Renewal through transformation in Dearborn

Ford brings modern district energy to its Research and Engineering Center via DBOOM

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The last decade has brought immense change to the automobile industry. Technological advances in automobile electrification, battery storage, autonomous vehicles and data analytics have profoundly impacted automakers and their business models. Uber, the multinational ridesharing and transportation network is just one of the agents of innovation, having developed its own self-driving cars and various delivery platforms, such as Uber Eats.

Recognizing these changes, Ford Motor Co. initiated an evolution to become a mobility company – not purely an automaker. It began implementing operational and facilities changes to support this over the past decade. One physical manifestation of this shift to mobility is the transformation of Ford's Dearborn, Mich., facilities into a modern, green, and high-tech campus. Changes began in Dearborn in April 2016 at the company's Research and Engineering Center (REC), which has served as the heart of Ford's operations since it was dedicated by President Eisenhower in 1953. In planning to modernize the REC, Ford set out to transform its workplaces into inspiring, innovative, and sustainable environments that support company business objectives.

In keeping with project sustainability goals, plans for the redesigned REC include construction of a new central energy plant and distribution system, with completion in December 2019. This project has been developed and is being executed using a design-build-own-operate-maintain – or DBOOM – model that offers integrated project delivery, external capital and operational efficiencies that have been improved over the traditional approach.

NEW TECHNOLOGIES AND PROJECT DELIVERY MODELS

Coinciding with the upheaval and evolution in the auto industry have been significant shifts within the energy industry. Increasing support for environmental sustainability has driven technological innovation in renewables, distributed energy generation, energy storage, controls, and approaches to building HVAC design. All of these have coalesced to increase acceptance of the value proposition of modern district energy.

Research and Engineering Center central energy plant. Completed 2019.

As laid out in the United Nations Environment Programme's *2015 District Energy in Cities* report, "fourth-generation," or low-temperature district energy networks are being implemented around the world. Integrating two-way district heating and cooling and using smart energy management and renewable or secondary heat production, such networks employ the type of infrastructure required of the sustainable environments envisioned for Ford's transformed REC.

These increasingly complex, integrated utility systems associated with district energy networks have given rise to alternative project development and operational models. The design-buildown-operate- maintain model has evolved to provide many potential benefits. For example, the DBOOM approach:

- embeds operational expertise in the design and construction process,
- reduces operating and maintenance costs by operating utility systems efficiently and reliably,

- reduces labor costs,
- reduces retail power costs through self-generation or efficiency improvements,
- reduces or eliminates capital spending on existing infrastructure or deferred maintenance, and
- improves emissions footprints associated with utility systems.

In the case of Ford's Research and Engineering Center, the critical benefits of this model are the preservation of capital availability for facility renewal and, with the role played by the DBOOM supplier, the ability of Ford to focus on its core business activities.

CURRENT REC FACILITIES

Ford's Research and Engineering Center has served as the global research and development heart of Ford's operations for more than 60 years. The campus consists of 6.5 million gross sq ft across 900 acres. It includes an array of facilities from conventional office buildings to laboratory facilities, a large dynamometer building and wind tunnels. The center is bisected by Oakwood Boulevard, which separates the test track and its facilities from most of the research and office buildings.

The broad programmatic uses of the center's facilities create a complex utility demand for conventional HVAC systems and a range of process energy uses to support climate-controlled vehicle testing and laboratory research environments. Historically, REC buildings have stood independently from one another and have been provided utilities via centrally generated steam from the Elm Street Powerhouse and grid-purchased electricity.

Much of the campus's legacy chilled-water production has been generated from individual, in-building absorption chillers; however, electric centrifugal equipment and lowtemperature process chillers also provide cooling to some facilities.

TRANSFORMATION SUSTAINABILITY OBJECTIVES

Ongoing planning and development at the REC will create a contemporary work environment that can accommodate thousands of additional employees. Early master planning defined a range of high-performance sustainability objectives to accompany the modernization program. From an energy and utilities perspective, these objectives included a

- 50 percent reduction in carbon dioxide emissions,
- 50 percent reduction in water use,
- 60 percent improvement in chilled water production efficiency, and
- 100 percent of space heating provided from recovered waste heat or geothermal energy sources.

