Project Title	Tomatoes: An investigation into apparent yield improvements associated with the installation of a micro-gas-turbine CHP facility – Phase I
Project number:	PC 228
Project leader:	Dr Andrew Marchant, Hennock Industries Ltd
Report:	Final report, May 2005
Previous report	None
Key staff:	Dr Andrew Marchant Gerry Hayman
Location of project:	Guy and Wright Ltd, Green Tye, Herts
Project coordinator:	
Date project commenced:	1 January 2005
Date completion due:	30 April 2005
Key words:	Tomato, CHP, micro-turbine, yield, quality, gas, CO_2

The results and conclusions in this report are based on a series of experiments conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Dr A Marchant
Director
Hennock Industries Ltd

Signature .... Date ....

G Hayman
Principal
Gerry Hayman Horticultural Consultancy

Signature .... Date ....

Report authorised by:

[Name]
[Position]
[Organisation]

Signature .... Date ....

[Name]
[Position]
[Organisation]

Signature .... Date ....

CONTENTS

Grower Summary

Headline

Reported increases in yields of tomatoes following the installation of a micro-turbine CHP system prior to the 2003 cropping season on Guy & Wright's nursery in Hertfordshire were above those expected, in comparison with three other sites without such a facility.

Detailed production figures for the site were compared with the other sites for the years 2002 to 2004. Yield increases achieved by Guy & Wright over this period were confirmed to be above those which might have been expected. These increases are not explained by any variation in solar radiation receipt between years or between sites, nor are they explained by differences in nominal output rating of the CO_2 systems employed on the sites compared.

Further comparisons of factors such as CO_2 distribution, glasshouse CO_2 levels actually achieved and the presence of potentially phytotoxic products of combustion from different CO_2 supply systems, would be necessary to come to more specific conclusions about any benefits of micro-turbine systems. More detailed crop data, such as a comparison of average fruit size, would also be useful in examining any potential crop effects in more detail and with more certainty.

Background and expected deliverables

- Guy and Wright Ltd installed Turbec T100 micro-turbines in 2002 and after the first full season of operation, in 2003, the production from a crop of classic tomatoes was significantly more than would have been expected.
- The installed system replaced a kerosene-fuelled CO_2 supply. The new system is equivalent to 15 m^3 natural gas /hour/1000m^2 theoretical maximum burning rate, which is similar in maximum capacity to the previous system.
- An increase in average yield of some 12.6kg/m^2 (50 t/acre) in 2003 over 2002 and in the most modern glasshouse block a yield of 70kg/m^2 (279t/acre) were reported from this site. These yields are greater than one would expect from dosing CO_2 at this rate on this site i.e. taking into account the production facilities in relation to glasshouse type, age and design.
- If there is an unexplained and disproportionate yield increase, there could be significant benefits to the industry from replicating this. The implications of this would relate to both existing CHP schemes and the potential for new ones, depending on possible causes, and to sites without CHP. In all cases there could be direct yield benefits that could be achieved by alterations to system design and installation on new or existing installations.
- There are also implications for the increased profitability of the installation of CHP units at sites currently without them, in particular benefiting smaller nurseries (<1.5ha), which tend to be the sites where CHP was not installed in the first wave.

- If potential benefits were found to be associated with factors such as increased air movement, better CO_2 distribution, or reduced pollutant levels, there could be opportunities for improvement in these areas on sites without CHP, i.e. those with conventional heating systems and CO_2 supply. The results would also contribute to a better understanding of the energy used for CO_2 generation, as opposed to glasshouse heating, an important consideration in achieving total energy use reduction and meeting Climate Change levy obligations.
- All of the above benefits could relate to other protected crops, in addition to tomatoes.
- There are also potential opportunities for the use of biogas derived from various organic materials to power micro-turbine installations on glasshouse sites.

Summary of the project and main conclusions

- Examination of production records for the site showed there to be an increase in average total yield of 12.58 kg/m^2 (50.1 t/acre) or 25.4% between 2002 and 2003.
- This compared with a **reduction** of 0.65kg/m^2 or 1.1% in these years for the average of three comparison sites. Comparison between sites was restricted to classic tomato types in these years.
- Production on the G&W site in 2002 was lower than in 2000 or 2001, whereas the reverse was the case for the other sites. The lower figure in 2002 may have been related to disruption caused by the installation of the turbine system in that year and problems this caused, in the interruption of CO_2 supplies for instance.
- A comparison of the G&W yield in 2003 compared with the average of the more normal years, 2000 and 2001, showed an increase of 20.2% compared with a 5.3% increase for the other three sites over this period.
- Annual yields at G&W went from figures of 2.2%, 6.7% and 14.0% below average of the other sites in 2000, 2001 and 2002 respectively, to 9.1% and 9.5% above average in 2003 and 2004.
- There were no material differences in factors such as sowing dates, cultivar or plant populations over the comparison period.
- Solar radiation measurements for G&W in 2003 were 10.5% above 2002 but were 11.4% higher for the three-site average in these years. The disproportionate increase in yield at G&W cannot be ascribed to a disproportionate increase in radiation levels therefore, compared with other sites.
- Production at all four sites in 2004 was lower, by an average of 10.4%, than in 2003 and solar radiation levels by 6.7%.
- Production at Site B in 2004 was unexpectedly low, which was due to a severe Botrytis infection.
- Average yields for G&W are very similar to those of Site A, but this site has all modern blocks with larger glass and significantly higher gutters than has 47% of the glasshouse area at G&W, which is much older.
- Average yields for the two modern blocks at G&W in 2003 and 2004 were 10.5% and 10.7% higher respectively, than those of Site A. Solar radiation levels were, however, 3.5% and 4.7% lower than Site A in 2003 and 2004 respectively.
- Site A also has a significantly higher rated CO_2 input from its CHP system than that at G&W.

