Taming the 900-Pound Gorilla

Using Integrated Design to Create a Net-Zero Dining Hall

PROCTOR
Live to Learn. Learn to Live.

Dining Commons

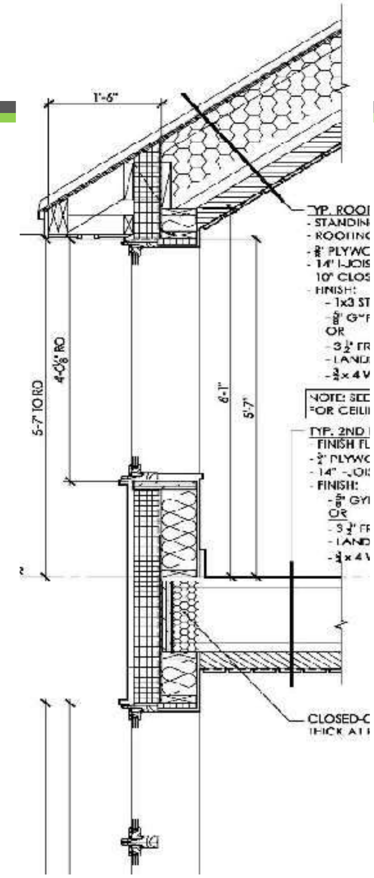
- 16,000 sf dining hall and commercial kitchen
- 350 seats
- Experiential Servery/Food Forest Layout
- Site Responsive Design
- Campus Social Center
- Net Zero Ready

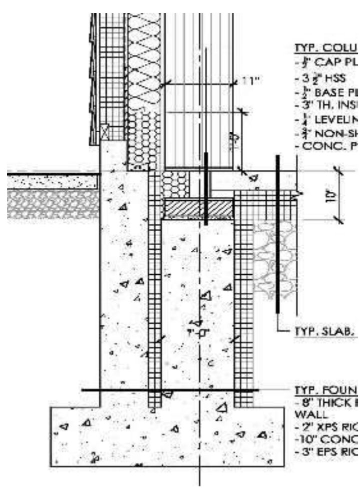
ACHIEVING NET ZERO READY?

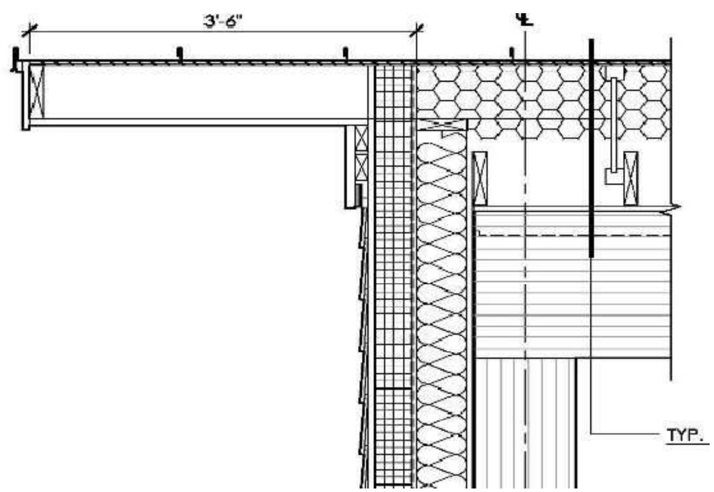
- Reduce envelope loads
- Reduce kitchen load s
- Efficient Mechanical Systems

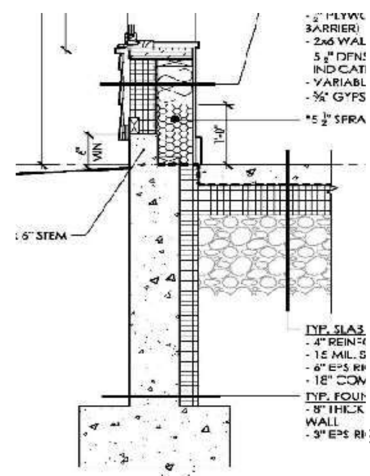
- Reduce envelope loads

Floor/Slab Assembly R-value:	R-27 to R-18 (6"-4" EPS)
Wall Assembly R-Value:	R-38 (5.5" cellulose w/ 4" polyiso)
Roof Assembly R-Value:	R-54 (13" HFO Two part PU Spray)
Windows:	Triple-glazed, Argon Paradigm U-0.23, R-4.35
Envelope Infiltration Rate:	0.1 CFM50 / sq. ft.