An overarching design goal for the energy system redevelopment was incorporation of the concept of low entropy – defined in this instance as a campus that minimizes energy waste and maximizes productivity. Two key components supporting this concept are development of a new central energy plant and an integrated campus energy infrastructure capable of providing conditioned environments for building occupants using water-based systems as close to room temperature as possible. These strategies will allow the REC to minimize the use of steam for process loads associated with laboratory and testing facilities.

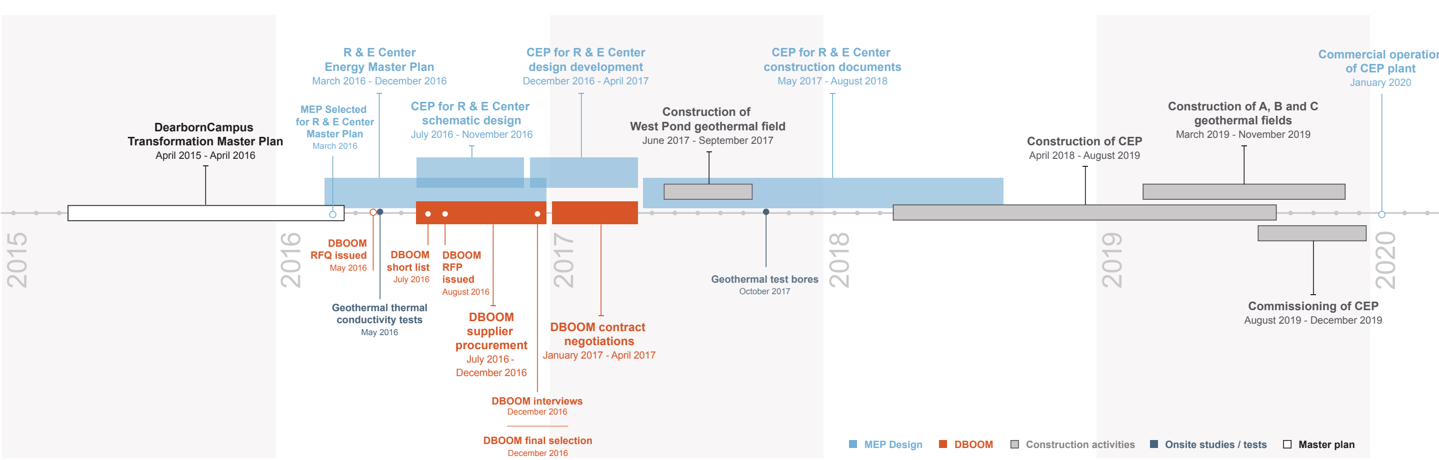
ENERGY MASTER PLANNING

Space planning for the complete REC transformation involved a multidisciplinary team of architects, engineers, planners, contractors and representatives from Ford and the company's real estate development entity, Ford Land.

This initial physical space planning was expanded by MEP Geothermal Engineering, PLLC (MEPGeo), in the form of an energy master plan for the REC and the schematic design of a central energy plant to serve it. MEPGeo utilized an integrated utility planning framework, which included hourly load models of electricity, steam, chilled water, cool water (for potential chilled-beam applications) and hot water. Building energy models were developed for all new buildings, defined by the physical master plan, major renovations, and existing facilities. Model outputs were coordinated with phasing plans for capital improvements and used as the basis for 30-year lifecycle cost assessments of central plant utility supply options.

As the energy master plan defined the components and scale of the new central energy plant, the process of selecting a DBOOM supplier began. This was an interactive process that started with a request for qualifications issued in May 2016 and wrapped up with final selection in December that same year. Bidders were provided a conceptual design narrative, central energy plant drawings and specifications from which to develop their proposals. Multiple bidder meetings were held with short-listed teams throughout 2016 to provide updates on energy planning and campus master

FIGURE 1. Planning, design and construction timeline for the Research and Engineering Center central energy plant project.



Source: MEP Geo

planning processes. Refer to figure 1 for a complete project timeline.