- Comparison of system CO_2 output capacity for the four sites does not suggest this to be the primary reason for the differences in results achieved, although records of actual glasshouse CO_2 levels recorded would be particularly useful in making more detailed analyses.
- Other potential benefits from the new system would be cleaner glass and improved light transmission from cessation of oil use (although this was already the case on two of the other three sites), and lower levels of pollutants in the combustion gases, possibly compared with the two gas-using sites and probably compared with the kerosene using one.
- More accurate monitoring and control of potential pollutants in glasshouses from the combustion gases from CO_2 generation demands a higher priority than it appears to receive at present, not only from a crop perspective but also in relation to the health and safety of staff employed in glasshouses.
- Records of average fruit size would be particularly useful in comparing the possible effects of varying CO_2 enrichment levels and solar radiation receipt, but unfortunately these are not available.
- The primary conclusion is that production levels achieved by Guy & Wright following the installation of the micro-turbine system are greater than would be expected from these facilities, given simply their specification. This was established by comparison with three other sites, which were chosen to reflect similarities with G&W in glasshouse types or CO_2 installations, both in relation to the replaced kerosene burning system and the new micro-turbine system.

Financial benefits

Without considering the economics of electricity generation from the micro-turbines, a yield improvement of 10% above comparable figures, or 5.5kg/m^2 for classic tomatoes, would produce an increase in income (net of marketing and picking costs) of approx £3.85/m^2 or £15,580/acre.

Action points for growers

- Consider micro-turbines for CHP installations as an alternative to conventional reciprocating engine types.
- Examine present arrangements for monitoring and controlling glasshouse pollutants from all fuel sources (natural gas, LPG or kerosene) and improve these where necessary.
- Provide more data for comparisons between sites, such as average and weekly fruit size assessments. Yield responses to CO_2 are primarily through effects on fruit size, all other factors, such as plant population, being equal.
- Consider other CO_2 sources, such as biogas and composting of organic material, such as straw. The latter could also make use of nutrients in run-off from systems such as non-recirculated rockwool for composting, also helping avoid nutrient pollution. This approach was developed by Peter Bailey, a cucumber grower in West Sussex in the 1980's with considerable success, but has not since been pursued.

Science Section

Introduction and background information

Previous installation – heating and CO_2.

In common with many nurseries the Guy & Wright site had a previous high temperature-lift heating system with pipe rails, which was then added to in order to install a low level CO_2 system. The heating system immediately prior to the installation of the micro turbines therefore comprised main heating boilers, with a secondary boiler used for CO_2 purposes, and thermal storage was installed to provide for heat buffering.

Glass area totals 1.22 hectares, comprising 2 blocks of 6.4m Venlo all with 1m glass, and 4 older blocks of Frampton Ferguson glass with 2ft square panes, the majority based on the 22ft x 18.25ft module size.

Fuel
The main heating fuel was HFO, with the CO_2 system operating on low-sulphur kerosene. Coal was used for some periods as the primary heating fuel source, depending on relative oil to coal prices.

Dosing rates
The equivalent rate expressed in conventional units was $14.5m^3/1000m^2$/hour assuming an efficiency of 85% (rated output to input).

Operation
The operation of the system followed conventional lines with the CO_2 boiler operating during daylight hours when there was a CO_2 demand.

Details of plant and equipment

CO_2 boiler:-

Make	Allen Ygnis
Rated output	1200kW
Type	packaged shell and tube
Year	pre 1995
Burner	Nu Way
Type	pressure jet
Fuel	kerosene

Main heating boiler	
Make	B & E European
Rated output	2370kW
Type	packaged shell and tube
Year	pre 1995
Burner	Saacke
Type	rotary cup
Fuel	HFO
Backup boiler	
Make	Allen Ygnis
Rated output	1500kW
Type	packaged shell and tube
Year	pre 1995
Fuel	coal
Thermal stores	
Quantity	3 off
Total capacity	$405m^3$ ($332m^3$/ha)
Environmental computer	
Brinkman	

Micro turbine installation

Installation
Four micro-turbine units were installed on the nursery located within a dedicated new plant room in 2002. These produce three outputs - electricity, heat and exhaust gases (CO_2).

