How a Second Look at CHP Can Save You Significant Headaches

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Agenda

- Current Installed Assets
- Identification of the Concerns
- Screening Process
- Analysis of the Alternatives
- Review of the Results
- Questions

ASU Tempe Campus Information

- Acres 642
- 15.9 Million square feet of facilities
- Research, Institutional, Residential & Sports
- 52,000 - Student population in 2016
- 60,000 – Planned Growth by 2020

Central Utilities

- Main Campus & Research Campus share Steam and Chilled Water (CHW) distribution system
- CUP – Main Campus: 240,000 pph Steam & 20,000 Tons CHW
- CHP – Resiliency for Research Campus: 80,000 pph Steam & 10,000 Tons CHW
- Satellite Chiller Plant for North Campus: 1670 Tons CHW
- TES – Thermal Storage 52,800 Ton-Hours

Goals of CHP

"Resiliency for the Research Community"

Arizona State University CHP Plant

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Arizona State University CHP Plant

- In service 2006
- 73,352 Sq. Ft
- 9 MW of Generation Capacity

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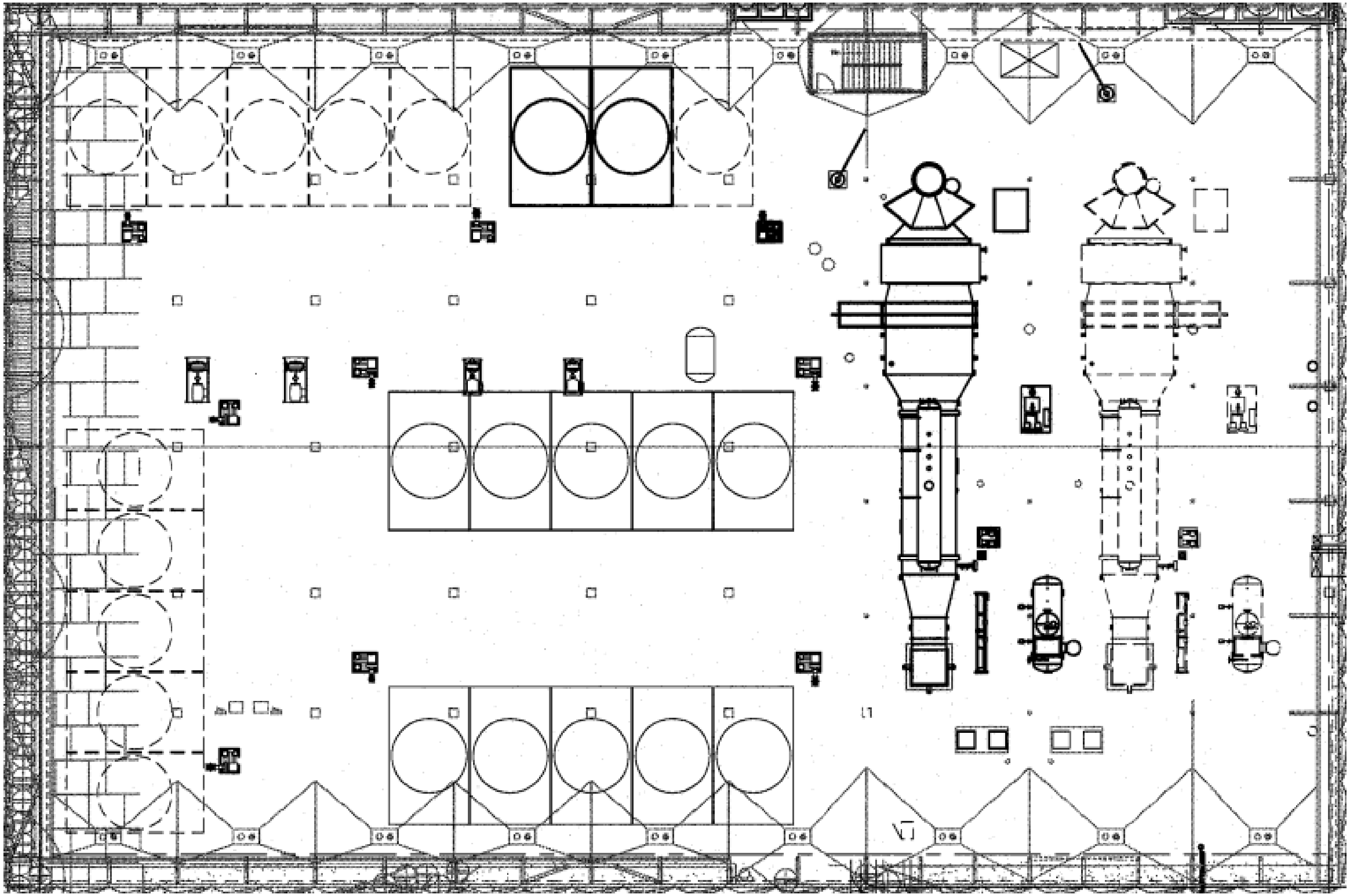
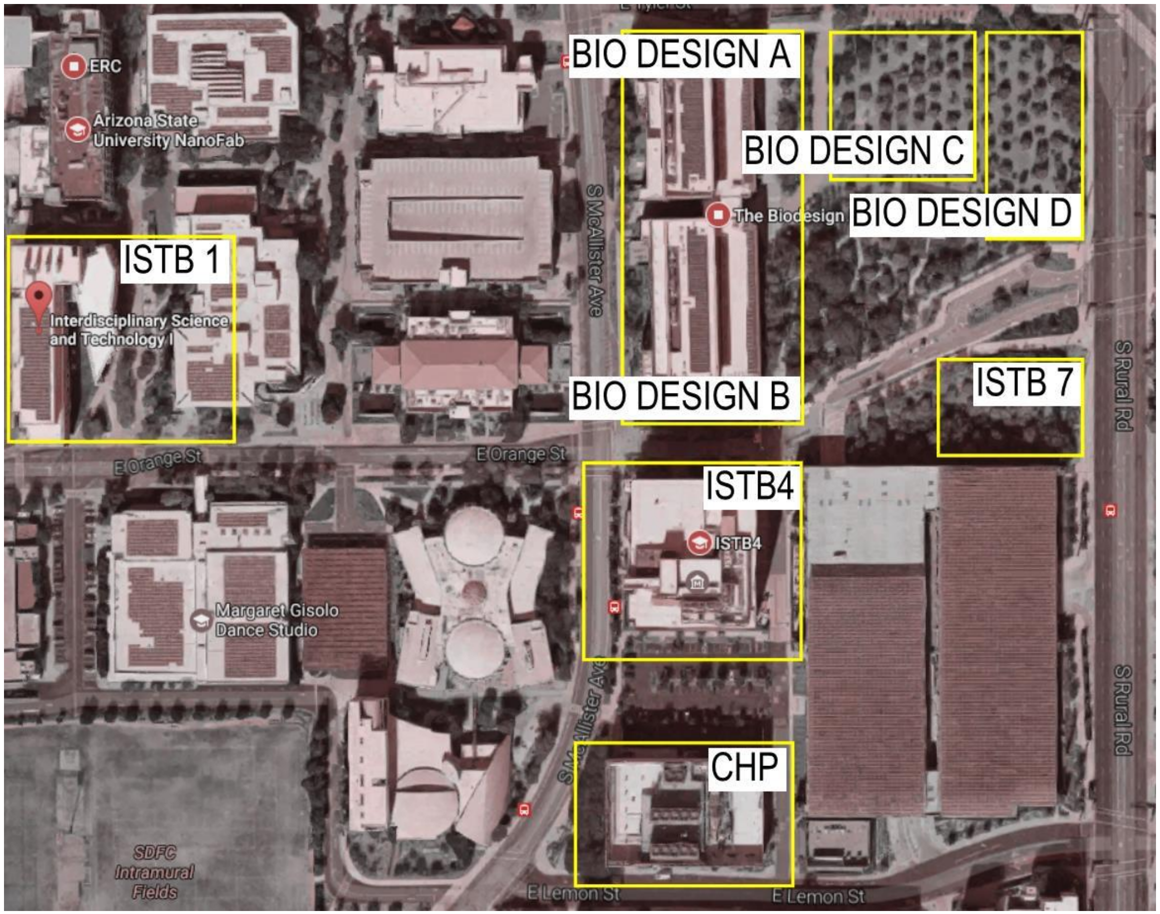
Installed CHP Capacity

