STATE OF ISRAEL
Ministry of Agriculture and Rural Development
Extension Service
Mechanization & technology Dpt.

Tracking energy saving and Greenhouse climate while using Agam's VLHC system

Eng. Ronny Amir, Manager of Mechanization & Technology Department, Extension service, Ministrey of agriculture, Israel

Brief

In the past, systems, developed by the engineer Gad Assaf, for water absorption from the air and drying the air, based on the principle of absorbing desiccant, were installed in greenhouses in Israel.

Due to financial reasons of cost vs. benefits, as well as some technical problems, the systems were abandoned.

Lately Agam has developed a new, more progressive, system, operating on a similar principle of a desiccant absorbing water vapor from the air, which I saw fit to test.

Together with absorption of the humidity, the system also reduces the humidity in the greenhouse during the night and, by this adiabatic process, reduces greenhouse's energy demands thus contributing to energy saving.

I have kept track of such system, installed in a greenhouse, owned by "Danziger Nurseries", in Mishmar Hashiv'a. It was established that the system saves about 40% of the energy, when combined with a heating system. In addition to that, there also was a reduction in the Relative Humidity as well a state of non-condensation of water which allowed earlier working hours and less greenhouse diseases.

When a thermo screen was installed, energy saving can reach 70% and removal of about 120 liters of water/night.

Introduction and problem description

Increasing energy costs brought about the need and feasibility for implementation of energy-saving systems. Such is Agam's heating system.

Agam's unit takes in humid air from inside the greenhouse, blowing it through a matrix of a very concentrated desiccant. Water vapor is drawn into a condensing device, which releases the latent heat from the humid air into the desiccant. In this process, vapor condensation naturally warms up the desiccant, and this heat is released by the unit into the greenhouse as warm, dry air.

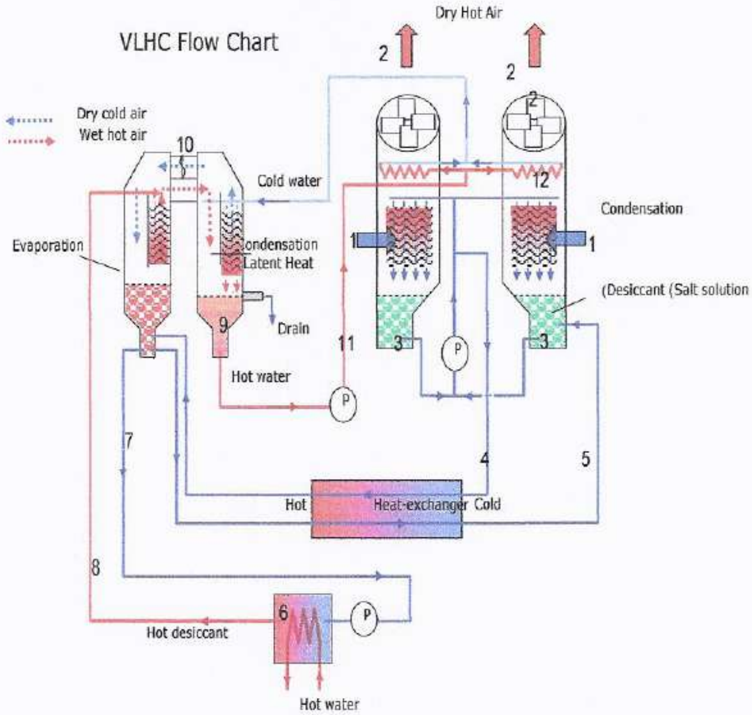
See the Ventilated Latent Heat Convertor's (VLHC) operational scheme in drawing no.1.

The system receives its energy supply out of the electricity system, as well as the heating system located in the greenhouse.

Heating system must supply hot water at a temperature of 85^0 C, at capacity of 5 M3/h and at a pressure of 10 M head of water. Electrical current of 20A.

STATE OF ISRAEL
Ministry of Agriculture and Rural
Development
Extension Service
Mechanization & technology Dpt.

Description of Agam's system - Ventilated Latent Heat Convertor (VLHC):



Drawing no.1: Scheme of Dehumidification system produced by Agam

The system is placed on a concrete surface, in the greenhouse, close to one of the walls, in order to extract the water from the greenhouse.

