

Ecodistrict and Beyond

SMUD Campus Case Study: Net Zero at Scale



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Twin Woods Development
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SMUD Campus: Net Zero at Scale

**Sacramento Municipal Utility District
East Campus Operation Center**



Changing the World



Zakir Hossain Chowdhury/Zuma Wire/Zuma Press

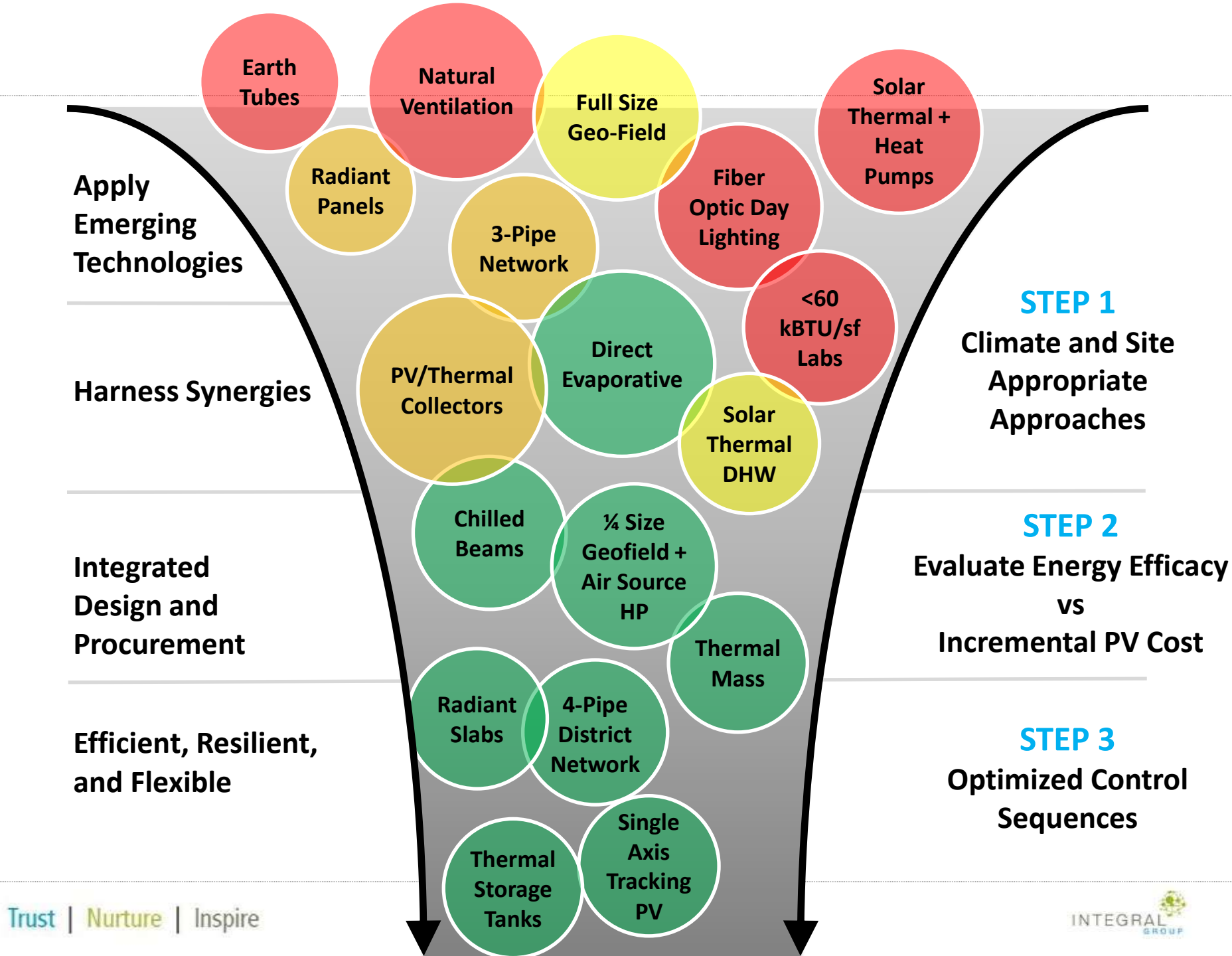
Climate Sensitive Approach

- Highly Shaded Envelope
- Direct/Indirect Evaporative Cooling
- Heat Recovery Wheels
- Radiant Heating/Cooling
- Horizontal Geothermal
- Air Source Heat Pump
- Heat Recovery Chillers



