WEBINAR SERIES

ETCC EMERGING TECHNOLOGIES COORDINATING COUNCIL

Demonstration of a Gas Engine Heat Pump (GEHP) with Scalable Solar Thermal Array in Multi-Family Central Water Heating

Webinar

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Energx Controls Incorporated

Tim Krause

Occidental Analytical Group

A. Ahmed

Project Description

This project will demonstrate an integrated and comprehensive solution for water heating in one multi-family apartment building

The solution combines three technologies

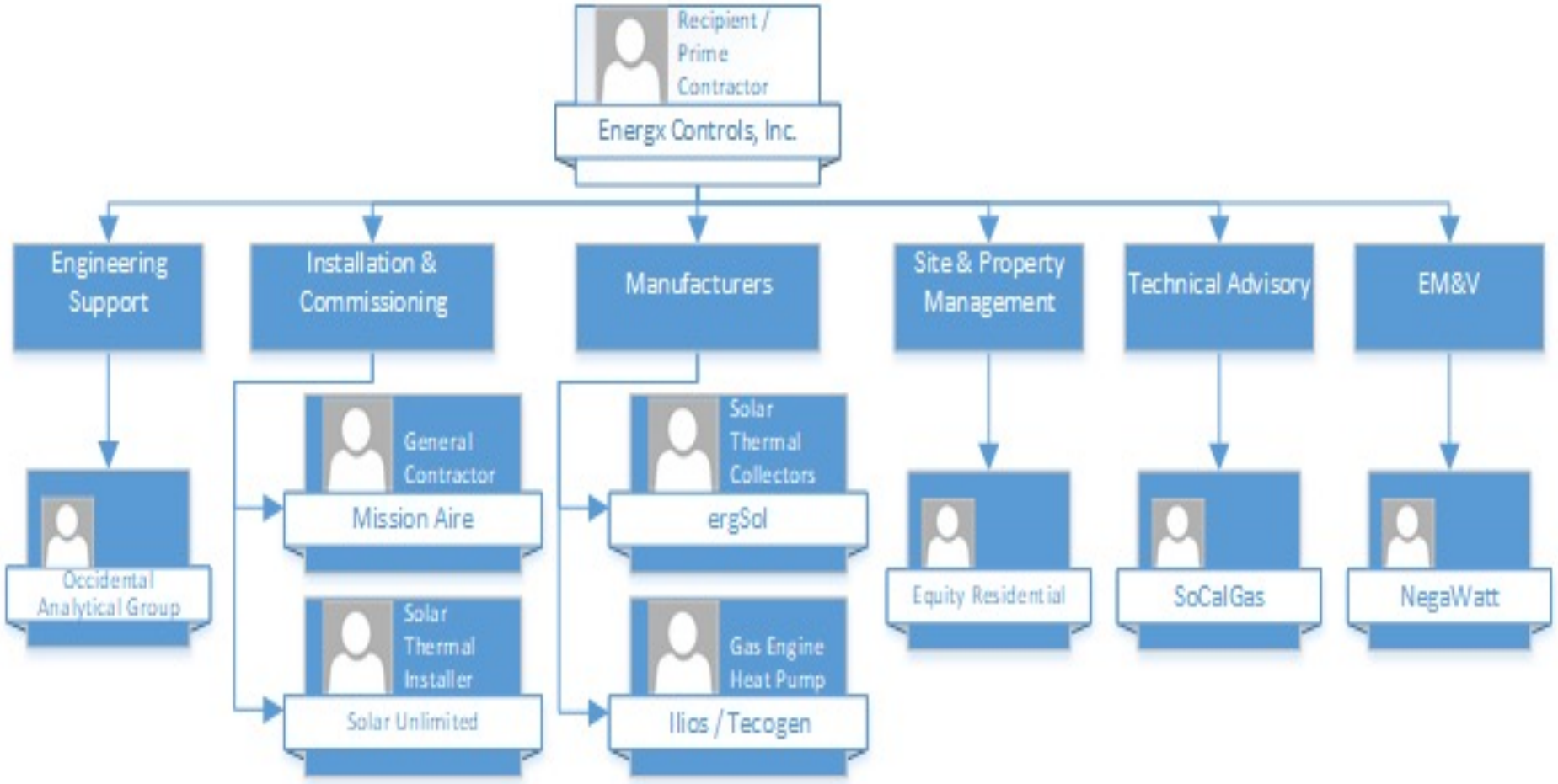
- advanced solar thermal water heating utilizing evacuated tube technology (ETC)
- emerging natural Gas Engine Heat Pump (GEHP) for Domestic Hot Water (DHW) in central water heating
- Energx developed central water heating loop controller

