Sustainable horticulture and poultry farms in South Africa

Jouke Campen
André Aarnink
Jan Broeze

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1 Summary

This report gives a trip report on the visit by Jouke Campen and André Aarnink visited South Africa from 24th of February till 1st of March 2009 as well as the preliminary calculations for the application of solar radiation as a heating source for greenhouses and poultry farms. This project is financed by the Dutch Ministry of Agriculture, Nature and Food quality (BO-10-006-118 Sustainable temperature control system in confined agricultural production)

The goal of the mission was

1. Discuss with stakeholders in the public and private sector in SA on a their view of a more sustainable confined agricultural production.
2. Identify the current status of protected horticulture and poultry farms in SA in terms of fossil fuel use and production levels.

The major outcomes of the mission are:

• Farmers are eager to learn about ways to heat the facilities with other means than coal.
• The climate is ideal for solar energy application

The preliminary calculations using the weather data provided show that the application of solar energy as a heating source in South Africa is economically feasible.
The next step should be to demonstrate the feasibility and to monitor the energy saving potential.
2 Introduction

2.1 South African agriculture

South Africa has a dual agricultural economy, with both well-developed commercial farming and more subsistence-based production in the deep rural areas. Covering 1.2-million square kilometres of land, South Africa is approximately 30 times the size of The Netherlands. The number of inhabitants is approximately 3 times the number of The Netherlands (43 versus 16 million). South Africa has seven climatic regions, from Mediterranean to subtropical to semi-desert. This variety in climatic regions, together with a coastline of 3000 kilometres long and served by seven commercial ports, favours the cultivation of a highly diverse range of marine and agricultural products, from deciduous, citrus and subtropical fruit to grain, wool, cut flowers, livestock and game. Agricultural activities range from intensive crop production and mixed farming in winter rainfall and high summer rainfall areas to cattle ranching in the bushveld and sheep farming in the arid regions. Maize is most widely grown, followed by wheat, oats, sugar cane and sunflowers. While 13% of South Africa's land can be used for crop production, only 22% of this area is high-potential arable land. The most important limiting factor is the availability of water. Rainfall is distributed unevenly across the country, with some areas prone to drought. Almost 50% of South Africa's water is used for agriculture, with about 1.3-million hectares under irrigation. Today, South Africa is not only self-sufficient in virtually all major agricultural products, but is also a net food exporter. Farming remains vitally important to the economy and development of the southern African region. Since the country's first democratic elections in 1994, the government has been working to develop small-scale farming.

(\text{http://www.southafrica.info/business/economy/sectors/agricultural-sector.htm})

The gross income of farmers amounted R 89 billion (1 Rand = 0.08 Euro) in June 2007. The gross income of the agricultural sector, which is derived from field crops, animal production and horticulture activities, has increased since 2006, mainly because of the strong performance of the livestock sector and is projected to grow further. Animal production accounts for more than 40% of the gross income of the agricultural sector.

2.1.1 Exports

South Africa is among the world's top five exporters of avocados, grapefruit, tangerines, plums, pears, table grapes and ostrich products. Farming contributes some 8% to the country's total exports. The largest export groups are wine, citrus, sugar, grapes, maize, fruit juice, wool, and deciduous fruit such as apples, pears, peaches and apricots. Other important export products are avocados, dairy products, flowers, food preparations, hides and skins, meat, non-alcoholic beverages, pineapples, preserved fruit and nuts, sugar, and wines. A number of high-growth niche markets are emerging, such as herbal beverages and luxury seafoods.

During 2006/07, the United Kingdom, The Netherlands, United States, Germany and Mozambique were the five largest trading partners of South Africa in terms of export destinations for agricultural products, with export values of R3 874 million; R3 287 million; R1 431 million; R1 428 million and R1 312 million, respectively.

2.1.2 Competitive advantages

South African agriculture and agribusiness have a number of competitive advantages, making the country both an important trading partner and a viable investment destination.

\textbf{World-class infrastructure}

South Africa has three deep-water ports, three international airports, a network of roads and railways, well-developed cold chain facilities, and a sophisticated financial sector.

\textbf{Counter-seasonality to Europe}

South Africa's counter-seasonality to Europe, the country's primary export market for horticultural and floricultural products, is a major competitive advantage. South Africa is the closest major southern hemisphere producer of horticultural and floricultural products to Europe, and has significantly shorter shipping times than its rivals.
**Biodiversity**
South Africa’s diversity of climates - tropical, subtropical and desert - allows for a vast and varied array of agricultural products.

