The Ohio State University

Infrastructure Master Plan

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Agenda

- What is an Infrastructure Master Plan?
- Ohio State and the IMP Scope
- The Architectural Master Plan says we have to serve HOW many buildings!?
- The game plan
- Beyond Business as Usual
- The Finale

What is an Infrastructure Master Plan (IMP)?

An IMP is an easy-to-follow road map that provides insight to facilities trying to maintain an efficient, reliable and sustainable utility infrastructure.

"The time is now to be proactive"

-Jim Riley,
Texas A&M University
Executive Director for Utilities & Energy Services

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Ohio State
Background

Founded in 1870

- Located two miles north of downtown Columbus
- Columbus Campus: 1,765 acre site with over 450 buildings
- One of the largest college campuses in the USA in terms of enrollment population
- Approximately 56,000 students and 26,000 employees
- 5 Regional Campuses in OH: Lima, Mansfield, Marion, Newark and Wooster

Ohio State Scope

Evaluations

Five main areas of campus to evaluate:

- Health Sciences District
- St. John Arena & North Residential District
- Academic Core North
- Herrick Dr. Research Corridor & River Housing
- Athletics District

Systems to be evaluated:

- Steam and Condensate
- Chilled Water
- District Electrical Service
- Natural Gas
- Domestic Water

Ohio State Scope

Plan Goals

Provide a 40 year road map for the University that includes benefits related to capacity, reliability, efficiency, and emissions by:

- Establishing a baseline and GATHERING DATA
- Reviewing and analyzing production and distribution options with modeling
- Evaluating enhancements such as thermal energy storage (TES), combined heat and power (CHP), geothermal and others deemed appropriate for OSU during the evaluations
- Developing life cycle cost analysis with sensitivity

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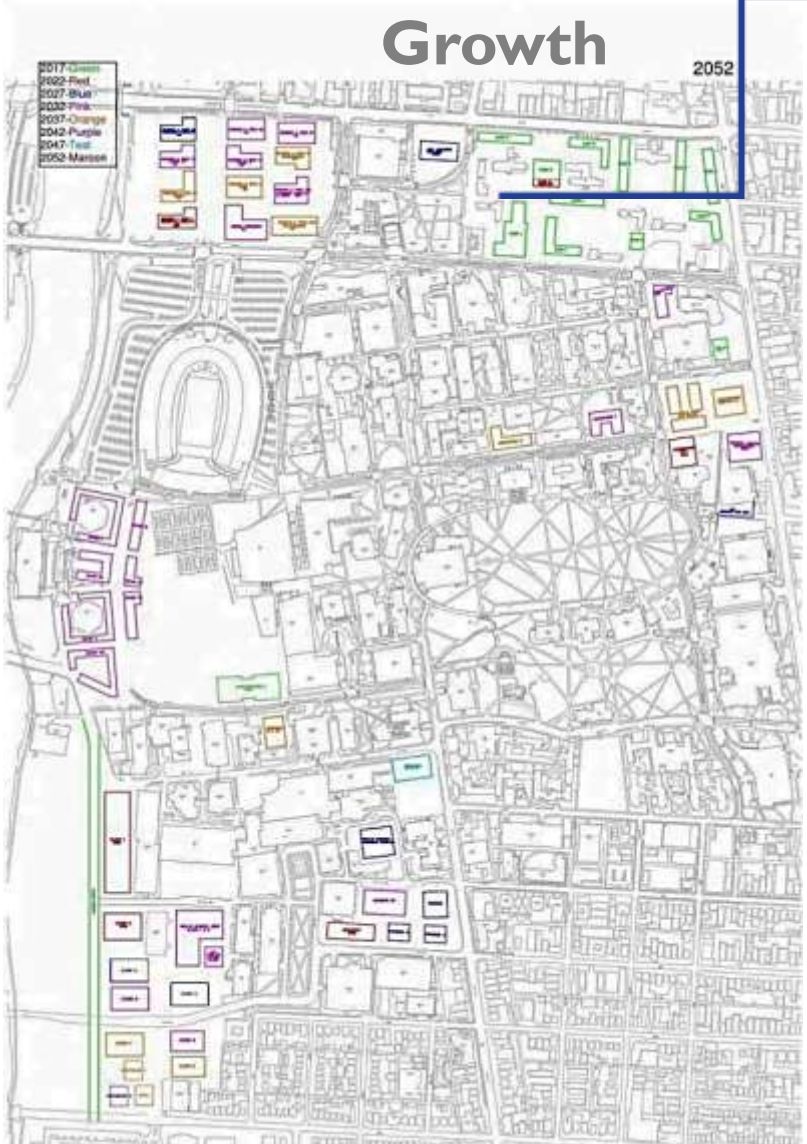
Ohio State Campus

