IDEA2016 embracing change

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Evaluating District Energy Options

Workshop Session 1

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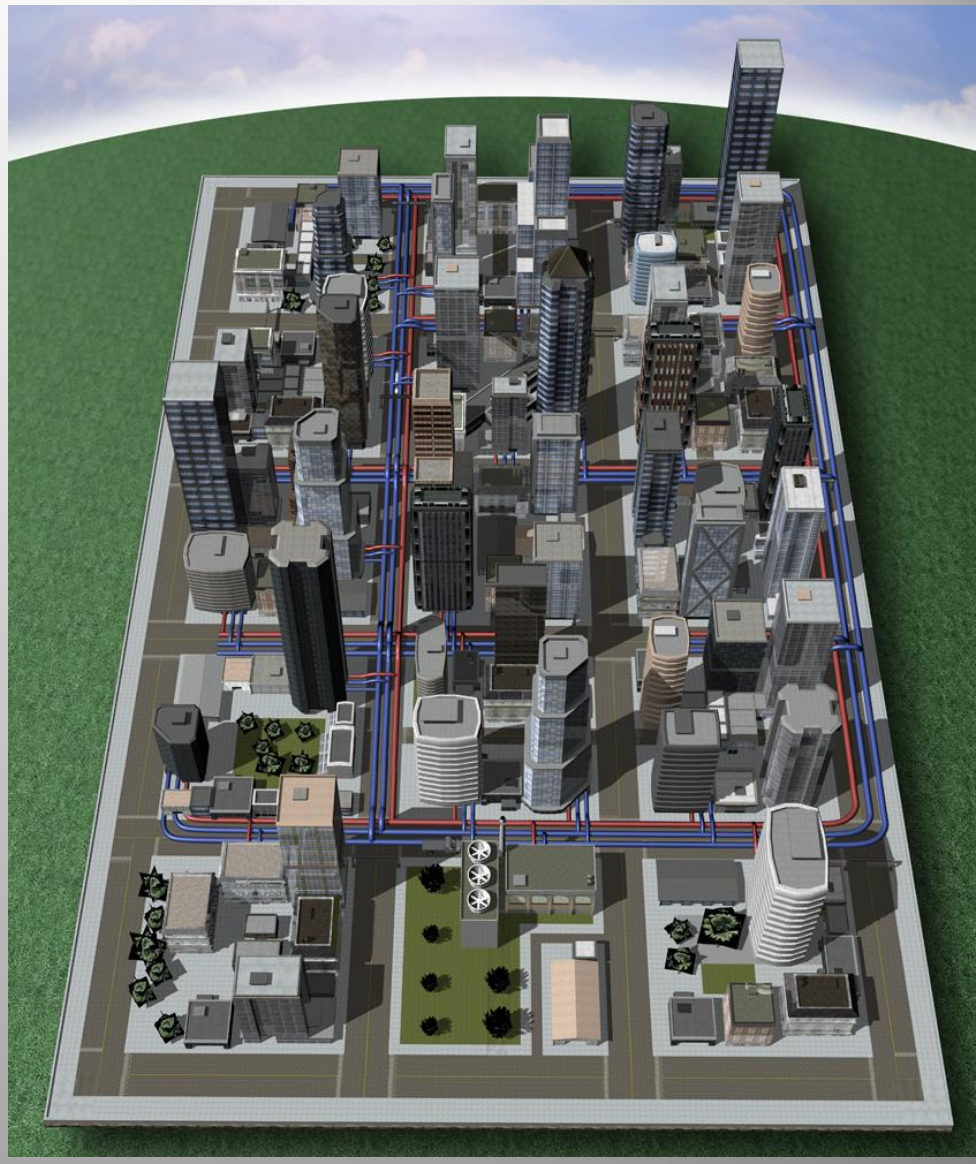
GLHN

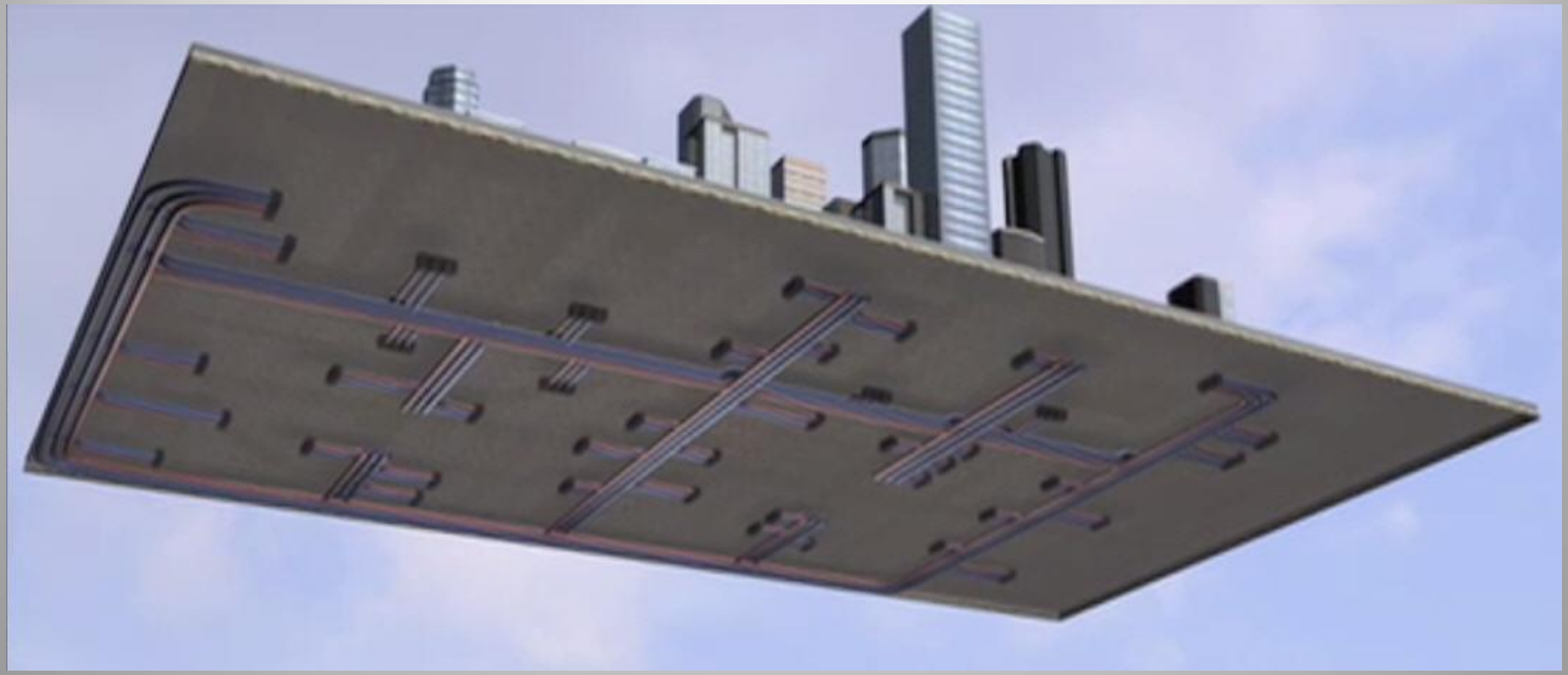
ARCHITECTURE | MECHANICAL | ELECTRICAL | CIVIL | TECHNOLOGY

District Energy Concept

- Central energy conversion plant(s) with underground network of heating and cooling lines, possibly electric power
- Aggregated thermal loads creates scale to apply fuels, technologies and strategies not feasible on single-building basis
- Provides Platform for Reliability, Resiliency, and Flexibility on a urban scale



District Energy Concept



- Economies of scale / load diversity
- Centralized operations
- Enables energy storage

- Adapts to smart grid
- High efficiency/ sustainability
- Alternative H&C Technologies
- Combined Heat and Power

District Energy Concept

Benefits

- Environmental
  - Improved energy efficiency
  - Reduced Greenhouse Gas
- Utility
  - Reduced energy utility costs
  - Consumption, Demand, Utilization
- Developer
  - Reduced initial capital cost
  - Reduced annual operating costs
  - Increased leasable SF
- Owner
  - Consolidated energy, O&M
  - Potential improved occupancy