Design Charrette





Air Source Plus Ground Field

Hybrid Design

Air Source Heat Pump



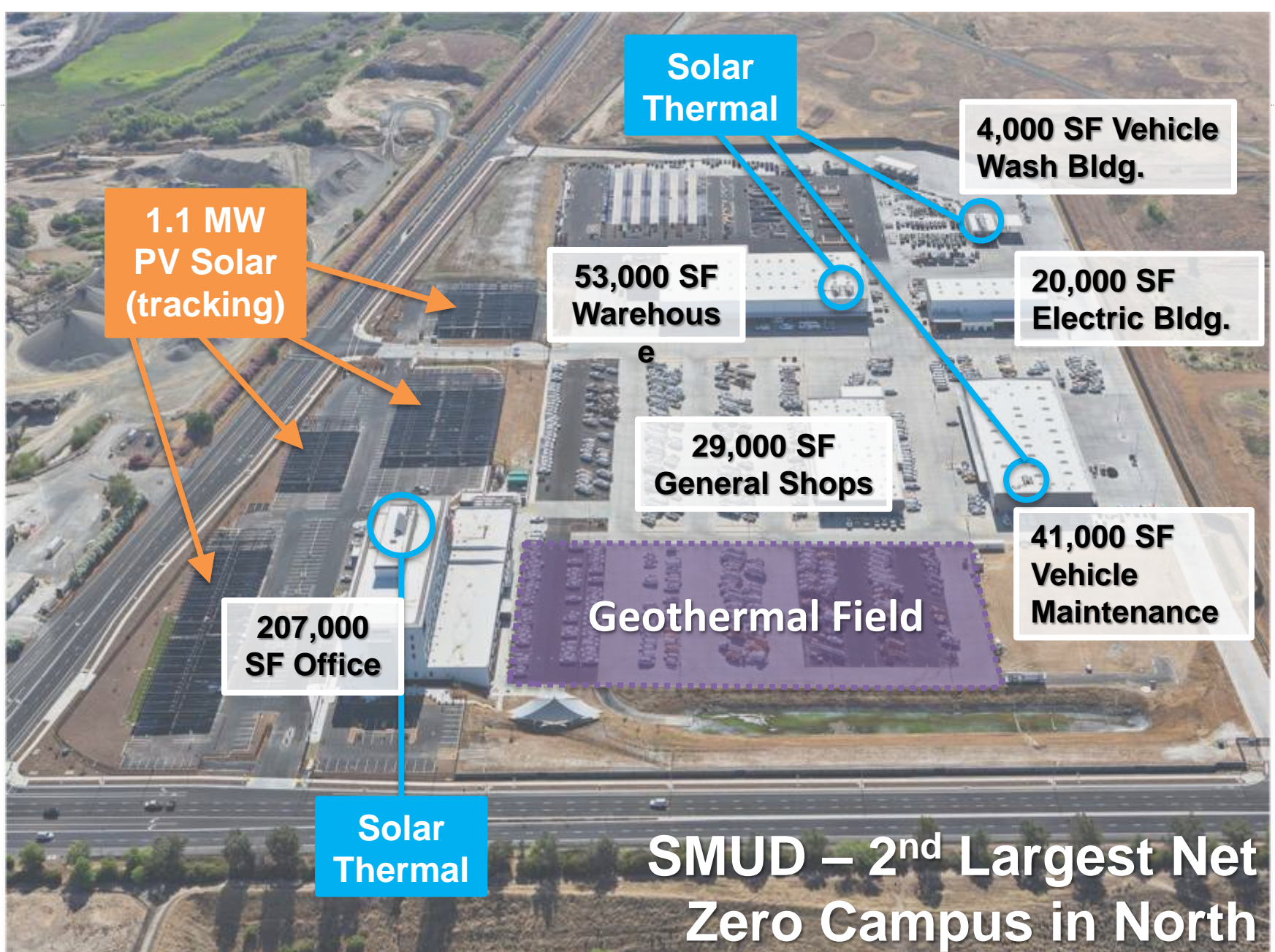
- 1/4 Ground field size
- ~\$600k savings
- Less than 5% increase energy consumption

VS.

