Renewable Energy
Applied to Air Conditioning

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That which has been is that which will be,
and that which has been done is that
which will be done.

So there is nothing new under the sun.

Ecclesiastes 1:9

What is new is that now we have to make
them work!

Definitions

- Sensible Heat –
  - That heat which can be measured by a thermometer.
- Latent Heat (of vaporization) –
  - That energy contained in water vapor which cannot be measured by a thermometer and which is required to cause water to change phase from a liquid to a vapor.
- Enthalpy –
  - The total energy (heat) contained in the gas.
- Btu – (British Thermal Unit)
  - The volume of heat required to raise one pound of water one degree Fahrenheit.
- Refrigerant Ton –
  - 12,000 Btu

Definitions

- EER – Energy Efficiency Ratio
  - Mbtuh moved divided by kWh electric power required to move it
- SEER – Seasonal Energy Efficiency Ratio
  - A phony baloney government number designed to make the numbers look impressively larger to trick the public into buying much higher efficiency equipment.
  - Based on an average of the typical climate month to month for the entire 48 contiguous states, and the efficiency (EER) of the system at various times of day based on the “average climate”.
  - Based on SENSIBLE heat only, ignoring LATENT heat and without regard to the behavior of the building occupants.

Definitions

- Coefficient of Performance
  - How much work it does for the amount of energy input. *Usually measured in similar units.*
  - *EER & SEER are actually a form of COP*
  - *Typical COP of an absorption chiller is 0.7 to 1.35*
  - *Typical COP of an electric chiller is 2.0 to 8.0*
  - *Typical COP of a 13+ SEER residential AC 2.0 – 2.3*

Residential AC Challenges

- A 12 SEER system will have a smaller electric bill than a 13 or 14 SEER most of the time.
- The LAW of Unintended Consequences
- The 13+ SEER System is inadequate at managing humidity, so the occupants are uncomfortable at 78F. Instead they will typically reduce the t-stat to 74 or 75F

Residential AC Challenges

- 13+ SEER systems are a poor solution to residential applications.
- 2 stage systems 15+ SEER can be part of a sound strategy
  - If it has controls to manage humidity, or if it is reasonable to oversize by 20 to 25%.
- Don’t Oversize unless you have a 2 stage system!

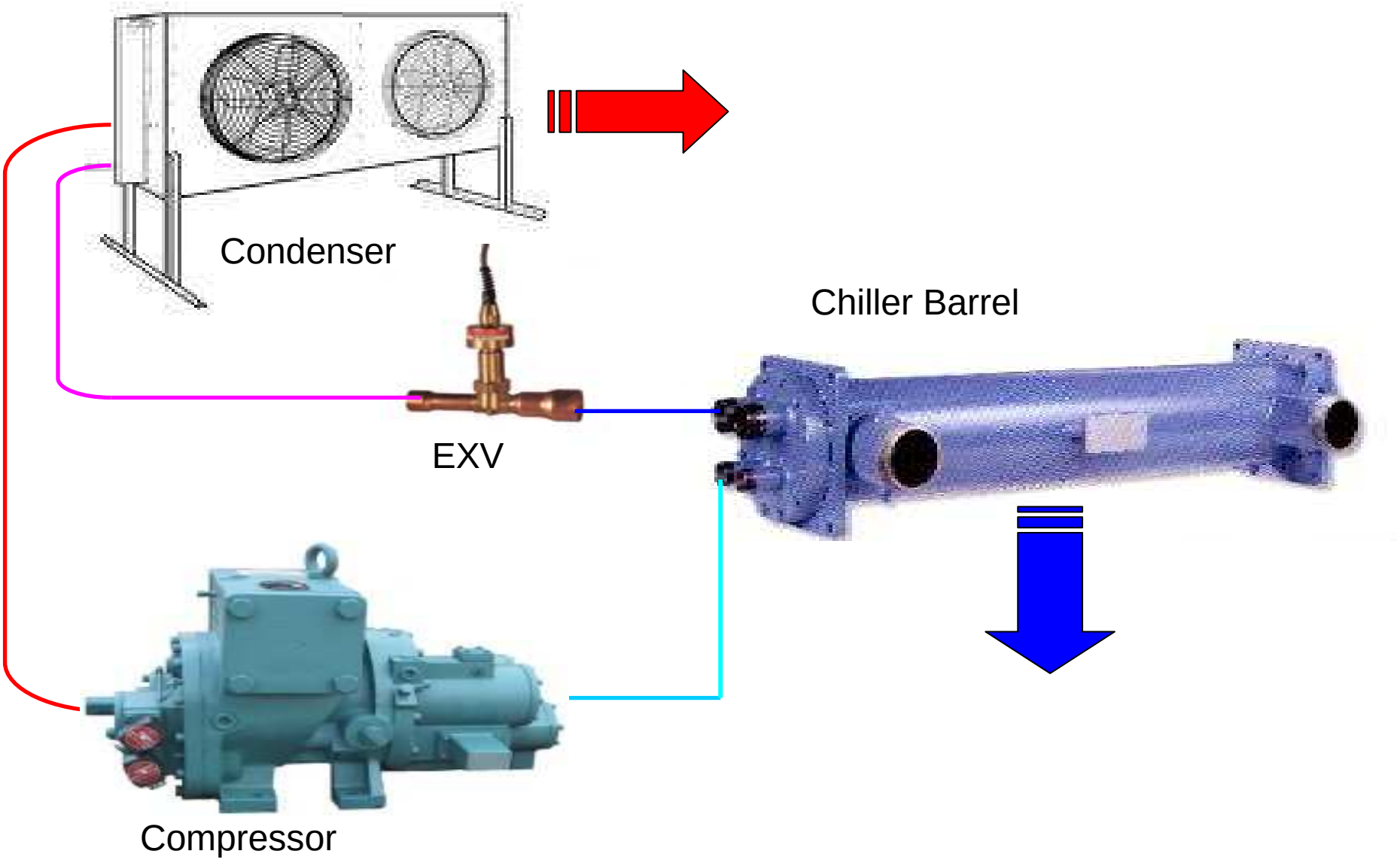
- Build / Rebuild for energy efficiency
- Solar will NEVER work for residential applications.
  Quantum Leap?
- Geo-Thermal has interesting possibilities

