RENEWAL THROUGH TRANSFORMATION

District Energy via DBOOM at Ford

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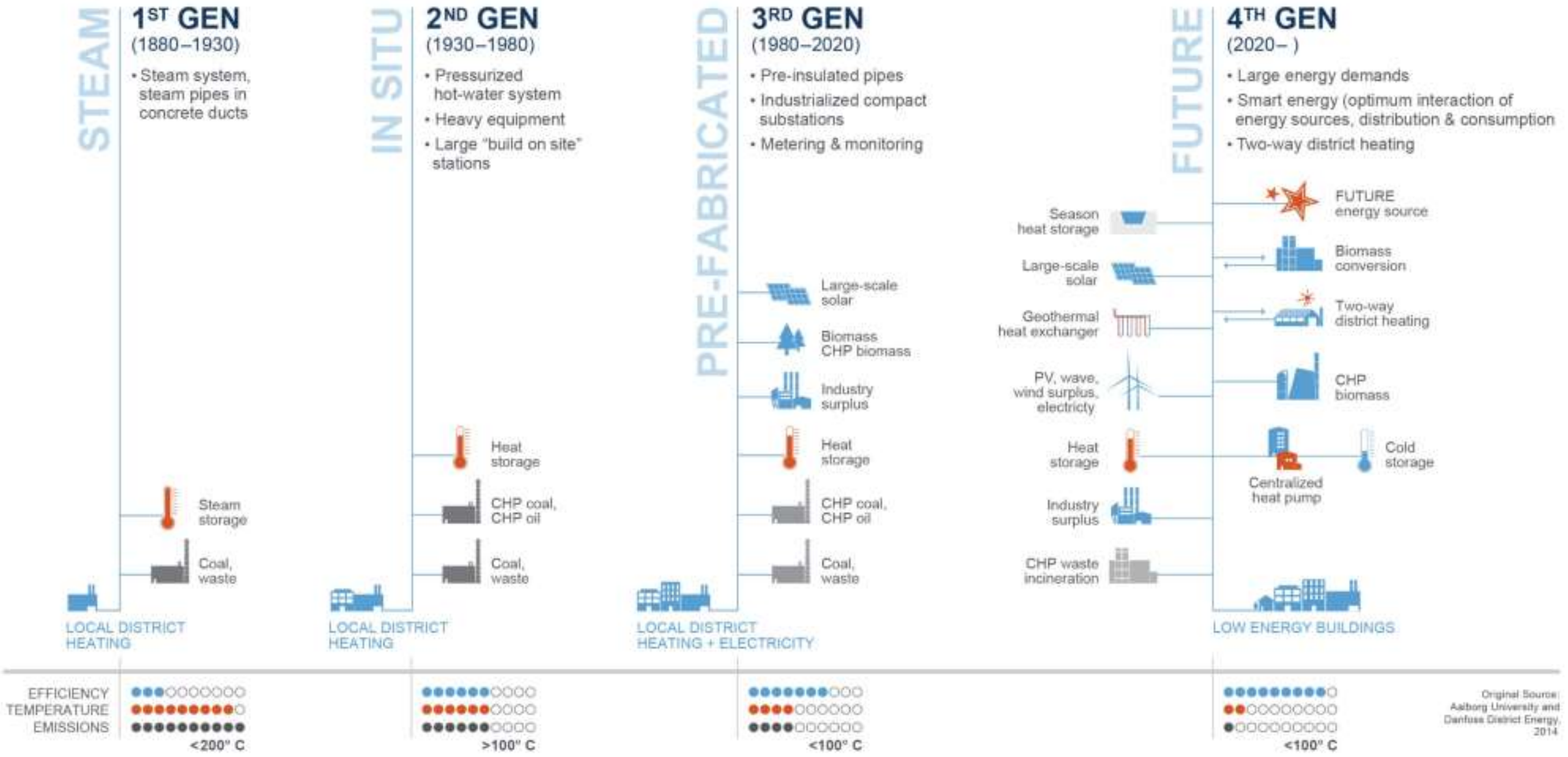
Project Partners

Ford Dearborn Campus

Auto Market is Evolving to Mobility:
A shift from making cars to moving people and goods.

Evolution in Utility Systems



Paradigm-Shifting Technology

TRADITIONAL MODEL	NEW PARADIGM
HIGH WASTE	**HIGH EFFICIENCY**
Central Steam Plant with large boilers and extensive distribution system for heating	Central Energy Plant for simultaneous production of heating and cooling utilities
Distributed cooling assets (chillers) in buildings	Integrated water-based distribution systems coupled with geothermal, energy recovery and thermal energy storage
Public utility supply for electricity	Utility integrated, highly efficient electrical production via combined heat and power
Isolated/stand-alone "process systems"	Process needs met by recovered energy
High maintenance requirements	Minimized maintenance, operations and waste

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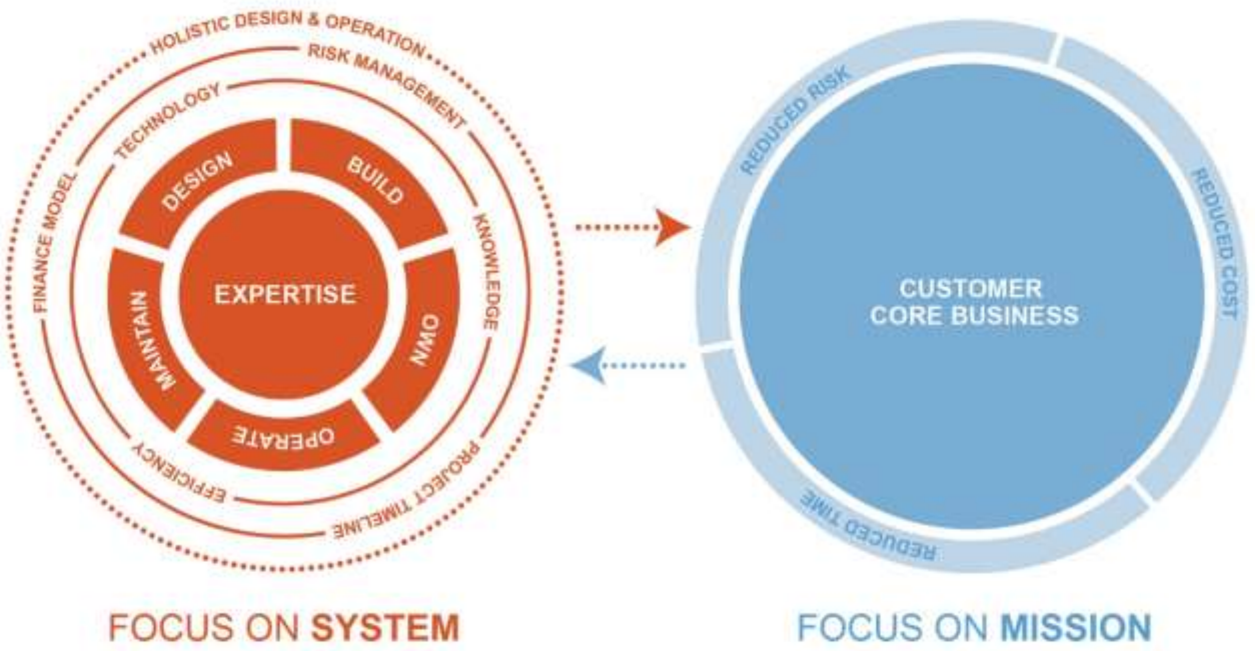
Evolution in Delivery Systems