Growth



Aggressive Architectural Master Plan, which serves as the source of developing load growth

22.7M SF becomes 34.9M SF

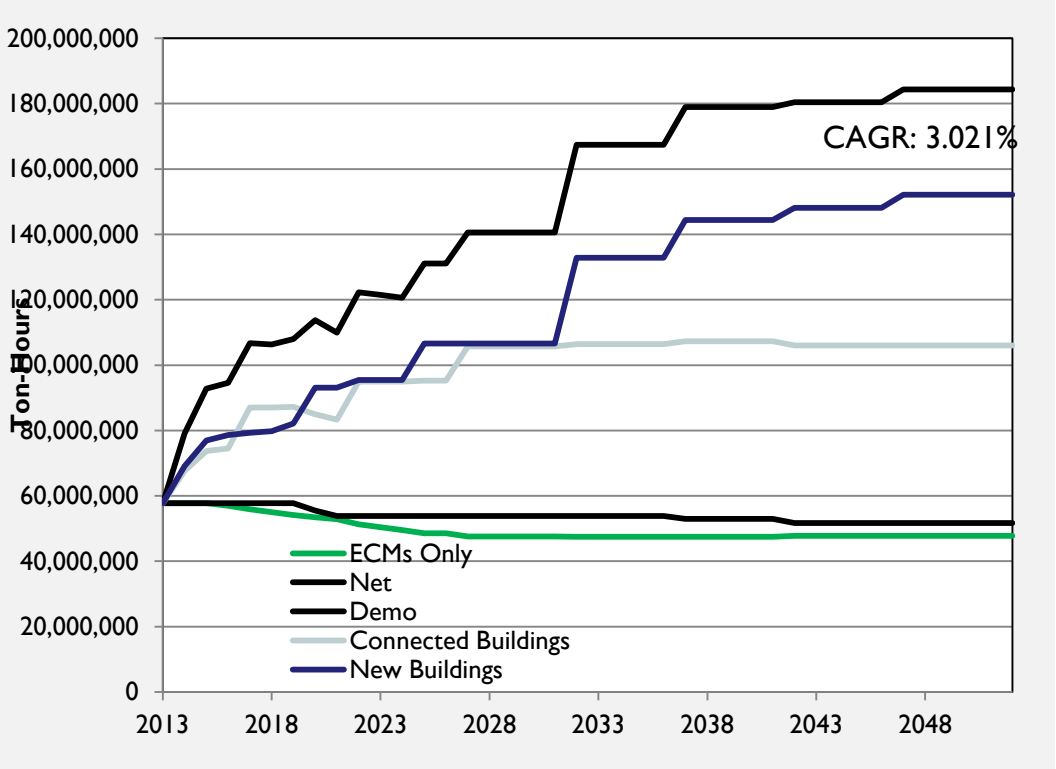
Nearly 55% Growth

Fiscal Year	Total Square Footage Added
Existing	22,685,282
2017	3,236,549
2022	1,979,600
2032	3,295,297
2052	3,730,724
Total	34,927,452 ft^2

The Campus
Load Projections

Development

- New Building 8760 profiles built from University recommended "Go-By" buildings
- Energy Conservation Measures assumed to meet the University's energy efficiency goals



- New Buildings – 2.5% reduction from "go-by" every 10YRS.
- Existing Buildings: (now through 2025)

SERVICE	PROJECTED ENERGY SAVINGS
Electrical	16.0%
Chilled Water	10.0%
Steam	24.5%

