SOLAR
INFRA SYSTEMS

SOLAR AIR HEATERS

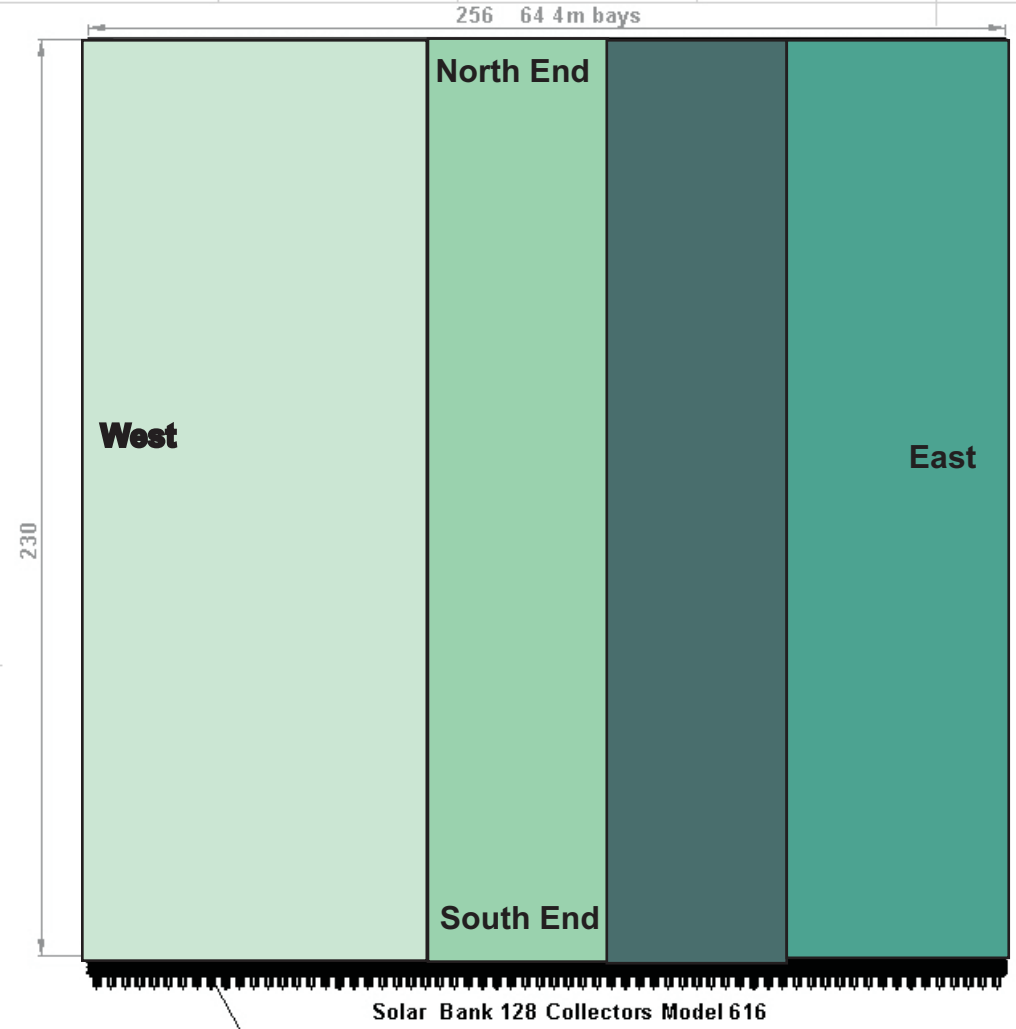
Solar Thermal for Greenhouses

SOLAR THERMAL AIR SYSTEM FOR GREENHOUSES TO SUPPLY HEATING, COOLING AND CARBON DIOXIDE

Features

1. Modular system assembly. Installation with minimum interference in the greenhouse growing cycle.
2. Provides different air flows and air temperatures to parts of the greenhouse to adjust separate growing cycles.
3. Supplies carbon dioxide growth requirements from fresh air. Reduces flue gas and supplier co2 requirements.
4. Recirculates solar heated air for destratification and co2 from fresh outside air. Destratification lowers high heat losses through the roof.
5. System used for summer bypass cooling. Used to dump greenhouse hot water storage tank heat build-up.
6. Recirculation for humidity control to prevent high humidity pockets.
7. Can lower greenhouse energy costs 40-60%.

Solar Infra Systems Int Ltd
209 19138 26th Avenue
Surrey BC, Canada V3S 3V5
t 604 535 2056 f604 535 0681



Blocks of Bay Modules can be run at different temperatures and air flows with plastic curtains.

Solar Thermal System for Greenhouse air heating and Carbon Dioxide Supply

Solar Thermal Air heating bank module (See Sh2 pg2) is mounted on the south end of each Greenhouse bay.

Each bay has a transparent distribution duct located in the roof apex that runs the length of the bay. The cooler solar air flow reduces the stratified temperature at the roof and lowers the roof heat loss. (See page 6)

In this layout, there are 64 bays with 128 solar air/water collectors, with separate bay computer monitor and control on fan speed for air flow and water temperature for heating the air on low solar radiation periods (hot water from the greenhouse storage tank is pumped through the solar collector tubing).

In operation,in each greenhouse bay, the solar module distribution fan (Sh2 pg2) draws air through the solar thermal bank and supplies solar heated air at the Greenhouse operating temperature (20°C). (See Diagrams 1 to 2 pg 7-8). Green house air can also be recirculated through the solar bank to mix with fresh air and conserve the carbon dioxide content.

Air flow is designed to change the air in each module 1/hr and supply 390 ppm CO_2 per hour to supplement flue-gas and liquid CO_2 production. Operating CO_2 level is 1500 ppm.

The solar bank is also set up to pump cooler night or day air to lower temperatures in the greenhouse by bypassing the collector bank. (See Diagram 3 pg9).

The tubing in the solar collectors can also be used to dump heat from the greenhouse storage tank that builds up during the summer flue gas manufacture of CO_2 with the greenhouse boilers. The storage tank hot water is pumped through the solar collector tubing and cooled by pumping night air through the solar collectors and exhausting to atmosphere. (See Diagram 4 pg10).