**Marine resources**
South Africa has almost 3 000 kilometres of coastline which is commercially used both for conventional harvesting and for mariculture and aquaculture.

**Competitive input costs**
While South Africa boasts infrastructure comparable to first-world countries, its cost structures remain highly favourable. Electricity is still relatively inexpensive, and labour rates are also competitive.

**Trade agreements**
South Africa’s agriculture and agribusiness sector are benefiting from increased market access to its key trading partners, the EU and the US, as well as to sub-Saharan countries, through a number of trade agreements.

2.1.3 Deregulation and market freedom
Since the end of apartheid in 1994, South African agriculture has evolved from a highly regulated and protected industry to one free from all constraints, unsubsidised by government and capable of competing with the best in the world. The Marketing of Agricultural Products Act of 1996 dramatically changed agricultural marketing in the country by closing agricultural marketing boards, phasing out certain import and export controls, eliminating subsidies, and introducing import tariffs to protect South African farming from unfair international competition. While a fairly radical process to some old-style producers in South Africa, deregulation has ensured a leaner and stronger agricultural industry, with farmers and agribusiness able to position themselves as players in a globally competitive environment. Phasing out controls and closing marketing boards led to a short-term shortage of essential services formerly provided by the boards and cooperatives, such as storage, grading, deliveries, value adding, information dissemination and research. As a result, specialised marketing support institutions, such as the South African Futures Exchange (Safex) and the Agricultural Futures Market of the JSE, were established to provide much-needed price risk management mechanisms.

2.1.4 Agricultural production areas
About 40% of South Africa’s potato crop is grown in the high-lying areas of the Free State and Mpumalanga. Limpopo, the Eastern, Western and Northern Cape, and the high-lying areas of KwaZulu-Natal are also important production areas. Of the total crop, about 50% is delivered to fresh produce markets and a further 18% processed, with the South African potato processing industry having grown tremendously over the past decade. Potatoes make up about 40% of vegetable farmers’ gross income, with tomatoes, onions, green mealies and sweetcorn contributing about 38%.
Tomatoes are mainly produced in Limpopo, the Mpumalanga Lowveld and Middleveld, the Pongola area of KwaZulu-Natal, the southern parts of the Eastern Cape, and the Western Cape. Onions are grown in Mpumalanga, the Western Cape and the southern Free State. Cabbage production is concentrated in Mpumalanga and the Camperdown and Greytown districts of KwaZulu-Natal.

South Africa’s poultry and pig farms are mainly found near the metropolitan areas of Gauteng, Durban, Pietermaritzburg, Cape Town and Port Elizabeth.
Dutch farmer who grows all kind of flowers. The greenhouses are not heated. The minimum temperature is this region is just above zero degrees. Sometimes temperatures drop below zero harming the crop. The hill located to the North causes the temperature to stay above freezing. The site is in production around 8 months a year. By the application of heating whole year production can be made possible. The profit coming from this additional production is estimated by the grower to be around 80 RAND per square meter. The temperature in the greenhouse should stay above 5 degrees Celsius for this. The site is located just below a small hill. The hill is located to the south making it an ideal location for collection solar energy.
This farm is heated. They produce Kalanchoe. The heat is produced by coal installations. The control is done by Priva. A pad and fan system is used for cooling. The same amount of water is needed for the cooling as for the plants. The specifications of coal are the price are given by this company and attached to this report. This company can provide us with weather data.
This farm has different broiler houses varying in size from 23,000 to 40,000 bird places. The houses are mechanically ventilated with side wall fans. Minimum ventilation is drawn through heat exchange tubes (see picture). This air can be pre-heated by a coal heater. On average for heating 12 to 30 tons of coal are necessary for 130,000 delivered birds per year. Birds are raised for 40 days to a weight of approximately 1.9 kg. The temperature inside the house is gradually lowered from 32 °C at day 0 to 22.6 °C at day 40. According to the farmer the heat distribution inside the house was ok. This is questionable, while the heat exchange tubes have a fast heat transfer. Energy use by coal could be reduced by: 1) better insulation, especially of the inlet valves and ventilator shafts or of the metal roofs (double metal sheets with a layer of air in between); 2) replacing the coal heater by a heat exchanger. In this way the incoming air is heated by the outgoing air; 3) using solar energy collectors.
Cucumber grower
GPS: S 25.498 E 27.710

This grower used gas to heat his greenhouse. He used this option since it is less time consuming to install and the greenhouse had to be finished. The amount of crop per square meter was limited to our idea but the grower set it was optimal since straying was more effective this way. The heaters produces a lot of water vapour which is a problem. The substraat used are wood chips.

