CampusEnergy2019

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Energy - Water -Cooling Nexus
An Examination of Opportunity

Henry W. Johnstone, P.E.
GLHN Architects & Engineers, Inc.

GLHN
ARCHITECTS & ENGINEERS, INC

- Agenda

Cooling in a changing environment

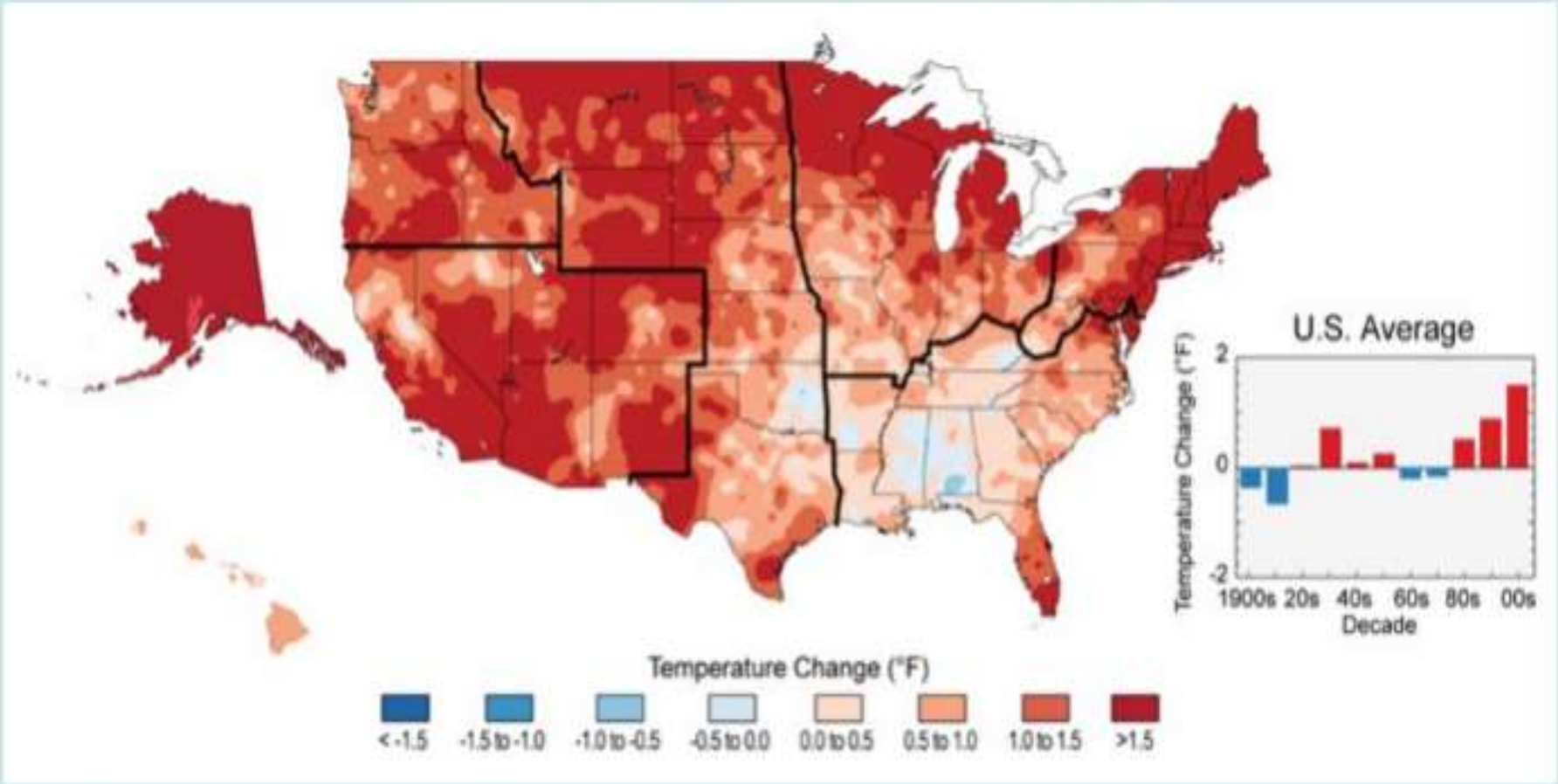
Water reclamation alternatives

Energy-Water Nexus for District Cooling

Opportunities and challenges in reclaimed water for campus cooling towers

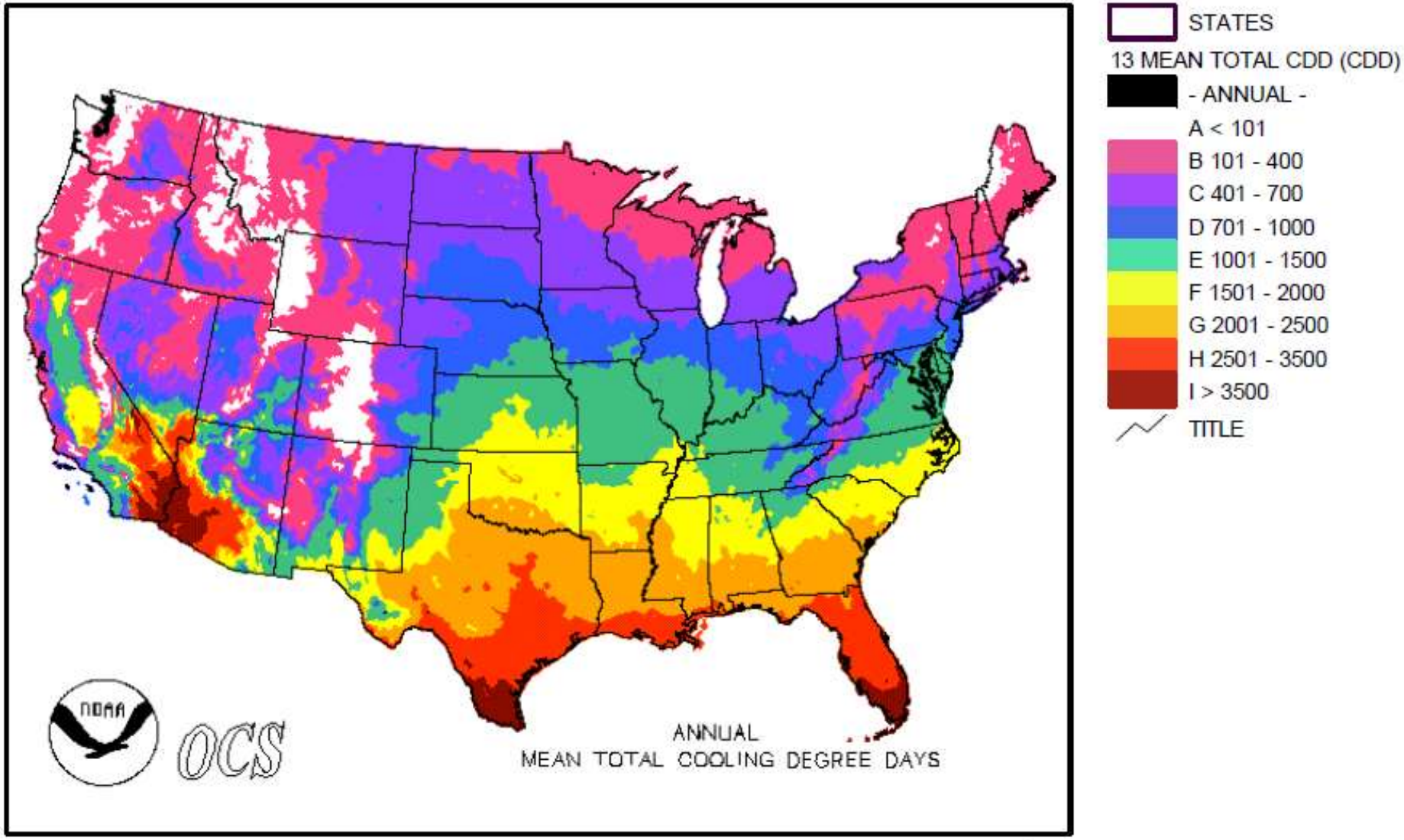
Climate

Observed U.S. Temperature Change



The colors on the map show temperature changes over the past 22 years (1991-2012) compared to the 1901-1960 average for the contiguous U.S., and to the 1951-1980 average for Alaska and Hawaii. The bars on the graph show the average temperature changes for the U.S. by decade for 1901-2012 (relative to the 1901-1960 average). The far right bar (2000s decade) includes 2011 and 2012. The period from 2001 to 2012 was warmer than any previous decade in every region. (Figure source: NOAA NCDC / CICS-NC).

