Atmospheric Water Generators

Demand Response Evaluation of Two Dehumidification Drinking Water Systems

DR18SDGE0001

Prepared for:

Emerging Technologies Program
Customer Programs & Services
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Acknowledgements

San Diego Gas & Electric's (SDG&E's) Emerging Technologies Program is responsible for this project. It was developed as part of SDG&E's Emerging Technologies Program under internal project number DR18SDGE0001. The Energy Smiths conducted this technology evaluation with overall guidance and management from Jeff Barnes. For more information on this project, contact ETinfo@sdge.com.

Disclaimer

EXECUTIVE SUMMARY

The Emerging Technologies Program at SDG&E chose The Energy Smiths to evaluate the electrical load and demand response capabilities of two (2) types of Atmospheric Water Generators, also known as dehumidification drinking water systems. These systems both generate drinking water by dehumidifying the air surrounding the unit. They also chill the water, and one of the units has a water heating capability as well. The units selected are the Skywell 5T and Drinkable Air Chameleon 8. Both units have Wi-Fi connectivity that was designed to be used for conducting demand response event load shedding. Each unit has water and air filters that need to be serviced and/or replaced once every six months or so.

The primary purposes of this evaluation were to:

1. Determine the load profile, baseline energy use and peak demand of the units.

2. Determine the available peak load reduction of the units for a demand response event. Multiple reduction strategies may be analyzed, including but not limited to turning the unit off or adjusting the water delivery temperature set points.

Also covered in the project scope was a water testing component. The purpose was to take water samples to an independent laboratory and run a panel of tests to compare the water quality to that of the local city's drinking water, and ensure the water was safe to consume.

The rollout of this project was severely impacted by the Covid-19 pandemic. There were ten (10) units placed throughout San Diego County at various types of businesses for use and evaluation. When the pandemic struck and lockdown happened, nearly all these businesses closed their doors to in office work. The pandemic shutdown stopped the evaluation of these water generators for almost two years. This produced several challenges for the evaluation. First, none of the units were connected to the internet anymore. The Skywell unit requires a trained technician to work through the onboard computer and set up a Wi-Fi connection. The Energy Smiths were unable to get a response from Skywell to send out a technician and reset these machines. The Drinkable Air units utilize a third-party device that is attached to the water generator in order to connect to Wi-Fi. The Energy Smiths had instructions for connecting the units directly, but we were unable to do so after the year plus of non-operation. Many attempts were made to work with the third-party vendor (Skycentrics) to assist with the connectivity issues, and they did ultimately respond, but they too were unable to get the units to connect to Wi-Fi. Without a Wi-Fi connection, the demand response tests were not able to be conducted. Instead, The Energy Smiths can evaluate the baseline data and make assumptions such as this is a non-essential load that can be completely shut down during a demand response event. Therefore, the baseline load becomes the emergency energy shed.

Other challenges and findings include water tests with a Nitrate failure, heat and noise byproduct, need for humid environment, data logging equipment removed/stolen, and mechanical unit failures. Reporting charts for the water tests will be provided in later sections of this report. To summarize, all 10 units plus City of San Diego tap water, City of Escondido tap water, and water from a purewater water cooler from SDG&E's Century Park business office were tested for a variety of metals and biologicals. There were two (2) Drinkable Air units that failed the Nitrate test. The allowable amount was 0.05 and two of these water generation units posted a score of over 10.0. The water laboratory suggested

that high Nitrate levels can cause birth defects in pregnant women, so those 2 units were pulled from the test sites.

An interesting observation is the amount of noise and heat produced by the water generators. They produce far more noise and heat than a traditional water cooler. So much so, it is not advised to place a machine near cubicles or offices. They are much better suited for a break room, warehouse, cafeteria, etc., where staff won't be bothered by these byproducts.

Atmospheric generators work by dehumidifying the ambient air and separating the water molecules from the air for filtration and producing potable water. This means the machines operate more efficiently and can produce water more quickly in a humid environment. The study found that even though the office spaces tested maintained about a 55% relative humidity level, they could not keep up with demand for water.

The following chart demonstrates the baseline data gathered and presented as an average. Since the demand response tests were not able to be conducted and these devices don't provide critical services to the buildings, the baseline energy consumption and peak demand are considered to be the potential reduction as well. The machines can simply be programmed to shut down for a demand response event as long as it does not last for four hours or more. Any shut down of more than four hours causes a need for special cleaning and filter replacement to prevent contamination.

TABLE-ES 1. SUMMARY OF ENERGY SAVINGS AND DEMAND REDUCTION

	ANNUAL ENERGY CONSUMPTION (KWH/YR)	ANNUAL ENERGY SAVINGS (KWH/YR)	PEAK DEMAND (KW)	PEAK DEMAND REDUCTION (KW)
Baseline	-	-	-	-
New Technology	1,976	-1,976	.44	-.44

Project Recommendations

The overall recommendation is this technology does produce water as advertised, but it costs far more in energy costs than having water delivered and cooled or permanently plumbed in standard water coolers. Due to Covid-19, we were unable to successfully test any of these water coolers in a demand response situation. The machines lost the ability to connect to the internet due to outdated software and the inability to communicate with the manufacturers. One manufacturer tried to assist, but the software platform was no longer supported. The other manufacturer failed to return myriad of emails and phone calls. For these reasons, we cannot recommend the atmospheric water generators, however the technology is available for demand response capability, it was just not ready for market at this time.

After speaking with site contacts, the overall reception of the machines was positive. People love the idea of making water from air. However, it was noted that the machines couldn't keep up with demand in many instances. This has to do with the fact that people tend to use the machines most early in the day and midday (lunch time). Also, people bring large water bottles to fill so they don't have to leave their desks as often for water. This taxes the machines all at once and drains reservoirs. In most cases, one machine wasn't enough to keep up with demand as it can't produce water fast enough. This means that the energy

usage we are reporting is per machine, but most likely multiple machines would be needed per floor in an office setting. This adds more electrical load than a traditional water cooler that has either a plumbed in water supply or interchangeable five-gallon water bottles to meet the needs of the space. For this reason, the atmospheric water generators aren't recommended.

These machines have several filters that are critical to their operation. These filters need regular replacing, and if they're not replaced the efficiency and production of the machines suffer. Also, the water quality can be compromised if biologicals are allowed to grow by neglecting this maintenance. The Skywell units did have a maintenance plan option, but that adds more costs to operating these machines, and once again makes them more expensive than a traditional water cooler. We did have two machines fail a water sanitation test, and this is likely due to a compromised filter. For these reasons, we can't recommend the atmospheric water generators.

ABBREVIATIONS AND ACRONYMS

DA	Drinkable Air
SW	Skywell
DR	Demand Reponse
SDG&E	San Diego Gas & Electric
AWG	Atmospheric Water Generator

CONTENTS

INTRODUCTION

The purpose of Atmospheric Water Generators (AWGs) is really following a mission to provide access to clean water in a sustainable fashion. AWGs can generate water in times of drought. AWGs can provide clean water when municipal sources are contaminated. AWGs remove the need for water transportation and single use plastic bottles. The concept of making water from air is very appealing, socially admirable, and environmentally friendly.

In the case of this project for San Diego Gas & Electric (SDG&E), combining the sustainable water production and delivery with potential demand response capabilities is the goal. Normally, we would look at similar technologies and compare their performance and energy consumption. However, there really is no other current technology that produces water in the manner, so there is nothing to compare AWGs to. In this case study, we installed AWGs from two different manufacturers for comparison. The goal was to identify energy load in terms of kilowatts (kW) that could be shed in a demand response event. Further, the test required automatic controls that would enable this demand shed.

The market segment this technology applies to is primarily commercial office space. These machines are designed to produce drinking water on a limited scale that would apply to a small office area for a few employees. While this water can be produced in this manner on a larger scale, at the time of the report we weren't aware of any such product in the market. This study placed several machines in different office spaces throughout the County of San Diego.

BACKGROUND

Atmospheric Water Generation is a new technology. The options it is replacing could be the following: people bringing their own single or multi use water bottles, five-gallon water delivery services, or directly plumbed water cooling machines. It is difficult to compare these options to AWGs. If people are bringing their own water to work, then there is zero energy being consumed at the workplace for this option. The workplace may have a water delivery service that typically brings five-gallon water containers to the workplace via truck. In this case, a carbon footprint impact could be discussed as the AWGs do away with the transportation component of the water, but they do require electricity to generate that same five gallons. The carbon footprint is within the scope of this demand response-based study, however. The delivered water containers usually are placed in a water cooler. This is the same case for plumbed water – they would typically be cooled by a machine as well. The traditional water coolers are simply plugged into the wall and cycle on and off during the day as needed to maintain chilled water.