This effort will achieve deep natural gas energy savings, with reduced associated greenhouse gas (GHG) and nitrous oxide (NOX) emissions.

Project Goals and Objectives

- Achieve at least a 75% reduction in natural gas use in DHW heating
- Demonstrate an integrated solution for achieving the target energy savings and investigate how the combination of technologies and measures can be optimized
- Investigate the performance and cost effectiveness of each of subsystems (ETC and GEHP) operating independently as well.
- Document the baseline and project impacted energy use, emissions.
- Estimate the total cost and conduct cost effectiveness analysis for potential viability as future utility energy efficiency measure or California Title-24 standard
- Address and help meet State of California's policy objectives (AB32, AB758, AB802, SB350, CPUC Energy Efficiency Strategic Plan, the California Energy Code)
- Build awareness through outreach efforts among multifamily property owners of the comprehensive solution to help transform or create the market
- Share lessons learned and technology performance information with stakeholders and in outreach activities such as symposiums and publishing in journals

PROJECT ORGANIZATION



Customer and Site

Participating Customer: Equity Residential

Equity Residential is an S&P 500 company focused on acquisition, development and management of high-quality apartment properties. Equity owns or has investments in 302 properties (77,498 apartment units) located in Boston, New York, Washington DC, Seattle, San Francisco and Southern California.

Equity's goals are to:

- Reduce energy consumption by 15% and reduce water consumption by 10% of 2011 levels by 2021
- Invest in clean and renewable energy generation technologies that reduce emissions, energy and water use
- Appropriately engage their communities to ensure high levels of customer satisfaction
- Maintain high corporate governance standards and attract, cultivate and retain a diverse work force
- Equity has a keen interest in the technologies being tested in this project as they could be applied in several of their properties.

Project Schedule and Budget

Schedule

From the date of approval of contracts, the project should last up to 24 months with the following:

- Baseline Analysis – max two months
- Technology Installation – 4-6 months
- Post installation Monitoring, Final Report, Outreach – 12-14 months

Budget:

• Total Project Budget	$ 946,445
• CEC Funding	$ 753,605
• Match Funding	$ 192,840

Project Site

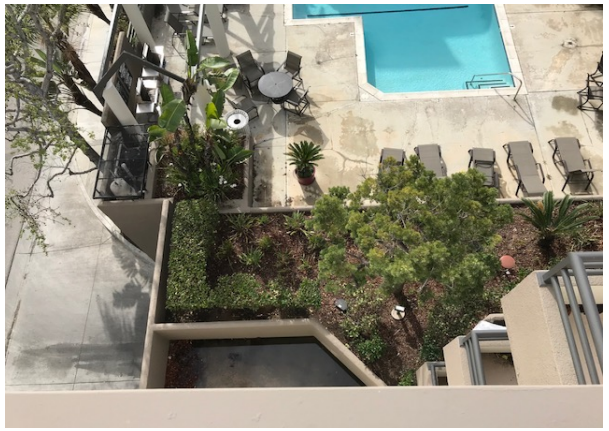
- **Park West Apartments**
- **Located at 9400 La Tijera Blvd, Los Angeles, Ca**
- **444 Unit L-Shaped apartment complex with interconnected buildings and a common roof**
- **Four story buildings with two levels of parking beneath**
- **Two swimming pools, one heated**
- **Three hot water boiler systems, 148 apartments/system**
- **Each system with two 750,000 btu Raypak boilers with a 275-gallon storage tank**