Previous farm of Hans van der Arend
GPS: 25.485 27.727
Some small tunnel greenhouses are located at this area. They are used to make seeds.

3.2 26 February 2009

Ministry of Agriculture
Sipho Masinga
Plant production specialist
Phone: +2712319 6287
Email: siphoms@nda.agric.za

Mmaserame Macucwa
Senoir Specialist
Phone: +27 12 319 6518
Email: gloriama@nda.agric.za

Kedibone Chueu
Cell: +27 73 251 3176
Email: KediboneC@nda.agric.za
GPS: 25.737 S 28.206 E
We had a very good discussion with the people of the Ministry of Agriculture. They were very interested in our project and ideas. With respect to animal production they would like to focus not only on energy use, but on emission of other greenhouse gases, mainly methane, as well. Climate change is a big issue for the Ministry, because livestock is a large contributor to greenhouse gas emissions. Worldwide this contribution is estimated to be approximately 20%.

**University North West**
Prof Mbewe
Email: Moses.Mbewe@nwu.ac.za
The university consists of faculties of Animal, Plant and Veterinary Sciences. In this area also a lot of coal is used to heat broiler houses. The size of broiler farms in this area is approximately 10 000 birds. Broiler houses are partly mechanically ventilated and partly naturally ventilated. Layer houses are mainly naturally ventilated.

**ARC meeting**
Dr. T L Nedambale
Cell: +27 79498 7006
Email: Lucky@arc.agric.za
GPS: 25.900 S 28.214 E
We were shown a breeding program on chickens. An important objective of this program is to store a wide variety of chicken genes by breeding different lines of pure bred birds. The houses at the experimental site were all naturally ventilated. Dr. Nedambale could help us contacting researchers in the area of poultry production and horticulture within ARC.

**Hytech Agriculture**
Jaco Boer
Greenhouse builder
Phone: +27 829535689
Email: hytech@lantic.net
S 26.114 E 27.815
Dutchman who recently started his own company. He first worked at a greenhouse builder. He can supply everything related to the installation of a greenhouse.
We met with the whole group dealing with climate change. At first they reverted to the ministry of agriculture for our project. During the conversion they were more interested. Specially on the release of greenhouse gases like methane for farms. In a month a report will be published on the greenhouse gasses released from various sectors.

**University of Pretoria**

Prof Puffy Soundy  
Email: [puffy.soundy@up.ac.za](mailto:puffy.soundy@up.ac.za)  
Cell: +27 82 773 0484

Prof John G Annandale  
Email: [John.annandale@up.ac.za](mailto:John.annandale@up.ac.za)  
Cell: +27 82 374 3706  
GPS: 25.756 28.235  
GPS: 25.751 28.259 E (Experimental site)

Dr. Esté van Marle-Köster  
Senior researcher Poultry Genetics  
She can bring us in contact with other researchers in the field of poultry production at the University of Pretoria.

This university would be a good partner in a project since they have the facilities and connections needed for the project.
This company has 22 ha of greenhouses. They produce chrysanthemums. The annual coal use of the company is 500 ton per hectare. This includes streaming. During winter time 24 men are needed to operate the boiler 24 hours a day. The minimum temperature is set at 16 degrees. The darkening screen is used as an energy screen as well. It is a Ludvig Svensson screen. The cover is cleaned in wintertime every week. During summer the rain cleans the cover. The lower heating system is located between the flowers. The maximum temperature of this system is 38 degrees. The upper system is used when more heat is needed.

The company is very well managed. Their IPM is very advanced. They did a lot of study on biological control. The amount of spin is determined every day by counting based on these results the biological control is applied. The biological control predators are also being counted and monitored.