The electrical outputs is connected to a site-owned transformer which steps up the output voltage to the grid voltage of 11kV, with export metering capability.

Heat contained within the turbine exhaust is converted to hot water by the recuperater within the unit, which produces a nominal 152kW of hot water per unit. These hot water outputs are all connected to the existing hot water system. Additionally a further heat exchanger is included within the ductwork which is designed to remove a further 77kW of lower grade heat, and the water side connections for this are connected to the heating system return.

All four exhaust outputs are commoned into a single larger one, and this is connected to a discharge to ambient and also to the CO_2 system. This ducting contains the additional heat exchanger and then passes to the main distribution plenum chamber. Connections from this are taken to the individual blocks, with three separate fans connecting ducting to individual blocks. Ducting was replaced as part of the installation and has been installed to maintain uniform pressures based on volume flow (according to house areas) and duct losses.

When CO_2 is not required for the houses it exhausts through the ambient discharge, which also has the potential to draw in ambient air since it is an open system operating according to system pressure.

The previous CO_2 boiler has been converted to gas, and is now used as a standby for CO_2 production in the event of turbine failure. It has only been used very infrequently.

The main heating boiler has been dual fuelled to run on gas most of the time, with light oil as back up.

Fuel
The site was connected to natural gas as part of the CHP installation.

Operation
The turbines are operated for a nominal 17 hours per day (see details of gas consumption below) including weekends. This will usually be 07.00 to 24.00 hours.

Details of plant and equipment

2002-3 season

Quantity	4 off
Make	Turbec
Model	T100
Electrical output (max rated)	100kW
Thermal output (rated)	152kW
Thermal output (site)	174kW

Theoretical maximum equivalent CO_2 input = $11m^3/1000m^2$/hour.

2003-4 season
During this season a 5th turbine was added, and the electrical output from the existing four units increased due to modifications by Turbec. The fifth unit became operational in July 2004, although full time operation did not occur immediately (see details of operating hours).

Quantity	5 off
Make	Turbec
Model	T100
Electrical output (max rated)	115kW
Thermal output (rated)	175kW
Thermal output (site)	191kW

Gas consumption
In order to ascertain equivalent dosing rates there are two factors to be considered, the maximum theoretical input and the actual gas input.

Theoretical input
Gas consumption for 5 units = 182m^3/hr at nominal rated input
This equates to a natural gas equivalent of 15.5m^3/1,000m^2/hour.

Actual input
The critical period for calculating CO_2 enrichment levels is during the main growing season, when vents are likely to be open and the plants assimilating large volumes due to greater leaf index and light levels. For this reason the figures for April to October have been selected, and are summarized below.

Gas used for CO_2 (turbines) over the main growing period (April – October inclusive assumed at 214 days). Note that in 2002 the turbines were only partially operating during April and May due to commissioning and connection issues, thus the figures for this season are only over June to October inclusive.

June to Oct 2002	2,491MWh
April to Oct 2003	4,937MWh
April to Oct 2004	5,484MWh

Equivalent *average* gas dosing rates are as below (assuming uniform distribution)

June to Oct 2002	8m^3/1000m^2/hour
April to Oct 2003	11m^3/1000m^2/hour
April to Oct 2004	12.5m^3/1000m^2/hour

In reality there have been periods when some units have not been operating due to mechanical problems, although it is difficult to quantify this. This would be particularly true of the 2002 summer, which was during the early days of the installation and electricity contracts had not been finalized, thus operation was more sporadic and tended to concentrate on the daytime periods when CO_2 was required.

Comments on accuracy of figures.

- There will be some slight variation due to meter reading dates – this is not a significant error.
- Some cross checking of figures is possible due to multiple metering, however the greatest meter accuracy is 2%, and this combines with an efficiency figure such that the cumulative accuracy is less (possibly ± 5%). A final certainty value for the figures is likely to be between ±5-10% allowing for meter inaccuracies plus reading errors.

Comments on installation

Points to note.

- There was a change from kerosene to natural gas as the fuel for CO_2 .
- There will be an implication for the cleanliness of the glass.
- Distribution of CO_2 on either installation (i.e. kerosene boiler or micro turbines) cannot be verified as being uniform although designed as such.

Comments on data.

The dosing rate under the kerosene system was a theoretical maximum of $14.5m^3/1,000m^2$/hour.
The theoretical dosing rate under the current 5 turbine installation is $15.5m^3/1000m^2$/hour.
The actual dosing rate under the previous kerosene system was typically equivalent to maximum dosing for 6.2 hours / day, or an average of $9m^3/1000m^2$/hour over a 10 hour day.

The actual dosing rate under the new CHP system has been a maximum of $12.5m^3/1000m^2$/hour in the 2004 season, $11m^3/1000m^2$/hour in the 2003 season and $8m^3/1000m^2$/hour in the 2002 season.