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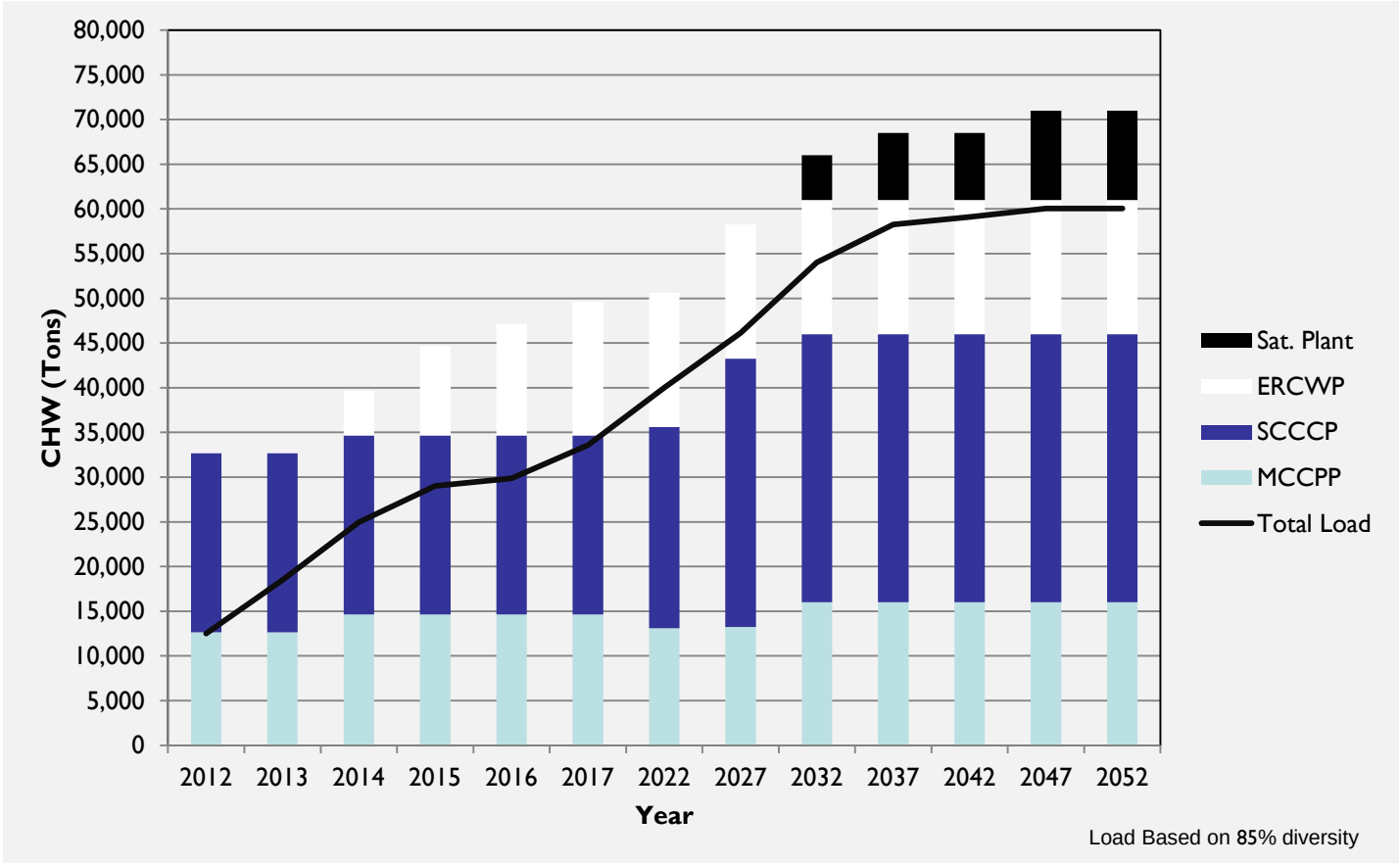
Campus
Chilled Water