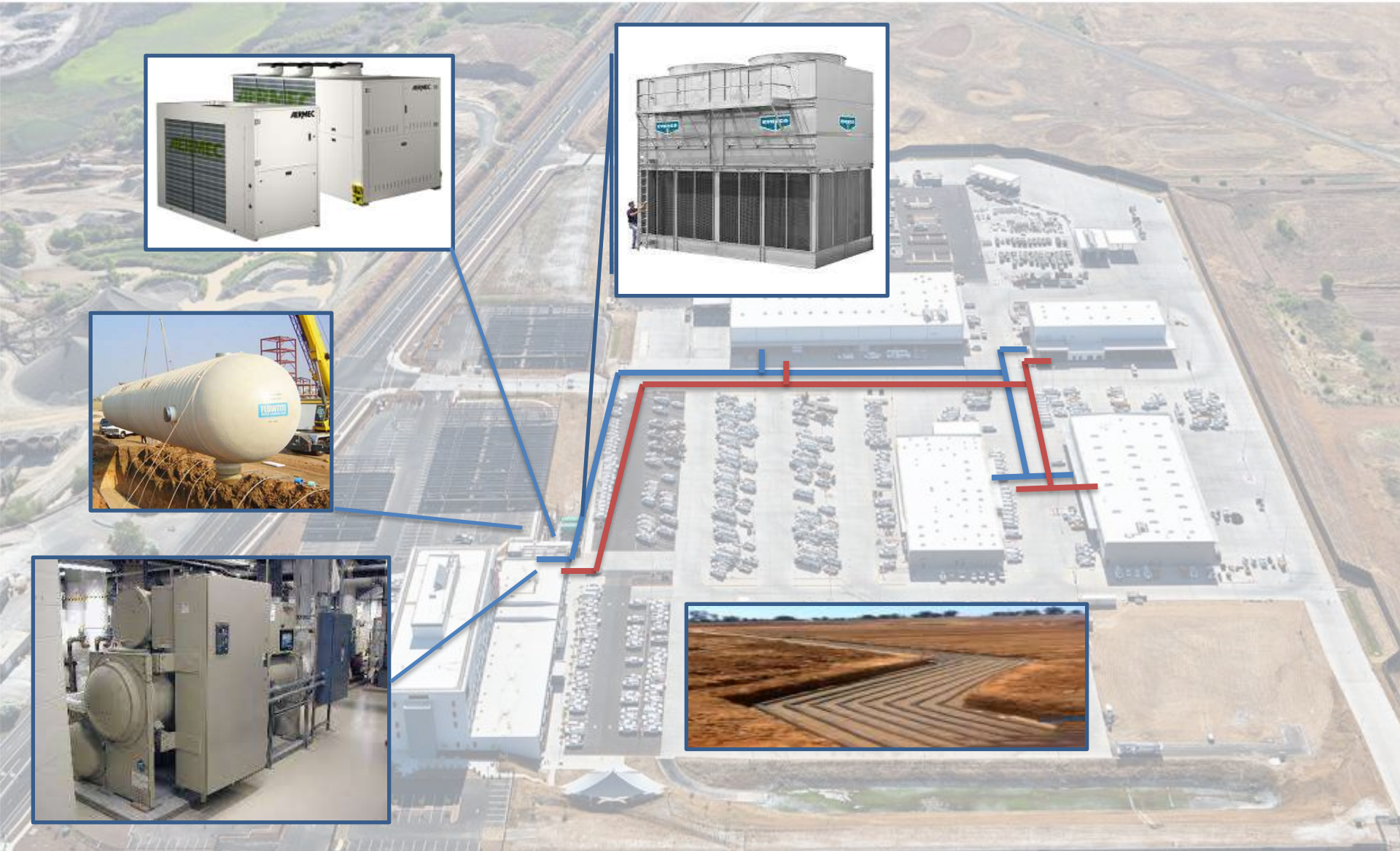
Conventional Geo-Exchange



Full Size Horizontal
Ground Field



4-Pipe Distributed Heating and Cooling Network



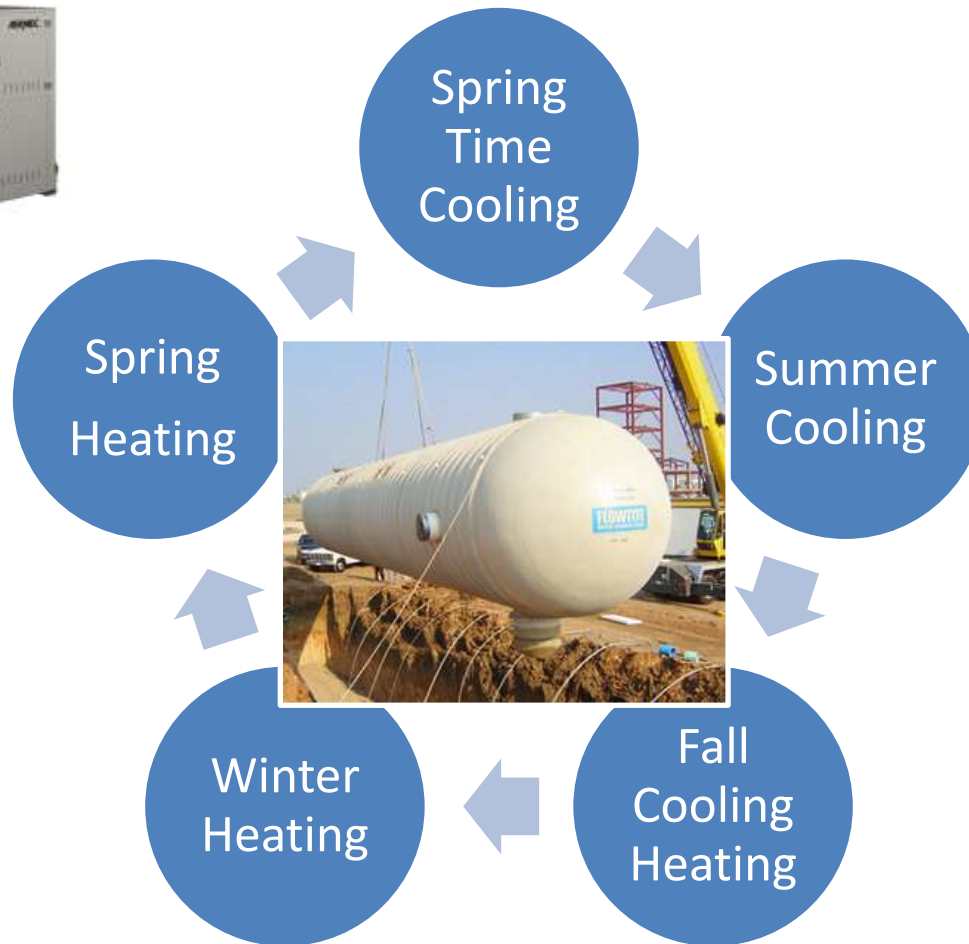
Hybrid System



Air Source
Heat Pump



Horizontal
Geofield



Cooling Towers

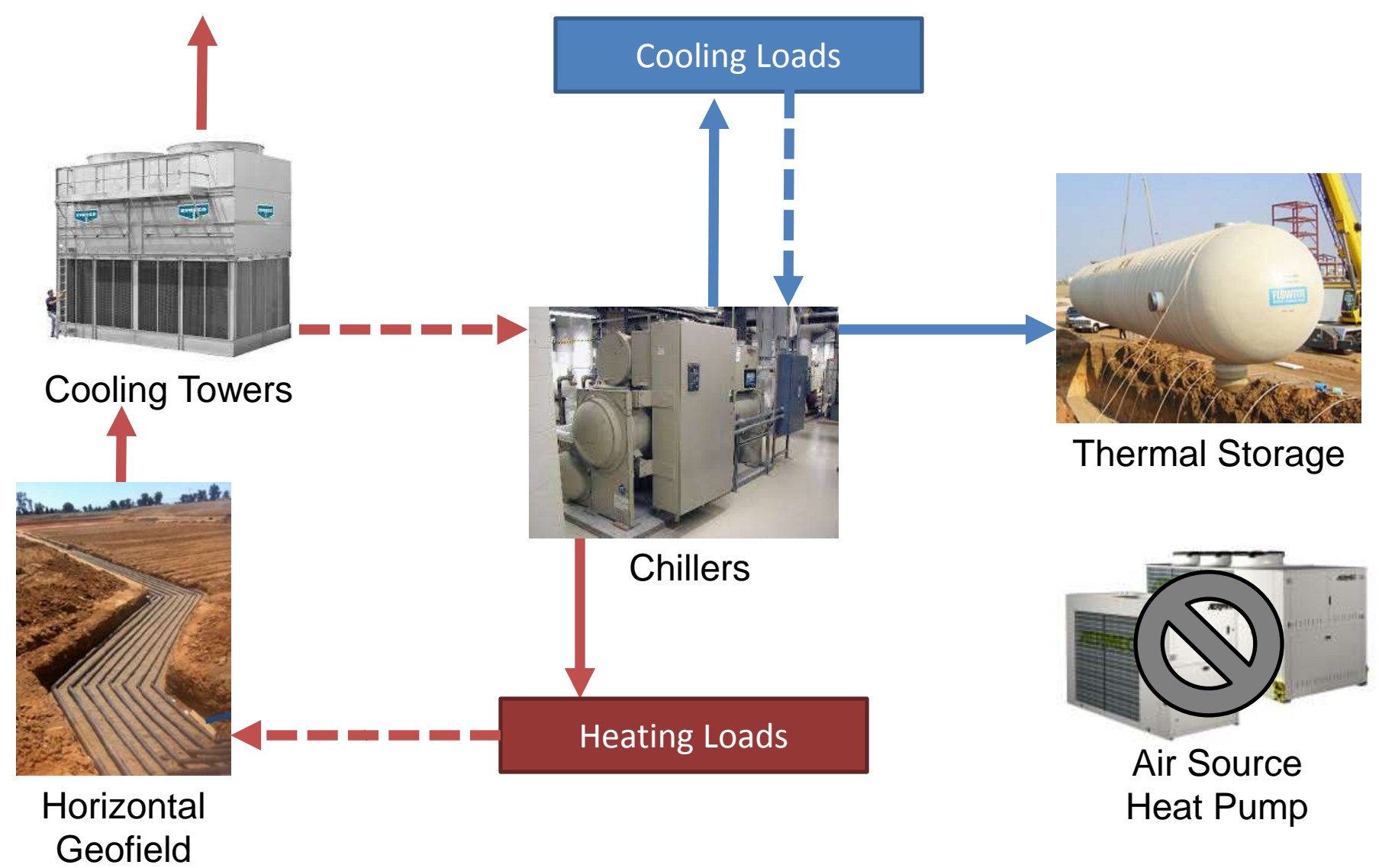


Chillers

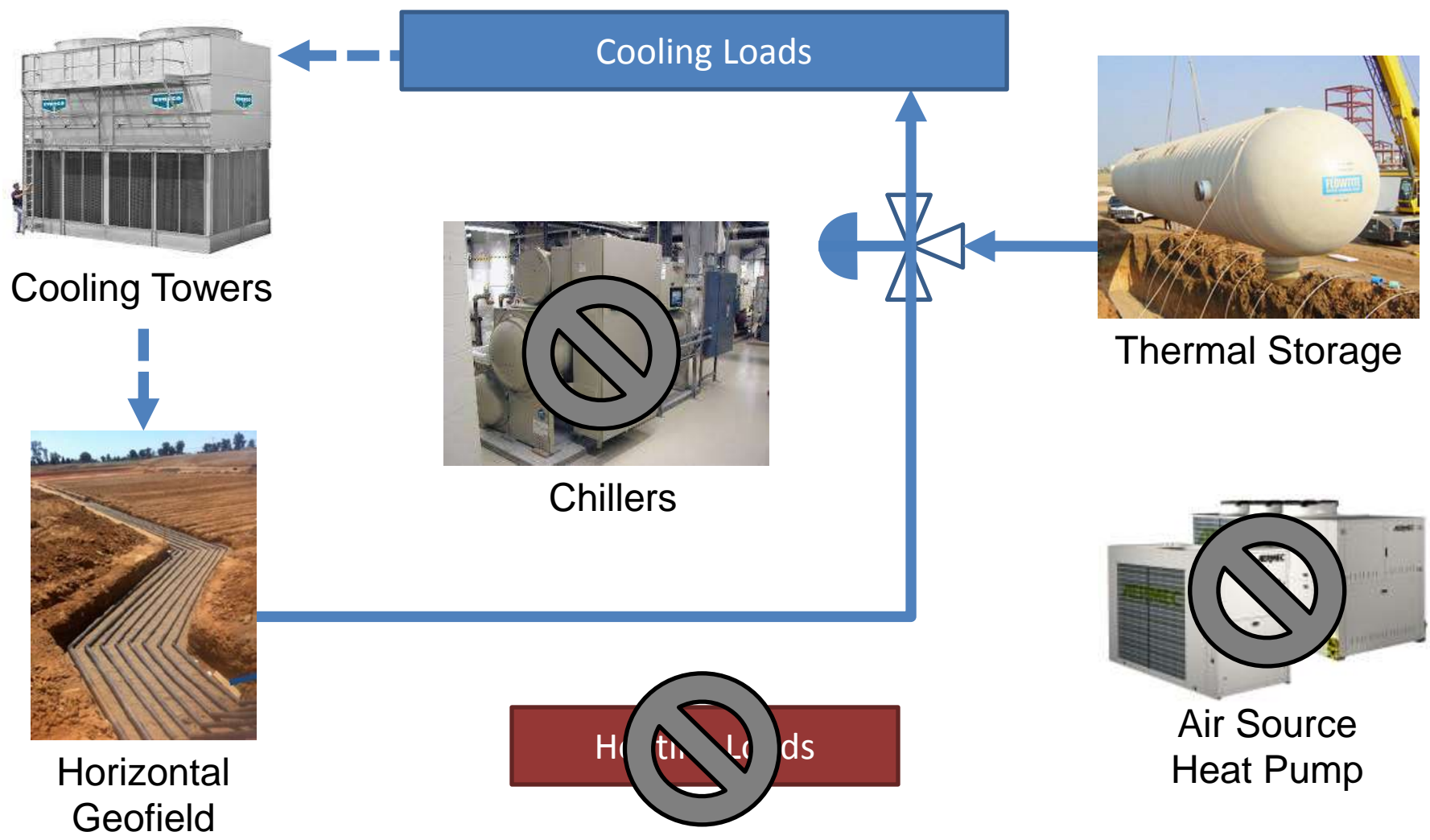
14 Optimized Modes of Operation

- 1A) TES tank charging with cold using the Cooling Tower and Chiller(s) only.**
- 1B) TES tank charging with cold using the Geofield and Cooling Tower with Chillers.**