Solar Air Conditioning

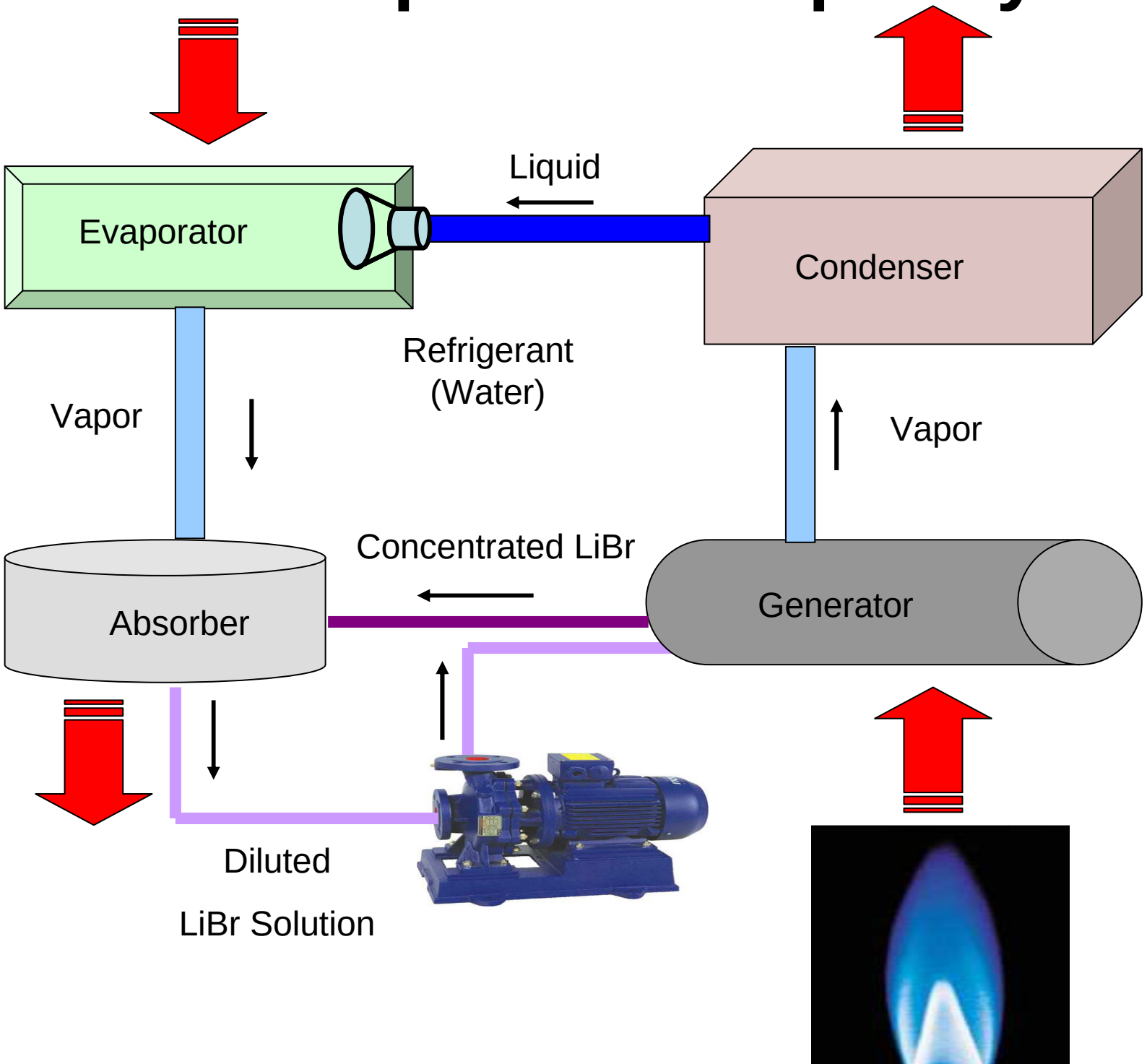
- It does have some possibilities in commercial applications
- As of January 2010, there are some 22 solar air conditioning systems installed in the US.
- The demand for Engineers to explore this field is currently growing exponentially.

How Does it Work?

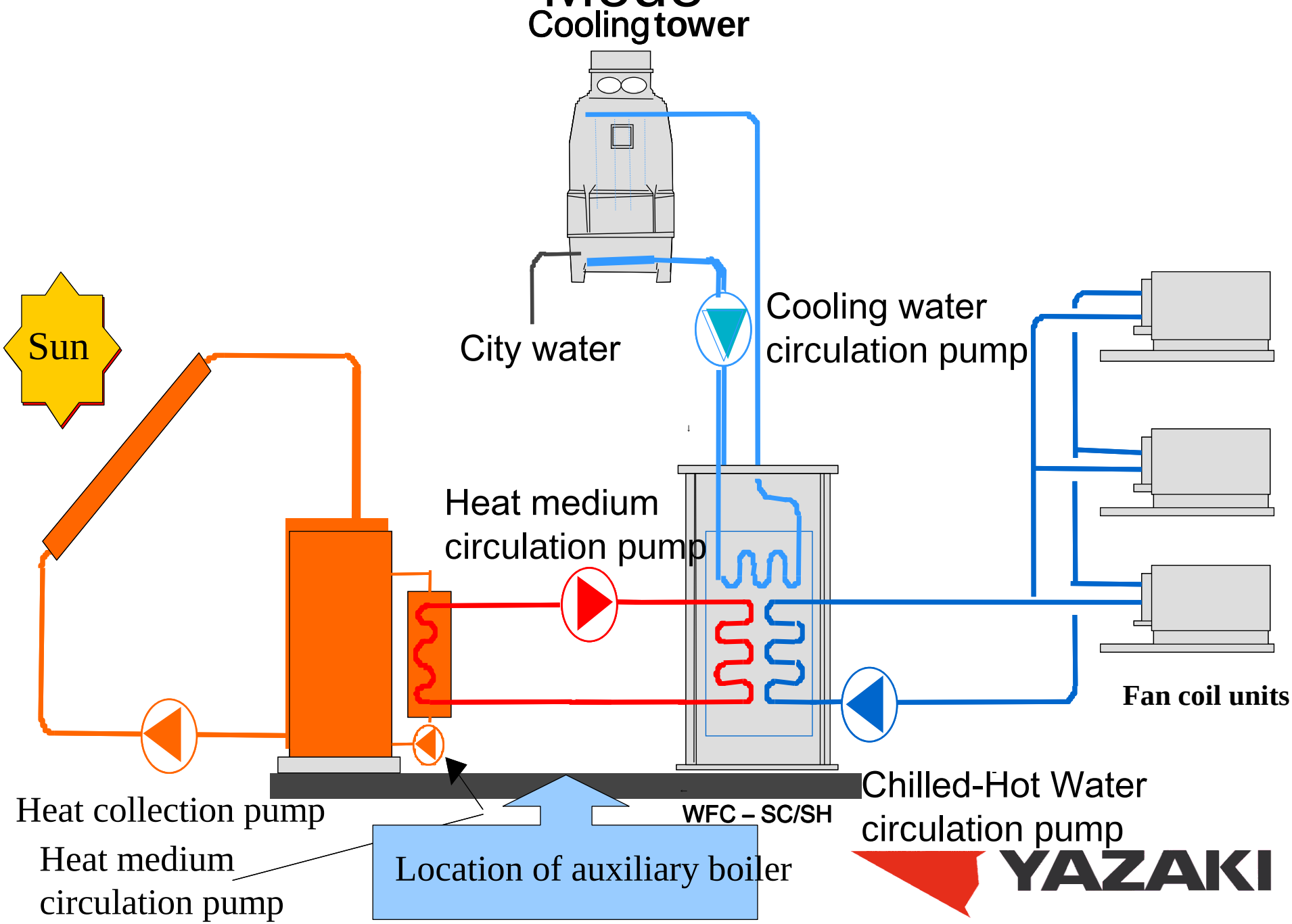
Absorption – Comparison to Vapor Compression Cycle



