INTEGRATED THERMAL ENERGY STORAGE

Presented to the IDEA Conference by
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Chiller Solutions, Technology and Innovation Group
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YORK®

Johnson Controls

Features & Benefits

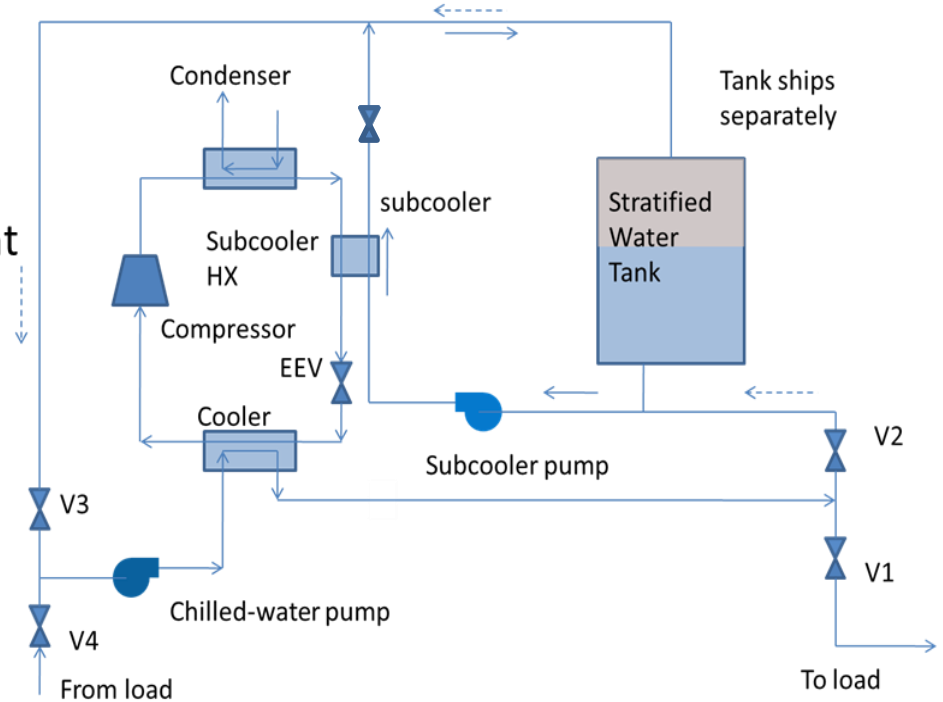
- Boost both capacity AND efficiency by approx. 50% under high ambient (115°F) conditions, 30% at 95°F ambient.
- Downsize chiller, and keep competitive footprint.
- Thermal storage using water allows faster recharge at night during off-peak.
- May allow for larger air-cooled chillers in California (meeting the thermal storage exception).
- Improved cost and performance vs. standard chiller, and vs. ice thermal storage systems.

Operation & Design

How It Works

Subcooling mode: Close valves V2 and V3 open V1 and V4. Run chilled-water pump and subcooler pump. Cold water at bottom of tank cools refrigerant liquid. Warm water returns to top of tank. Subcooler water flow is a small fraction of cooler flow.

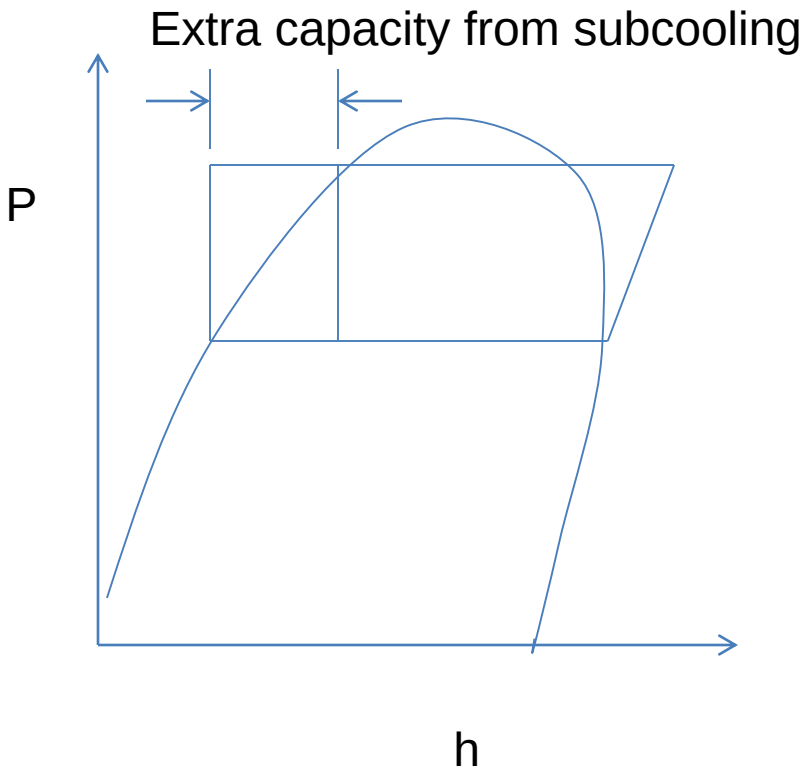
Recharge mode:
Valves V1 and V4 close;
V2 and V3 open. Subcooler pump is off; chilled-water pump is on. Chiller gradually cools water in tank with large flow of water.