- Efficient Mechanicals – Systems Selectin Matrix

Proctor Dining Hall Mechanical Options 5/20/2015 11:22

	Ground Source Heat Pump (GSHP)	**Ground Source Heat Pump (GSHP) + Boiler hybrid**	**Air Source Heat Pump (ASHP) + Boiler**	**Ground Source Heat Pump (GSHP) + air source hybrid**	**Air Source Heat Pump (ASHP) only**
Space heat	water-loop heat pump	water-loop heat pump	ASHP indoor unit except when too cold, then hydronic heat with cost-optimized switchover	ASHP for space heat, GSHP for makeup air and ventilation post ERV conditioning	ASHP indoor unit for space heat, multiple air-water HP's for makeup air and ventilation post ERV conditioning
Space cool	water-loop heat pump	water-loop heat pump	ASHP indoor unit for all cooling loads	ASHP for space cooling and GSHP for cooling post ERV ventilation air	ASHP indoor unit for all cooling loads
Kitchen Hood	variable speed demand controlled, with heat recovery makeup air	variable speed demand controlled, with heat recovery makeup air	variable speed demand controlled, with heat recovery makeup air	variable speed demand controlled, with heat recovery makeup air	variable speed demand controlled, with heat recovery makeup air
Ventilation air	ERV for ventilation in dining areas with demand controlled (CO2) control	ERV for ventilation in dining areas with demand controlled (CO2) control	ERV for ventilation in dining areas with demand controlled (CO2) control	ERV for ventilation in dining areas with demand controlled (CO2) control	ERV for ventilation in dining areas with demand controlled (CO2) control
Makeup air heat	coils from GSHP	coils from GSHP or boiler	ASHP or boiler	coils from GSHP	ASHP multiple makeup air unit – only up to 3 or 4 tons/unit – more info needed
Makeup air cool	coils from GSHP	coils from GSHP	ASHP makeup air unit	coils from GSHP	ASHP makeup air unit
Service hot water	GSHP preheat + resistance boost + chemical dishwashing, solar DHW possible add	GSHP preheat + resistance boost + chemical dishwashing, solar DHW possible add	boiler + solar DHW possible add	GSHP preheat + resistance boost + chemical dishwashing, solar DHW possible add	Solar DHW with off-peak electric backup + chemical dishwashing
Coldest weather issues?	No	No	No	No	Yes [2]
All renewable possible?	Yes, all electric	Yes, if boiler is pellet-fired	Yes, if boiler is pellet-fired	Yes, all electric	Yes, all electric
Energy Modeling assumptions	All thermal energy from GSHP	Half of thermal energy from GSHP/half from pellet boiler, except vventilation heating makeup all pellets	Half of thermal energy from ASHP/half from pellet boiler	Half of thermal energy from ASHP/half from GSHP	All thermal energy from ASHP

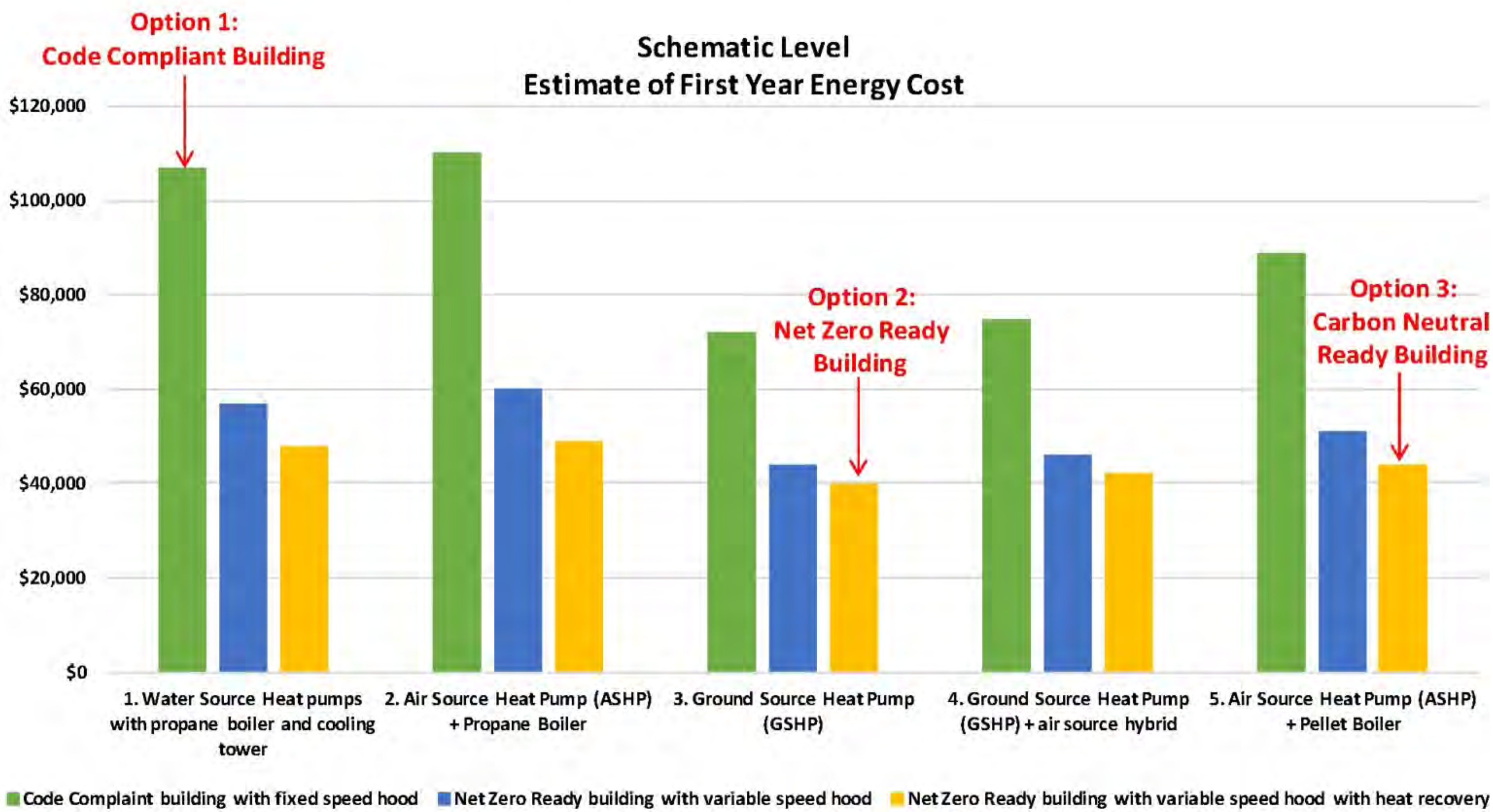
[2] More research under way about this issue
[3] closed loop ground heat exchangers