EMERGING TECHNOLOGY/PRODUCT

The Emerging Technology is Atmospheric Water Generation. The products that were assessed in this study were from two manufacturers: Skywell and Drinkable Air. Both manufacturers utilize the same basic means to produce their end product of water.

An explanation of the physics behind this technology is relatively simple. The concept relies on the fact that our air has a certain level of humidity. Of course, the humidity levels will vary depending on outside weather conditions, but this product is being studied inside buildings with HVAC controls that keep humidity levels relatively even from day to day. The concept is to pull in the outside air (again, in this case, it is conditioned air from within an office space) and capture the water vapor in that ambient air through a dehumidification process. The ambient air is pulled into the machine through an air filter to remove contaminants and then the air is passed across cold coils. When the air is cooled, it can't hold onto the water molecules, and they are separated and dropped into a collection tank. At this point, there are several more levels of filtration that occur, and finally the water is stored in a tank ready for personal consumption. This tank is also cooled so the water poured out of the machine will be cold water.

The incumbent products are basically tap water with filtration and cooling or delivered water that has already been filtered and then placed into a machine that will cool and dispense for individual consumption. The advantages of the AWG machines are there's no need for plumbing for the machines that cool and filter tap water, or there's no longer a need for monthly service in the water delivery model. Specifically, a delivery truck can be eliminated and the inconvenience of receiving a delivery that may occur multiple times a month. Also, the AWG machines can be programmed for remote demand response, while the incumbent technology can't. Both technologies require filters that need to be maintained, so that isn't an advantage.

There's one significant market barrier we see with this product. Initial upfront cost is the largest barrier and these machines at the time they were purchased and observed cost between $4,000 and $6,500 per unit. This cost does include programming the capability of remote demand response. Simple water coolers that require either a plumbed water line and filters that need maintaining or coolers that accept the delivered water bottles can be as inexpensive as $100-$200.

ASSESSMENT OBJECTIVES

The main objective of this assessment is to identify the demand response capability of Atmospheric Water Generation machines. Since this is a new technology, we are also interested in the baseline energy consumption. Each of our units that are put out into the test sites are data logged. The objective is to capture the baseline energy consumption and also simulate a demand response event and collect the data on potential demand shed capabilities. The plan for the simulated demand response event was to have an option to shut down the machines entirely (water production and water cooling) as well as an option to allow the machines to still dispense water, but to shut down the water generation only. There's no plan to data log existing water cooling machines as most of the sites don't currently have water coolers at all, so this is deemed a new electrical load.

TECHNOLOGY/PRODUCT EVALUATION

The Atmospheric Water Generators were field tested. Two manufacturers were selected for the evaluation as there were two known options for the technology in the United States at the time. The field test is the best option for identifying demand response capability as it represents real customer usage patterns, as opposed to a calculated approach that would involve assumptions about end user patterns of usage. Together, SDG&E and The Energy Smiths reached out to several potential test sites and 10 sites accepted the offer to participate. The following sites were selected, in no particular order of importance:

- School administration building
- Restaurant and Brewery
- A business office with two locations
- The Energy Smiths office
- A millwork shop
- A laboratory and research facility
- SDG&E facilities (three sites)

These sites were selected because they would all have a consistent amount of people and usage patterns for the assessment. However, they're not all office spaces. The restaurant and brewery placed their test machine in the brewery section of the facility for its workers to use. Initially, the millwork shop placed their machine in the warehouse for its workers, and the office sites placed 1 of 2 machines in a warehouse setting as well. This way we could see if conditions or usage patterns changed drastically or not in a non-office setting. It's worth noting that it was very difficult to get customers to agree to sign the field test agreement form, and many proposed customers were unable to participate.

The Energy Smiths placed all of the units into each site and installed the data logging equipment. The Energy Smiths has over 10 years of experience with data logging-based energy efficiency and demand response consulting and evaluation. However, COVID-19 occurred in the early stages of this project and effectively killed all evaluation. This will be discussed in the upcoming sections as no evaluation beyond data logging for baseline data and lab testing water quality was able to be performed.

TECHNICAL APPROACH/TEST METHODOLOGY

FIELD TESTING OF TECHNOLOGY

- Is this a single technology or a system of technologies?
  - This is a single technology
- Provide the criteria for the site selection so that it will generate unbiased test results. This means a site where extraneous factors will not affect either test results, or where the assessor can control those extraneous factors.
  - The site selection criteria were centered around non-residential entities that would have employees who could be offered to use these water dispensing devices. The devices themselves must be used indoors, but warehouse settings are ok as well. We chose a combination of office space, warehouse, and a school administration building. These are all locations with people that would be likely to drink water or fill water bottles.
- Describe the system in the field where the technology/product is installed and tested. If this system contains multiple devices, describe each one including: its operation, function, and how it may affect the overall results.
  - This question really does not apply. The AWG devices simply need an outlet to plug into. They are stand alone devices and do not need any systems to function. However, in order to be activated for automated demand response, they did require access to Wi-Fi connection.
- Describe the existing and/or incumbent technology/product in the test site
  - The existing technology is basic water-cooling towers. Some are directly plumbed and some use five-gallon water containers that are delivered by truck. These systems aren't smart and can't be programmed for demand response.
- Describe the change out of the incumbent technology/product and replaced with the new technology/product.
  - There was no change out of the incumbent technology. The old water coolers remained in place, and people had the choice to use the existing or the new water dispensers. As we will get to in the results, this was needed as the AWG machines couldn't keep up with demand.
- Describe how the system is being controlled
  - There is no control for basic functions such as generating water and dispensing it. The only controls were for automated demand response. These controls included specialized software that was embedded in the Skywell unit and attached as an external device to the Drinkable Air unit. In the end, neither of these technologies were able to work properly.
- Provide a schematic diagram of the system with the location of the technology/product being tested
  - N/A
- Identify the locations where the measurements are being monitored

- The following are the locations selected. The full addresses were provided to SDG&E as an attachment to this report.
- School administration building
- Restaurant and Brewery
- Three offices
- A millwork shop
- A Research and laboratory facility
- Three SDG&E facilities

The baseline data was simply collected by data loggers. Each machine had its own logger. Each machine operates independently and there are no other systems that can control or influence the operation. Eventually the data was organized in a fashion to follow the protocols for 10 in 10 evaluation.

TEST PLAN

Describe how the testing between the baseline performance of the incumbent technology/product and new technology/product will be a fair comparison. Example, the existing lamps and ballasts will be replaced with new lamps and ballasts so that both technologies meet the original specifications. For HVAC equipment, the baseline must be the equipment with the refrigerant correctly charged, coils are cleaned, and filters are replaced.

There is no comparison between the baseline performance of the incumbent technology and the new technology. The simple reason is that these machines do not produce enough water and a rapid enough rate to meet the water dispensing demands of any of our test clients. Combine that with the extreme high cost of the machine relative to a simple water cooler and there is zero expectation of the AWG machine to be able to replace the existing water coolers. Further, this is a very different and new technology that does not compare to anything in place at this time. This is very much an added energy load.

Describe how to monitor the energy input and output of both technologies. If the incumbent technology/product has been replaced by the new technology in the field, what procedure is used to establish the performance of the incumbent technology?

Again, this question really is not relevant. Standard data logging was used on the Atmospheric Water Generation machines. We have plotted kW and air temperature on an hourly basis. Data was collected every 60 seconds.

Identify all the variables that will provide the output performance of each technology/product and power input to the technology/product so that the efficiency of the technology/product can be determined.

The variables that can impact the performance of these machines are only related water production. These variables are ambient air temperature and humidity levels. It seems the machines require greater than 25% humidity and the Drinkable Air machine claims it needs to be operating between 69 and 100 degrees Fahrenheit. The current version of the Skywell machine states an operating temperature range of 37 – 201 degrees Fahrenheit.

Identify the locations of all the variables on the schematic diagram presented in the earlier section showing the sensors locations.

N/A

Specify the monitoring periods for both incumbent and new technologies in order to establish the energy savings and demand reduction load profile for the work paper. Specify the IPMVP requirements. State how the monitoring period meets or exceeds the International Performance Monitoring and Verification Protocol for Technology Assessment.

Since the monitoring of the new technology is completely isolated for all other systems, the IPMVP requirements are met. Again, this is a new technology and it does not replace any incumbent technology so there is no technology comparison. We are logging for baseline energy use and offering that as a potential shed for automated demand response. There are no energy conservation measures in this study.