To accelerate the project schedule, the energy master plan and schematic design of the central energy plant were concurrently finalized in December 2016, as the DBOOM supplier selection progressed and concluded. As such, the energy master plan and plant design were closely coordinated with the selected DBOOM provider: DTE Energy Services - a wholly owned, nonregulated subsidiary of DTE Energy Co., which is a Detroitbased energy holding company that also consists of regulated gas and electric utilities, as well as other nonutility businesses.

As Ford and DTE Energy Services progressed with contract negotiations, design development of the facility was initiated with DTE Energy Services' development, engineering, and operations teams. Concurrent work streams for project development (estimating, contract negotiation, equipment supplier bidding, etc.), engineering (central energy plant systems, civil infrastructure) and site logistics brought a large, collaborative team together to maintain the project schedule while integrating construction, operations and maintenance, prefabrication, and equipment expertise into the early stages of the project to ensure long-term operational success.

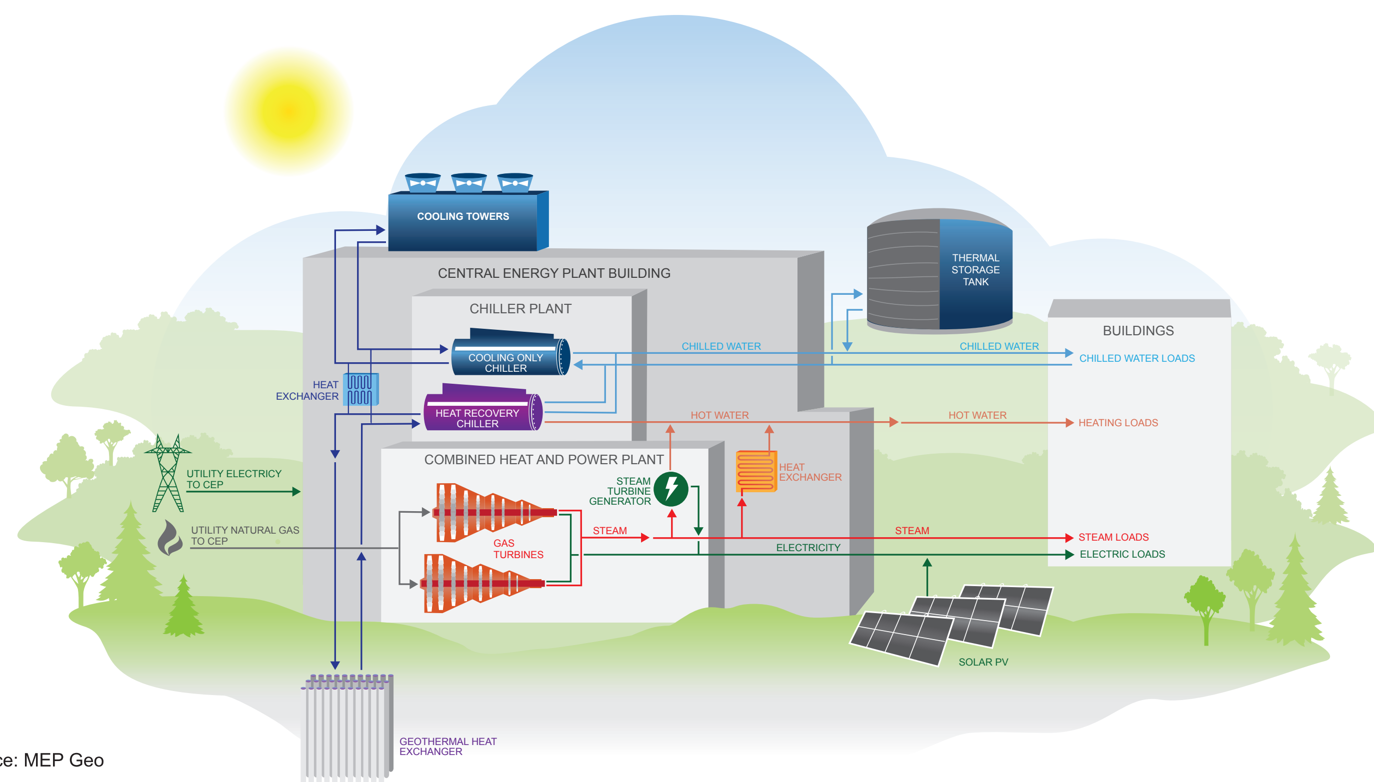
CENTRAL PLANT OVERVIEW

Energy master planning for the REC provided a conceptual basis for the technologies deployed in the central energy plant. However, the DBOOM contractual relationship with DTE Energy Services (and involving DTE Electric Co., described more below) resulted in a unique opportunity to modify the scale of some project components to optimize economic and energy efficiency. The plant, illustrated in figure 2, includes the following:

- a 34 MW on-site combined heat and power plant, equipped with two Solar Turbines Titan 130 gas turbine generator sets and a Siemens 5 MW steam turbine generator
- two Trane centrifugal heat pumps – 1,200 and 1,800 tons, both utilizing R-1233ZD refrigerant
- four Trane centrifugal chillers – each 3,200 tons with series evaporators and series condensers, utilizing R1233ZD refrigerant (counter flow arrangement between chillers No. 2/No. 3 and No. 4/No. 5)
- geothermal-ready infrastructure including piping connections at the plant for the future addition of a 3,000-ton vertical heat exchanger
- 4 MW of solar electrical generation via roof-mounted solar panels integrated into the REC site's electric infrastructure
- approximately 40,000 ton-hr of thermal storage capacity with a single tank
- distribution system supplying 42 F chilled water, 120 F low-temperature heating hot water and steam (legacy heating and process use)

