Solar Radiant Heating for Greenhouses

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Why is it important?

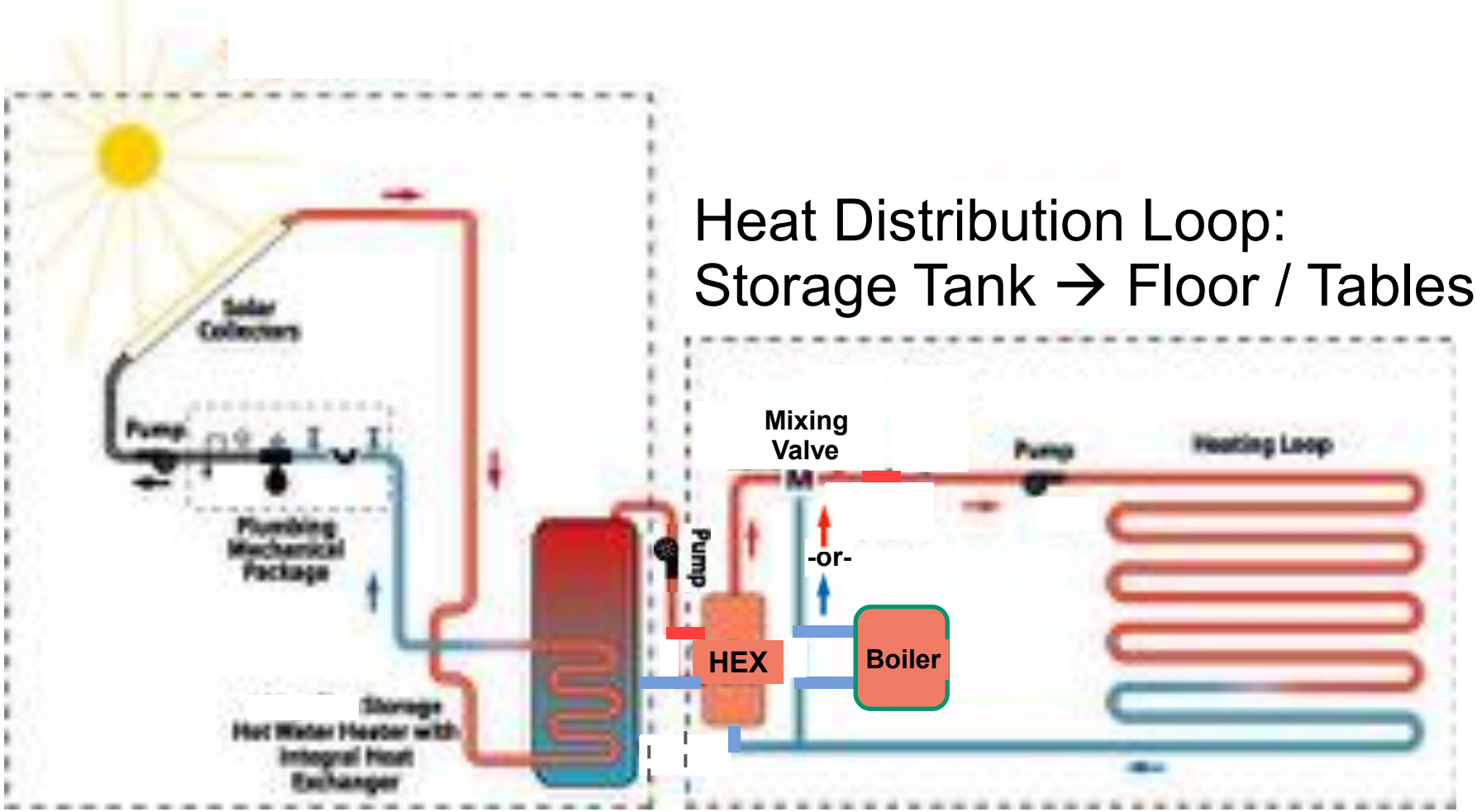
- Save energy, money
- Provides stable growing environment
- Year around profitable food production opportunity even in cold climates
- Coupled with LED lighting for plant growth in low light months
- Automated
- Low maintenance
- Can adapt to existing greenhouse / heating

How Does Solar Radiant Heat Work?