Absorption – Simple Cycle

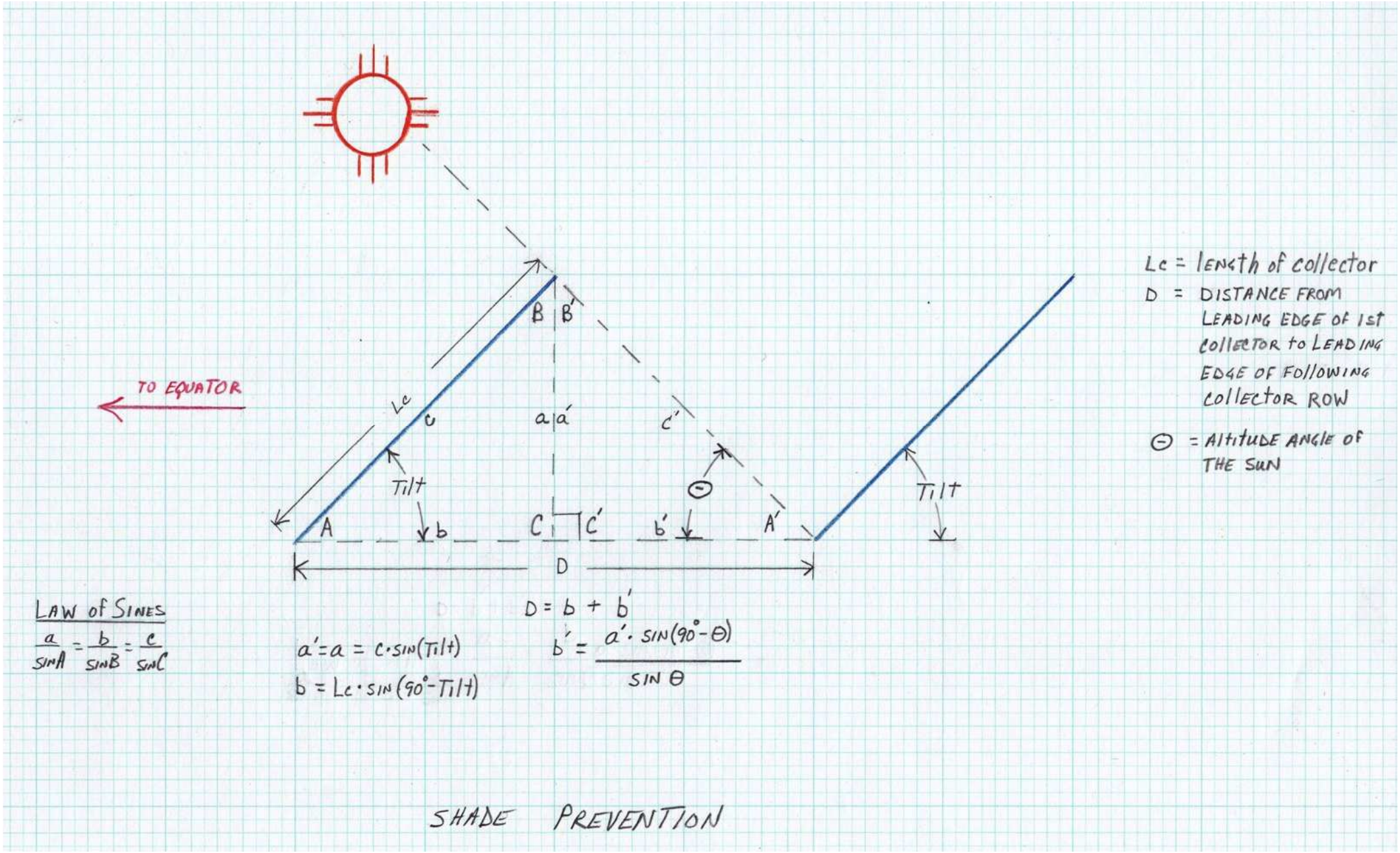


Solar Powered Chiller/Heater – Chill Water Mode

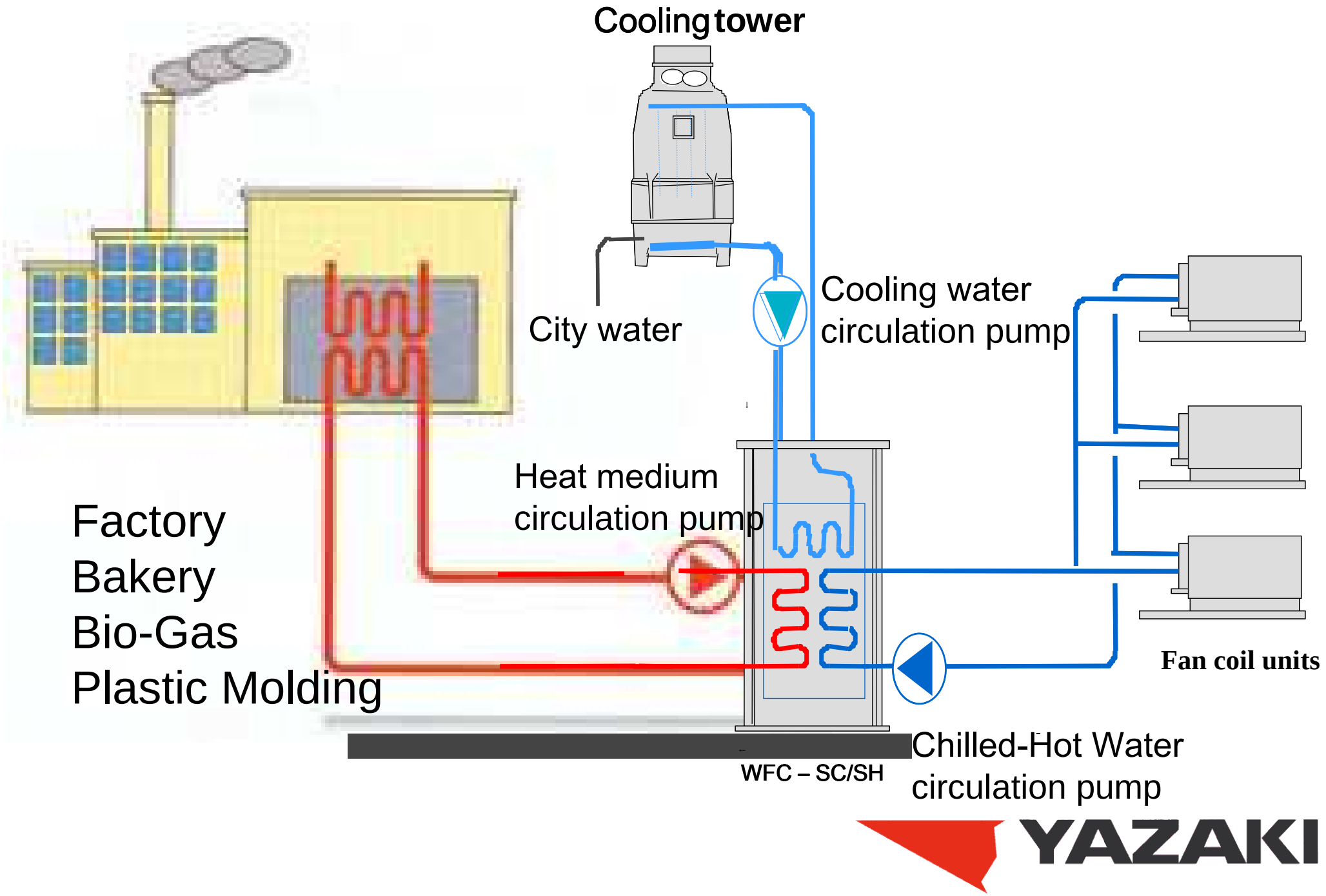


30 Ton Solar Fired Chiller

The Law of Sines



Waste Heat Powered Chiller/Heater – Chill Water Mode



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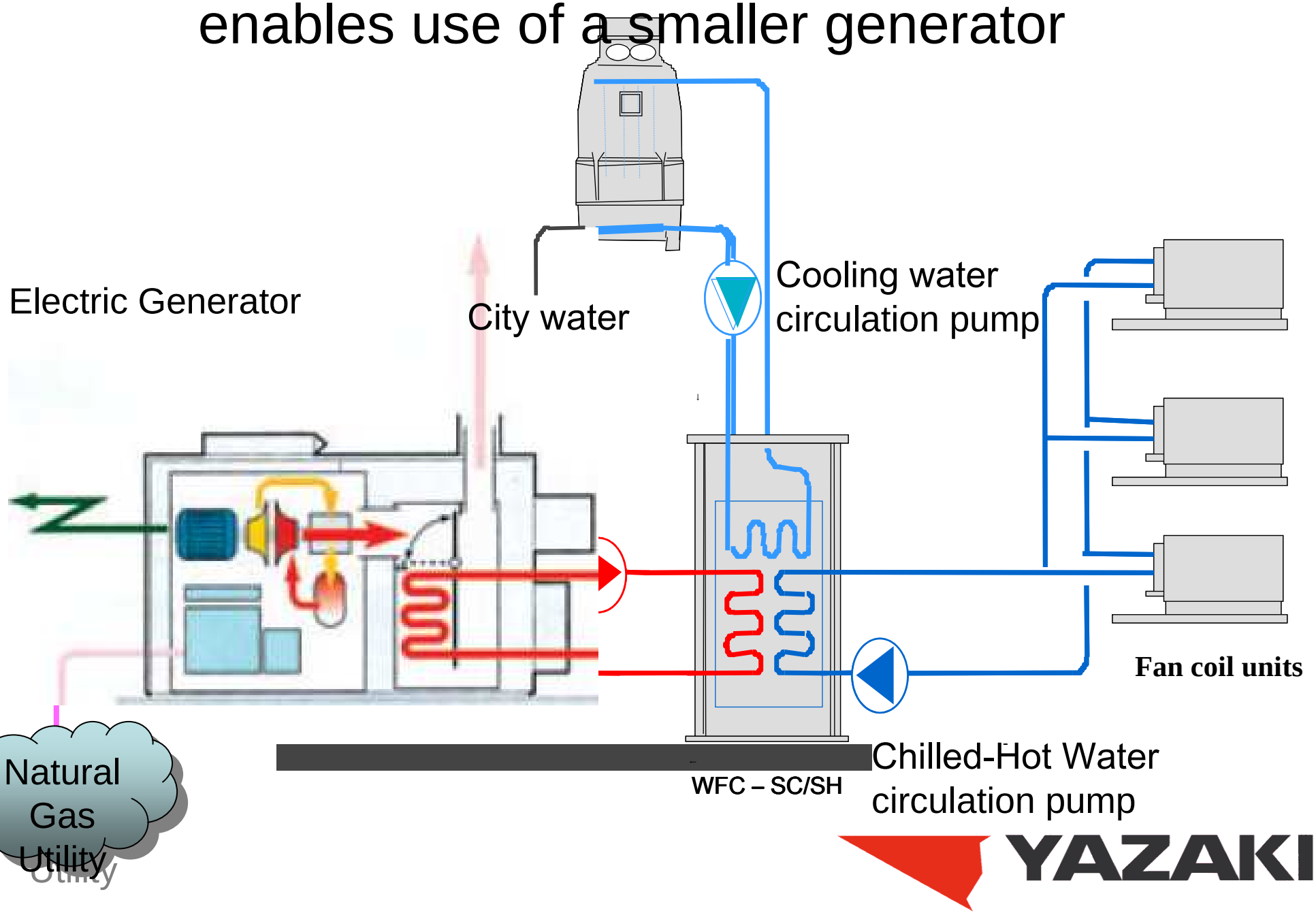