These figures are summarized in the table below.

	Kerosene	CHP 4 units	CHP 5 units
Max theoretical rate ($m^3/1,000m^2$/hour)	14.5	11.0	15.5
Actual rate 2001 ($m^3/1,000m^2$/hour)	9.0		
Actual rate 2002 ($m^3/1,000m^2$/hour)		8.0	
Actual rate 2003 ($m^3/1,000m^2$/hour)			11.0
Actual rate 2004 ($m^3/1,000m^2$/hour)			12.5

Materials and Methods

- Examine data from the site and comparative data from other grower holdings to establish whether there has been an unexplained additional yield increase, after taking into account seasonal solar radiation levels, other factors common to the season and other growers' results. Two years' data were examined i.e. 2003 and 2004.

- In the event of a positive answer to this first phase, a project extension will be proposed to undertake subsequent preliminary investigations to suggest or rule out possible causes

Results

Comparison of Sites

Table 1

Guy & Wright Glasshouse Details						
Block	**1**	**2**	**3**	**4**	**5**	**6**
Area m²	2,024	1,117	1,416	1,117	2,185	4,330
Type	FF Q22	FF Q22	FF Q22	FF Q22	Double Venlo	Double Venlo
Glass size	610 mm (24 ins)	610 mm (24 ins)	610 mm (24 ins)	610 mm (24 ins)	1,000mm	1,000mm
Date (approx)	1970s	1970s	1970s	1970s	1998	2000

Table 2

Comparison Sites Glasshouse Details			
	Site A	**Site B**	**Site C**
Area ha	1.6 ha	0.9 ha	0.67 ha
Type	Double Venlo	Cambridge	Venlo + Hancock
Glass size	1,125 mm	735mm	735mm
Date	1990, 1996	1977	1972
Fuel	Gas	HFO	Gas
CO_2 source	Gas and CHP	Kerosene	Gas
Maximum firing rate for CO_2	$30m^3/1000m^2$ from 2 MW capacity CHP $15m^3/1000m^2$ from boiler	$12m^3/1000m^2$	$16m^3/1000m^2$

Table 3

Crop Details – All Sites												
Site	**Guy & Wright**			**Site A**			**Site B**			**Site C**		
Year	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**
Sowing date	10/11 24/11	09/11 23/11	07/11 21/11	26/10 14/11	24/10 14/11	23/10 12/11	02/11	28/10	24/10	10/11 13/11	20/10 02/11	07/11 12/11
Variety	Espero	Espero Encore	Espero Encore	Espero	Espero	Encore	Espero	Espero	Encore	Encore	Encore	Encore
Plants /m2 Initial	2.25	2.25	2.25	2.00	2.00	2.00	2.00	2.00	2.00	2.01	2.01	2.00
With shoots	3.50	3.50	3.88	4.00	4.00	4.00	3.50	3.50	3.50	3.52	3.52	3.76
System	RW	RW	RW	NFT	NFT	NFT	RW	RW	RW	NFT	NFT	NFT

Table 4

Guy & Wright - Yields (kg/m²) 2000-2004								
	Block							
Year	1	2	3	4	5	6	Average	% 2000
2000							51.49	100.0
2001							51.95	100.9
2002							49.61	96.3
2003	55.81	59.86	56.64	60.62	62.90	67.33	62.22	120.8
2004	50.58	54.05	52.26	50.98	60.38	59.16	55.93	108.6