- **Electrical Assets**
  - CTG: Solar Taurus 70 - 7.2 MW
  - STG: Murray - 1.8 MW
- **Heating Assets**
  - HRSG: 30,000 pph steam @ 150 psig
  - Duct burners: additional 50,000 pph
  - Total: 85,000 pph steam
- **Cooling Assets**
  - 5 York Chillers: 2,000 Tons each
  - Total: 10,000 Tons
- **Emergency Assets**
  - 2 Diesel Generators – 2 MW each
  - Total: 4.0 MW



- Designed with expansion in mind
- Additional T-70
- More cooling capacity

Research Community



Research Community Microgrid is comprised of:

- Bio Design A
- Bio Design B
- ISTB 1
- ISTB 4

Planned Additions:

- 2017: Bio Design C
- 2020: Bio Design D – Loc. TBD
- 2022: ISTB 7 – Loc. TBD

Research Community Concerns…

1. Is there enough power output from CHP for 2022 buildings?
2. How can ASU safeguard the resiliency of the Research?
3. Cost of electricity is increasing by 6% in 2018.
4. What Technologies should be evaluated for expansion?
5. Can proposed changes be implemented to:
   - Improve performance and efficiency?
   - Reduce carbon footprint?
   - Reduce cost of operation?
   - Increase resiliency for Main Campus as well as Research?