Bio-Gas & Waste Heat Fired Chillers

Inland Empire Municipal Utility

Co-Generation Chiller/Heater – Chill Water Mode

enables use of a smaller generator



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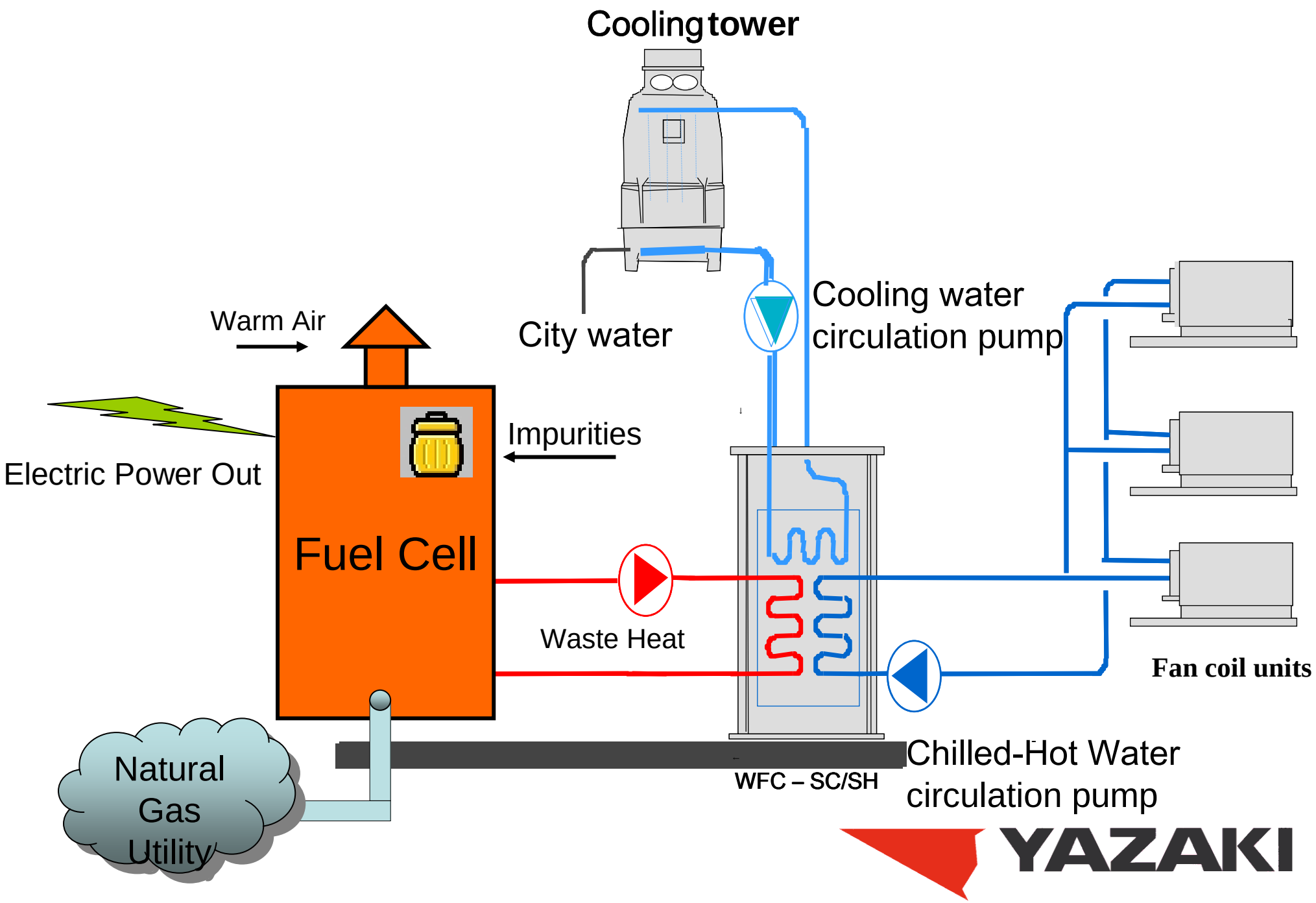
Ahava Food Corporation
Cogeneration Plant
Engine Room – 1 MW
RUDOX
RUDOX