3.4 Overall summary of the meetings

- We have visited intensive horticulture and poultry farms in SA. These intensive farms will be the focus of our project, while they use considerably more fossil energy per unit product than small scale low-input low-output farms.
- Water seems to be no problem for the farmers since they all have a well or a river in the vicinity of their farm. People from ministry and university stress that it is a problem now and even more in the future. Water is not being charged so for the farmers it is not an issue.
- The burning of coal is the common way to heat greenhouses and poultry farms. Some growers use liquid gas. The burning of coal is becoming more costly and the supply of coal can be insecure. Moreover, the process is labor intensive.
- All of the growers we visited are very interested in alternatives for their heating. The idea of using solar energy has been thought of by them as well but not been put into practice at the moment.
- Governmental agencies have sustainability and food safety high on their agenda. Through the available programs they are willing to invest in new developments. Capacity building should be an important issue in this process.
- Research institutes and universities are doing proper research. They are willing to participate in a new project.
- Climate conditions vary depending on location. Some locations do not have any frost and some have temperatures of minus 8 degrees.
Sustainable production in South Africa

A sustainable alternative for coal can be solar energy. South African climate is ideal for the application of solar energy. First of all, there is a sufficient amount of solar energy also in wintertime (3.5 GJ in the second and third quarter of the year according to measurements by Fides). Secondly, the climate is not very harsh. So by application of insulation the heat needs during cold nights can be kept minimal.

The application of sustainable energy is to be economically feasible for growers. The solar energy concept competes with the traditional way of heating by coal or a way to extend the crop production to wintertime.

4 Opportunities for solar driven heating and optionally cooling for sustainable horticulture and poultry farming in South Africa

The coal installation costs come from the coal itself, the maintenance of the system and the labor needed to operate the system. The coal is priced currently at around 800 RAND per ton.

4.1 Opportunities for solar driven heating and optionally cooling

Solar heat can be used for heating and optionally cooling of e.g. greenhouses and poultry farms. Solar collectors convert solar energy into heat (hot water). Solar collectors absorb the energy of the sun and convert it into usable heat.

Solar collectors

<table>
<thead>
<tr>
<th>Solar collector type</th>
<th>Efficiency η at specified conditions</th>
<th>Net conversion (W/m²) at</th>
<th>Cost per m²</th>
<th>Installed cost per Net kW elec. or thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat Panel: single-glazed (tₗ = 0.86), black paint (αₗ/αₑ = 0.96/0.06)</td>
<td>0.15</td>
<td>0.15</td>
<td>0 @ max.</td>
<td>$616-$740</td>
</tr>
<tr>
<td>Flat Panel: double-glazed (tₗ = 0.79), black paint (αₗ/αₑ = 0.96/0.06)</td>
<td>0.76-4.9(Tᶜₒ ― Tᵣ)/tₗ</td>
<td>0</td>
<td>0</td>
<td>$175</td>
</tr>
<tr>
<td>Flat Panel: single-glazed (tₗ = 0.89), solar-selective (αₗ/αₑ = 0.90/0.20)</td>
<td>0.80-3.8(Tᶜₒ ― Tᵣ)/tₗ</td>
<td>0.162</td>
<td>133</td>
<td>$200</td>
</tr>
<tr>
<td>Flat Panel: double-glazed (tₗ = 0.79), solar-selective (αₗ/αₑ = 0.95/0.15)</td>
<td>0.75-3.4(Tᶜₒ ― Tᵣ)/tₗ</td>
<td>0.179</td>
<td>147</td>
<td>$225</td>
</tr>
<tr>
<td>Evacuated Flat Panel (EFP); etched single-glazed (tₗ = 0.95), solar-selective (αₗ/αₑ = 0.92/0.10)</td>
<td>0.874-1.754(Tᶜₒ ― Tᵣ)/tₗ</td>
<td>0.580</td>
<td>477</td>
<td>$250</td>
</tr>
<tr>
<td>Compound Parabolic Concentrator (CPC); CR = 10, etched single-glazed (tₗ = 0.95), solar-selective (αₗ/αₑ = 0.92/0.10)</td>
<td>0.613-0.381(Tᶜₒ ― Tᵣ)/tₗ</td>
<td>0.549</td>
<td>451</td>
<td>$375</td>
</tr>
</tbody>
</table>

αₑ = 0.60, β = 20°, tₑₑ = 0.2, qₑ = 822 W/m².

* Costs of additional PV needed for HVAC added onto 3 kW array for non-HVAC usage.