- Efficient Mechanical Systems

Ground Source Heat Pump (GSHP)	Ground Source Heat Pump (GSHP) + Boiler hybrid	Air Source Heat Pump (ASHP) + Boiler	Ground Source Heat Pump (GSHP) + air source hybrid	Air Source Heat Pump (ASHP) only

Mechanical analysis

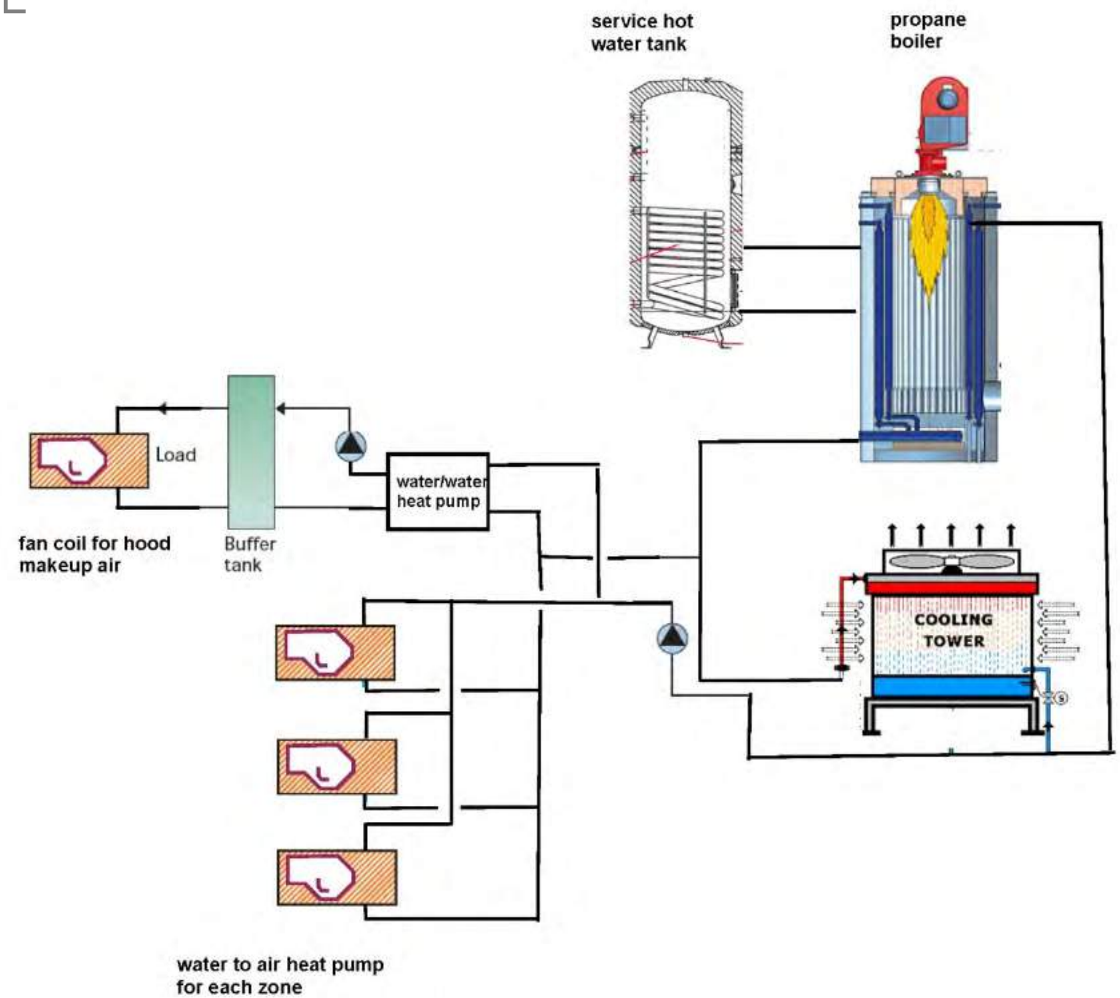
- 5 mechanical systems + 3 kitchen hood options