Ahava Food Corporation
Cogeneration Plant
Chiller Plant – 50 Tons

Co-Generation Chiller/Heater – Clean Fuel Cell



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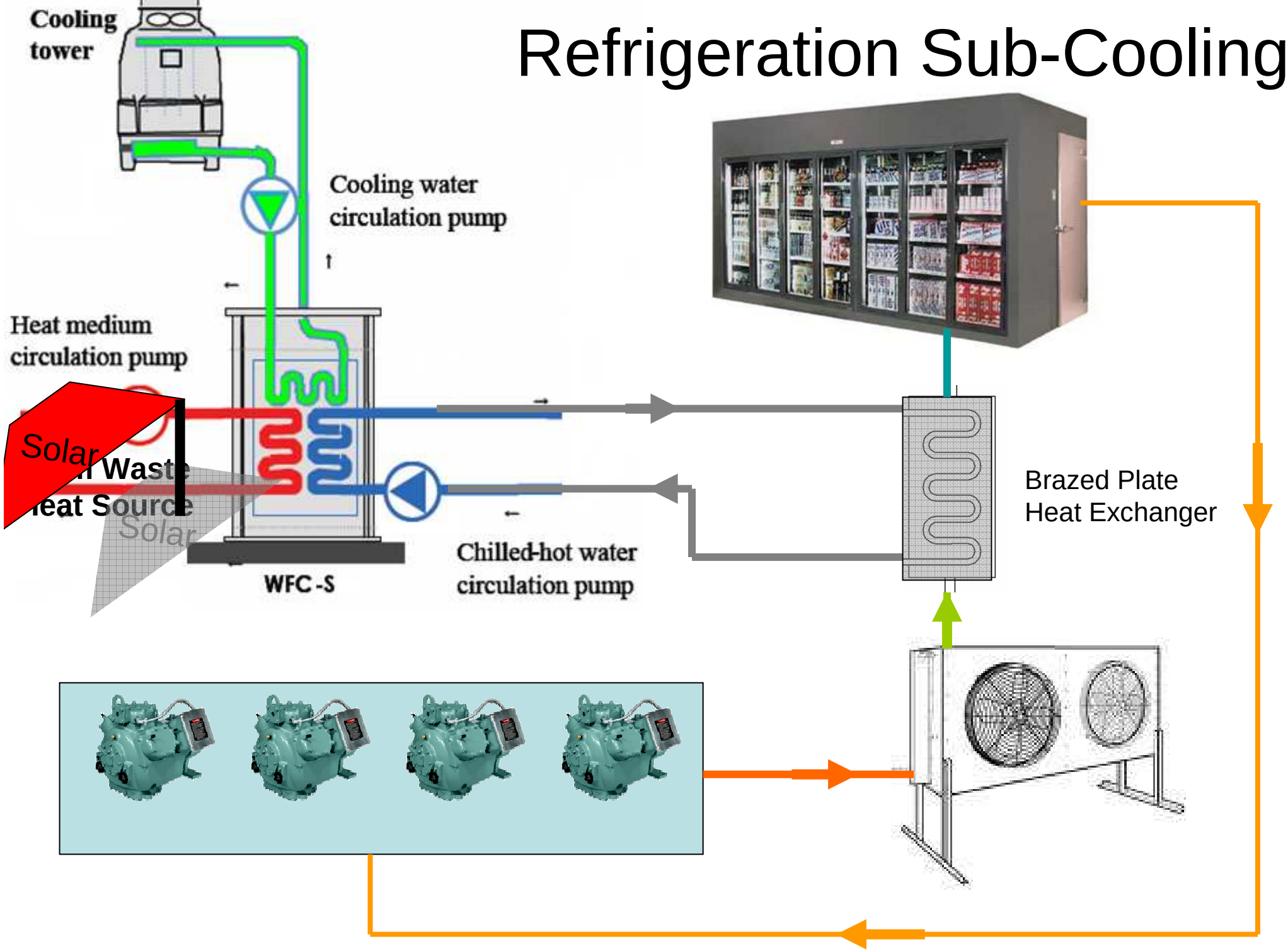
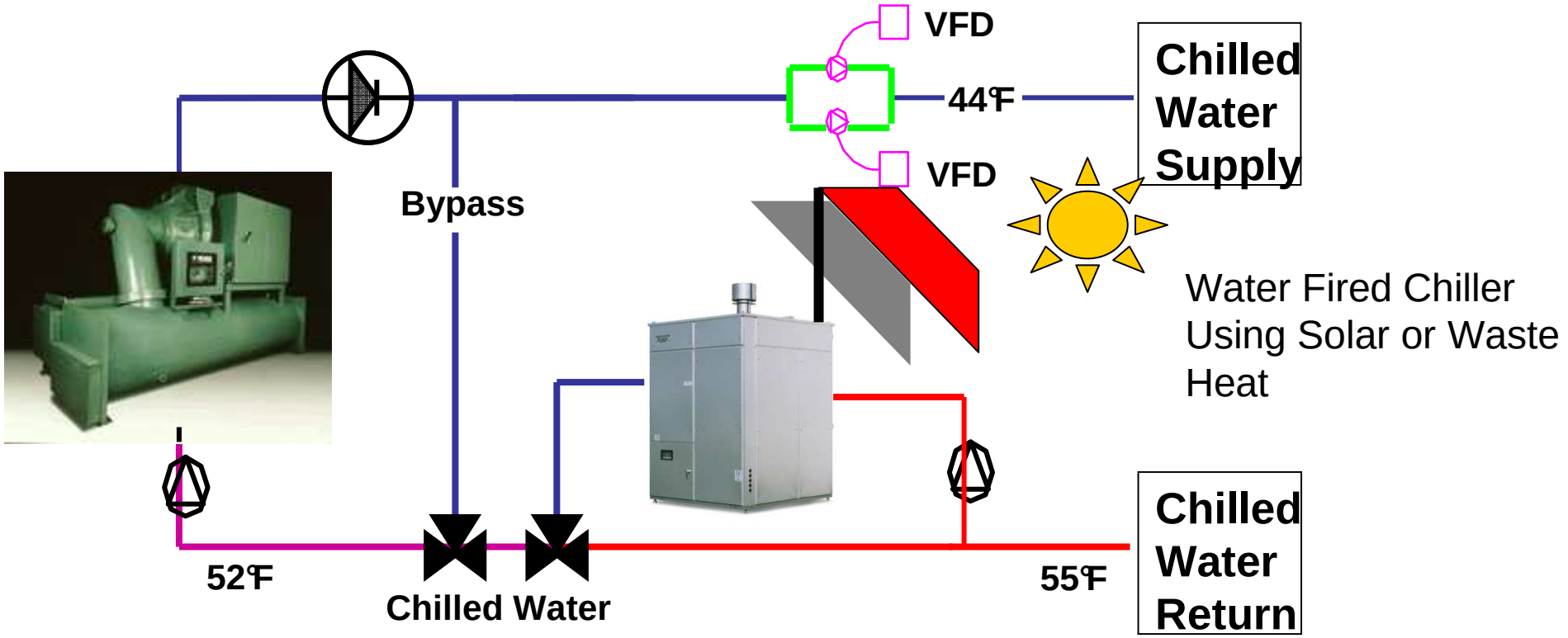
Refrigeration Sub-Cooling



