9.0 – 16.1
December	15.5 – 28.5	11.9 – 18.7

Figure 3 – Data
Mean minimum and maximum temperatures



3.1.1. SUNLIGHT

Overall Badgerys Creek receives around 1.5 times the amount of light as the Westland district (Figure 2), though it is the seasonality and spread of this light that can really influence production potential.

Wintertime light levels are dramatically different with the Netherlands receiving only around 22% of that experienced in Badgerys creek during their comparative lowest light months (December and June respectively). The summer light levels are more comparable, with the Netherlands receiving around 87% of the light in Badgerys creek, but importantly over an extended time period, with a day length some 14% longer.

This type of light profile limits the Netherlands to only summer cycles for most crop species (unless artificial lights are used), whilst Badgerys Creek can feasibly carry out summer or winter cropping cycles*. The extended day length of the Netherlands summer period means that it is unlikely we will out yield in a comparable period even though we technically receive more sunlight, simply put, much of the light in Australia is too intense and unusable by the crops so light utilisation efficiency drops.

Note:

**Summer and winter cycles refer to the primary production window for a given crop, with a total cycle taking around 12 months. A 'summer crop' is identified as a winter planting date with the peak production period in summer, and crop termination again in winter. Conversely a 'winter crop' is planted in the summer months with peak production occurring in winter and crop termination in the summer months.*



3.1.2. TEMPERATURE

Growers in the Netherlands have a climate that is more easily controlled and must contend with a much lower range of average temperatures compared to those in Badgerys Creek. The difference between the annual minimum and maximum being 5.5°C and 16.3°C respectively, though we note that both Pad & Fan and Semi-closed production systems are also viable alternatives.

The Netherlands is dramatically cooler over the entire year with both lower minimum and maximum temperatures (absolute and averages). This situation means the Dutch growers will have a higher heat energy requirement over the course of a cropping period. The milder summers and longer, less extreme days in the Netherlands will result in lower crop stress and a reduction in heat-related disorders (such as poor pollination, fruit/flower abortion) and overall crop stress.

Growers in Badgerys creek still require a heating system as per the Dutch growers, though will also require some form of cooling to combat the summer period. This will likely be in the form of evaporative cooling and shade screens (both of which are effective in the region). These cooling solutions typically result in higher electrical demand and increased capital cost during establishment (as it is in addition to heating, not instead of). In our economic models, we have assumed high pressure fogging and shade screens have been installed for this purpose.

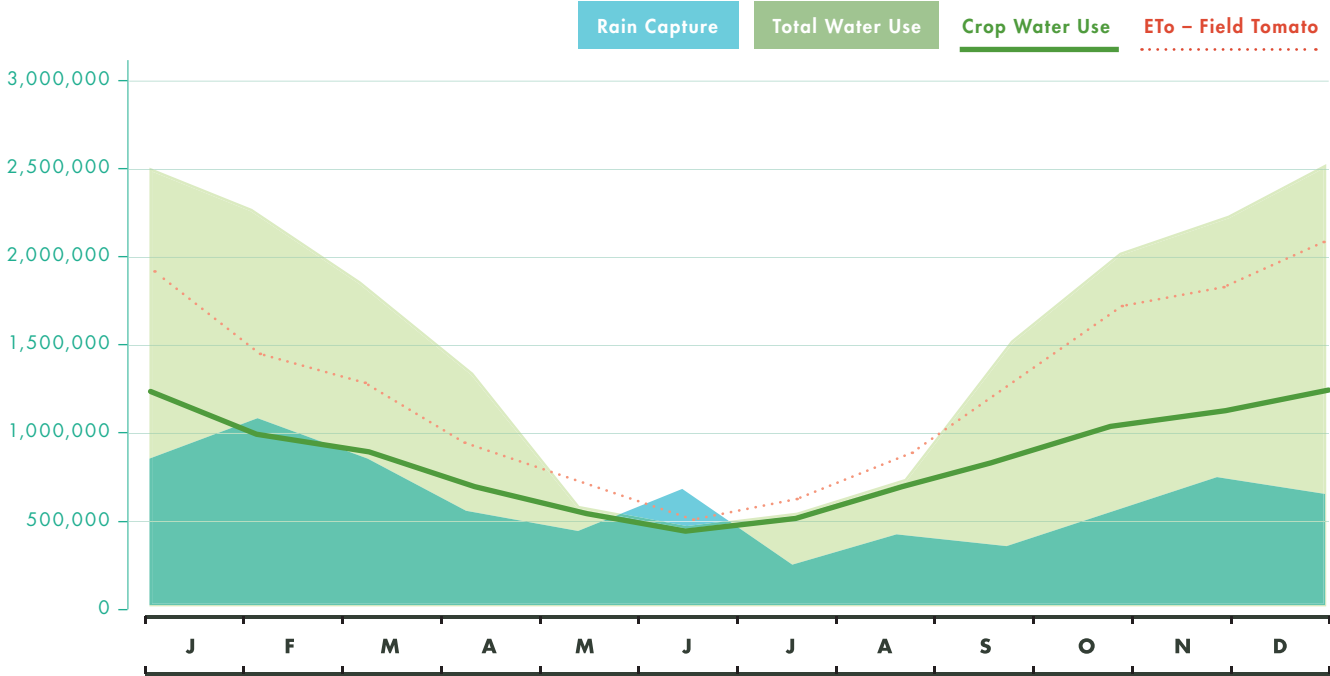


3.1.3. WATER

Overall the cost of water does not play a significant part in the operation of facilities in either the Netherlands or Australia (<1% of total costs) and we will therefore not go into detail on this in terms of cost, but we still need to ensure adequate water is available. Water security rather than cost is the most important issue; quite obviously without a secure high-quality water source production is not possible.

Dutch growers are mostly self-sufficient with an average year’s rainfall accounting for 90–115% of the needs of the crop. Growers in Badgerys creek, however, would only receive around 30–50% (Figure 4) of the full sites water needs (crop water use and cooling solutions) as rainfall and therefore a secure high-quality alternative must be accounted for.

In this case, we have verified that the precinct level solution can be the enabler for the supply of this water. Through engagement with Sydney Water, we have been able to identify the opportunity for to access high-quality water made available as part of their sustainability program. The assumptions in our model allow for the deficit beyond captured rainfall to be purchased for \$0.50 per kilolitre, a rate validated in discussion with Sydney Water.



Potential site water capture per hectare based on rainfall, versus site requirements.

ETo of field tomato is provided for reference sake only.

Figure 4

Month	Rain Capture	Total water use	Crop water use	ETo field tomatoes
January	819,424	2,476,277	1,276,277	1,916,200
February	1,062,156	2,220,286	1,020,286	1,448,640
March	841,693	1,818,195	918,195	1,287,120
April	524,457	1,320,097	720,097	930,960
May	409,964	556,304	556,304	716,400
June	656,874	442,784	442,784	514,080
July	243,805	525,124	525,124	647,280
August	390,977	699,453	699,453	885,360
September	338,248	1,485,425	885,425	1,296,000
October	535,876	1,977,189	1,077,189	1,719,540
November	735,583	2,216,815	1,166,815	1,837,260
December	613,930	2,497,194	1,297,194	2,064,420



3.2 Production Equipment and Technology

With highly sophisticated systems available around the globe we can now enable protected cropping production in almost any climate. Currently there is an appropriate technology to deploy production in both markets, however, there is a difference in the cost.

The cost of equipment and infrastructure in Australia is significantly higher when compared to Dutch farms. Some of the identified factors behind this are noted below:

- The Dutch have a very strong/competitive local production and distribution networks for greenhouse solutions, this is driven by the enormous market size (scale) and density in a rather centralised location. The Netherlands has over 9,000 hectares under glass and some ~1,700 for tomato alone (WUR, 2018). Comparatively, we estimate similar tomato production systems in Australia to be under 300 hectares in total. This creates economies of scale in the Dutch market that we simply do not see in Australia. The outcome is that the cost of comparable technology is lower for a Dutch farmer than an equivalent Australian farmer.
- Dutch growers typically transport their goods for construction and growing inputs less <250km from the supplier (WUR, 2018), resulting in low transport cost. Due to our remote location (as a country) and the majority of site establishment and consumable goods being transported here originating overseas, transport costs increase the capital outlay and operating expenses. On a square meter for square meter comparison most facilities in Australia, even of comparable technology are more expensive than their Dutch counterparts.
- Glasshouse technology was originally developed for extending growing seasons in high northern latitudes, enabling them to plant earlier and crop later. Although this technology has been adapted for warmer regions (like Australia), it comes at a cost, and typically any greenhouse with cooling solutions added will have a higher cost (both CapEx and Opex) than a comparable non-cooled solution (noting that most greenhouses still utilise heating).
- Land in the Netherlands has a typical slope of <0.5%, in its natural form being ideal for Glasshouse production (WUR, 2018). In Australia finding flat land can be much more challenging. Undulating land parcels will require earthworks that can add significant costs, in so increasing the capital outlay of developments.
- Dutch greenhouse districts tend to have direct access to paved roadways and connectivity to utilities such as gas, electricity, water and even CO₂ (for example the OCAP pipeline in the Westland). In Australia, this is generally not the case and growers are forced to invest in connecting to services at great expense or deploying alternate remote solutions that are often more costly from an operational perspective.
- In Australia, protected cropping structures do not currently have a defined relevance to the current construction code; Building Code of Australia 2016 (Hort Innovation, 2019b). This results in increased costs for producers, such as:
 - Project delays due to building classification uncertainty;
 - Delays due to resolving design complications of non-relevant regulatory restrictions;
 - Upfront costs of fire and egress infrastructure; and
 - Ongoing costs of maintaining fire and egress infrastructure.

Note:

Due to the complex nature and specificities of each site, we have removed the capital outlay and depreciation cost from this analysis and have instead focused on true operational costs. We suggest that a detailed study is carried out to further quantify these costs and enable planning pathways to assist Australian developments in the future.

At a high level, we have identified key differences between the two markets which we note below.

Infrastructure and Establishment Costs

In our analysis of typical large scale Australian projects, we tend to see a price range of \$300–\$400/m² of growing area for the total project outlay of a conventional modern Venlo style glasshouse, and we would notionally suggest \$350/m² of grow area for allowance of full greenfield site development (including all necessary equipment from production to endpoint consumer-ready product), excluding land value.

Data for the Netherlands was again sourced from the KWIN (WUR, 2018) which provided a value of only €81.60/m² or A\$130.57, this figure is based on 10ha blocks inclusive of “all possible necessary equipment” excluding land. We have carried out further discussions with various Dutch suppliers which provided some contradictory figures, and we recommend a detailed investigation is carried out to verify or adjust this assumption.

Land Value

Whilst establishment costs related to infrastructure appear much higher in Australia, we have identified that there are potential savings in regard to land, even in high-value peri-urban regions such as South West Sydney. Independent valuation of land in the region was recently carried out by a specialist firm, providing an indicative value ~A\$275,000 per hectare (A\$27.5/m²) for RU zoned land (personal communication, July 2019).

In comparison, land of sufficient size for large scale developments in the Netherlands (block width >160m) is scarce and of high value. In 2015 prices in the major growing region of the Westland were estimated at €50/m² or A\$80/m² and the evolving region of Noord Holland (Agriport A7 location) was valued at €23/m² or A\$36.8/m² (WUR, 2018). These prices are actually far below some of the historic data of over €95/m² or A\$152/m² (WUR, 2018) preceding the challenges in the global market of 2008. Since 2015 land prices have been steadily rising again with anecdotal evidence suggesting land in the region of the Agriport A7 is now valued at closer to €50/m² or A\$80/m² (personal communication, December 2018).