** Equals retail price plus estimated installation cost of $50/m².
Table 1 gives an overview of efficiency and costs of modern solar collectors (for “house-owner scales”; for large-scale applications some discount is expected).

Heat production by solar panels will depend on:
- solar panel type
- collector or setpoint temperature (closely related with the chosen thermal chiller system)
- actual solar radiation (influenced by solar angle and weather conditions).
- hot-water buffer size and isolation.

![Figure 1](image)

**Figure 1.** Efficiency of various solar collector types with solar radiation of 800 W/m². Source: Alois Stork, Munchen

![Figure 2](image)

**Figure 2.** Figure 1. Dependency of solar collector efficiency for solar radiation intensity (flat plate collector). Source: www.apricus.com

**Literature and further info**


### 4.2 The application of solar energy on greenhouses

The annual radiation is around 7.5GJ which is twice the amount of solar radiation in The Netherlands. Due to the clear skies in winter the amount of solar radiation is still 90% of that in the summer.

Solar radiation can be collected relatively easy and stored into the form of heat using water. The most simple way is by placing a black plastic pipe in the sun and letting water run through it. The system can be made
more effective by placing a transparent cover over these pipes insulating the system. The efficiency of the system is expressed by the amount of solar radiation collected. Well insulated solar collectors can have an efficiency up to 80% (figure 1). The efficiency depends on one side on the insulation and transmissivity of the system and on the other hand on the temperature level of the outgoing water. If the temperature level is to be around 80 degrees more losses can be expected than at 40 degrees. The wanted temperature depends on the application of the warm water. The size of the heat storage tank decreases with increasing water temperature.

Figure 2 shows the energy use for heating for a greenhouse with and without an energy screen. (K value of 8 W/m2K or 4 W/m2K) for as a function of the temperature difference between the greenhouse air and the average night time temperature. For example is the greenhouse temperature is set to be 20 degrees and the average outside temperature is 10 degrees the energy use by the heating system is 1.8 MJ for that day if a thermal screen is applied. Based on a yearround simulation the size of the heat storage tank can determined. Losses on transporation of heat should be minimized by good insulation of the transport pipes and by storing the heat close to the greenhouse.

Figure 3. Energy needed for heating as a function of the temperature difference between the greenhouse air and the average night time temperature for a greenhouse with and without a screen.

Figure 3 shows the energy use for heating as a function of the temperature difference between the greenhouse air and the average night time temperature. For example is the greenhouse temperature is set to be 20 degrees and the average outside temperature is 10 degrees the energy use by the heating system is 1.8 MJ for that day if a thermal screen is applied. Based on a yearround simulation the size of the heat storage tank can determined. Losses on transporation of heat should be minimized by good insulation of the transport pipes and by storing the heat close to the greenhouse.
Figure 4. The radiation over the year 2007 and 2008.

The figure above shows the radiation near Krugersdorp over a two year period. The annual radiation is this area is 6.9 GJ/m².

Figure 5. Average and minimum temperature over a two year period

Based on the radiation information and the temperature the size of the solar collector and the heat storage can be determined in more detail. The amount of heat collected over the year is based on the daily radiation, the size of the collector and the efficiency of the collector. The amount of heat which can be stored depends on the size of the daily heat storage and the maximum temperature at which it is stored. For the calculation this maximum temperature is set to be 70°C. The size of the heat storage is set to be 100 m³ per hectare of greenhouse which is common in the Netherlands. The efficiency of the solar collector is set to be 60% for this temperature which is normal for a low tech solar collector as shown in the previous
paragraph. The heat losses from the greenhouse depend on the minimum temperature maintained in the greenhouse and the heat transfer coefficient. The minimum temperature in the greenhouse is set to be 16°C.

\[ \text{Size of solar collector [m}^2\text{m}^{-2}\text{]} \]

**Figure 6.** Hours per year the solar collector system does not supply a sufficient amount of heat as a function of the size of the solar collector for different heat transfer values of the greenhouse.

The figure above shows the amount of hours annually the system can not provide enough heat to keep the temperature in the greenhouse above 16°C as a function of the size of the solar collector. The size of the solar collector is related to the size of area of greenhouse. So when the size of the solar collector is only 10% of the area of the greenhouse 110 hours of the year the system can not provide enough heat when the heat transfer coefficient of the greenhouse is 4 W m\(^{-2}\) K\(^{-1}\). The heat transfer coefficient of a greenhouse depends of the covering material and the application of a thermal screen. A glass greenhouse of a plastic greenhouse with IR treatment has a heat transfer of around 8 W m\(^{-2}\) K\(^{-1}\). If a thermal screen is applied the heat transfer is reduced to around 4 W m\(^{-2}\) K\(^{-1}\). So a well insulated greenhouse can depend completely on solar energy by installing solar collectors covering 40% of the greenhouse area.