- Efficient Mechanical Systems

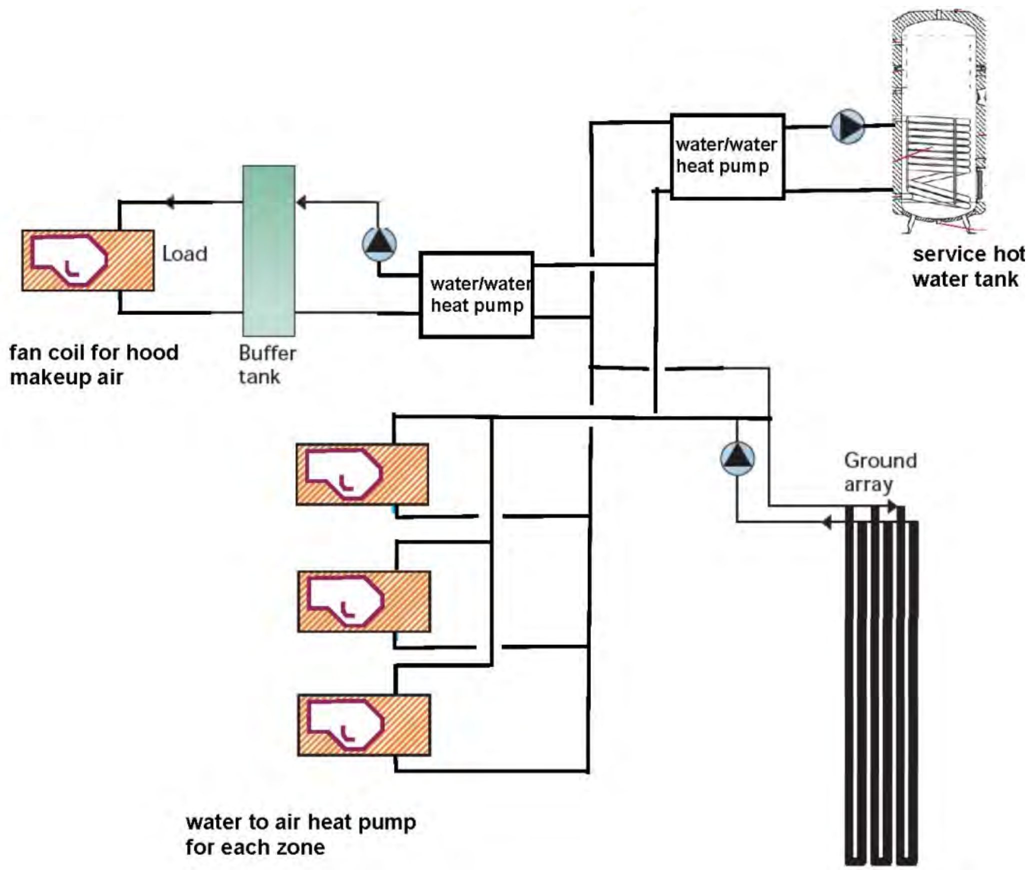
  - HVAC OPTION 1: CODE

    – Propane Fired Conventional Water Source Heat Pump System



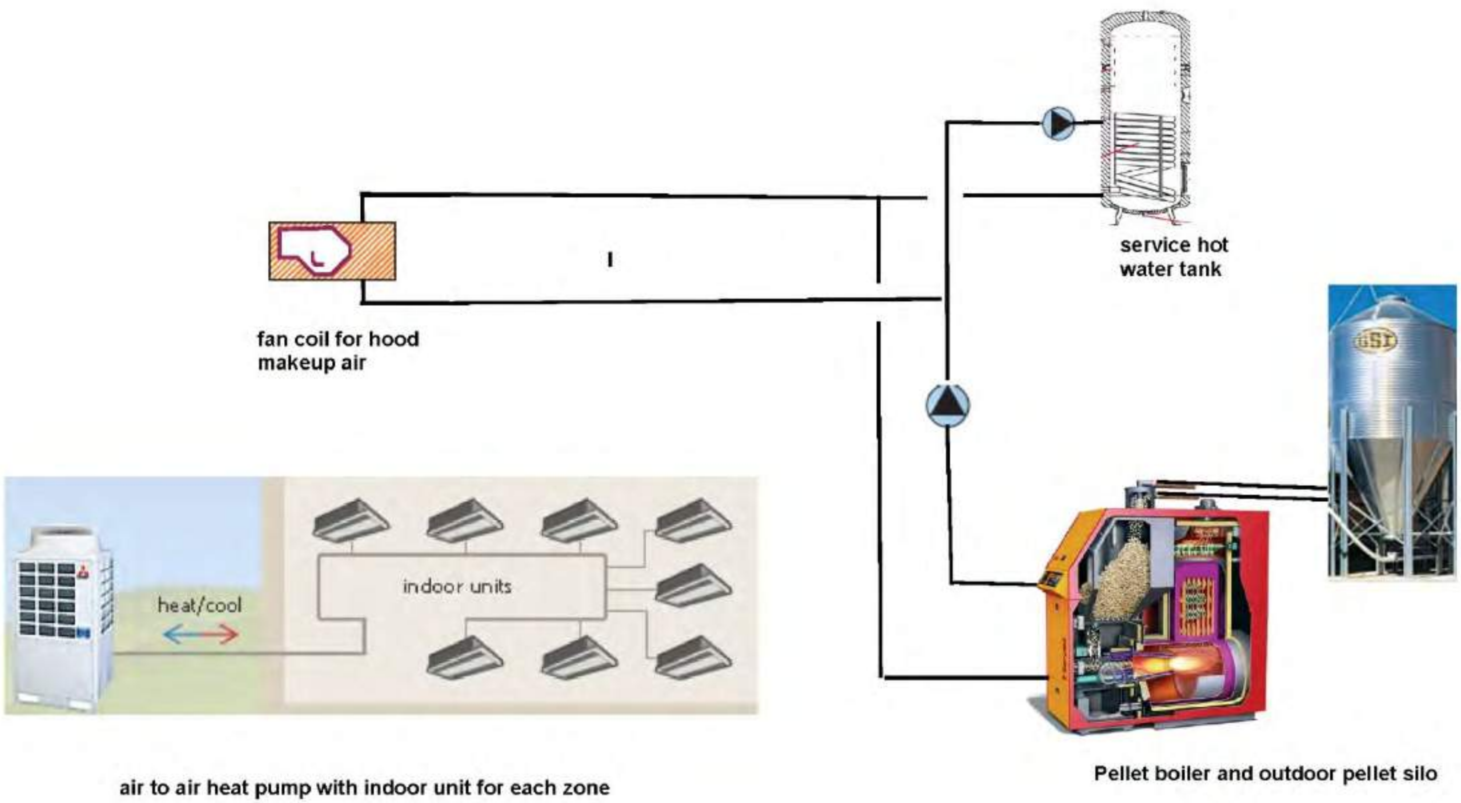
- Efficient Mechanical Systems

  - HVAC OPTION 2: NET ZERO