Modelling the cost of land is a complex topic and highly dependant on the business model of each enterprise, zoning, topography/suitability and demand functions. Some models consider it as a ‘land bank’ and an appreciating asset, or others as a lease function and an ongoing occupancy cost, with various models in between. The one fact we can confirm is that current valuations indicate land for Australian producers in the IIPH is lower than that of the Dutch.

3.3. Access to Knowledge and Skilled Personnel

In the modern world of high-speed internet, one would think that information is only a click of the mouse away, and most any developed country can be on a level playing field. However, in such a specialised knowledge-intensive field as this, the local nuances play a vital role in influencing the value outcome of information.

The Dutch have a large-scale industry with enormous support programs and research institutions. Wageningen University & Research (WUR) — regarded as one of the world's top agricultural research institutions, and World Horti Centre, an industry lead self-funding hub for innovation and education are two key examples. These types of institutions drive industry-focused research and development and have become catalysts for the growth of clusters of agricultural technology companies, forming what is now referred to as 'Food Valley'.

These industry-focused research hubs result in the development of specific knowledge and expertise which help keep the Dutch ahead of the rest of the world.

It is true, much of the Dutch research is applicable in other regions/globally, but there are inevitably specific development programs that benefit local (Dutch) growers more than international counterparts. Furthermore, the Dutch industry has direct and easy access to this information. In Australia, we still lack both the industry scale and research focus to fairly compete.

Another issue is the lack of skilled personnel here in Australia. It is simple economics that a low supply to demand ratio drives prices up, and in an isolated market with low numbers of skilled personnel, it drives an increase in wages. Australian greenhouse growers would arguably be some of the highest-paid in the world. This, of course, is a fixed operating cost that must be considered in the overall cost of production.

The large centralised industry in the Netherlands has resulted in a superb consultant network, where specialists for each facet of the business (crop physiology, Integrated pest management, energy etc) are readily available and affordable for Dutch operators. In Australia, our heavily dispersed market and low scale mean most specialists must fly in only occasionally, and at great cost, this limits the collaborative style of knowledge sharing and development for Australian growers.



3.4. Access to, and Cost of Labour

The Average cost of labour for greenhouse growers in the Netherlands is estimated at €16.50/hour (WUR, 2018), which equates to around A\$26.40/hour. The Australian horticultural award wage ranges from A\$19.49–A\$22.70/hour for fulltime employees and A\$24.35–A\$28.38 for casual staff. On the surface, this would suggest a relatively comparable labour rate, but in reality, we find Australian operations end up with a much higher total cost to the business.

Where we find real practical differences is driven by the availability of willing labour, or therefor lack of in Australia. Dutch growers still have their own challenges, but overall continue to have access to willing labour forces from other countries, historically this was Turkish and Moroccan, whilst more recently it is the Polish. The competitiveness of the workforce keeps efficient relatively low-cost employees readily available.

In Australia, many producers have struggled to source local labour and are now reliant (or part thereof) on programs such as the Pacific Island workers program or offering higher wages to attract employees to what is often deemed an unfavourable type of work.

The end result is that we tend to find in real terms Australian operators are paying a total cost to business of around A\$28–A\$35 per hour. We also find that the majority of operators in Australia are less efficient than their Dutch counterparts, utilising more labour per hectare for similar kilograms of output.

The result of our lower efficiencies and higher cost labour in Australia is a significant net increase in the cost per kilogram of production.

3.5. Market Access and Competitiveness

It is clear from a cost competitiveness standpoint the Dutch have a lot in their favour (as outlined in the prior sections), unfortunately, they also have a clear market access advantage too. Due to the open borders of Europe, along with land connectivity and large coastline (with ports) of the Netherlands, the potential market for Dutch producers is astronomical when compared to Australian growers. The main market for Dutch greenhouse growers is Western Europe, much of which can be serviced within 750kilometres (WUR, 2018).

This cross-border access also drives competitiveness. Australian growers have very limited pressure from overseas suppliers so are not pushed to innovate to outcompete producers in markets with lower labour costs. The Dutch farmer, on the other hand, must compete against countries with much lower labour costs (such as Spain) who all have direct access to most of the same customers. This competitive tension in the market forces innovation and makes Dutch produces some of the most efficient on the planet.

Through their efficiency, the Netherlands has become a major exporter of fresh vegetables and is the second-largest exporter in the world (Fruit logistica, 2019), inclusive of domestically grown product and value-adding/transit hub functions. In 2018 the Netherlands produced some 905million kilograms of tomatoes and exported over 83% of this, with the neighbouring nation of Germany being the main export destination (>46%) of Dutch exported tomatoes (Fruit Logistica, 2019).

In comparison, Australia only produced ~256million kilograms of fresh tomatoes (total including field) with around 33–40% of this production coming from glasshouses this equates to a maximum of ~100million kilograms (Hort Innovation, 2019a). Of this total fresh production, only 804,000 kilograms was exported in 2018 (Hort Innovation, 2019a).

Another challenge is our limited access to neighbouring countries, and market access for Australian Horticultural crops still has room for improvement. A recent study carried out by Arris in 2018 analysed the market access potential for key Greenhouse-grown horticultural crops. This can be seen in Table 3, which contains information derived from the MICO database (<https://micor.agriculture.gov.au/>). This data shows that whilst we do have good market access to the middle eastern markets, we have relatively limited access to high-value targets of Asia; such as India, China and Japan.

Australian produce is often regarded as having a high standard of food safety and quality assurance, and as such low incidence of microbial contamination or issues regarding residues (fungicides and pesticides). This perception is advantageous for Australian growers if they are able to access markets that are willing to pay a premium for such security (e.g. China and India). However, at the moment there are significant market access constraints that must be addressed to leverage this opportunity.

YES Access to the market with suitable documentation, phytosanitary certificates

YES Open access to the market

NO Currently no market access

Region/Country	Tomato		Strawberry		Berries/Rubus		Capsicum / Chilli	
	Access	Reqm	Access	Reqm	Access	Reqm	Access	Reqm
MIDDLE EAST								
Bahrain	Yes	Phyto	Yes	Phyto	Yes	Phyto	Yes	Phyto
Kuwait	Yes	Phyto	Yes	Phyto	Yes	Phyto	Yes	Phyto
Qatar	Yes	Phyto	Yes	Phyto	Yes	Phyto	Yes	Phyto
Saudi Arabia	Yes	Phyto	Yes	Phyto	Yes	Phyto	Yes	Phyto
UAE	Yes	Phyto	Yes	Phyto	Yes	Phyto	Yes	Phyto
SOUTH ASIA								
India	No		No		Blueberries	Protocol	No	
SOUTH EAST ASIA								
Singapore	Yes	Open	Yes	Open	Yes	Open	Yes	Open
Indonesia	Yes	Protocol	Yes	Protocol	Blueberries	Protocol		
Malaysia	Yes	Open	Yes	Open	Yes	Open	Yes	Phyto
Thailand			Yes	Protocol	Blueberries	Phyto		
Vietnam	No		No				No	
Philippines	No		No		No		No	
EAST ASIA								
China	No		No		No		No	
Hong Kong	Yes	Open	Yes	Open	Yes	Open	Yes	Open
Taiwan	No		No		No		No	
South Korea	No		No		No		No	
Japan	No		No		No		No	
OCEANIA								
New Zealand	Yes	Phyto	Yes	Protocol			Capsicum	Phyto

NOTES:

1. Protocol requirement is usually the need for cold storage / vapour heat / sterilisation treatment for fruit fly from areas outside recognised fruit free regions (usually Tasmania and Riverland of SA).

QATAR, SAUDI ARABIA, UAE AND BAHRAIN:

No fruit fly restrictions on Phyto.

TAIWAN:

Workplan and protocols in place for some fruits into Taiwan, eg. grapes, stone fruit.

THAILAND:

Strawberries from WA require MeBr treatment.

CHINA, PHILIPPINES:

None of these crops have a specific listing in the general MiCoR database, however both countries have quarantine protocol requirements in place for other fruit fly susceptible crops.

NEW ZEALAND:

Strawberry protocol is MeBr fumigation from outside fruit free fly zones.

Table 3

Market access for typical greenhouse-grown food crops.

(Source: Arris, 2018). We note the lack of access options for key Asian markets as a barrier to success.

4 Cost of Production Analysis



The cost of production has been estimated exclusive of land/occupancy, retailer rebates, depreciation and interest. We have assumed a 20ha conventional Venlo style greenhouse operation growing the dominant crop of large (~150gram fruit size) truss tomatoes for comparable Australian and Dutch businesses. We have allowed for appropriate technology for each climatic region and utilised industry rates for all key inputs.

Currency has been converted to allow a direct comparison, in this instance, a rate of A\$1.60 : €1.00.

In our analysis, we assume an equal yield of 70kg/m² for both operations. This estimate can be deemed as an achievable yield for a summer* crop cycle of a high-performance grower in either location (though we concede that yields can be lower and higher than this depending on many factors).

There was some variation in the method of data collection between our Australian studies and that obtained for the Netherlands. In order to make these as comparable as possible, we have consolidated various costs into categories as described in [Table 4](#).

 Growing inputs All growing inputs and consumable such as seedlings, substrate, fertiliser, IPM, hooks and strings, waste removal etc. The Netherlands includes an allowance for liquid CO ₂ .	 Electrical Full cost based on consumptions, network charges and energy taxes.	 Heating The full cost to site. We have allowed for energy screens and heating for summer CO ₂ dosing, the system used is a gas boiler with heat buffer tanks of 2million litres.
 Labour All labour, excluding fixed salaries (e.g. grower, admin, HR etc). This includes manual pollination in Australia.	 Water The total cost of water — note in the Netherlands data this is captured within “General Costs” which in our comparison falls under “Other Expenses”.	 Fixed Salaries Netherlands allowance of ~480hours/ ha (~5 people for 20hectares). The cost of these hours is omitted in the provided balance sheets within the KWIN so we have calculated all labour at the provided rate of €16.50/hour, <i>*noting that in many operations this will be much higher.</i> Profit distribution to owner-operators is also likely, though not quantified in this report. We note that Australia has a much higher expectation and we would see something in the range of 10–20 people for a 20hectare site, and a higher hourly rate.
 Packaging & sales cost All packaging, leased or disposable and levies (e.g. Auction fees etc).	 Freight Total Freight cost, normally external service providers.	 Other expenses All other expenses such as admin, insurance, audits, maintenance etc. This includes water for the Netherlands data.
 Depreciation, land & interest Omitted from both case studies due to the variability of data.		

Table 4
Description of cost centre categories used in this analysis.

4.1. Overall Comparison: Australia verse the Netherlands

Overall the analysis indicates a cost of production of A\$1.63/kg in Australia verse A\$1.06/kg for the Netherlands (Table 5), in this instance, Australian growers incur a cost increase of around 54% when compared to their Dutch Counterpart.