To support the low entropy concept, a low-temperature heating hot water system is included. This 120 F water is provided by heat pump chillers and waste heat from the CHP system via steam-tohot-water heat exchangers. As the campus transformation occurs over the coming years, existing in-building steam systems (or entire buildings that use steam) will be decommissioned and replaced with hot water systems. The heat pump system is designed to accommodate a future geothermal heat exchanger of up to 3,000 tons capacity, which can be constructed with the campus redevelopment and ongoing implementation phasing.

FIGURE 2. New central energy plant and distribution system to serve Ford's transformational Research and Engineering Center campus.



Source: MEP Geo

DBOOM: WHAT IS IT?

The DBOOM delivery model seeks to optimize the efficacy of infrastructure investments throughout the lifecycle of a project (30-50 years). The model aims to align risks, expertise (design, construction and operation), ownership and performance incentives with the project parties who are best-suited to effectively address them. The DBOOM approach encompasses:

- **Design** – design of the project as a holistic system
- **Build** – construction, balancing the design specification and long-term operational needs
- **Own** – integration of risk throughout the project's lifecycle, including financial, construction and performance risks
- **Operate** – optimizing operation for the benefit of the customer/end user of the utilities
- **Maintain** – maintenance and upgrading of technologies throughout the lifecycle by implementing and deploying improvements and additional capital expenditures

The traditional delivery model is compared to DBOOM in figure 3.

In the case of the REC, a complex district energy plant was conceived to meet the sustainability objectives of the campus transformation. Recognizing the need for a specialized operator to guarantee the long-term performance of the facility, Ford chose the DBOOM delivery model for the project. Integrating the operational knowledge of DTE Energy Services and the deep experience of the project's skilled contractors into the design and construction process ensured long-term operational needs would be met as the design progressed through various approval and costing stages.

DBOOM PROJECT STRUCTURE

The typical structure of a DBOOM project involves the creation of a special purpose vehicle (SPV) as the legal corporate entity. The SPV establishes a variety of contracts with a project operator, design team, contractor, and the customer. In most cases the controlling member (or even sole member) of the SPV will be the project operator, but the SPV may have a wide range of potential participants including financer, operator, contractor, manufacturer, or designer(s). The SPV will typically provide project funding using a combination of project debt and project equity.

This typical project structure is customized for each unique project and its requirements and participants. In the case of the Ford REC project, where Ford contracted with DTE Energy Services, the DBOOM structure was simplified as indicated in the diagram in figure 4.