    - Ground Source Heat Pump System



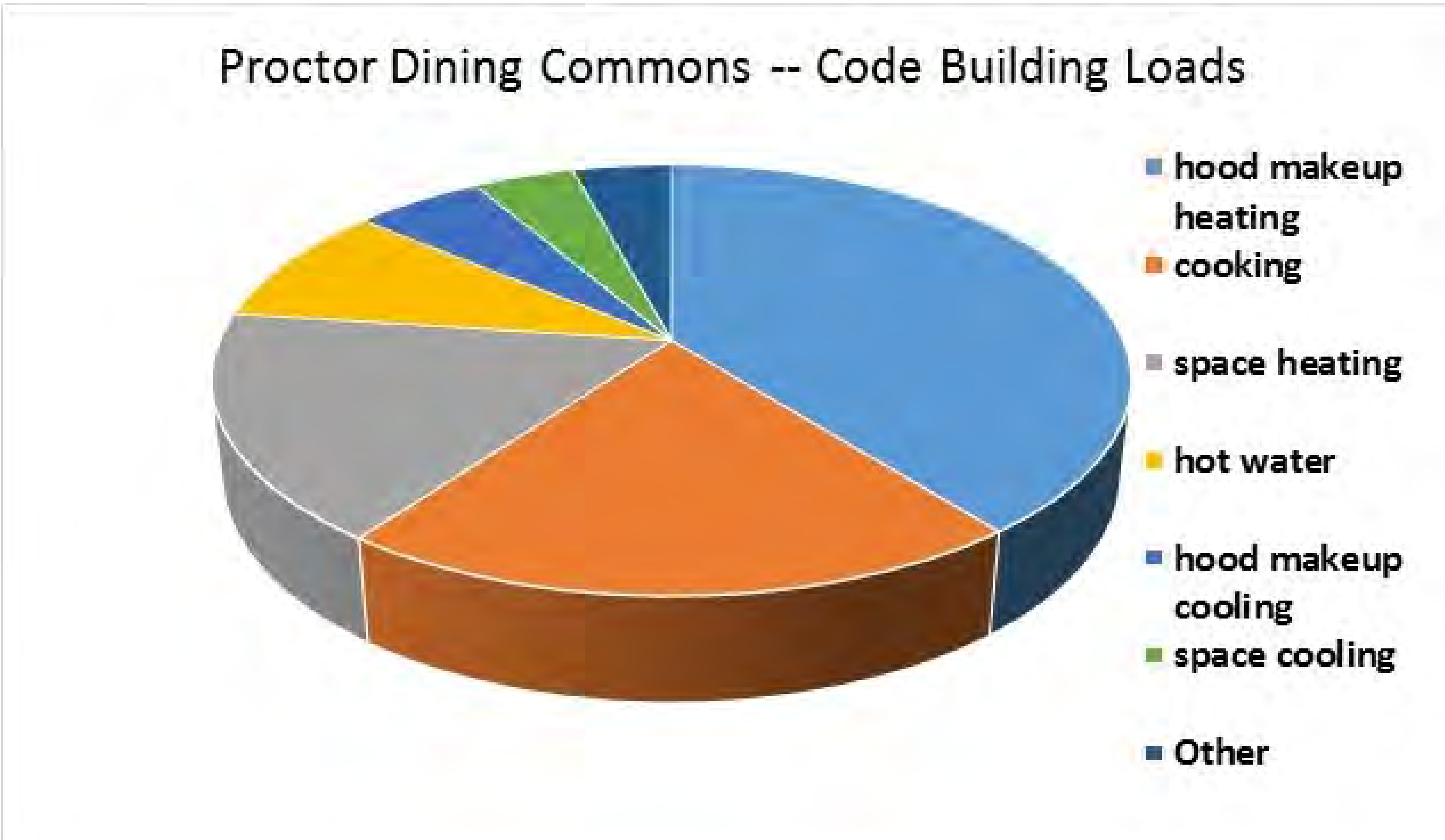
- Efficient Mechanical Systems

- HVAC OPTION 1: ALL RENEWABLE, INCLUDES COMBUSTION
  - Air Source Heat Pump System for Building Conditioning
  - Wood Pellet Boiler for Hot Water and Make-up Air