Cooling Degree Days



Cooling Degree Day Projection

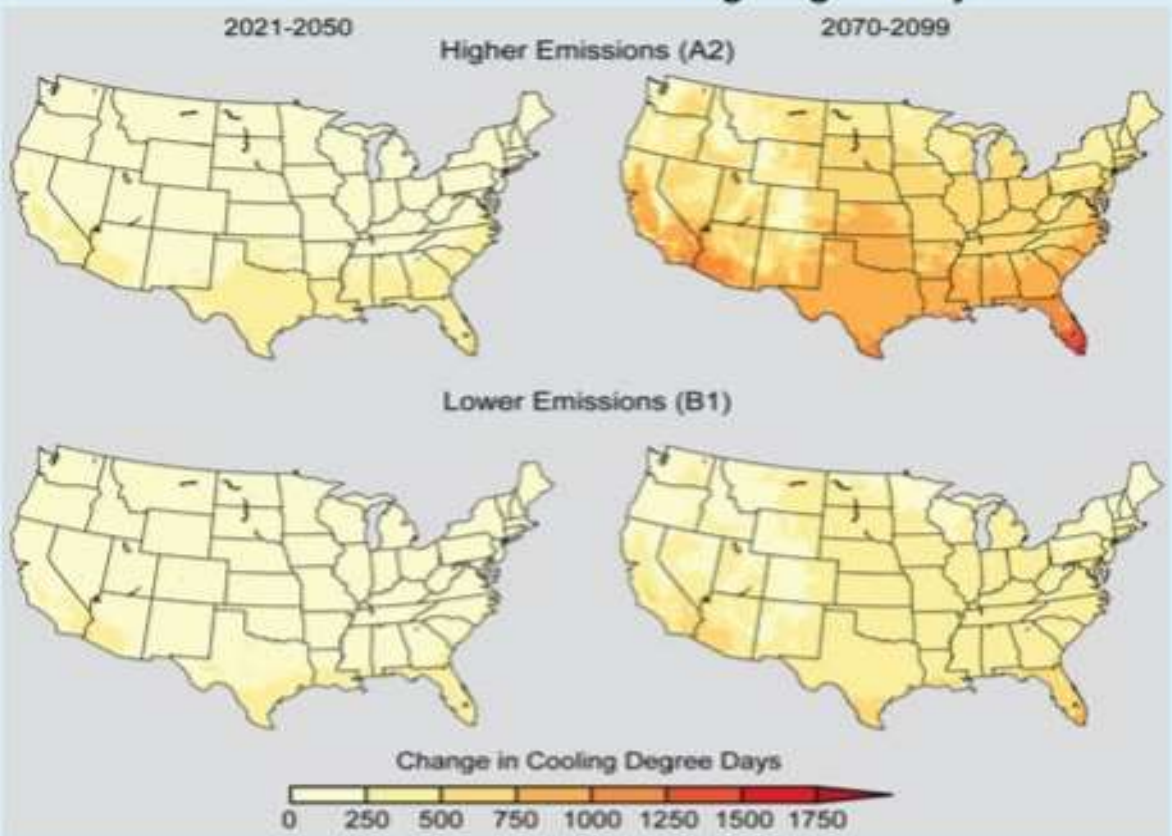


Figure 4.3. These maps show projected average changes in cooling degree days for two future time periods: 2021-2050 and 2070-2099 (as compared to the period 1971-2000). The top panel assumes climate change associated with continued increases in emissions of heat-trapping gases (A2), while the bottom panel assumes significant reductions (B1). The projections show significant regional variations, with the greatest increases in the southern United States by the end of this century under the higher emissions scenario. Furthermore, population projections suggest continued shifts toward areas that require air conditioning in the summer, thereby increasing the impact of temperature changes on increased energy demand.[18] (Figure source: NOAA NCDC / CICS-NC).

Water Supply Projection

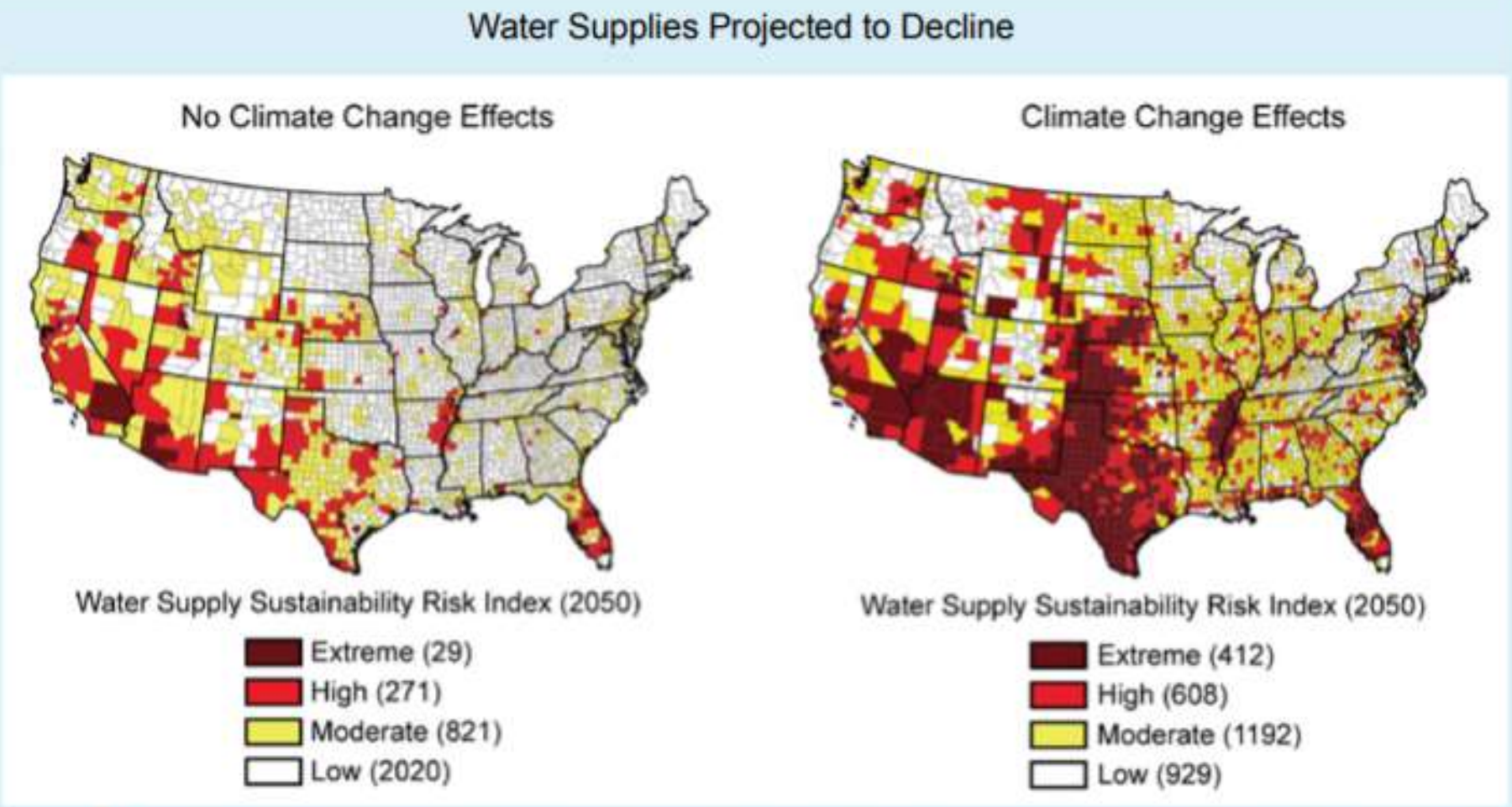
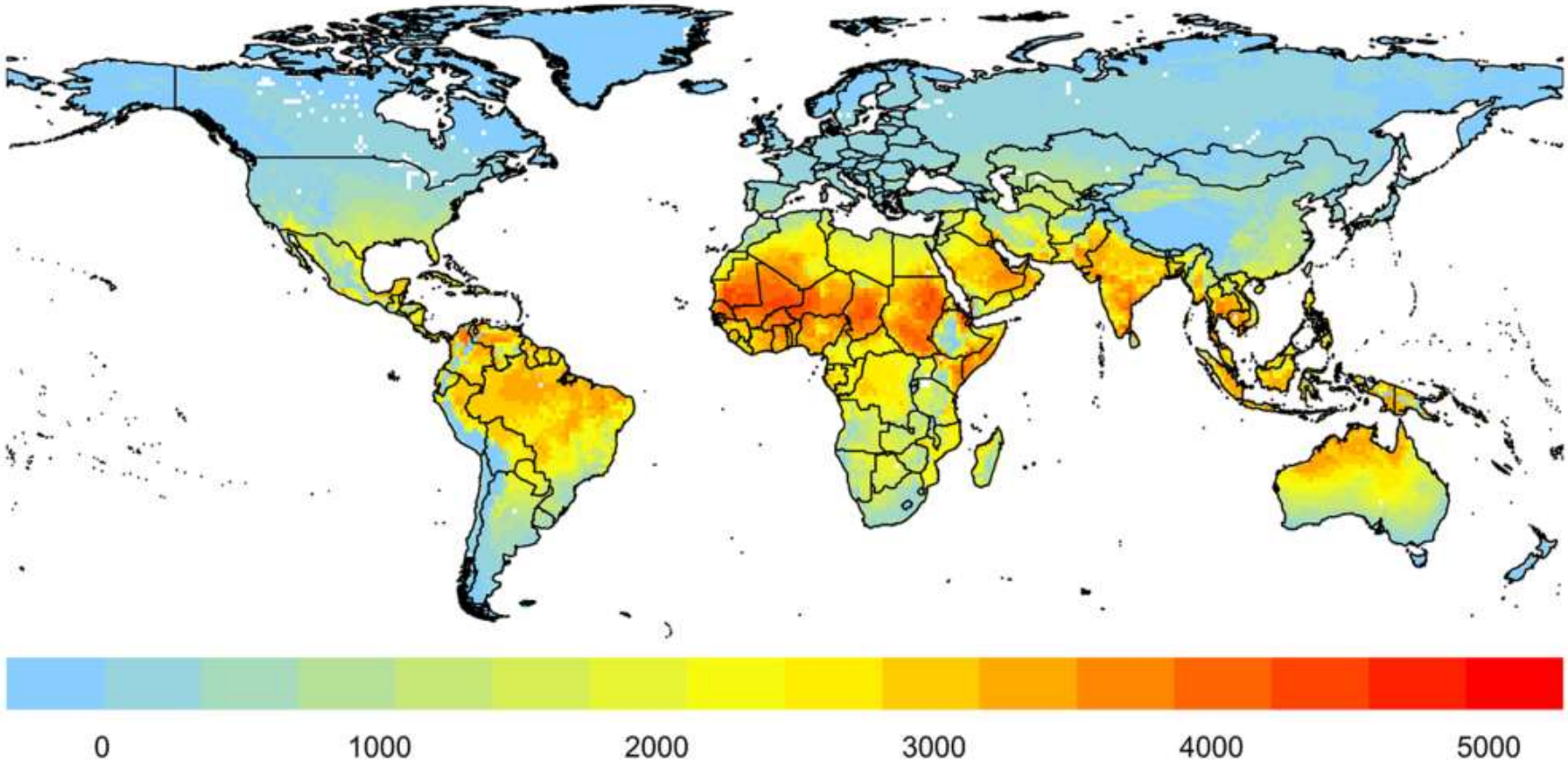