Combined Cycle Side-Stream Piping

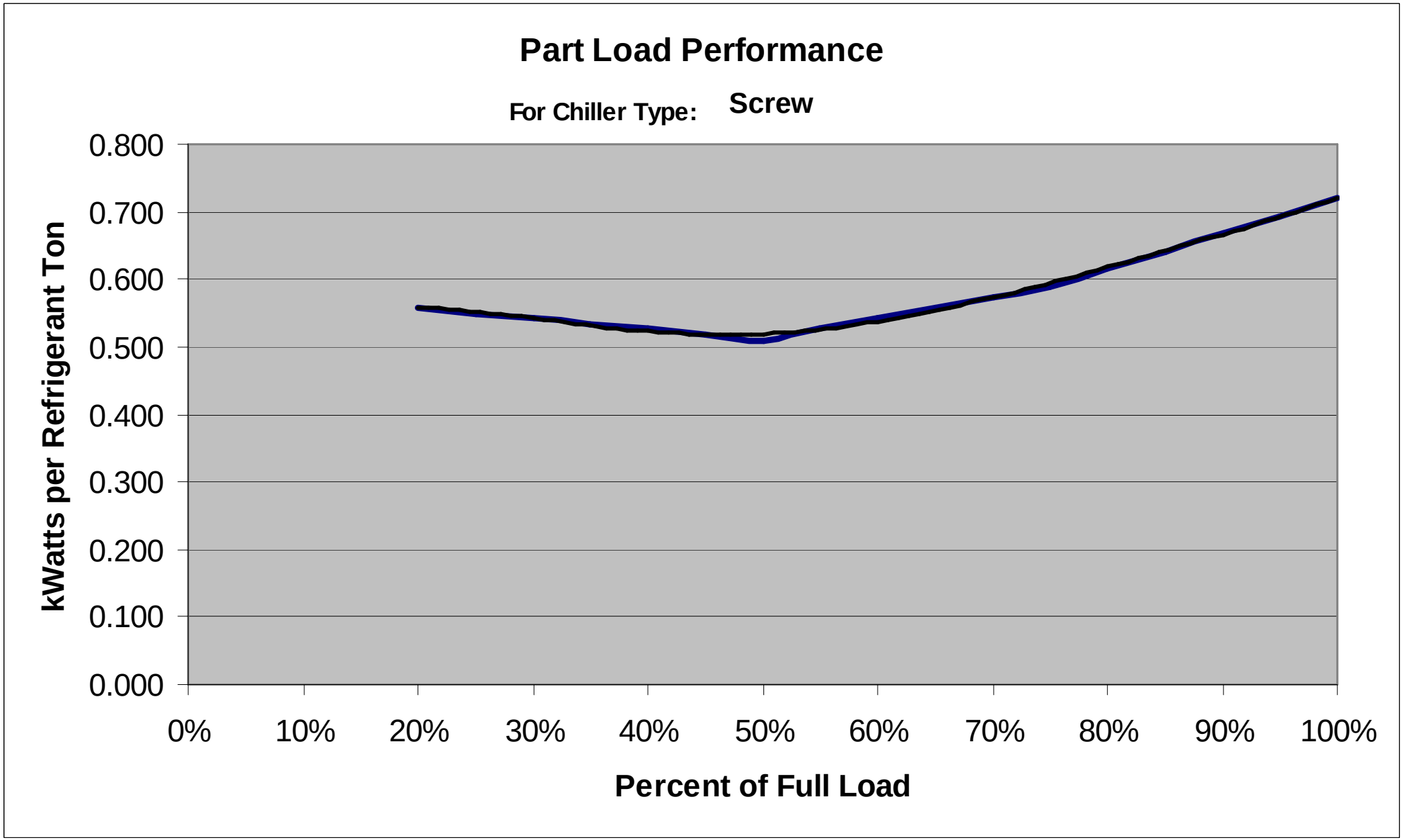


Utilizing Solar or Waste Heat, this configuration provides additional capacity to the system, when the need is the greatest, and the energy source for it has no recurring cost. The Electric Chiller is now running in “Part Load” mode increasing the energy efficiency (COP) of the electric chiller.