2022 Data – Total Load Projection

	Total Steam (mmBtu/hr)	Total Chilled Water (tons)	Research Community Electric (MW)	Campus Electric (MW)	Total Electric (MW)
Maximum	159	24,087	12.3	44.6	52.9
Average	50	9,314	7.9	25.4	30.8
Minimum	14	567	5.4	13.8	11.6

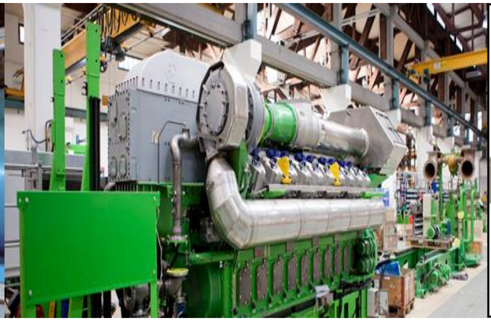
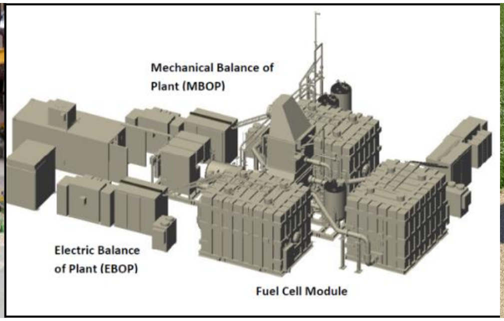
Existing Electrical Generation

Equipment	Current Total Capacity (MW)
CTG: Solar Taurus 70	7.2
STG: Murray	1.8
Total Capacity	9.0
Projected Max Load	12.3/7.9
Deficit	(3.3)

Noted Utilization & Efficiency Issues

- Short on power in peak season
  - Limited chiller operation during peak season
- Low annual utilization at 65% (2015)
- Low efficiency with low utilization
- Utilization goes up to 96% with new loads but resiliency reduced w/ power shortage worsening
  - Add the 2nd CTG, increase resiliency but decrease utilization and efficiency
  - What are the other options?

Technology Screening

Combustion Turbine

- Good electrical efficiency
- Primary heat recovery medium is steam with some hot water

Reciprocating Engine

- Excellent electrical efficiency
- Primary heat recovery medium is hot water with some steam

Fuel Cells

- Best electrical efficiency
- Low amount of waste heat
- Heat recovery medium is hot water (no steam)
- Works well with low temperature heating demands
- No 24/7 operations staff

Battery Storage

- Clean energy
- Increase Reliability of the grid
- Excellent pairing with renewables

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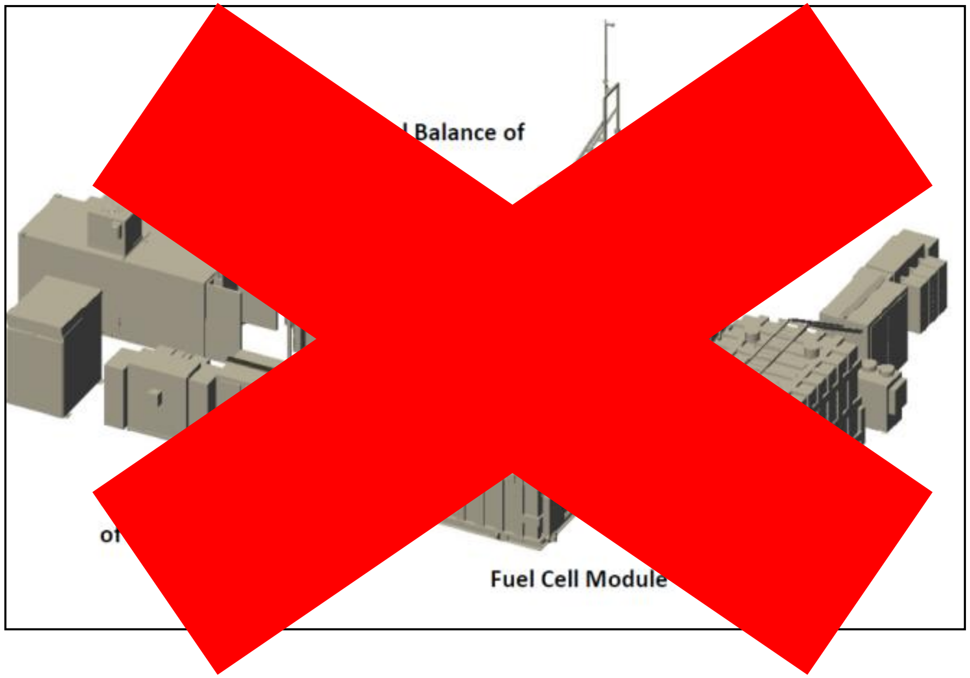
Reciprocating Engine