The solar system can also be used as an air recirculation system to control high humidty-disease build ups. (See Diagram 5 pg 11)

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CHKD				
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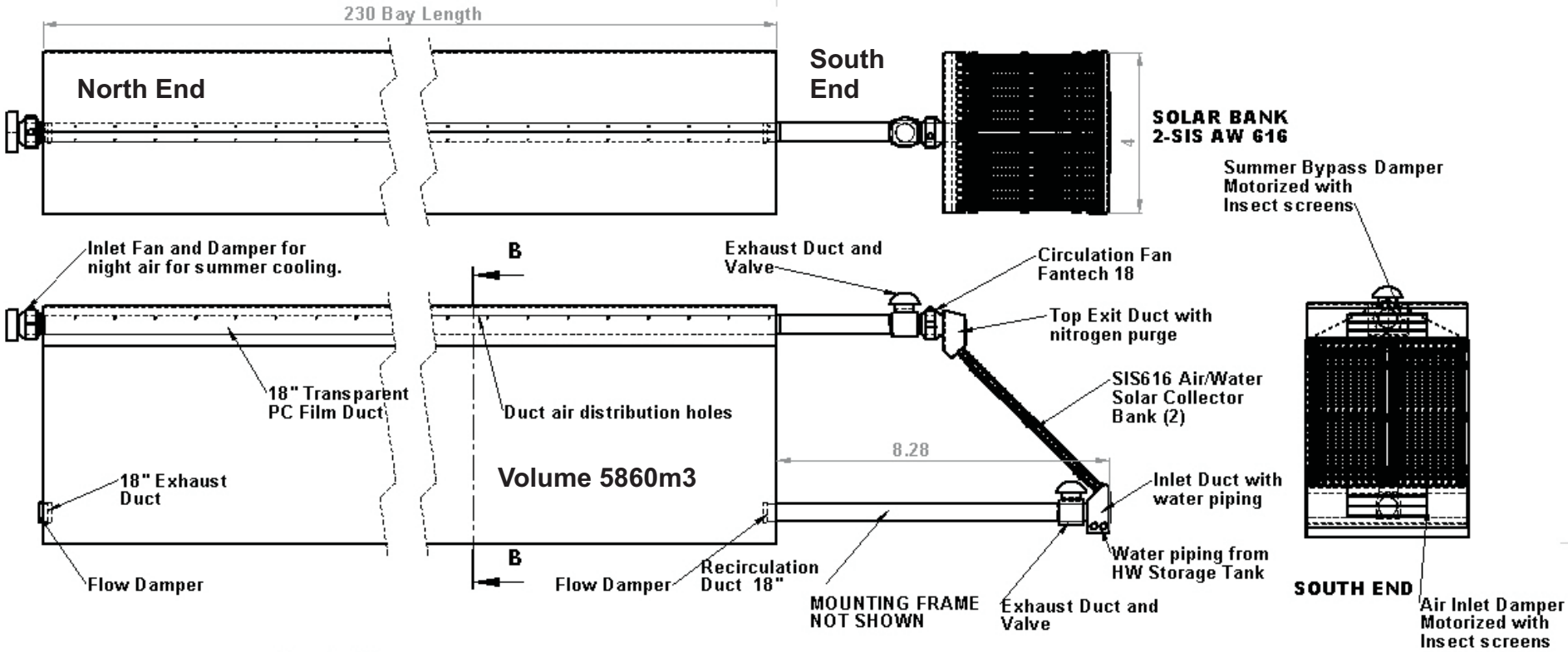
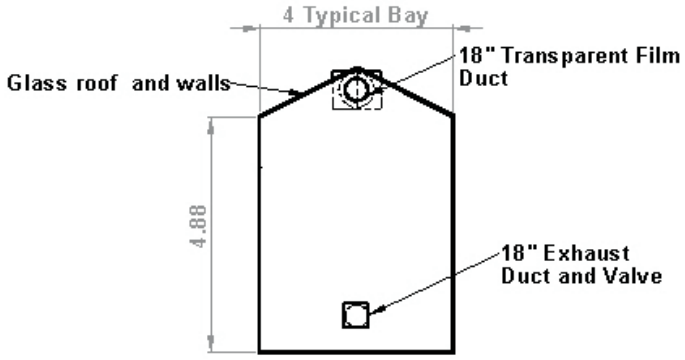
SIS SOLAR THERMAL HEATER
Windset Farms Greenhouse

Greenhouse Assembly SH1

A3





SECTION B-B
SCALE 1 : 100

All exterior ducting and piping
insulated
All air inlets with filter screens

The solar module is moved away from the south end of the greenhouse to reduce solar shading (See pg 3). The collectors can be inclined lower to move closer to the south wall if required.

DO NOT SCALE DRAWING

Solar-Infra Systems Int Ltd

3/12/2014

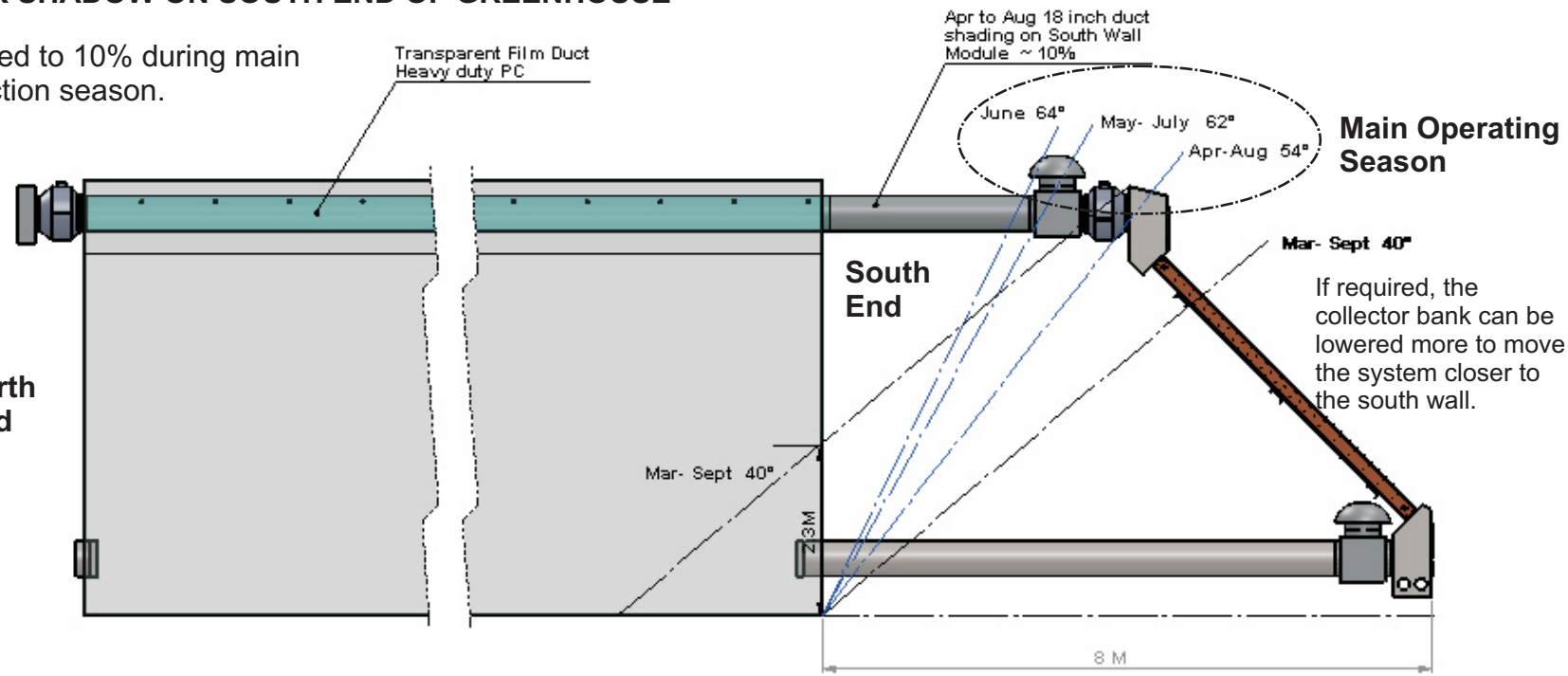
SIS SOLAR THERMAL HEATER
windset Farms Greenhouse Bay
SOLAR MODULE DETAIL