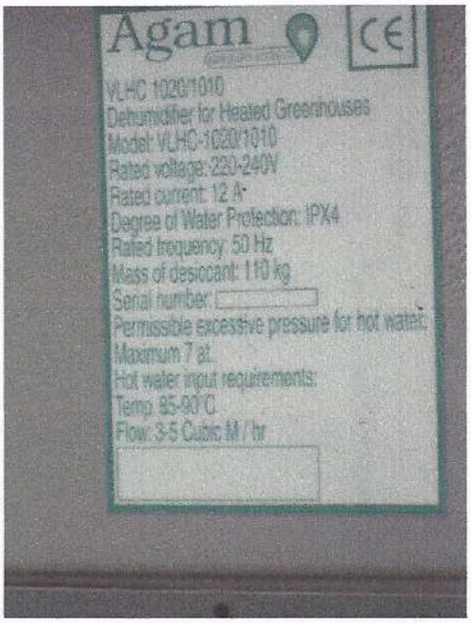
See drawing no. 5. This system, which deals with the issue of humidity in the structure as well as saving energy on heating, distributes the heat through blowers that are an integral part of the drying device (and not through heat exchangers, distributing the heat through radiation, as customary in hot water systems). The blowers deliver warm, dry air into the greenhouse, thus succeeding to also dry the inner surface of greenhouse cover.

The inner surface condenses a layer of water, especially during the night, due to big temperature difference between the warm inside to the outer surface being in contact with cold ambient air. This layer is one of the main reasons to heat loss, since it causes excellent heat transfer from the inside to the outside, and therefore energy loss.

Reduction of humidity in this layer, caused by Agam's system, is one of the factors assisting energy saving. The system functioned with no technical mishaps throughout the entire experiment.

To optimize the system's functioning, the greenhouse has to be sealed as well as possible and also isolated during the night with a well-sealed, reflective, thermo screen.

The system requires hot water at a constant temperature of 85 degrees C, approximately 40,000 KK (4 M3/h).



Picture no.2: Agam's system in a 1,000 m2 greenhouse

Picture no.3: Specifications of Agam's system in the greenhouse

Goals of the research

Testing heating methods, which will enable energy saving through combined systems, allowing improvement of growing conditions through heating and reduction of Relative Humidity in agricultural habitats, and comparing them to conventional methods that are being used today.

Methods & Materials

Location: The test was conducted at Danziger "Dan" flower farm in the area of the Beit Dagn junction.

Greenhouse: An "Azrom" greenhouse approx. 1,000 M2. See picture no. 4. In the greenhouse pots of mother plants are being grown on tables.

Picture No.4: Tested greenhouse

Heating system in the greenhouse

Hot water heating system from a central heating system – heating stove with capacity of 1,500,000 kkl/h, including heat exchangers of metal leaved pipes in which hot water flows. Pipes placed under the tables for heat distribution. Oven is operated with fuel oil. See picture no.5.

The rate of water flow is set according to temperature demand in the greenhouse. Usually the temperature during the night is 18^0 Celsius.

The agricultural habitat is covered by IR plastic and surrounded by 50 mesh curtains. Greenhouse is equipped by Thermo screen only. Screen is made of a blank reflective sheet which casting 50% shade.

Picture no.5: hot water pipe system under the tables for heat distribution

Measuring system and technique

During the experiment a manual testing of temperature and humidity was taken once a week.

The test:

The greenhouse was equipped with a measuring system for temperature, humidity, fuel (energy) consumption' quality parameter.

Measuring system:

- Water flow meter (detecting no. of pulses per 1/2 h , in 10 Liter units).
- External air temperature and humidity meter.
- Air temperature and humidity meter in the greenhouse.
- Data logger with thermocouple for measuring temperature of hot water pipe inflow to the greenhouse and temperature of hot water pipe outflow from the greenhouse. Based on measurement data, the specific energy was calculated.

Testing technique:

Some of the days the greenhouse was heated by Agam's VLHC whereas on other days it was heated by the conventional hot water heating system. This was done randomly. Quantity of water extracted by the system during the night was sample-measured on a few days.

Regimen of partial activation, which was taken into account in the surveillance, is presented in table no.1

STATE OF ISRAEL
Ministry of Agriculture and Rural Development
Extension Service
Mechanization & technology Dpt.