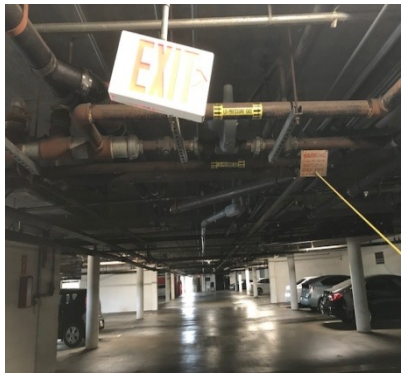
Satellite View of Site

EQUIPMENT SITING

- Existing DHW piping from boilers are routed to mains in the ground level garage then up a chase and distribution lines feed apartments
- This enabled a point of connection for new hot water piping to be in the ground floor garage level
- The new equipment could be located in a large storage space near the entrance to the garage
- Only the solar hot water piping had to be routed up to the roof
- The garage level also contains all services (DHW, DCW, NG, HW Recirc Line) running along concrete ceiling, enabling easy connections and shorter pipe runs

Large Swimming Pool Area/Garage Entrance





PHOTOS

- Following pages illustrate site conditions through photographs

Boilers on Roof

Piping under first floor/below slab on upper garage

Parking Garage Showing Piping Above and vertical pipe runs up to apartments

Equipment Room (was storage)

Pre-Install M&V Instrumentation

TECHNOLOGIES

Project focus is on demonstration of three (3) energy efficiency technologies

– Gas Engine Heat Pump (GEHP) water heating

- Evacuated tube solar thermal water heating

- Energx Dual Sensor Water Heater Controller

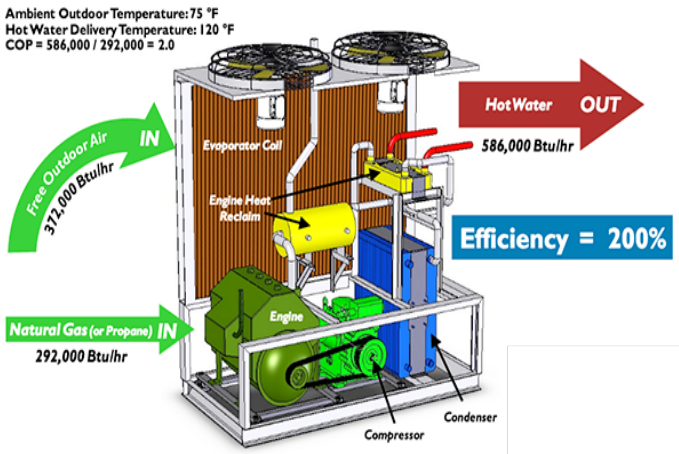
Technologies are synergistic in that they all can work together to reduce water heating energy use

Target sizing of GEHP +Solar Thermal WH to reduce natural gas use by 60%-75% with additional 5%-10% reduction through use of the Energx controller

Technology

Gas Engine Heat Pump (GEHP)- Tecogen

- Ilios HEWH-500-AS
- Twice the efficiency of a conventional boiler
- 400,000 to 600,000 BTU/hour of hot water ideal for DHW, swimming pools, space heating and process heat
- Hot water delivery temperature 100°f to 160°f with near zero criteria pollutants
- COP of up to 2.2 utilizing a highly efficient heat pump with reclaimed engine waste heat
- 50% reduction in carbon footprint
- Ultra-low emissions with near-zero criteria pollutants
- Internal 5 kW generator for parasitic load
- Low-pressure, HFC-134a