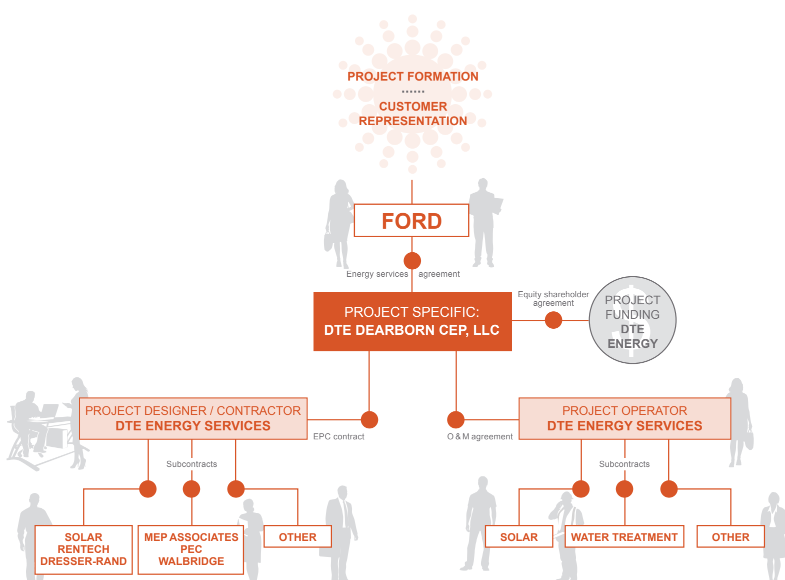
The REC project established DTE Dearborn CEP LLC as the SPV for Ford's DBOOM development. DTE Dearborn CEP LLC was developed as a subsidiary of DTE Energy Services. While this initially created a simple contractual structure, the nature of the central energy plant components – specifically the presence of CHP assets – established a desire for DTE Electric, the regulated public utility, to also play a role in the project. DTE Electric understood the value of a significant distributed production asset as part of its integrated resource strategy and thus successfully sought to develop the CHP assets within the central energy plant project. The contractual responsibilities and boundaries are identified in figure 5.

FIGURE 3. Comparison of the traditional and DBOOM models of project delivery.