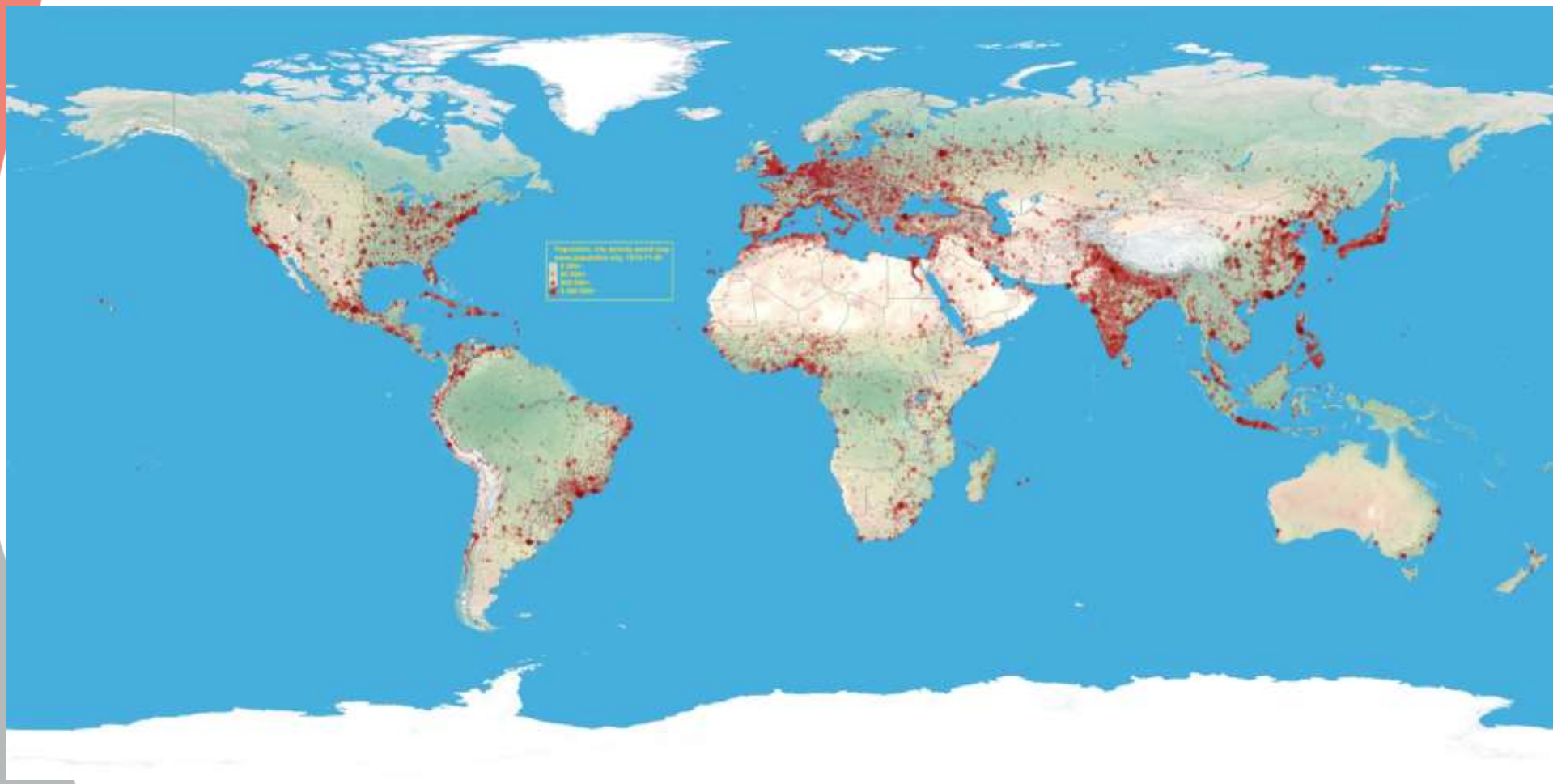
Figure 8.1. Climate change is projected to reduce the ability of ecosystems to supply water in some parts of the country. This is true in areas where precipitation is projected to decline, and even in some areas where precipitation is expected to increase. Compared to 10% of counties today, by 2050, 32% of counties will be at high or extreme risk of water shortages. Projections assume continued increases in greenhouse gas emissions through 2050 and a slow decline thereafter (A1B scenario). Numbers in parentheses indicate number of counties in each category. (Reprinted with permission from Roy et al., 2012.[27] Copyright 2012 American Chemical Society).