- 2A) Free cooling using the Geofield and Cooling Tower directly.**
- 2B) Free cooling using Geofield and Cooling Tower augmented with discharge from the TES.**
- 2C) Free cooling with Cooling Tower only.**
- 2D) Free Cooling with Cooling Tower augmented with discharge from the TES.**
- 2E) Cooling with the Chiller(s) using Geofield and Cooling Tower to cool condenser water.**
- 2F) Cooling with the Chiller(s) using the Cooling Tower to cool condenser water.**
- 3A) TES tank charging hot using Chiller and Geofield only**
- 3B) TES tank charging hot using Chiller, Geofield, and Air Source Heat Pump**
- 4A) Heating dominant with Chiller and Geofield only**
- 4B) Heating dominant with Chiller, Geofield, and Air Source Heat Pump**
- 4C) Heating dominant with Chiller, Geofield, and TES discharging**
- 4D) Heating dominant with Chiller, Geofield, TES discharging, and Air Source Heat Pump**

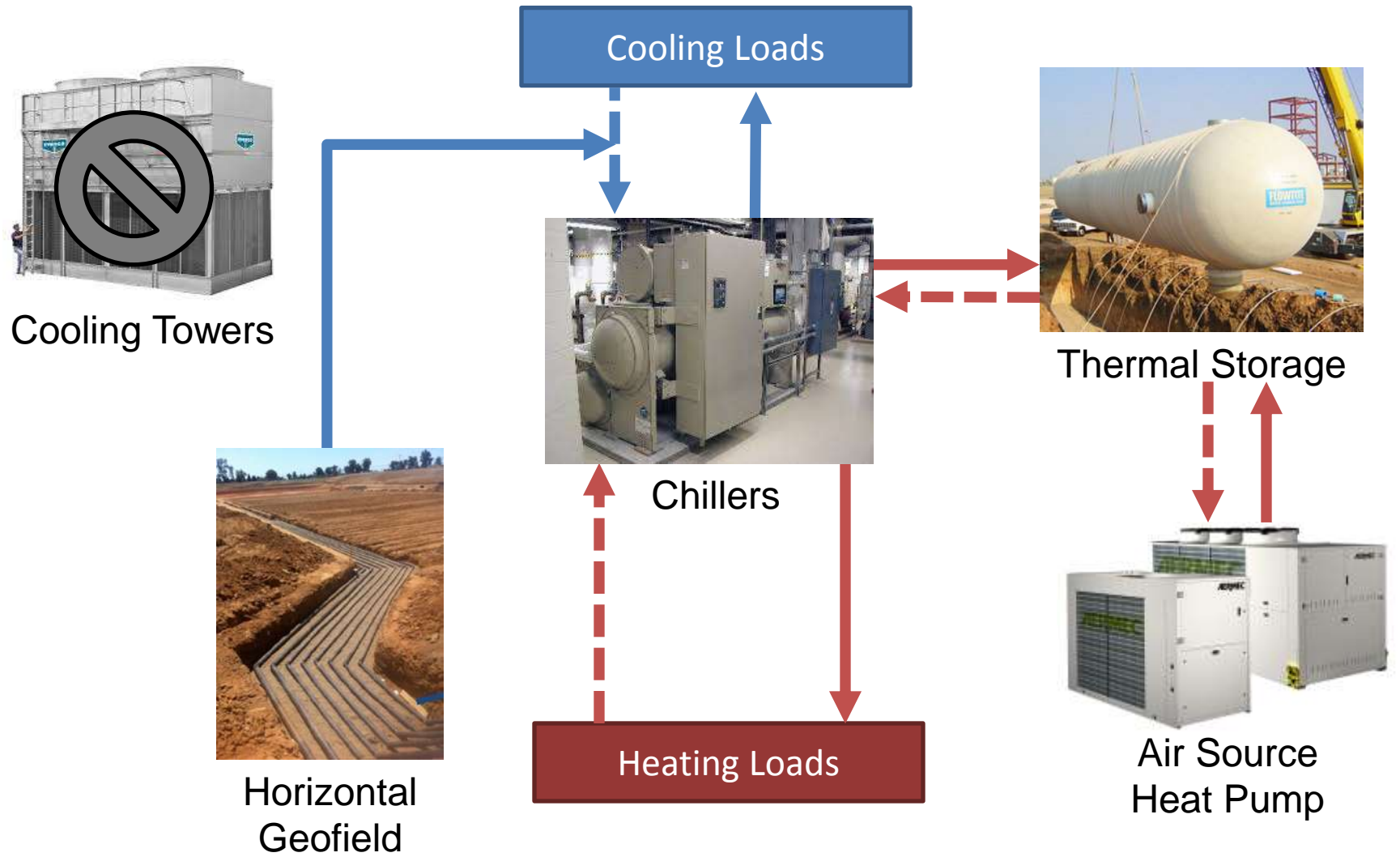
Hybrid System: (1B) TES tank charging with cold using the Geofield and Cooling Tower with Chillers.