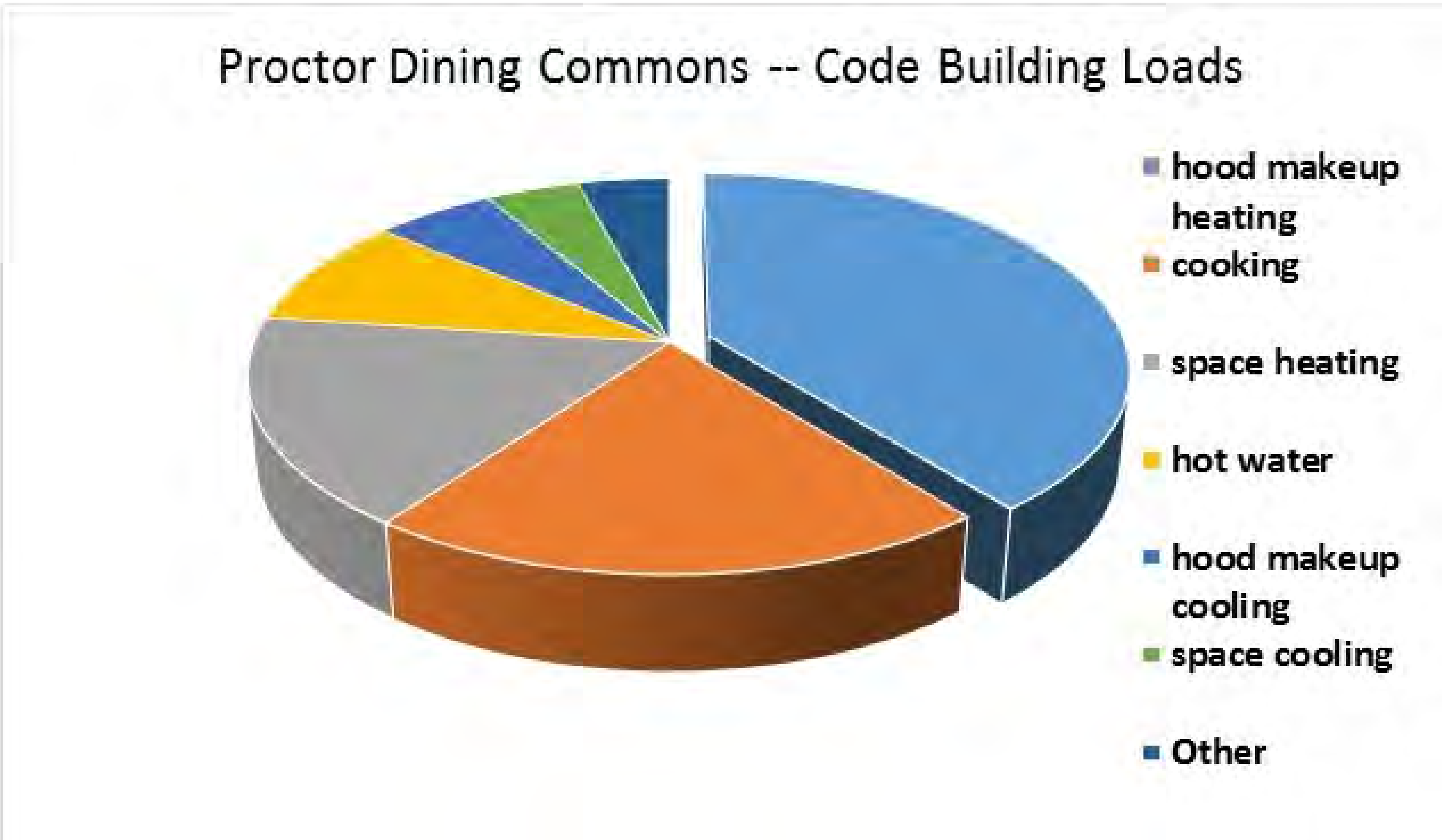
Energy Modeling and Optimizing Systems

- Question #1: What are the Loads?



Energy Modeling and Optimizing Systems

- Biggest Slice: ***Hood Makeup Air***



- Client Commitments and Goals
  - Healthy Food Fresh Local Ingredients
  - Continued "From Scratch" Cooking and Baking
  - No Menu Sacrifices
  - Sustainability

- Reduce Hood Make-up Air
  - Objective #1 – Minimize hood lengths

- Client Commitments and Goals
  - Healthy Food Fresh Local Ingredients
  - Continued from Scratch Cooking and Baking
  - No Menu Sacrifices
  - Sustainability

MORE COMPACT LAYOUT **=**

Less SF/Less building

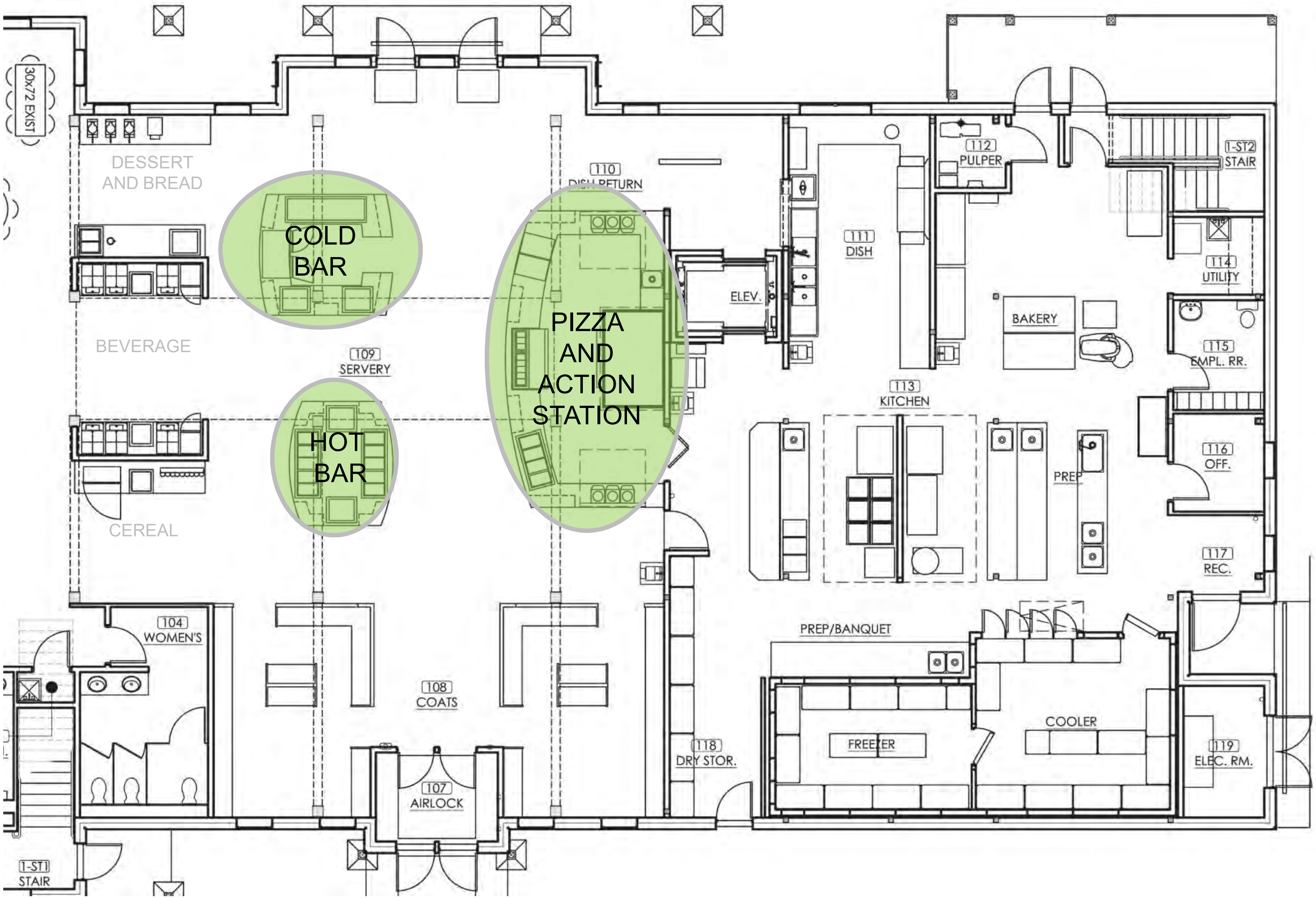
- 100 SF /smaller kitchen
- 17 fewer LF of hood
- Significant Building Cost Savings