Specify the test standard used in the testing of the technologies. For example, ARI Standard 210/240 is used to test unitary air-conditioning and air source heat pump equipment. Provide the reference to the test standard (so that the source may be verified independently)

The testing is based on 10-10 baseline standards. The charts and analysis will be provided in a later section.

Specify how often the data are downloaded from the instrument. This depends on the storage capacity, number of data points, size of the data, and the frequency of measurements.

The Data is downloaded at 1 minute intervals 24/7.

INSTRUMENTATION PLAN

The data instrumentation plan is very simple for this assessment. The only variables we are monitoring are temperature and relative humidity. Then we monitor performance based on energy consumption. The goal is to determine kW that can be

claimed for an automated demand response event. For this, the instruments used are the data loggers from Onset Corporation. The power was monitored by brand new loggers model number UX120-018. These were purchased on 7/17/2018 and factory calibrated to within 0.5% accuracy. These loggers were used to collect: Volts, Amps, W, Watt hours, power factor. The data loggers used for collecting temperature and relative humidity are also Onset brand, model number HOBO U12-013. The accuracy level regarding temperature data is 0.63 degrees Fahrenheit. The accuracy level regarding relative humidity is + or – 2.5%. Each AWG machine was fitted with both of these loggers. The UX120 is plugged directly into the water machine. The temperature logger was placed nearby where it would not be affected by the heat produced by the machine itself.

The data was collected in 60 second intervals. Since the evaluation plan was to use the 10-10 Baseline strategy for identifying potential demand response capabilities, we collected data for several months and selected two sets of 10 day increments in different months to demonstrate the expected baseline energy consumption.

Finally, the water quality was also tested to ensure clean and safe water was actually being produced. For this, a local laboratory was contracted to perform a series of standard water quality tests. The lab selected was EnviorMatrix Analytical, Inc. The samples were analyzed using EPA and/or ELAP approved methodologies. The following are the categories and specific items that were tested for:

- Metals
    - Calcium
    - Copper
    - Iron
    - Magnesium
    - Lead
- Conventional Chemistry Parameters by Standard/EPA Methods
    - Hardness
    - Nitrate
    - pH
- Microbiological Parameters by Standard Methods
    - Total Coliforms
    - E. Coli

RESULTS

Unfortunately, the desired automated demand response testing was never able to be performed. The details of why will be covered in the Discussion section following the results. The only two tests/results that are available to report are the energy consumption baseline using the 10-10 Baseline strategy and the water quality reports (lab generated). The 10-10 Baseline summary findings are as follows (page break):

Atmospheric Water Generators: Drinkable Air and Skywell 10-10 Baselines

The purpose of the study and charts is to show the equipment (customer) peak load reduction options for Drinkable Air and Skywell atmospherics water generators. The following charts are the projected 10-10 baselines for the hourly estimates of what the logged equipment load would have been on the day of the demand reduction (DR) event without taking any DR actions.

Each chart was made following the 10-10 Baseline standards as defined by the CPUC:

- Baselines are based on the hourly average of 10 days of energy use
- The consecutive 10 days only include Monday through Friday, excluding holidays

Each chart follows the same format:

- Two curves, one with kW demand and a second one to show the average Outside Air Temperature (OAT) dry bulb (DB).
- The common X-axis shows the hour ending (HE) over one day (24 hrs.)
- All data utilized was collected with data loggers measuring every 1-min followed by calculating the corresponding hourly average demand (kW) and OAT for that 1-hour interval.
- Ten energy usage and corresponding temperature days are selected, the hourly averages of these 10 values are averaged to determine the baselines

The following is the list of all Baselines included in this report:

Drinkable Air Millwork Shop 10 – 10 Baseline August:

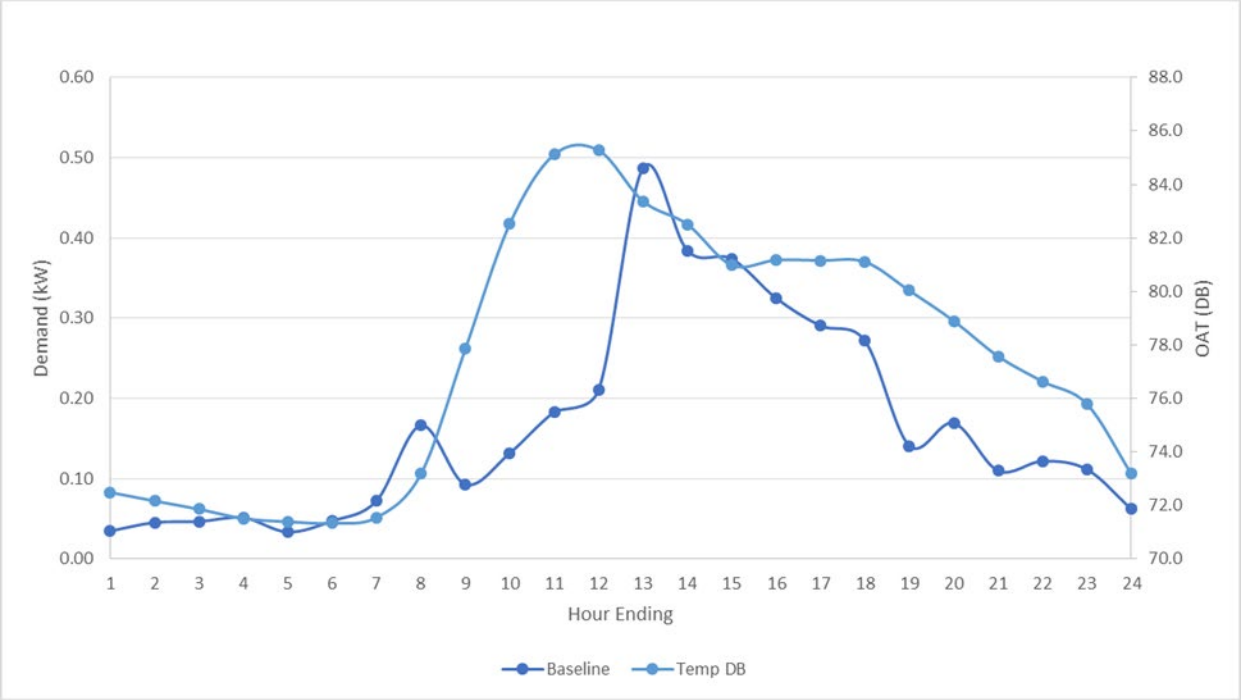

FIGURE 1: DRINKABLE AIR 10-10 BASELINE AUGUST 8TH TO 21ST

Drinkable Air Millwork Shop 10 – 10 Baseline:

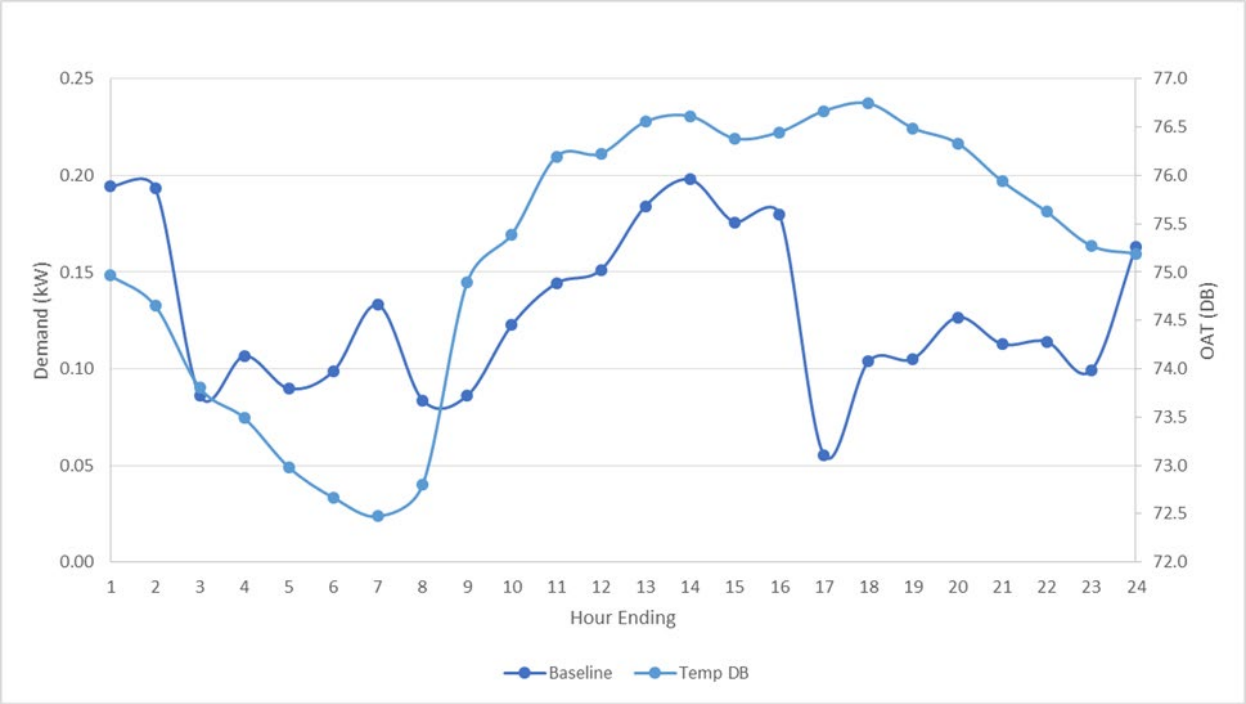

FIGURE 2: DRINKABLE AIR 10-10 BASELINE OCTOBER 15TH TO 28TH

Office Site Skywell August 10 – 10 Baseline:

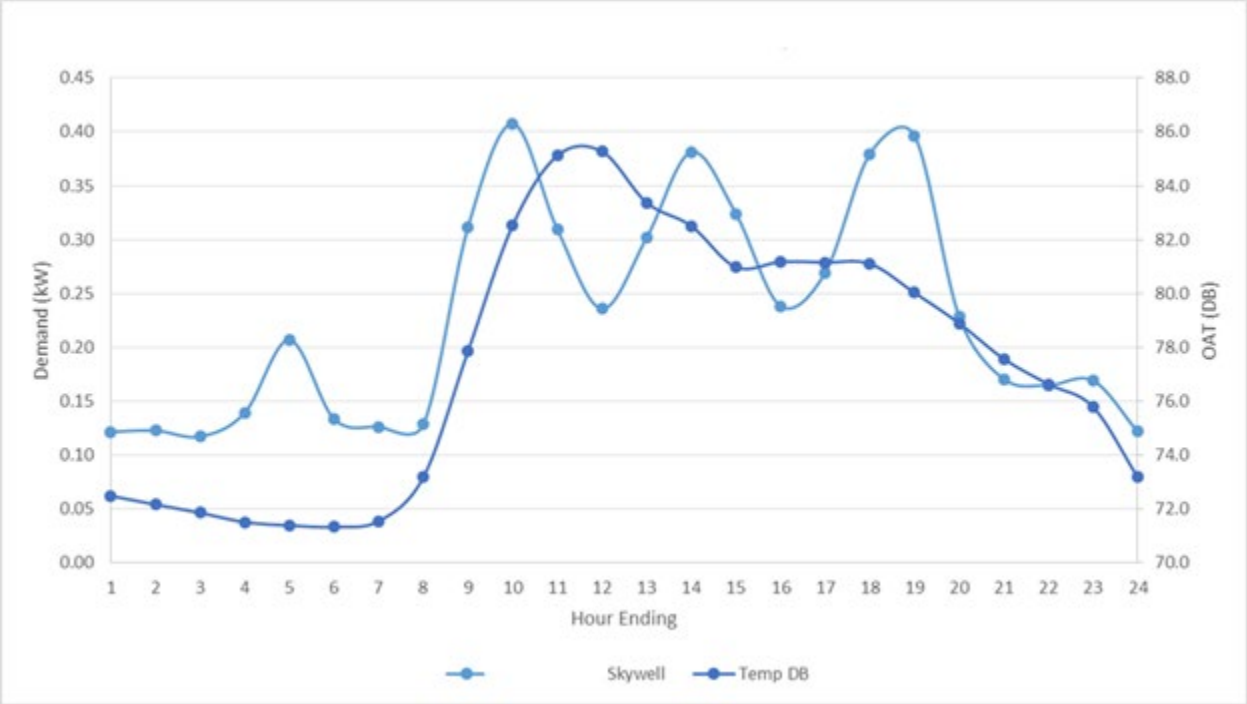

FIGURE 3: OFFICE SITE SKYWELL 10-10 BASELINE AUGUST 8TH TO 21ST

Office Site Skywell October 10 – 10 Baseline:

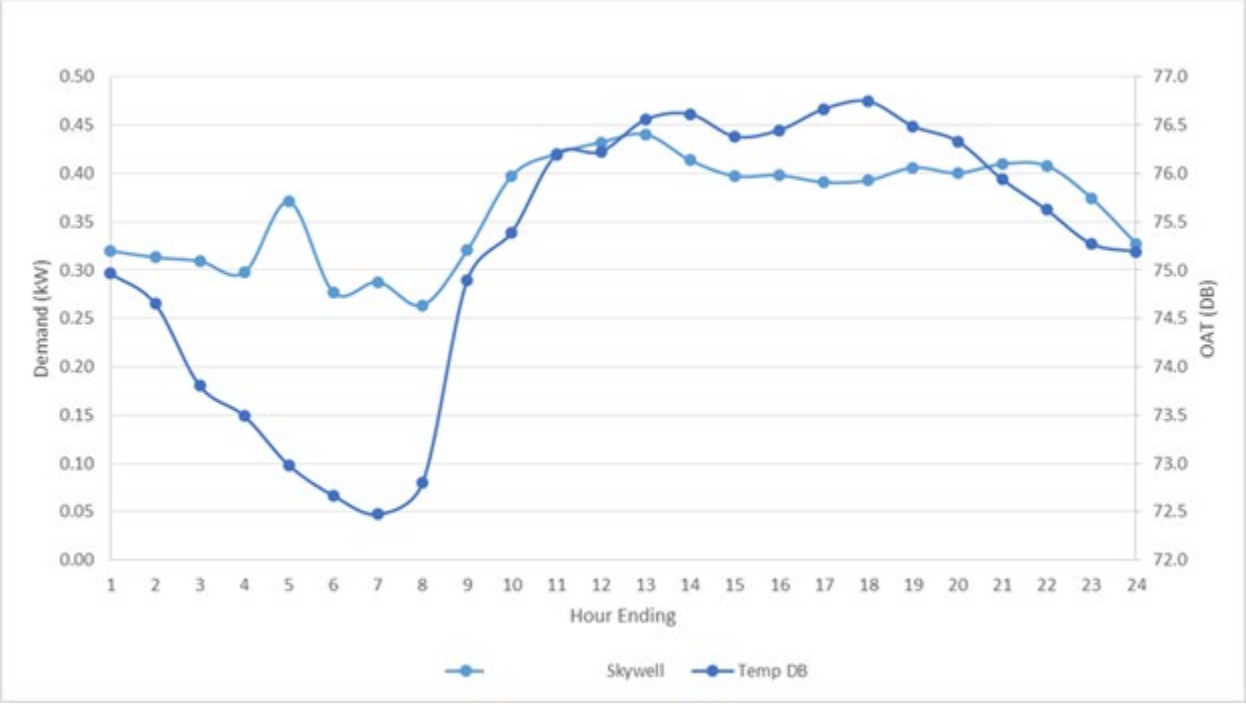

FIGURE 4: OFFICE SITE SKYWELL 10-10 BASELINE OCTOBER 15TH TO 28TH

SDGE Facility Skywell August 10 – 10 Baseline:

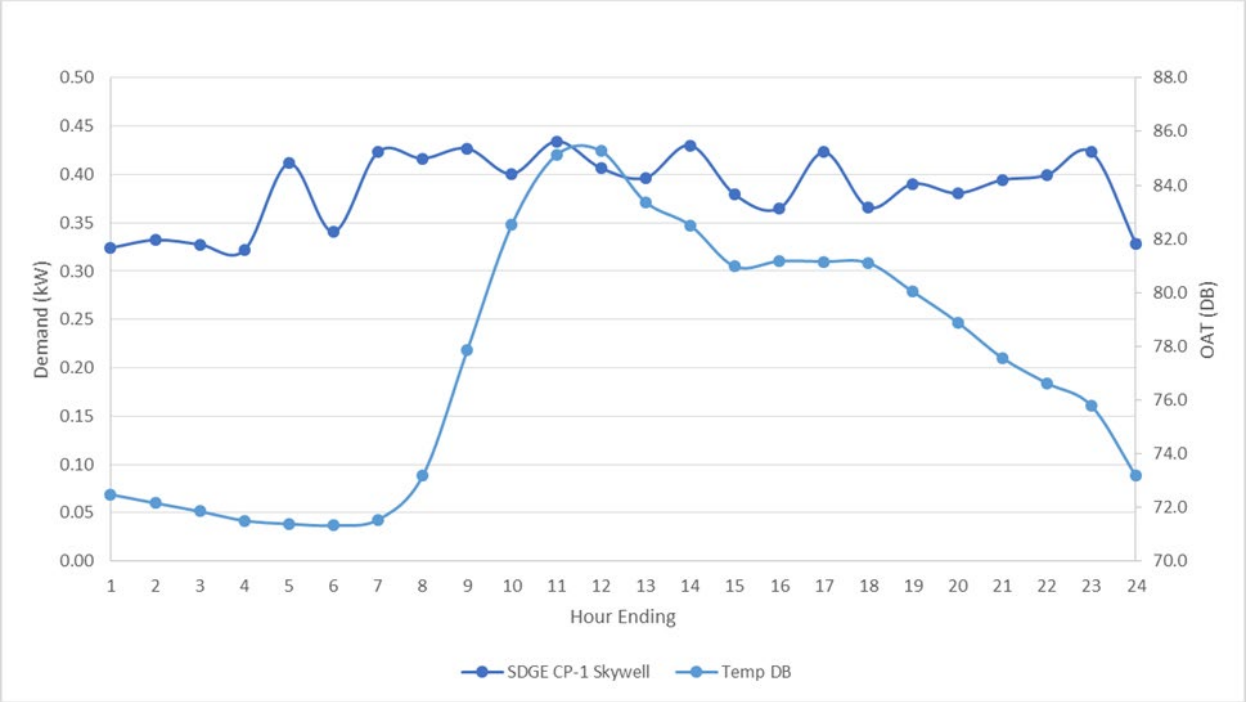

FIGURE 5: SDGE CP-1 SKYWELL 10-10 BASELINE AUGUST 8TH TO 21ST

SDGE Facility Skywell October 10 – 10 Baseline:

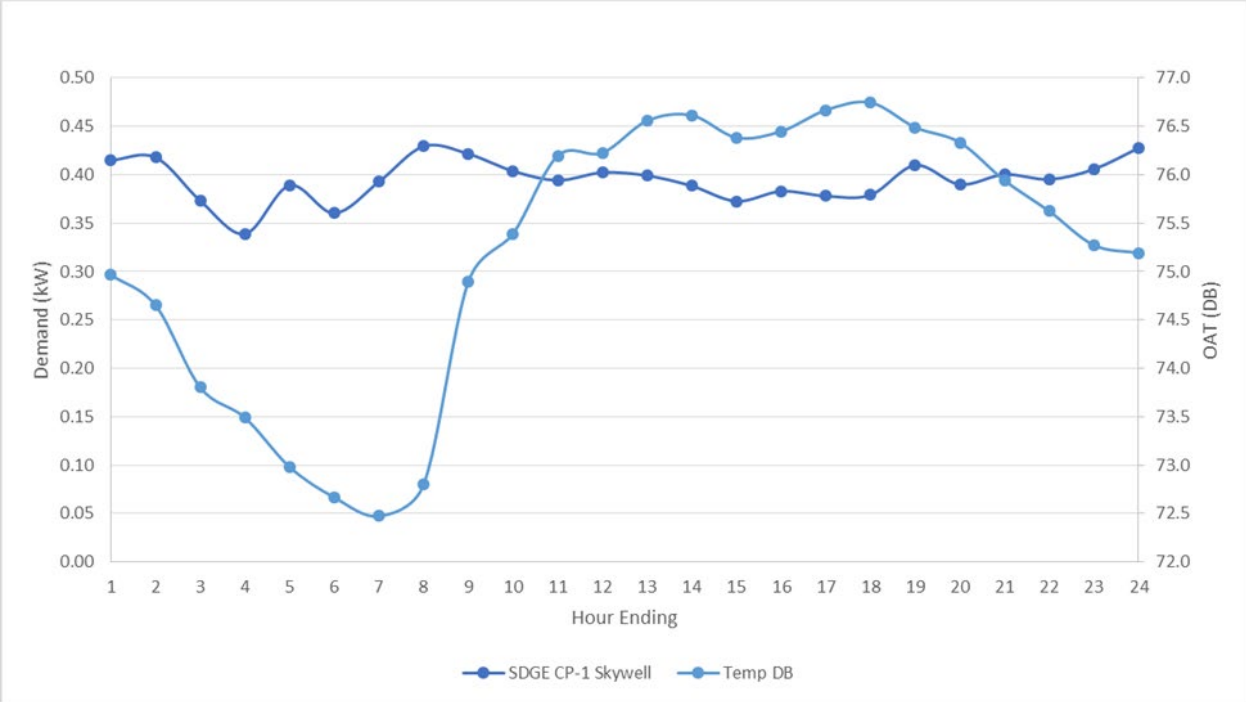

FIGURE 6: SDGE FACILITY SKYWELL 10-10 BASELINE OCTOBER 15TH TO 28TH

School Admin Bldg Skywell August 10 – 10 Baseline:

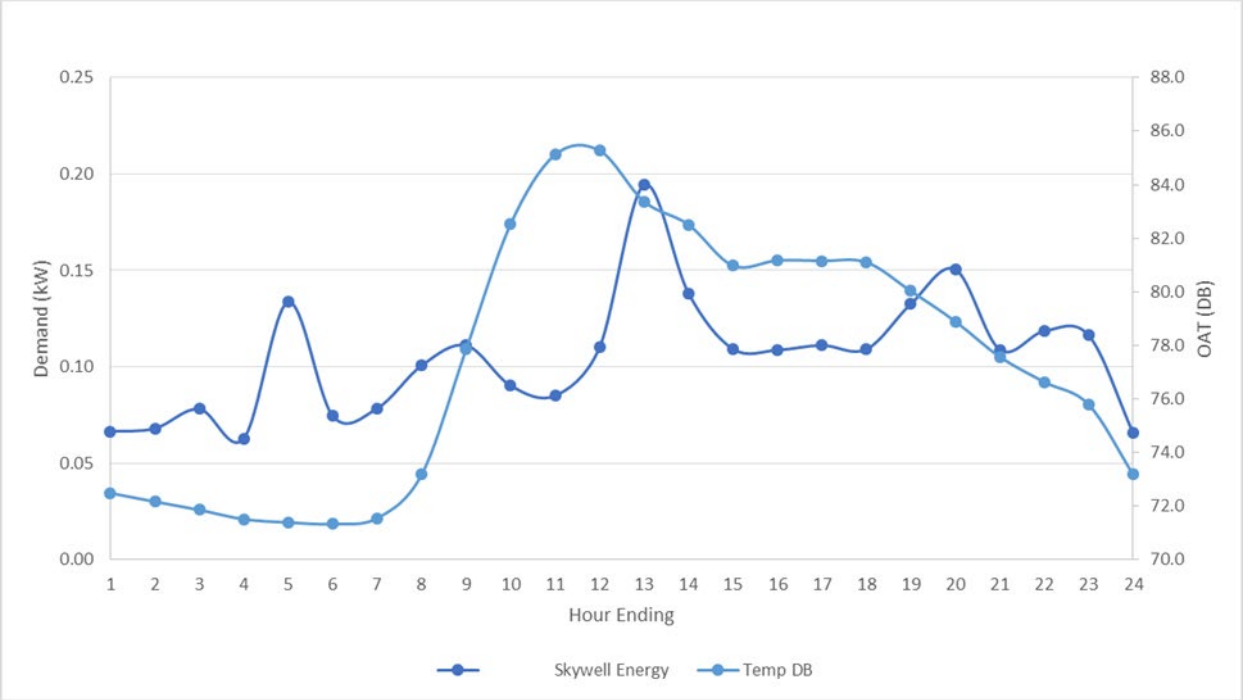

FIGURE 7: SCHOOL ADMIN BLDG SKYWELL 10-10 BASELINE AUGUST 8TH TO 21ST

School Admin Bldg Skywell October 10 – 10 Baseline:

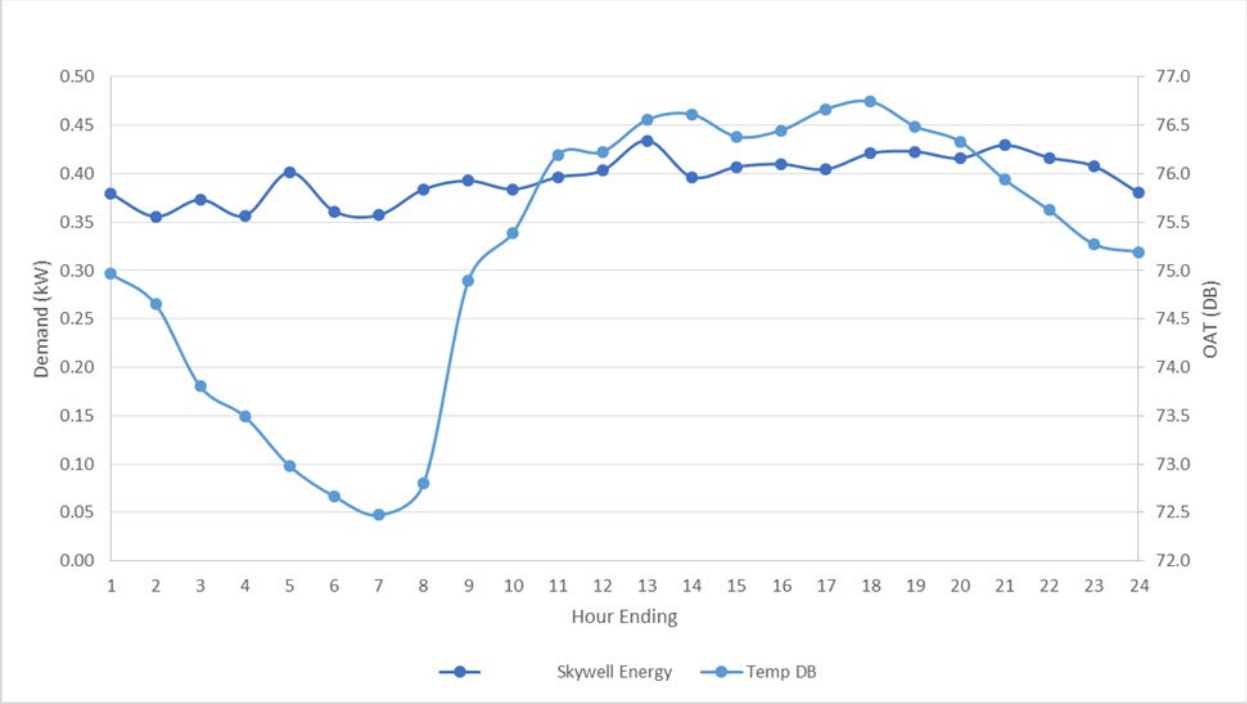

FIGURE 8: SCHOOL ADMIN BLDG SKYWELL 10-10 BASELINE OCTOBER 15TH TO 28TH

The Energy Smiths Office Skywell August 10 – 10 Baseline:

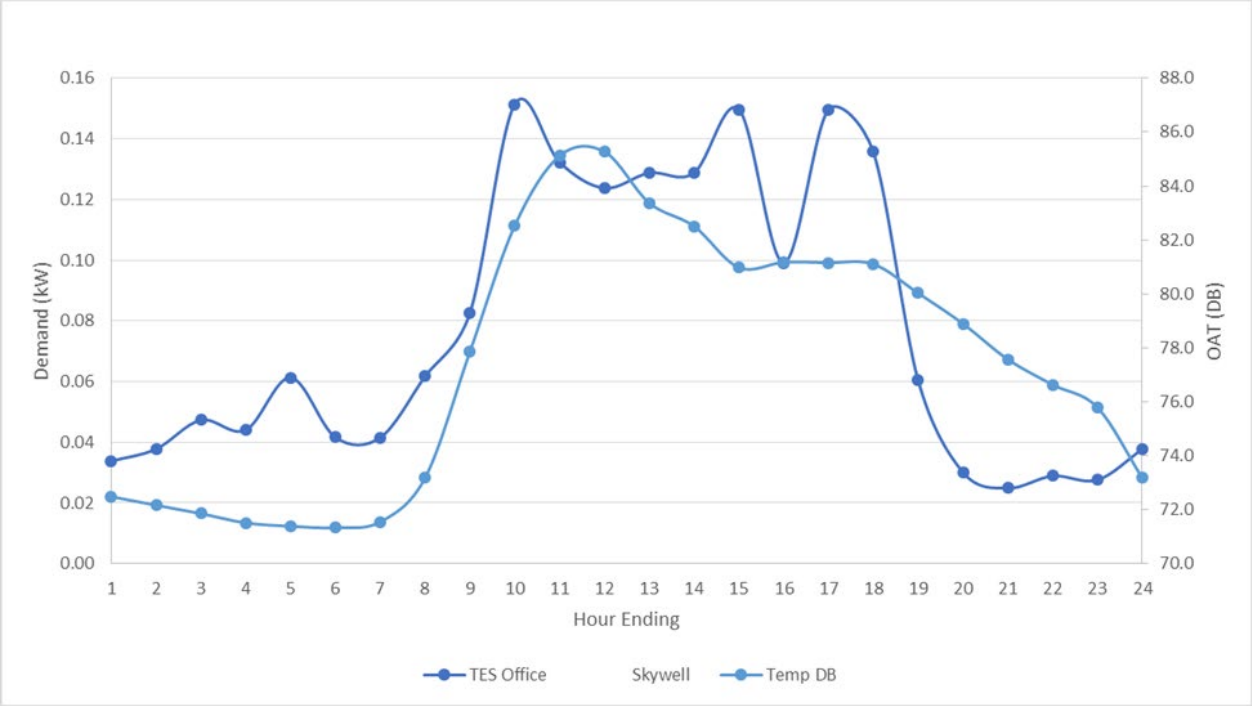

FIGURE 9: THE ENERGY SMITHS OFFICE SKYWELL 10-10 BASELINE AUGUST 8TH TO 21ST

The Energy Smiths Office Skywell October 10 – 10 Baseline:

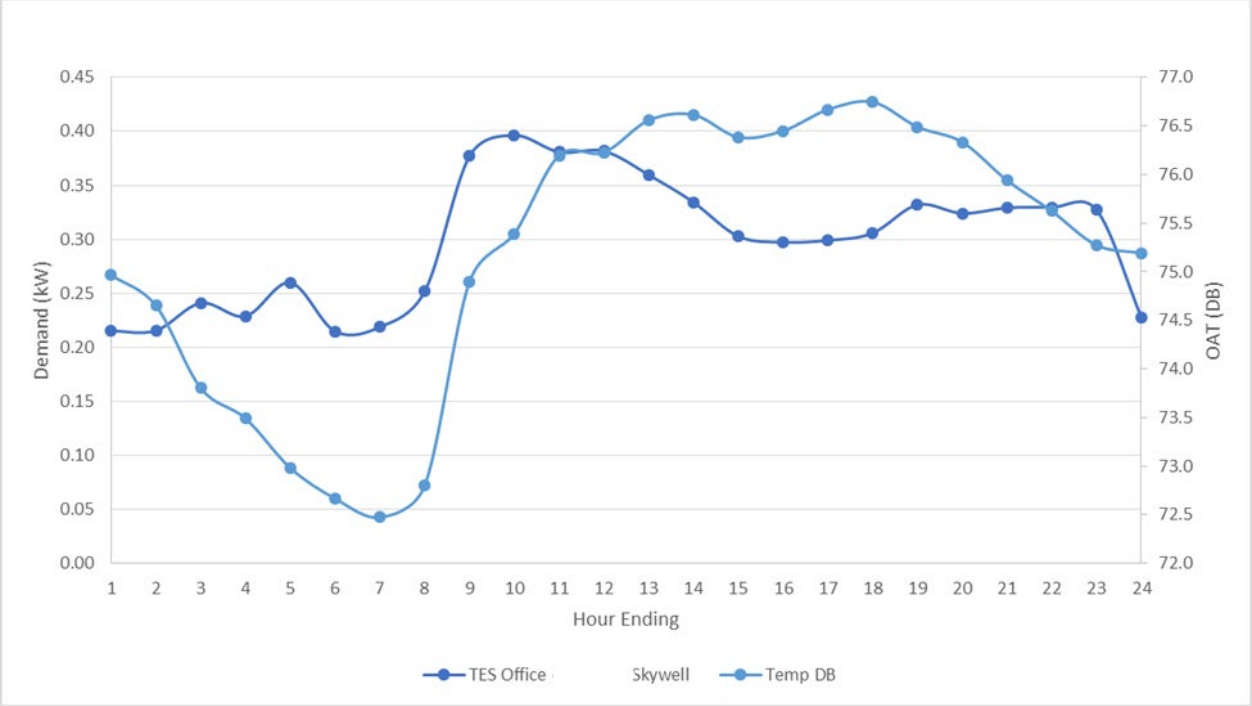

FIGURE 10: THE ENERGY SMITHS OFFICE SKYWELL 10-10 BASELINE OCTOBER 15TH TO 28TH

Water Quality Test Results:

The following are a series of charts summarizing all of the test results for the water quality. We tested San Diego and Escondido Tap water just as a comparison to what people could be drinking if they do not use an AWG or some other water source such as bottled water. Finally, the entry for SDG&E Pure Water Filter is a water sample taken from the water filter and cooling station that is plumbed in at the SDG&E Building 1 office.