Item	Australia	Netherlands	Difference	% Increase
 Growing inputs	\$0.21	\$0.20	\$0.01	3%
 Electrical	\$0.03	\$0.01	\$0.01	113%
 Heating	\$0.24	\$0.16	\$0.08	48%
 Labour	\$0.58	\$0.33	\$0.25	75%
 Water	\$0.01	\$0.00	\$0.01	~0%
 Fixed Salaries	\$0.13	\$0.02	\$0.11	~590%*
 Packaging & sales cost	\$0.20	\$0.21	-\$0.01	-6%
 Freight	\$0.07	\$0.02	\$0.05	334%
 Other expenses	\$0.17	\$0.10	\$0.07	67%
Total	\$1.63	\$1.06	\$0.57	54%

Table 5
Comparison of the cost of production for 1kilogram of tomatoes in Australia versus the Netherlands.

Note:

This is not the total cost of production and one must apply factors such as depreciation, interest and land cost/occupancy to the final figures to determine the overall business profitability. Given the different methods of calculating these functions and the possible discrepancies between different sites, we have omitted them from this analysis.

As noted in Section 3.2, infrastructure and establishment appear to be much lower for Dutch producers, whilst the cost and availability of land are heavily favouring Australian producers. We suggest further work is required in this respect.

4.2. Australia – Cost Summary

The following graphical representation (Figure 5) exemplifies a ‘typical’ corporate greenhouse in Australia (20ha+). In general, our analysis of the marketplace shows that the largest owner-operator sites are more efficient than the corporate model provided, with lower fixed salaries and labour. Overall two items account for over 50% of the production costs — Labour and Energy (heat and electrical combined).

The energy (heating) requirement in this scenario has been adapted to suit the region around the Western Sydney Airport (WSA) and is based on the climatological analysis prepared for the Production Possibilities Report (Agrology, 2018). Glasshouses in cooler climates (E.g. rural Victoria and Guyra in NSW) will typically have a higher energy input requirement for heating, though the cost can be comparable, higher or even lower depending on the fuel stock used. As there is currently no gas mainline in the region of the intended sites we have assumed LPG (Propane) gas at high-volume industry rates, pricing was based on the current market rates for hedge pricing over the next twelve months (Elgas, 2019).

Labour is the major cost of production representing some 36% of the overall operating cost (excluding fixed salaries of management), with 5.4% of the total cost attributed directly to labour related to manual hand pollination, a topic that is further discussed in Section 5.1.1. Energy comes in at second position at 16% (heat and electrical combined).

4.3. The Netherlands – Cost Summary

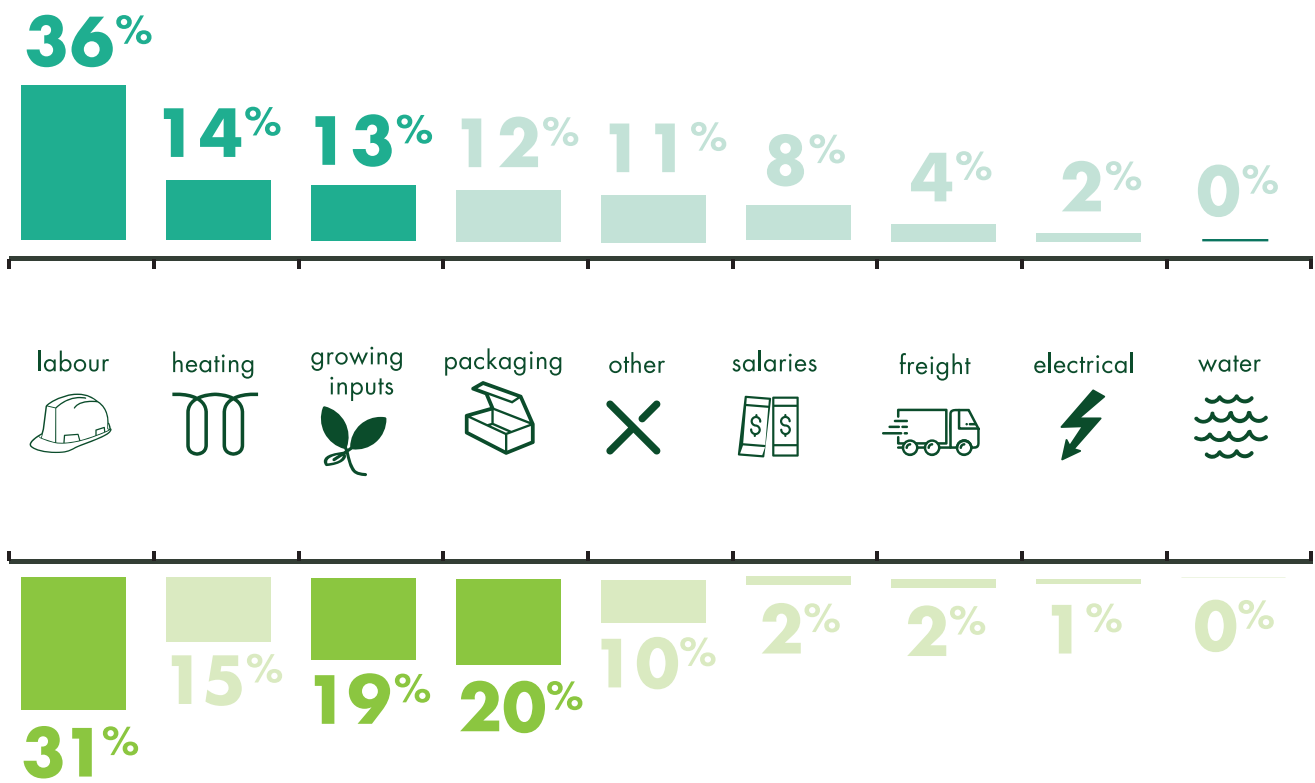
Although the absolute costs are dramatically higher for an Australian versus a Dutch operator, the distribution of cost is quite comparable. In general, Dutch operations run more efficient labour (when compared to corporate Australian growers), and although they do have a higher heat requirement, their significantly lower cost of fuel sources (per heat unit) means the net outcome is cheaper when compared to Badgerys Creek.

The leading costs for producers in the Netherlands is labour (31%), followed by packaging (20%), growing inputs (19%) and energy (16%).

The full cost distribution can be seen in Figure 6.

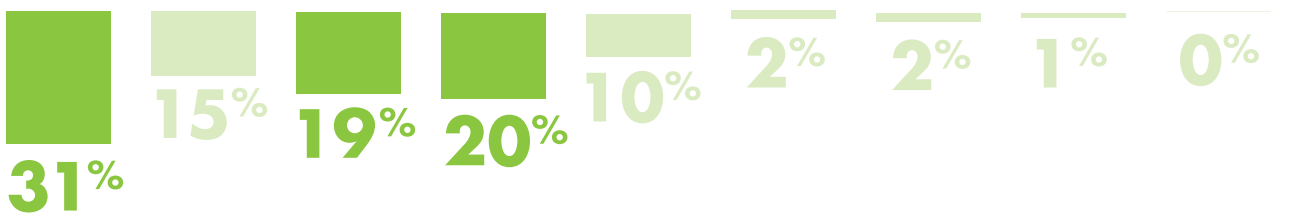
Cost distribution of truss tomato production in Australia (top).

Figure 5



Cost distribution of truss tomato production in the Netherlands (bottom).

Figure 6



Graphical representation of the major cost of production as a per kilogram basis.
Figure 7



4.4. Comparison of Major Operating Costs

The relative distribution of costs is comparable for both markets, however, in absolute terms, almost all inputs are more expensive for Australian producers.

Labour costs for an Australia producer are some 75% higher, estimated at A\$0.58/kg vs A\$0.33/kg for a Dutch farm, this is driven by both lower efficiencies and increased hourly costs (wages).

Energy is a very interesting point. While an Australian grower would use around 31% less heat energy than a comparative Dutch Greenhouse, an operator in the Western Sydney region would pay 33% more on their energy bill due to increased cost of fuel stocks.

A comparative analysis of the cost centres can be seen in [Figure 7](#) and is further explained in the following sections.

4.5. Further Information on Operating Costs

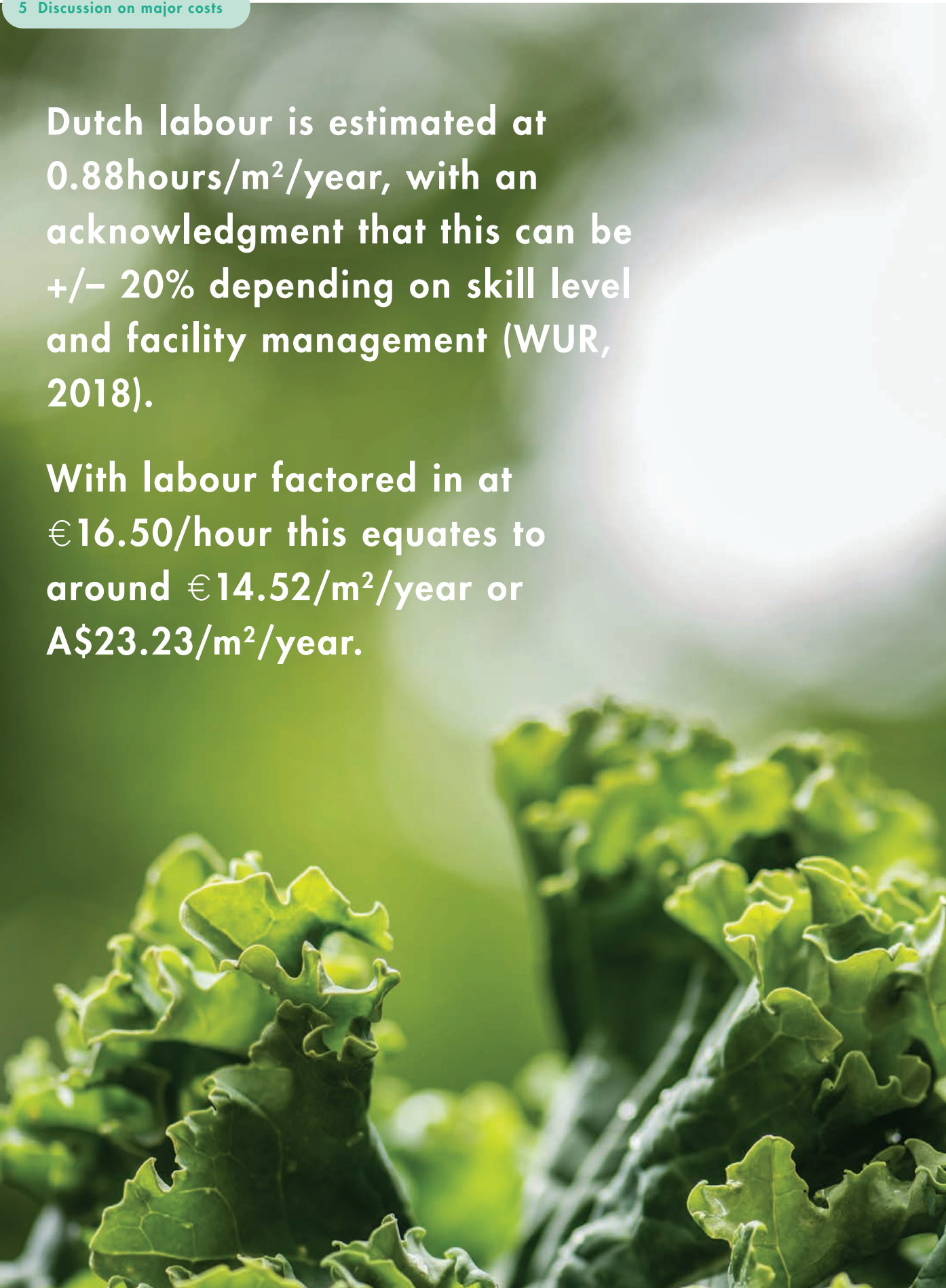
We note the following points that will add context to the data that follows in [Section 5](#).