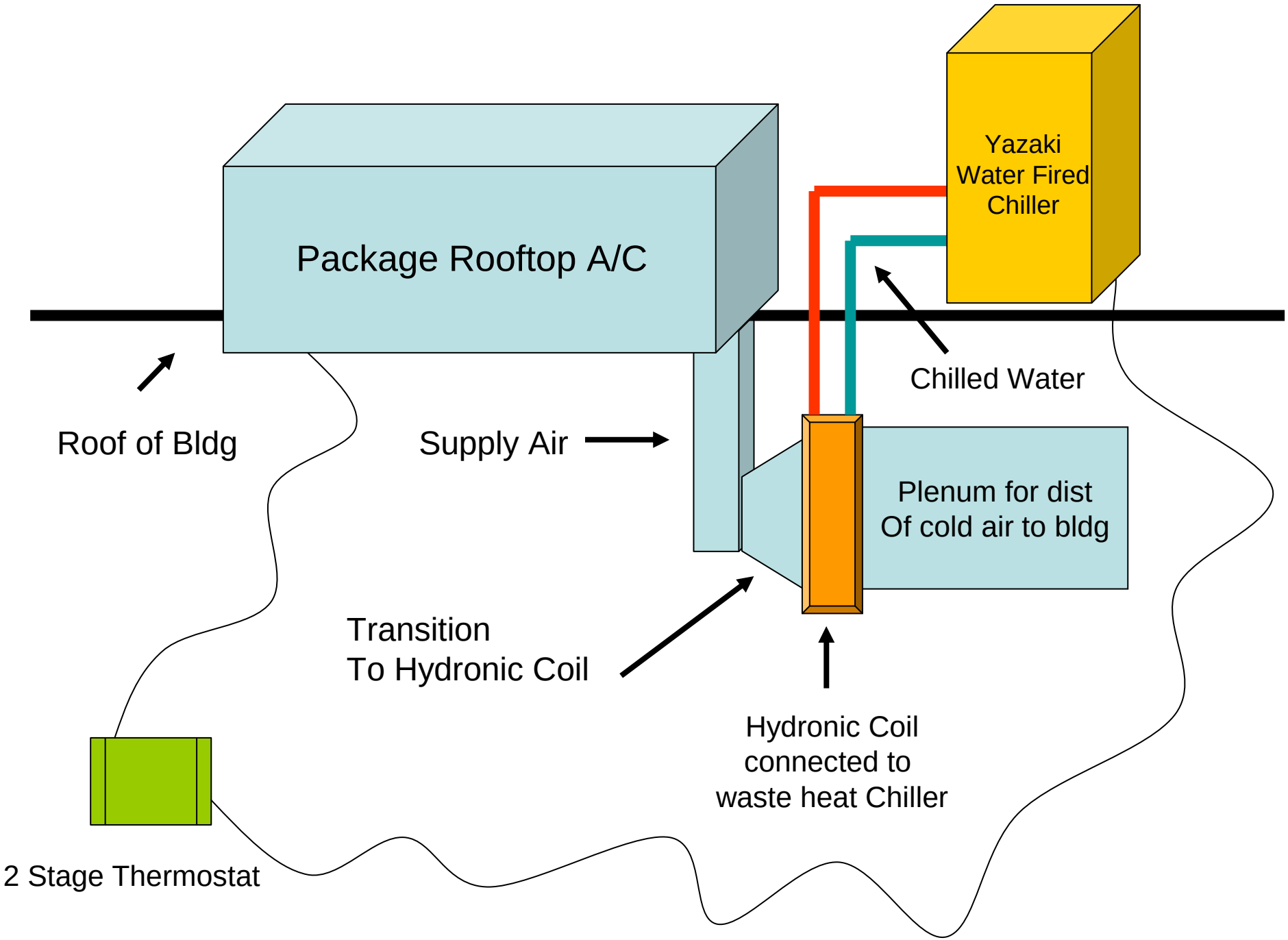
Electric Cost Savings from Unloading

COP	4.88	5.91	**21%**
Input KW elec	105.1		
Output kW cooling	513.2		
KW electric / Ton	0.720228	0.595	
Cost per KW	$0.1266		
Cost per Ton Hour	$0.0912	$0.0753	-$0.0159

Typical Chiller Power Curve



Waste Heat Chiller Assist of Small Package Rooftop.



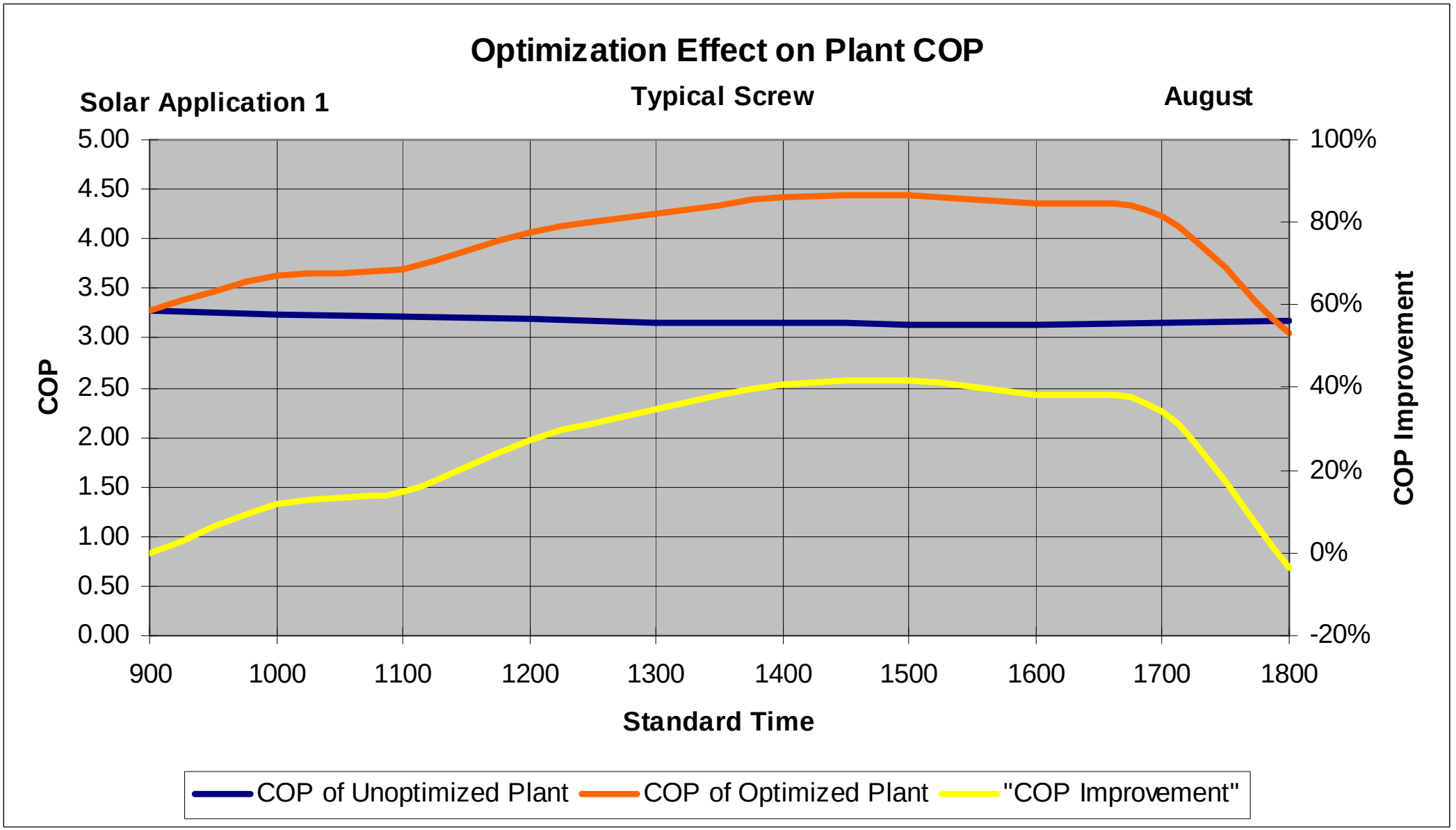
Conclusion

- Solar thermal chilled water can impact energy use beyond the solar contribution.
- Don’t under-power the system.
- Size the collectors coincident with the load.
- Do NOT attempt to STORE heat for use after the sun is gone.
- Always have a heat dump.
- For a practical system, combine sound engineering principles with a healthy dose of common sense.
- Don’t forget the heat balance!