DBOOM Model

- Reduces operating and maintenance costs by operating utility systems efficiently and reliably
- Reduces labor costs
- Reduces retail power costs through self generation or efficiency improvement
- Reduces or eliminates capital spend on existing infrastructure
- Improves emissions footprint associated with utility systems
- Allows customers to focus on core business

Ford Dearborn Facilities
Aging Infrastructure

1950s buildings are fragmented, have an inefficient footprint, and are unsupportive of collaboration, productivity, and innovation

- Ford Land Property
- Primary Study Area

1 R & E Campus
2 World Headquarters Campus
3 Town Center
4 Office Park West
5 Office Park East
6 Fairlane North
7 Commerce Park North
8 Commerce Park South
9 Rouge Complex
10 Rotunda Center

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AIR	WATER	SOIL / HABITAT	MATERIAL USE	WELLNESS	ENERGY
50% reduction in CO_2 emissions	**50%** reduction in water use	Transform site into a **healthy, living landscape**	**Zero waste** sent to landfill	Create a **healthy + active** workplace	**60%** improvement in chilled water production efficiency Water heated by **100% geothermal and waste heat**

Dearborn Campus Sustainability Objectives

> To utilize a global facility **lifecycle planning process** to transform our workplaces into **inspiring, innovative, and sustainable environments** that support Company business objectives and improve the Employee Value Proposition.

Campus Transformation Objectives

Creating a modern, sustainable, high-tech campus

Future R&E Campus

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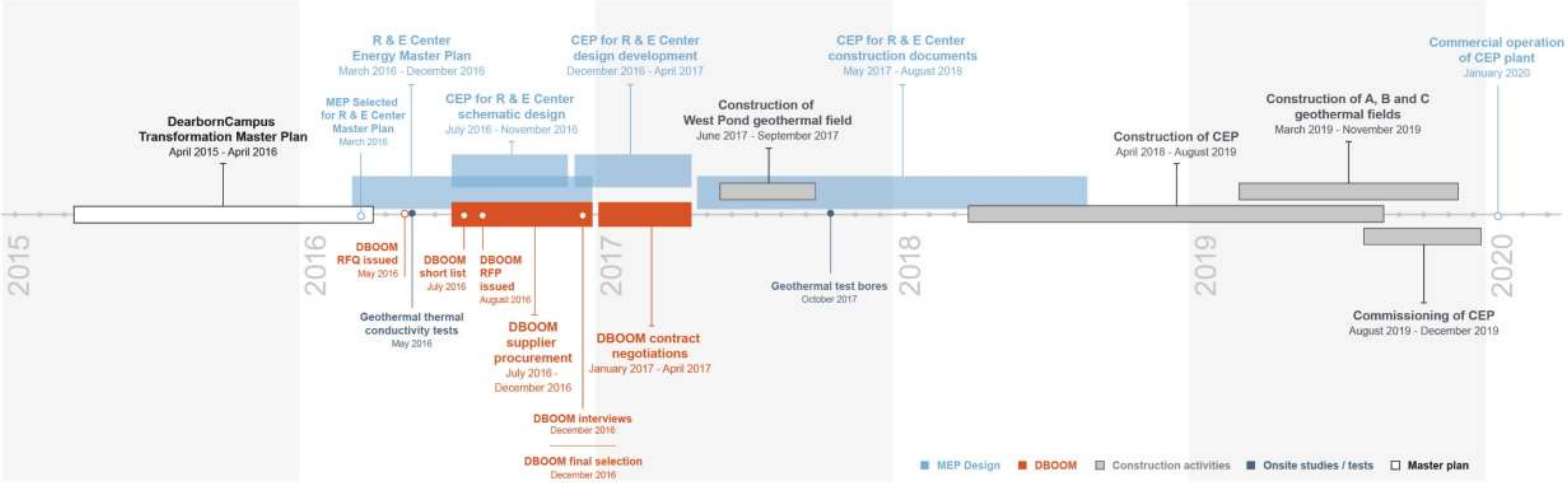
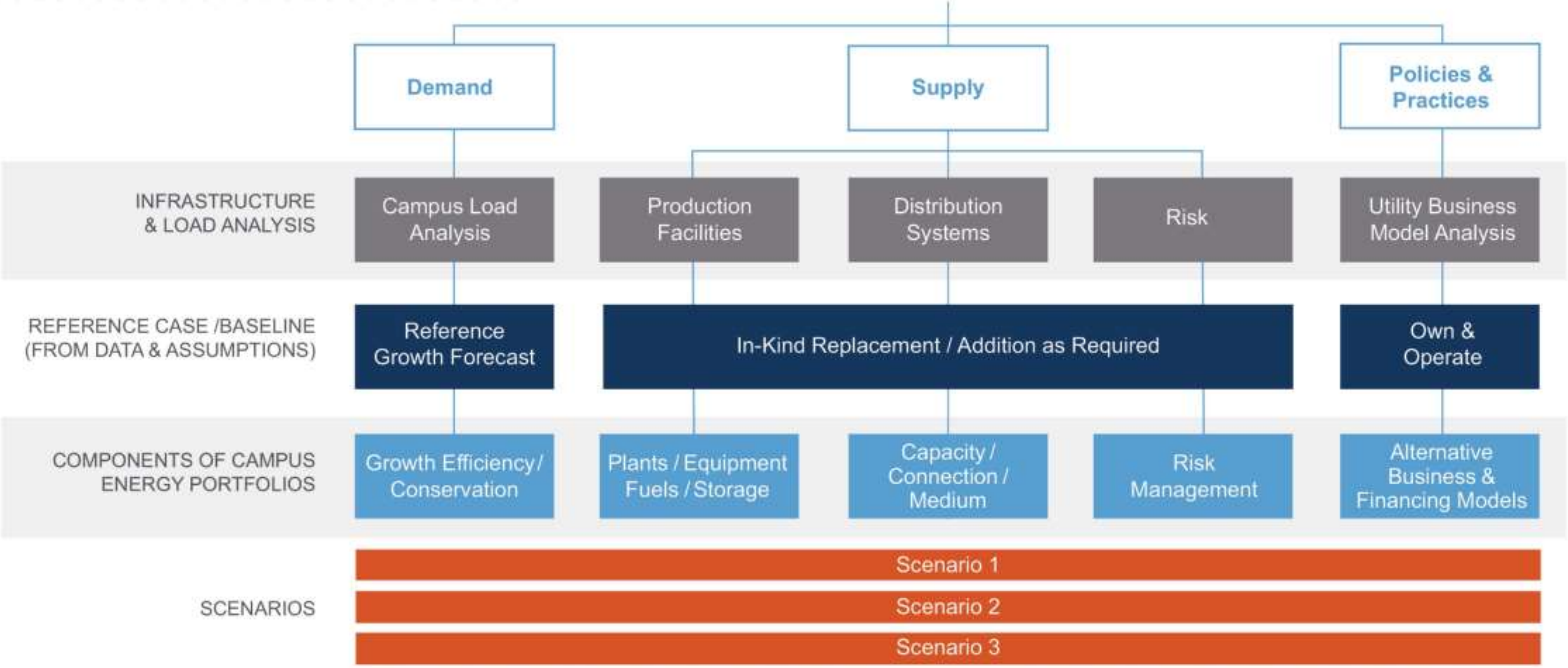
Ford Project Timeline