- Excellent electrical efficiency 48%
- Can easily fit in the existing CHP

- Sensitive to load changes
- Economically not ideal
- Lacking infrastructure for waste heat
- Noise would require building in building
- Significant HVAC

Fuel Cells

- Best electrical efficiency at 58%
- Low amount of waste heat
- No 24/7 operations staff
- Best Carbon Reduction vs. grid power



- Lacking infrastructure to deliver waste heat to end users
- Weak economic performance and incentives
- Large footprint: 7.4 MW = 125’ x 125’ (does not fit in CHP; need new site

Battery Storage

- 100% automated system
- Increase reliability of the grid
- Excellent pairing with renewables
- Manage peak shaving

- Need large footprint for quantity of storage needed (250 kW = parking space)
- Expensive Install with limited projected savings at ASU
- No state incentives

Combustion Turbine Generator

- Responsive to load changes
- Increase reliability of the grid
- Fits inside the existing CHP
- Financially strong

- Low utilization of turbine
- Lower efficiency than fuel cells/recip. Engines ~ 35%

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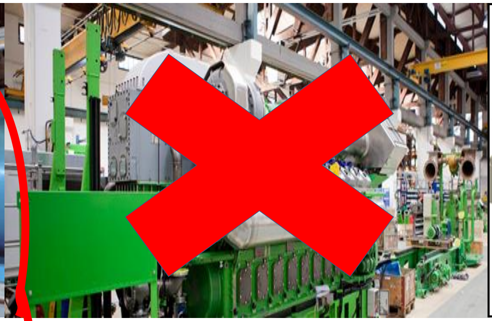

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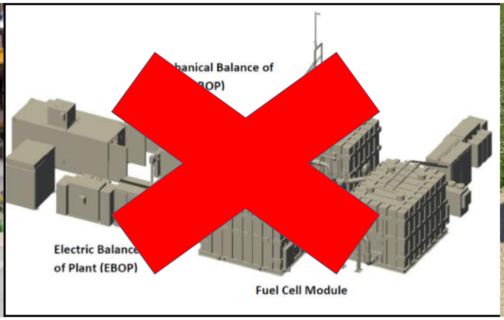

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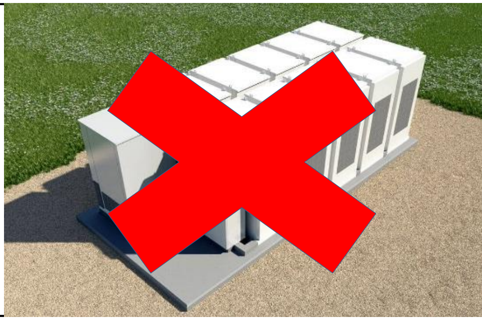

Battery Storage

- Clean energy
- Increase Reliability of the grid
- Excellent pairing with renewables

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CTG Utilization – Business as Usual (BAU)

BAU (1 - CTG)	BAU 2 (2 - CTGs)
96%	59%

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How Do We Load the Turbines?