- Typical solar hot water system
- Closed loop (probably) vs. Drainback (best)
- Collector loop moves heat to the storage tank
- Floor loop moves heat from tank to the mass

- Typical hydronic heating system
- Use 2-stage thermostat function
- Solar is the *primary heat source*
- Boiler is the back-up

Solar Hot Water & Radiant Loops



Heat Distribution Loop:
Storage Tank → Floor / Tables

Solar Heat Collection Loop:
Collectors → Storage Tank

Hydronic Heating Considerations

- If an all-new system, design the solar first, then add the hydronic heating
- On retrofits, determine where to cut into existing return boiler feed loop first, then locate the solar storage as close as possible
- Oversize water to water heat exchanger
- Used condensing boiler with outdoor temp sensor
- Boiler never adds heat to solar storage
- Boiler does not come on until solar is exhausted

Solar Design Considerations

- Typical solar hot water parameters
- In cold climates - use 1:1 ratio for storage (gal.) to collector absorber area (sq.ft.)
- In temperate climate – use 1.5 : 1 for storage to absorber area
- Decide on the solar design first, then adapt to the existing hydronic system
- Keep all pipe runs to a minimum and well insulated

Solar Design Consideration - 2

- Keep solar fluid separate from hydronic system
- Use solar “rules of thumb” for pump sizing, flow rates, and system pressure
- Compare efficiency and reliability trade-offs between mixing valves vs. heat exchangers
- No make up water in solar loop; purge it, forget it
- Install check valves to prevent reverse siphon

Solar Design Considerations - 3

- Remember – solar heating is different from hydronic heating – keep it simple
- Solar loop control is independent of the hydronic controls – do not integrate
- Do not use PEX near solar collectors
- Atmospheric tanks are most versatile, least cost and simplest to maintain – build your own
- Storage can be buried in the greenhouse

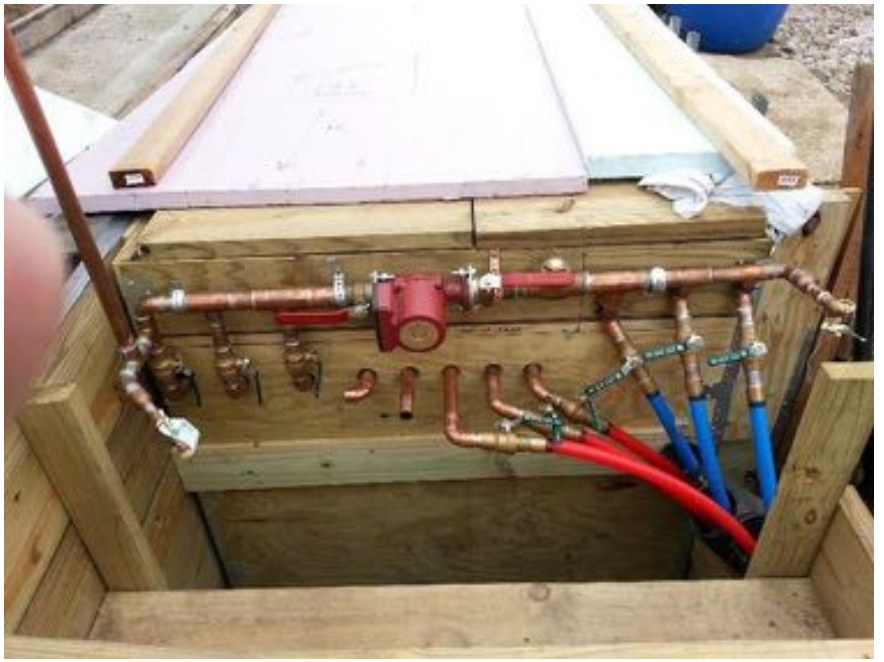
Solar Storage Tank Designs

- Vertical tanks stratify heat better
- Horizontal tanks are easier to bury
- Atmospheric tanks are more versatile and easier to build
- Heat exchangers are PEX or coils of soft copper
- Moving tank water transfers heat better so the radiant heating circuit is best as an open loop