Greenhouse Solar Bay Detail VER2 SH2

A3

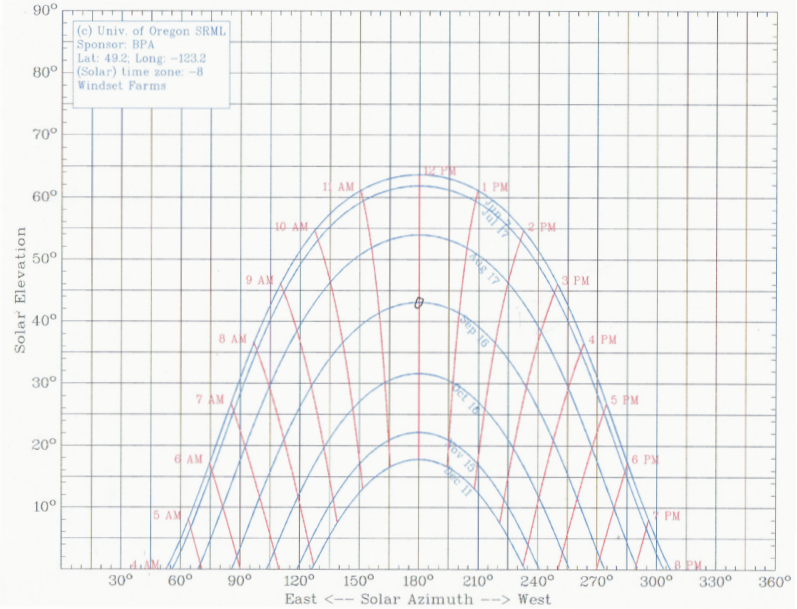
SOLAR SHADOW ON SOUTH END OF GREENHOUSE

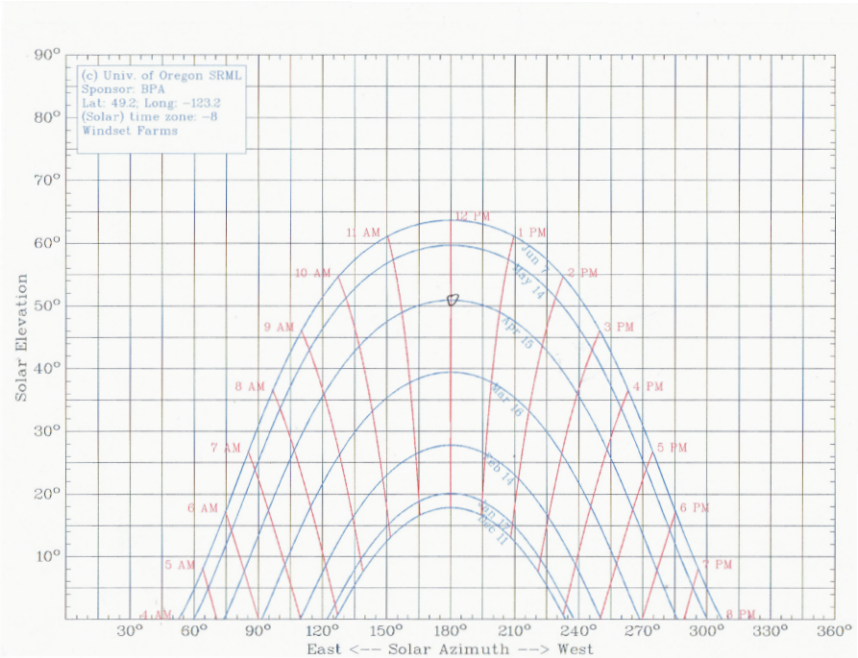
Reduced to 10% during main production season.



If required, the collector bank can be lowered more to move the system closer to the south wall.

SOLAR SUN PATH FOR SITE





Solar Module Description

Each solar module consists of two solar thermal air/water heaters connected in parallel to an inlet duct and outlet duct.

In operation, the bottom inlet duct damper is opened to outside fresh air and the circulation fan on the outlet duct pulls the fresh air through the collectors and distributes the solar heated air through a transparent distribution duct running along the roof of the greenhouse bay.

There is piping in the bottom inlet duct that connects each solar collector water flow tubing to the greenhouse storage hotwater tank. This hot water supply and return piping connects all solar units to the storage tank system in a parallel circuit.

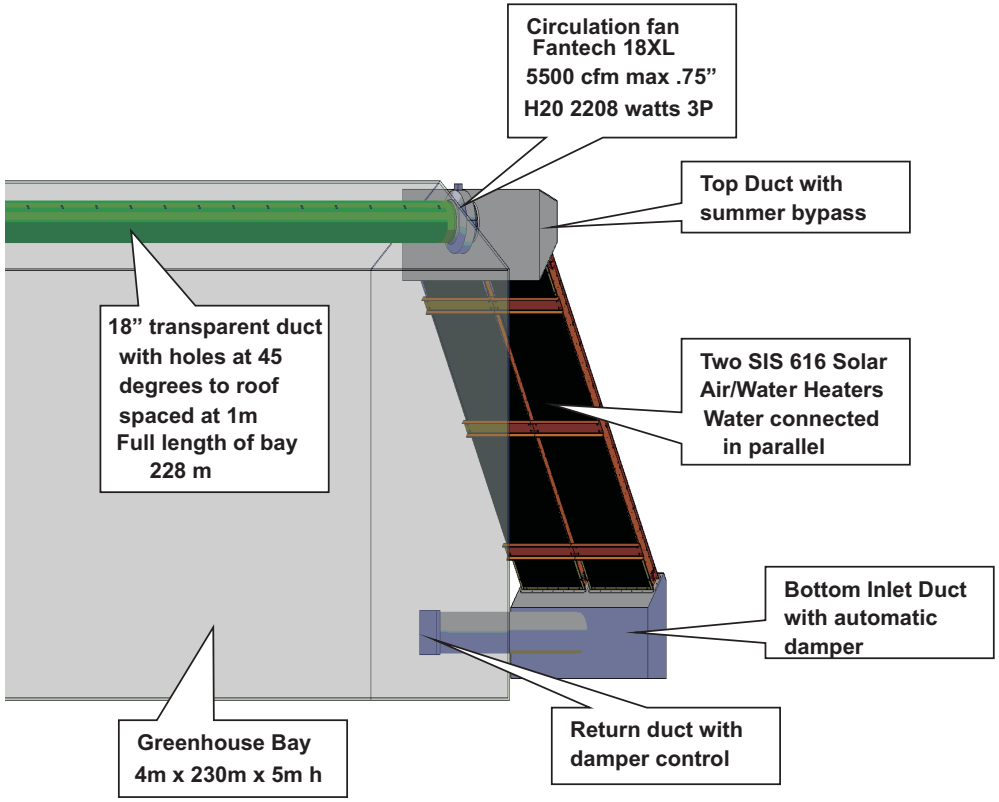
Each collector has 300 ft of corrugated stainless steel tubing.