Master Planning

Integrated Utility Planning Framework



Master Planning
Analysis Methodology

Scenario Summary
Shows information monthly, for
10 years condensed into Electricity,
Chilled Water, Hot Water, and Steam

Annual Models
Hourly models for all campus
buildings for each specific year of
the DCT development horizon

Building Hourly Models
Each existing and planned building

Master Planning

Building Level Energy Analysis

Master Planning
Campus Level Energy Analysis

Master Planning

Campus Level Energy Analysis

Central Energy Plant: One Year Supply Model	
Model Outputs	
Dashboard	Allows the user to select a pre-defined scenario or create a custom scenario of the proposed Central Energy Plant. The dasbhoard includes: * Summary economic metrics * Peak loads by utility for the selected year * Load duration curves with associated supply sources * One-week hourly load and supply explorer
CAPEX/OPEX Detail	Detail of the assumed capital and operating expenditures
Loads and Supply by Hour (8760)	8760 hourly view of all utility loads and sources of supply
Hourly Campus Profile	A table that can be imported into fordcampus.foveaservices.com for online visualization
GLD Output	Output formatted with monthly outputs necessary for a GLD model run
Model Inputs	
Scenario Definitions	A table with the pre-defined scenarios and areas to define custom scenarios
Hourly Demand Profile (pre-defined)	This shows the hourly load profile for the pre-defined year that has been selected in Dashboard cell D4
Hourly Demand Profile (custom)	Use this sheet to energy a custom hourly load profile in the provided range
Price Deck	A table where the monthly commodity pricing assumptions can be viewed and modified
Hourly Model	
Hourly Chilled Water Model	Chilled Water Model
Hourly Hot Water Model	Hot Water Model
Hourly Steam Model	Steam Model
Hourly Electricity Model	Electricity Model

Master Planning

Campus Transformation Energy Scenarios

Scenario Assumptions

Thermal Energy Storage Assumptions		
Chilled Water Capacity in TES	65,400	ton-hours
Number of Tanks	1	
TES Pumping Load	0.1	kW/ton
	Start	End (inclusive)
Charge Times (24 hour format)	19	6
Discharge Times (24 hour format)	11	18
Months used	5	9

Geothermal Borefield/Pond Assumptions		
Number of Vertical Boreholes	525	see cell comment
Bore Depth	606	linear feet
Bore Cost	$40	per linear foot
Single Bore Capacity	6	tons per borehole
Borefield Capacity	3,150	tons
Pond Capacity	0	tons

Chilled Water and Hot Water Assumptions		
Use Heat Recovery Chillers	Yes	
Central Chilled Water	Yes	
Use Steam to Hot Water Conversion	Yes	95.0% Efficient
Edit Chiller Unloading Curves	HRC	Centrifugal
Default Unit Size (central)	3,200 tons	3,200 tons
Units Installed	0	0
Installed Capacity (central)	6,400 tons	12,800 tons
Cooling Towers (central)		16,050 tons
Installed Capacity (distributed)		0 tons
Cooling Towers (distributed)		0 tons
HRC CAPEX	$1,200 per ton	
Cooling Tower CAPEX (central)	$125 per ton	
Centrifugal Chiller CAPEX (central)	$1,000 per ton	

Steam and Electricity Assumptions		
CHP Turbine 1:	Mars 100	Edit Assumptions
CHP Turbine 2:	Mars 100	Edit Assumptions
Steam Turbine Generator Size:	5.0 MW	
STG Peak Only:	No	
	CEP	
Peak Steam Load	209,992 lbs	
Boiler Efficiency	85%	

Forecasted Energy Prices			X for Default
Natural Gas			X
Purchased Electricity (Energy)			X
Purchased Electricity (Demand)			X

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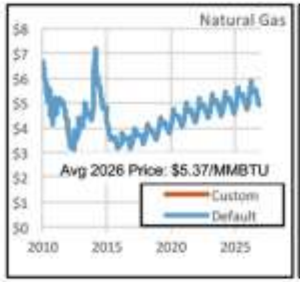
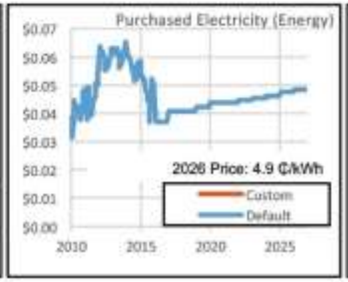
Master Planning

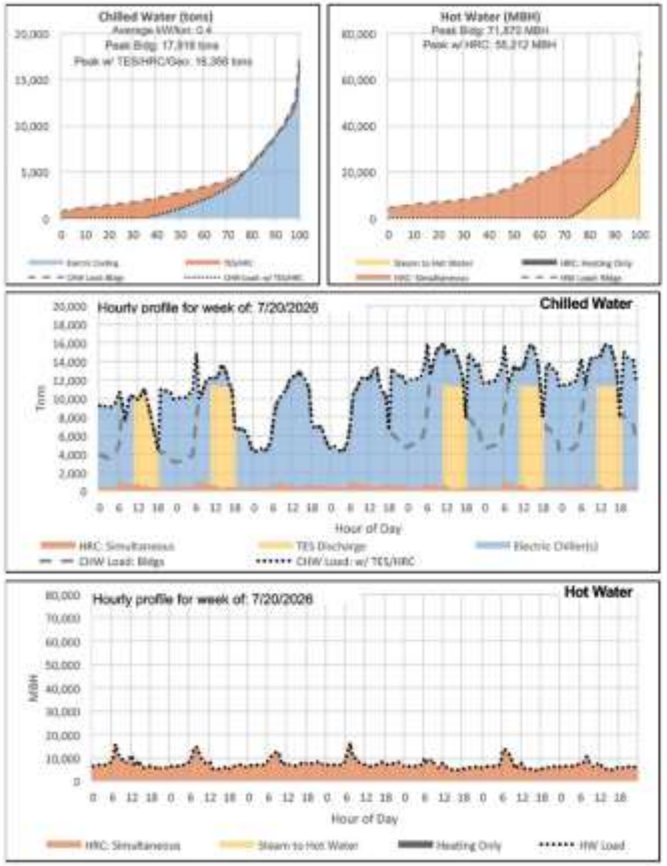
Campus Transformation Scenario Dashboard