Risk

- Cost of infrastructure
- Return on investment
- Certainty of load

District Energy Decision Making

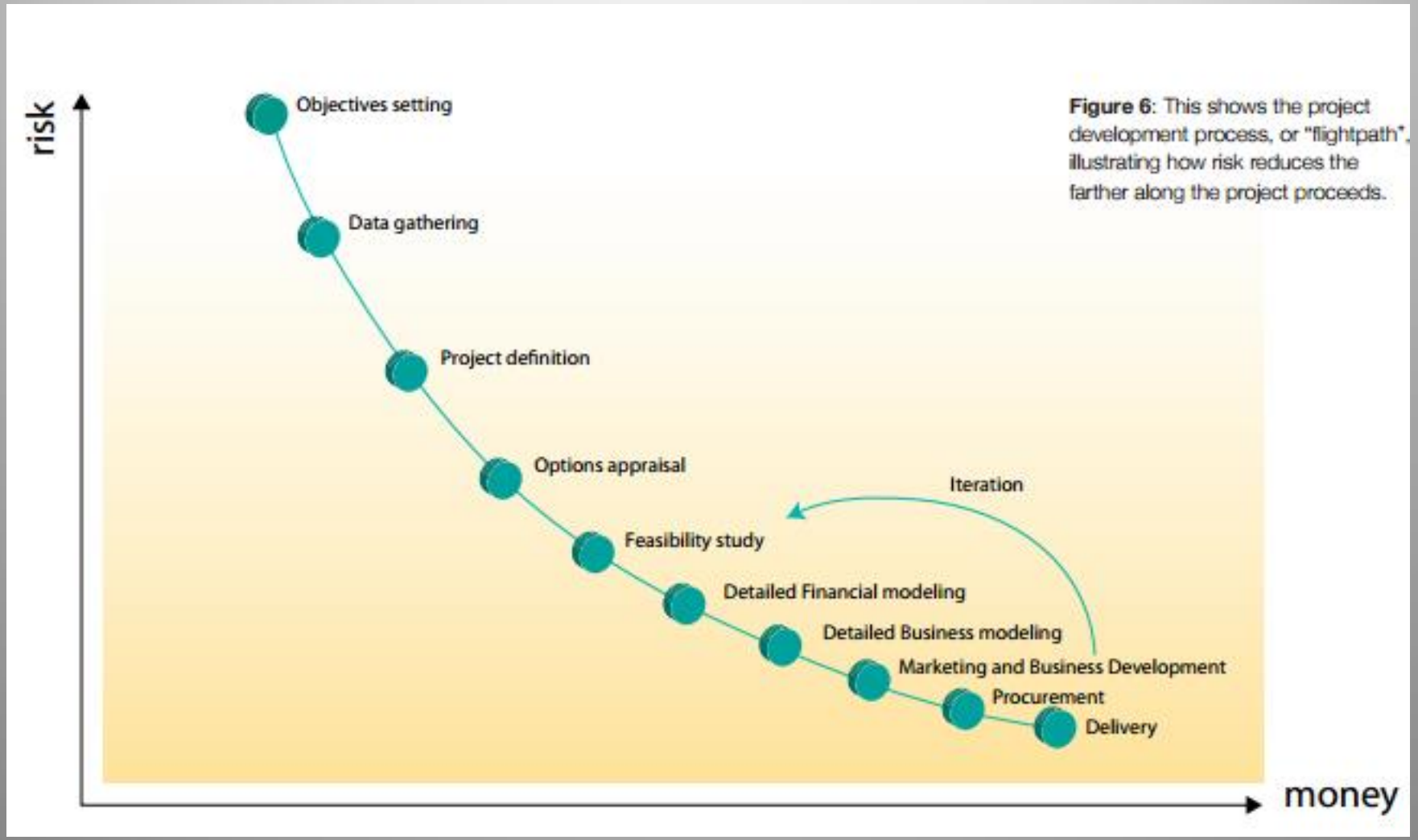


Figure 6: This shows the project development process, or "flightpath", illustrating how risk reduces the farther along the project proceeds.

IDEA partners with US DOE CHP Technical Assistance Partnerships to provide first order screening

- For **Projects** with a proposed **Multi-Building/Mixed Use Development.**
- **With** identified **Champions/Stakeholders/Decision Makers.**
- To provide a **Green-Yellow-Red** first order assessment of options for phased district development & the value of **CHP and District Energy.**
- To assist **Champion**/**Stakeholders/Decision Makers** in moving the **Project** Forward.

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

High Density Planned Mixed Use Development

- Common Characteristics
  - Mixed Use: Live, Work, Play
  - Proximity to Mass Transit
  - High Efficiency, Low Carbon Footprint
  - Greenfield or major site redevelopment
  - Building Energy Efficiency Standards
  - Highly planned/documented/rendered/costed/branded

  - Little or no thought toward district heating, cooling or power

High Density Planned Mixed Use Development

Relevant Planning Parameters

- Scale
  - 1 msf-10 msf
- Time to build out
  - 10-20 yrs
- Intended Occupancy
  - Hotel/Conference
  - Corporate Office/Office
  - Retail
  - Entertainment
  - Data Center
  - Residential*
- Developer Team -Building Ownership

Pittsburgh PA

Boulder CO

Westminster CO

Austin TX

Oakland CA

Mooretown CA

Tucson AZ

Example

Illustrative Model

View looking east with Harlan Street in the foreground and city hall with its tower in the background.

Illustrative Model

View looking south along the new Eaton Street "green boulevard." On the left-hand side of the image, US 36 leads towards Denver.

Occupancy Type	*input values here*	*input values here*	
	SF	# Bldg	
Large Office	1,000,000	***2***	
Medium Office	-	***4***	
Small Office	500,000	-	
Warehouse		-	
Stand Alone Retail	300,000	***5***	
Strip Mall	-	-	
Primary School		-	
Secondary School		-	
Supermarket	100,000	-	
Quick Service Restaurant		-	
Full Service Restaurant	100,000	***5***	
Hospital		-	
Outpatient Health Clinic		-	
Small Hotel	-	***1***	
Large Hotel	1,000,000	-	
Midrise Apt	1,000,000	***5***	
User Building 1	-	-	
User Building 2	-	-	
User Building 3	-	-	
User Building 4	-	-	
User Building 5	-	-	
Total	***4,000,000***	***22***	