Solar Storage Tank - Horizontal

Tank Assembly

Buried Tank

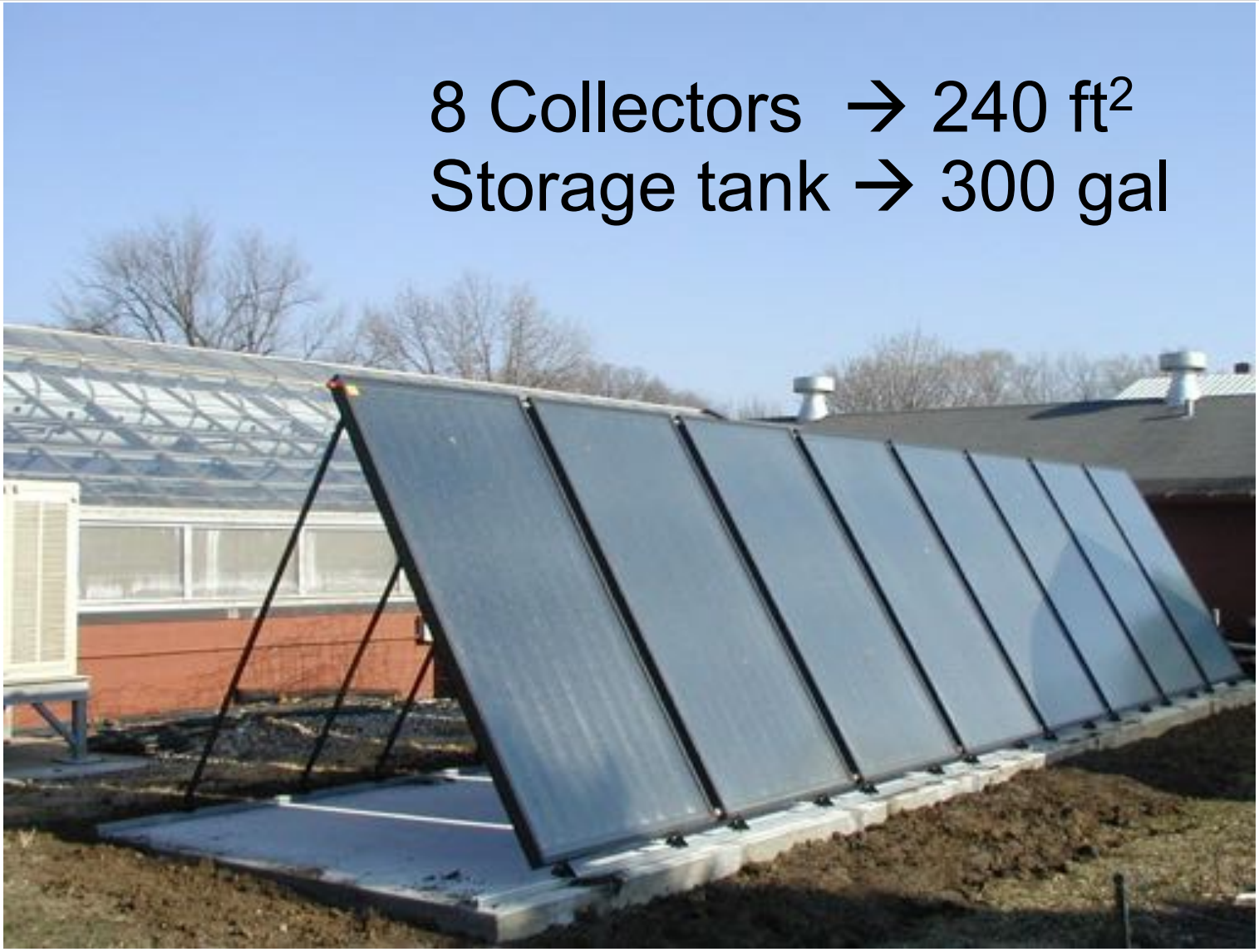


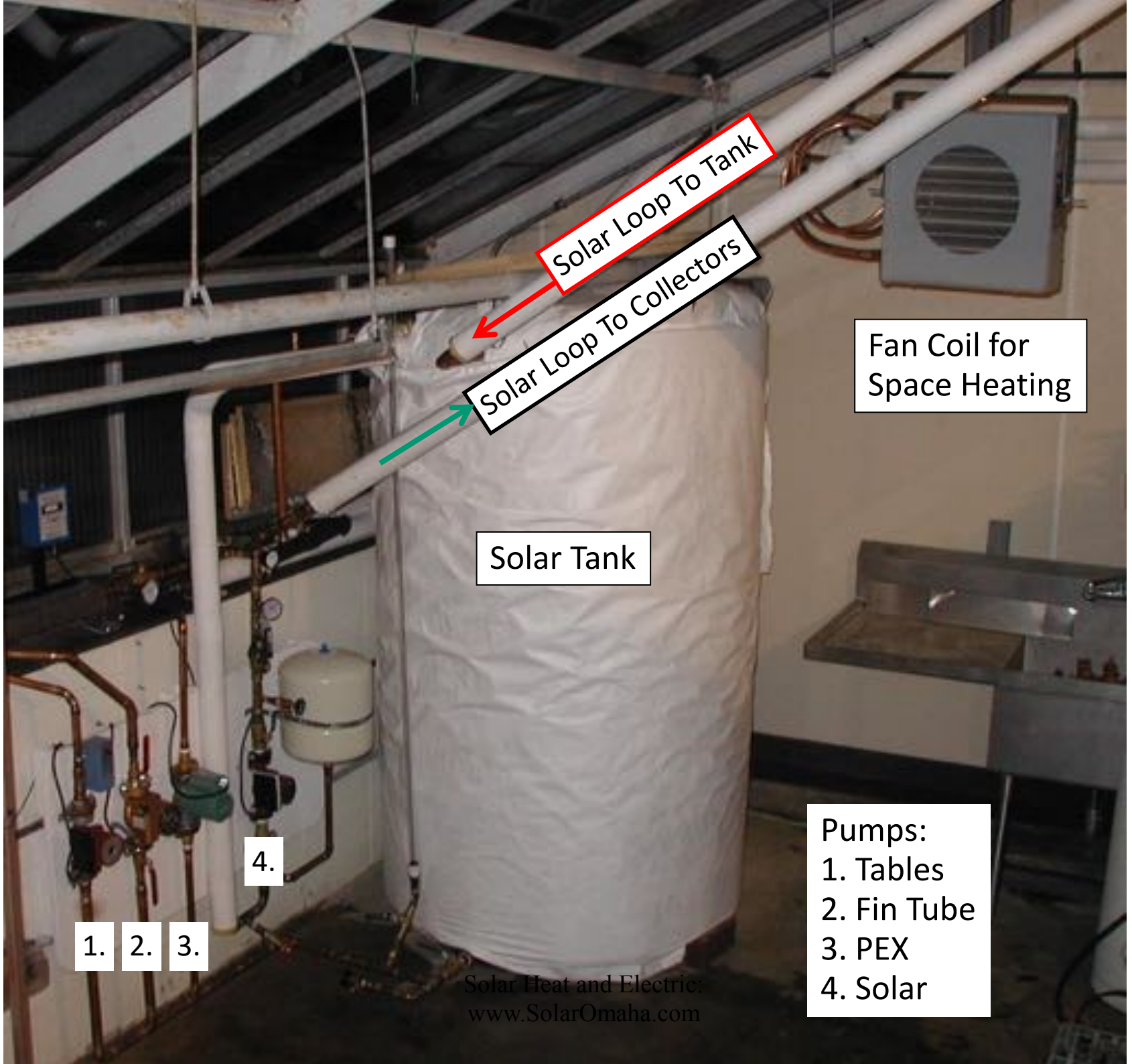
The tank was lowered into the ground and then the copper heat exchanger loops were added inside. The pump, gauges and headers were connected externally.

Solar Storage Tank - Vertical

- Heat exchangers using PEX loops drop inside the cylindrical tank
- Tank is high temperature fiberglass (180F limit)
- Bottom loop is solar
- Top loop is radiant
- Insulation on the outside
- Bungs above water level