Global Cooling Degree Days



Global Water Supplies

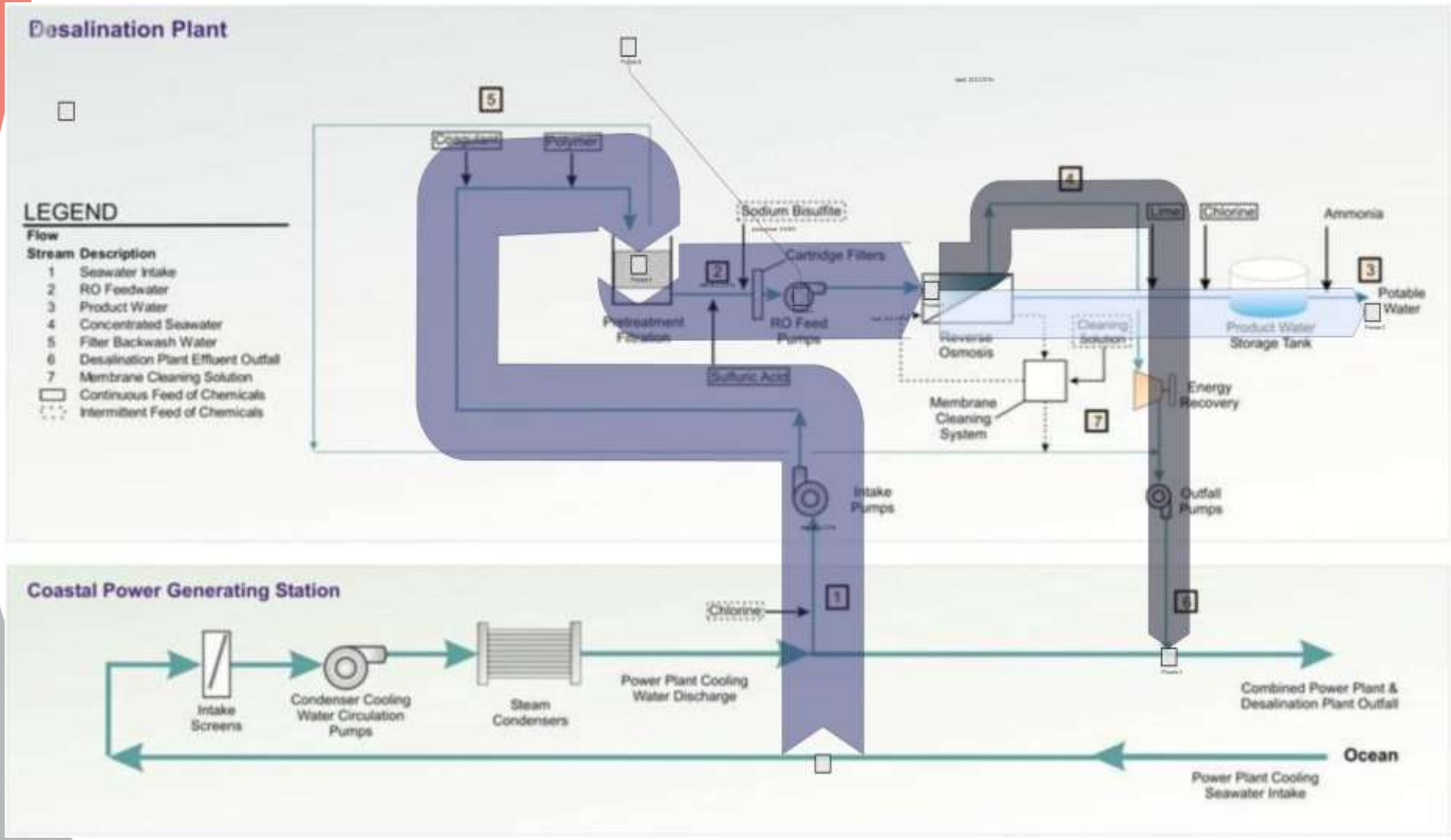
Population Density



Observations from the Middle East

- Urban Density
- Desalination
- District Cooling
- Treated Sewage Effluent

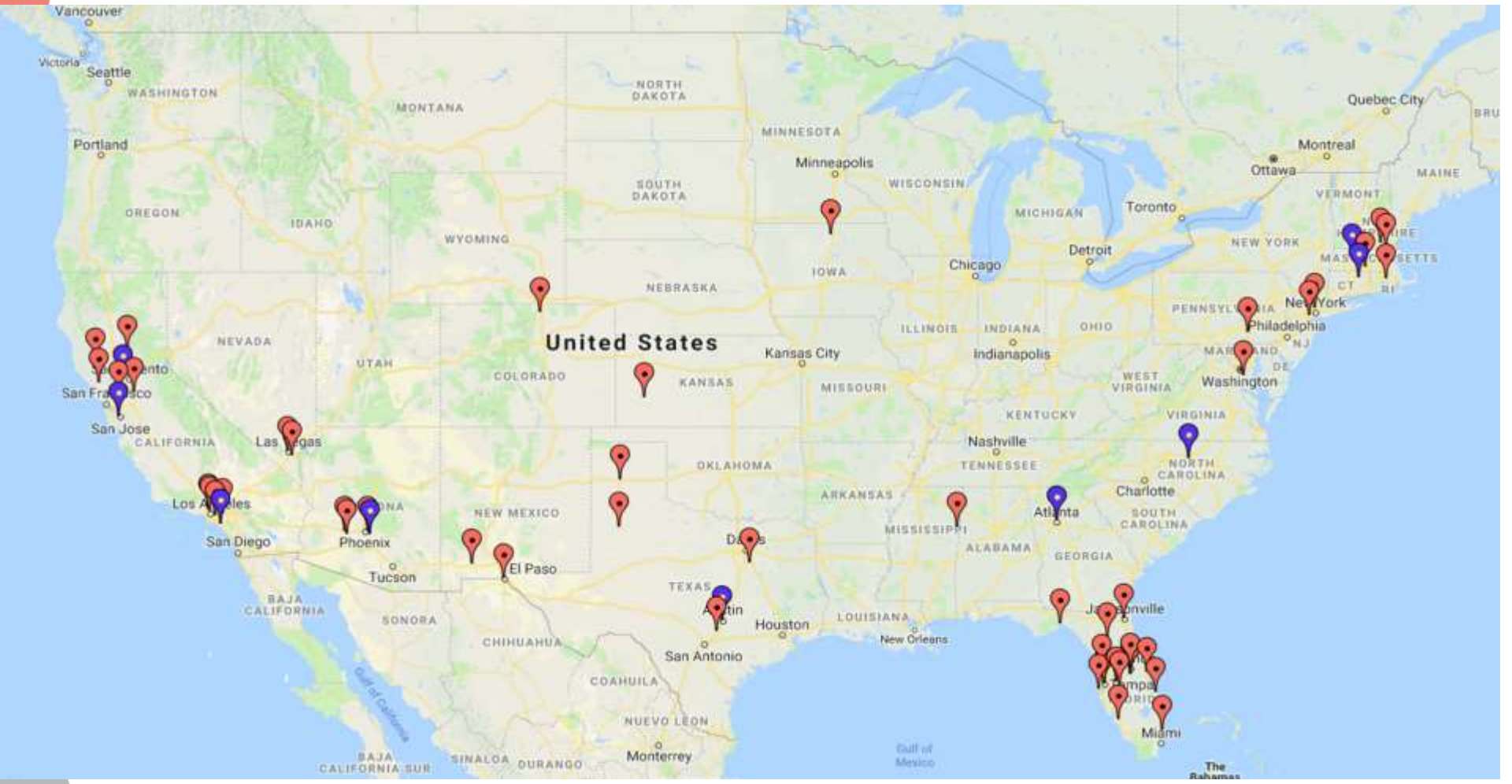
Desalination in US



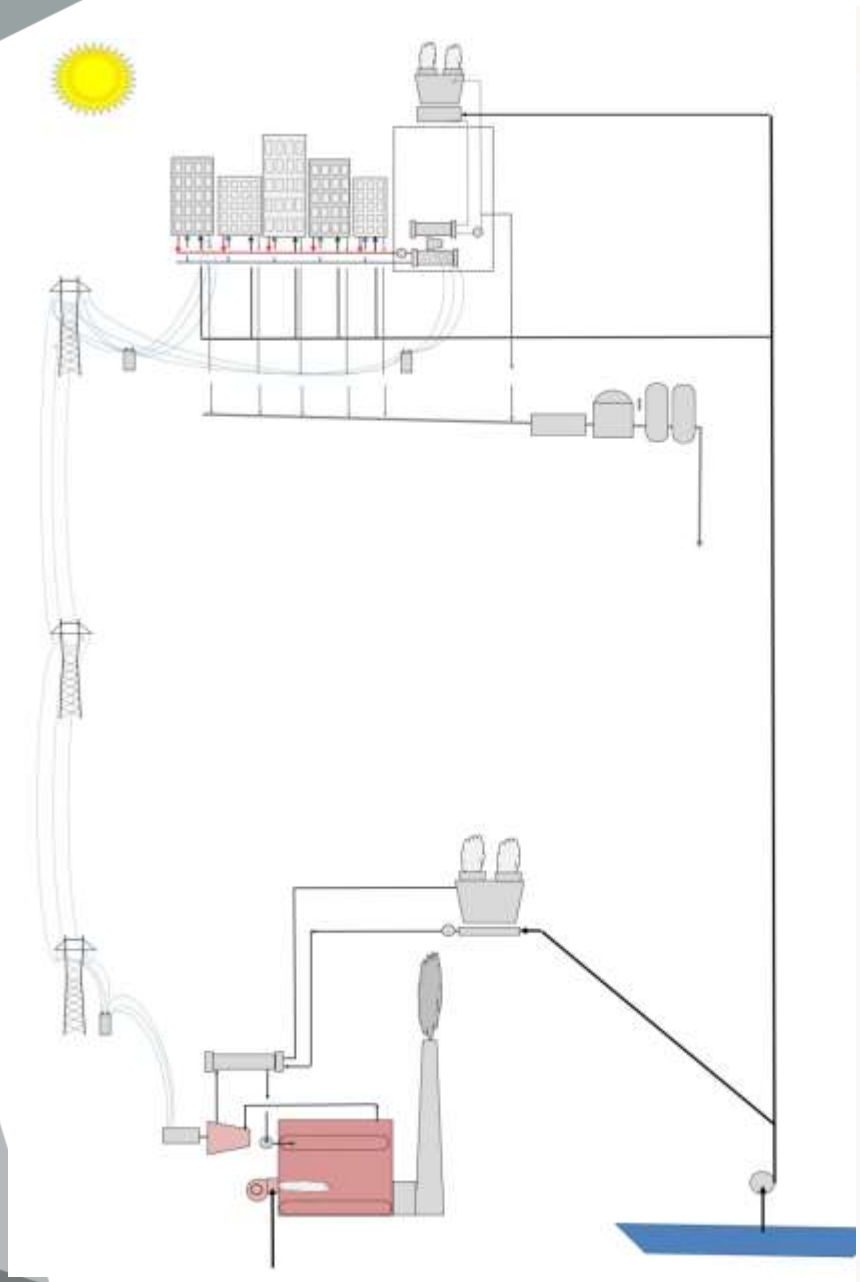
Treated Sewage Effluent in US

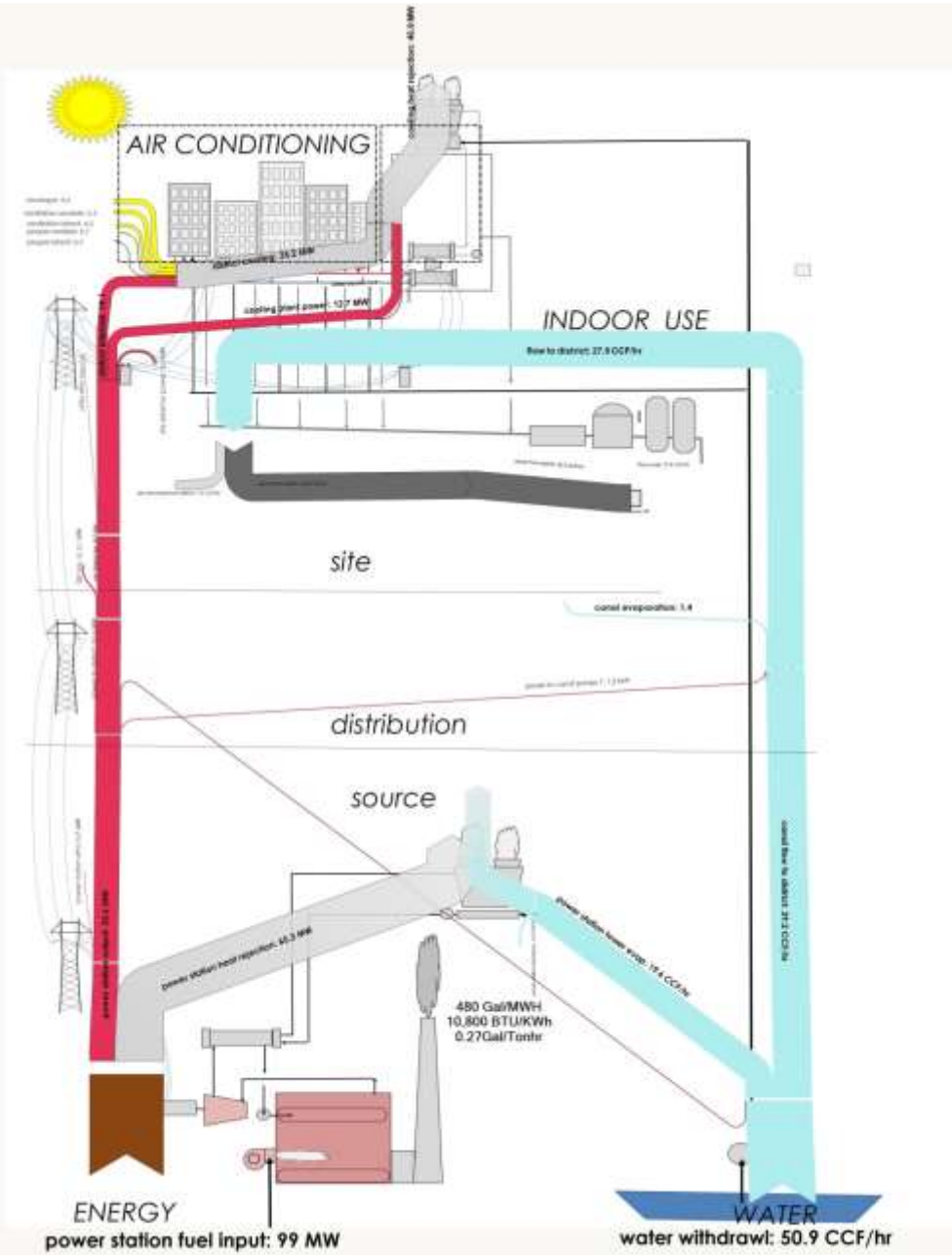