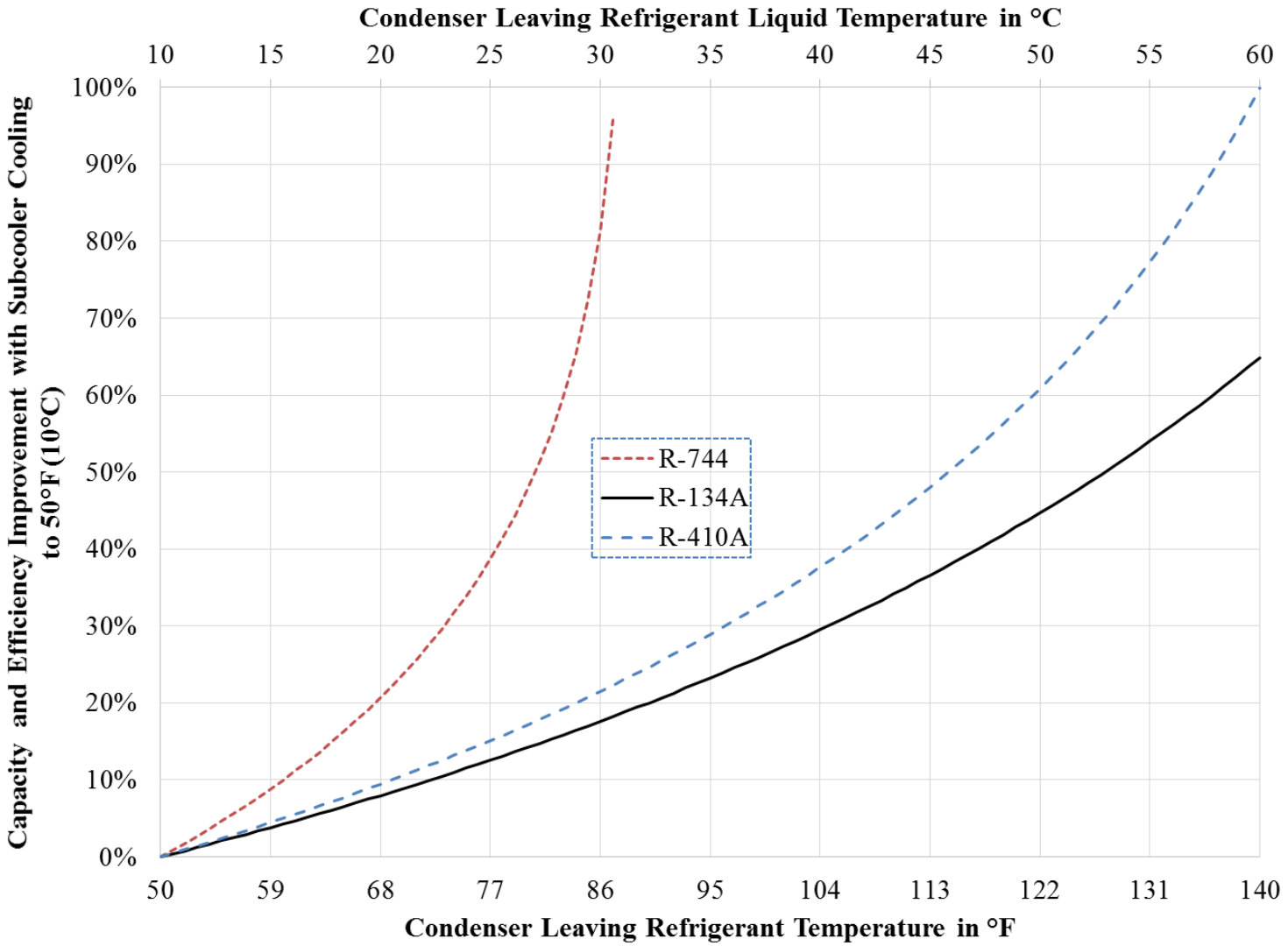
Valves provide pressure isolation for tank in both operating modes. Multiple tanks may also be used.