Site Summary and Chart Legend

Brand of AWG	Site List	Site ID
Tap	City San Diego Tap	1
Purewater	SDG&E Pure Water Filter	2
Skywell	SDG&E Cafeteria	3
Skywell	SDG&E Bldg 1	4
Drinkable Air	Restaurant & Brewery	5
Skywell	Office site	6
Drinkable Air	The Energy Smiths office	7
Drinkable Air	Warehouse	8
Skywell	School admin bldg	9
Drinkable Air	Millwork shop	10
Drinkable Air	SDG&E EIC	11
Tap	Escondido Tap	12
Skywell	Research & lab facility	13

Metals Test in Mg/L

Brand of AWG	Site ID	Calcium (Ca)	Reporting Limit (Ca)	Copper (Cu)	Reporting Limit (Cu)
Tap	1	32.6	.5	.046	.01
Purewater	2	1.04	.5	Not Detected	.01
Skywell	3	Not Detected	.5	.02	.01
Skywell	4	Not Detected	.5	.011	.01
Drinkable Air	5	15	.5	Not Detected	.01
Skywell	6	.81	.5	Not Detected	.01
Drinkable Air	7	34.6	.5	Not Detected	.01
Drinkable Air	8	40.8	.5	Not Detected	.01
Skywell	9	Not Detected	.5	Not Detected	.01
Drinkable Air	10	39.5	.5	Not Detected	.01
Drinkable Air	11	23.4	.5	Not Detected	.01
Tap	12	28.6	.5	.102	.01
Skywell	13	Not Detected	.5	Not Detected	.01

Metals Test in Mg/L (Continued)

Brand of AWG	Site ID	Iron (Fe)	Reporting Limit (Fe)	Magnesium (Mg)	Reporting Limit (Mg)
Tap	1	Not Detected	.05	15.2	.5
Purewater	2	Not Detected	.05	Not Detected	.5
Skywell	3	Not Detected	.05	Not Detected	.5
Skywell	4	Not Detected	.05	Not Detected	.5
Drinkable Air	5	Not Detected	.05	Not Detected	.5
Skywell	6	Not Detected	.05	Not Detected	.5
Drinkable Air	7	Not Detected	.05	Not Detected	.5
Drinkable Air	8	Not Detected	.05	.918	.5
Skywell	9	Not Detected	.05	Not Detected	.5
Drinkable Air	10	Not Detected	.05	.541	.5
Drinkable Air	11	Not Detected	.05	Not Detected	.5
Tap	12	Not Detected	.05	13.1	.5
Skywell	13	Not Detected	.05	Not Detected	.5

Metals Test in Mg/L (Continued)

Brand of AWG	Site ID	Lead (Pb)	Reporting Limit (Pb)
Tap	1	Not Detected	.005
Purewater	2	Not Detected	.005
Skywell	3	Not Detected	.005
Skywell	4	Not Detected	.005
Drinkable Air	5	Not Detected	.005
Skywell	6	Not Detected	.005
Drinkable Air	7	Not Detected	.005
Drinkable Air	8	Not Detected	.005
Skywell	9	Not Detected	.005
Drinkable Air	10	Not Detected	.005
Drinkable Air	11	Not Detected	.005
Tap	12	Not Detected	.005
Skywell	13	Not Detected	.005

Conventional Chemistry Parameters by Standard/EPA Methods

Brand of AWG	Site ID	Hardness (mgCaCo3/L)	Reporting Limit (MgCaCo3/L)	Nitrate (mg/L)	Reporting Limit (Mg/L)
Tap	1	144	10	.2	.5
Purewater	2	Not Detected	10	.24	.5
Skywell	3	Not Detected	10	Not Detected	.5
Skywell	4	Not Detected	10	Not Detected	.5
Drinkable Air	5	38	10	Not Detected	.5
Skywell	6	Not Detected	10	Not Detected	.5
Drinkable Air	7	88	10	Not Detected	.5
Drinkable Air	8	106	10	10.6	.5
Skywell	9	Not Detected	10	Not Detected	.5
Drinkable Air	10	101	10	11.1	.5
Drinkable Air	11	59	10	.1	.5
Tap	12	126	10	.29	.5
Skywell	13	Not Detected	10	Not Detected	.5

Conventional Chemistry Parameters by Standard/EPA Methods (Continued)

Brand of AWG	Site ID	pH at 25 deg C	Reporting Limit (pH)
Tap	1	7.91	.1
Purewater	2	6.95	.1
Skywell	3	6.45	.1
Skywell	4	6.4	.1
Drinkable Air	5	7.21	.1
Skywell	6	6.92	.1
Drinkable Air	7	7.1	.1
Drinkable Air	8	7.35	.1
Skywell	9	7.27	.1
Drinkable Air	10	7.22	.1
Drinkable Air	11	7.38	.1
Tap	12	7.63	.1
Skywell	13	7.69	.1

Microbiological Parameters by Standard Methods

Brand of AWG	Site ID	Total Coliform	E.Coli
Tap	1	Absent	Absent
Purewater	2	Absent	Absent
Skywell	3	Absent	Absent
Skywell	4	Absent	Absent
Drinkable Air	5	Absent	Absent
Skywell	6	Absent	Absent
Drinkable Air	7	Absent	Absent
Drinkable Air	8	Absent	Absent
Skywell	9	Absent	Absent
Drinkable Air	10	Absent	Absent
Drinkable Air	11	Absent	Absent
Tap	12	Absent	Absent
Skywell	13	Absent	Absent

Data Analysis

The first item to point out in the data analysis of the Skywell and Drinkable Air Atmospheric Water Generation Assessment is that we were only able to collect usable data on five out of the 10 sites. The reasons are many. One of the businesses selected closed their office that hosted one of our machines. One of the Drinkable Air machines malfunctioned and started dispensing water constantly, so it was taken out of service. Two of the machines failed the Nitrates water quality test, and the test facility informed us that high levels of nitrates such as those that showed up in the test were dangerous to pregnant women or women who might become pregnant so these two Drinkable Air machines were taken out of service. Finally, data loggers were lost or stolen at a couple of sites. The Energy Smiths managed to shuffle the machines around to the clients that were the safest and most interested in the machines. So the 10-10 Baseline Analysis was used for the machines that eventually resided at the following locations:

- Millworking shop (Office)
- School administration building
- Office site
- SDG&E facility (Office)
- The Energy Smiths (Office)

When we look at the data, we can note only a few things. The temperature kept a very strict range of less than three degrees with only one exception. The temperature was about 10%-12% higher at the school administration building site during August. However, the energy demand really was not affected. We believe that this is due to the fact school wasn't in session during those weeks in August, but the office staff was full time employed. The air conditioning schedule simply had not been modified for the employees working in the office. Their consumption of water was consistent, and the Skywell machine was operating at the

higher limits of its range consistently as well because it was struggling to keep up with the water demand by the office staff.

The energy consumption patterns show us the machines generally consume an idle mode and a high production mode. The idle mode consumes approximately .10 kW to .25 kW, whereas the high production mode consumes approximately .35kW -.42kW. These numbers are averaged over the course of an hour (creating an hourly averaged demand). Once again, all weekends and holidays were omitted and the data represents 10 consecutive days following those rules.

The energy consumption doesn't change drastically. When you look at the sites individually, they may have different usage/consumption patterns, but the energy demand doesn't change in a significant way. These machines are relatively small consumers so the low end of consumption being near the .10kW mark in August, and the high end average being near the .35kW mark in August isn't a significant impact on demand at any given facility. In other words, this level of demand reduction pales in comparison to large systems such as HVAC or even lighting. The overview of October shows us the demand never really went down for most of the sites. The demand hovered around the .35-.40kW mark the entire 10 days. Again, this is a relatively low demand when considering inclusion for demand response events. However, October showed a consistent demand that would be appealing for this purpose.

Once again, the actual testing for simulated auto demand response wasn't able to be conducted, so the baseline values are assumed to be accurate for the purposes of demand response.