- Cost of labour has been determined based on interviewing major operators in Australia and review operating P&L statements. The information is highly sensitive so the sources cannot be disclosed.
- The lowest labour we have observed in Australia for Truss tomato production is around A\$25–30 per m² but this was generally from winter crop cycles with yields below 55kg/m², equating to around \$0.45–\$0.55/kg.

- Energy costs have been estimated using industry rates for South West Sydney and assume a conventional glasshouse with energy screens and heat buffer tanks. The boiler would utilise propane as a fuel stock at a rate of A\$0.47/litre. In other regions and examples total energy cost will be impacted upon by:
 - Type of growing structure
 - Use of energy screens
 - Local climate
 - Type of fuel stock
 - Price of fuel stock (varies by region for same sources)
- Electrical prices are based on current grid rates for high volume consumption, averaged to include all network and associated fees; the value is estimated at A\$0.17/kWh.



5 Discussion on Major Costs



Dutch labour is estimated at 0.88hours/m²/year, with an acknowledgment that this can be +/- 20% depending on skill level and facility management (WUR, 2018).

With labour factored in at €16.50/hour this equates to around €14.52/m²/year or A\$23.23/m²/year.

5.1. Labour

Our analysis of a ‘typical’ corporate-run glasshouses in Australia with full-season supply (12month supply profile) we see labour rates range of 1.2–1.65hours/m²/year. In this analysis, we have factored a time per job ratio from data derived from the anticipated crop density seasonally adjusted (summer crop) and a target yield of 70kg/m². The result is an overall figure of 1.43hours/m²/year. Labour cost to business has been estimated at A\$28.50/hour (though the range we have seen is about A\$27–35) giving us an estimate A\$40.82/m²/year.

In this case, we can see that a typical corporate glasshouse in Australia would incur a 75% increase in labour cost as opposed to a standard Dutch operator.

Overall Australia has a higher labour requirement (total hours) when compared to a similar operation in the Netherlands. Our data analysis and interviews with growers indicate that Dutch greenhouses typically utilise five-to-six people per hectare whilst large Australian operations typically have seven-to-ten.

Some of the labour increase in Australia can be accounted for in the direct cost of manual pollination (~one person per hectare) and slightly higher plant densities, (due to our higher light levels growers will run higher densities for longer and jobs are done at a ‘time per 100plant’) basis. However, it is still apparent that we also tend to suffer from overall lower efficiencies, possibly an outcome of our corporate structures and increased levels of mid-level management. Additionally, we note that the indirect cost of poor pollination should not be ignored, as this can cause slower picking and grading rates (See below).

Item	Australia	Netherlands	% Increase
Hours / m ² / year	1.43	0.88	63%
Cost \$ / hour	\$28.50	\$26.40	8%
Cost A\$ / m ²	\$40.82	\$23.26	75%
Cost \$ / Kg	\$0.58	\$0.33	75%

Table 6
Comparison of labour in Australian versus the Netherlands.

Note:

There are more efficient operations in Australia than the ‘typical’ examples provided, and the most efficient business we have been fortunate enough to review operated at 0.85hours/m²/year, though they also have lower total yield and a high hourly rate, with a total cost to business of around A\$30/hour – this is driven by the fact they pay more for skilled staff. The result is still significantly more positive equating to around A\$25.50/m²/year (\$0.45–\$0.55/kg).

5.1.1. POLLINATION LABOUR

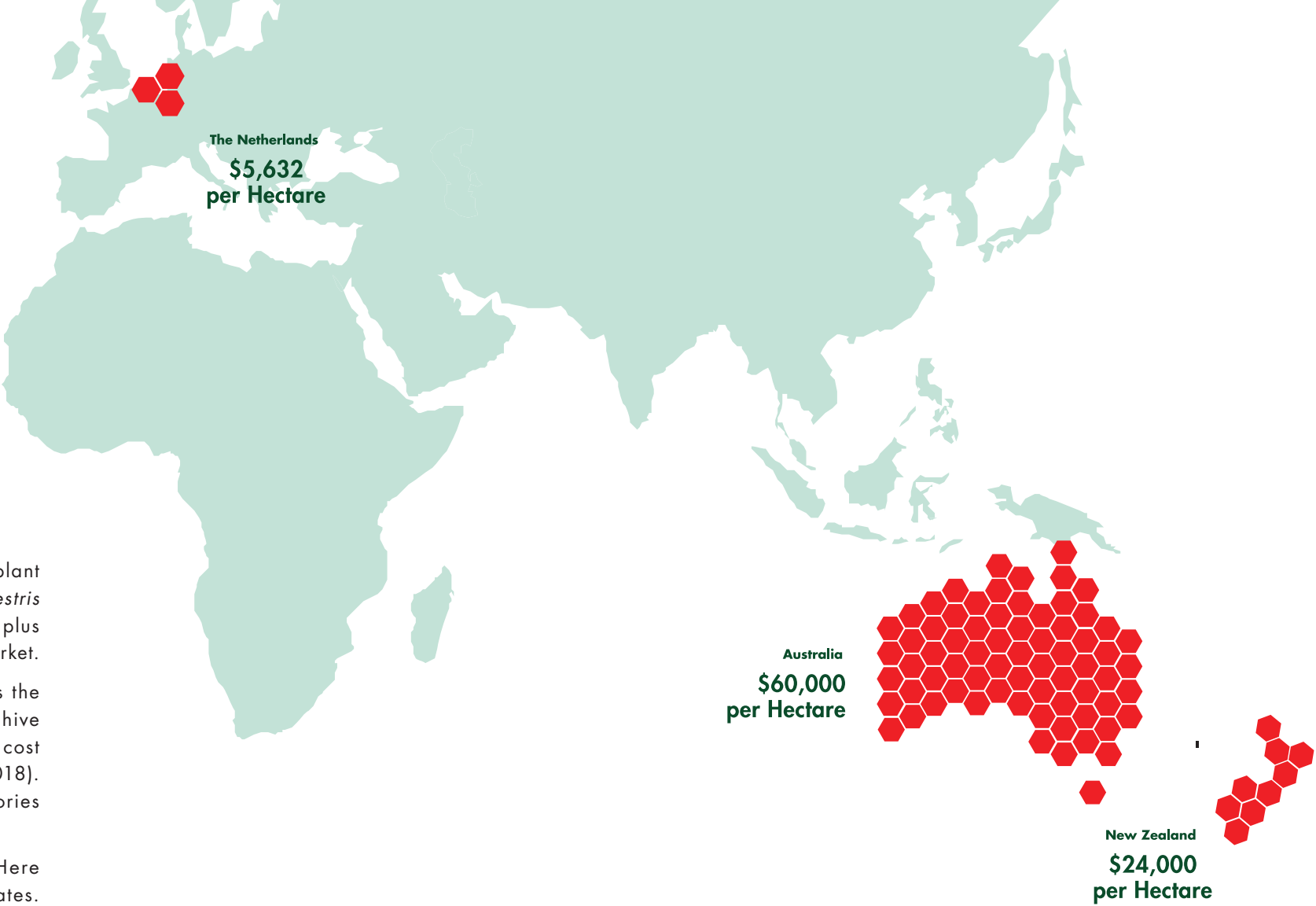
In most areas of the world glasshouse grown fruiting crops such as tomatoes, eggplant and capsicum are pollinated with biologicals, typically bumble bees. *Bombus terrestris* is used in the European Union and New Zealand, whilst both *Bombus impatiens* plus *Bombus occidentalis* are used to cover the United States, Canadian and Mexican market.

Typically, the only cost to a tomato grower in the Netherlands for pollination is the cost of purchasing and maintaining the bumblebees, approximately 20 euros per hive and two-to-four hives per hectare per week of production, resulting in an annual cost of €1,760–3,520 (A\$2,816–\$5,632). (Source: Koppert biological systems, 2018). This is extremely cost-effective, with low prices enabled via large scale bee factories in Israel and Slovenia.

Australia’s closest production region using bumblebees is New Zealand. Here growers incur increased prices because of reduced scale and higher labour rates. New Zealand’s growers tend to use around five-to-six hives per week, with a total annual cost of NZ\$26,000/ha (~A\$24,000). (Source: Zonda Beneficials, 2018).

Comparatively, an Australian Farmer is forced to hand pollinate tomatoes three times per week, with an estimated annual labour bill of ~A\$60,000/hectare (Figure 8). This equates to ~A\$0.09/kg of production for Truss tomatoes, A\$6/m² or ~5% of total costs.

Further to the direct costs, and arguably just as significant—hand pollination results in suboptimal fruit set leading to reduced yield potential and overall lower product quality. The latter is directly attributed to increased picking and packing labour, and a higher percentage of second-grade fruit.



The direct cost of pollination in the Netherlands (lowest rate), New Zealand and Australia.

Figure 8
All values are converted and displayed as AUD.

5.2. Energy

5.2.1. HEAT

Dutch growers use natural gas at the rate of around 33.1m³/m² of grow area (WUR, 2018), they convert this to a Net Caloric Value (NCV*) of 35.17MJ/m³, equating to around 1.164GJ/m² per year. In comparison, in Badgerys creek we estimate energy use to be around 0.805GJ/m².

Currently, in the agribusiness precinct area, there is no natural gas line available, so the likely energy source for heat would be Propane, which has an NCV of 22.86MJ/litre. A price analysis of growers showed a price range of A\$0.45 to A\$0.70/Litre, with current high-volume agricultural pricing in the region sitting at ~A\$0.47/Litre, a figure we have settled on for this analysis.

Our calculations, therefore, estimate that growers in the region would be paying around A\$16.55/m²/year. In contrast, a Dutch grower would expect to pay a total annual fee of around 6.99/m² or A\$11.18/m²/year (note this includes all cost, energy taxes and capacity charges, but does not include additional liquid CO₂ purchased).

The result is that a grower in Southwest Sydney would be using some 31% less heat energy than a Dutch grower but paying around 48% more (Table 7).

Whilst Badgerys Creek has a markedly warmer and sunnier climate than the Netherlands, the heat energy cost per kg of production is still drastically higher than that of the Netherlands. This reflects the higher domestic energy price of the available source rather than the total heat use. Availability of pipeline liquid natural gas would likely reduce this cost over tanker-based propane, but arguably more significant reductions will come from alternative novel solutions such as those inspired by the principles of circular economies.

The case for regulatory reform to enable the consideration of economically incentivised onsite energy production for sale back to the grid is another matter that warrants further investigation. This could enable an alternate revenue stream for growers, and thus increasing the effective sale price per kg and adding resilience in years of low product prices.

We also note that whilst energy sales have been a good option for Dutch producers in recent years, this is changing, the cost price advantage of using gas in a CHP as compared to using gas in a boiler, is decreasing towards zero, due to the decreasing price of the electricity that is supplied back to the national electricity grid (WUR, 2018), something that we should consider in our modelling with the opportunities of cheaper renewables entering the Australian market place.

Item	Australia	Netherlands	% Increase
Heat use GJ/m ²	0.805	1.164	-31%
Total cost \$/GJ	\$20.56	\$9.61	114%
Cost A\$/m ²	\$16.55	\$11.18	48%
Cost \$/kg	\$0.24	\$0.16	48%

Table 7
Comparison of heat energy in Australia versus the Netherlands.