Developer built stand alone

Package Equipment

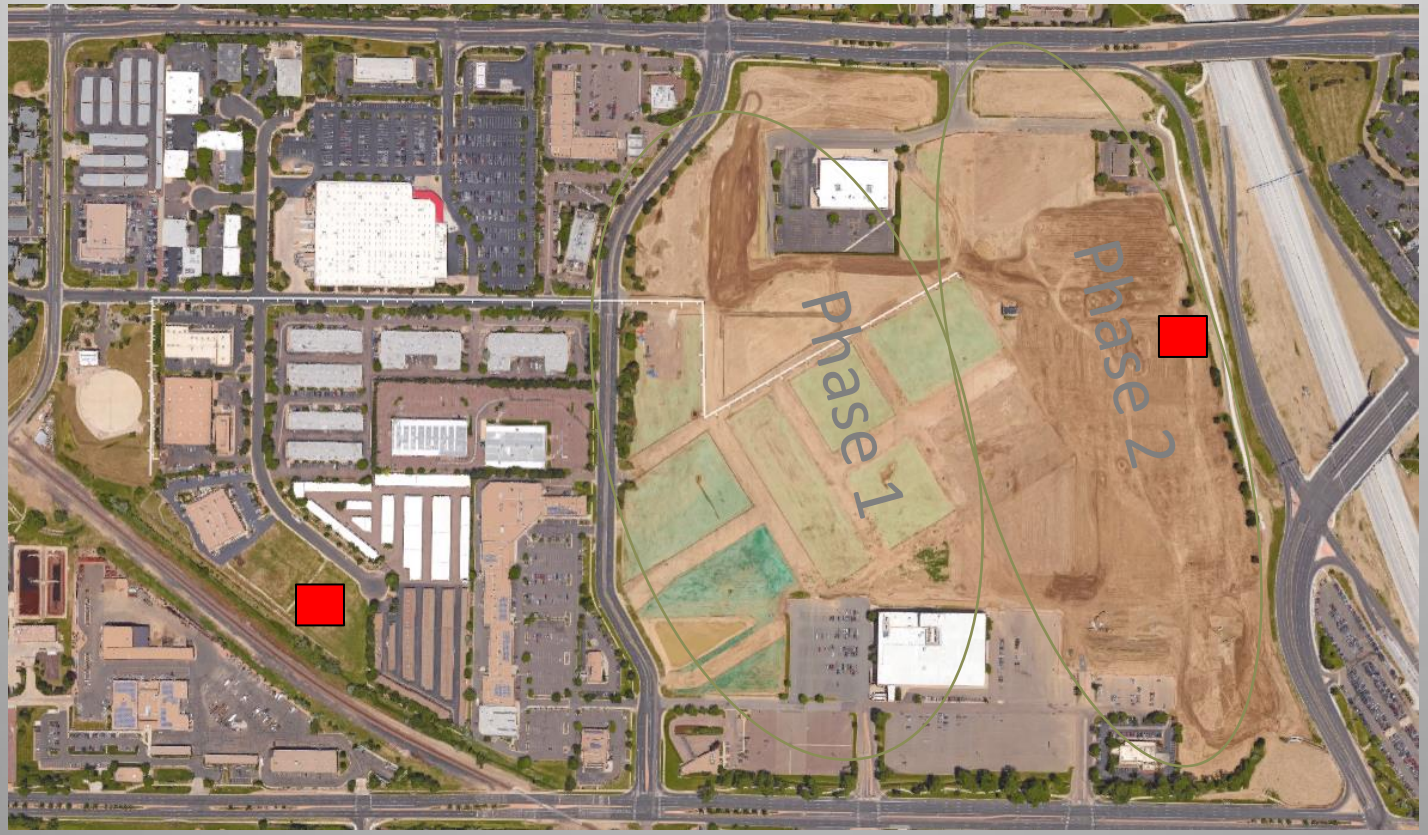
Performance

A/C:1.1kW/Ton (peak)
Gas Furnace Heat: 80% eff
Single Duct VAV

Capital Cost

Include increased building elec
5.00-6.00$/SF installed
Additional Leaseable Space
(including rooftop real estate)

District Energy Alternatives

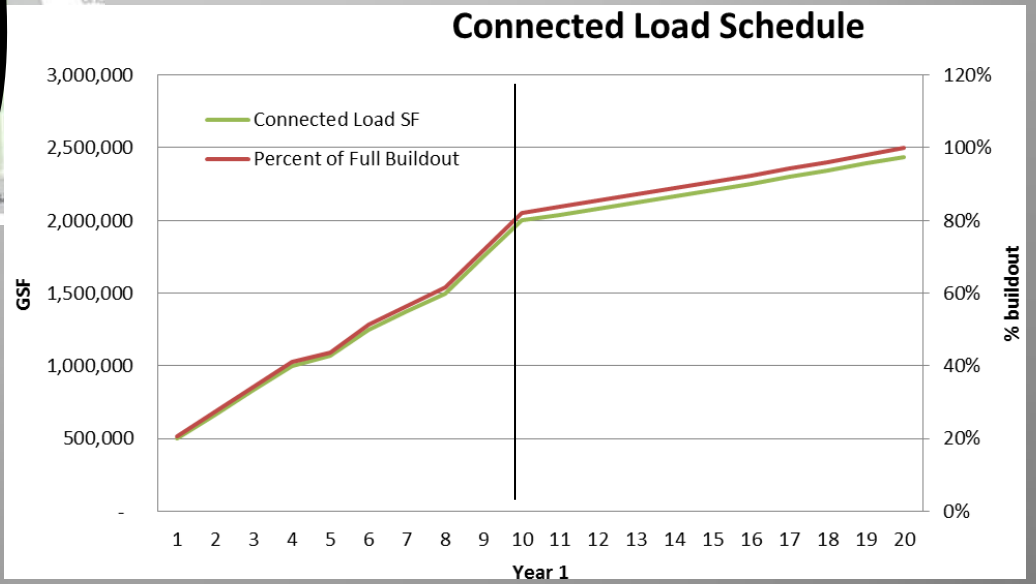


Remote

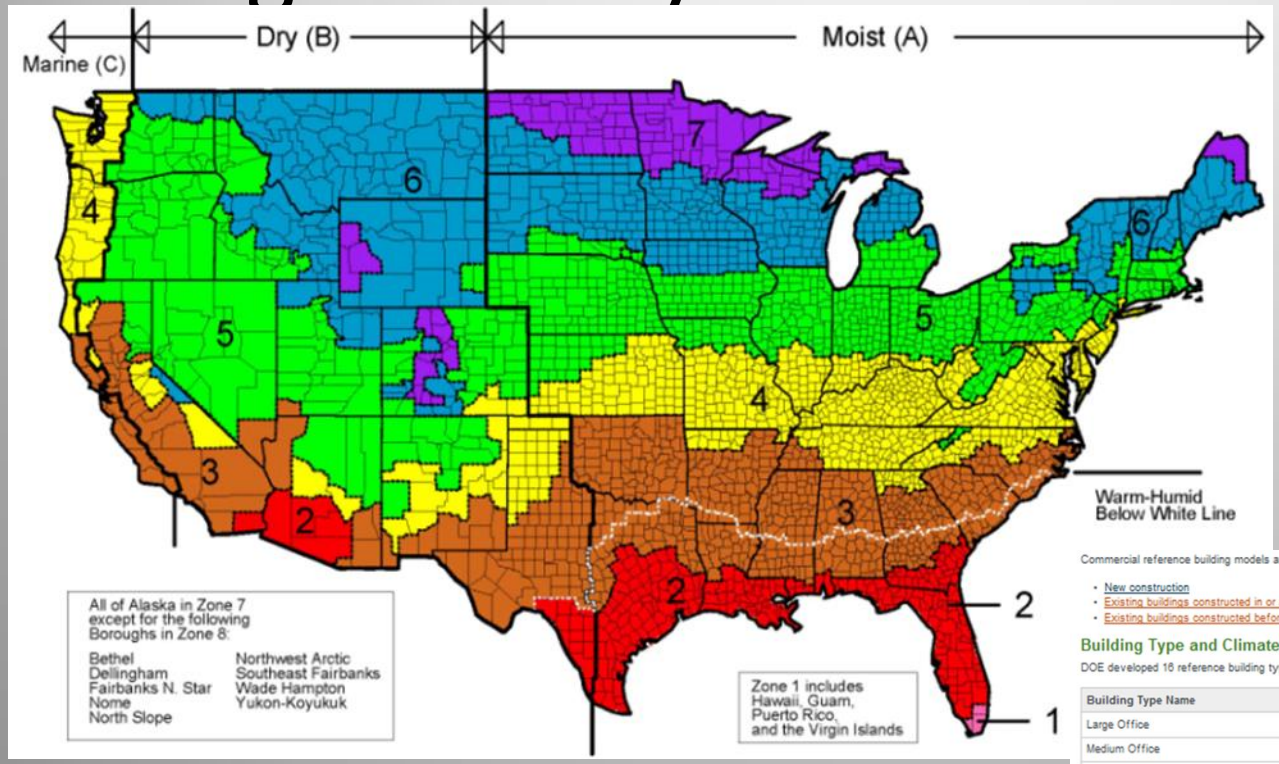
Local

phase 2 load assumptions

Occupancy Type	*input values here*
	SF
Large Office	1,000,000
Medium Office	-
Small Office	300,000
Warehouse	
Stand Alone Retail	100,000
Strip Mall	-
Primary School	
Secondary School	
Supermarket	-
Quick Service Restaurant	
Full Service Restaurant	100,000
Hospital	
Outpatient Health Clinic	
Small Hotel	-
Large Hotel	500,000
Midrise Apt	
User Building 1	-
User Building 2	-
User Building 3	-
User Building 4	-
User Building 5	-
Total	***2,000,000***