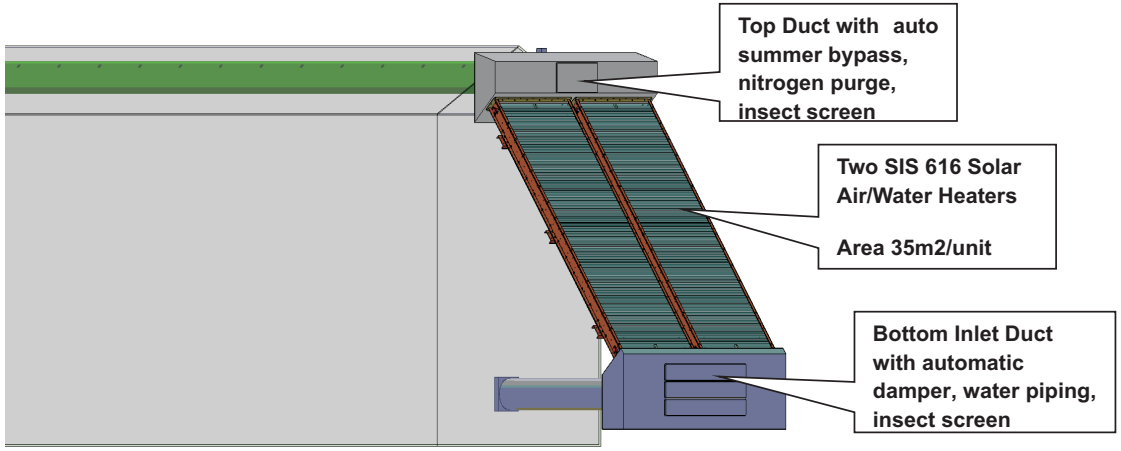
To prevent water freezing in the collectors, when the sully pump is shut off, the water in the solar collector will drain back into a sump tank. A nitrogen blow down is also provided to make sure the solar tubing is cleared.

Fan speed, inlet dampers and air flow ducts are computer controlled and monitored to adjust air flow.

Water flow and isolation valving for each solar collector is located in the bottom inlet damper.

All inlet and outlet ducts have filters and screens to control dust and insects.

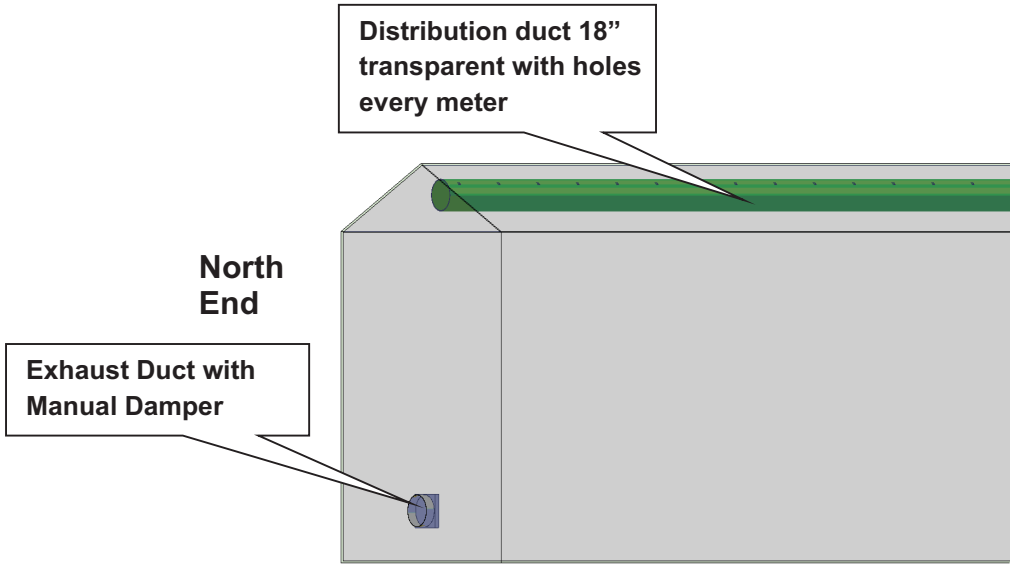


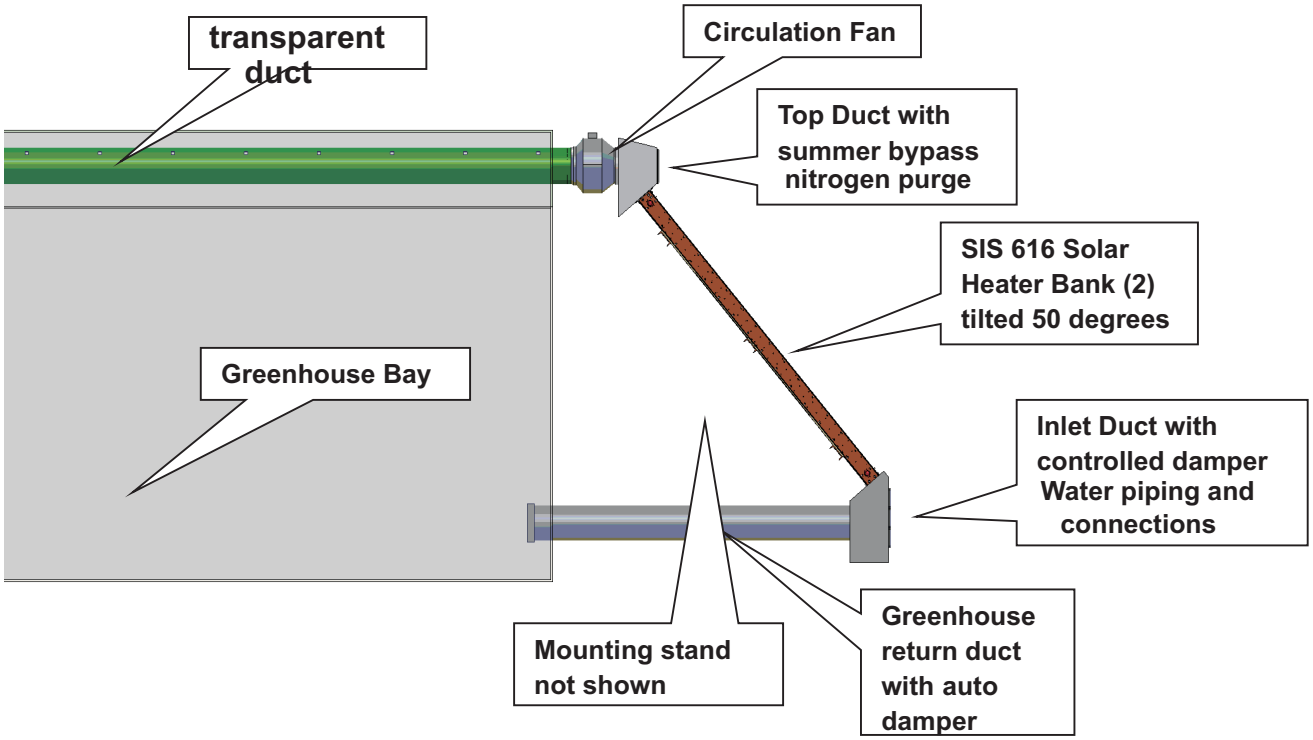


Solar Module Description

At the north end of the distribution duct the end can be sealed or connected to an inlet fan for night cooling (See Diagram 3-4 pg 9-10).