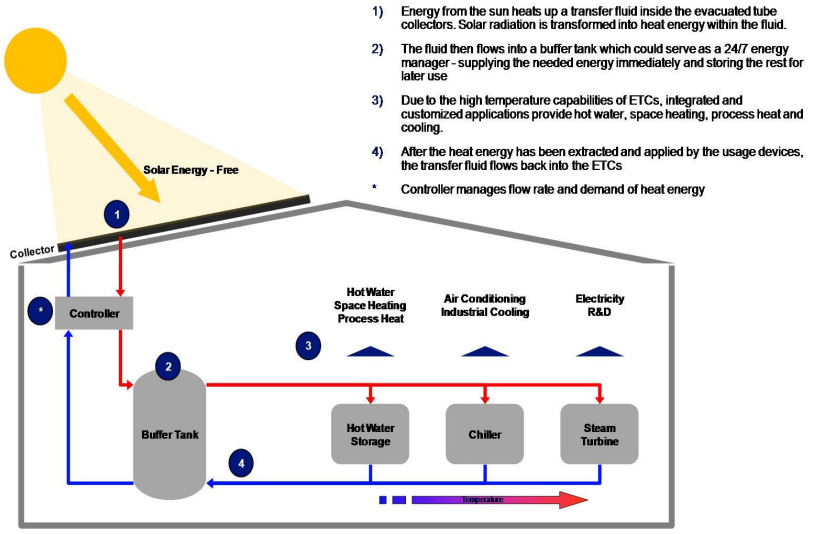


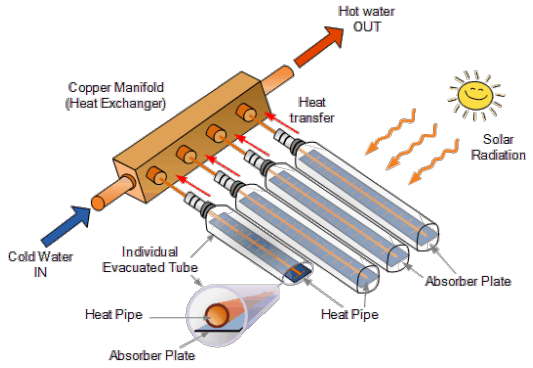
Technology

Evacuated Tube (ETC) Solar Collector- ErgSol

Why Evacuated Tube Collectors?

- Flat-plate collectors can be prone to condensation buildup resulting in corrosion
- Because the space inside the tube is a vacuum, ETC have much better heat retention than the glazing/air space (R-7) design of flat-plate collectors.
- ETC are capable of producing higher temperatures overall and can produce more heat in cold weather
- ETC perform much better under cloudy and windy conditions
- Modular design of ETC, individual tubes can easily be replaced
- Evacuated tubes are less sensitive to sun angle and orientation
- Individual tubes can be carried to the location and then assembled in place





Technology

Evacuated Tube (ETC) Solar Collector-ErgSol

Low Profile -
sits flat on roofs and facades

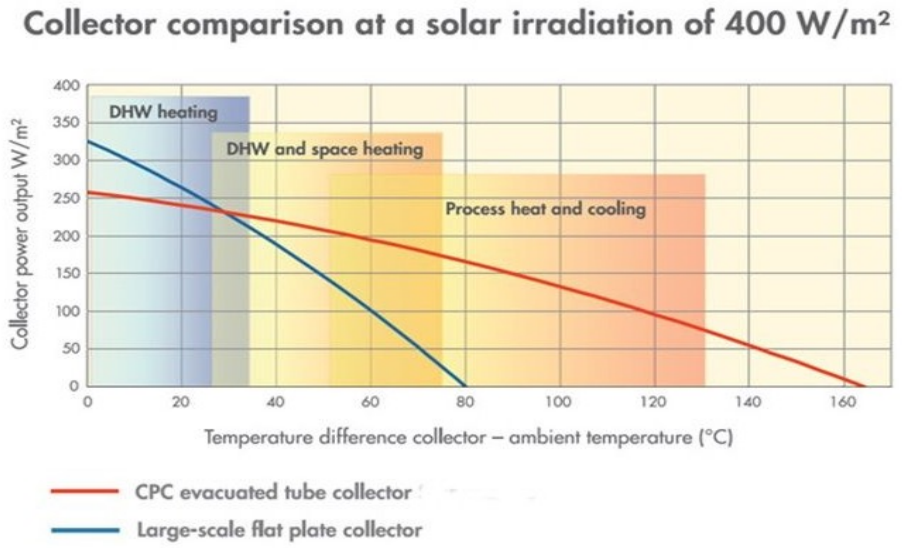
Utilization of Direct and Diffuse Light -
state-of-the-art for non-concentrating, non-tracking solar thermal design