Source: Google Earth

Treated effluent in US cooling towers



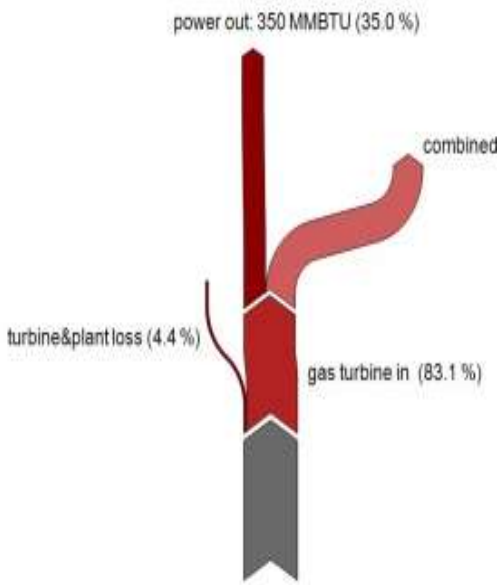
District Cooling Energy and Water



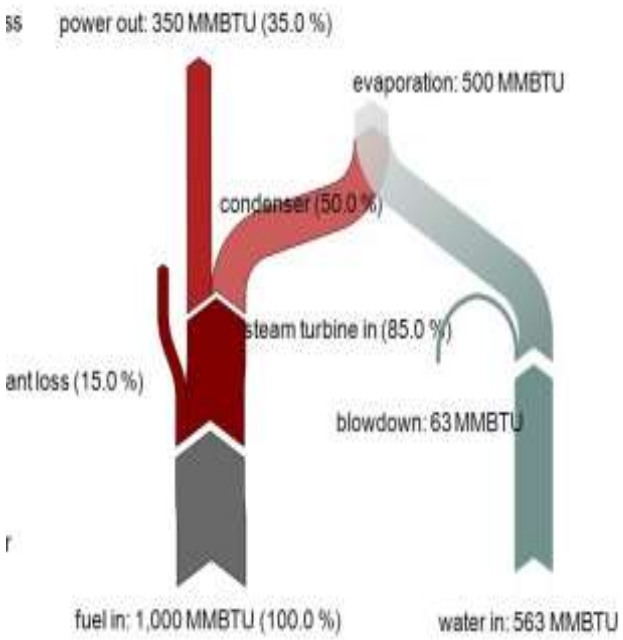


Water in Energy

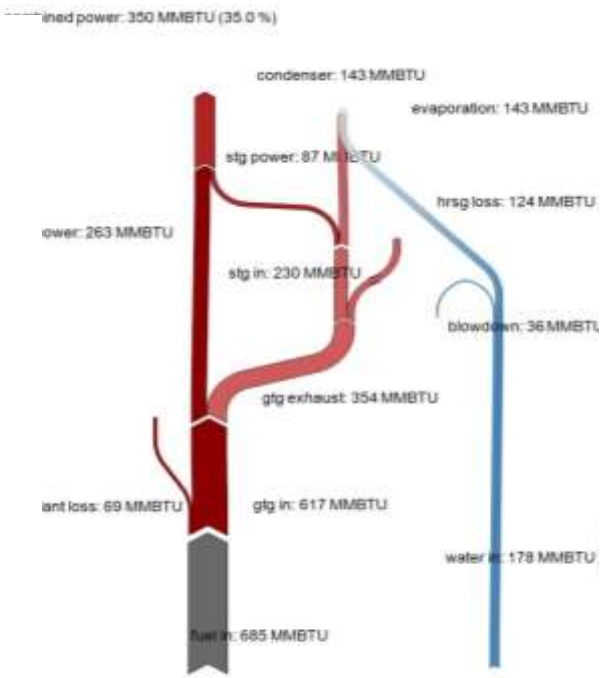
Simple Cycle



Rankine Cycle



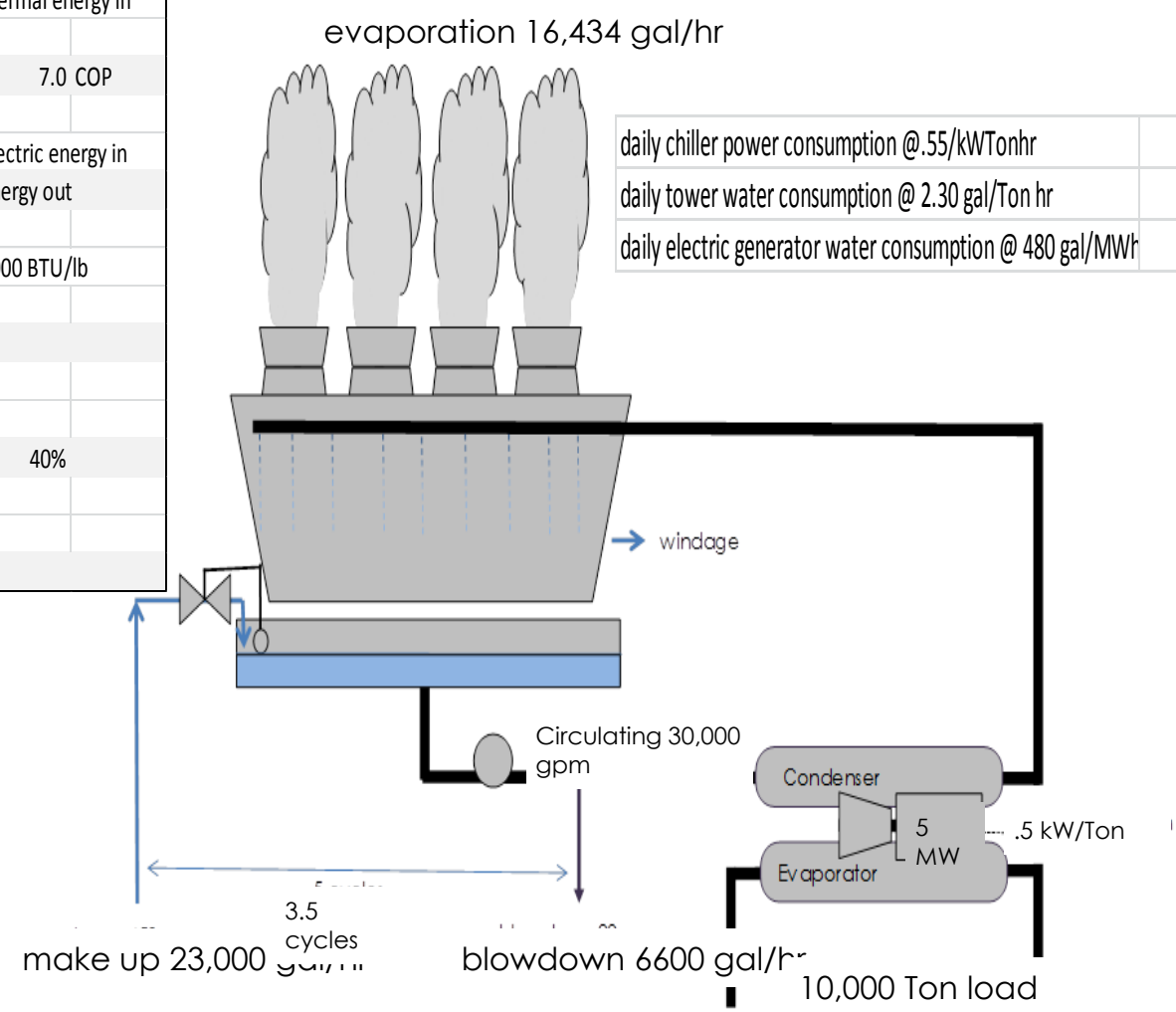
Combined Cycle



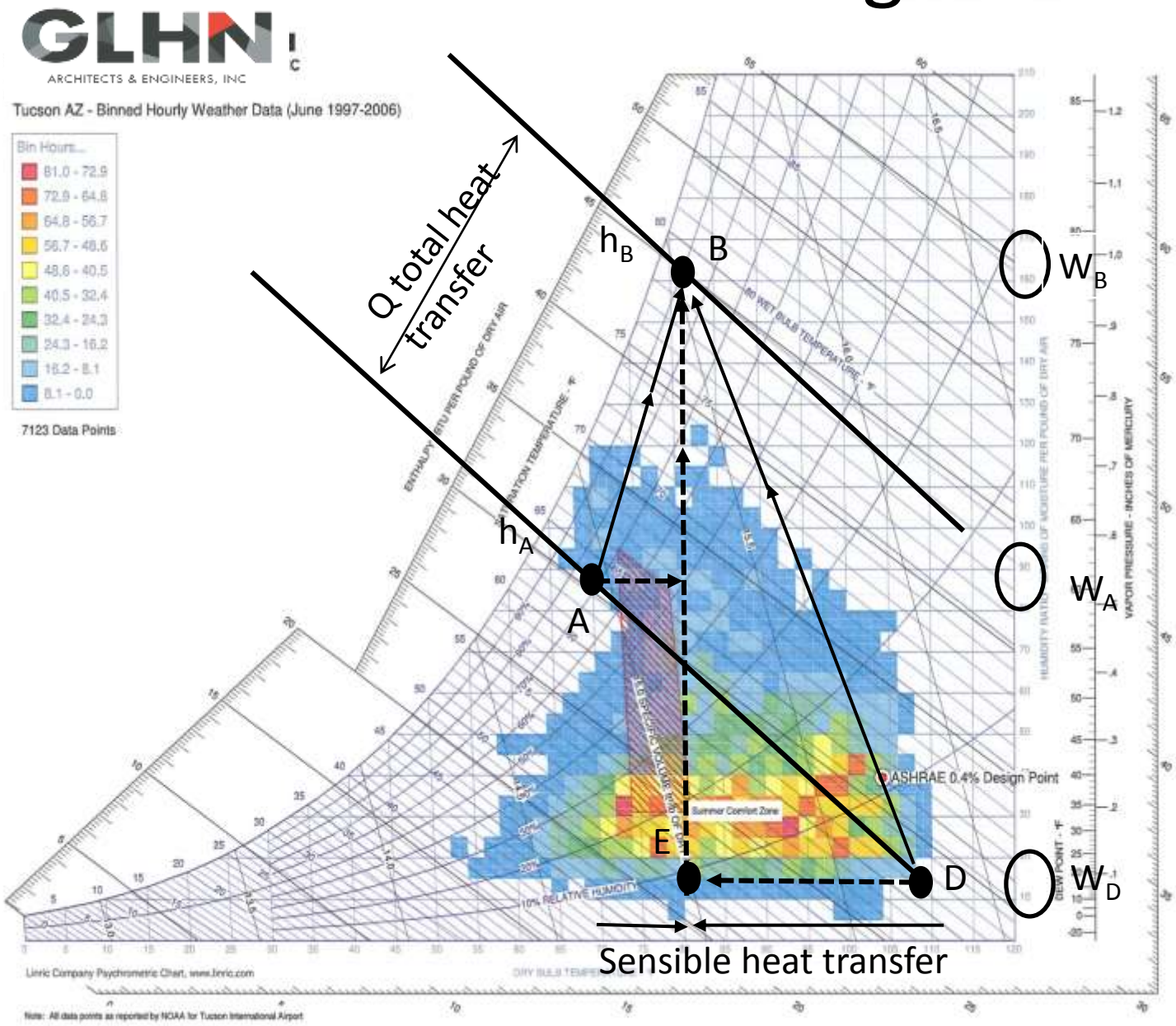
Water in Cooling

thermal extracted	10,000	Ton		
	120	MMBTU/hr	thermal energy in	
chiller efficiency	0.5	kW/Ton	7.0	COP
	5,000	kWhr		
	17.1	MMBTU/hr	electric energy in	
heat rejected	**137.1**	MMBTU/hr	energy out	
latent energy	137,060	lbm/hr	1000 BTU/lb	
Evaporation	16,434	gal/hr		
	1.64	**gal/tonhr**		
Blowdown Cycles	3.5		40%	
Blowdown	**0.66**	**gal/Tonhr**		
Make Up Water	**2.30**	**gal/Tonhr**		