Main Campus CHW future load projections versus plant capacity

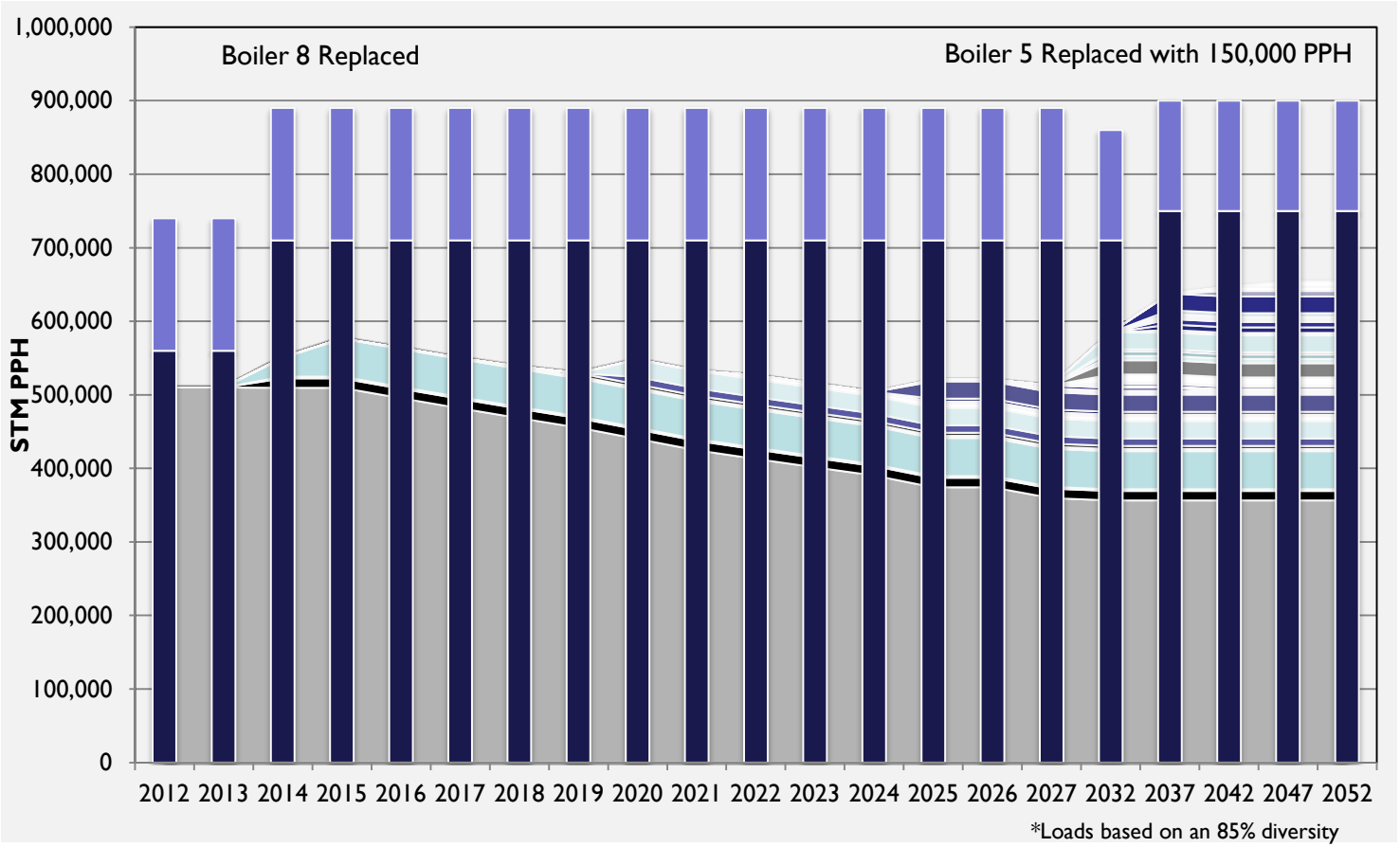
- A new facility will be required in the South Health Sciences District by 2032.



Campus Steam

Main Campus STM future load projections versus plant capacity.