The exhaust ducts and return ducts are opened to atmosphere to direct greenhouse air out of the module.





I

Indoor Temperature - Building Stratification

In a Industrial solar application, you enter the temperature stratification in the building before installation of the solar air heater. This value represents the difference between the air temperature measured at ceiling level and the air temperature measured near the floor.

In high-ceiling industrial buildings, there can be a significant temperature gradient between the floor and the ceiling as heat generated within the building naturally rises. This effect, known as stratification, can result in increased heat loss through the roof and through rooftop exhaust vents.

A solar destratification ventilation system can reduce this effect by delivering relatively cool ventilation air at ceiling level, promoting mixing of indoor air. In doing so, the ceiling air temperature is reduced and the building temperature becomes more uniform, thus less stratified.

Stratification temperature can be measured directly in an existing building. Buildings with low ceilings, and low internal gains (e.g. warehouses) will have modest stratification (1 to 6 ºC). Generally 1°C per meter in height is used. For a 16ft plus apex (6.37m) greenhouse, the stratification temperature difference used is 6°C.

Buildings with high ceilings and high internal gains (e.g. manufacturing facilities) may have significant stratification (5 to 15 ºC).

The system pressurizes the greenhouse and reduces entry of gnats and other harmful insects.

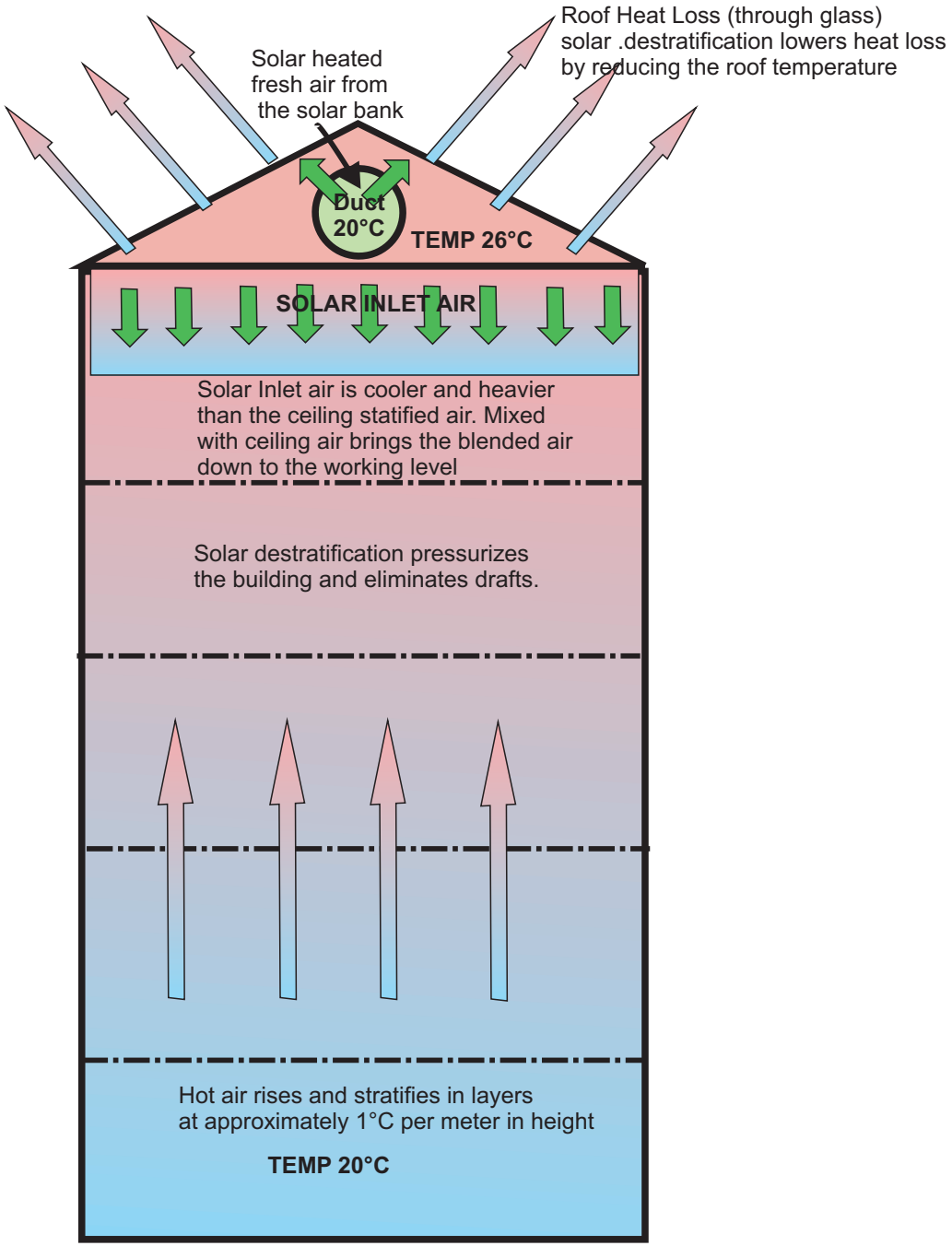
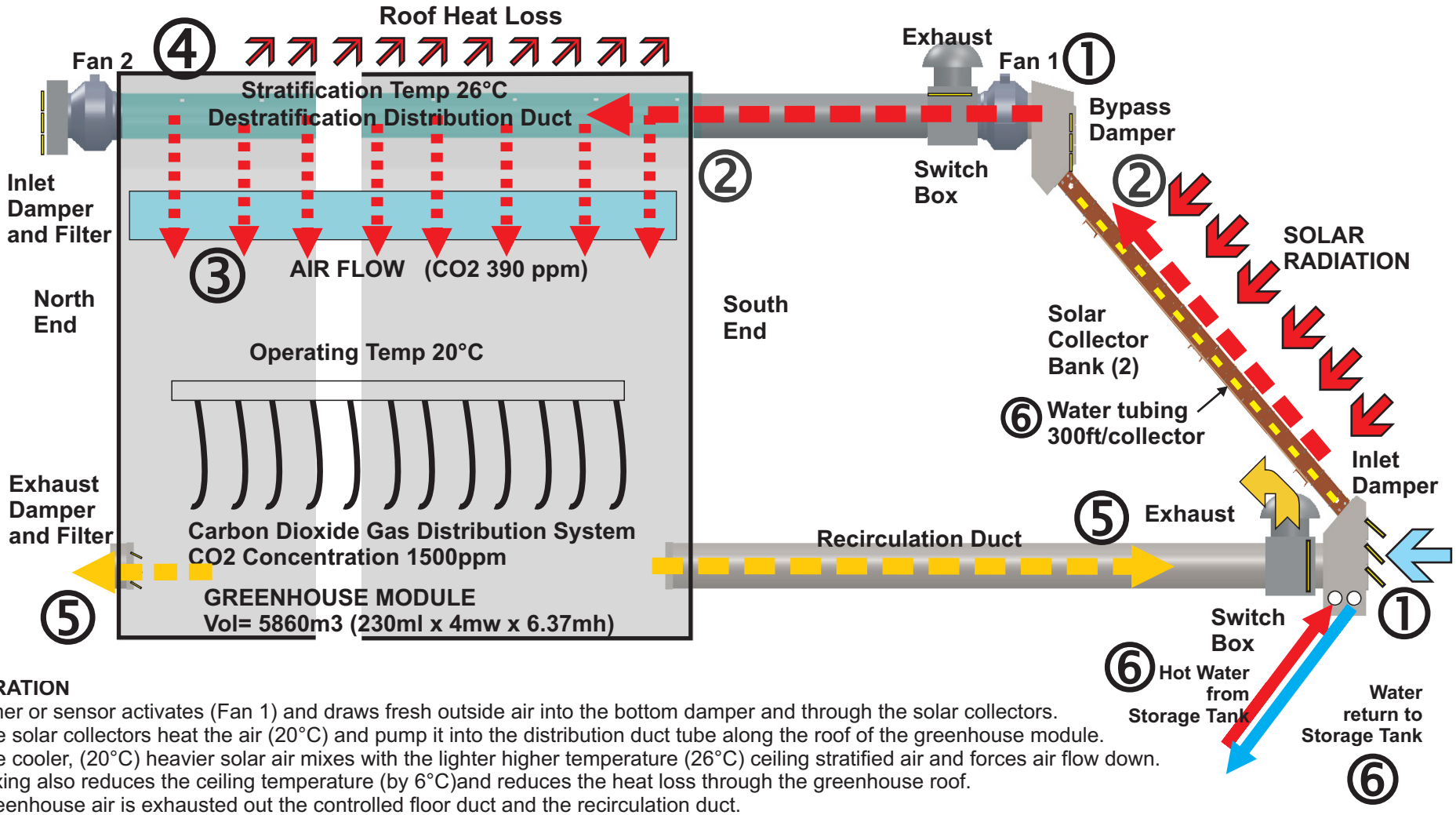