Table no.1: the days on which the different heating regimens were activated

Date	Day	Done	planned
11/02/2010	Thursday	Dehumidifier	
12/02/2010	Friday	Regular heating	
13/02/2010	Saturday	Dehumidifier	
14/02/2010	Sunday	Dehumidifier	
15/02/2010	Monday	Dehumidifier	
16/02/2010	Tuesday	Dehumidifier	
17/02/2010	Wednesday	Dehumidifier	
18/02/2010	Thursday	Regular heating	
19/02/2010	Friday	Regular heating	
20/02/2010	Saturday	Regular heating	
21/02/2010	Sunday	Dehumidifier	
22/02/2010	Monday	Dehumidifier	
23/02/2010	Tuesday	Regular heating	
24/02/2010	Wednesday	Regular heating	
25/02/2010	Thursday	Dehumidifier	
26/02/2010	Friday	Dehumidifier	
27/02/2010	Saturday	Dehumidifier-mishap	
28/02/2010	Sunday	Dehumidifier-mishap	
01/03/2010	Monday	Regular heating + Dehumidifier	
02/03/2010	Tuesday	Regular heating + Dehumidifier	
03/03/2010	Wednesday	Dehumidifier	
04/03/2010	Thursday		Dehumidifier
05/03/2010	Friday		Regular heating
06/03/2010	Saturday		Regular heating
07/03/2010	Sunday		Dehumidifier
08/03/2010	Monday		Dehumidifier
09/03/2010	Tuesday		Dehumidifier

From the table one can see that the test was conducted during the second half of February and during a few days of March. The number of days was small due to warm weather conditions.

During the last year, upon which the test was conducted, the greenhouse itself was not sealed although it is equipped with a thermo screen.

Also, the water transfer to Agam's system is long and not insulated, a fact that reduces the system's efficiency in terms of saving (the heat in the pipe isn't lost but it reduces Agam's

system's advantages by far since, in practice, Agam's system is activated together with the regular heating system) – this affect grows when outside temperature is close to greenhouse temperature.
All in all 9 days of proper tests were conducted, out of which 5 were with regular heating and 4 with Agam's system.
The last tests were done when, following my request, it was insisted upon a closed greenhouse – these tests created a more realistic condition.

The temperatures of water for Agam's system, coming in and out of the pipes, arriving from the central system, were at an average of 80^0C coming in and 70^0C coming out. The difference in temperature is an acceptable datum, but inlet water temperature of 80^0C is a bit lower than required for the dehumidifying system and could somewhat disrupt it's performances.

Results & Discussion

Quantity of water extracted by the system was about 110 – 120 Liters/night.

Following an engineering analysis of greenhouse energy consumption- I have summarized the results in table no. 2.

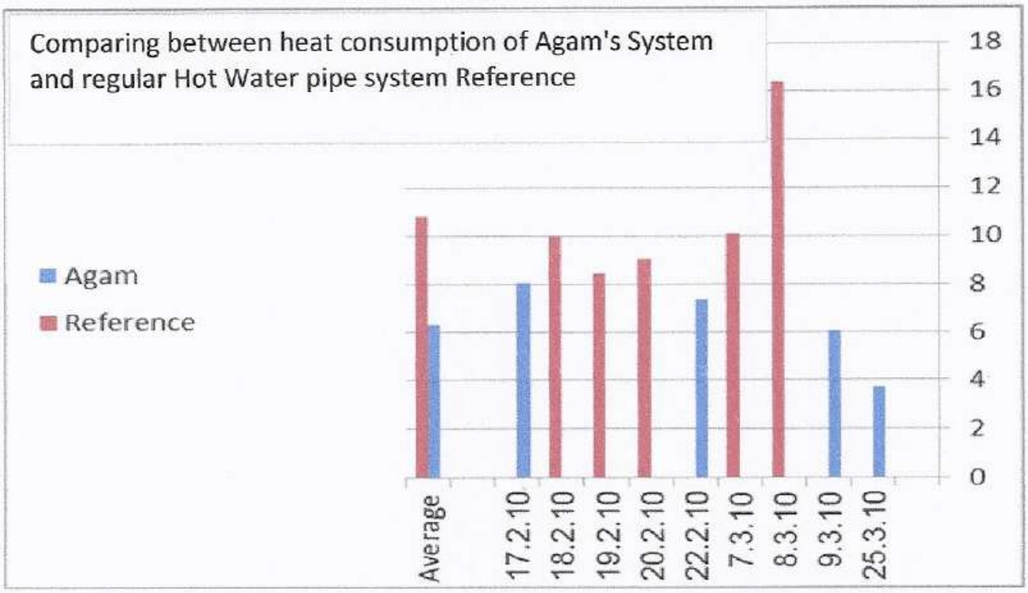
Table no. 2: Comparison of energy consumption using the different methods
Comparison of energy consumption **w/m^2*C**