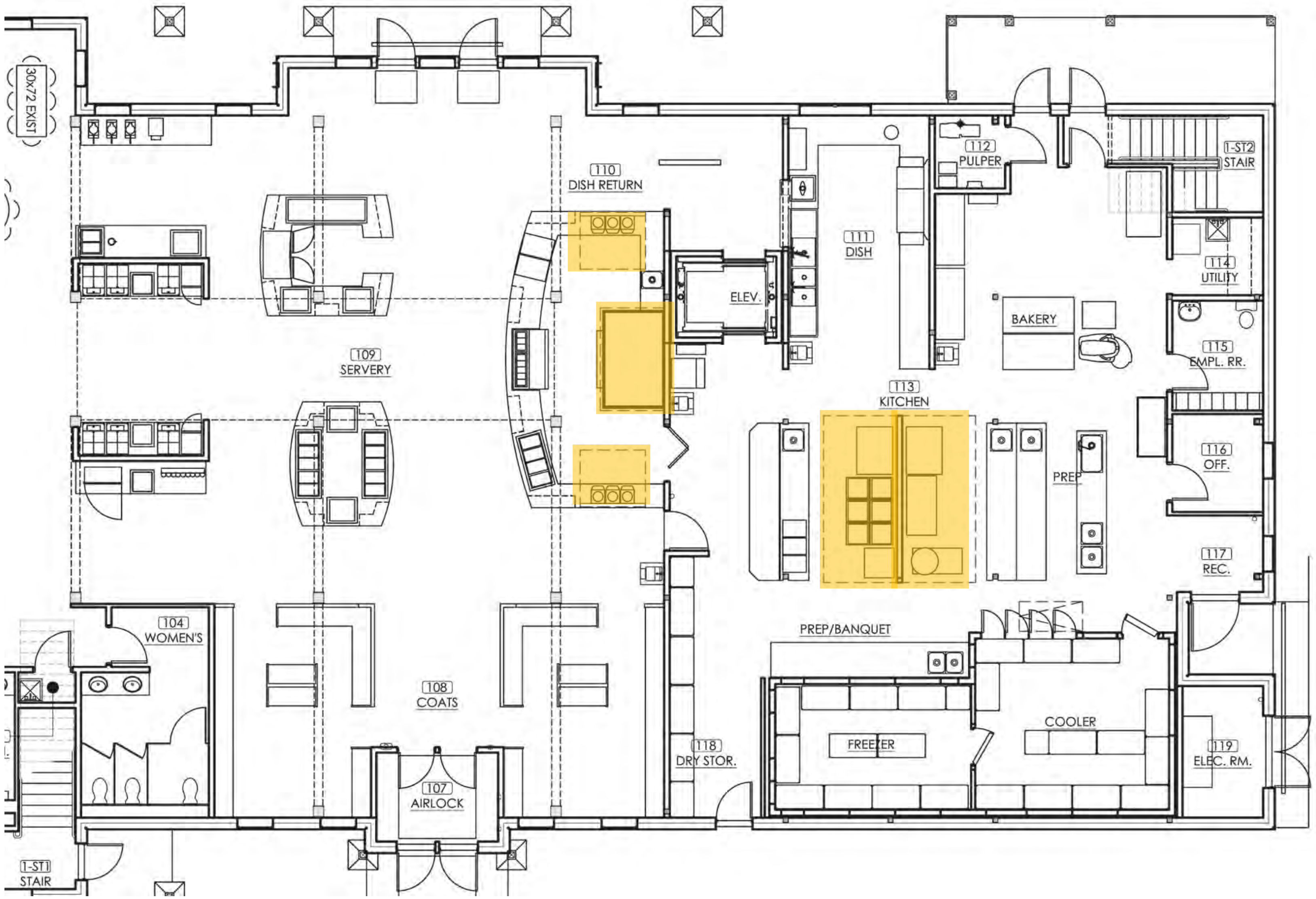
Additional Cost for Equipment ($50,000)

- 1st Year Energy Savings ($40,000)

- Reduce Hood Make-up Air
  - Objective #1 – Minimize hood lengths
  - Objective #2 – Minimize number of hoods