District Energy For High Density Planned Development



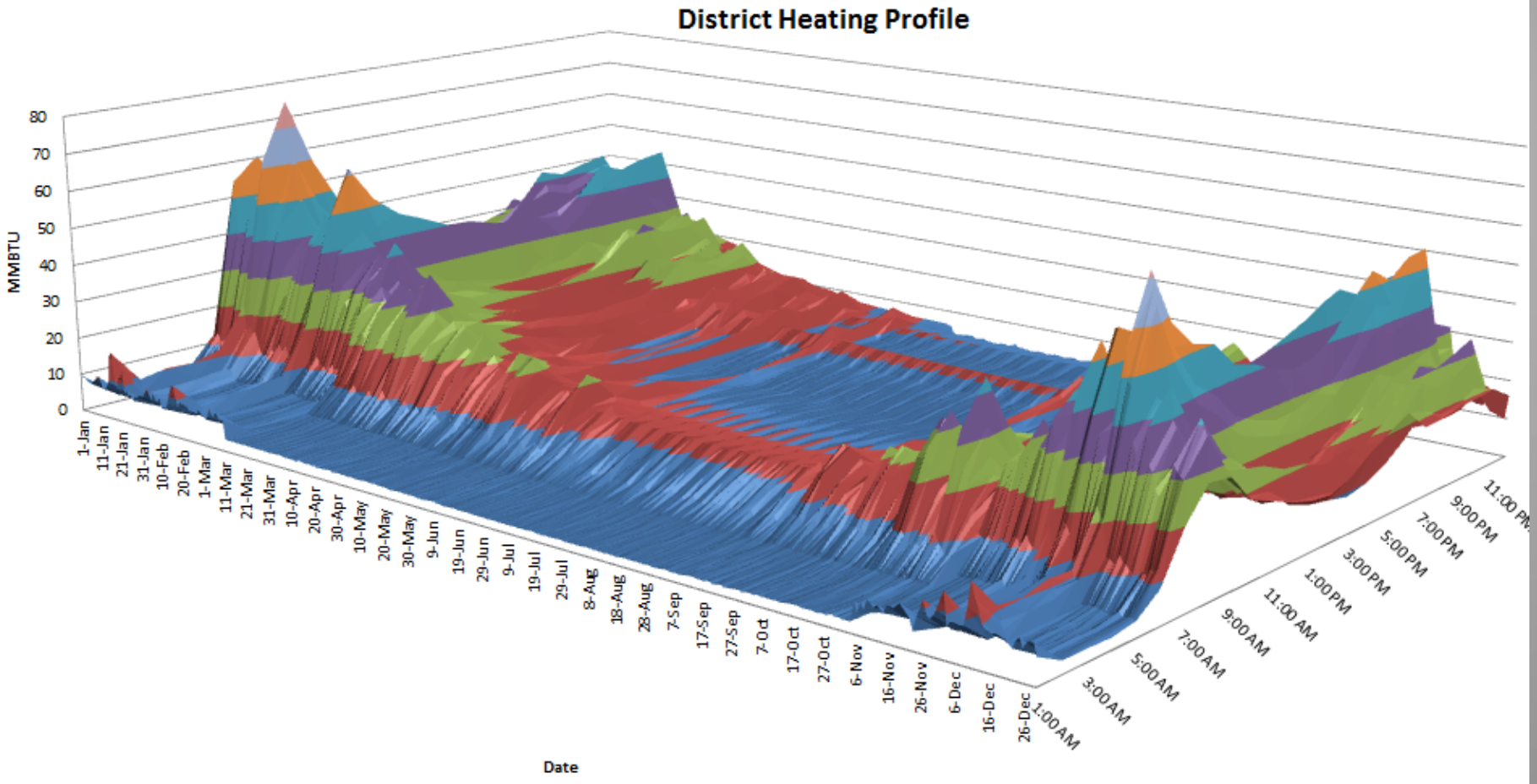
Commercial reference building models are available for the following categories:

- New construction
- Existing buildings constructed in or after 1980 ("post-1980")
- Existing buildings constructed before 1980 ("pre-1980")

Building Type and Climate Zone

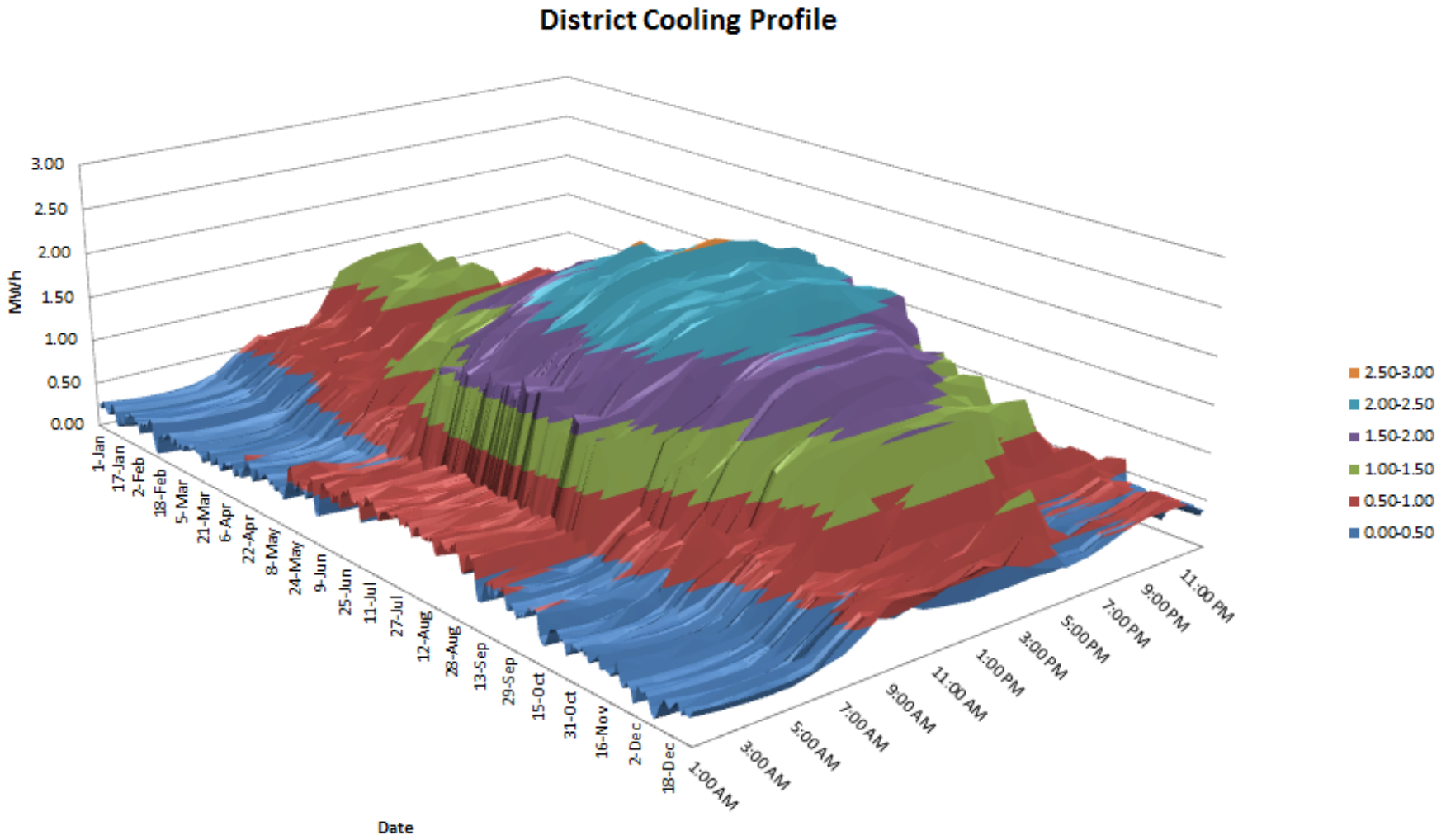
DOE developed 16 reference building types that represent most commercial buildings across 16 locations, which represent all U.S. climate zones.