Table 5

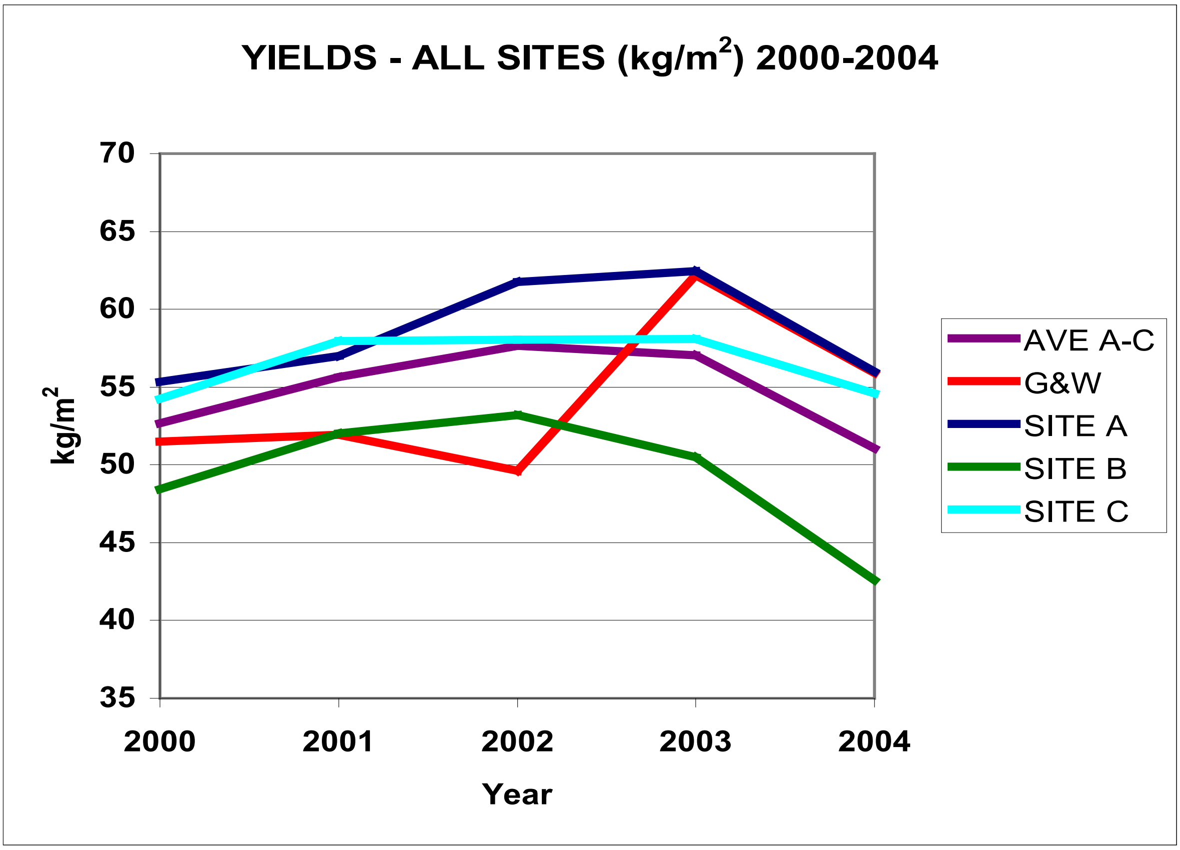


Table 6