Commodity Forecasts for Energy Prices

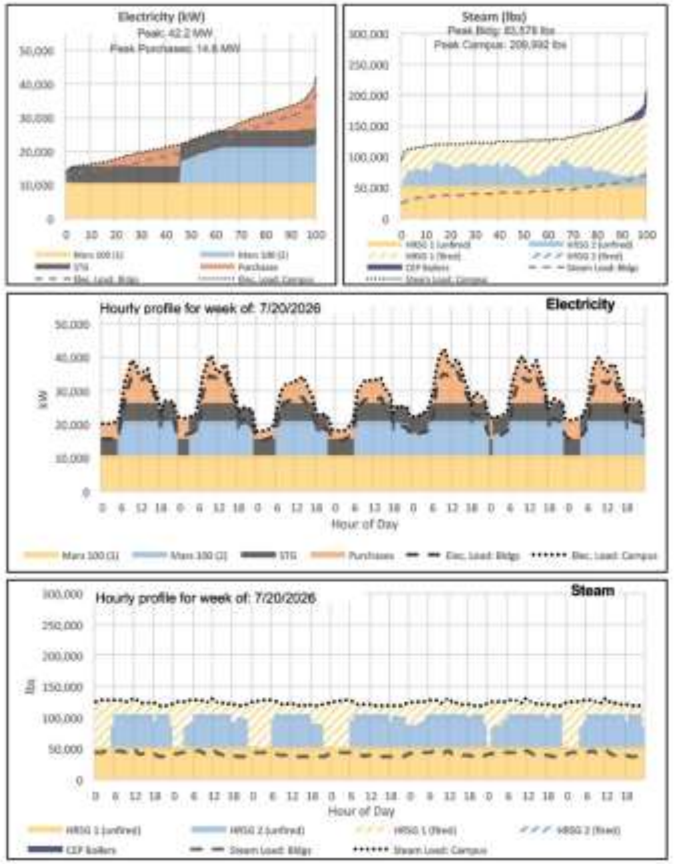




Chilled/Hot Water



Electricity/Steam



Outcomes of Energy Master Plan

Low Entropy Systems for Campus

Central Energy Plant and Associated Distribution System

- Eliminate steam for non-process systems
- Low temperature hot water
- Centralized chilled water
- Geothermal
- Thermal storage
- Combined heat and power