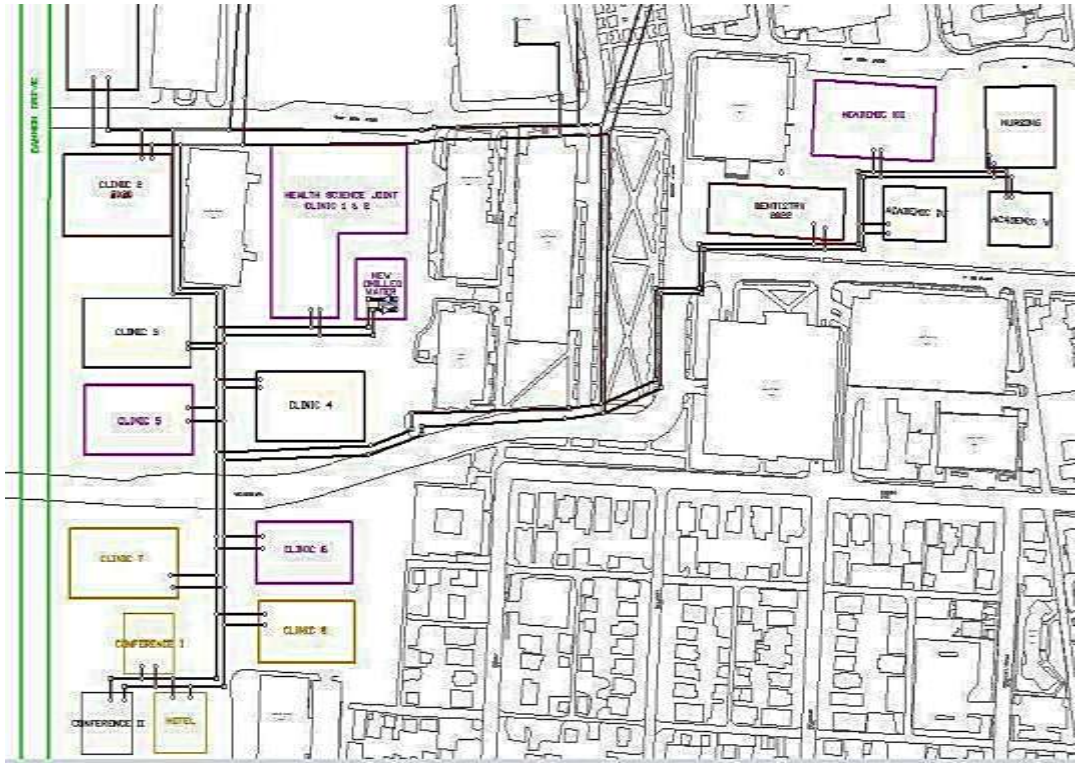
- Coal Boiler 8 will be replaced in 2014 and Boiler 5 will require replacement in 2037.



Flat curve is the result of the ECMs

Energy

Production Modeling



Develop Production Energy Models:

- Models were developed for ELECT and NG existing and projected consumptions
- Basis for LCC energy portion of evaluations and assigned costs developed from actual billing data provided by the University
- Accounted for ECMs and other items such as Ohio State's commitment to higher condensate return percentages.

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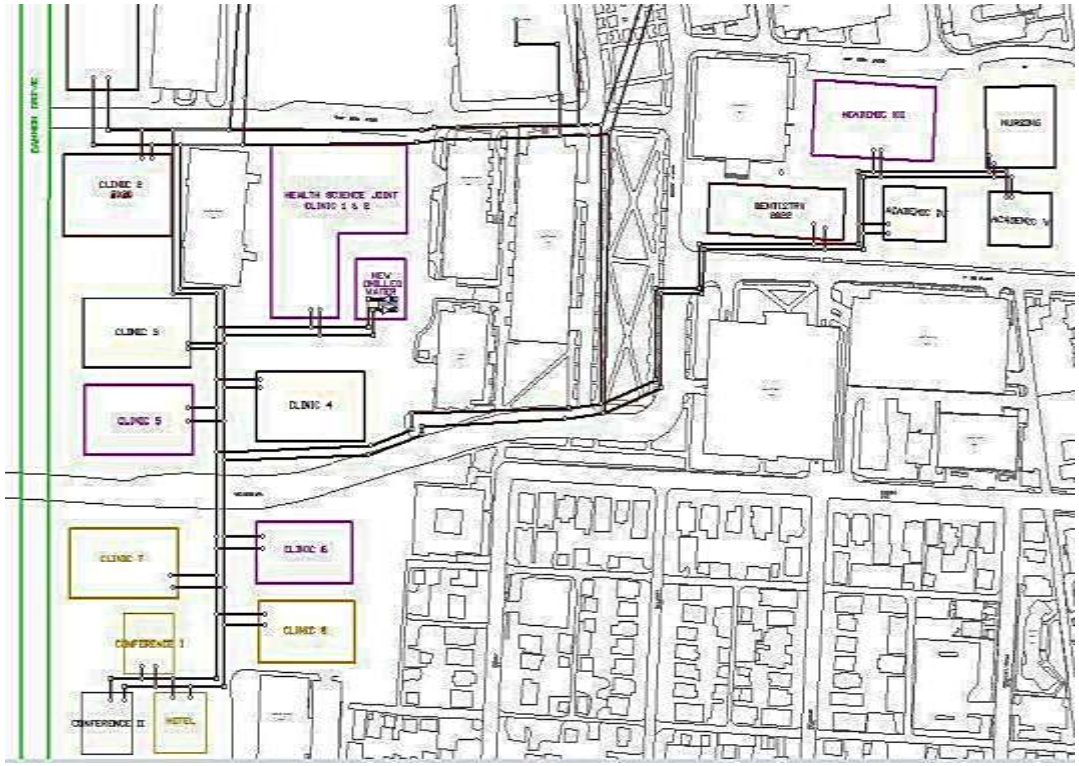
How Does it Get There?