Add electric and CW loads

59%

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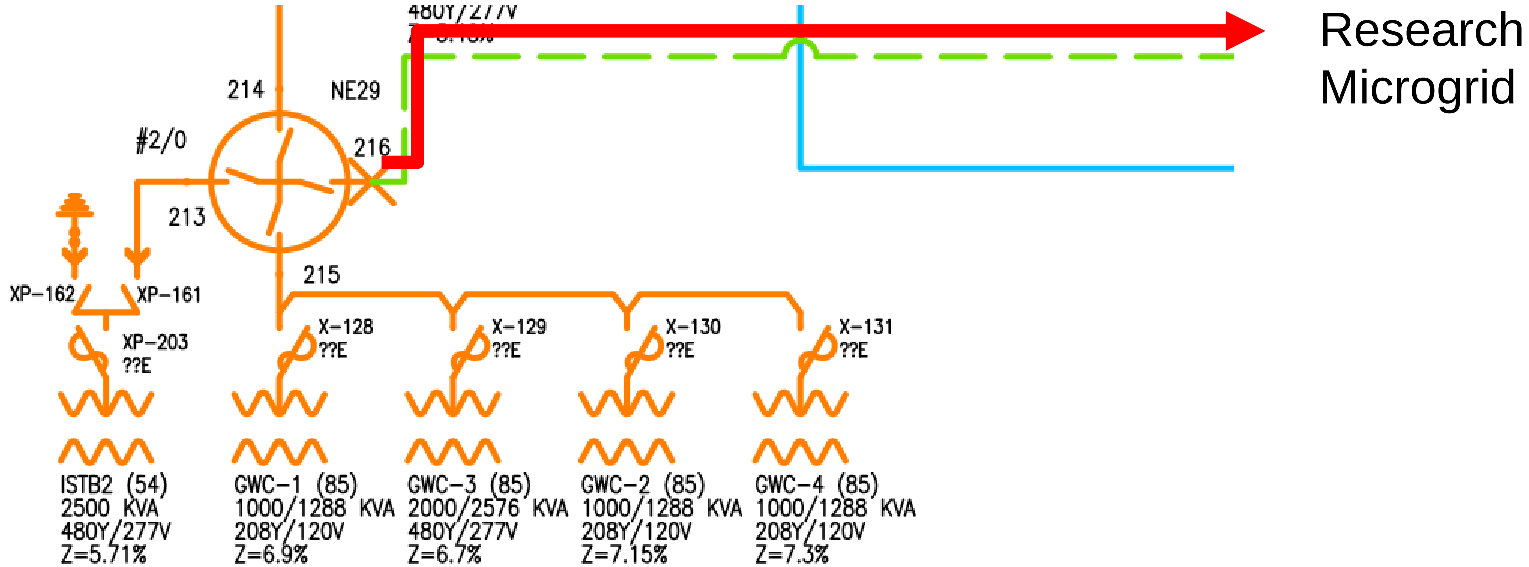
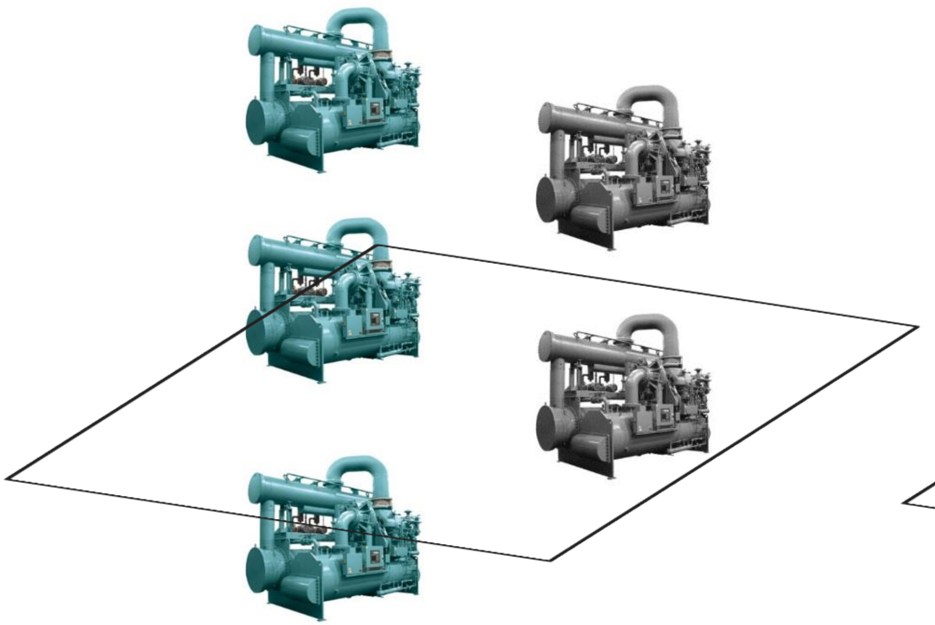
Add Buildings



- Single line diagram showed that Goldwater and ISTB 2 were previously connected to the Research Microgrid

