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## DISTRICT ENERGY & COOLING DOWNTOWN SYSTEM

AUSTIN, TX, USA

AUSTIN ENERGY, A CITY OF AUSTIN SERVICE

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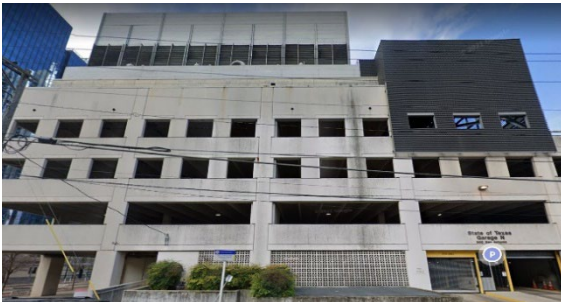
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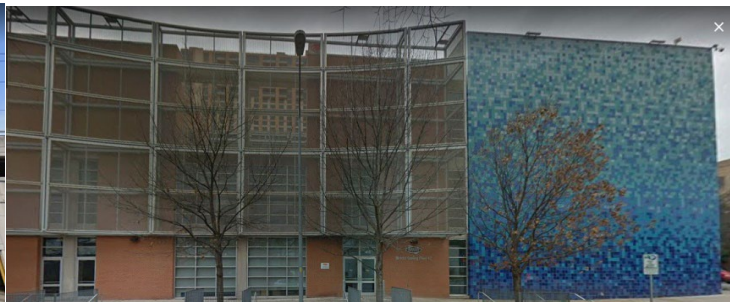


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DCP1



DCP2



DCP3



DCP4

## 1 SYSTEM DESCRIPTION

Austin Energy owns and operates three district energy systems, one serving the Downtown Central Business District, one serving the Domain, and one serving the Mueller redevelopment site. The District Energy & Cooling (DEC) program began serving its first customer in April 2001 and has grown to serve 73 customers, covering a total of 25 million square feet of space, including residential towers, office buildings, hotels, Whole Foods grocery, the Austin Convention Center, City Hall and Austin Community College Highland Campus. The Downtown and Domain systems provide chilled water services only, whereas the Mueller Energy Center provides chilled water to neighboring buildings and chilled water, steam and on-site electrical generation to the Dell Children's Medical Center.

The Downtown District Cooling System in downtown Austin comprises four district cooling plants connected by a network of pipes as shown diagrammatically in Figure 1. The capacity of the system is 29,200 tons. Two of the four chiller plants generate 76,000 ton-hours of ice storage and are used to shift load during peak hours: 3 to 6 pm.



Figure 1: Downtown System Map

The downtown system serves 48 of the 73 customers, with two new buildings to be added in late 2023 or early 2024. Austin Energy added two new district cooling plants and signed four new customers within the last five years, with the potential to sign two more customers and two more plants to the expanding downtown Austin skyline. Our newest plant, District Cooling Plant 3 (DCP3), was designed to be resilient, redundant, efficient, safe and environmentally friendly. As such, adding new plants to our system now requires the following considerations:



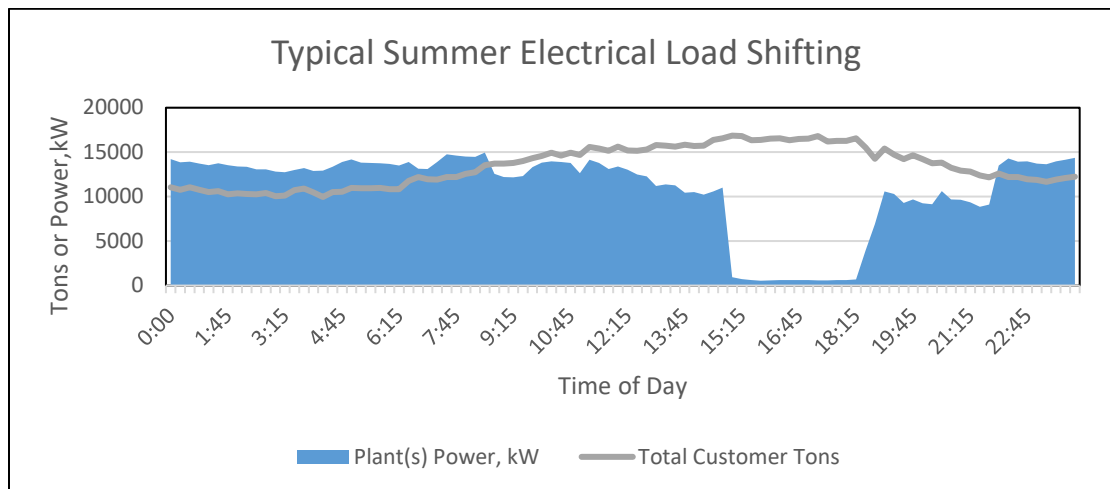


- Utilize variable speed chillers, pumps, cooling tower fans and HVAC system.
- Redundant Allen Bradley programmable logic controllers (PLC) based control system.
- All major equipment except for the water chillers has a spare in case of equipment failure.
- Electrical switchgears have remote open and close breaker capability via the control system. Also, the switchgear breakers can be remote racked in and out.
- Utilize sulfuric acid to increase cycles of concentration from 6 to 12; thus, the plant uses less water for its cooling tower system.
- Equipment and piping are in conditioned space or enclosed space. Small diameter outdoor piping is heat-traced.
- The water chiller plant is shut down and turned off from 3 to 6 pm to help reduce the overall load on the electrical grid. Our customers during this timeframe are served by the thermal ice storage system.
- Roof rainwater and the air handling unit's condensate drains to a capture tank that is pumped into the cooling tower water system.
- All underground chilled water piping 24" and below is pre-insulated carbon steel piping. Above 24" the piping is epoxy coated carbon steel piping.
- All chilled water piping inside mechanical rooms or the plants is insulated with 2" insulation.

## 1.1 District Cooling Plants and CHW Distribution Piping

The Downtown District Cooling System has a network of piping of more than 8 miles, cooling more than 18 million square feet of downtown buildings. The distribution system is buried below downtown streets and sidewalks.

As part of Austin Energy's daily operations, load shifting is implemented by the Downtown District Cooling System. Thermal ice storage tanks are discharged between 3 and 6 p.m. and recharged during evening and overnight hours, when electrical demand is typically low. As indicated in Graph 1, we turn off all water chillers from 3 till 6 p.m. and distribute chilled water through ice tanks. During this timeframe, only secondary distribution pumps are operating from two plants. In the summer, we shift 15 megawatts per hour from the electrical grid for 3.5 hours each day. The thermal ice storage tanks have a capacity of 18 MW, and by 2024 we will be capable of shifting the maximum capacity.



Graph 1: Daily Electrical Load Shifting

We deliver chilled water to our customers through heat exchangers between the chilled water distribution system and the chilled water system of the building. The heat exchangers are designed to handle 50% of the building's design load and maintain the chiller's design differential temperature, not the building's differential temperature. We require our customers to design their facilities for a differential temperature of 15° F across their side of the heat exchanger. This design criteria improves overall distribution pumping power and allows plants to operate at their designed capacity rather than at reduced capacity due to low differential temperatures requiring excess flow.

Austin Energy installs a PLC cabinet at each customer's heat exchanger room to control building supply temperature based on customer supply or return temperatures. Controls automatically switch from supply temperature control to return temperature control if the customer does not provide the correct differential temperature. By ensuring that the customer returns the appropriate return temperature, the plant runs efficiently and with increased capacity. Ten years ago, the return temperature of the system was 49° F. Today, based on this change alone, the system has an average return temperature to the plants of 52 to 53° F. With this change, the chillers can operate at design conditions with 30% more flow capability.