Item	Australia	Netherlands	% Increase
Electrical kWh/m ²	11.4	10	14%
Cost \$/kWh	\$0.17	\$0.09	86%
Cost A\$/m ²	\$1.94	\$0.91	113%
Cost \$/kg	\$0.03	\$0.01	113%

Table 8
Comparison of electrical energy in Australia versus the Netherlands.

5.2.2. ELECTRICAL

We have estimated annual usage for a 20hectare site to be around 11.4kWh/m² compared to 10kWh/m² for Dutch growers. This variation in the estimate is reasonable given the additional expected costs of operating a cool room in a warmer climate and also pump systems for fogging etc that Dutch growers would not utilise.

Our estimated cost for energy for growers in Sydney is A\$170/MWh (A\$0.17/kWh), whilst Dutch growers only pay around €57/MWh which equates to around A\$91/MWh (A\$0.09/kWh). Overall an Australian grower will pay around 113% more for their electrical energy, yet they only use around 14% more actual power.

Table 8 provides a bit more clarity on this, and in the scheme of things is a relatively inconsequential value in terms of total costs. We note that alternate growing systems such as semi-closed greenhouse can consume significantly more power, up to 93kWh/m², though they will also typically produce more fruit. This should be taken into consideration when assessing the types of structures to be deployed into the precinct.

5.3. Other Factors Besides Energy and Labour

Whilst labour and energy are both key items that we can focus in on, there are other costs that need to be taken into consideration. Some of these we believe worth noting are listed below and warrant further investigation:

- **Fixed management salaries** in corporate operations (such as those in Australia) management salaries significantly impact the bottom line, various roles must be accounted for, including general managers, production managers, growers, compliance officers etc. Dutch farms tend to run much leaner in this respect (and pay lower salaries), whilst owner-operator farms here generally have a lot of these roles consolidated into the owner's profile. We note that the KWIN does estimate time allowance for fixed salary type roles, but does not specify the average rate or include this in the profit and loss statements. As an estimation, we have applied the same figure of €16.50/hour to the total allocated hours provided by the KWIN. In reality, this hourly rate could be much higher but we have not been able to source any verifiable data to challenge this figure.
- **Fertiliser cost** in Australia appears at an initial assessment to be much higher than in the Netherlands, further analysis is required as to if this is correct, what the quantum is and why. We suspect it is a combination of more flexible regulations here (our growers still discharge occasionally whereas Dutch run a zero discharge model) and potential price difference in our marketplace.
- **Controlled Expenses** such as insurance and maintenance are also higher in Australia and a detailed analysis would provide insight as to why this is.
- **Direct CO₂ injection** is something that Dutch growers are regularly tapping into these days, reducing the combustion of natural gas. Programs such as the OCAP CO₂ pipeline serviced by the Linde Group (Linde, 2019) provides direct connectivity to over 580 greenhouses. In Australia, there is no such option, but more recently we are seeing some growers justifying the cost of having tankers full deliver CO₂ to site.



6 What Benefits can a Precinct Solution Deliver?

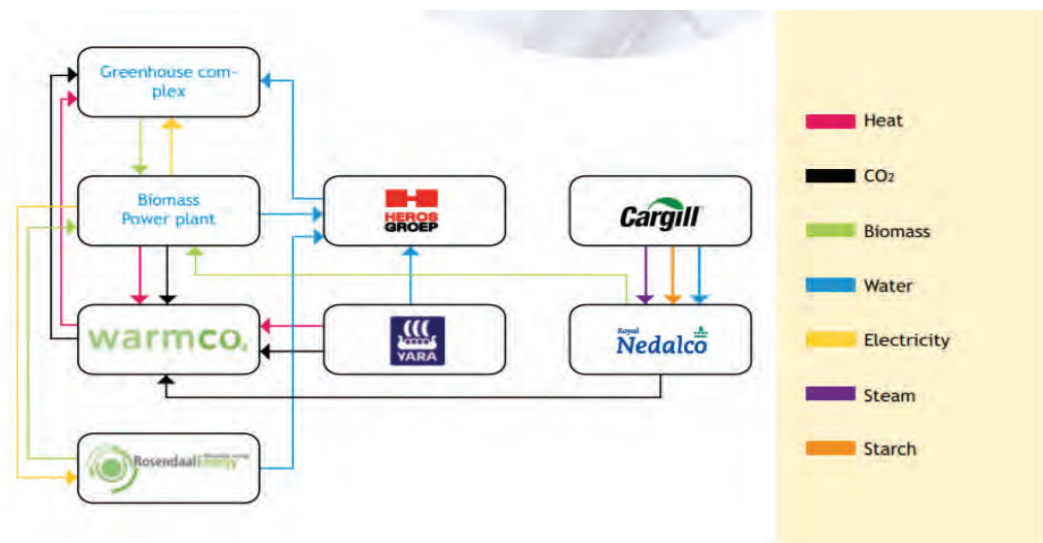


The following section outlines what is possible when the strategy of precinct activation is realised. These types of approaches are based on cutting edge solutions that are purposefully designed for large-scale sites with integration beyond just the greenhouse production systems. They deliver outcomes that reduce the overall operating cost and increase productivity, whilst also being more sustainable and efficient in terms of resource management and environmental impact.

Precinct solutions already exist, and many of the most successful examples (of greenhouse) precincts, unsurprisingly, reside in the Netherlands.

A question often asked is what scale is required to enable precinct-level solutions, and what does a precinct really deliver? In our studies, we have been fortunate to visit various successful examples. We have selected two that exemplify what is possible, ranging from a heavily integrated solution of a modest scale to that of the Mega-precinct. We have outlined these two examples below to set the scene.

6.1. Bio-Park Terneuzen: Medium-Scale Cross-Industry Integration



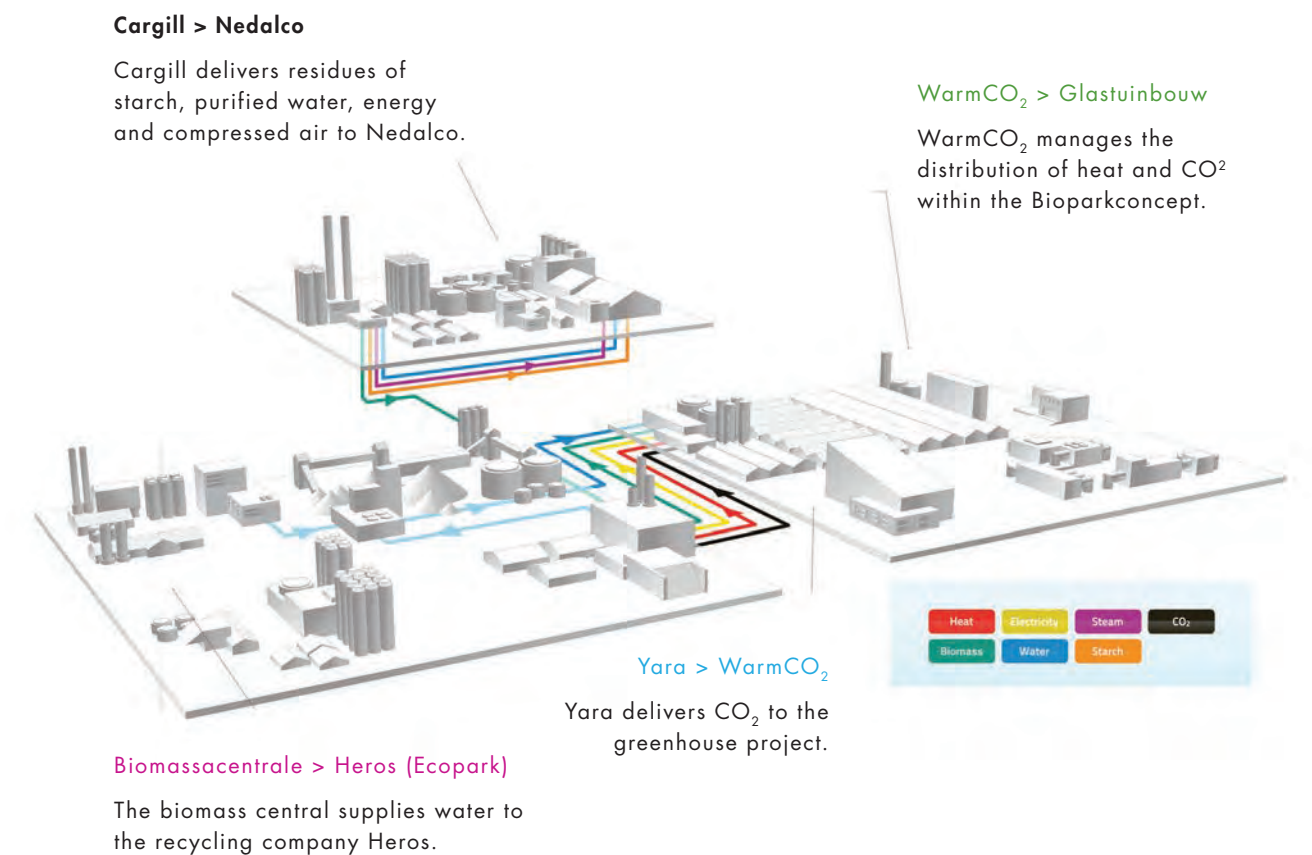
Interconnections between businesses within Bio-park Terneuzen and complex, but highly beneficial.
Figure 9

Bio-ParkTerneuzen is a heavily integrated precinct leveraging the existing opportunities of a variety of industries in the same location. It has a relatively small-scale greenhouse component of 68hectares, that was purposefully added to take advantage of the waste streams (resources) that were already present.

The precinct promotes and facilitates the exploitation of synergies between businesses located in the same geographic area. Specifically, it helps to maximise the use of each other’s by-products and waste products, which then become feedstock for their own production processes (Biopark Terneuzen, 2019).

On this site, greenhouse vegetable production is linked to industrial Partners Yarra Fertiliser and its subsidiary WarmCO₂ (Figure 9 and 10). The shared infrastructure allows ‘waste’ CO₂ and heat from the fertiliser factory to be delivered to the neighbouring greenhouses. The outcome from a growers perspective is a significant reduction in the capital requirements (for boilers or cogeneration power units), along with much lower operational costs of per unit heat energy or CO₂ (personal communication, December 2018).

Beyond the obvious benefits to the greenhouse producers, there are of course economic benefits for the industry partners, who are now able to monetise their waste streams. Arguably, and more importantly, a solution such as this provides an opportunity to conserve non-renewable resources, exploit the recoverable value of resources after first use and reduce the waste and pollution burden on the natural environment.



Bio-park Terneuzen Site Plan.
Figure 10
(Biopark Tenrneuzen, 2019).



Aerial view of the Agriport A7 agricultural precinct in the Netherlands.
Figure 11



An aerial image of the Agriport A7.
Figure 12
The red line is a 2km reference to add scale the enormous greenhouse operations. In the south, you can see the co-located Microsoft data centre.

6.2. Agriport A7: Mega Scale Purpose Built Greenfield Site

The Airport A7 is a precinct of Mega-scale. Currently, around 420ha of high-tech, ultra-modern glasshouse vegetable production resides within the precinct, with room for further expansion. There are individual greenhouse businesses of over 100hectares in size, with lengths of well over 1km each (Figure 11). Growth of the precinct has been rapid, and benefits on both a local and national scale are significant and ongoing.