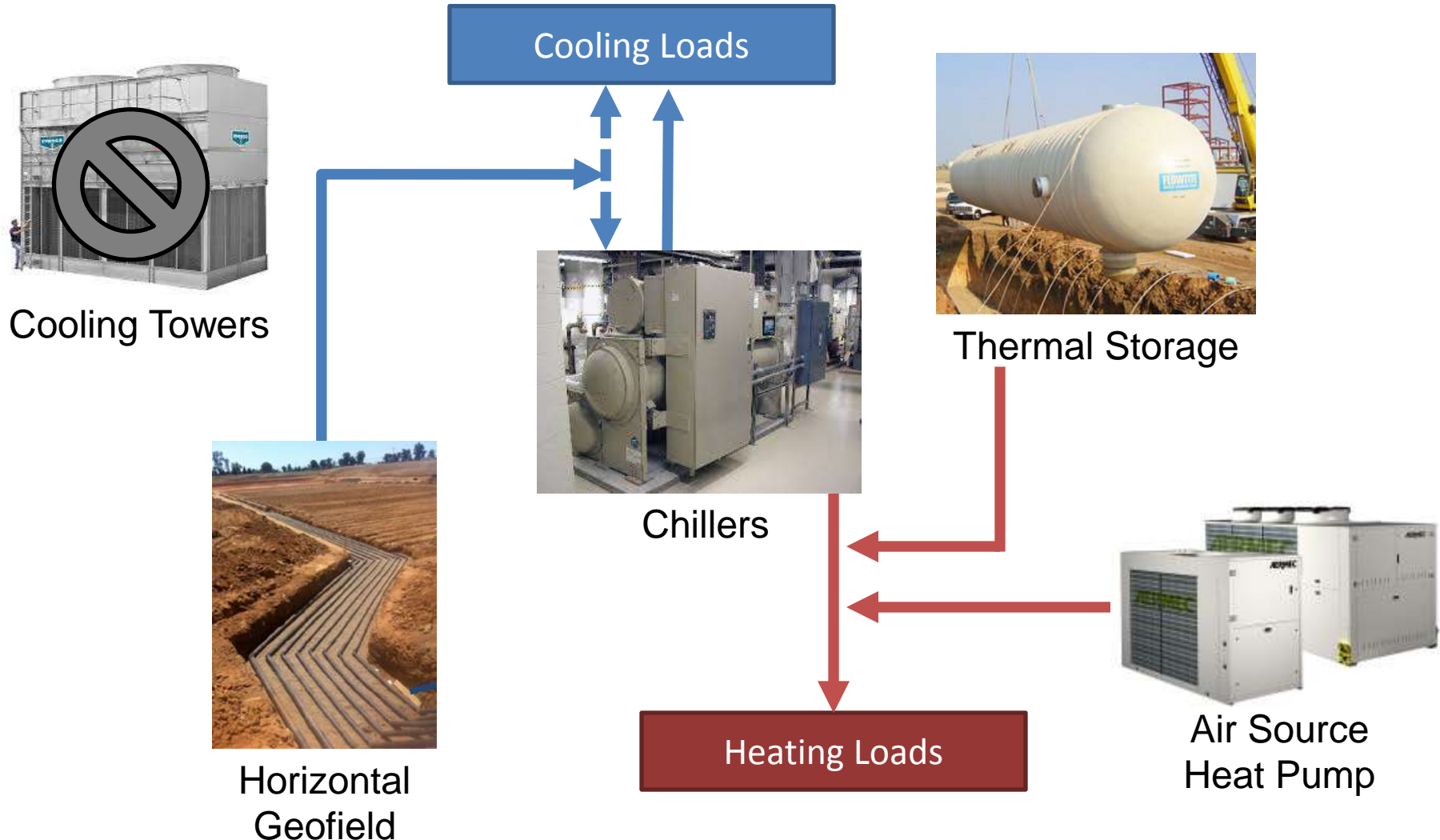
Hybrid System: (2B) Free cooling using Geofield and Cooling Tower augmented with discharge from the TES.



Hybrid System: (3B) TES tank charging hot using Chiller, Geofield, and Air Source Heat Pump