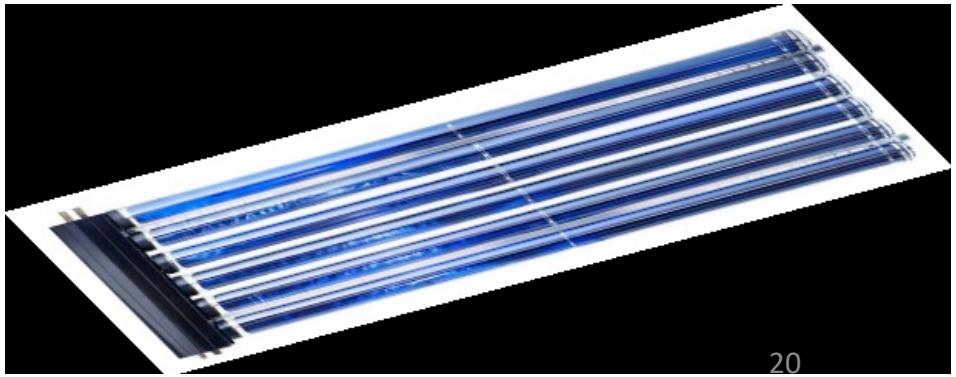
Small Footprint -
offer significantly higher energy density per square foot of roof area