Central Energy Plant

34MW **250 K-LB/Hr** cogeneration system

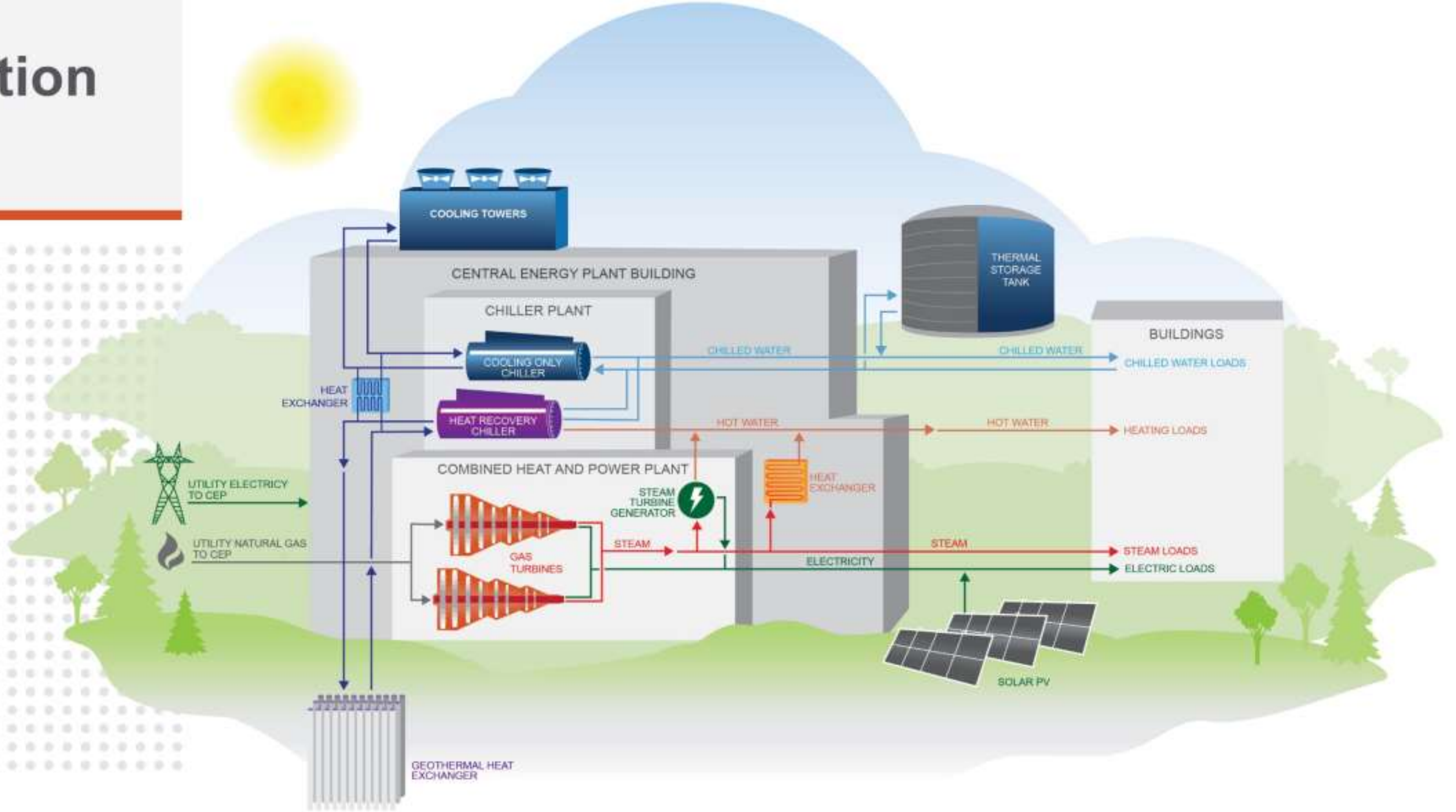
16,000 **TON CHILLER** system

156,000 **MMBtu/Hr** hot water supply

3000 **TON GEOTHERMAL** system

40,000 **TON-Hr** chilled water storage

Water Distribution System



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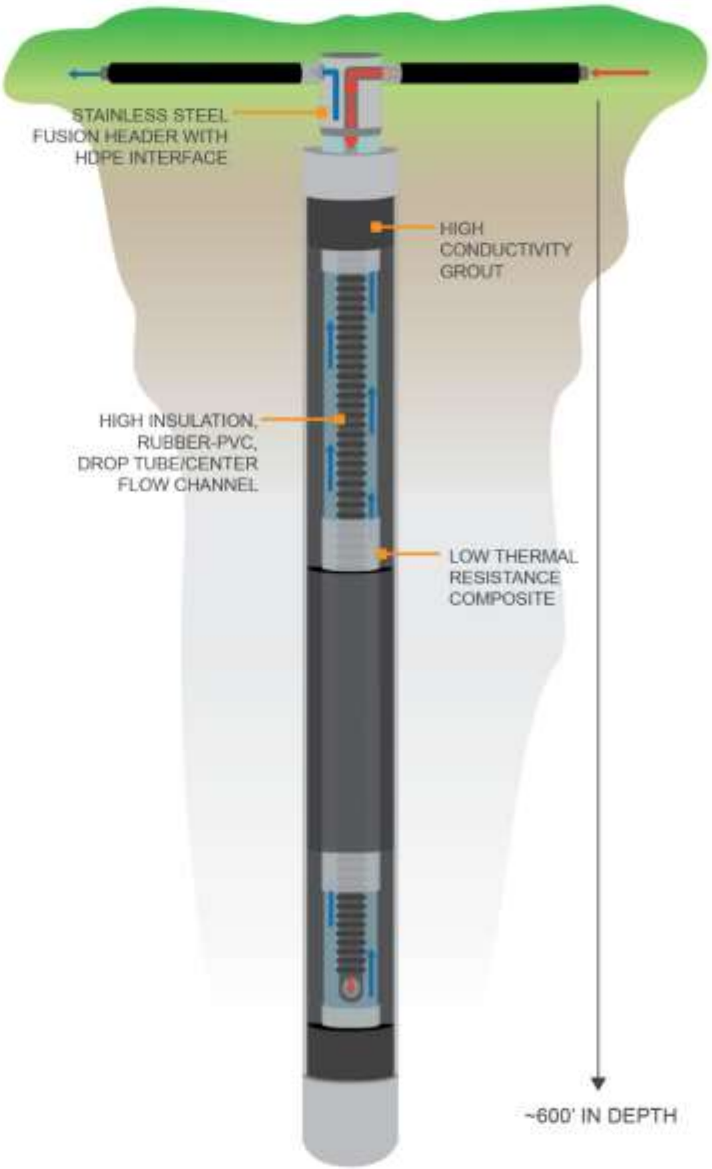
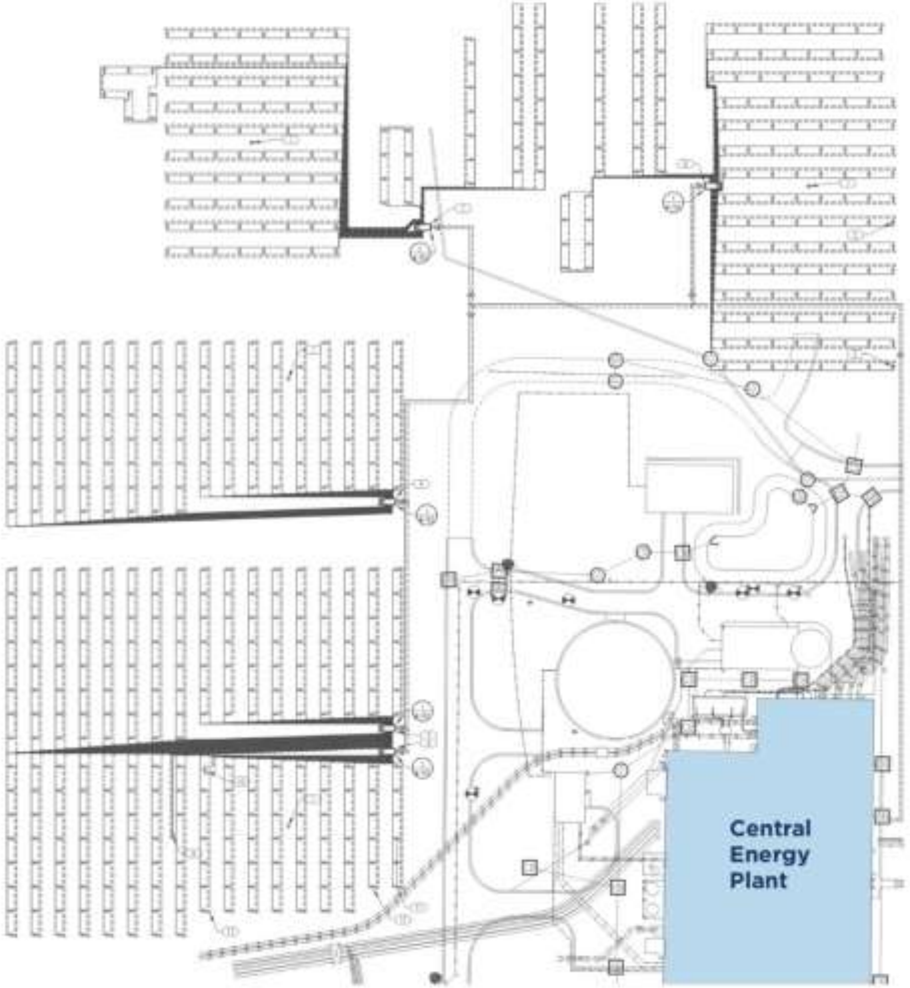
Geothermal System