First Greenhouse Using Solar Hot Water




Solar Loop To Tank
Solar Loop To Collectors
Fan Coil for Space Heating
Solar Tank
4.
1. 2. 3.
Pumps:
1. Tables
2. Fin Tube
3. PEX
4. Solar
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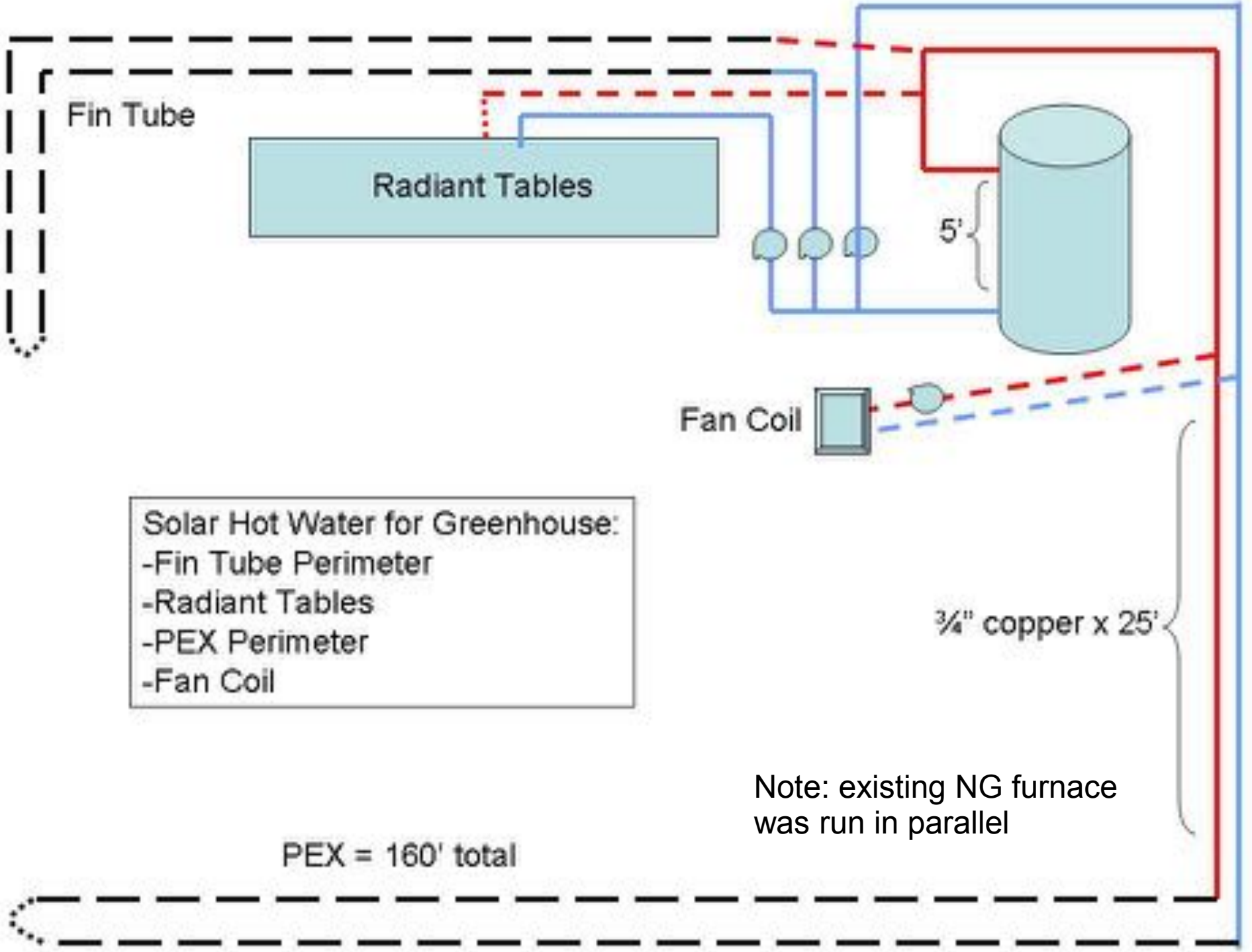
Fin Tube
Radiant Tables
5'
Fan Coil
Solar Hot Water for Greenhouse:
-Fin Tube Perimeter
-Radiant Tables
-PEX Perimeter
-Fan Coil
¾" copper x 25'
Note: existing NG furnace was run in parallel
PEX = 160' total

Solar Heating a Greenhouse

The storage water is circulated through four different circuits to compare space heating

What was done	*What was learned*
Perimeter fin tube	Requires water >140
Tubes under plant tables	Best embedded in concrete
Perimeter PEX tube	Not effective
Water to air fan coil	Useful, temps >10° room

Second Greenhouse Using Solar Hot Water

Solar Greenhouse - Radiant Table

Second Greenhouse Using Solar Hot Water

- Used radiant tables for heating in 15’ x 70’ house
- Initial solar results were estimated at 40% of heating needs, expect 80% with refinements in operating controls
- Radiant tables were successful application, plants seemed to prosper
- Next step considering LED lighting to stimulate more winter growth
- Partial funding with Nebraska Environmental Trust grant as model for commercialization

Final Thoughts

- Greenhouses can heat themselves during the day but need additional heat at night so plants do not go into shock from cold temps
- Solar heat is supplemental so the boiler must have capacity to carry the whole load
- Optimal solar system size may be space or budget available
- Keep collectors from shading the greenhouse
- 30% federal tax credit and depreciation (business)

Future …

Combine Technologies…

Greenhouse InTheSnow.com

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