The site was first established in 2006 and has since received over €810million in private investment dedicated to the greenhouse park and its associated solutions (personal communication, December 2018). Prior to this investment the region was regarded as poorly serviced from a utility point of view, 12years later and it is one of the finest in the Netherlands. The Agriport A7 has its own internal electrical grid deployed by the energy company ECW, (established by the greenhouse businesses) and is one of only two privately owned grids in the nation (the other being Schiphol Airport).

The greenhouse producers have invested in industrial cogeneration plants that generate electrical power, heat, and CO₂. The latter two are used in the greenhouses, whilst much of the electrical power is transferred from ECW to the national grid and the neighbouring business park, including the two billion euro data centre operated by Microsoft (Dutch News, 2016).

It seems that innovation never stops at the Agriport A7. The relationship with Microsoft has become truly symbiotic in nature, with waste heat from the data centre being delivered to the greenhouses to grow the vegetable crops at a reduced cost. Other recent developments include investment by ECW into two geothermal heat pumps, which now provide around 20% of the total heat needs of the greenhouses, further reducing non-renewable resource consumption.

The direct benefits for the agricultural sector are of course quite astounding. Before the precincts establishment, the region generated ~€60 million in agricultural sales, in 2018 that figure exceeded €350million (personal communication, September 2019). The intensity and efficiency of production solutions are highly impressive, noting that in 2018 over 85% of the value of agricultural production came from an industry that did not exists 12years earlier, yet only 5% of the total agricultural land has been modified.

Of course, the benefits of such an investment flow on to the surrounding communities. We have already mentioned the increased quality of utility service provisions in the region, and of course, the economic gains are also clear. Furthermore, employment opportunities have flourished, with an enormous increase in both skilled and unskilled jobs. Direct job creation in the glasshouse precinct exceeds 2,000 full-time equivalents, not to mention the ongoing service providers that are contracted to maintain the facilities infrastructure.

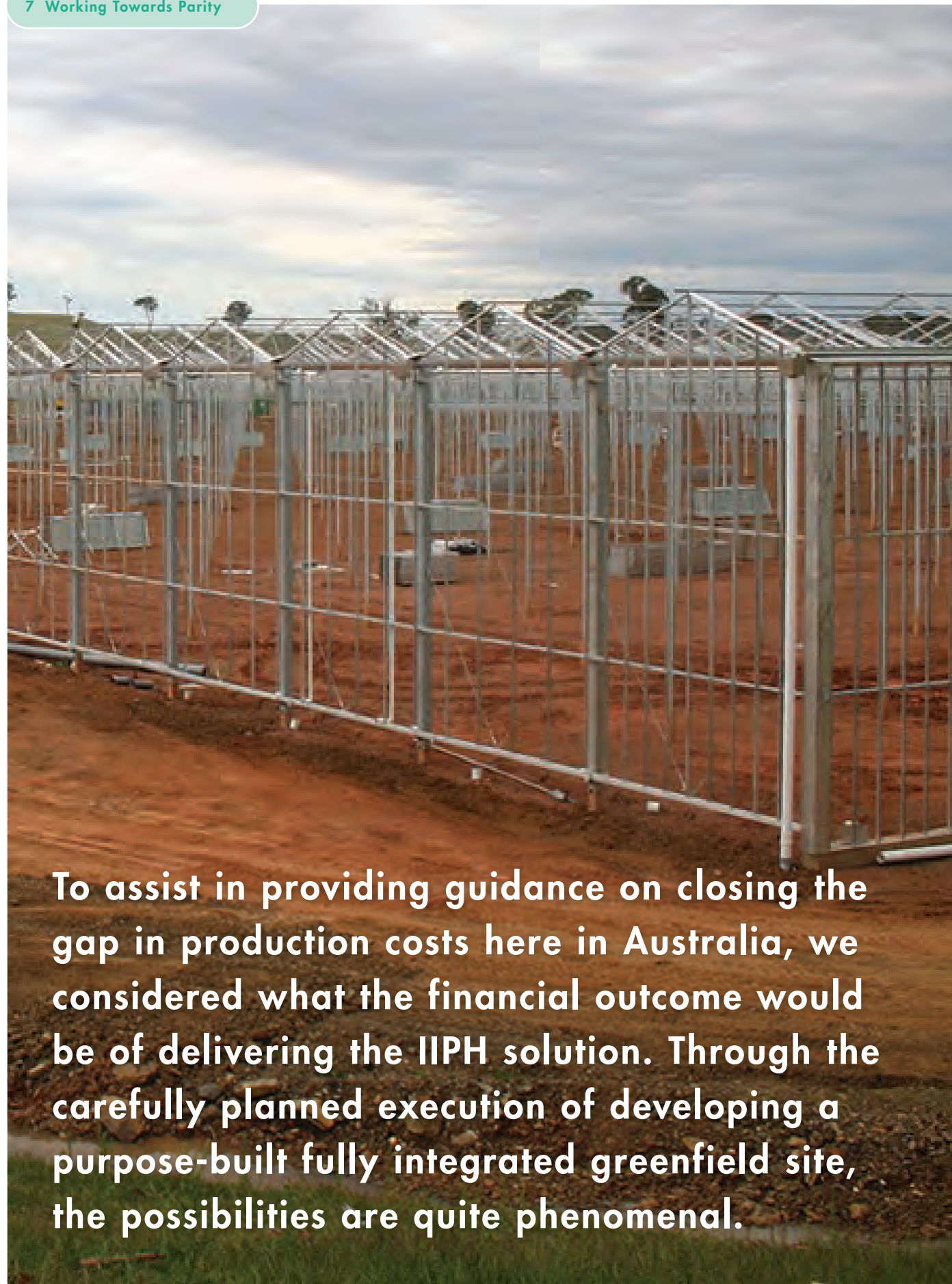
The Agriport A7 is arguably the only precinct-level solution of this kind and scale in the world today, certainly, we have not identified any that rival it. Their success can largely be attributed by the fact that it started with a blank canvass on a greenfield site, and development and planning has always been collaborative in nature and outcome, with any benefits fairly distributed between the participants.

The proposed IIPH can perhaps be the second such solutions in the world. There would be much to learn from those involved in this project, and we strongly recommend that engagement with these businesses and service providers is ongoing and collaborative.

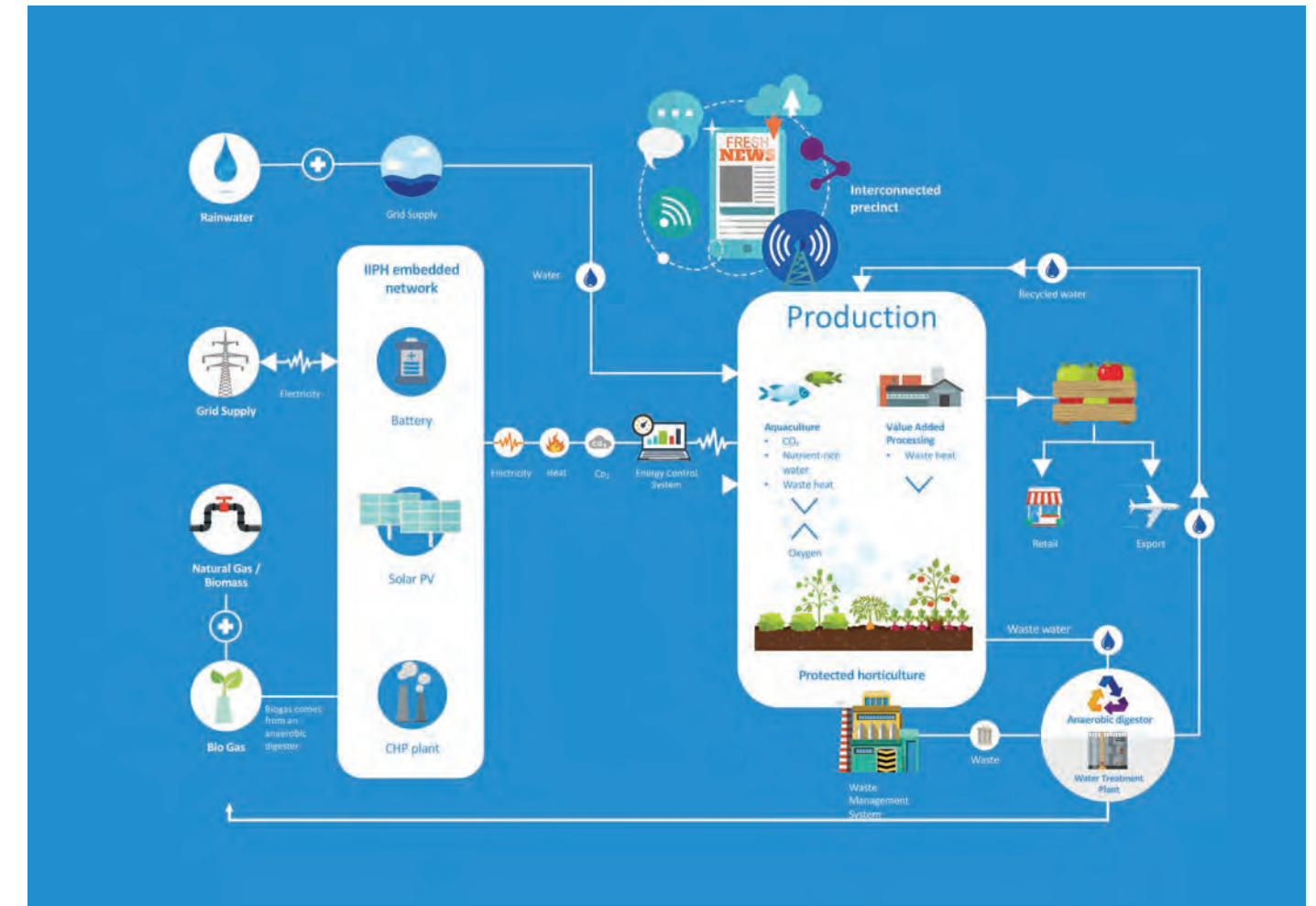


7 Working Towards Parity

The IIPPH, a Solution for Australia



To assist in providing guidance on closing the gap in production costs here in Australia, we considered what the financial outcome would be of delivering the IIPH solution. Through the carefully planned execution of developing a purpose-built fully integrated greenfield site, the possibilities are quite phenomenal.



Resource management and optimisation will be a key priority of the precinct (KPMG, 2019).

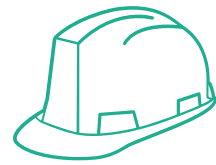
Figure 13

Some of the more significant solutions will revolve around the effective implementation of circular economy principles, with a high priority on water and energy. An example envisaged was delivered in the 2019 KPMG report as shown in Figure 13. These solutions have the potential to meet and exceed the benefits exemplified in the two previously discussed Dutch solutions, though require an enormous amount of collaboration and planning to be successful.

When realised the IIPH will help put Australian greenhouse growers on an equal footing in terms of key operating costs for intensive food production. Furthermore, this once in a generation opportunity can lift us onto the world stage, helping us define what best practice really is.

Given the focus of this report, in the following sections, we have attempted to quantify what these gains may amount to in economic terms for producers. These are a preliminary assumption based on initial communication with a variety of businesses, and detailed modelling will be required once the location of the site is finalised and collaboration between government, industry and utility providers can commence.