Building Type Name	Floor Area (ft^2)	Number of Floors
Large Office	498,588	12
Medium Office	53,628	3
Small Office	5,500	1
Warehouse	52,045	1
Stand-alone Retail	24,962	1
Strip Mall	22,500	1
Primary School	73,960	1
Secondary School	210,887	2
Supermarket	45,000	1
Quick Service Restaurant	2,500	1
Full Service Restaurant	5,500	1
Hospital	241,351	5
Outpatient Health Care	40,946	3
Small Hotel	43,200	4
Large Hotel	122,120	6
Midrise Apartment	33,740	4



Sum of individual annual stand alone building heating system gas bills: $801,215 (current $)

District Natural Gas					
max	77.49	MMBTU			
average	12.03	MMBTU			
min	1.87	MMBTU			
total	105,423	MMBTU			
if gas cost	$ 7.60	$/MMBTU	then	$ 801,215	$/yr
conditioned SF	2,000,000	19.37	BTU/SF	$	



Sum of individual annual stand alone building cooling system electric bills: $847,115 (current $)

District electric chilling power			stand alone			
max	2.57	mW	3023	T		
average	0.83	mW	2818	f		
min	0.00	mW				
total	7240	mWhr	8,517,999	ton hr		
if electric cost	0.117	$/kWh	then		$ 847,115.04	$/yr
conditioned SF	2,000,000	661.56	SF/Ton		$ 0.42	$/SF/Yr

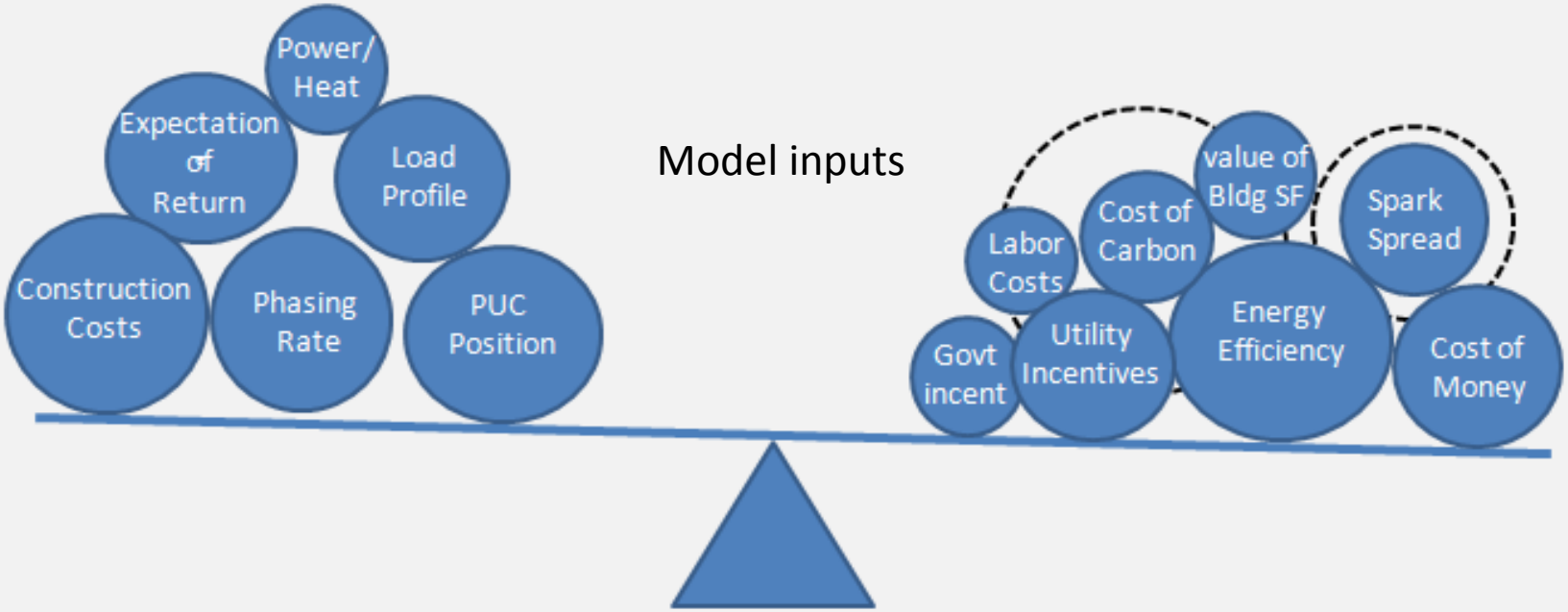
District Energy For High Density Planned Development

- Energy Source Alternatives
  - Heating
    - Natural gas
    - Biomass
  - Cooling
    - Electric
    - Recovered Heat
    - Alternative
  - Electric Power
    - Utility purchase
    - CHP
    - On-site Renewable

District Energy For High Density Planned Development

- Utility Cost Factors
  - Minimum Demand
  - Variability
  - CHP Gas
  - Cooling energy sources
    - Electric
    - Recovered Heat
    - Thermal Energy Storage
  - Electric Power
    - Utility purchase
      - Demand, Time of Use
    - Distributed On-site Renewable
    - CHP
    - Trends

balance


Power/ Heat
Expectation of Return
Load Profile
Construction Costs
Phasing Rate
PUC Position
Model inputs
value of Bldg SF
Spark Spread
Cost of Carbon
Labor Costs
Govt incent
Utility Incentives
Energy Efficiency
Cost of Money

screening tool

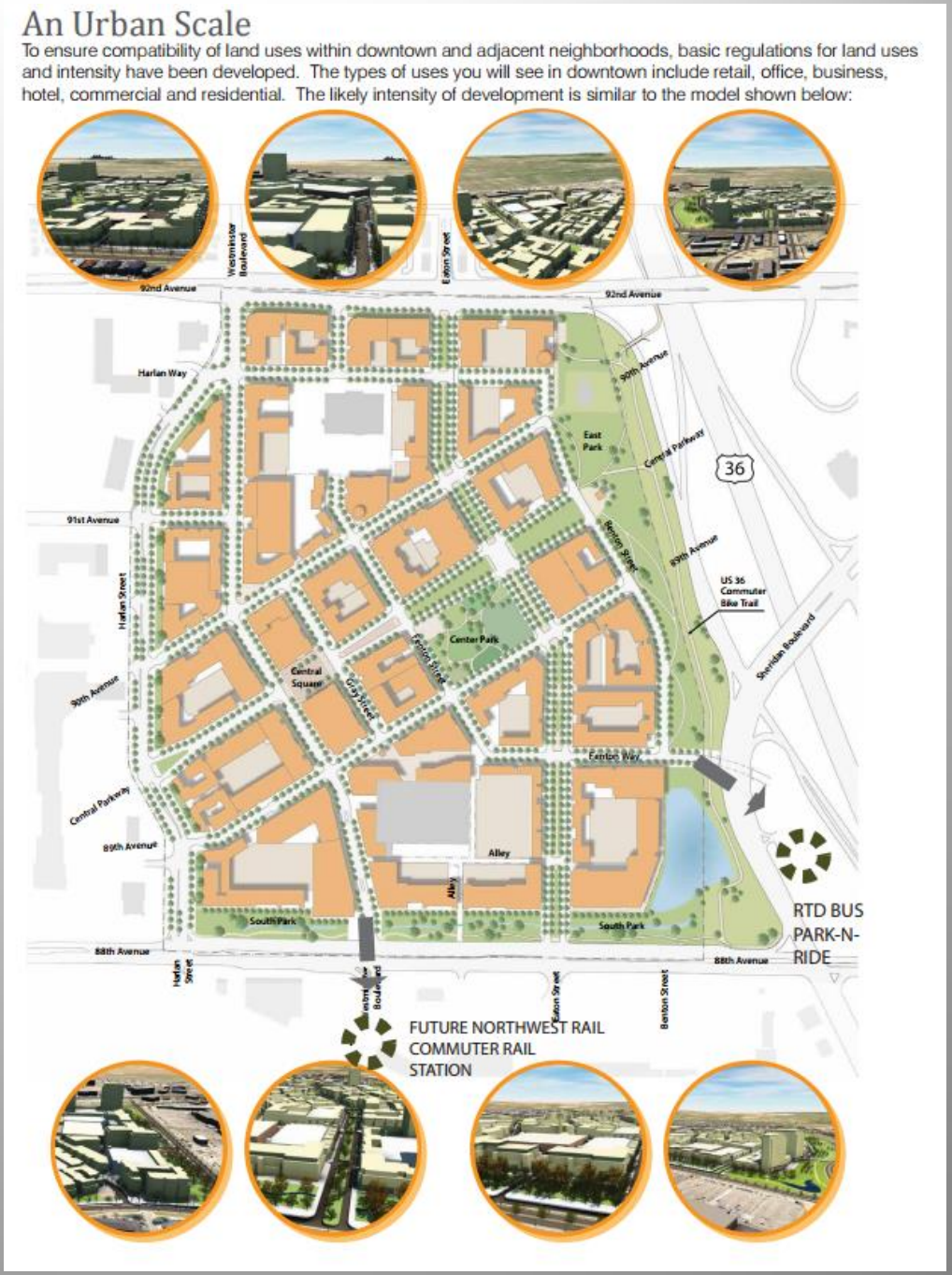
Inputs

- Location
- Building Types, Size, Age
- Utility Costs
- Finance Costs
- District Energy Alternative
- Conversion Efficiency
- Construction Costs
- Labor Costs
- Project Phasing