## 1.2 Operations and Modeling

The Downtown District Cooling System distributes chilled water at 36° F or 32° F during chiller or ice tank operation, respectively. With these lower temperatures, the overall system has a better return temperature profile. As a result, distribution pumps operate lower on their pump curve. This reduces their electrical load requirements and overcomes the increase in electrical consumption of the chiller operating at a lower supply temperature. Additionally, this change improved our hydraulics, which gave us more pumping capacity and enabled us to serve more customers with chilled water. As a result of supplying 32° F water during ice melt out, we've achieved a higher return temperature to the plants because chilled water had more residence time within the heat exchangers. This yielded an overall plant efficiency improvement from 1.0 kW/ton to 0.85 kW/ton.



A hydraulic model of the chilled water system has been developed. The hydraulic model includes the transmission piping, each customer interface (piping, instrumentation, and equipment) and the four chilled water plants (piping, instrumentation, and equipment). The hydraulic model provides mechanisms for improving, troubleshooting and determining how efficiently our system is functioning. Based on the model, we can determine if new customers or plants can be added to our system at various locations. Similarly, our hydraulic model has helped troubleshoot hydraulic concerns and provided a general location of where problems may exist. Our model is also updated as new piping and customers come online, allowing us to make sure we can serve our customers efficiently, reliably and without causing unintended consequences.

## 2 DEMONSTRATED EFFICIENCY

Every year, Austin Energy uses historical data from the previous year to track tons/kW and ice thermal storage utilization. This data allows Austin Energy to determine our service efficiency. The information is then sent to Austin Energy Green Building, which analyses the data and information to determine LEED (Leadership in Energy and Environmental Design) points for our customers connected to our distribution system and the carbon footprint offset through load shifting. In 2022, our tons/kW was 1.32 tons/kW. Our efficiency in 2021 was 1.10 tons/kW. The 2021 efficiency was lower than in 2019 due to repairs in one of the thermal ice storage tanks forcing us to run chillers through the demand window. As a correlation to our continued improvement in plant efficiency, in 2019, our efficiency was 1.18 tons/kW. The equation for calculating tons/kW is as follows:

$$\frac{\text{tons}}{\text{kW}} = \frac{\text{total customer tonnage}}{\text{total plant kW}}$$

By using total customer tonnage instead of total plant tonnage, we can better identify our efficiency as it relates to the customer, not just what the plant produces. As part of our everyday operations, using plant tonnage could present an abnormal representation, especially during supply temperature changes. Total plant kW is derived from the plant incoming electrical meters power usage and includes pumps, motors, HVAC equipment, lighting and fans.

## 3 DEMONSTRATED AVAILABILITY/RELIABILITY

The Downtown District Cooling System prides itself on being available and reliable. Our availability and reliability were calculated for 2021 and 2022 as indicated in Table 1. The calculation only included district cooling plants. Our plants are designed, maintained and operated to keep our customers supplied with chilled water to meet their cooling needs. Throughout our system, we leverage redundancy, maintenance and communication to ensure reliability and availability.



Table 1: Availability/Reliability Chart

	Availability (%)		Reliability (%)	
	2022	2021	2022	2021
<b>District Cooling</b>	100.0	100.0	100.0	100.0
<b>Overall Systems</b>	100.0	100.0	100.0	100.0

### 3.1 Redundancy

Our plants have multiple electrical feeds entering the main-tie-main electrical switchgear. Electrical utility feeds are provided by different transformers at the Austin Energy substation. Even if one of the substation transformers fails, our plants can still provide chilled water to our customers. For all significant equipment except water chillers, each plant maintains N+1 redundancy and we design our customer loading profile such that a spare 2,000 ton chiller is always available at one of our four plants. We have redundant processing controllers and redundant power to our PLC power supplies for both 120 VAC and 24 VDC control systems. Uninterruptible power systems are connected to all our PLC controllers, ensuring that plant controls stay up and operational even in a power blimp condition. Our thermal ice storage system is also utilized as a backup system in case our plants experience equipment failures or trips. If a chiller(s) trips, the thermal ice tank acts like an N+1 chiller and automatically comes online. The transition is seamless, and our customers do not even realize that there was a chiller or pump failure. These design conditions and control programming provide the ability for us to keep our system 100% available and 100% reliable throughout the year, even during extreme weather conditions.