Rygan Heat Exchanger





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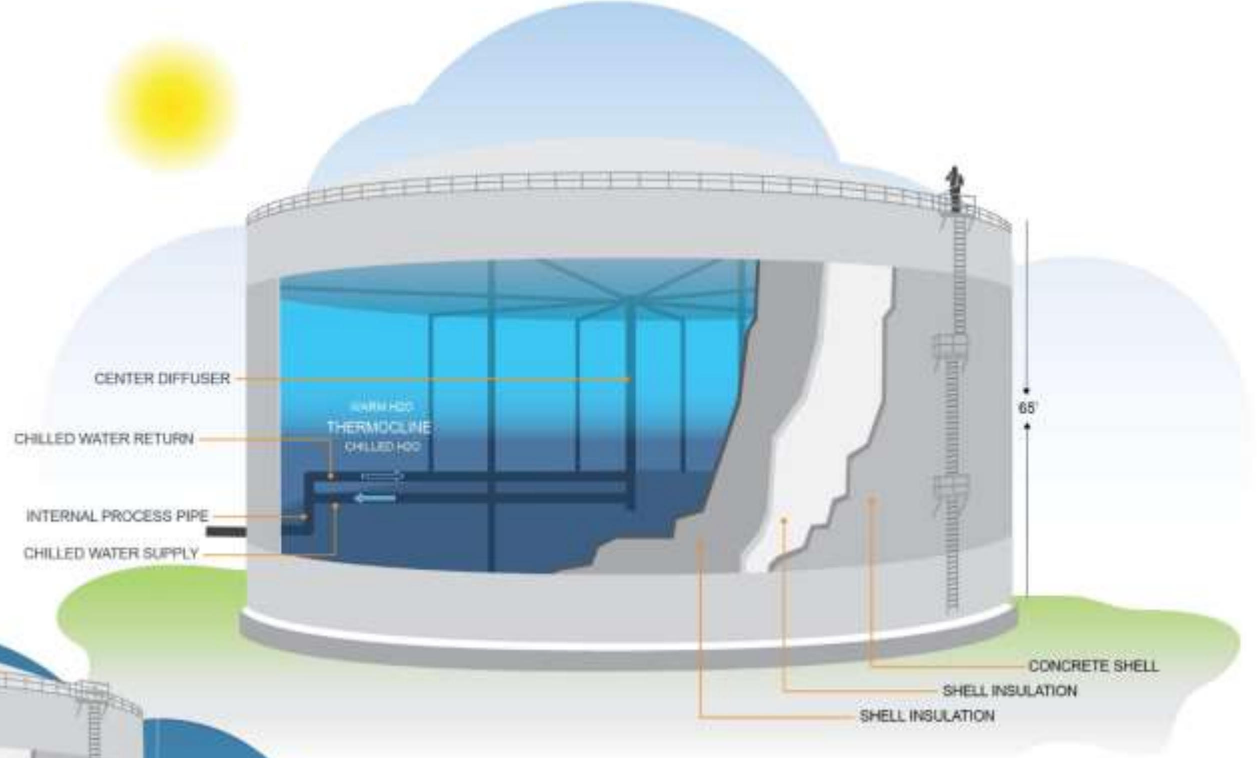
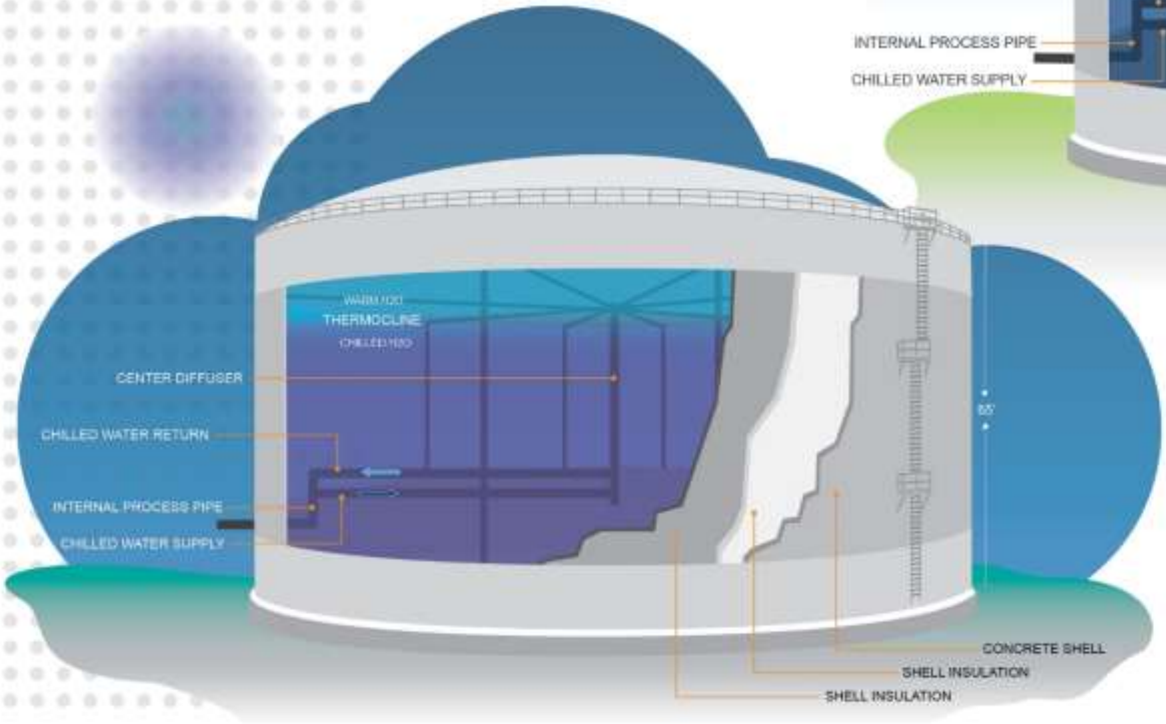
Thermal Energy Storage





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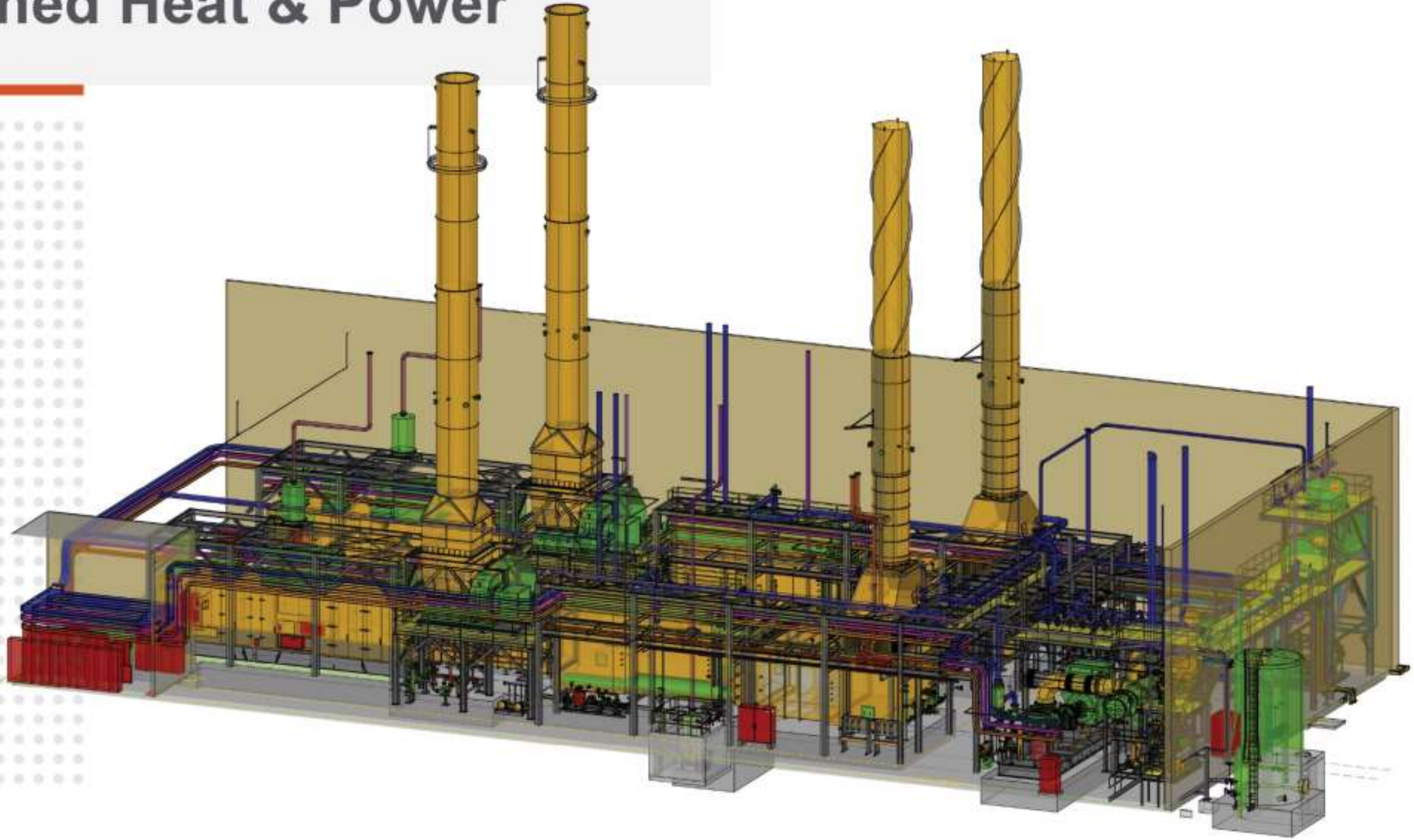
Combined Heat & Power



What is DBOOM?