TRADITIONAL MODEL	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

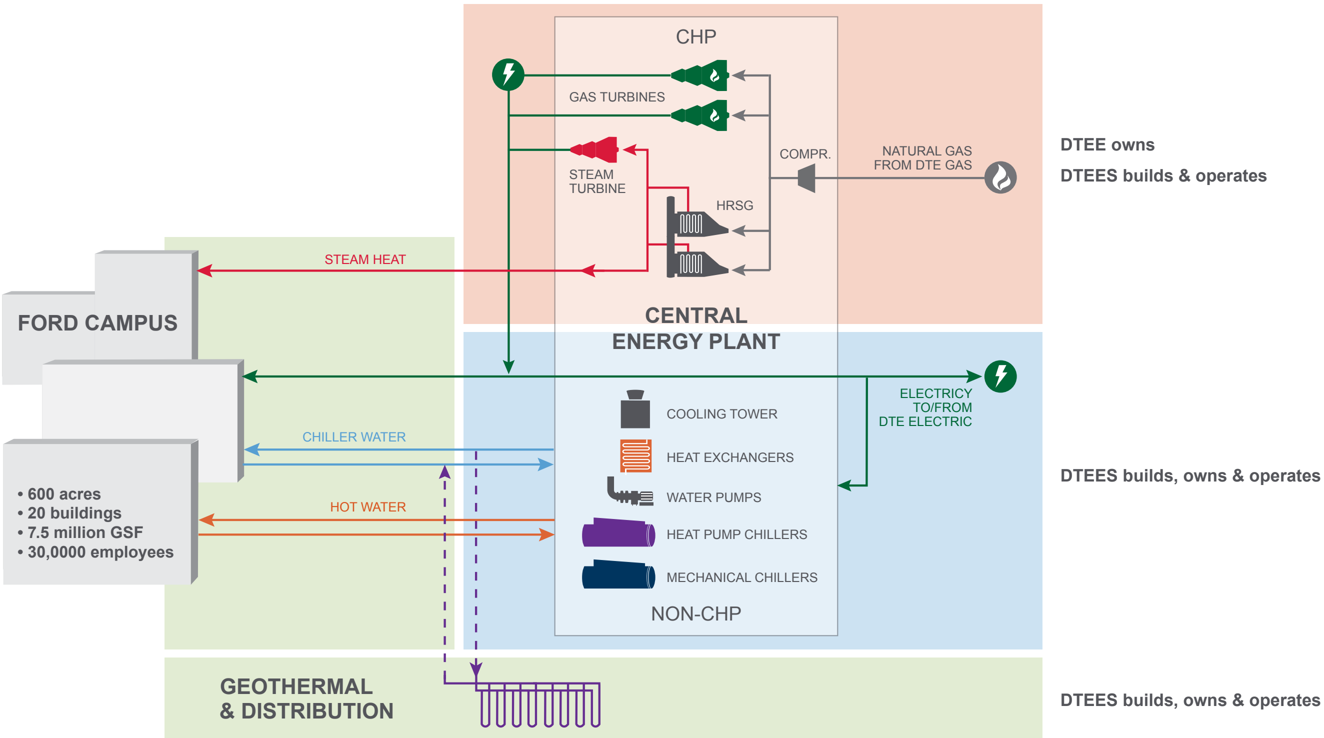
Source: MEP Geo

FIGURE 4. The Ford Research and Engineering Center project DBOOM structure.



Source: MEP Geo

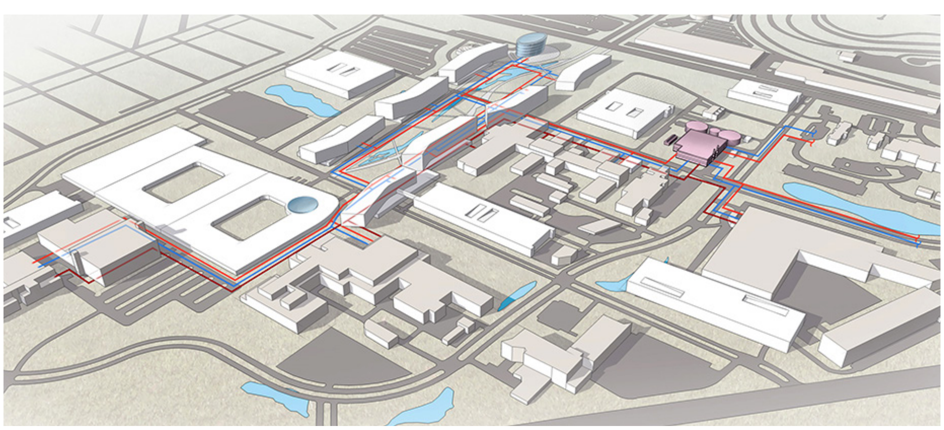
FIGURE 5. Contract boundaries for regulated and unregulated utility providers in Ford's Research and Engineering Center project.



Source: MEP Geo

Through the regulated, public process, DTE Electric participates in this district energy project by owning the central energy plant assets. DTE Energy Services, an unregulated utility provider, maintains ownership of all non-CHP assets, including the campus distribution systems for geothermal energy, chilled water, and hot water. DTE Energy Services operates the entire plant, including the DTE Electricowned CHP facility. In this manner, significant external capital could be committed to the project, and operability among electrical generation, the electrical grid and the thermal network could be optimized.

The DBOOM development model used for the new central energy plant at Ford's Research and Engineering Center is an exemplary approach that can be taken for true sustainable infrastructure development. Through Ford's leadership in the project, a successful pursuit of environmental goals and financial responsibility will result in a dramatically improved work environment for the thousands of company employees leading mobility innovation in Dearborn, Mich.



Central Energy Plant piping

***Mike Walters**, PE, is the Regional Director of MEP Geothermal Engineering, PLLC. With a background in energy planning and the design and construction of geothermal systems and central energy plants, Walters has guided Cornell University's standard-setting climate action plan, the transformation of Ford Motor Company's Dearborn Research and Development Center and energy planning and conceptual design for the RiverLInC district energy system in Long Island City. His project roles include project management, engineering leadership, and comprehensive techno-economic analysis of energy systems and alternatives.*