Distribution Modeling



Expand/Develop Hydraulic Flow Models:

- Models were developed or expanded for CHW, STM, CD, DW, and NG
  - **Ohio State actively manages models!**
- Expanded to serve future buildings throughout campus
- Alleviated problematic areas such as low pressures, choke points, and high velocities
- Over $133M in distribution projects planned over 40YRS

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Ohio State's Commitment To Distribution

Major Utility Corridors

- STM/CD and CHW will be routed in tunnels

Branch Piping

- STM/CD in removable top concrete trench boxes
- CHW direct buried HDPE

This is the key to long term system resiliency but at a cost that needs to be planned/ budgeted for in an IMP.

- A lack of planning leads to the reaction syndrome where cheap/quick repairs result in system vulnerability

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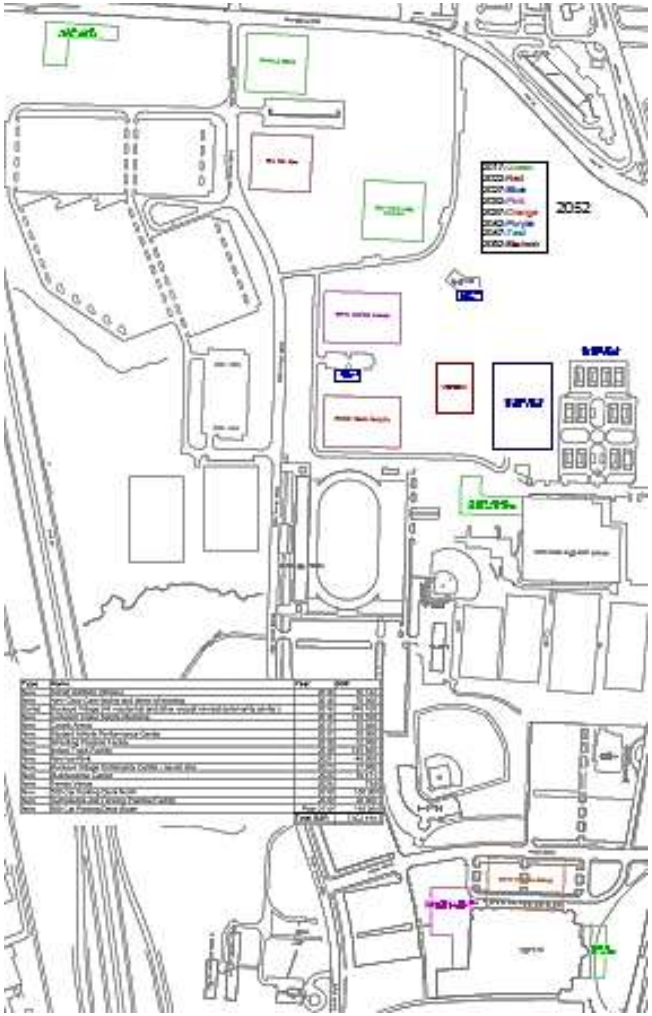
Athletics District



Significant New Growth

- Stand Alone, Tie to Central, or New CUP?
- Low Density (Buildings)
- Low and sporadic loading at athletic type facilities
- LCC not even close
  - Distribution costs could not be overcome despite energy and O&M savings