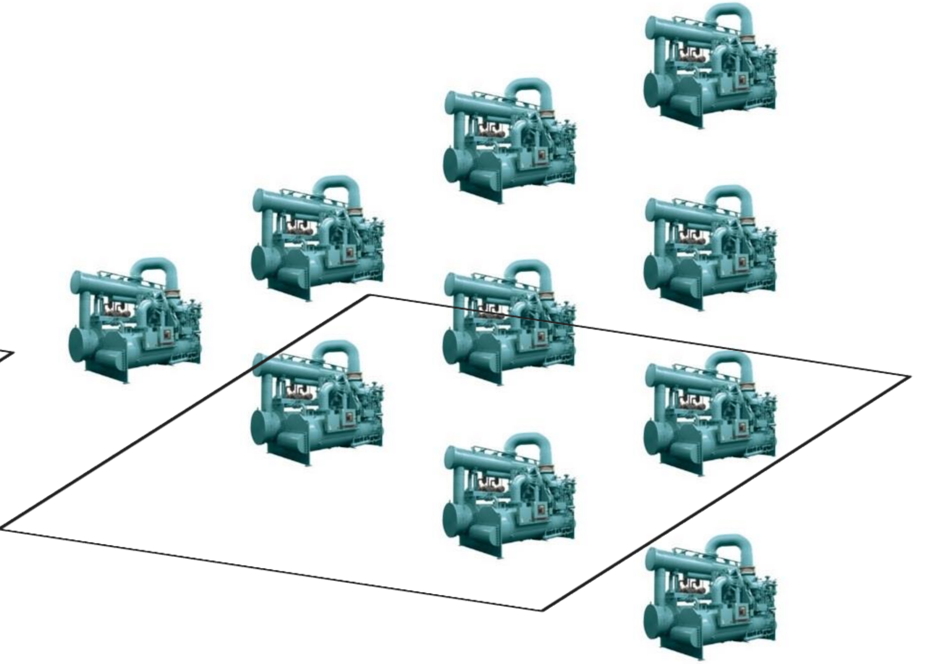
Asset Staging

CHP



- 10,000 Tons Cooling
- Limited to operating 3

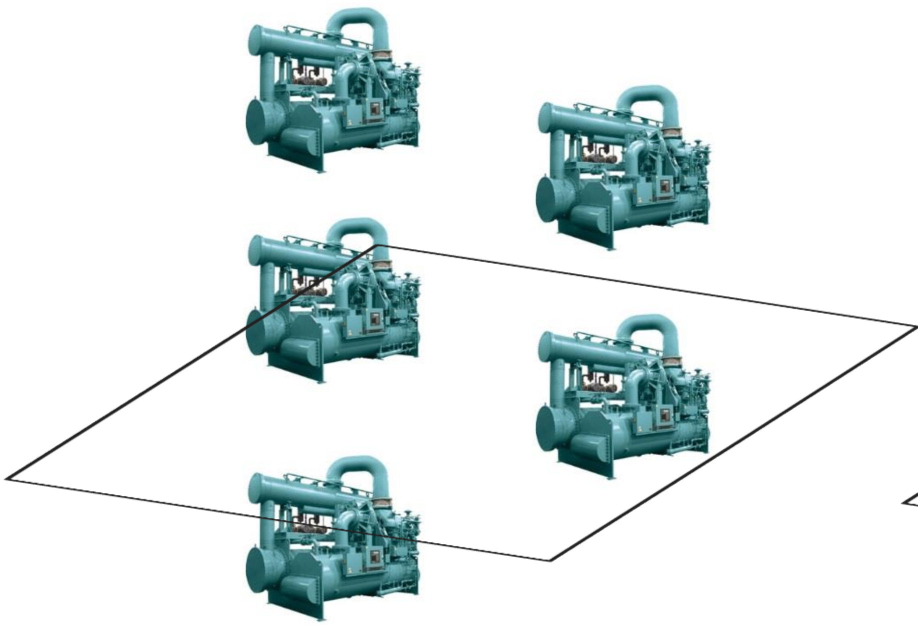
CUP + TES



- 20,000 Tons Cooling
- Primary source
- 5 Million Gallons TES

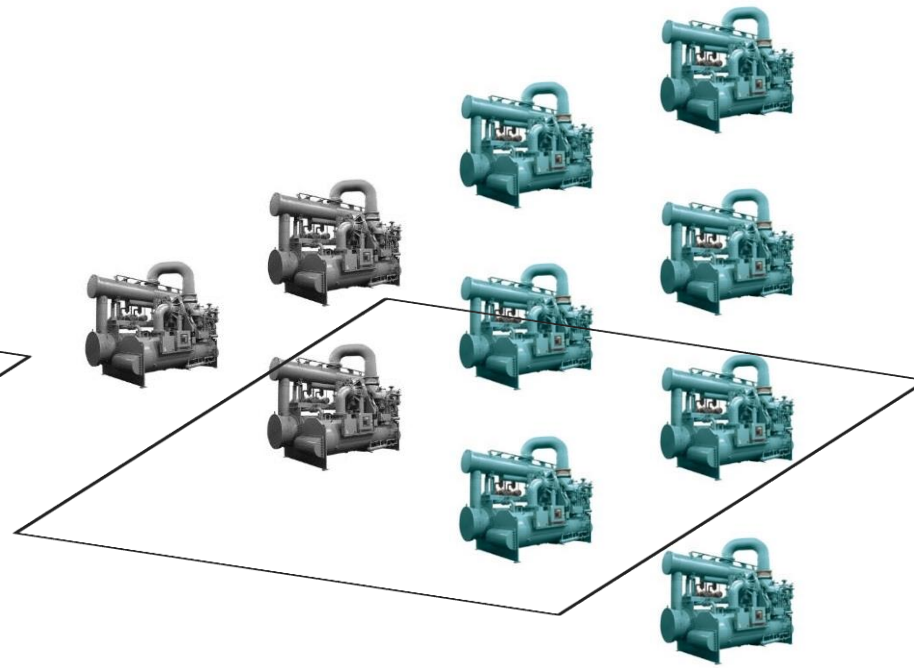
Proposed Asset Staging

CHP



- Switch as the primary cooling source

CUP + TES



- Dispatch as needed

2022 Data – NEW Load Projection

	BAU Electric Load (MW)	NEW Modified Electric Load (MW)
Maximum	12.3	15.2
Average	7.9	11.7
Minimum	5.4	6.5