Outputs

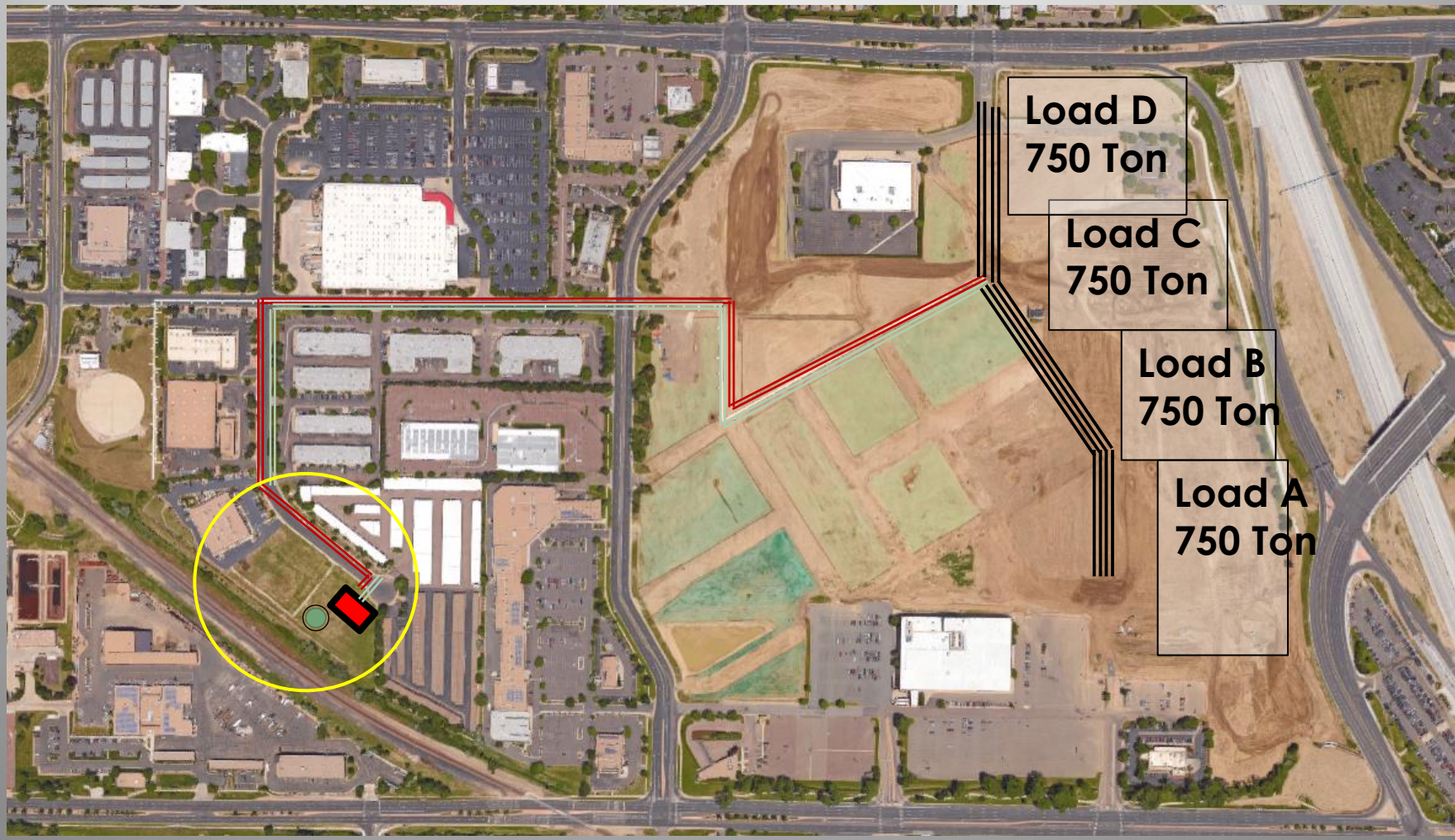
- Energy Load Profile
- 20 year Cash Flow Projection
  - Capital Expense
  - Operating Expense
- Simple Payback of Alternatives
- Return on Investment of Alternatives

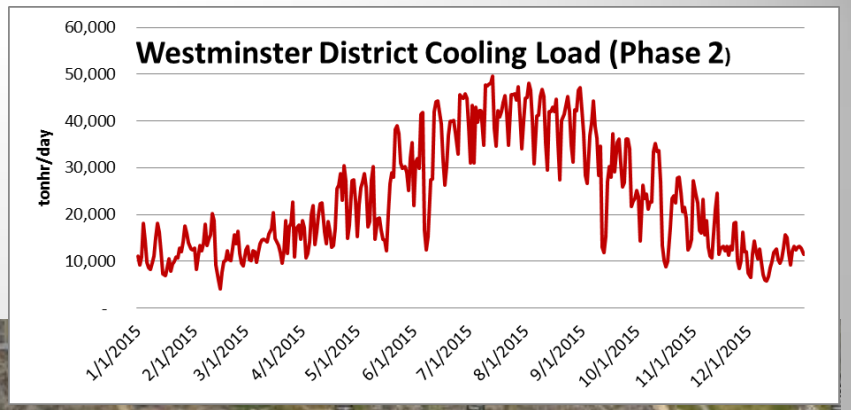
Example

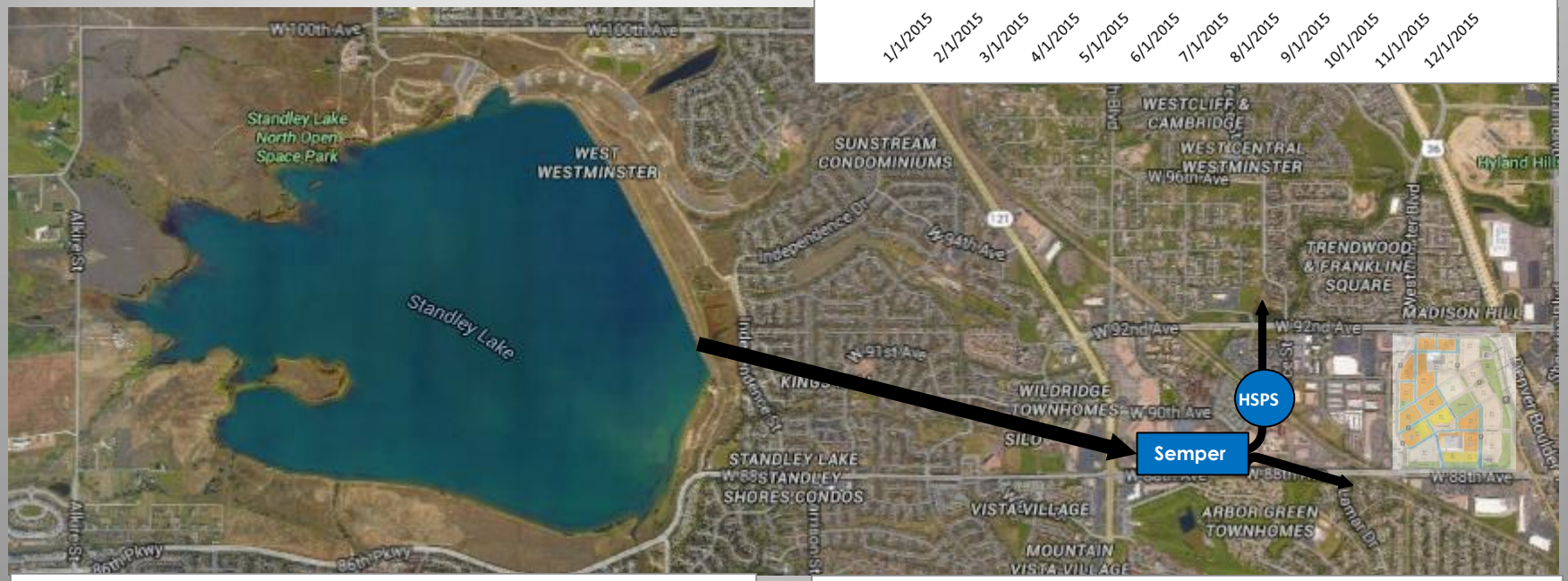

An Urban Scale
To ensure compatibility of land uses within downtown and adjacent neighborhoods, basic regulations for land uses and intensity have been developed. The types of uses you will see in downtown include retail, office, business, hotel, commercial and residential. The likely intensity of development is similar to the model shown below:
92nd Avenue
Westminster Boulevard
Eaton Street
Harlan Way
East Park
Central Parkway
36
91st Avenue
Benton Street
89th Avenue
US 36 Commuter Bike Trail
Harlan Street
Center Park
Fenton Street
Central Square
90th Avenue
Grey Street
Sheridan Boulevard
Fenton Way
Alley
South Park
88th Avenue
RTD BUS PARK-N-RIDE
FUTURE NORTHWEST RAIL COMMUTER RAIL STATION