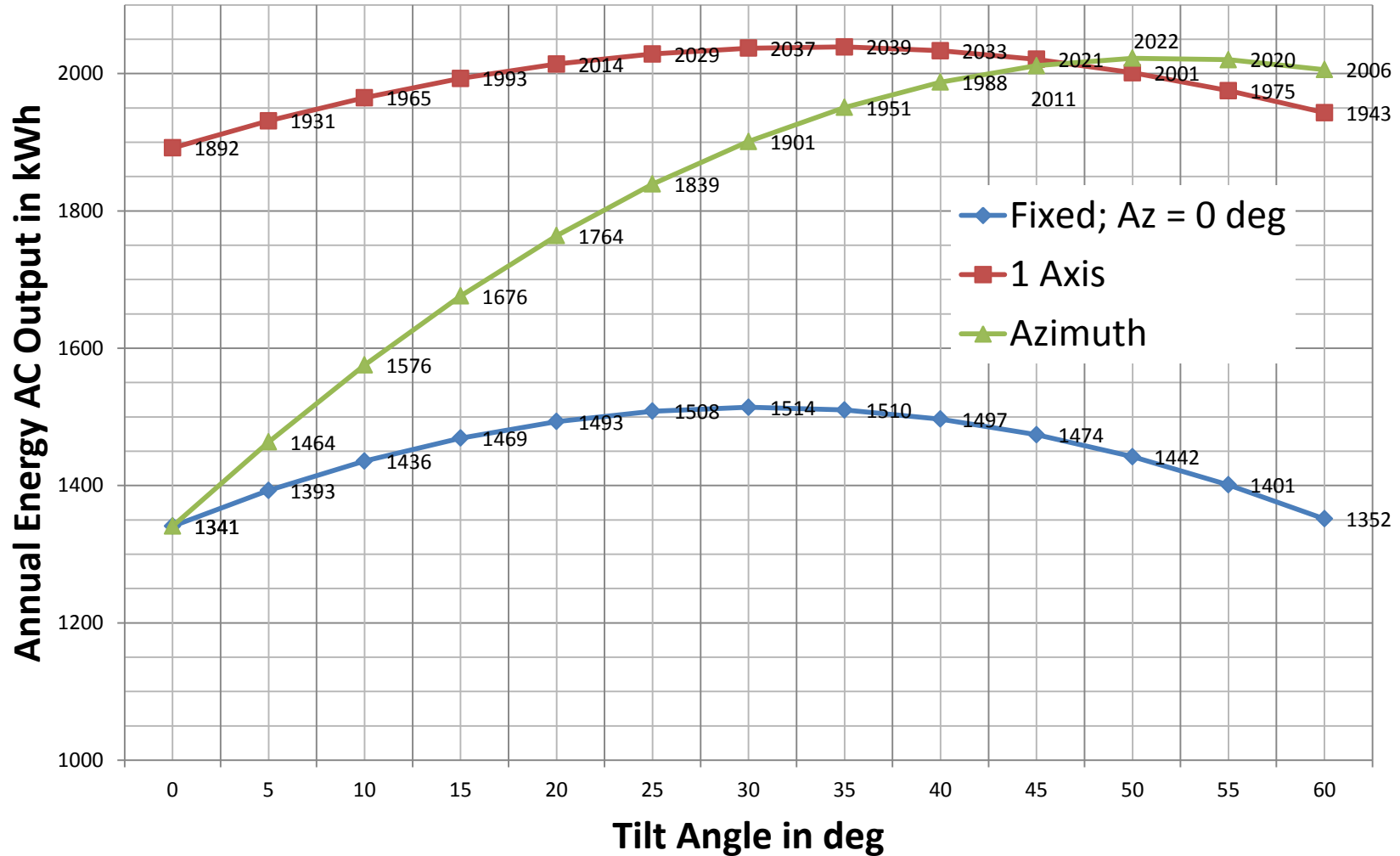


Hybrid System: (4D) Heating dominant with Chiller, Geofield, TES discharging, and Air Source Heat Pump



Single Axis Tracking: 1.6 MW drops to 1.1 MW

Climate Sacramento; 1kWdc Sanyo HIP-200BA3; Total Derate factor 84%



Efficient Building and Efficient HVAC Plant

Net Zero Campus Design

- 1.1 MW Single Axis Tracking Array
- 2,014,000 kWh per annum
- 2/3 the Energy Requirement of Concept
- 0.5 MW less PV due to Single Axis Tracking
- PV Differential of \$6M from Concept

CAMPUS ENERGY

$$2,756,000 \text{ kWh} \\ +10\% = 3,032,000 \text{ kWh}$$

PV w/ 10° TILT & 80% COVERAGE

$$\text{SYSTEM} = 2.3 \text{ MW} \\ = 3,069,000 \text{ kWh}$$

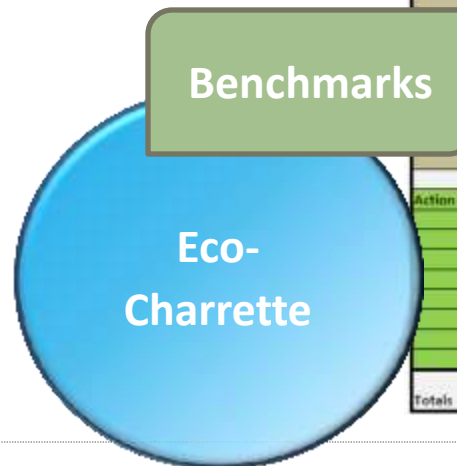
PV w/ 0° TILT & 80% COVERAGE

$$\text{SYSTEM} = 2.3 \text{ MW} \\ = 2,855,000 \text{ kWh}$$



Energy Use Intensity (EUI) Targets

- Benchmark Data Prior to Workshop
- Estimate Reductions During Workshop
- Validate and Reset Targets During Schematics