An economic evaluation of the application of solar panels in greenhouse horticulture is made.

**Table 2.** Estimates of the solar panel costs per MJ for different panel types

<table>
<thead>
<tr>
<th>Collector type</th>
<th>net conversion</th>
<th>heat collected per m(^2) per day</th>
<th>panel cost per m(^2)</th>
<th>area needed per MJ/day</th>
<th>system cost per MJ/day</th>
<th>annual capital costs per MJ (used 100 days/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat panel, single-glazed</td>
<td>68 W/m(^2)</td>
<td>1.7 MJ/m(^2)</td>
<td>$175</td>
<td>0.58 m(^2)</td>
<td>$102</td>
<td>$11.93</td>
</tr>
<tr>
<td>Flat panel, double-glazed</td>
<td>211 W/m(^2)</td>
<td>5.3 MJ/m(^2)</td>
<td>$200</td>
<td>0.19 m(^2)</td>
<td>$38</td>
<td>$4.39</td>
</tr>
<tr>
<td>Flat panel, single-gl, solar-select</td>
<td>290 W/m(^2)</td>
<td>7.3 MJ/m(^2)</td>
<td>$200</td>
<td>0.14 m(^2)</td>
<td>$27</td>
<td>$3.20</td>
</tr>
<tr>
<td>Flat panel, double-gl, solar-select</td>
<td>280 W/m(^2)</td>
<td>7.1 MJ/m(^2)</td>
<td>$225</td>
<td>0.14 m(^2)</td>
<td>$32</td>
<td>$3.73</td>
</tr>
<tr>
<td>Evacuated flat plate, single glas</td>
<td>437 W/m(^2)</td>
<td>11.0 MJ/m(^2)</td>
<td>$250</td>
<td>0.09 m(^2)</td>
<td>$23</td>
<td>$2.65</td>
</tr>
<tr>
<td>Compound parabolic concentrata</td>
<td>349 W/m(^2)</td>
<td>8.8 MJ/m(^2)</td>
<td>$375</td>
<td>0.11 m(^2)</td>
<td>$43</td>
<td>$4.99</td>
</tr>
</tbody>
</table>

These calculations are based on write-off period of 15 years and interest rate of 8%. Note that additional costs for ground, buffers and installation are not included.

Coal costs 0.03 Rand per MJ (annex 1), which is far below the listed costs of solar heat, but the operational and investment costs are not considered in this case. Including these costs and the fact that the price of coal is going to be higher in the near future, we are convinced that with smart solutions, solar heat can be a sustainable and feasible alternative. In Kenya a project using solar energy for heating greenhouses has been applied successfully as can be written in annex 2.
4.3 Solar heat in broiler production

Starting points for calculations:
- Growing period broilers: 6 weeks
- Temperature requirement (with linear interpolation between set points):
  - Day 1: 32°C
  - Day 7: 26°C
  - Day 14: 25°C
  - Day 21: 22.6°C
  - Day 21 – day 42: 22.6°C
- Present heat use poultry farm: 400 MJ/m² per year
- 20 broilers per m²
- Broiler house of 1000 m²
- Efficiency solar collector: 50%
- Storage period solar energy: 1 day

![Figure 7. Average heat requirement per day for each month of the year for a house with 20,000 broilers and the average heat production from solar panels of 100 and 200 m².](image)

![Figure 8. Average heat requirement per day for each month of the year for an optimal insulated and climate controlled house for 20,000 broilers and the average heat production from solar panels of 100 and 200 m².](image)

In figure 8 the average daily heat requirement is given for each month of the year. In this figure the heat produced by solar panels of 100 and 200 m², respectively 10 and 20% of the floor area of the broiler house, is given, as well. This figure shows that there is a big variation in the heat required during the year. In 10 of the 12 month a solar panel area of 200 m² seems to be sufficient to deliver the required heat. Only in the
winter months June and July a lot more heat is required. In this broiler house the heat required per year is approximately 400 MJ/m². This was the situation for the visited broiler farm in the area of Rustenburg. When the broiler house would have been optimally insulated and optimal climate controlled, then the heat requirement would reduce to approximately 135 MJ/m² (figure 9). Important points for improvement to reduce the energy requirement are a well insulated roof and a well controlled minimum ventilation. Furthermore, for broilers older than 3 weeks the set point temperature could be lowered.