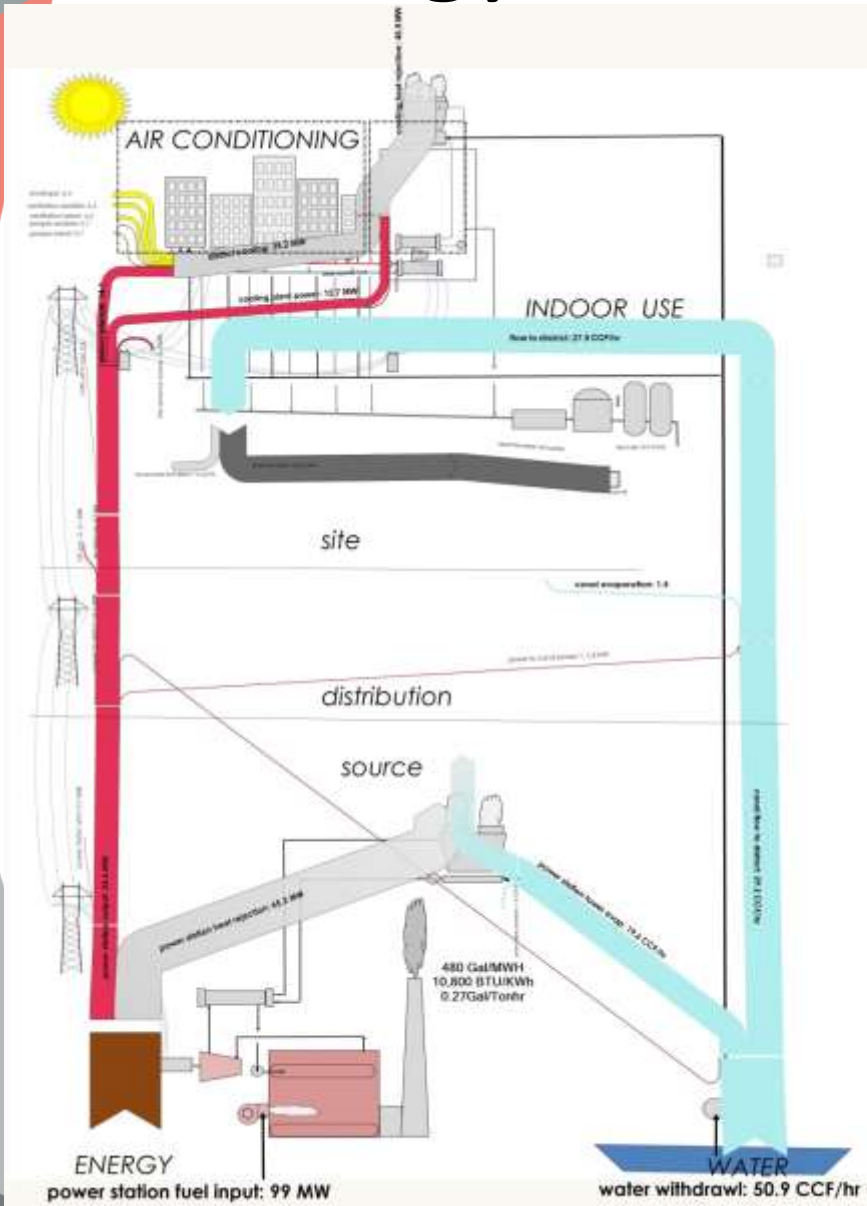
daily chiller power consumption @.55/kWTonhr	132,000	kWh
daily tower water consumption @ 2.30 gal/Ton hr	552,000	gal
daily electric generator water consumption @ 480 gal/MWh	63,360	gal