	Athletics	Academic CN
Cooling (ton/acre)	18	177
HTG + CLG (MBH/acre)	348	5,000

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The Game Plan

Project Development

Chiller Number	Replacement Capacity (Tons)	Replacement / Addition Year	Cost (2013 Dollars)	Cost Escalated to Install Year
McCracken				
4	2,000	2023 Replacement	$1,842,543	$2,417,576
6	2,000	2029 Replacement	$1,842,543	$2,803,647
7	2,000	2029 Replacement	$1,842,543	$2,803,647
8	2,000	2030 Replacement	$1,842,543	$2,873,738
9	2,000	2031 Replacement	$1,842,543	$2,945,582
10	2,000	2031 Replacement	$1,842,543	$2,945,582
2&3	2,000	2032 Replacement	$2,120,580	$3,474,817
4	2,000	2048 Replacement	$1,842,543	$4,482,051
SCCCP				
9	2,500	2020 New	$2,640,415	$3,217,089
10	2,500	2025 New	$2,640,415	$3,639,841
11	2,500	2027 New	$2,640,415	$3,824,108
12	2,500	2027 New	$2,640,415	$3,824,108
1	2,500	2037 Replacement	$2,591,190	$4,803,921
2	2,500	2037 Replacement	$2,591,190	$4,803,921
3	2,500	2038 Replacement	$2,591,190	$4,924,019
4	2,500	2038 Replacement	$2,591,190	$4,924,019
5	2,500	2038 Replacement	$2,591,190	$4,924,019
6	2,500	2039 Replacement	$2,591,190	$5,047,120
7	2,500	2040 Replacement	$2,591,190	$5,173,298

Business As Usual

- Equipment projected life expectancies used to plan major equipment replacements
- CHW load development along with chiller age tells us when Ohio State's CHW plants should replace or install new chillers
- The University has planned well for their STM growth. Closest production project in 2029
  - Replace existing 600# Boiler 5 with a 200# boiler (no more STM driven chillers.

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Enhancement Projects Beyond BAU

- **Geothermal**
  - 3 Districts Analyzed
  - Feasible project for a single building where central distribution offers many challenges.
  - $5M in annual energy savings

Other Opportunities:

- **Thermal Energy Storage**
  - Potential partial storage option installation in lieu of a new satellite CHW plant (or 3 x 2500T offset).
  - 40YR LCC savings of over $16M
- **Condensing Economizer**
  - 40YR LCC savings of $14M
  - Under 5YR payback
  - Annual GHG emissions reduction of 10,000Tons
  - Not recommended should CHP be implemented as CHP would require a separate stack.

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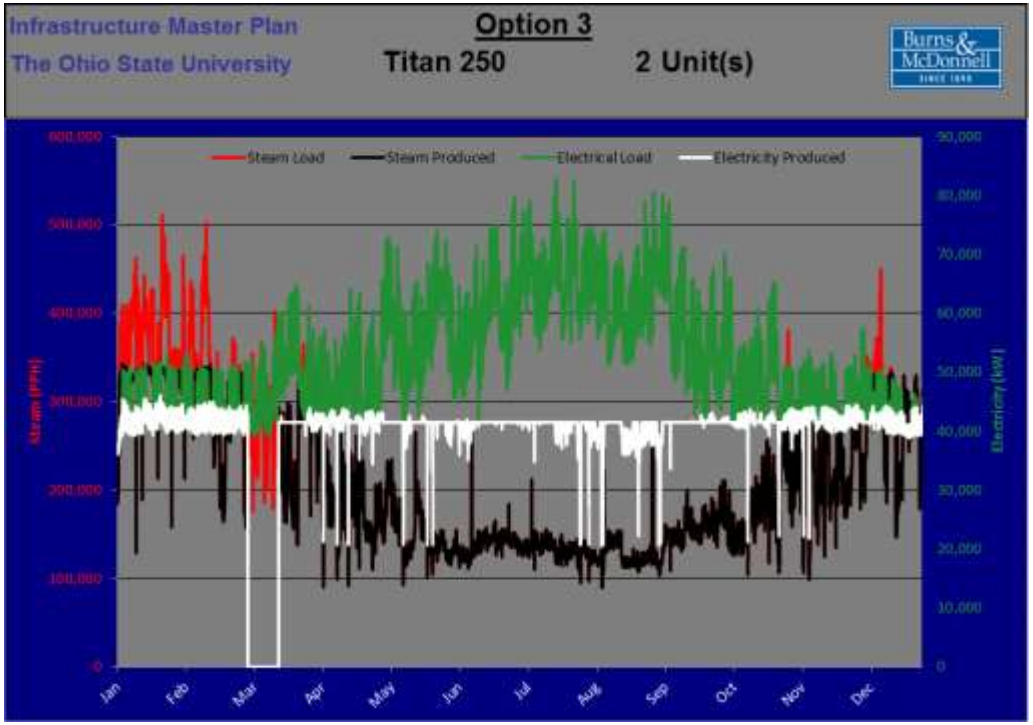
Enhancement Projects