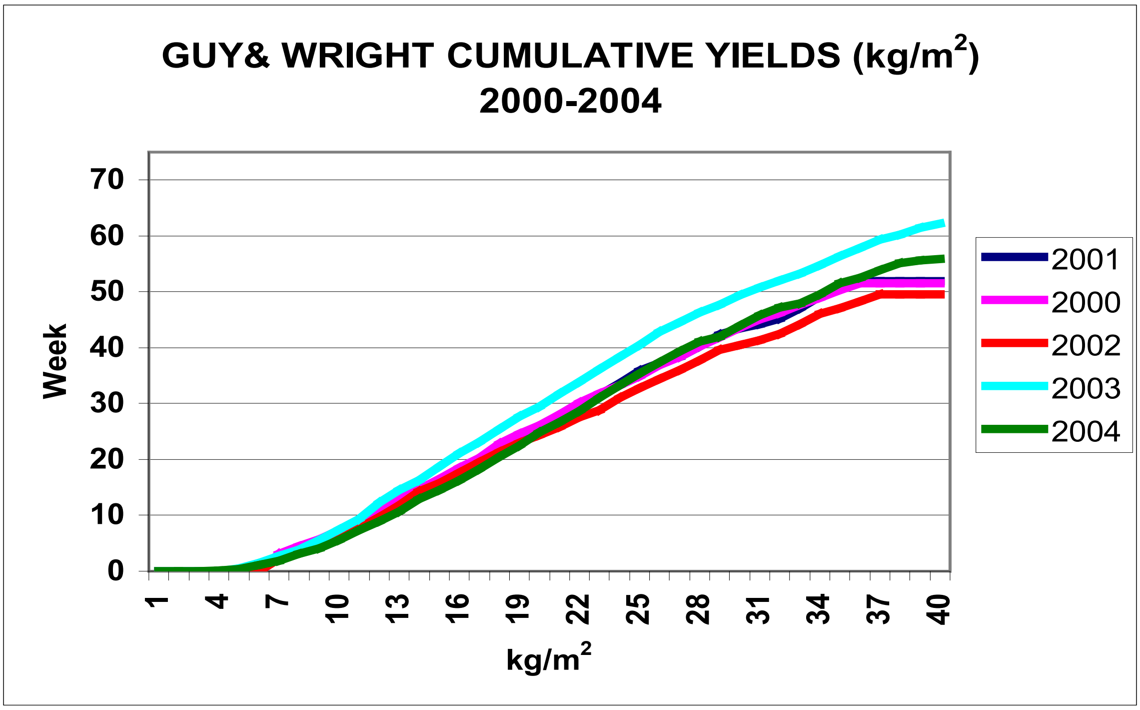
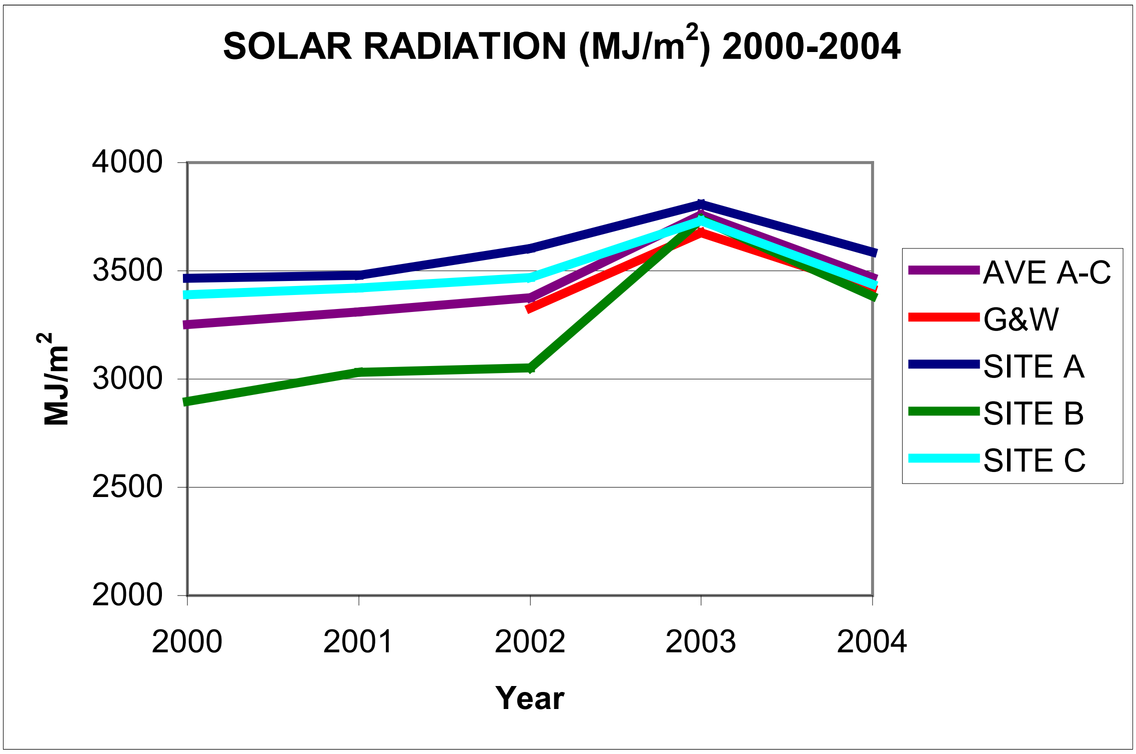