Theory of Operation

- Subcooling adds ~.5-.7%/°F in capacity
- No increase in compressor work
- Counterflow HX allows water to approach refrigerant liquid temperature
- Warm water reduces tank recharge energy

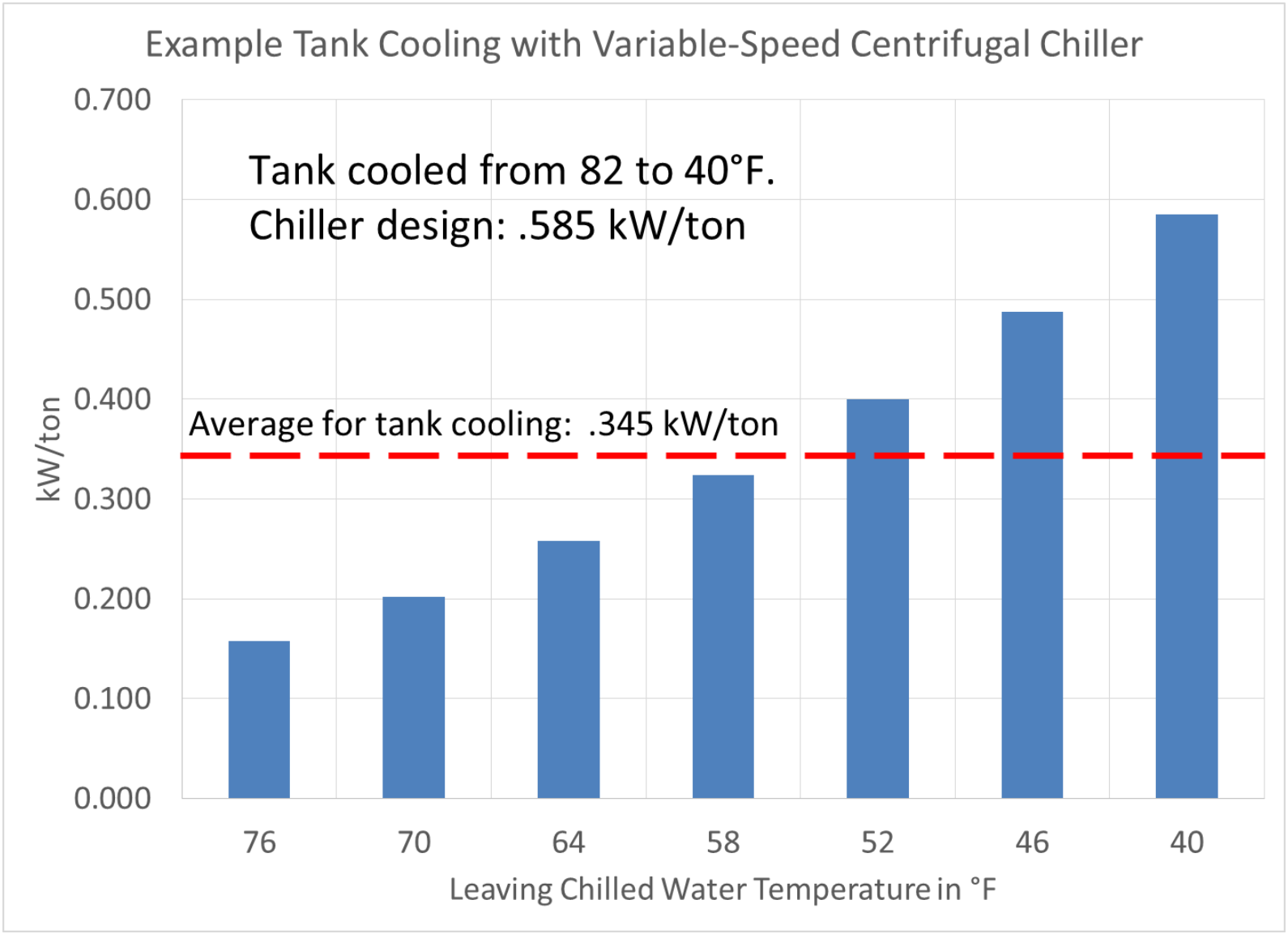


Theoretical Benefit from Subcooling