Date	Agam	Regular
25.3.10	3.74	
9.3.10	6.08	
8.3.10		16.38
7.3.10		10.09
22.2.10	7.42	
20.2.10		9.05
19.2.10		8.47
18.2.10		9.93
17.2.10	8.12	
Average	6.34	10.784

Agam's system has helped drying the humidity in the greenhouse as can be seen in the graphs. Until 2:00 AM, Agam's system reduces the humidity by 6 to 7% and expels the possibility of wet plants by distancing from the Dew point, which is highly significant because free water on the plant is a catalyst of increased-wetness caused diseases.

STATE OF ISRAEL
Ministry of Agriculture and Rural Development
Extension Service
Mechanization & technology Dpt.

Graph no. 1: Energy consumption data in regular heating versus heating with Agam's system



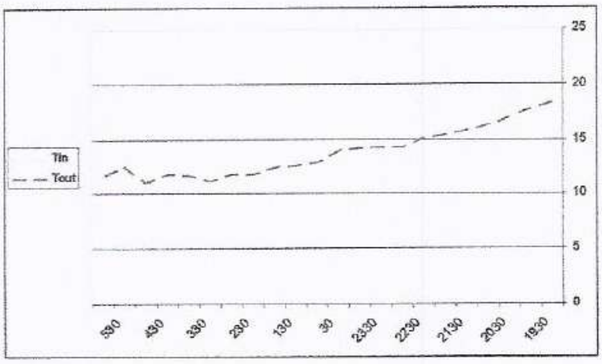
Agam's system deals with greenhouse humid air - it dries it while absorbing the energy, and returns it into the greenhouse warm and dry, abolishing the necessity to open the greenhouse and expose it to external air, this saves about 70% of the energy invested in a greenhouse equipped with a thermo screen.

Agam's system has reached energetic saving of about 40% average compared with a parallel heating system which uses hot water to heat the greenhouse. Both systems used a thermo screen system.

The Relative humidity in the structure heated by Agam's system is lower than the Relative humidity in the structure heated by the conventional hot water system. In the test the difference reached as much as 10% (82% - 92%) and this difference will grow as the insulation of the greenhouse is improved.

Outside air temperatures, during most nights, ranged between 8.5^{0}C and 11^{0}C but there were nights where temperature reached 15^{0}C and then there was almost no heating. See temperatures during a sample night on Graph no.2.

Graph no.2: Night temperatures inside and out of the greenhouse



When comparing the best result in both cases, the saving of Agam's system is: 56%
Whereas if one takes the worst result in both cases, saving is: 50%.
There is no doubt that the cost of Agam's system per 1,000 m2 in greenhouses that consume about 15,000 liters fuel/year and more, and in which value of merchandise/fruit is as expensive as is in greenhouses, the system is worthwhile and will contribute also in the aspects of plant protection and work quality.
It is suggested that the heating systems will be tested during another season in order to characterize heat and humidity dispersing in the different methods as well as the insulation of the greenhouse and the thermo screen.

Summary
Use of Agam's system resulted in average saving of 40% of the energy consumed for reducing humidity during the night and in the morning.

Gratitude
I am thankful to Mr. Sha'har, an agronomist at Danziger greenhouses, who took on the task of testing and related to every request.

Ronny Amir, M.Sc.
Head Department of Mechanization and Technology
Ministry of Agriculture
Extension Service, P.O. Box 28
Bet Dagan 50250, Israel
Mobile: 972-50-6241428
romir@shaham.moag.gov.il