DESIGN	Design project as a holistic system
BUILD	Construct balancing the design specification and operations needs
OWN	Integrate risk throughout life-cycle, including financing risk, construction risk and performance risk
OPERATE	Optimize for the benefit of customers
MAINTAIN	Maintain and upgrade technologies throughout life-cycle by implementing and deploying improvements and additional capital expenditures

Why DBOOM?

Aligns design with construction and operations

New technology operated by domain experts

Eliminates the loss of knowledge during transfers from design to deployment to operations

More powerful incentives to operate infrastructure efficiently

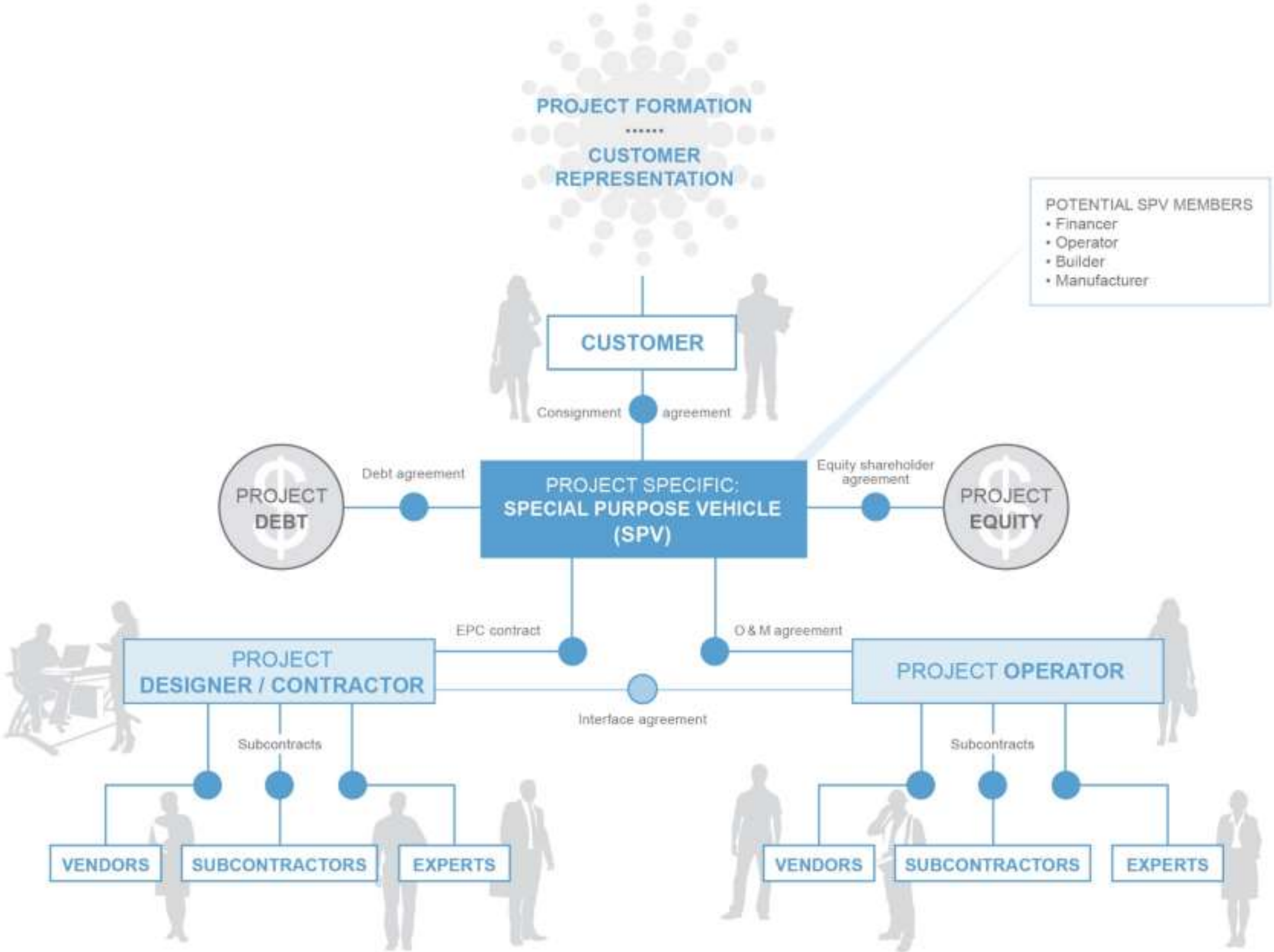
Directs focus and resources on the mission of the organization