### 3.2 Maintenance

The DEC takes a proactive approach to maintenance and implements three maintenance programs: Condition monitoring/predictive maintenance, preventative maintenance and break down maintenance. All our equipment is scheduled for weekly, monthly, and yearly maintenance each week using Maximo. By monitoring approach temperatures in our heat exchangers and water chillers, operations identify any anomaly, possible scaling or fouling and determine what type of maintenance needs to be performed to return the equipment to design conditions. To keep our condenser water and chilled water systems clean, weekly water chemistry meetings are attended with our chemistry vendor to discuss the health and cleanliness of our systems. As soon as a water system starts to exceed tolerance, the system is treated right away to prevent upset conditions. When an upset occurs, we determine a course of action and maintain constant monitoring until the system returns to normal conditions. Calibrations of instrumentation are done per the manufacturer's recommendations to ensure our billing and plant instrumentation is reliable and accurate.



Our predictive maintenance program is highly valuable to Austin Energy and the customers it serves, as the program helps to ensure service reliability and reduce instances of unscheduled or unplanned equipment downtime resulting from equipment or process failure. Vibration analysis is a critically important tool in the toolbox of a predictive maintenance program and is recognized as one of the most effective and insightful technologies available for the identification of faults and early detection of potential failures. We track an asset over time and establish priority levels, criticalities to the system processes and products and how frequently the asset will be needed. Continuously running machines are monitored monthly, with less frequently run systems checked approximately every three to six months, depending on each system's redundancy. If an unexpected issue arises, program workers immediately implement a series of established troubleshooting procedures to address the issue as quickly and thoroughly as possible. There are four primary steps involved in the troubleshooting process as follows:

- Utilize the historical vibration spectral data and trends to determine what change has occurred.
- Implement pertinent aspects of training, certifications, and hands on experience to accurately assess potential disruptions, either mechanically or electrically, which might account for the observed change relative to the spectral data previously collected.
- Following the identification of potential causes, perform a visual inspection of needed adjustments such as balancing, verifying alignment, or a further inspection with isolation of components to find the root cause of vibration issues on the system, to name a few.
- Conduct and record a final follow up collection of vibration data to establish a new baseline to be used going forward.

Maintaining our vibration analysis program is crucial to extending the lifespan of the machines monitored, increasing productivity, avoiding unexpected failures, and reducing costly maintenance expenses.

### 3.2 Plant Controls Communications

The control systems at each plant have a dedicated secure Ethernet network that is not connected to the Austin Energy WAN. Within the PLC controls system, the connection to the HMI system has its own Ethernet module separate and independent of the input/output controls of the PLC. Each customer's PLC is connected to a dedicated fiber network different from Austin Energy WAN, thus keeping our system available regardless of an outage to the primary WAN. Operations can respond 24/7 to any adverse condition by viewing and responding instantly when a customer or plant system has an issue or deviation from normal conditions.

## 4 DEMONSTRATED RESILIENCY

There are several ways in which the Downtown District Cooling System has proved its resiliency. During the global pandemic, we were in the process of constructing our two newest plants. Austin Energy placed safeguards and procedures to keep employees and contractors in a safe workplace environment. DCP4 was





completed on time and was in operation in May 2020. DCP3 continued progressing with adjusted work schedules and achieved substantial completion in October 2021. During severe weather conditions, Austin Energy downtown DEC also has procedures and mechanisms to safeguard our equipment. Our chilled water system and customers were not affected by the snowstorm of February 2021 in Texas, and no major piece of equipment failed. Our plant remained operational, and we served our customers without a reduction in service. Similarly, during the ice storm in February 2023 in Austin, once again, our chilled water system remained operational with no loss of service to our customers or loss of equipment afterward. To ensure our customers are served chilled water even in an equipment upset condition, our thermal ice storage systems available. These processes, procedures and the backup availability increase the downtown DEC system's resiliency in adverse environments and situations. Thermal ice storage not only increases the resiliency of our downtown system, but it also lessens the load on the electrical grid during the peak period.