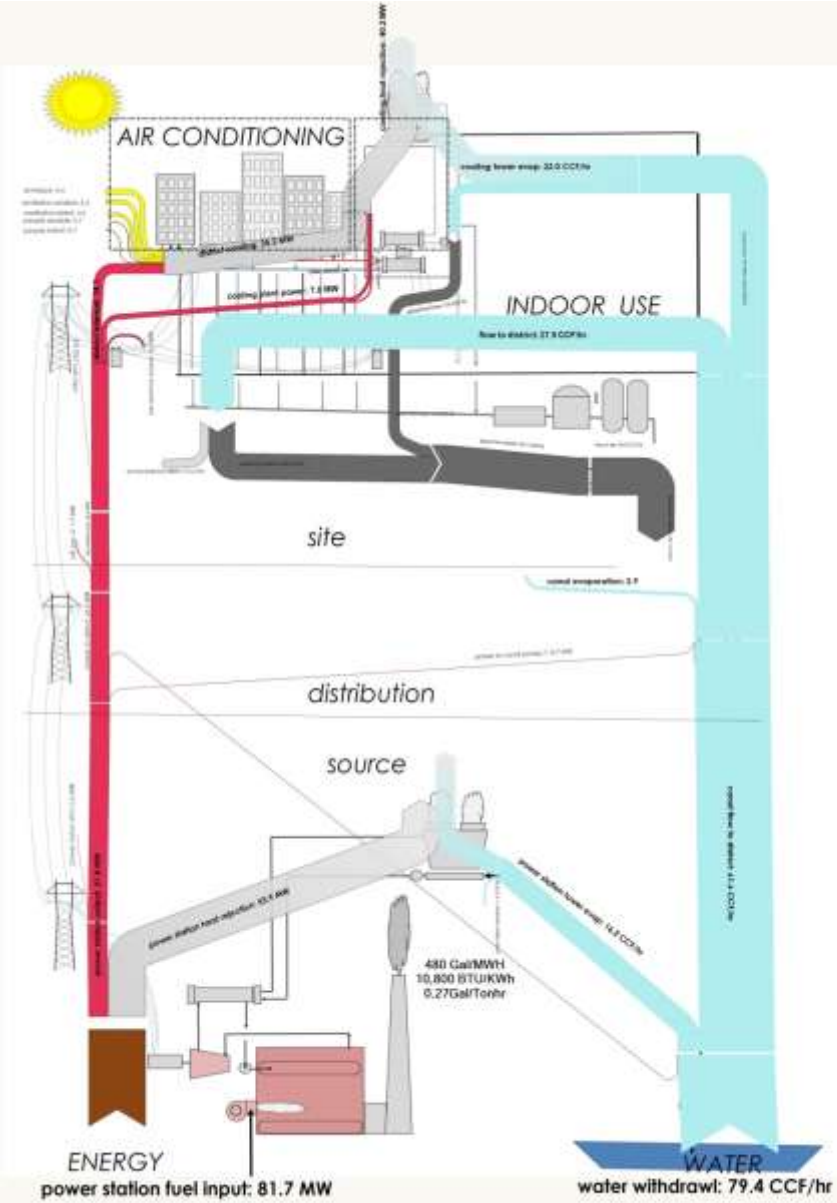


Water in Cooling



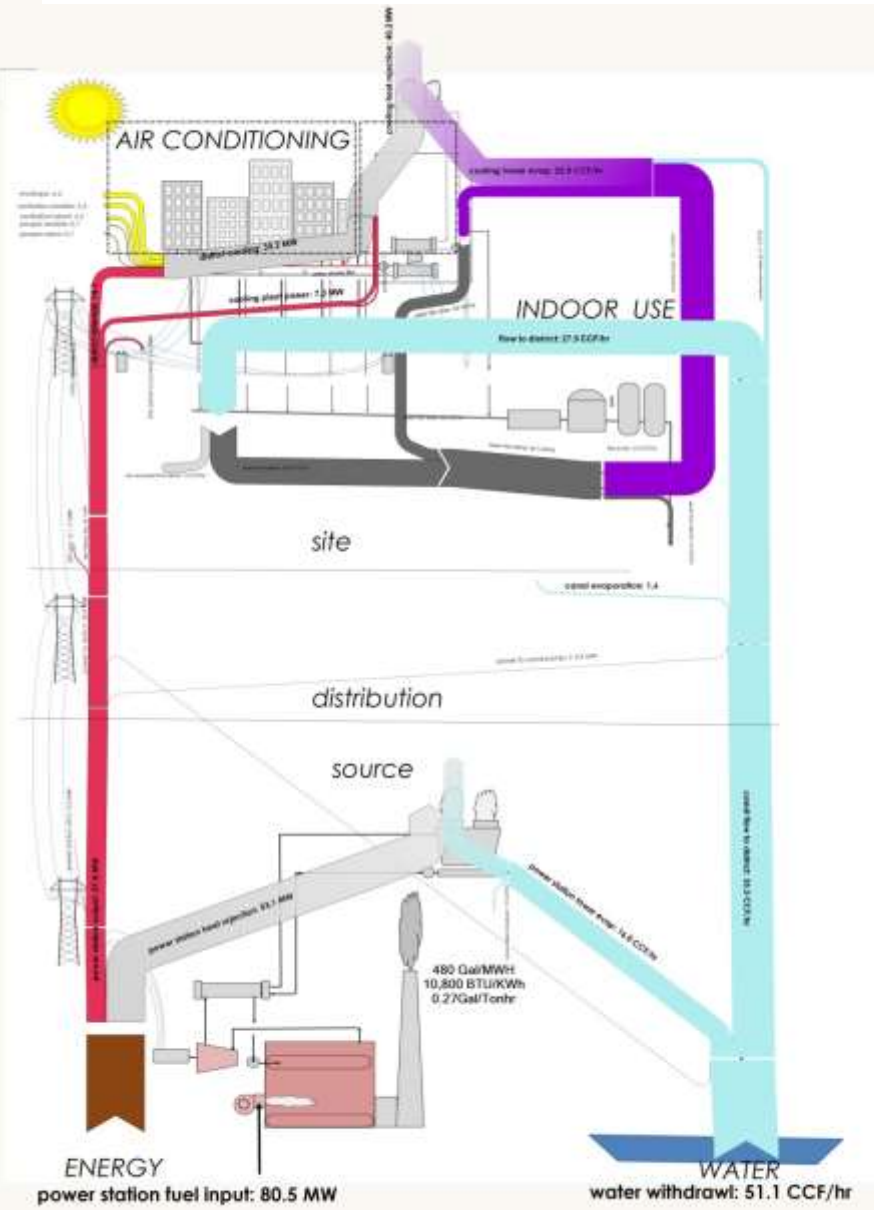
Energy –Water-District Cooling



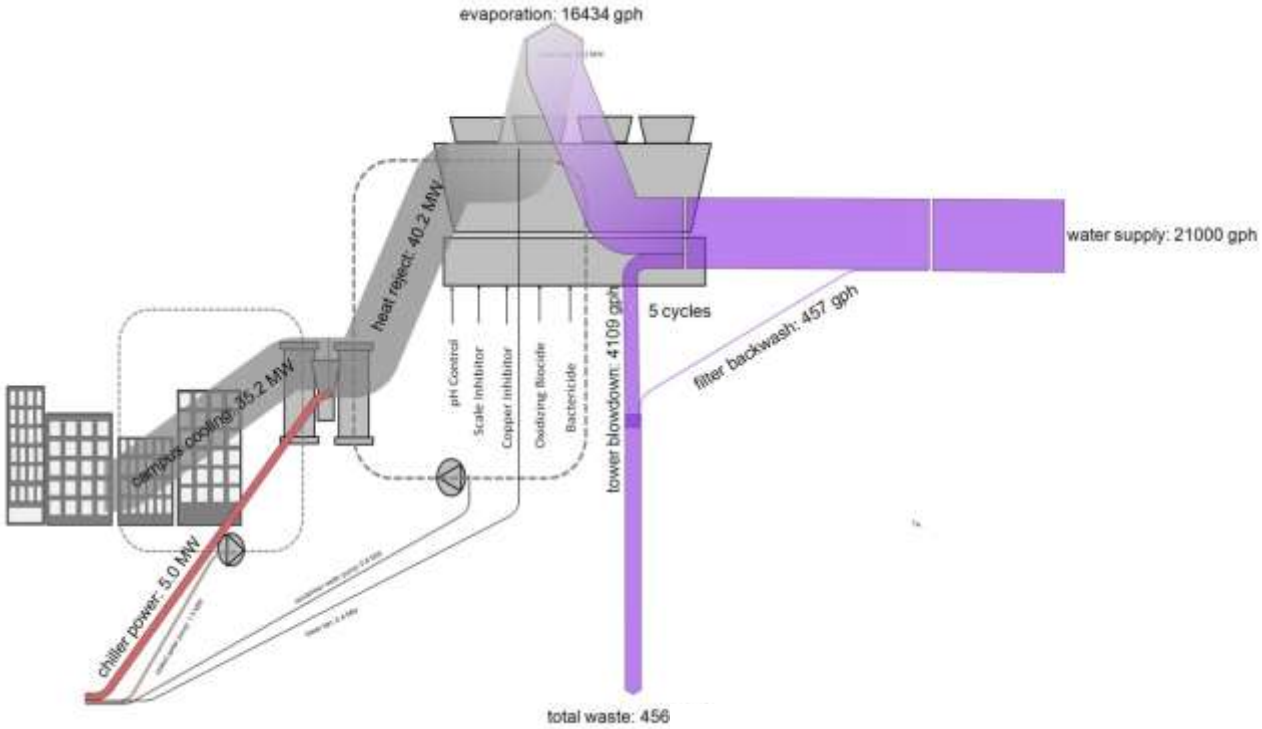


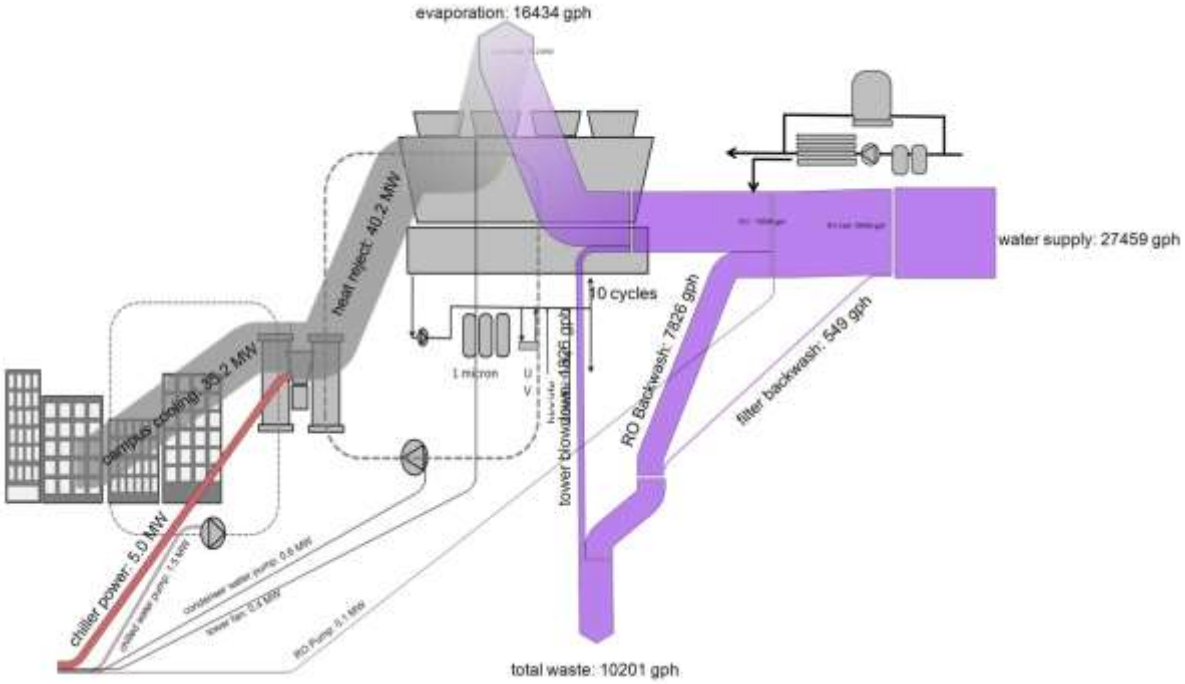
Reclaimed Water in District Cooling

- Treatment Approaches
  - Blowdown and chemical control
  - Mechanical methods
  - Decentralized and biological treatment



Alternatives





Summary

- History and success in power plants –
- Specific Issues are geographic
  - Water to Energy Cost Ratio
  - Water constituent quality
- Decentralized and Public Utility Alternatives
- Best and Highest Use

- Recycled water -an opportunity for district cooling at university campus scale