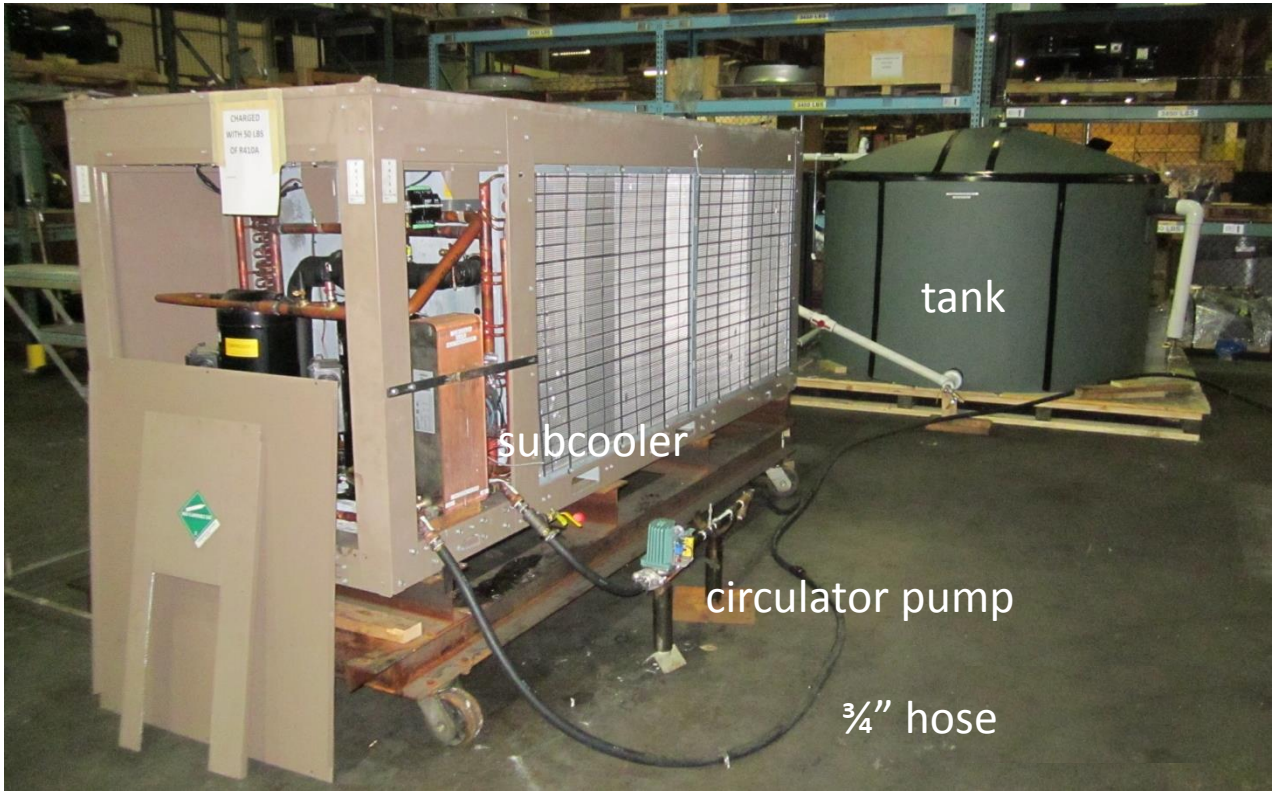
Source: W.L. Kopko, “Integrated Thermal Energy Storage”, Purdue Conference 2016.

Energy (kWh) Benefit

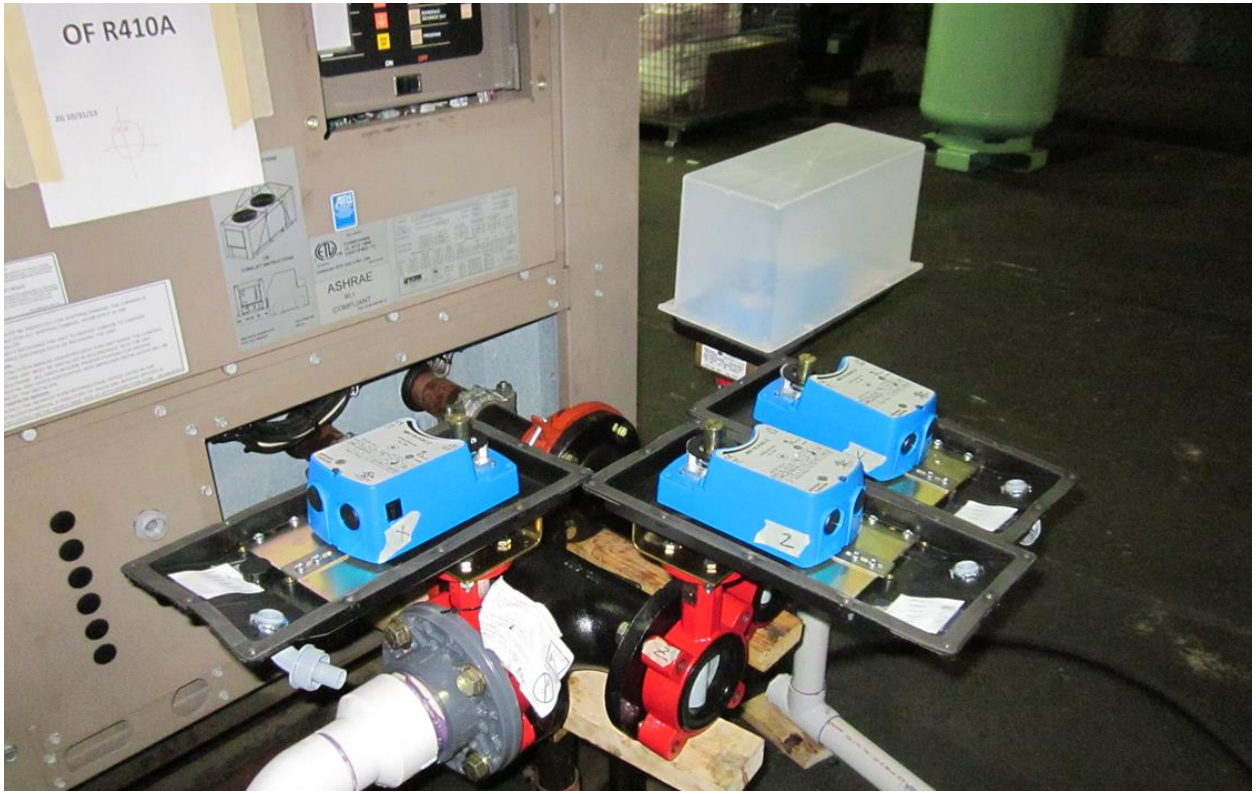


Performance Data

Laboratory Setup



Valving for Lab Test



Valves were oversized for test chiller.