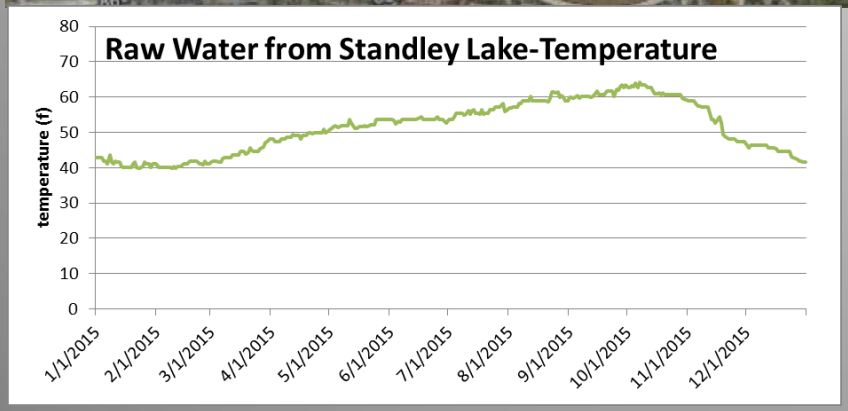
Piping Mains Sized for full site build out
Cooling Mains- 5300 Ton peak – 7,000 GPM@ 18F dT – 18” D - $1,000/ft
Heating Mains– 33 MBH peak – 1,750 GPM@40 F dT – 10” D - $500/ft
Phase A-D branches (to building stubout) Cooling and Heating 1500 LF
Thermal Storage Tank sized for load level of 2 MSF (850,000 gal, 60’D, 40’H 9,300 Tonhr@16 FdT)

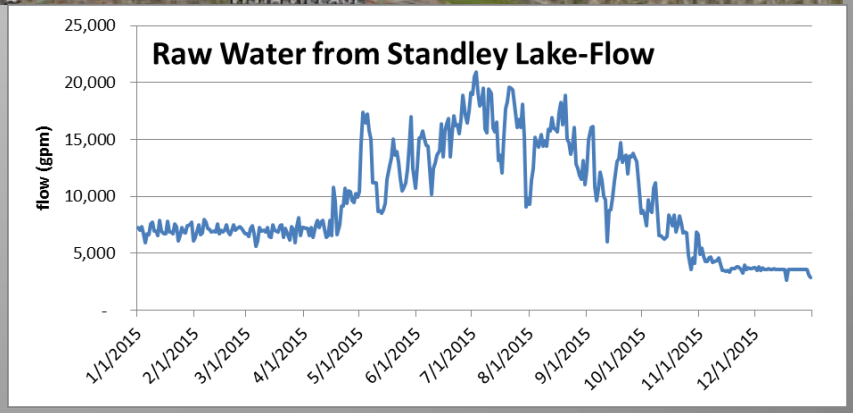
Plant Site



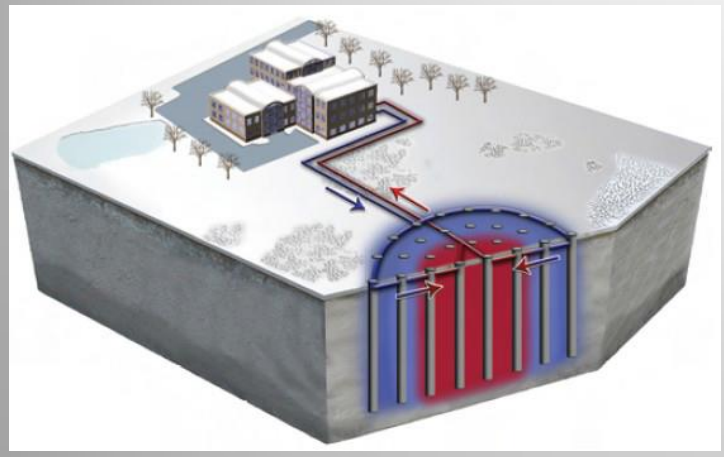

Westminster District Cooling Load (Phase 2)
tonhr/day
60,000
50,000
40,000
30,000
20,000
10,000
-
1/1/2015
2/1/2015
3/1/2015
4/1/2015
5/1/2015
6/1/2015
7/1/2015
8/1/2015
9/1/2015
10/1/2015
11/1/2015
12/1/2015


Standley Lake
North Open Space Park
WEST WESTMINSTER
SUNSTREAM CONDOMINIUMS
WESTCLIFF & CAMBRIDGE
WEST CENTRAL WESTMINSTER
TRENDWOOD & FRANKLINE SQUARE
MADISON HILL
WILDRIDGE TOWNHOMES
STANDLEY LAKE SHORES CONDOS
VISTA VILLAGE
ARBOR GREEN TOWNHOMES
MOUNTAIN VISTA VILLAGE
HSPS
Semper


Raw Water from Standley Lake-Temperature
temperature (f)
80
70
60
50
40
30
20
10
0
1/1/2015
2/1/2015
3/1/2015
4/1/2015
5/1/2015
6/1/2015
7/1/2015
8/1/2015
9/1/2015
10/1/2015
11/1/2015
12/1/2015


Raw Water from Standley Lake-Flow
flow (gpm)
25,000
20,000
15,000
10,000
5,000
-
1/1/2015
2/1/2015
3/1/2015
4/1/2015
5/1/2015
6/1/2015
7/1/2015
8/1/2015
9/1/2015
10/1/2015
11/1/2015
12/1/2015

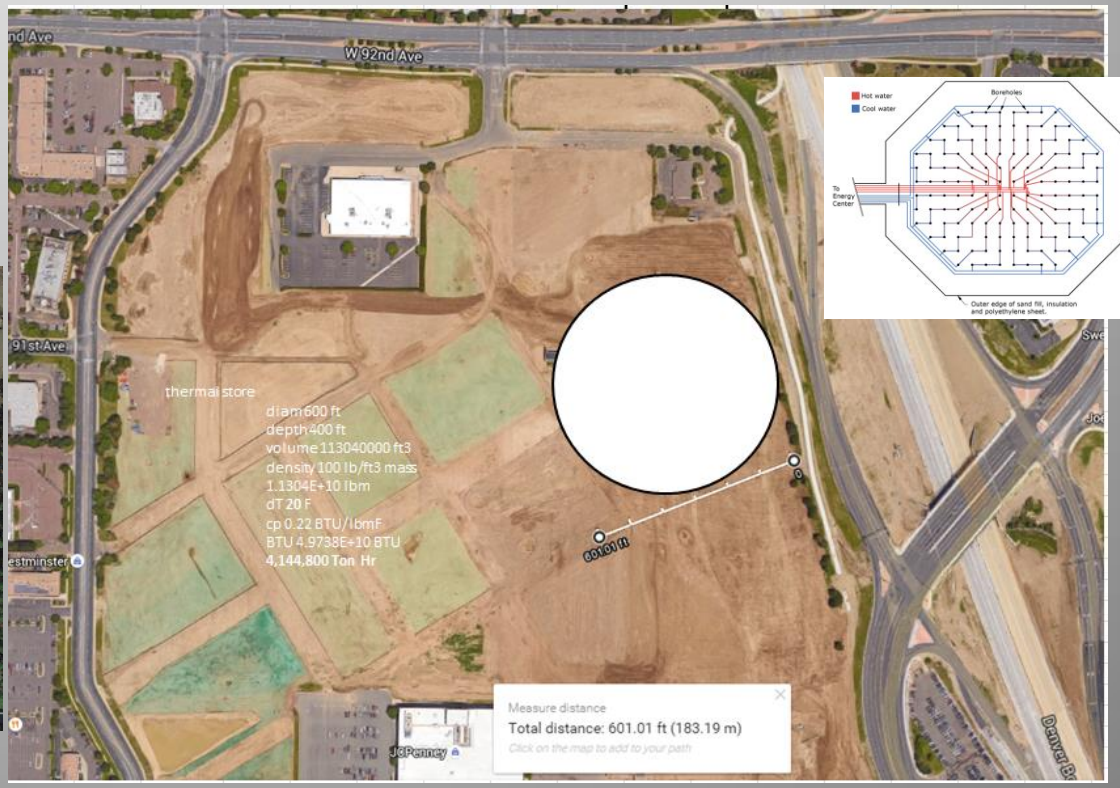
Lake water cooling- UTES Seasonal Energy Storage