The water quality testing was quite comprehensive. The details are beyond the scope of this assessment, so there are very few noteworthy findings. First, overall, the water quality for both the Skywell and Drinkable Air machines produced higher quality water than both City of San Diego and City of Escondido tap water. In terms of water quality between the brands, Skywell seemed to outperform Drinkable Air in Calcium, Hardness, and Nitrates. All other categories they were effectively the same. It is noteworthy that the Nitrate category seemed the most dangerous in the opinion of the laboratory. It was highly recommended to stop the use of the 2 Drinkable Air units that scored very high in Nitrates as this is a danger to pregnant women. Of course, these units were immediately removed from the field.

DISCUSSION

This technology assessment of Atmospheric Water Generators allowed us to test the product performance, customer satisfaction, energy consumption, and water quality. However, the main objective wasn't able to be met due to both the interference of Covid-19 and software that was no longer being supported. This section will discuss the issues and realities of this assessment.

Technology assessment of the product

The technology of a machine that can separate water from ambient air is an incredible concept. Every person we spoke to at every field testing site thought it was an amazing idea and felt it was a great thing for the environment. Simply put, they all loved the idea of the machine. In practice, everyone seemed to enjoy the water that was dispensed. The machines were used frequently, and in most cases constantly. The negative responses we heard from the site managers were that the machines were extremely noisy. The machines at office sites and the millwork shop had to move their machines because the noise was so loud it was distracting staff members during basic conversations and phone calls. Units placed in warehouses didn't have this concern, of course. Another piece of negative feedback that the energy consumption data supports is that the machines couldn't keep up with the water demands of the people. The staff at the SDG&E location confirmed this as we know that the location is highly staffed and it's no surprise that one machine couldn't keep up with demand as these machines can only produce up to five gallons a day, and when everyone fills up their quart sized reusable water bottles, that means 20 people can fill their water bottles if the machine was able to reach full capacity. This means that multiple machines are needed in each floor of a densely populated office building.

A huge market and technology barrier is the cost of these machines. The upfront cost at the time of purchase for these machines (with the inclusion of software and hardware to allow for auto demand response capabilities) was between $4,000 and $6,500 depending on which brand was selected. This is not a cost that most small businesses or schools or restaurants/breweries will entertain. These businesses are more likely to hire a water service for a small monthly fee and purchase a $200 water cooling station that doesn't need the maintenance of replacing filters. The Drinkable Air units required new filters while under evaluation and we were required to purchase them. The cost of filters was $90 for a set of water filtration units and $60 for a set of 4 air filters. The water filters are suggested to be replaced twice a year. The Skywell units were serviced and filters replaced as part of the initial purchase contract. Also, it's worth noting the reason the Skywell unit was more expensive is because it had more features. The unit was able to provide hot water as well as cold. The digital user interface had many customizable options and opportunities to post messages or logos for the business that purchased the unit. Even though the technology is impressive and universally well liked, the upfront and continued maintenance cost are a large market barrier.

The technology that was most pertinent to this assessment was the demand response capabilities. Skywell integrated their software into the onboard computer. Drinkable Air used a bolt on unit that could control the machines software and operations for the purposes of demand response events. Both machines required Wi-Fi access to do this. The Wi-Fi access proved to be a very difficult hurdle. Customer Wi-Fi access was a big challenge. For example, the SDG&E machines were only given temporary Wi-Fi access from the IT department. This means every 30 days the password changes and the machines have to be reprogrammed manually. The Skywell machine that was placed in one office space was too loud for the people working in the main office space, so they moved the unit

to a more distant wing with less people. This location was too far away and the Wi-Fi signal was too weak for the machine to be able to connect. Other sites took months to get approval from IT departments in order to allow these machines to access their secure Wi-Fi for fear of cyber security.

Covid-19 combined with the initial Wi-Fi set up difficulties created an insurmountable barrier to test these machines in a simulated Demand Response event. The initial set up was very difficult with the Drinkable Air machines. Since their technology for communicating with Auto Demand Response was a third-party device, the machines did not come programmed from the factory. Rather, The Energy Smiths had to program each machine in the field. This process had many challenges and took several attempts to get machines to communicate properly. If the machine was unplugged and moved or a power outage occurred, or the Wi-Fi credentials were changed we had to start over. Skywell brought their own technicians out to initially set up the machines. Those that were granted Wi-Fi access were working initially. Before we could get all the machines up and communicating for a simulated demand response event, Covid lock down occurred. During the approximate year and a half of not being able to access almost all of these sites, the AWGs were either moved, disconnected, or the Wi-Fi was changed. As we slowly returned to the office spaces and tried to get the AWG machines working again, we encountered many problems. First, they all needed new filters. We ordered filters from Drinkable Air and replaced them. We contact Skywell and were not able to get a response for months. When we did, I believe they were only able to service the machine at The Energy Smiths office and at the school administration building. But the filters were serviced, and demand response software wasn't updated, and it no longer would communicate. We were never able to get any further responses from Skywell after this. Drinkable Air was responsive, but their machines needed a third-party to deal with the internet connections and programming. The Energy Smiths reached out several times and made several site visits with tech support on the line to help. We struggled with the customer Wi-Fi connections, so we took a Drinkable Air machine back to our office and spent another 6 weeks trying to get back in touch with SkyCentrics (the third-party software company). Finally, we connected and began troubleshooting. The result was the software was out of date and no longer supported. There was no way for us to get these machines to operate properly for a demand response test.

The other major issues during this assessment centered around heat, noise, water quality, mechanical failure, stolen data logging equipment, and businesses closing doors. Again, one of the reasons we had issues maintaining Wi-Fi connectivity is because the customers moved the machines. The reason they moved the machines is because they produced a lot of heat and noise. This was intolerable to most people who had workstations nearby. This is a significant issue, because it severely limits where the machines can be installed in an office building. They do have quiet modes, but when in quiet mode, they can't produce water. So this forces the AWGs to be placed in break rooms or hallways far enough away from open offices. The water quality overall was quite good, and better than City tap water. However, we had two Drinkable Air machines fail the Nitrate test, and those needed to be removed from the assessment. Further, a mechanical failure on the drinkable air machine at The Energy Smiths office caused the machine to uncontrollably dispense water without anyone attempting to do so. This caused a flood, but luckily it was in the warehouse at the time and nothing was damaged. Multiple sites data logging equipment disappeared when we came to download our data. It was usually the temperature and humidity loggers, so this caused us to reset the timeline for logging. Finally, both the research and laboratory site and the millwork shop closed their businesses, so we lost two program participants.

The Atmospheric Water Generation assessment concludes with baseline energy consumption data from five machines. Since these machines represent added load to the grid, as they

don’t yet replace existing technologies, they really don’t fit the mold for a demand response candidate. However, baseline data was collected, and the assumption can be made that it’s not a critical load for any building. Therefore, if AWG machines must be considered for demand response (once the capability is fully operational), the entire baseline load could be considered for a demand response event. The remote operation that was the concept can shut down the machines completely as long as it doesn’t remain shut down for four hours or longer. After four hours, these machines need to be drained and filters cleaned or replaced to ensure biological contamination did not occur while the UV treatment and other filtration was suspended.

CONCLUSIONS

The overall assessment of the Atmospheric Water Generation technology is a positive reception to the concept, but in practice there were many challenges and failures. People loved using the machines and the water quality overall was excellent, with the exception of two machines. However, the machines themselves generate far too much noise and heat to be installed in convenient locations within an office space. The speed of water generation and size of holding tank are not adequate for most office spaces. Further, the extreme high upfront purchase cost and continued maintenance are significant market barriers. The technical difficulties and the drastic upset in the workplace caused by Covid-19 prevented the main objective of the assessment from being conducted. The simulated Auto Demand Response event was unable to be performed as the machines were not successfully connected to Wi-Fi as needed for these tests. Therefore, at this time the AWG machines tested are not qualified for demand response.

RECOMMENDATIONS

There are no recommendations to continue considering this technology for any demand response or energy efficiency programs at this time. This technology is a wonderful concept, but it doesn't provide enough water with quick enough recovery time (water generation) to meet the demands of most office spaces as tested. This means that the existing water coolers would need to remain in operation and the AWG machines would simply be putting new electrical load on the grid. This technology is more useful and exciting under different scopes such as: areas with contaminated municipal water supply, areas of extreme drought, or for purposes of sustainability concerns such as potentially lowering carbon footprint compared to truck delivered water or single use plastic water bottles. The technology of separating water from air works, but at a high cost and not efficient enough to meet the water demands of most office spaces. There's no need to further consider this technology for energy efficiency or demand response programs.

APPENDICES

Attachments containing the detailed analysis from each customer site were provided to SDG&E.