- Client Commitments and Goals
  - “Food Forest”
  - Face to Face/Personal Staff and Student Connection



30x72 EXIST
DESSERT AND BREAD
COLD BAR
110 DISH RETURN
PIZZA AND ACTION STATION
BEVERAGE
109 SERVERY
HOT BAR
CEREAL
ELEV.
111 DISH
112 PULPER
1-ST2 STAIR
114 UTILITY
BAKERY
115 EMPL. RR.
113 KITCHEN
PREP
116 OFF.
117 REC.
104 WOMEN'S
108 COATS
107 AIRLOCK
PREP/BANQUET
118 DRY STOR.
FREEZER
COOLER
119 ELEC. RM.
1-ST1 STAIR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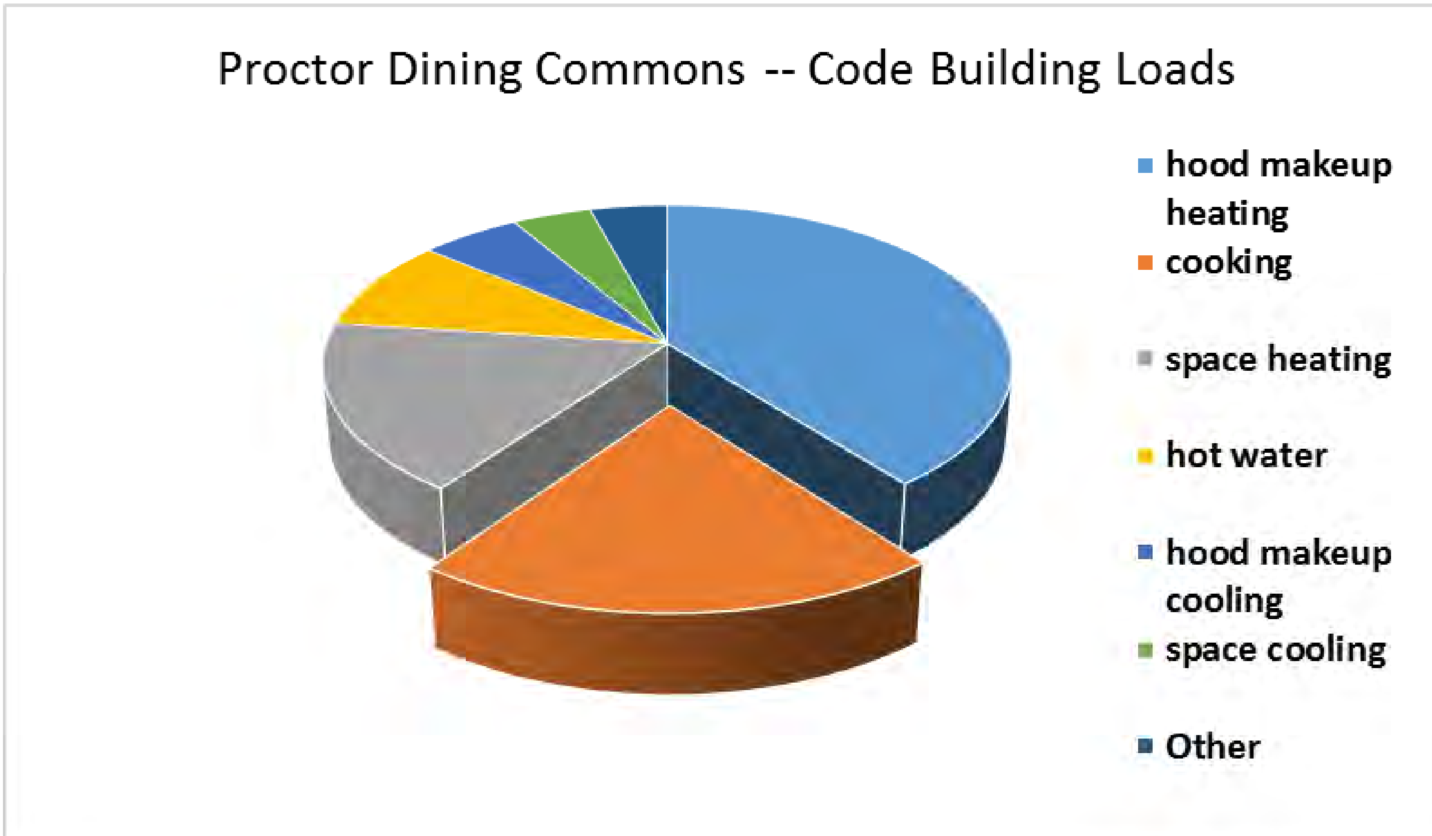
2nd Biggest Slice: Kitchen Equipment

Peak Load:
- ~100 kW (rough)

Annual Load:
~150,000 kWh/yr



Wild Card – Gas Pizza Oven

Approaches:
- Burn wood?
- Offset with more PV?
- Make methane?
- Student boycott of gas-fired pizza?

Gas Fired Pizza Oven					
Hrs/ day	Hours/ year	Avg%full load	MMBtu/ yr	Total Btu/hr	**gal/yr. propane**
4	1,038	0.25	91	350,000	**993**

Energy Modeling and Optimizing Systems

3rd Biggest Slice: Space Heat

NZR building energy

- **36 MMBtu/yr (14 MWh/yr)**

Approaches:

Super-insulate

- 0.1 cfm50/sq.ft. shell
- R- 5 windows
- R-20 slab
- R-40 walls
- R-60 roof

- ***GSHP with heat recovering water source heat pump loop***