Measured Performance at AHRI Conditions

	Base	ITES	Change	units	% Change
Capacity	27.8	35.6	7.9	tons	**28%**
Input power	32.0	31.4	-0.5	kW	**-2%**
EER	10.4	13.6	3.2	Btu/W-hr	**30%**

Performance at 95°F ambient 54/44°F chilled water temperature.

Measured Performance at High Ambient Conditions

	Base	ITES	Change		%Change
Capacity	23.5	34.9	11.4	tons	**49%**
Input Power	38.4	37.5	-0.9	kW	**-2%**
EER	7.33	11.2	3.8	Btu/W-hr	**52%**

Performance at 115˚F ambient 54/44˚F chilled water temperature.

NYSERDA Demonstration in Syracuse, New York

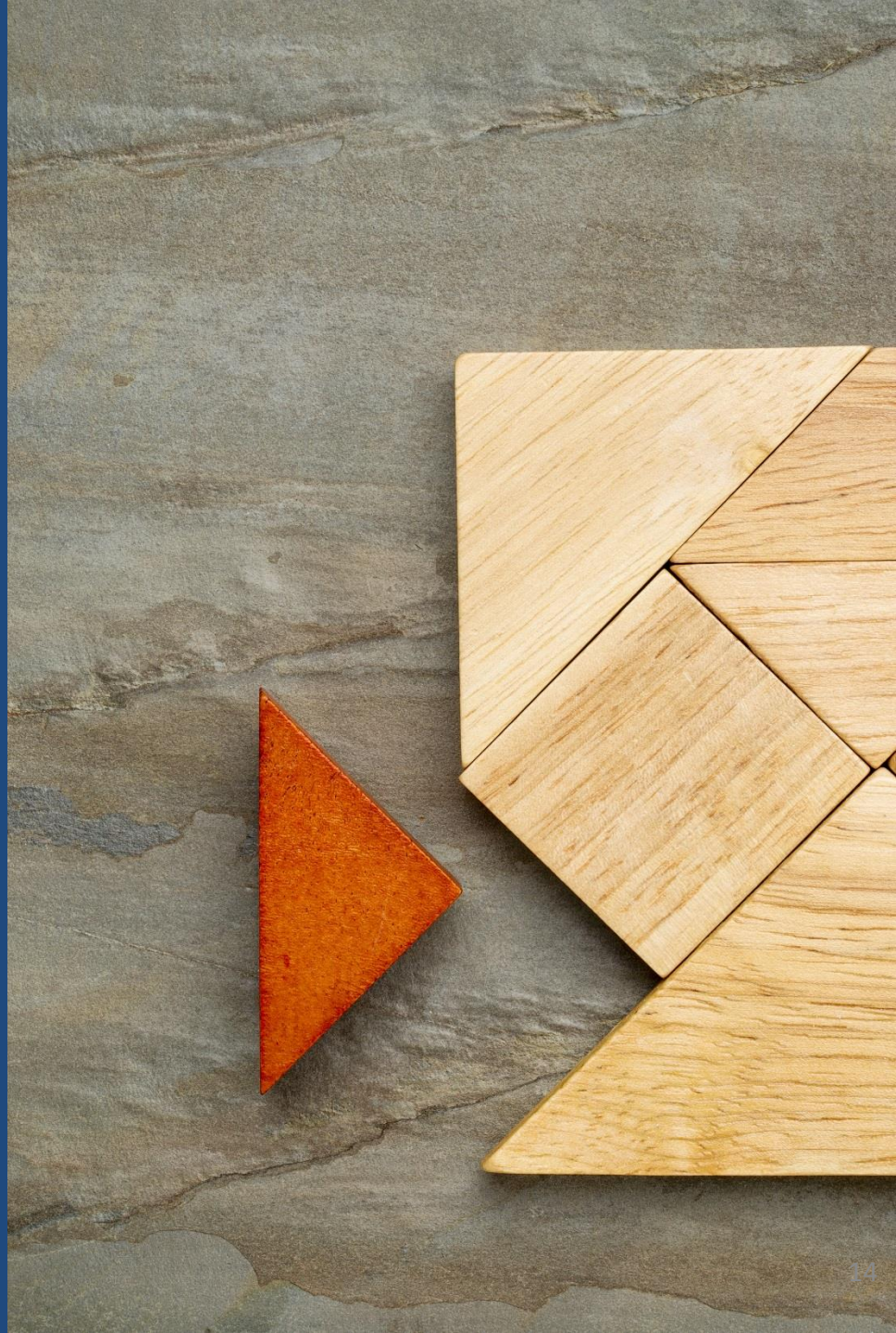
Added system to existing air-cooled scroll chiller