Model Comparison

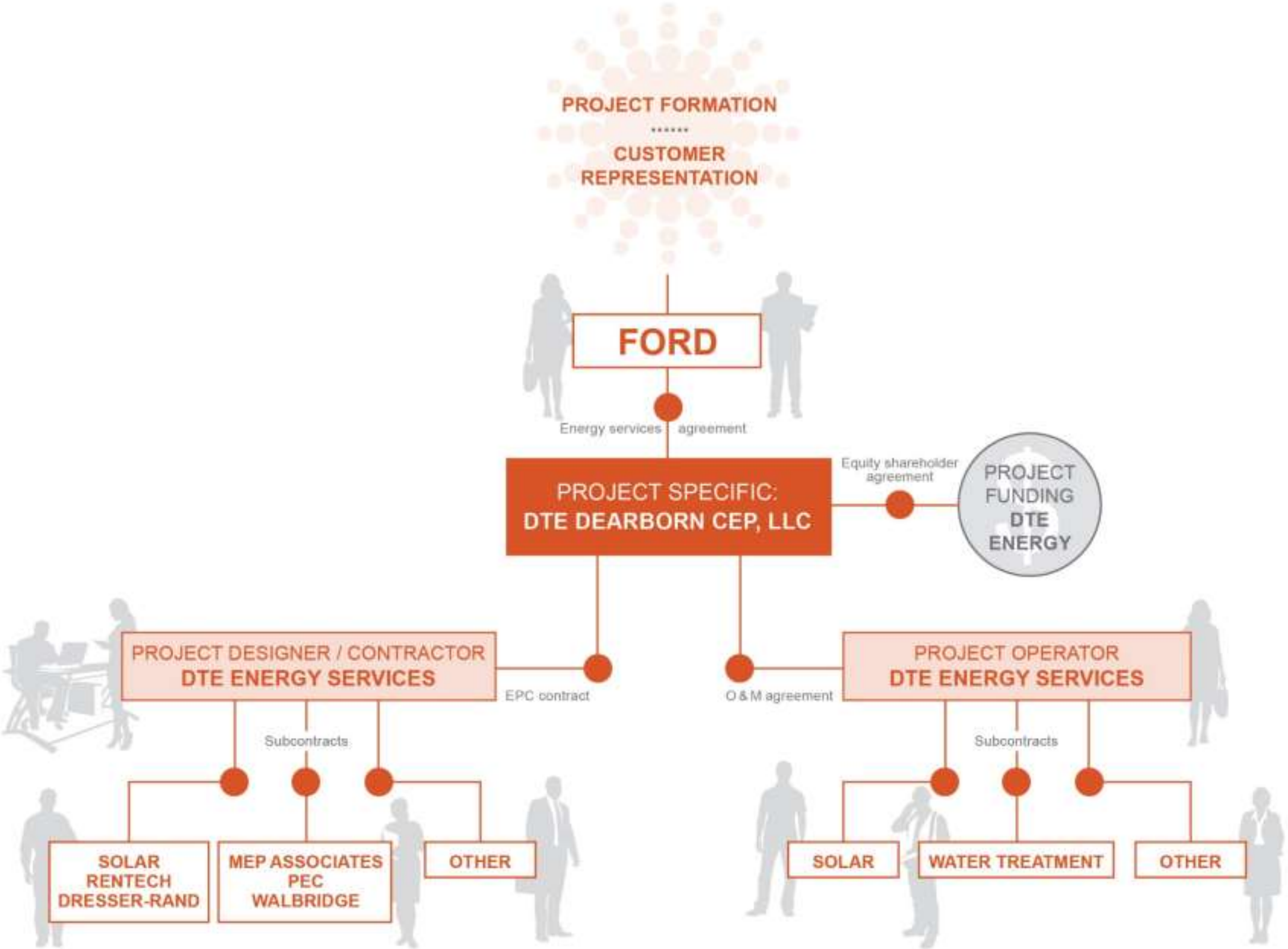
TRADITIONAL MODEL	VS	DBOOM MODEL
Develop strategic plan		Develop strategic plan
Design holistic infrastructure system with multiple components		Conceptualize holistic infrastructure system and critical attributes
Disaggregate and prioritize components		Integrate Owner/Operator and its domain experts with design process
Competitively select contractors for highest priority components		Identify system components which should be operated by domain experts
Construct and integrate these components		Align risks with parties best suited to manage
Hand off responsibility for operating new infrastructure to primary client		Design and implement contracts with performance incentives
Re-evaluate budget for remaining components		Monitor performance of infrastructure system

Traditional Model	VS	DBOOM Model
ABROGATION & AVERSION		**PERFORMANCE BASED**
Ownership by customer		Ownership by 3rd party
Purchasing at lowest cost per component		Purchasing based on highest lifestyle value
Quality at minimum compliance		Quality at highest value
Latent defects are the responsibility of Customer		Latent defects are the responsibility of Owner/Operator
Technology/efficiency risk borne by Customer		Technology/efficiency risk borne by Owner/Operator
Decisions biased towards Customer behaviors		Decisions utilize best available human capital
Requires more calendar time		Minimize calendar time
Engineered products purchased and applied independently		Integrated system
Limited Customer input after design stage		Opportunity for Customer involvement throughout

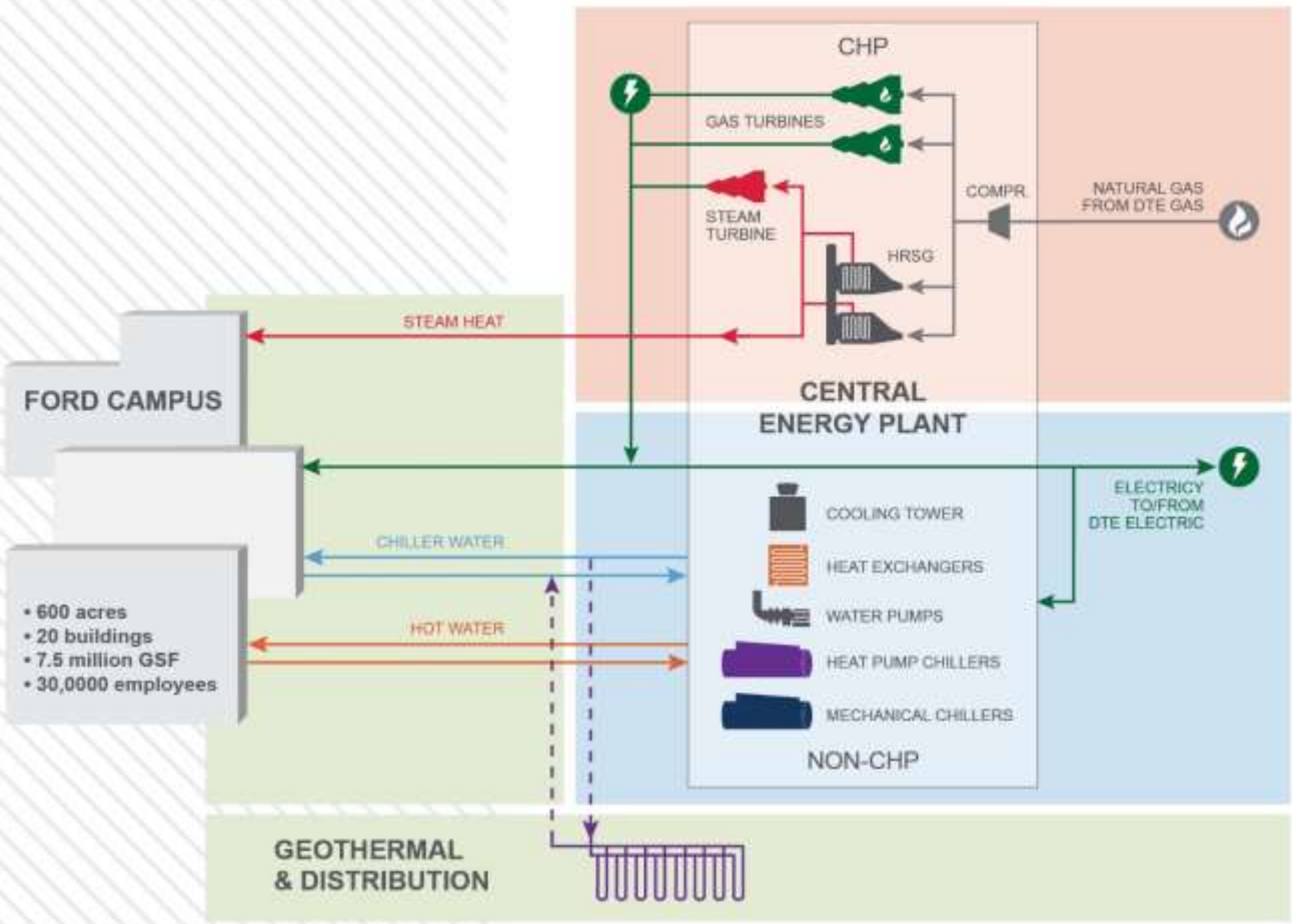
Typical DBOOM Structure



Ford DBOOM Structure



Contractual Relationships



DTEE owns

DTEES builds & operates

DTEES builds, owns & operates

DTEES builds, owns & operates

Ford-DTE Service Agreements