Table 7



Conclusions

Micro-turbine CHP installations do appear to afford potential yield benefits to glasshouse tomato crops. Further detailed examination of crop responses and glasshouse environmental factors are necessary to elucidate the possible mechanisms involved.

Technology transfer

HDC report
Presentation to the TGA Technical Committee on 1 June 2005.

APPENDIX 1 - WEEKLY PRODUCTION (kg/m^2) 2000-2004

	GUY & WRIGHT					SITE A				
Week	2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.10	0.01	0.20	0.01	0.01
10	0.00	0.00	0.00	0.00	0.00	0.52	0.55	0.20	0.10	0.20
11	0.00	0.00	0.00	0.00	0.08	0.71	0.62	0.52	0.59	0.40
12	0.00	0.00	0.00	0.53	0.27	0.85	0.66	0.62	0.46	0.48
13	0.00	0.00	0.00	0.92	0.73	0.93	0.86	0.61	0.65	0.56
14	3.09	2.74	2.18	1.24	0.78	0.92	1.10	0.90	0.72	0.82
15	1.37	1.07	1.16	1.18	1.20	1.28	1.12	0.90	1.00	1.00
16	1.19	1.15	1.18	1.73	1.09	1.23	1.12	0.90	1.20	0.93
17	1.73	1.26	1.62	1.84	1.39	1.30	1.20	1.30	1.93	1.48
18	1.75	1.42	1.53	1.90	1.76	1.60	1.30	1.70	2.20	1.62
19	2.10	1.57	1.99	2.91	1.62	1.83	1.50	2.10	2.60	1.76
20	1.71	1.66	2.17	2.24	1.82	1.87	1.70	2.90	2.50	1.95
21	1.68	2.18	2.39	1.78	2.17	1.63	2.10	2.90	2.10	2.40
22	1.86	2.11	1.60	2.43	1.68	1.97	2.10	2.10	2.00	1.78
23	1.96	1.79	1.86	2.41	1.70	2.15	1.99	1.70	3.00	1.60
24	1.86	1.79	1.86	1.99	1.92	2.21	2.20	1.90	2.10	2.10
25	2.56	2.54	1.87	2.34	2.28	2.61	2.50	2.40	2.30	2.10
26	1.75	2.26	1.61	2.24	1.97	2.10	2.60	2.60	2.40	2.20
27	1.47	2.07	1.34	1.79	2.34	1.98	2.63	2.00	2.40	2.40
28	1.95	2.35	1.52	2.31	1.91	1.90	2.30	2.00	2.30	1.70
29	2.12	1.70	1.68	2.12	1.92	2.10	1.90	2.60	2.70	2.40
30	1.60	1.86	1.26	2.20	2.46	1.95	2.30	2.30	2.20	2.60
31	1.53	2.09	2.25	2.31	2.24	1.62	2.30	2.60	1.80	2.30
32	1.68	2.24	1.76	2.11	2.02	1.80	1.90	2.50	2.20	1.90
33	1.91	1.44	1.55	2.31	2.10	1.85	1.60	2.10	2.50	2.10
34	1.51	1.08	1.62	1.77	1.92	1.41	1.20	2.30	1.90	2.00
35	1.89	1.78	1.77	1.67	1.69	1.92	2.40	1.70	1.50	1.60
36	1.61	2.20	1.88	1.47	0.96	1.40	2.10	1.70	1.30	1.50
37	1.66	1.12	0.87	1.73	2.00	1.40	1.20	1.60	2.30	1.60
38	1.51	0.76	0.82	1.30	1.83	1.60	1.20	1.30	1.60	1.60
39	1.12	0.93	1.12	1.34	1.41	1.40	1.63	1.20	1.00	1.30
40	1.57	1.89	1.78	1.18	0.73	1.20	1.70	1.70	1.20	1.10
41	1.26	2.12	1.81	1.43	1.62	0.80	1.20	1.30	2.20	1.30
42	1.26	1.53	1.00	1.68	1.90	1.70	0.90	1.40	1.90	1.30
43	1.26	1.22	1.30	1.47	1.04	1.68	2.40	2.40	1.40	1.70
44	0.00	0.00	1.27	1.49	1.37	1.40	0.92	2.60	2.20	2.40
45	0.00	0.00	0.00	0.93	1.23	0.40	0.00	0.00	0.00	0.00
46	0.00	0.00	0.00	1.15	0.50	0.00	0.00	0.00	0.00	0.00
47	0.00	0.00	0.00	0.76	0.29	0.00	0.00	0.00	0.00	0.00
Total - kg/m^2	**51.5**	**52.0**	**49.6**	**62.2**	**55.9**	**55.3**	**57.0**	**61.8**	**62.5**	**56.0**
% of 2000	**100.0**	**100.9**	**96.3**	**120.8**	**108.6**	**100.0**	**103.1**	**111.6**	**112.9**	**101.2**
G&W % Ave	**97.8**	**93.3**	**86.0**	**109.1**	**109.5**					
Solar radiation										
MJ/m^2			**3329**	**3677**	**3417**	**3466**	**3478**	**3605**	**3808**	**3587**
MJ % 2000	**NA**	**NA**	**103.5**	**114.3**	**106.2**	**100.0**	**100.3**	**104.0**	**109.9**	**103.5**
% 2003 of 2002				**110.5**					**105.6**	
Ratio yield to radiation (g/MJ/m2)			**14.9**	**16.9**	**16.4**	**16.0**	**16.4**	**17.1**	**16.4**	**15.6**