Diagram 1: Standard Operation: Solar Heated Air Supply for Destratification and Carbon Dioxide from Fresh Outside Air

1. Solar Air CO2 content: 390 ppm (0.35 kg/100m2)(.756g/m3) Greenhouse Operating CO2 level:1500 ppm
2. Air Flow per Greenhouse Module (230m x 4m x ((4.87*4) +6)= 5860 m3/hr 1 air change/hr
3. CO2 delivery/hr = 5890m3*.756 g/m3=4.45kg/module/hr Solar CO2 =390/1500= 26% of requirements
4. Operating Temperature: 20°C Stratification= 1°C/m height.

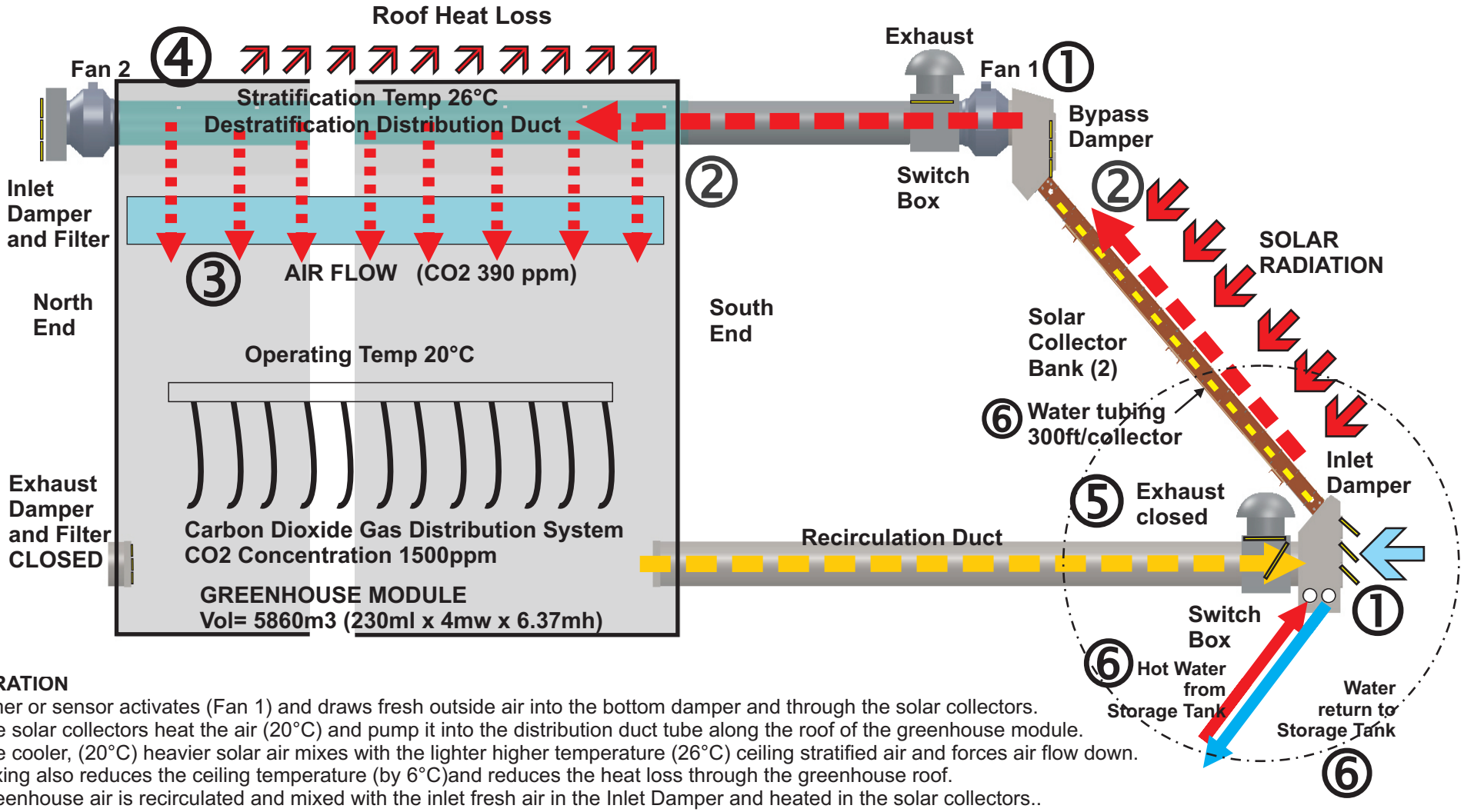


OPERATION

1. Timer or sensor activates (Fan 1) and draws fresh outside air into the bottom damper and through the solar collectors.
2. The solar collectors heat the air (20°C) and pump it into the distribution duct tube along the roof of the greenhouse module.
3. The cooler, (20°C) heavier solar air mixes with the lighter higher temperature (26°C) ceiling stratified air and forces air flow down.
4. Mixing also reduces the ceiling temperature (by 6°C)and reduces the heat loss through the greenhouse roof.
5. Greenhouse air is exhausted out the controlled floor duct and the recirculation duct.
6. When there is low solar radiation, sensors will activate a pump to pump hot water from the greenhouse storage tank through the water tubing in the collectors, heating the air flow by radiant heat transfer to the operating temperature.
7. Sensors and computer control monitors temperature sensors, fan speed, dampers, switch boxes.