## 5 ENVIRONMENTAL BENEFITS

During peak electrical demand periods, Austin Energy downtown DEC is dedicated to reducing its carbon footprint. By load shifting, we reduce our carbon dioxide equivalents as shown in Table 2 and Table 3. Each day we shift approximately 64% of the carbon dioxide equivalent from 2 pm to 8 pm to the evening hours. Carbon dioxide equivalents were calculated using 2022 ERCOT data. Our newer plants DCP3 and DCP4 have provided significant demand reduction at the most carbon intense time on the grid, early evening during the summer months, although these emissions are shifted to the overnight hours. The Green House Gas (GHG) emissions during the thermal storage load shifting window and the utility peak electrical demand window decreased 25% and 20% respectively from 2019 to 2022. Based on the tables below, our plants' carbon footprint is 38% of average building onsite chiller plants.

Year	DES w/ Load Shifting [lb CO <sub>2</sub> e]	DES w/o Load Shifting [lb CO <sub>2</sub> e]	Onsite Plant [lb CO <sub>2</sub> e]
2019	5,584,236.36	14,232,364.75	12,119,904.53
2022	4,553,801.35	14,203,941.23	11,843,090.35

Table 2: Annual Carbon Dioxide Equivalents during Peak Electrical Demand Period (2pm – 8pm)

Year	DES w/ Load Shifting [lb CO <sub>2</sub> e]	DES w/o Load Shifting [lb CO <sub>2</sub> e]	Onsite Plant [lb CO <sub>2</sub> e]
2019	3,597,249.49	8,315,640.27	6,864,315.05
2022	2,902,825.40	7,954,428.01	6,426,166.00

Table 3: Summer Months Carbon Dioxide Equivalents during Peak Electrical Demand Period (2pm – 8pm)



where DES with load shifting customer load at the time of use with thermal ice storage system between 3 and 6 pm, DES without load shifting represents the district energy plants meeting the customer load at the time of use with average monthly plant efficiencies and Onsite Plant represents if all our customers had their own chiller plant.

Austin Energy as a utility values reducing the GHG in the electrical generation. When compared to ERCOT's electrical generation mix to Austin Energy's, Austin Energy as a utility is approximately 40% of the Texas ERCOT grid generation portfolio. The annual average component gas breakdown for the ERCOT and AE generation mixes are shown in the Table 4.

GHG Emissions Component Gases	ERCOT Generation Mix [lb/kWh]	AE Generation Mix [lb/kWh]
Carbon Dioxide equivalents [CO <sub>2</sub> e]	0.817169	0.328964
Carbon Dioxide [CO <sub>2</sub> ]	0.813552	0.327508
Methane [CH <sub>4</sub> ]	0.000054	0.000022
Nitrous Oxide [NO <sub>2</sub> ]	0.000008	0.000003
All Oxides of Nitrogen [NO <sub>x</sub> ]	0.000472	0.000190
Sulfur Dioxide [SO <sub>2</sub> ]	0.000587	0.000236

Table 4: GHG Emissions Component Gases for ERCOT vs Austin Energy

## 6 SUSTAINABILITY EFFORTS

By connecting to Austin Energy's downtown district energy systems, many building projects have earned points in LEED and the local Austin Energy Green Building Commercial rating system. Both ratings recognize the benefits associated with the DES (Distributed Energy Storage) systems' efficiencies and especially their thermal storage capabilities. The significant demand flexibility they afford through their inherent thermal mass and storage tanks helps connected buildings navigate peak demand periods and limit their demand charges. By shifting cooling load to off peak times the DES plants also contribute to lower system-wide peak electric demand. When energy demand is reduced during peak periods, it can help prevent blackouts and reduce the need for expensive peaker plants. This yields lower energy costs for residents and businesses in the community and improves access to reliable energy services. Reducing peak electric demand also reduces emissions, which can improve air quality and public health in the community, which is especially important for low-income households that may be more vulnerable to the negative health effects of air pollution.