Area Name	Building Name	General Building Type	Bldg Area (SF)	CEBCS EUI (kbtu/sf)	Target EUI Reduction (%)	Target EUI (kbtu/sqft/yr)	Target Energy Use (kbtu/yr)
Other							
	Affiliated Exhibit Expo	Exhibit	8,640	98.3	75%	24.6	212,246
	National Exhibit Expo	Exhibit	8,640	98.3	75%	24.6	212,246
	Arena Restrooms	Restrooms	960	20.7	85%	3.1	2,982
	Arena Show	Service/Shop	9,660	78.6	60%	31.5	303,873
The Cove							
	Boat House	Warehouse	6,620	46.3	75%	11.6	76,640
	Cove Dining	Fast Food	3,300	431.6	60%	172.6	413,099
	Area Restroom 1	Restrooms	820	20.7	85%	3.1	2,547
	Area Restroom 2	Restrooms	780	20.7	85%	3.1	2,423
	Better Body, Better Life	Theater	8,000	98.3	70%	29.5	235,829
	Conservation Lodge	Exhibit	13,000	98.3	70%	29.5	326,128
	Cove Outfitters	Retail	6,240	95.0	55%	42.7	266,625
	Climbing & Rapelling	Warehouse	1,210	46.3	70%	13.9	16,810
Legacy							
	National Scout Museum	Exhibit	30,000	98.3	70%	29.5	834,244
	Merit Badge Center	Activity	3,020	98.3	90%	9.8	29,675
	Spirit of Scouting	Theater	17,376	98.3	45%	54.0	364,581
	Eagle's Flight	Theater	13,869	98.3	40%	59.0	512,928
	Eagle's Lodge	Lodging	14,720	104.3	70%	31.3	234,596
	Eagle's Lodge	Classroom/Conference	14,500	88.3	70%	26.5	344,362
	The Summit Lodge	Restaurant	10,886	268.9	50%	134.5	1,463,862
	Lakeside Village Fast Food	Fast Food	3,780	431.6	60%	172.6	652,554
	The Boy Scout Emporium	Retail	7,740	95.0	55%	42.7	330,718
	Area Restroom 1	Restrooms	1,110	20.7	85%	3.1	3,448
	Area Restroom 2	Restrooms	1,060	20.7	85%	3.1	3,292
Gateway/Arrow							
	Sustainability Treehouse	Activity	6,845	98.3	80%	19.7	62,298
	Fish Camp	Warehouse	2,364	46.3	80%	9.3	21,894
	Visitor Center	Exhibit	22,940	98.3	70%	29.5	528,492
	Food Pavilion	Fast Food	4,860	431.6	60%	172.6	749,896
	Trading Post	Retail	22,250	95.0	55%	42.7	950,707
	Arrow Lodge	Exhibit	11,000	98.3	70%	29.5	324,265
	Arrow Lodge	Lodging	11,760	104.3	70%	31.3	367,847
	Buffet Dining	Restaurant	5,900	268.9	50%	134.5	793,385
	Area Restroom 1	Restrooms	1,260	20.7	85%	3.1	3,913
	Area Restroom 2	Restrooms	1,260	20.7	85%	3.1	3,913
	Media Lab	Office	11,500	98.5	50%	49.2	566,226
Action Pt							
	Accessibility Pavilion	Activity	12,982	98.3	65%	34.4	448,473
	Skateboard/BMX/Bike	Activity	42,585	98.3	70%	29.5	657,373
	Shooting Sports Lodge	Exhibit	5,979	98.3	70%	29.5	88,436
	Archery Lodge	Exhibit	15,333	98.3	70%	29.5	451,995
	Action Point Dining	Fast Food	6,380	431.6	45%	237.4	1,148,839
	Wheelworks Retail	Retail	5,400	95.0	60%	38.0	208,515
	Area Restroom 1	Restrooms	1,260	20.7	50%	10.4	13,045
	Area Restroom 2	Restrooms	1,260	20.7	85%	3.1	3,913
Totals			379,139				13,505,966

*** Buildings in Green Text are to Meet Living Building Challenge

Demand Side Reduction

Ceiling Fans 56 Watts

Typical Ceiling Fans 180
Watts

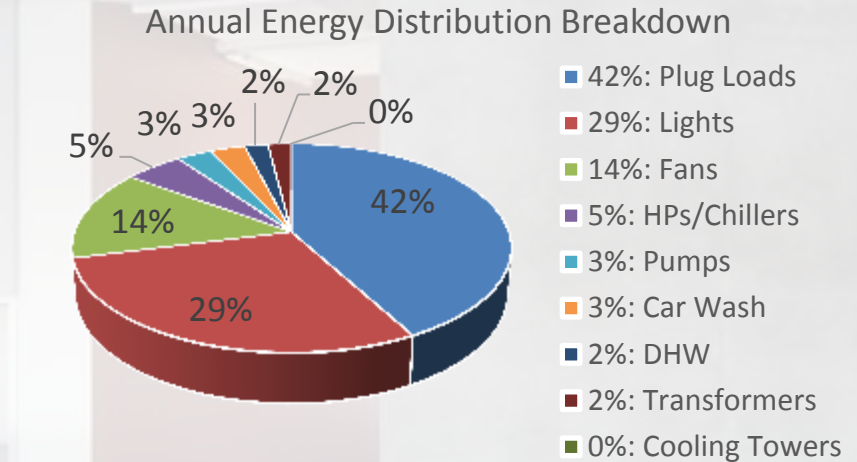
VOIP Phones
2 Watts

Standard Phones
24 Watts

18" LCD Energy
Efficient Monitors
12 Watts

Typical 19"-24"
Monitors
30-50 Watts

Workstation Load – 55 Watts
Laptop, Docking Station, 2
Monitors



Desk Fans
Low 9 Watts
High 14 Watts

Multi-Function Devices
160 Watts (Continuous)

Removing desktop printer
Save ~ 460 Watts/printer

UPS – High Efficiency

No Space Heater – Saves
1500 Watts

Laptop 30 Watts

Desktop Computer
(Energy Star) 300 Watts

LED Task Lights 6 Watts

Fluorescent Task Lights
35 Watts

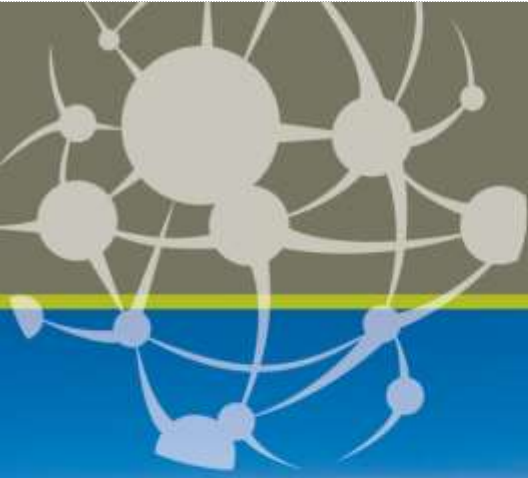
Project Successes

- ❑ Net Zero at market cost
- ❑ Highly efficient hybrid blend of renewable solutions
- ❑ Effective trade-off between competing technologies
- ❑ Very comfortable environment even in extreme conditions
- ❑ Ultra low Office EUI 16.9 kBTU/sf
- ❑ Net Zero renewable energy bundled into first cost

Design Challenges

- ❑ Competitive Procurement Necessary to Allow Innovative Designs to Compete against Conventional
- ❑ Turn-down on chillers was limited
- ❑ Thermal storage costly \$4.5/gallon
- ❑ Control sequences complex
- ❑ PV/Thermal tied to Solar Desiccant AHU

Thank You!



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