![Figure 9](image.png)

**Figure 9.** Number of days extra heating is required. Red line: situation broiler house Rustenburg area; Green line: for an optimal insulated and climate controlled broiler house.

Figure 10 shows the number of days extra heating is required during the year. The number of days extra heating is required can be reduced by storing the solar energy for a number of days and/or by increasing the size of the solar panels. For the optimal situation a solar panel area of 200 m² would be sufficient to heat the animal house during the whole year. For the present situation in the broiler house in Rustenburg area a solar panel area of approximately 700 m² would be necessary to heat the broiler house with 20,000 broilers during the whole year. It should be calculated, however, what the optimal size is of the solar panel, in relation to the extra costs of an extended solar panel and the energy saved by this extended area.

The solar panels could be installed on top of the roof of the broiler house. For new buildings the solar panels could also be integrated in the roof itself.

### 4.4 Water usage

The pad and fan system uses water for cooling. By evaporative cooling the greenhouse air is cooled. This method uses a substantial amount of water. Growers estimate that the water use by the pad and fan system is equal to the water use of the plants. Moreover the fans are operated by electrical power and are in operation almost yearround. There is no sustainable method available to replace this pad and fan system. Only by air conditioning the cooling can be done but this costs a tremendous amount of electrical energy. The only way to reduce the application of the pad and fan system is by reducing the amount of solar radiation entering the greenhouse. New techniques in this area are being developed where part of the solar radiation not contributing to the plant production is being reflected. The application of the new technique will not be successful if growers do not have to pay for their water.
5 Conclusions and the way forward

Main conclusions
- Growers are willing to use an alternative for the coal burning for heating.
- Governmental organizations are willing to participate in a project with the goal to make horticulture and poultry farming more sustainable.
- Simple calculations show that the potential of solar energy as an alternative for heating is realistic.

Figure 10. Artist impression of the research and demonstration center

Way forward
The concept of using solar energy has to be proven in practice. The saying “Seeing is believing” applies when new technologies are introduced. Though this is not a new technology as soon in the previous section, users what to see this technology working in their vicinity. Farmers want to be convinced the alternative heat source can be applied. For this reason a demonstration project has to be set up where the principle of using solar energy as a source for heating is demonstrated. The ultimate goal of the project is to make South African agriculture more sustainable

Subjects presented at the centre are:
- Using solar energy for heating
- Water use efficiency “More crop per drop”
- Application of covering materials

Concrete results from the project:
- Demonstration of sustainable heating system
- Training trainers to disseminate the knowledge to other farm managers and workers.
- To exchange best practices at farm level.
- To enhance the collaboration between government, universities and research institutes aiming at a shared focus and a higher performance of the sector.
Annex 1 Coal information by Fides

DATE: 24 February 2009

TO: Sapropa
ATT: Henk
RE: Coal Supply Quotation

With reference to our recent discussions, CMS has pleasure in forwarding an offer for the supply of coal for delivery as detailed below.

Introduction

CMS Coal Marketing Services is a national distributor of coal, including neighbouring states. We have sound relationships with both large and small coal producers, plus exclusive marketing agreements with some producers which ensures quality conformity and consistency of supply. CMS has an alliance with some of the largest road transporters in the coal industry, which allows for excellent transport rates and timeous deliveries. Our years of experience in the coal industry coupled with our policy to supply selected reputable consumers only, ensures a high level focussed service.

Pricing and Specification

<table>
<thead>
<tr>
<th>Element</th>
<th>Peas ex Twistdraal</th>
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<tr>
<td>Calorific Value</td>
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<tr>
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<tr>
<td>Volatiles</td>
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<td>Inherent H20</td>
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<td>Fixed Carbon</td>
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<tr>
<td>Delivered Price</td>
<td>R765.00 per ton</td>
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</tbody>
</table>
Annex 2 Project in Kenya

Source: Flowertech 2009, vol 12, nr 5

Greenhouse heating with free-of-charge energy

Climate control