Diagram 2: Recirculation: Solar Heated Air Supply for Destratification and Carbon Dioxide from Fresh Outside Air

1. Recirculating the greenhouse air with a high carbon dioxide content (1100-1200ppm)and mixing it with outside fresh air (390ppm)

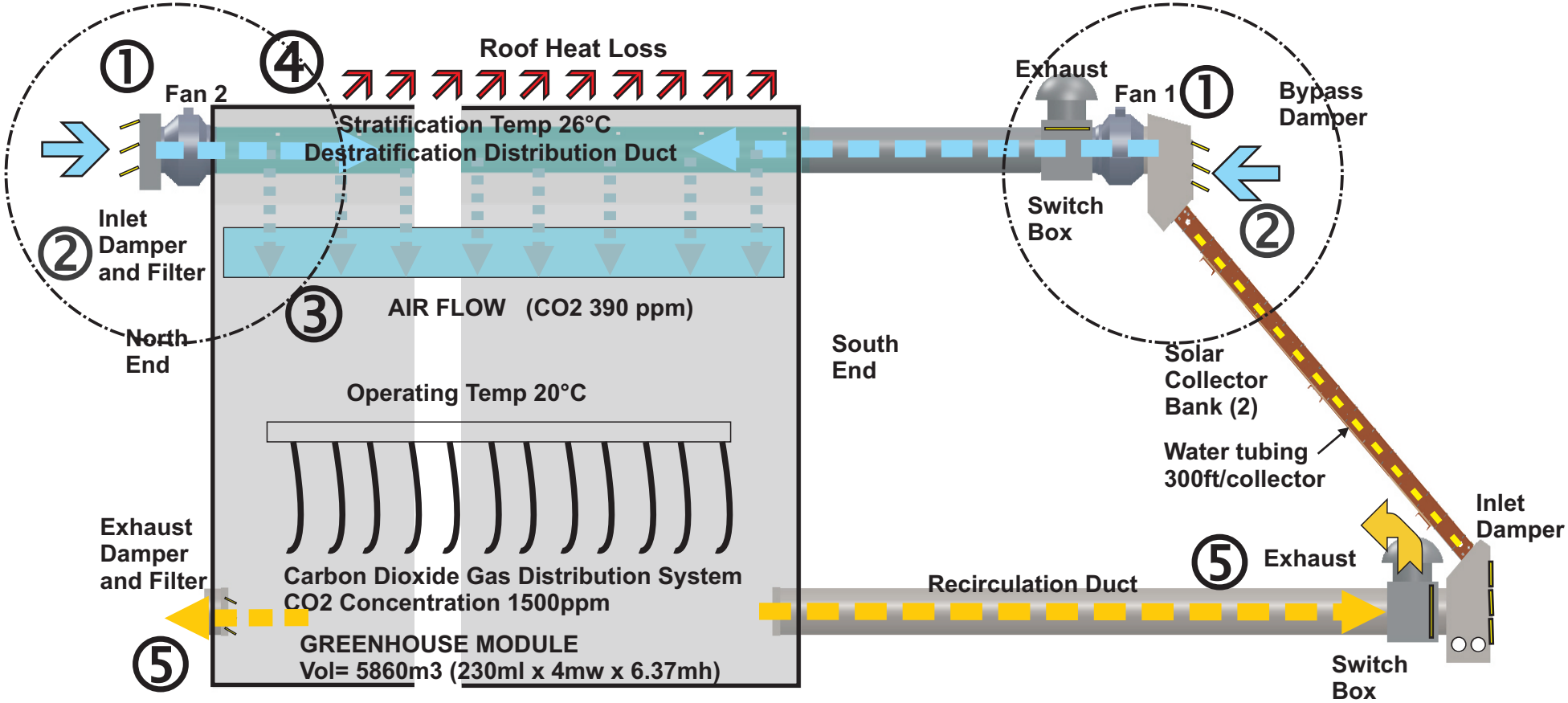


OPERATION

1. Timer or sensor activates (Fan 1) and draws fresh outside air into the bottom damper and through the solar collectors.
2. The solar collectors heat the air (20°C) and pump it into the distribution duct tube along the roof of the greenhouse module.
3. The cooler, (20°C) heavier solar air mixes with the lighter higher temperature (26°C) ceiling stratified air and forces air flow down.
4. Mixing also reduces the ceiling temperature (by 6°C)and reduces the heat loss through the greenhouse roof.
5. Greenhouse air is recirculated and mixed with the inlet fresh air in the Inlet Damper and heated in the solar collectors..
6. When there is low solar radiation, sensors will activate a pump to pump hot water from the greenhouse storage tank through the water tubing in the collectors, heating the air flow by radiant heat transfer to the operating temperature.
7. Sensors and computer control monitors temperature sensors, fan speed, dampers, switch boxes.