We should also be constantly aware of the fact that these types of solutions also afford enormous environmental benefits, reducing waste and improving the efficiency of resource conservation. When fully integrated these projects not only reduce operating cost for growers, but also provide similar benefits to the co-located industry partners and the surrounding community.

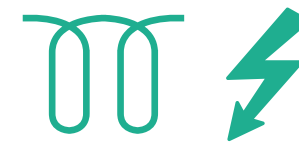


7.1. Labour Costs

We substituted Australian labour rates for those of Dutch operators benchmarked at €16.50/hour (A\$26.40). This is a realistic possibility when we consider the availability of labour around the IIPH (southwest Sydney), and that most positions would be classed as a level two on the Horticulture award wage with a fulltime hourly rate of A\$20.06 (FWC, 2019). Even when we apply an additional 25% to cover the approximate true cost to the business (superannuation, leave, payroll tax, insurance etc) this is still only A\$25.08/hour. Acknowledging that there will be some leading hands and level three staff within this mix we think it is possible that the average variable labour rate could match the Dutch figures of around ~A\$26.40.

We have also assumed parity on crop labour efficiencies, and this, of course, will be one of the most challenging functions to achieve. To deliver this would require changes in cultural practices, research into optimised planting densities and crop management, investment in automation/robotics and delivering a viable pollination method beyond the current manual practices. We acknowledge that this would not be a short-term objective and industry-driven research will be required.

The result of this is that the new analysis assumes that labour is at parity (A\$0.33/kg).



7.2. Energy

On the energy front, we have assumed that energy can be provided at the same unit rate (\$/GJ or \$/kWh) as that in the Netherlands through innovative solutions that the precinct will enable.

From our initial engagement with service providers and technology solution companies, we have identified that this is not only achievable but also a target we can likely better. Further quantification as to the types of solutions and policy enablers that can delivery this needs to be carried out.

When we apply this modest saving of energy price parity, and consider our lower heat energy consumption, we see the cost per kilogram reduced to A\$0.11/kg verse A\$0.16/kg for the Netherlands.

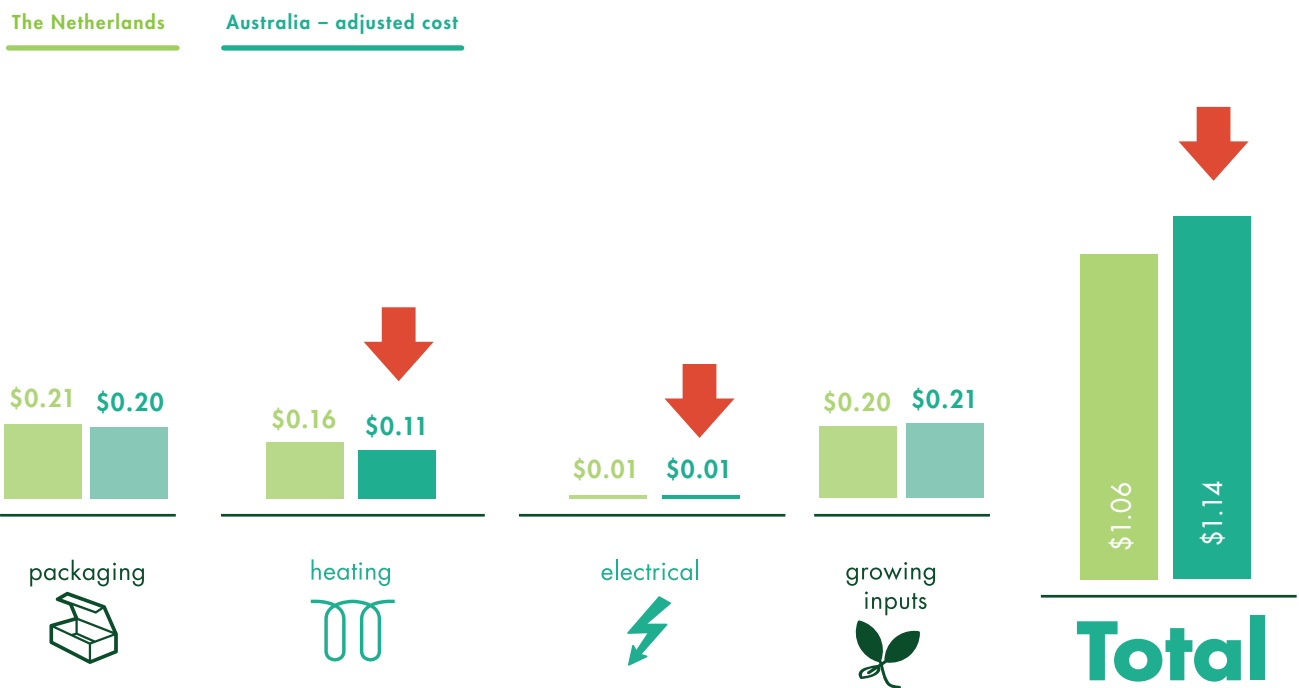
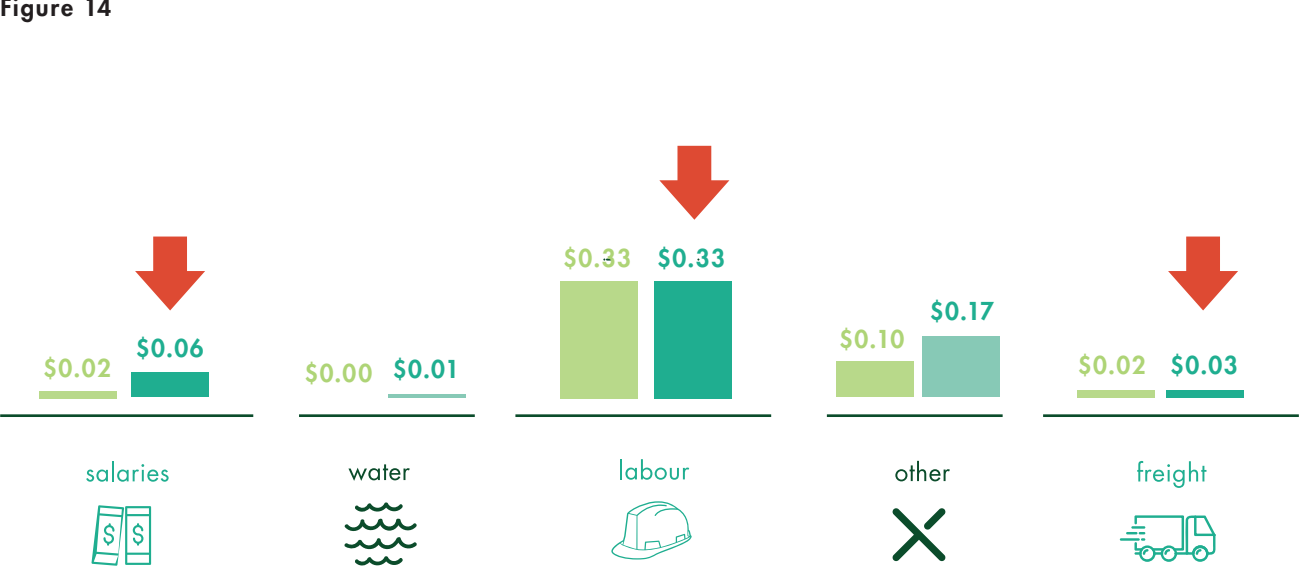


7.3. Other Costs

After we apply the cost functions on energy and labour, we are only left with a delta of A\$0.18/kg, and there are numerous precinct-level solutions that may be able to reduce this even further. We considered and then applied the following scenarios into the theoretical model, you can note these changes in [Table 9](#):

- The freight component will be significantly reduced if the precinct is delivering large volumes to a centralised logistics hub at the airport, this would likely result in a cost more compared to the Netherlands. Our current allowance of \$50/pallet space (double-stacked pallets of conventional 5kg boxes) is a reasonable allowance for transport to multiple distribution centres (industry rates), however, if the majority of this is sent to the centralised logistics hub in close proximity we could anticipate a halving of this value (~\$25/pallet).
- At a precinct-level, the fixed salaries would be dispersed over a larger production area reducing the cost per kilogram dramatically, the quantum to what this will be is highly dependent on the size of the operations that are established, but we note that many of the positions could easily be expanded over a site of over 40hectres without too many additions (if any at all), potentially halving this figure.

Graphical representation of the adjusted major cost of production as a per kilogram basis.
Figure 14



7.4. The Overall Outcome

When we have applied our logic to the theoretical model on direct operating costs the outcome was quite compelling, reducing the cost gap from 52% (A\$0.55/kg) down to as little as 8% (A\$0.08/kg). Table 9 shows the output of this analysis.

Note:

A key aspect still missing from this analysis is the function of depreciation (a direct derivative of capital cost), land and interest rates. All of the site establishment costs have a direct impact on the viability of the overall business (discussed in Section 3.2), and we suggest this should be further analysed. We believe that the recommendations in Section 1.1 exemplify some of the gains that can be made in this regard, although further work is required to quantify this.

Item	Australia	Netherlands	Difference	% Increase
Growing inputs	\$0.21	\$0.20	\$0.01	3%
Electrical	\$0.01	\$0.01	\$0.00	14%
Heating	\$0.11	\$0.16	- \$0.05	- 31%
Labour	\$0.33	\$0.33	\$0.00	0%
Water	\$0.01	\$0.00	\$0.01	N/A
Fixed Salaries	\$0.06	\$0.02	\$0.04	245%
Packaging and sales cost	\$0.20	\$0.21	-\$0.01	- 6%
Freight	\$0.03	\$0.02	\$0.02	117%
Other expenses	\$0.17	\$0.10	\$0.07	67%
Total	\$1.14	\$1.06	\$0.08	8%

Table 9
Comparison of Australia verse the Netherlands cost of production. Energy and labour rates within Australia substituted for Dutch values and freight and fixed salaries now representative of precinct-level solutions and centralised export hub.

7.5. Further Gains—the Potential for Yield Increase

In this analysis we have only modelled the cost reduction potential, yet there is still another significant opportunity to be considered: yield increase.

Quantifying the potential yield increases is quite specific and requires details as to the production solutions that will be implemented. Any claims presented in a broad context (such as this report) would be easily challenged, so we have avoided their inclusion, though the reader should be aware of the opportunity.

Such a focused investment towards an integrated food production precinct will undoubtedly afford growers the opportunity to increase their yield potential, and this will in turn make the economic analysis even more favourable. From our investigation of other integrated precincts around the world productivity increase are evident, and we note some opportunities as follows.