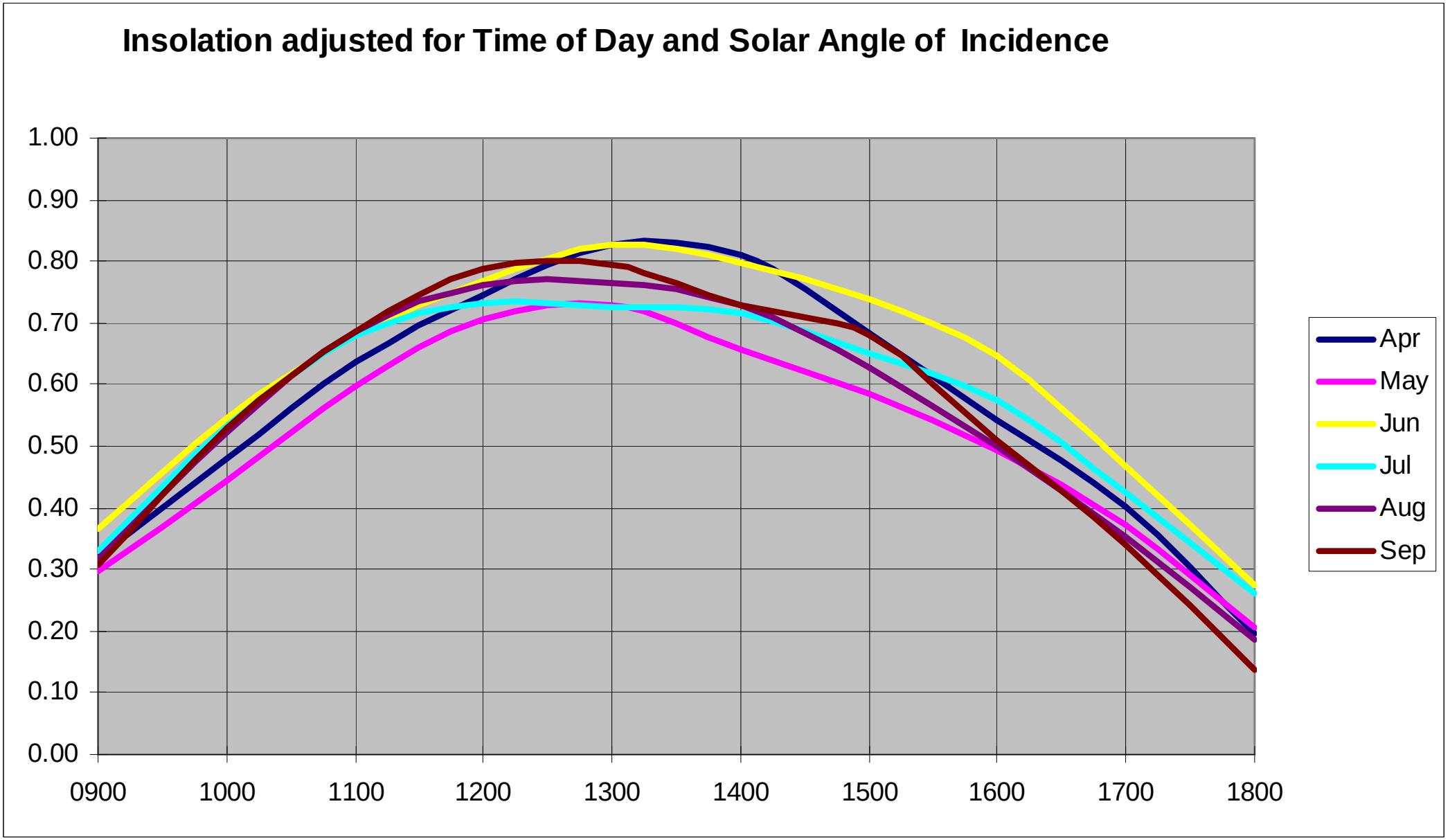
Beware of Junk Science

- Radiant Cooling
- Chilled Beams (indefinite maybe)
- Parking Lot solar collector
- Dark Body Radiation Cooling
- SEER
  - Or any other “Propaganda” or “One Size Fits All” based program.
  - Most Energy Star requirements are now based on real engineering

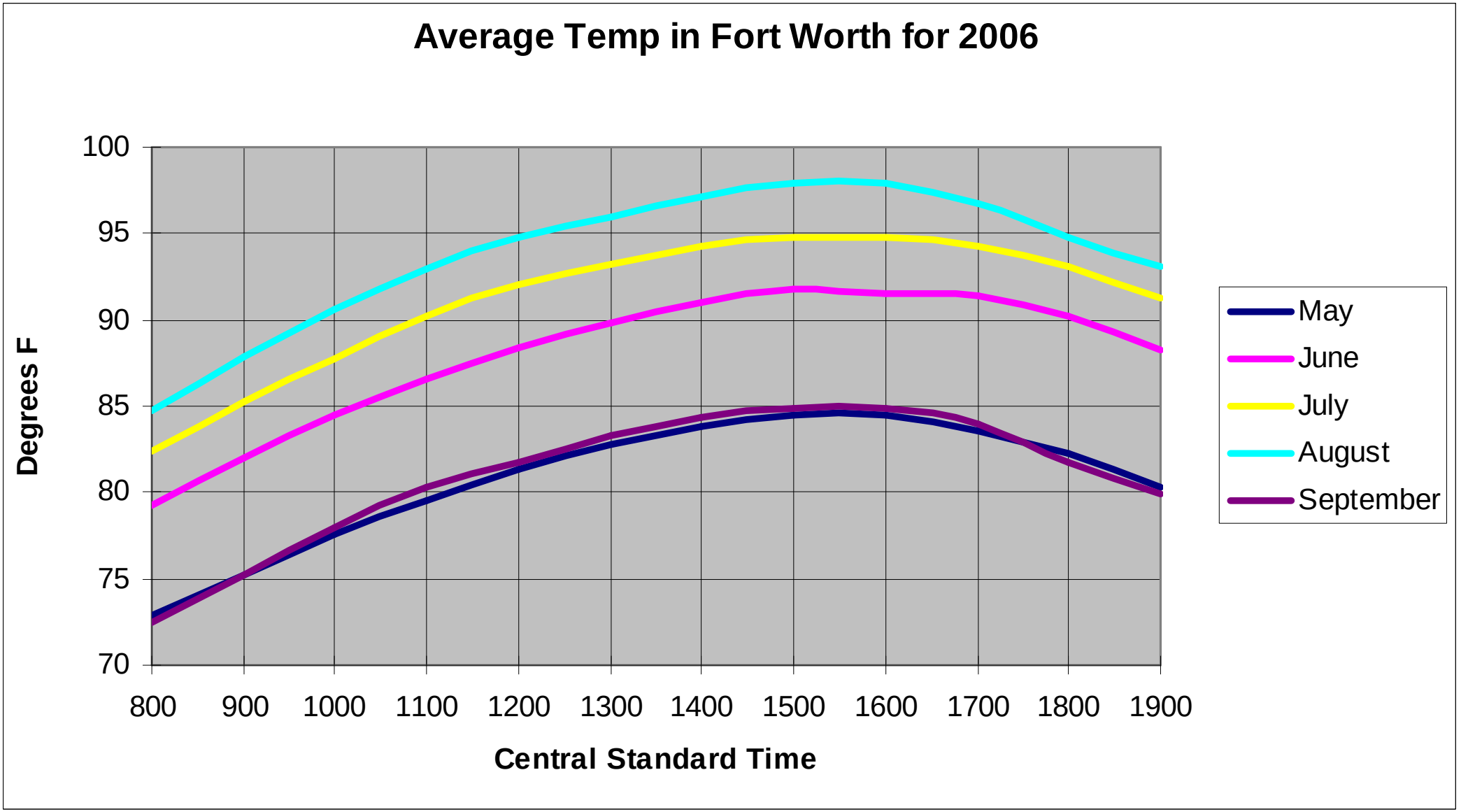
Does this design achieve a 40% improvement in plant efficiency?



How much solar energy is available at my location?



What time of day represents the peak load on the building?



The Final Result