Diagram 3: Summer Bypass Cooling

1. The Solar Collectors are bypassed and outside air is brought directly into the greenhouse

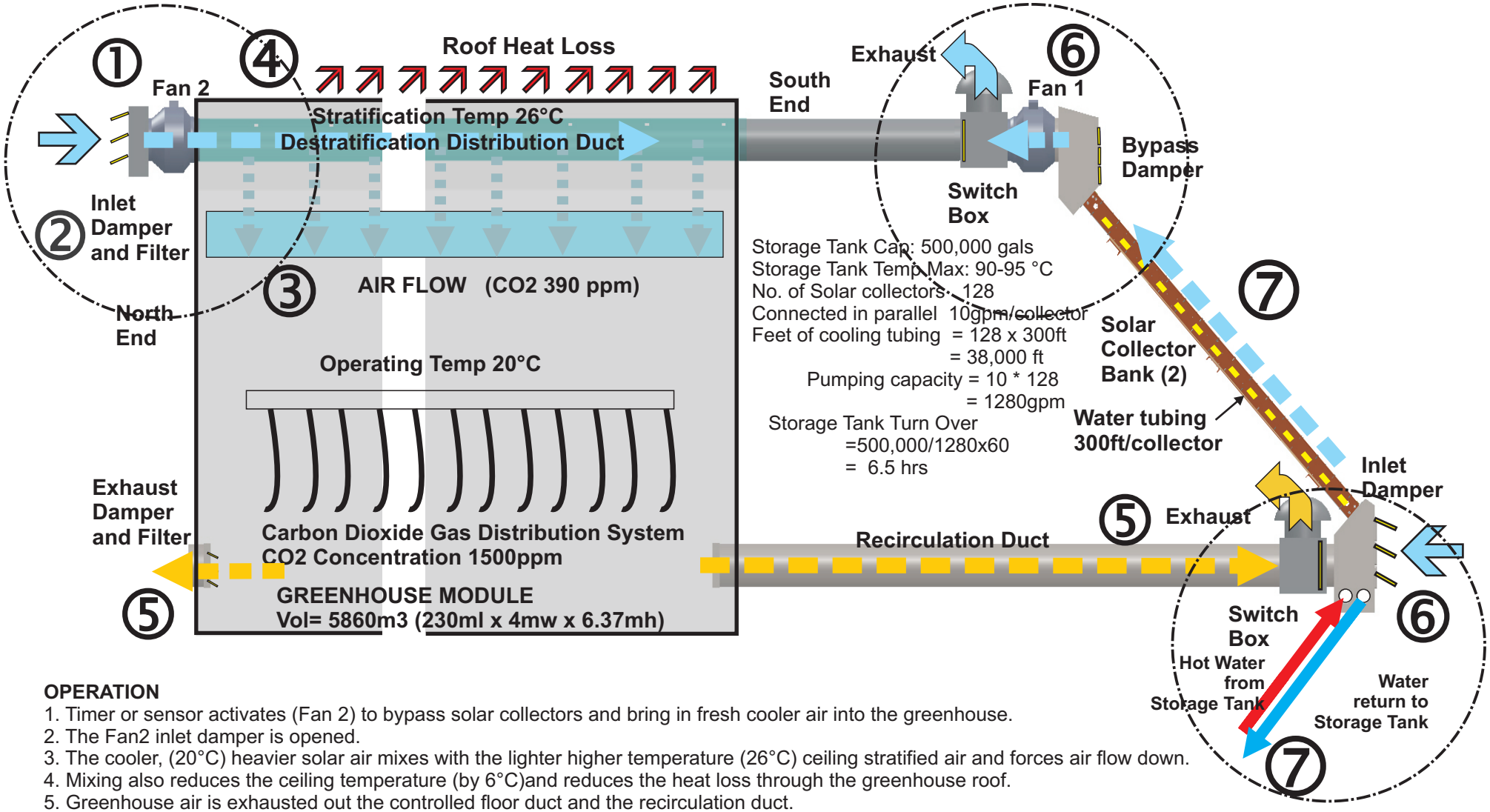


OPERATION

1. Timer or sensor activates (Fan 1) and/or (Fan 2) to bypass solar collectors and bring in fresh cooler air into the greenhouse.
2. The top bypass damper and/or the Fan2 inlet damper is opened.
3. The cooler, (20°C) heavier solar air mixes with the lighter higher temperature (26°C) ceiling stratified air and forces air flow down.
4. Mixing also reduces the ceiling temperature (by 6°C)and reduces the heat loss through the greenhouse roof.
5. Greenhouse air is exhausted out the controlled floor duct and the recirculation duct.
6. Sensors and computer control monitors temperature sensors, fan speed, dampers, switch boxes.
7. Setup can also be operated during the night to use night air to cool the greenhouse down.

Diagram 4: Summer Bypass Cooling and Dumping Storage Tank Heat Build-Up.

1. The Solar Collectors are bypassed and outside air is brought directly into the greenhouse with the North End Fan.
2. Using the gas flue system to produce carbon dioxide eventually raises the greenhouse storage tank temperature to maximum as the boilers are operating at maximum capacity. By using the solar collector water tubing as a heat exchange radiators, storage tank hot water is pumped through the collector bank and cooled by the night airflow.

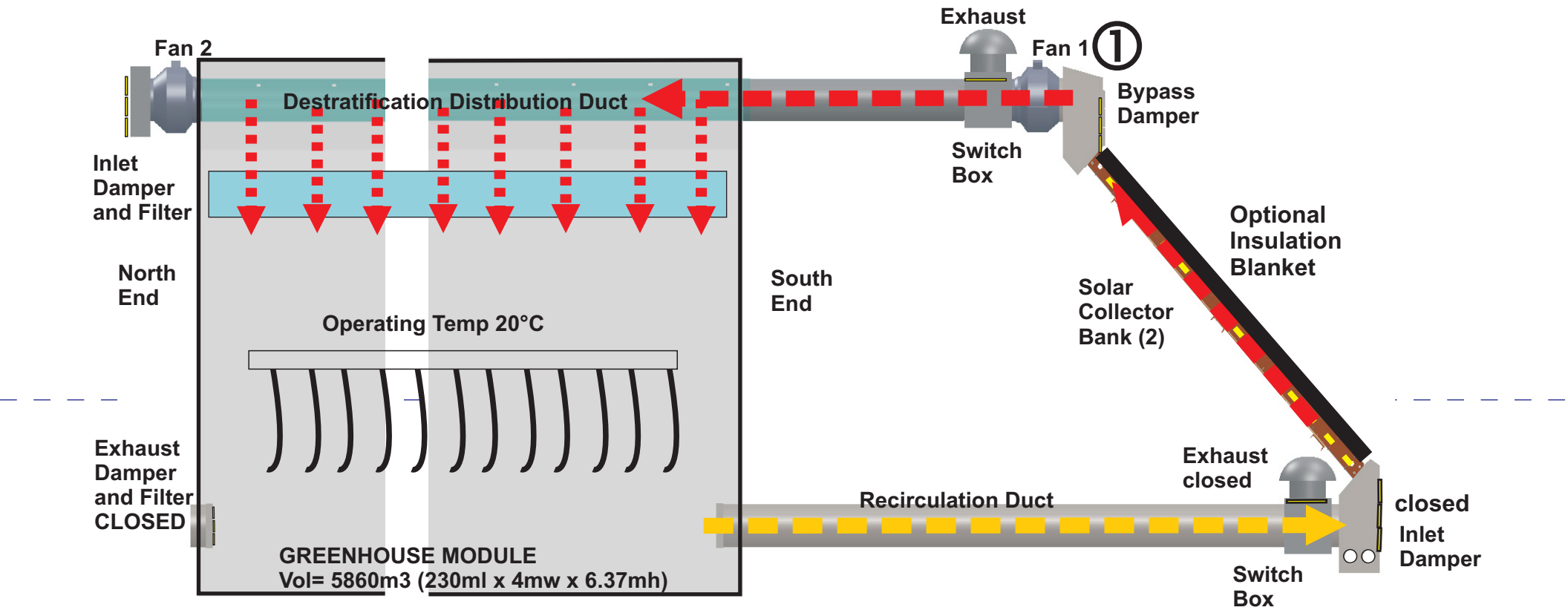


OPERATION

1. Timer or sensor activates (Fan 2) to bypass solar collectors and bring in fresh cooler air into the greenhouse.
2. The Fan2 inlet damper is opened.
3. The cooler, (20°C) heavier solar air mixes with the lighter higher temperature (26°C) ceiling stratified air and forces air flow down.
4. Mixing also reduces the ceiling temperature (by 6°C)and reduces the heat loss through the greenhouse roof.
5. Greenhouse air is exhausted out the controlled floor duct and the recirculation duct.
6. Cool night air is drawn through the solar collectors and their water tubing by(Fan 1) and exhausted to atmosphere.
7. The Greenhouse storage tank hot water is pumped through the solar collector tubing and cooled by the collector airflow..

Diagram 5: Recirculation: For Humidity Control to prevent disease-producing high humidity pockets.

1. Recirculating the greenhouse air with a high carbon dioxide content (1100-1200ppm)and mixing it with outside fresh air (390ppm)



OPERATION

During cold weather, when greenhouses are virtually closed in, there is often insufficient air circulation to maintain desired conditions. The solar system air ducting and fan will help obtain a more uniform relative humidity and proper air movement using a recirculation set up. Air flow can be controlled and monitored. Continuous circulation produces gentle air movement and has been reported to maintain better leaf surface microclimates and prevent pockets of disease-producing high humidity. An optional insulation blanket can be placed over the solar collector to prevent heat loss and the water tubing in the collectors can maintain heat settings using flow from the greenhouse hot water storage tank.