Water conservation is vital for maintaining our current and future water needs. Cooling towers use a substantial amount of water, and we believe minimizing the amount of water cooling towers use is paramount to our water conservation goal. A typical cooling tower has an average of 2 to 4 cycles of concentration. By using sulfuric acid in our condenser water chemical treatment systems at DCP2 and DCP3, we cycled our towers up to 12 cycles of concentration. This will realize a total savings of over 25 million gallons of water each year. At DCP1, we utilize a softened water system for our condenser water system. Our DCP1 cycles of concentration is between 15 to 18. At a minimum, 10 million gallons of water is saved yearly at DCP1. Over 35 million gallons of water each year helps extend water availability for current and future needs.

## 7 WORKPLACE SAFETY/EMPLOYEE TRAINING

One of Austin Energy's key strategic goals is safety. Austin Energy believes that the path to zero recordable injuries is through awareness, prevention, and education. Austin Energy encourages all employees to take responsibility for the safety of themselves and others, by creating a safe work environment and supporting the safe delivery of energy services. Each employee has access to the Austin Energy Safety Manual. This manual provides information and the requirements necessary to safely perform work. All employees are required to review the manual and abide by the guidelines and requirements detailed within. Each month, the occupational, health and safety department facilitates company-wide safety meetings with both in-person and virtual presentations. The meetings cover topics such as changes in safety standards, worksite safety and regulations, safety milestones and health safety in the workplace. Throughout the year, to ensure employees are up to date on safety, the safety department has online and in-person training awareness classes that employees can or are required to take depending on their job roles and duties. In the last two years, Austin Energy downtown DEC has not had a recordable injury. This is due to Austin Energy's safety policies and philosophy to make sure everyone arrives safely to work and home again every day.

## 8 CUSTOMER RELATIONS STRATEGY

Austin Energy uses multiple communications channels to communicate with customers including [Austin Utilities Now](#), a monthly newsletter about all city services. Additionally, the utility regularly interacts with customers on social media, works closely with media partners to tell our story and get vital information to customers. We also use text alerts for those customers signed up for power outage information and use emails to communicate with customers who have signed up for that service.

### 8.1 Social Goals Matrix

Austin Energy downtown DEC receives social goals from the City Council. Austin Energy then leverages the AA bond rating to create a business model by constructing chiller plants that provide thermal energy and

cooling. Chilled water customers through fees and charges over long term service agreements provide revenue back to Austin Energy. This revenue provides the return on the capital employed. Financially, the program is self-sustaining: money out - money in. As a dividend, the Council's social goals are met. See Figure 2 below for a graphical representation.