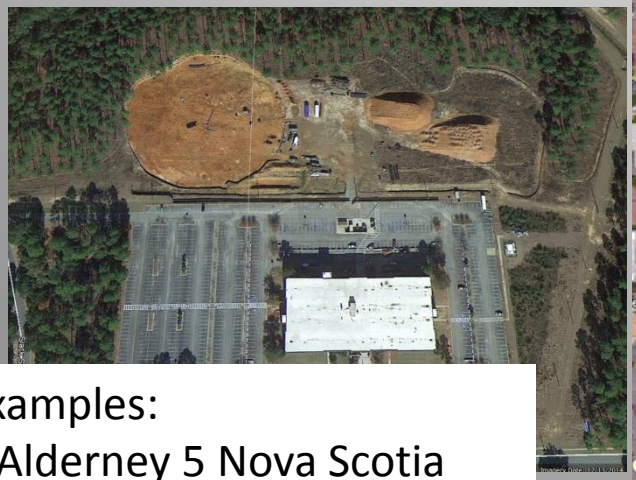


UTES to Semper supply heat exchanger

Taken off-line at Max water to storage at 45 F
Annual potential cooling energy 4.8 M Ton hr

Fundamental Problem: Space





Examples:
- Alderney 5 Nova Scotia
- Ft. Benning GA

Local

Concept: Minimize upfront infrastructure costs by minimizing underground utility piping and installing heating and cooling capacity in discrete modules. Reduce energy cost with load leveling Thermal Ice Storage

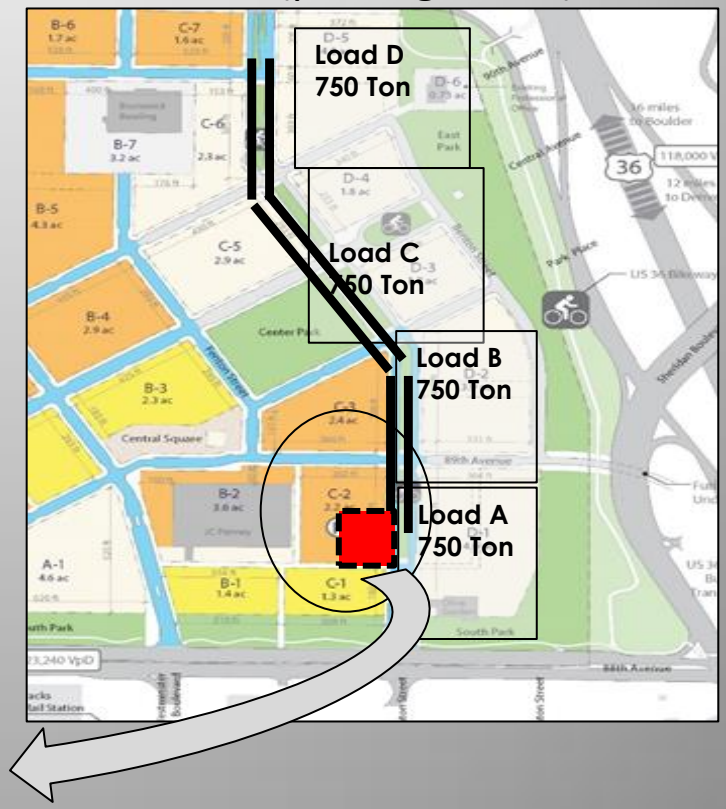
Assumes: Adequate space is available in proximity of Phase 2 loads (parking deck?)

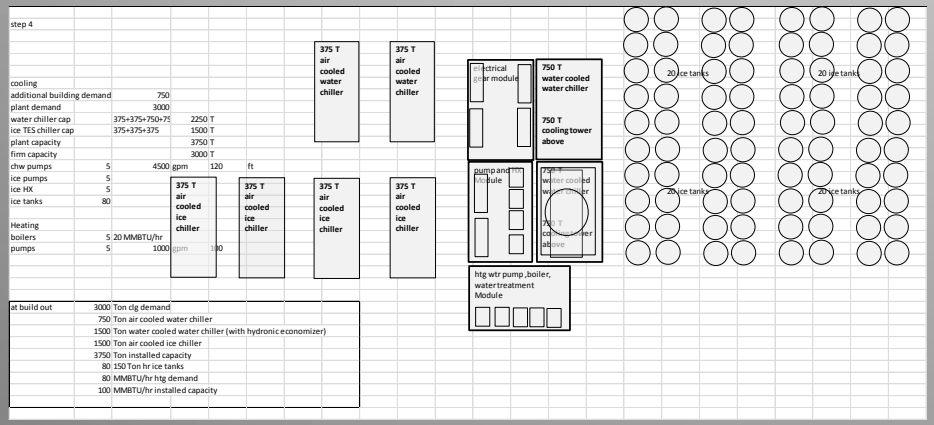
Pros:

- Piping size and extents limited to Phase 2 service only
- Invest in modular H/C plant only as load develops

Cons:

- Space for plant and TES: on site real estate value
  - Plant: 75 x 100 ft : 7,500 SF
  - Storage (at buildout) 5,000 SF (stacked)
- Cost reduction limited by ice production efficiency kW/Ton
- Cost of Components





Financial Modeling Assumptions: all options

Assumes
Third party purchase/install the piping distribution and thermal storage tank.
These costs are not included in financial models.

Other assumptions:

Year beginning	2019
Model duration (ROI horizon)	20 years
Energy cost escalation	3%
Inflation	5%
Cost of borrowing (private developers)	8%
Cost of Capital private sector	15%
Growth of PH II development (after build out)	2%

District Energy Screening Tool Results

Life Cycle Cost: Net Present Value

	Stand Alone	District Energy	District Energy + CHP
** **Project Capital Distribution** (Chilled Water/ Hot Water Pipe)	$0	-$3,761,427	-$3,761,427
** **Project Capital Equiptment** (Chillers, Boilers, Pumps, etc…)	-$3,918,545	-$1,748,782	-$1,748,782
** **Project Capital CHP** (Combined Heat and Power Generator)	$0	$0	-$212,997
** **Total Project Capital** (Distribution + Equiptment + CHP)	-$3,918,545	-$5,510,209	-$5,723,206
** **Operation Cost** (NG + Electricity + Building Operator)	-$33,043,128	-$25,358,799	-$24,752,621
** **Project Capital + Operation Cost**	-$36,961,673	-$30,869,008	-$30,475,827
Total Life Cycle Cost Net Present Value **(Lower Number = More Attractive)**	**-$17,051,445**	**-$15,219,369**	**-$15,146,713**

** Includes Debt Service

Developer Benefits

Initial developer capital cost savings -	$6.00/SF
Averaged annual operating cost savings-	$0.45-$0.55/SF/YR
Potential increased leasable SF-	%2
Potential increased leasable SF total	45,000 GSF

100,000 GSY Example (current $)

Developer initial capital cost savings -	$600,000
Reduced Debt Service-	$45,550/yr
Averaged annual operating cost savings-	$55,000/yr
Potential increased leasable SF-	2,000 SF
Based on 4.5% Cap Rate (increased value)	$3,560,000

District Energy Screening Lessons Learned

- Examine district energy concepts early
- Every situation is unique-Test the edges
- Accelerate build out
- Explore split financing
  - Underground piping
  - Plant Construction
- Early screening is as much an education tool as a financial calculator