Increased peak capacity and efficiency by about 25% at 90°F ambient

Conventional water tank with insulation

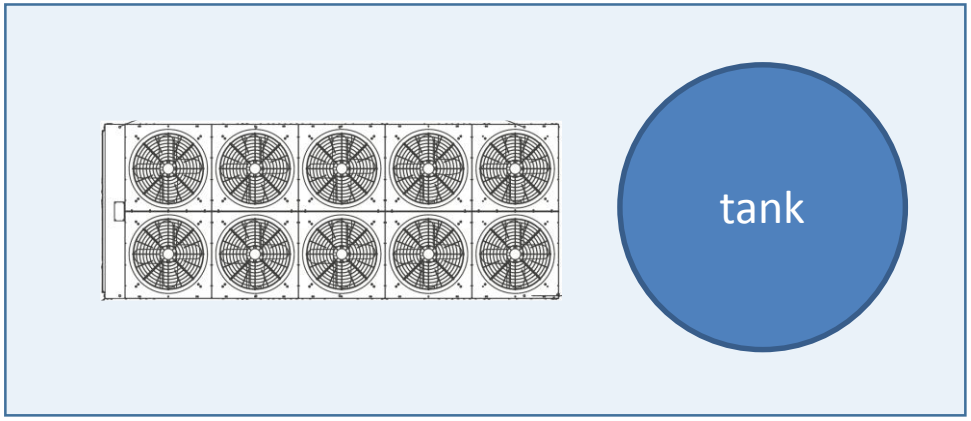
Used a second small chiller for tank cooling to simplify installation