• ELEVATED CO₂ LEVELS:

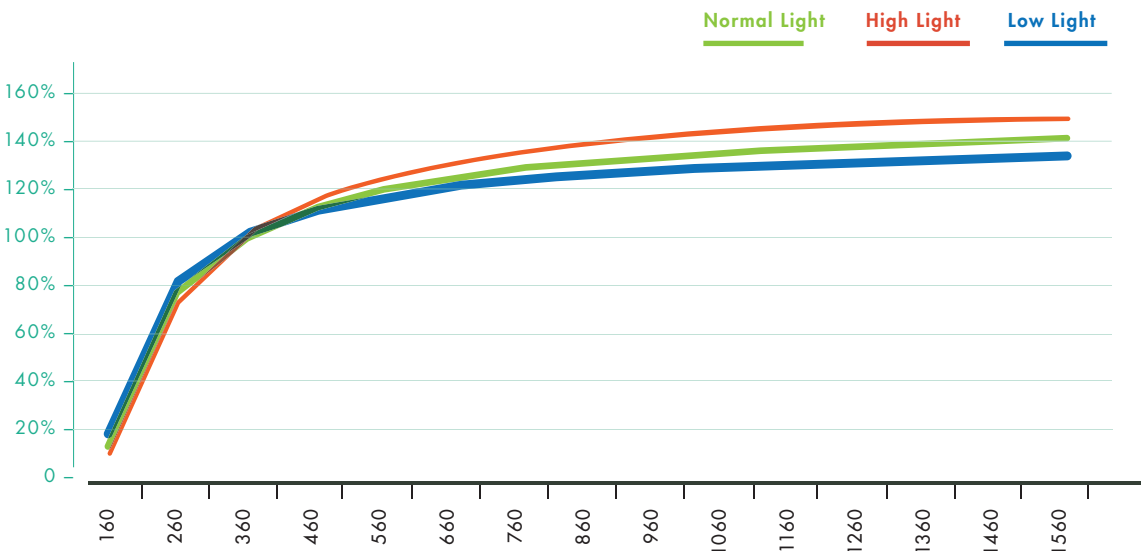
The relationship between CO₂ supplementation and yield increase of greenhouse crops has been well documented and can lead to gains of up to ~45% (Nederhoff, 2004). Whilst most Australian growers already use some form of CO₂ injection, they are normally constrained due to the cost (liquid CO₂) or availability at sub-optimal moments for the crop (gas boilers). Through improved access and decreased costs growers can utilise this resource more effectively, in so increasing the yield potential. The impact of CO₂ injection is also more effective in high light climates like Australia, so our possible gains are also higher (Figure 15).

Most integrated precincts have some form of centralised CO₂ delivery system (for example Bio-Park Terneuzen) or utilities such as Combined Heat and Power units that enable the growers to not only access cheaper CO₂ but do so at the optimal time for plants production. In the vision of the IIPH this consideration can clearly be seen in Figure 13.

• ARTIFICIAL LIGHTS:

When energy sources are made more affordable either via onsite generation or close to other generators, we see the viability of artificial lighting improved, and adoption of this has become quite common in large precincts (for example Agriport A7). The application of artificial lights can help even out production waves and increase overall production dramatically, even in high light regions such as Australia. Arguably, the establishment and operating cost (domestic electrical prices) means this is not economically viable at present. However, the IIPH has the potential to enable onsite energy generation and/or access to more affordable energy streams in so making the viability of artificial lights more likely.

Of course, the dual combination of artificial light and accessible supplementary CO₂ has more significant gains than either prospect on their own.



Potential yield gains of CO₂ supplementation.

Figure 15

Crop production % is shown for various levels of CO₂ with 100% production considered at ambient CO₂ levels of ~350ppm (although atmospheric levels are now considered to be closer to 400ppm).

• ACCESS TO KNOWLEDGE:

As described in Section 3.3 of this report, the clustering effect driven by precinct development will likely result in a more focused approach by industry and the potential for increased investment in research and collaboration. These are the kind of knowledge-based solutions that the Netherlands has relied on for decades, helping make them one of the most productive regions in the world. A domestic approach to this method of research and development will see local solutions that help optimise production systems for our region.

Figures

Figure 1. 13

Dutch tomato growers are recognised as the most efficient in the world.
(Source: National Geographic Magazine, 2017.)

Figure 2. 20

Comparison of average daily light levels. Months for the Netherlands have been opposed (i.e. July = January) to allow direct comparison between Northern and Southern Hemisphere seasons.

Figure 3. 20

Comparison of average minimum and maximum temperatures. Months for the Netherlands have been opposed (i.e. July = January) to allow direct comparison between Northern and Southern Hemisphere seasons.

Figure 4. 25

Potential site water capture based on rainfall verse total site requirements. ETo of field tomato is provided for reference sake only.

Figure 5. 43

Cost distribution of truss tomato production in Australia.

Figure 6. 43

Cost distribution of truss tomato production in the Netherlands.

Figure 7. 44

Graphical representation of the major cost of production as a per kilogram basis.

Figure 8. 51

The direct cost of pollination in the Netherlands (highest rate), New Zealand and Australia.
All values are converted and displayed as AUD.

Figure 9. 60

Interconnections between businesses within Bio-park Terneuzen and complex, but highly beneficial.

Figure 10. 61

Bio-park Terneuzen Site Plan.

Figure 11. 62

Aerial view of the Agriport A7 agricultural precinct in the Netherlands.

Figure 12. 62

An aerial image of the Agriport A7.

Figure 13. 67

Resource management and optimisation will be a key priority of the precinct (KPMG).

Figure 14. 70

Graphical representation of the adjusted major cost of production as a per kilogram basis.

Figure 15. 73

Potential yield gains of CO₂ supplementation.

Tables

Table 1. 14

Core assumptions used in this analysis.

Table 2. 19

Climate comparison of Netherlands verse Badgerys Creek.

Table 3. 34

Market access for typical greenhouse-grown food crops (Source: Arris, 2018).
We note the lack of access options for key Asian markets as a barrier to success.

Table 4. 40

Description of cost centre categories used in this analysis.

Table 5. 41

Comparison of the cost of production for 1kilogram of tomatoes in Australia verse the Netherlands.

Table 6. 49

Comparison of labour in Australian verse the Netherlands.

Table 7. 53

Comparison of heat energy in Australian verse the Netherlands

Table 8. 53

Comparison of electrical energy in Australian verse the Netherlands.

Table 9. 71

Comparison of Australia verse the Netherlands cost of production.

References

Agrology. (2018). Production possibilities. Western Sydney airport agribusiness precinct. October 2018.

BOM. (2019). Australian Bureau of Meteorology 2019.
<http://www.bom.gov.au/climate/data>

Arris. (2018). Collie Futures – Protected Cropping Prefeasibility Investigation.
For: Department of Primary Industries and Regional Development. Western Australia.
March 2018

Biopark Terneuzen. (2019).
<http://www.bioparkterneuzen.com/en/biopark.htm>

Dutch News. (2016). Microsoft builds massive €2bn data centre in Noord Holland News.
(2016) Microsoft builds massive €2bn data centre in Noord Holland.
<https://www.dutchnews.nl/news/2016/08/microsoft-builds-massive-e2bn-data-centre-in-noord-holland/>

Fruit Logistica. (2019). European statistics handbook.

FWC. (2019). Fair Work Commission. Horticulture Award 2010 classification and payguide.
<https://www.fwc.gov.au>

Hort Innovation. (2019a). Australian Horticulture Statistics Handbook. Vegetables. 2017/18.
Horticulture Innovation Australian Limited.

Hort Innovation. (2019b). Developing Technical Guidelines National Construction Code
2019 Proposals for Change. Horticulture Innovation Australian Limited.

Koppert. (2018). Direct dialogue with Koppert Biological Systems. The Netherlands.
<https://www.koppert.com/>

KPMG. (2019). World-class intensive integrated production hub in the Western Sydney
Aerotropolis. NSW Government's Agribusiness Precinct. A pre-feasibility study for the
NSW Department of Primary Industry.

Elgas. (2019). Direct dialogue with Major accounts Manager.

Linde. (2019). CO2 for Greenhouses.
https://www.the-linde-group.com/en/clean_technology/clean_technology_portfolio/co2_applications/greenhouse_supply/index.html

NASA. (2019). POWER Data Access Viewer. 2019.
<https://power.larc.nasa.gov/data-access-viewer/>

National Geographic Magazine. (2017). This tiny country feeds the world.
September 2017 issue of National Geographic magazine.

Nederhoff. (2004). Energy in greenhouses. Crophouse Ltd, New Zealand.
Published in the Grower.

Statistics Netherlands. (2018). Agricultural Census 2017, conducted by Statistics
Netherlands (CBS).

WUR. (2018). Wageningen University and Research. Quantitative information on
Dutch greenhouse horticulture 2016 – 2017. English version. "KWIN"

WUR. (2019). Wageningen University and Research Centre Agro & food Portal.
<https://www.agrimatie.nl>

Zonda. (2018). Direct dialogue with Zonda Beneficials, New Zealand.
<https://www.zonda.net.nz/>

9. Appendix 1 – Data Derived from KWIN Analysis

The following data is what we have utilised in our analysis noted within this report, albeit we have consolidated some of these costs under broader categories.

We note that the hours for fixed salaries were obtained from references in table 51 of the KWIN and incorporated within. The hourly rate was not provided so has been fixed at the same value of €16.50/hour that they provide for all other labour functions.

Glasshouse Area (m2)	40,000			
Crop	Tomato Vine (150-190gram) no CHP			
	Yield (kg/m2)	Price	Income	Comment
Estimated sales price	70	€ 0.85	€ 59.39	Reverse Calculated at cost of production
Direct Cost	Quantity	Price	Costs	Comment
Plant cost	1.25	€ 3.00	€ 3.75	Cost of plant material from propagators
Substrate use once (m3)	0.1		€ 0.65	Rock wool
Gas (use and energy tax) (m3)	33.1	€ 0.19	€ 6.29	Gas usage and energy rating
Gas (Cap and transport) (m3/hour)	0.01	€ 70.00	€ 0.70	Fees based on capacity and transport
Electricity (included tax) kWh	10	€ 0.06	€ 0.57	10kWh/m2
Income Electricity (kWh)	0	€ 0.00	€ 0.00	N/A
Liquid CO2			€ 0.65	No CHP so has additional CO2 use
Other Sterilisation			€ 0.00	N/A only for soil crops
Crop Protection			€ 0.55	Average for treatments, includes bumble bees
Fertiliser			€ 1.20	Assume full recirculation system
Water			€ 0.00	Covered in General Cost
Other Materials			€ 0.65	Floor covers, string, hooks
Contractors			€ 0.25	cleaning, removal of waste etc
Transport cost products	70	€ 0.01	€ 0.70	External transport company
Cooling storage products		€ 0.00	€ 0.00	N/A
Boxes and Packaging	70	€ 0.12	€ 8.40	All packaging and crates to auction etc
Levies		€ 0.00	€ 0.00	N/A covered below
Auction Cost	€ 59.39	2%	€ 0.89	Percentage of sales (2%)
Destruction cost of plants			€ 0.50	All transport and destructions costs
Interest on invested value	€ 59.39	1%	€ 0.59	Interest on cost of plant establishment
Subtotal			€ 26.34	
Cost Labour calculated	0.881	€ 16.50	€ 14.54	can be +/- 20%
Fixed Salaries	0.048	€ 16.50	€ 0.79	No hourly rate provided by KWIN
Annual Cost Equipment and land	1	€ 16.00	€ 16.00	Interest on land and investment (5%)
General Cost	1	€ 2.50	€ 2.50	Communication, insurance, information, water etc
Total Cost			€ 60.18	

Note: For our study we have had to remove annual cost on land and equipment, this is where maintance would normally reside in the NL data set. For this reason we have estimated maintenance based on data found in Table 50 of the KWIN. We have doubled the value of a 10ha vegetable greenhouse to get to this figure.

Due to market sensitivity true sales prices and turnover is no longer available. In this case the sales price price represents the operating cost. In reality the actual price tends to fluctuate above and below the cost of production. In many instances from 2010-2015 it was noted that the sales price was lower than the calculated growing cost for many crops.



Agrology