- Load increase to increase utilization of turbines

CTG Utilization

BAU (1 CTG)	BAU 2 (2 - CTGs)	OPTION 1A (2 - CTGs)	OPTION 1B (2 - CTGs)
96%	59%	64%	82%

Other Investigations & Discoveries

- Can the buildings be switched to Microgrid? *YES*
- Can the chilled water be pumped to remote areas on campus? *YES*
- Is it cost effective? *YES*
- Will there be unused waste heat? *NO*
- Are there any necessary infrastructure upgrades? *YES*
  - *Fix CHW Bottlenecks*
  - *Correct undersized Feeder*
  - *Implement Best Practices*
- Operating recommendations

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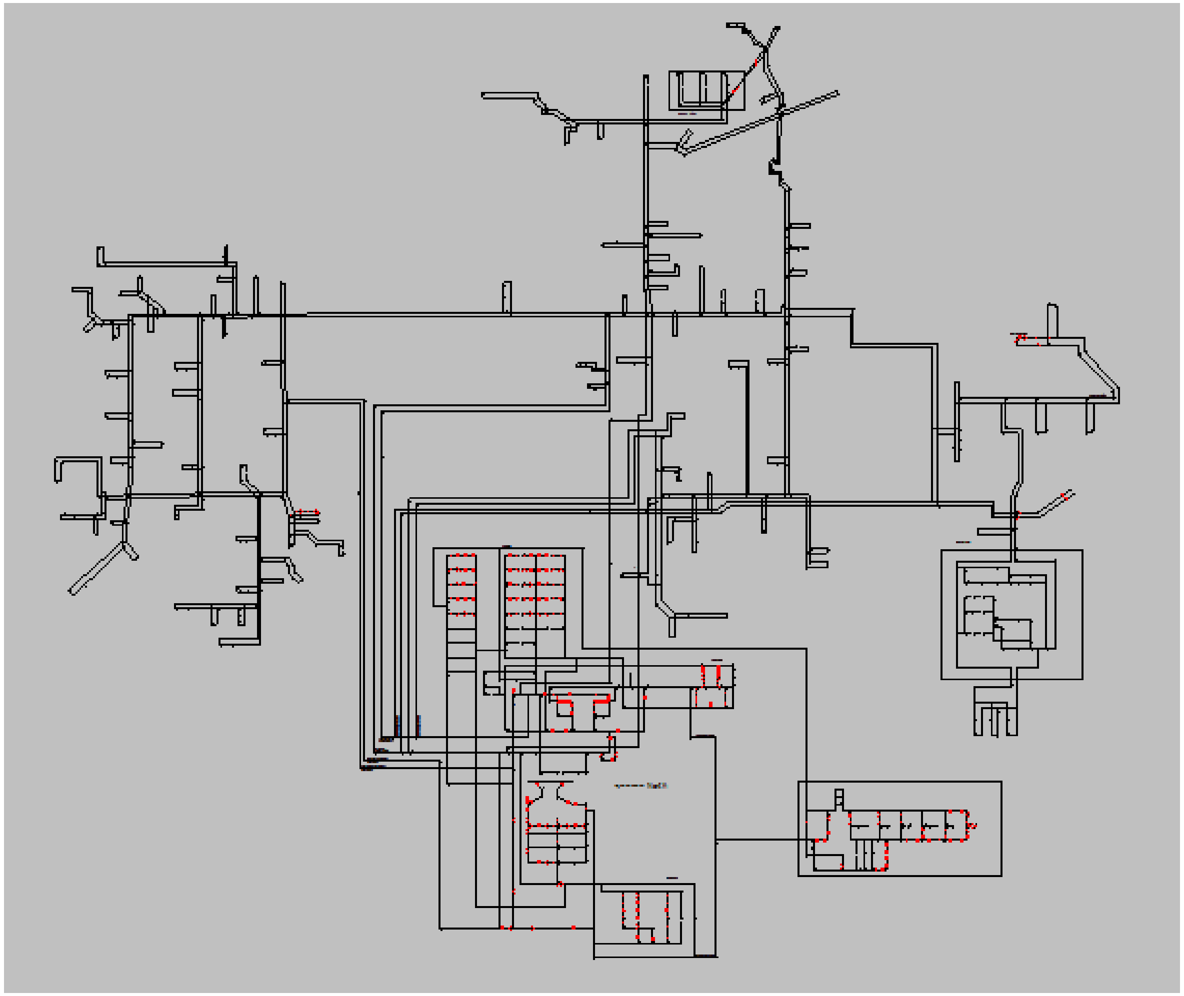
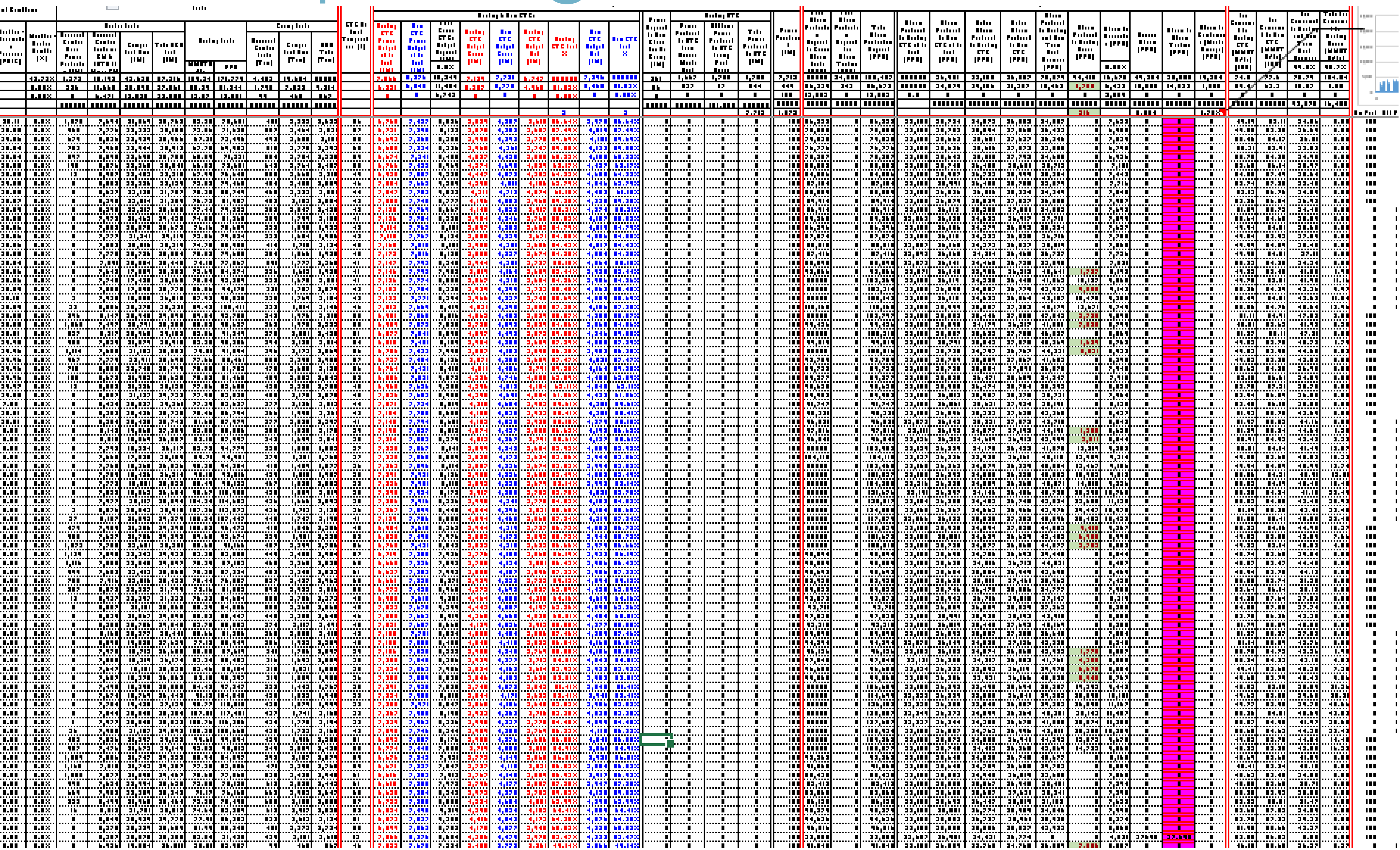
Hydraulic Model