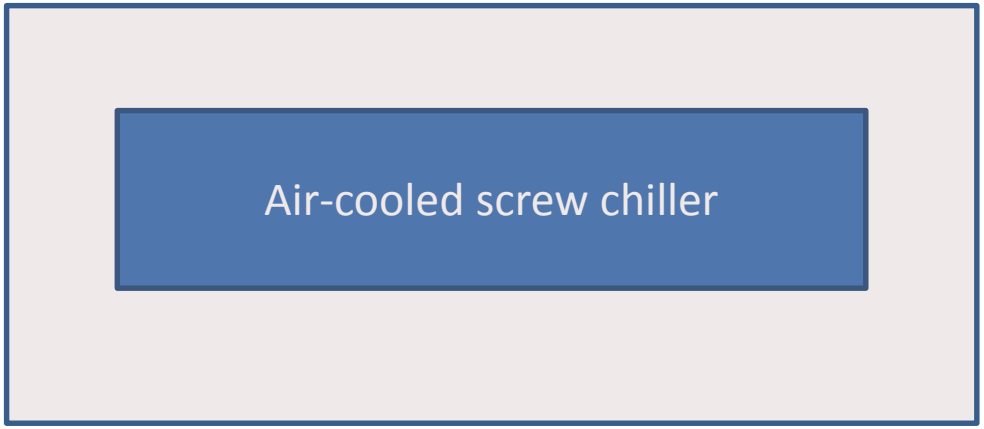
Comparison with Existing Chillers



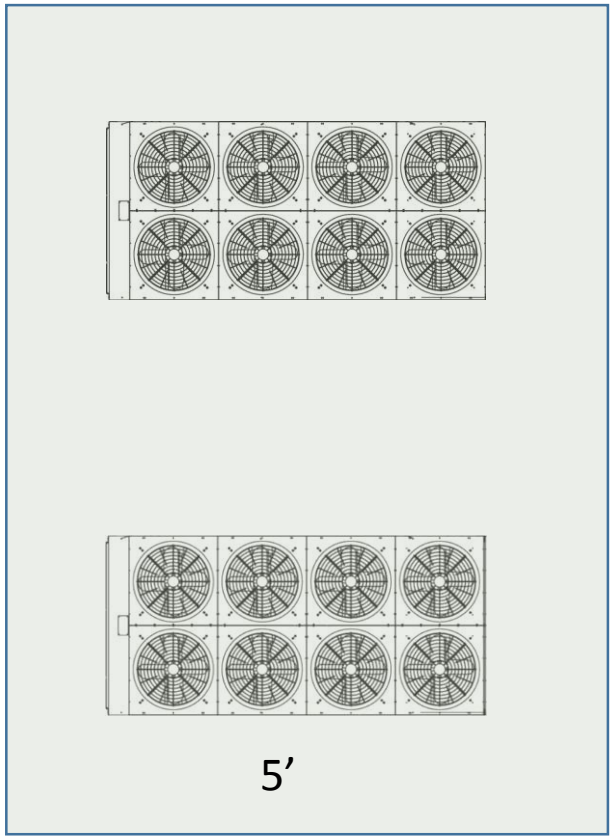
ITES Footprint is Competitive

ITES with scroll chiller 40ft x17.5 ft = **700** ft²





40.5 ft x 17.5 ft = **708** ft²



Two air-cooled scroll chillers

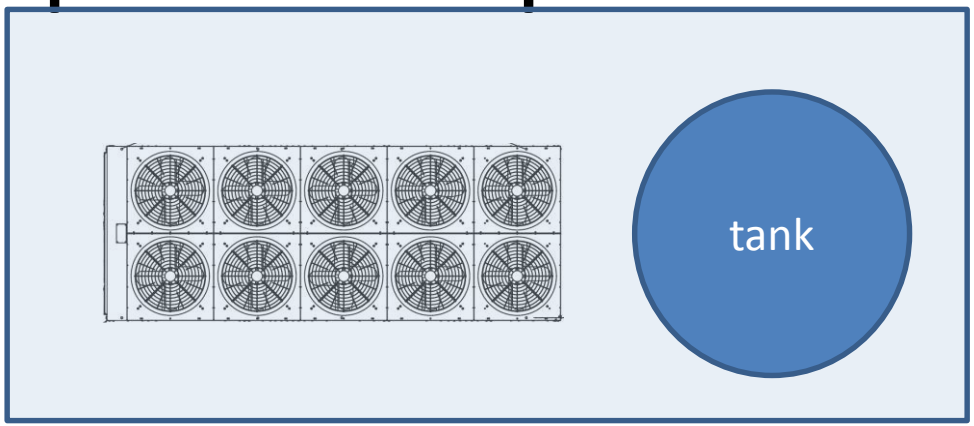
24.5 ft x 35 ft = **857**ft²

All systems have about 220-ton capacity at 115 °F ambient.