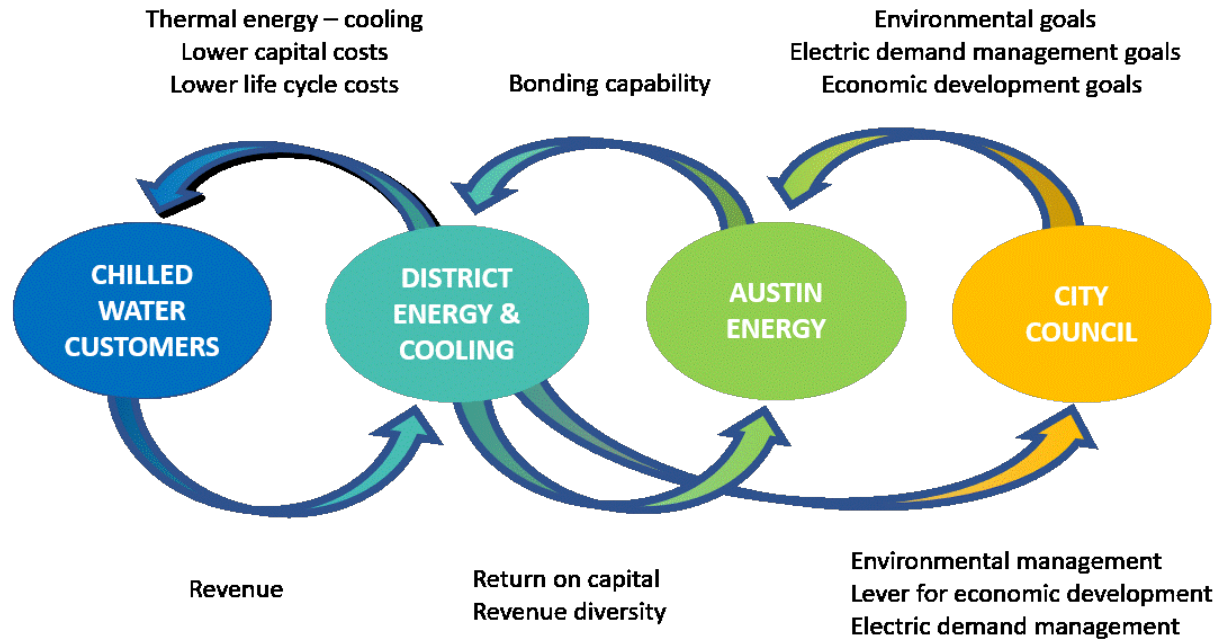


Figure 2: District Cooling Value Chain

## 9 COMMUNITY INVOLVEMENT

Austin Energy's mission is to safely deliver clean, affordable, reliable energy and excellent customer service. Austin Energy's vision is powering a cleaner, brighter future with customer-driven, community-focused solutions. We believe community involvement is paramount to achieving our mission and our vision for today and in the future.

Austin Energy values align with the city of Austin's PRIDE values: Public service and engagement, Responsibility and accountability, Innovation and sustainability, Diversity and inclusion, Ethics, and integrity. A few of our strategic goals:

- Strive to make it easy to do business with Austin Energy while delivering valuable services and solutions for an exceptional customer experience.
- Diverse and results focused workforce creating a culture of inclusion, development, and engagement.
- Sustainably meet our customers' energy needs and lead our community to net-zero carbon.
- Commit to enhancing the health and safety of ourselves and our community.



## 9.1 Community Outreach

Austin Energy also does a significant amount of community outreach and involvement around building new cooling plants. The utility routinely works with neighbors for many years before even breaking ground, and then has architects build in design features to reduce noise and redirect air flow. Austin Energy works to build good relationships during construction, so neighbors feel positively about Austin Energy and the plant once it is up and running. We intentionally work on informing and educating nearby neighbors and local associations.

Austin Energy downtown DEC hosts tours throughout the year. Tour attendees have ranged from community leaders, IDEA members, our chilled water customers, college students, elementary school kids, to other businesses who want to learn how we distribute chilled water. We readily share our knowledge of lessons learned through construction and plant operations. Sharing of expertise allows for growth and an increase in understanding and fellowship of our local community and the community of district cooling plant engineers, operations and management personnel.

## 9.2 Awards

Austin Energy downtown DEC has been nominated and received various awards.

- 2021 – Nominated for the AIA Austin design award for District Cooling Plant 3 from a member of the Downtown Austin neighborhood Association
- 2020 – Finalist for the Evoqua Water Sustainability Award. Nominated by an Evoqua employee
- 2020 – ENR Texas & Louisiana Award of Merit in Energy/Industrial for DCP4. Submission by Stanley Consultants, Inc.

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