Hydraulic Model

- **Validated full export of 10,000 tons from CHP to campus**
  - 100% installed capacity
  - No bottlenecks/constraints
- **Bottlenecks identified in various other locations**
  - Central Plant Headers
  - Inside several campus buildings
  - Distribution as a result of satellite plant
- **Other issues identified:**
  - Delta T problems in buildings
  - Uneven distribution of cooling within buildings
  - Not all buildings with hot calls have delta T issues
  - Noisy buildings: potentially high velocities

8760 Operating Model



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Results: Financial Proforma Summary

CASE	BAU 1-CTG	BAU 2 2-CTG	OPTION 1B (OPTION 1A + Chiller Shift)
Annual Purchased Electric	$5,787,000	$4,010,000	$555,000
Annual Purchased Fuel	$4,938,000	$5,702,000	$6,843,000
Annual O&M Expenses	$795,000	$1,430,000	$1,465,000
Total Annual Expenses	$11,519,000	$11,142,000	$8,862,000
Annual Savings vs. BAU	N/A	+$377,000	+$2,657,000
Capital Cost Estimate	N/A	$18,000,000	$18,000,000
Simple Payback Period	N/A	48 years	7 years

Load & Asset Optimization

Equipment	Quantity (EA)	2022 1-CTG (MW)	2022 2-CTG (MW)
CTG: Solar Taurus 70	1	7.2	14.9
STG: Murray	1	1.8	1.8
Total Capacity	-	9.0	16.7
Deficit/Surplus	-	(3.3)	1.5
Utilization	-	96%	82%
CHP Efficiency	-	65%	60%


QUESTIONS?