ITES Footprint Compared to Ice

ITES: 40 ft x 17.5 ft =

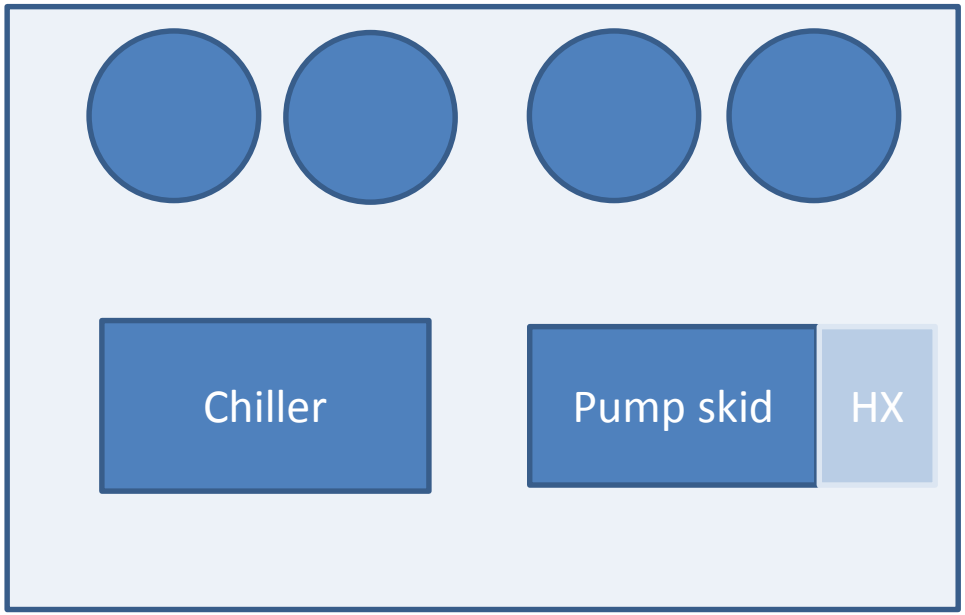
700 ft^2



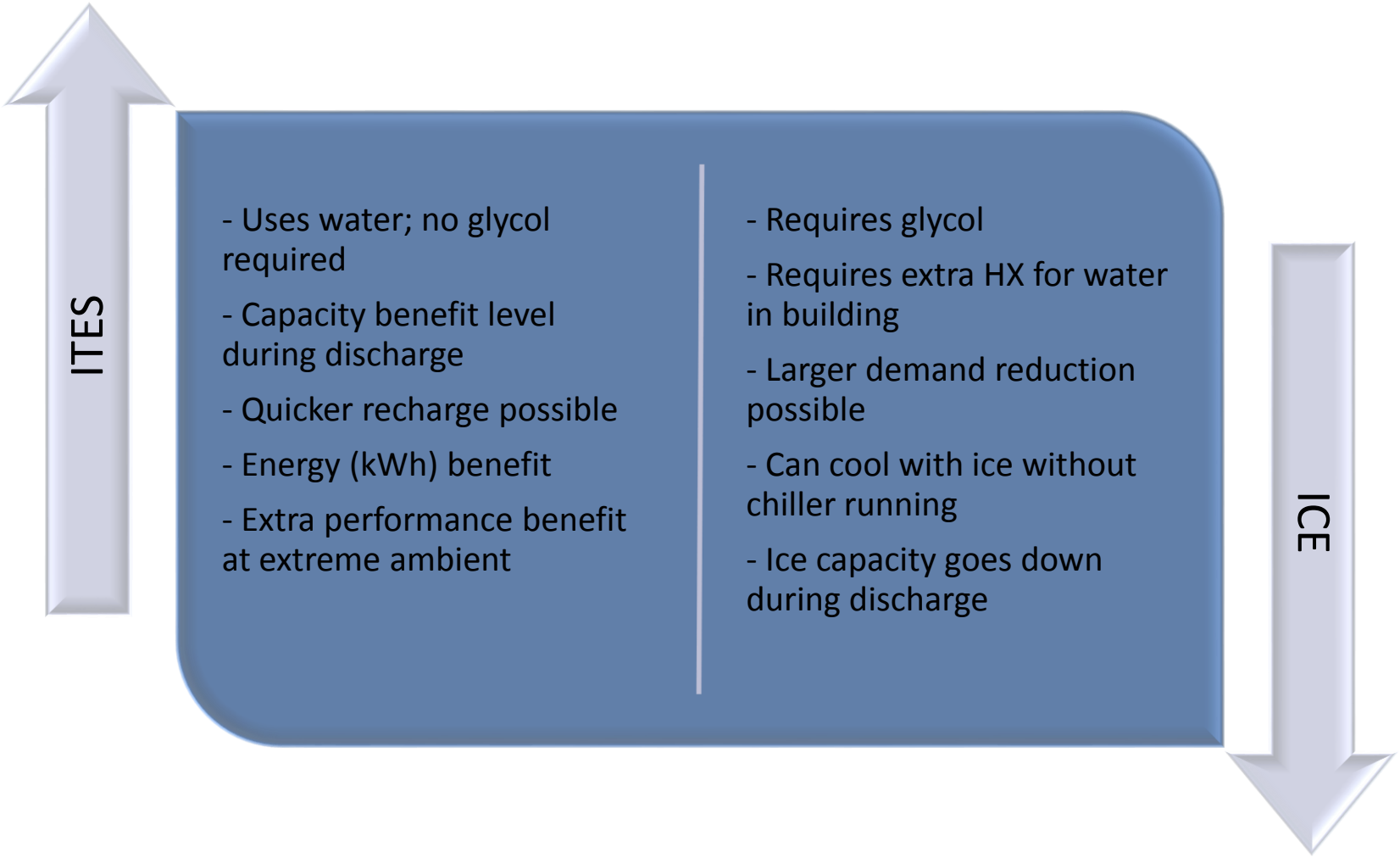
Example ice system:

40 ft x 25 ft =

1000 ft^2



Comparison with Ice Systems



Analysis for Middle East Two-Stage Centrifugal Chiller with Dry Towers

	Base system	ITES system at peak	
Peak Capacity	2000	2563	tons
Input power	2752	2484	kW
COP	2.556	3.629	
Capacity change	0%	**28%**	
Efficiency change	0%	**42%**	
Heat rejection per ton	0%	**-37%**	

Peak Electric Demand for 10,000-Ton Chiller Plant

	Base	ITES System	
Chillers	13760	9136	kW
Condenser pumps	600	377	kW
Condenser fans	1827	1148	kW
Subcooler pumps	0	12	kW
Total power	16187	10674	kw
Savings		**5513**	**kW**
		34%	

Base plant used five 2000-ton chillers.
ITES system with subcooler uses four 2500-ton chillers.
Plant load is assumed to be lower at night and morning to allow recharge.

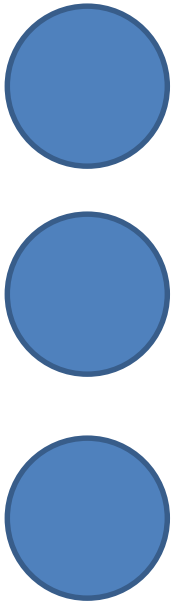
New System Can Reduce Total Footprint

Base with 35 radiators

1	13	25
2	14	26
3	15	27
4	16	28
5	17	29
6	18	30
7	19	31
8	20	32
9	21	33
10	22	34
11	23	35
12	24	

New with 22 radiators and 3 tanks

1	12
2	13
3	14
4	15
5	16
6	17
7	18
8	19
9	20
10	21
11	22



Radiator dimensions are 52 x 21 ft including space between units.
Tank diameter is 42 ft and height is 30 ft. Both systems are 10000 tons in size.
The third tank is a spare; other tank configurations are possible.

Wide Range of Possible Applications

- Air-cooled or water-cooled chillers
- Screw, scroll, or centrifugal
- New or existing systems
- Increase capacity of existing chilled water storage system
- Non-chiller systems

Advantages of ITES

- Energy density close to that for ice storage using conventional water tanks
- ~50% increase in peak capacity demonstrated
- Capacity benefit increases at higher ambient conditions
- Simple valving provides pressure isolation
- Can improve overall system efficiency
- Potential for lower first cost than system without energy storage

Thank you!

Any Questions?

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Visit me at booth 67.