APPENDIX 1 - WEEKLY PRODUCTION (kg/m^2) 2000-2004

SITE B					SITE C					AVERAGE (exc G&W)				
2000	2001	2002	2003	2004	2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.05	0.00	0.07	0.00	0.00
0.20	0.20	0.00	0.00	0.00	0.54	0.02	0.00	0.01	0.00	0.42	0.26	0.07	0.04	0.07
0.50	0.80	0.37	0.00	0.10	0.75	0.30	0.00	0.12	0.00	0.65	0.57	0.30	0.24	0.17
0.60	0.70	0.62	0.10	0.30	0.92	0.67	0.03	0.44	0.00	0.79	0.68	0.42	0.33	0.26
0.70	0.80	0.72	0.50	0.70	0.91	0.95	0.35	0.73	0.20	0.85	0.87	0.56	0.63	0.49
0.90	0.90	1.00	0.70	0.90	1.16	0.98	0.89	0.84	0.60	0.99	0.99	0.93	0.75	0.77
1.15	0.80	1.10	1.10	0.90	1.07	0.95	1.08	1.13	0.95	1.17	0.96	1.03	1.08	0.95
1.22	1.10	1.00	1.50	1.10	1.18	0.99	1.10	1.34	1.00	1.21	1.07	1.00	1.35	1.01
1.47	1.30	1.31	1.50	1.20	1.46	1.25	1.45	1.47	1.43	1.41	1.25	1.35	1.63	1.37
1.78	1.20	1.44	1.30	1.40	1.67	1.65	1.75	1.65	1.90	1.68	1.38	1.63	1.72	1.64
1.95	1.50	1.65	1.60	1.60	1.95	1.68	1.95	2.03	1.73	1.91	1.56	1.90	2.08	1.70
1.67	1.80	2.10	2.10	1.30	1.76	2.16	2.07	2.20	1.77	1.77	1.89	2.36	2.27	1.67
1.48	1.70	2.50	1.70	2.10	1.60	1.83	2.49	2.00	2.36	1.57	1.88	2.63	1.93	2.29
1.98	1.90	1.80	1.90	2.10	1.70	1.99	2.21	2.06	2.17	1.88	2.00	2.04	1.99	2.02
2.01	1.90	1.60	2.40	1.80	1.89	2.03	2.02	2.26	1.76	2.02	1.97	1.77	2.55	1.72
1.89	2.20	2.10	2.00	1.80	2.04	2.51	2.33	2.22	2.00	2.05	2.30	2.11	2.11	1.97
2.30	2.50	2.30	2.10	1.60	2.14	2.50	2.57	2.23	2.80	2.35	2.50	2.42	2.21	2.17
1.60	2.80	2.30	1.90	1.40	2.05	2.45	2.43	2.03	1.76	1.92	2.62	2.44	2.11	1.79
1.40	2.10	1.90	1.80	1.50	1.46	2.20	1.93	1.86	1.80	1.61	2.31	1.94	2.02	1.90
1.80	2.10	1.80	1.80	1.50	1.74	2.41	1.76	2.02	2.06	1.81	2.27	1.85	2.04	1.75
1.86	2.00	2.30	2.60	1.50	2.16	1.77	2.45	2.60	1.86	2.04	1.89	2.45	2.63	1.92
2.03	2.30	1.70	2.10	1.80	2.34	2.19	2.00	2.00	2.07	2.11	2.26	2.00	2.10	2.16
1.41	2.20	2.00	1.80	1.90	2.03	2.56	2.62	1.84	2.30	1.69	2.35	2.41	1.81	2.17
1.42	1.70	2.30	2.20	1.60	1.65	2.32	2.01	2.12	2.00	1.62	1.97	2.27	2.17	1.83
2.09	1.50	1.80	2.10	1.40	2.22	1.62	1.79	2.43	1.67	2.05	1.57	1.90	2.34	1.72
1.47	1.50	1.60	1.70	1.20	1.44	1.48	2.22	1.64	2.02	1.44	1.39	2.04	1.75	1.74
1.33	1.70	1.50	1.50	1.20	1.41	2.03	1.82	1.33	1.67	1.55	2.04	1.67	1.44	1.49
1.40	1.70	2.10	1.20	1.10	1.49	1.72	1.87	1.74	1.47	1.43	1.84	1.89	1.41	1.36
1.54	1.30	1.40	1.20	1.60	1.58	1.32	1.66	1.49	1.86	1.51	1.27	1.55	1.66	1.69
1.25	1.00	1.00	1.30	1.20	1.65	1.13	1.34	1.75	1.74	1.50	1.11	1.21	1.55	1.51
1.10	1.00	1.40	1.20	0.80	1.78	1.83	1.60	1.62	1.36	1.43	1.49	1.40	1.27	1.15
0.87	1.20	1.50	0.70	0.70	0.95	1.76	1.78	1.02	1.04	1.01	1.55	1.66	0.97	0.95
1.14	1.40	1.40	0.80	0.80	1.40	1.35	1.51	1.73	1.21	1.11	1.32	1.40	1.58	1.10
1.04	0.90	0.70	1.40	0.90	1.50	1.10	1.53	2.23	1.86	1.41	0.97	1.21	1.84	1.35
0.79	0.70	0.80	1.00	0.90	1.65	1.34	1.80	1.60	1.58	1.37	1.48	1.67	1.33	1.39
0.70	0.80	1.00	0.80	0.50	0.83	1.82	1.64	1.62	1.52	0.98	1.18	1.75	1.54	1.47
0.24	0.60	0.80	0.90	0.20	0.15	1.10	0.00	0.70	0.85	0.26	0.57	0.27	0.53	0.35
0.14	0.20	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.05	0.07	0.10	0.00	0.08
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48.4	**52.0**	**53.2**	**50.5**	**42.6**	**54.3**	**58.0**	**58.1**	**58.1**	**54.6**	**52.7**	**55.7**	**57.7**	**57.0**	**51.1**
100.0	**107.4**	**109.9**	**104.3**	**88.0**	**100.0**	**106.8**	**107.0**	**107.1**	**100.6**	**100.0**	**105.7**	**109.5**	**108.3**	**97.0**
2898	**3030**	**3052**	**3737**	**3384**	**3389**	**3422**	**3468**	**3730**	**3438**	**3251**	**3310**	**3375**	**3758**	**3470**
100.0	**104.6**	**105.3**	**129.0**	**116.8**	**100.0**	**101.0**	**102.3**	**110.1**	**101.4**	**100.0**	**102.0**	**103.9**	**116.3**	**107.2**
			122.4					**107.6**					**111.4**	
16.7	**17.2**	**17.4**	**13.5**	**12.6**	**16.0**	**16.9**	**16.7**	**15.6**	**15.9**	**16.2**	**16.8**	**17.1**	**15.2**	**14.7**