Beyond BAU



Combined Heat & Power

- Initial screening process of best matching steam and electricity demands resulted in four options.
- Option with highest LCC Savings was two Titan 250s totaling 43.5MW and 326KPPH fired.
  - $23.7M in 40YR LCC Savings
- $86.6M all in Project Cost.
- 10YR simple payback
- CO2 Reduction – 173M LBs (seen by utility). SB315 incentives from utility.
  - Permitting is a long process

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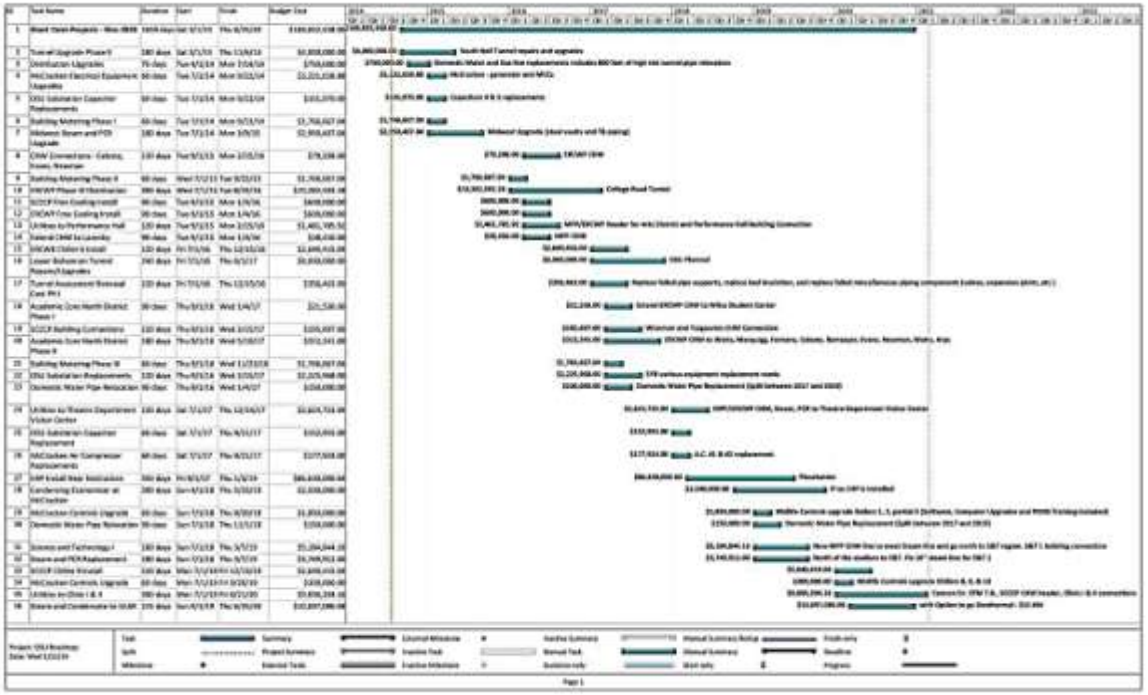
The Finale

Planning Roadmap



40YR Roadmap:

- Provides Ohio State with one document for use in their capital planning efforts
- Gantt Chart that includes project start, duration, costs and detailed project descriptions
- Split in near term, mid term, and long term projects
- Near term: $169M in projects
- Mid term: $195M in additional projects
- Long term: $176M in additional projects
- Total over $541M in projects planned over 40YRS

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Questions

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Thanks for Attending.
Have a great Day.