Minimal Wind Load –tubes spaced

Low Maintenance -Applicable in any climate zone

Leading Performance -SRCC Clear E=4.039 kWh/m2/day

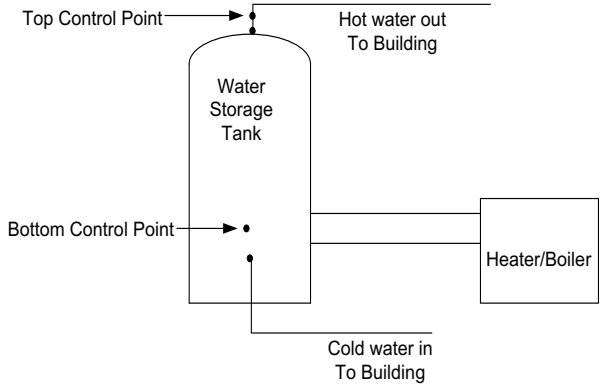


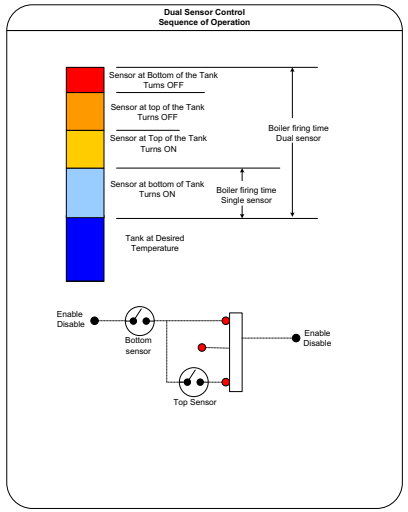


Technology

Energx Dual Sensor Central WH Controller

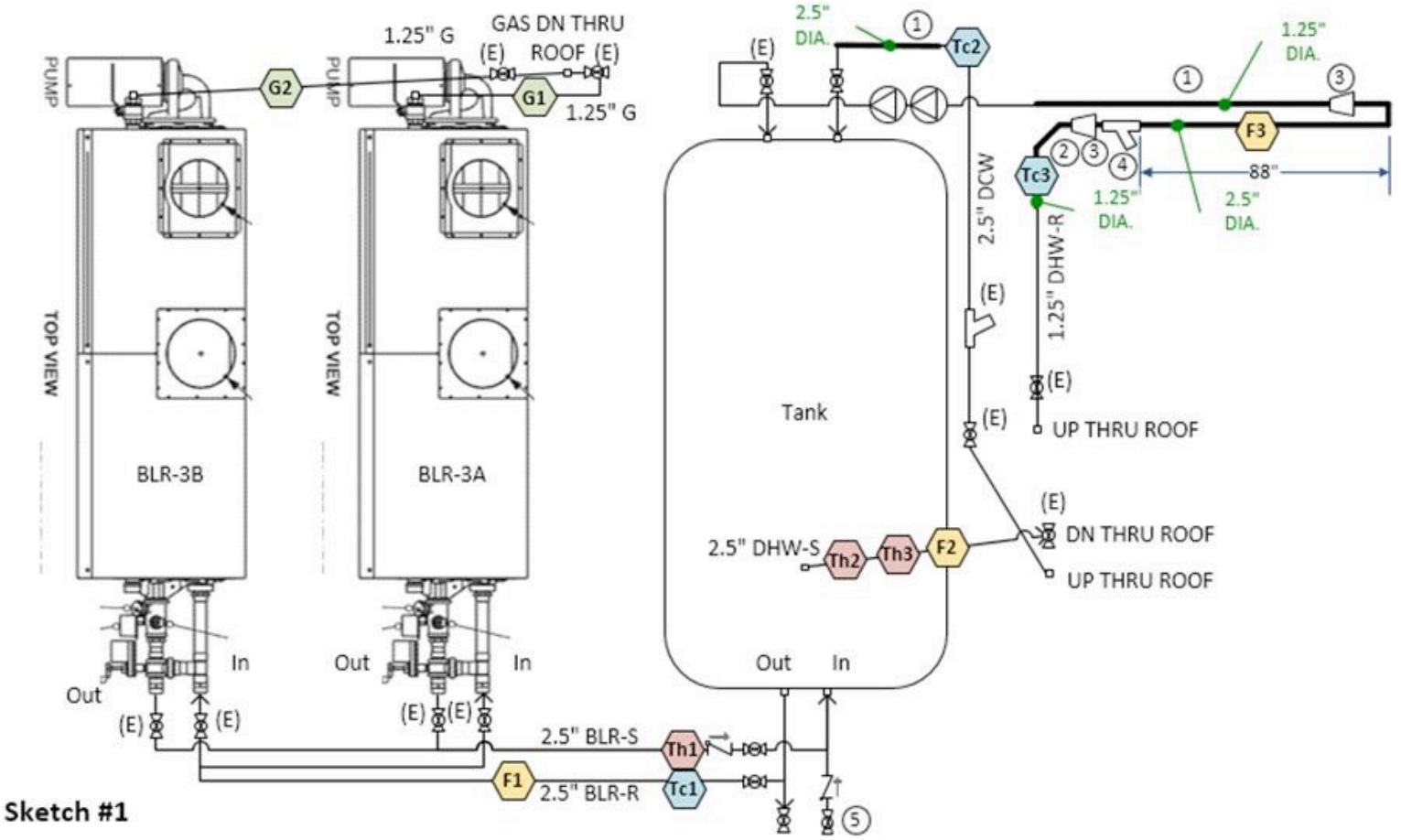
- Dual Sensor Controller stops short cycling of boilers and water heaters
- Uses digital controls and relays to sense the temperature at two separate locations in the water heating storage tank
- Control is in addition to the existing water heater or boiler controls
- When the system temperature is satisfied nothing is operational or on
- When the tank cools down, the bottom sensor of the tank will call for heat but the burner will not fire until the top sensor calls for heat
- With both sensors calling for heat, the control system is energized and the heater or boiler control system will fire
- When the top sensor is satisfied and the bottom sensor is not satisfied, the control system will stop the water heater or boiler from firing and it stay in stand-by mode until both sensors call for heat
- Energy savings of 10%-15% result from system





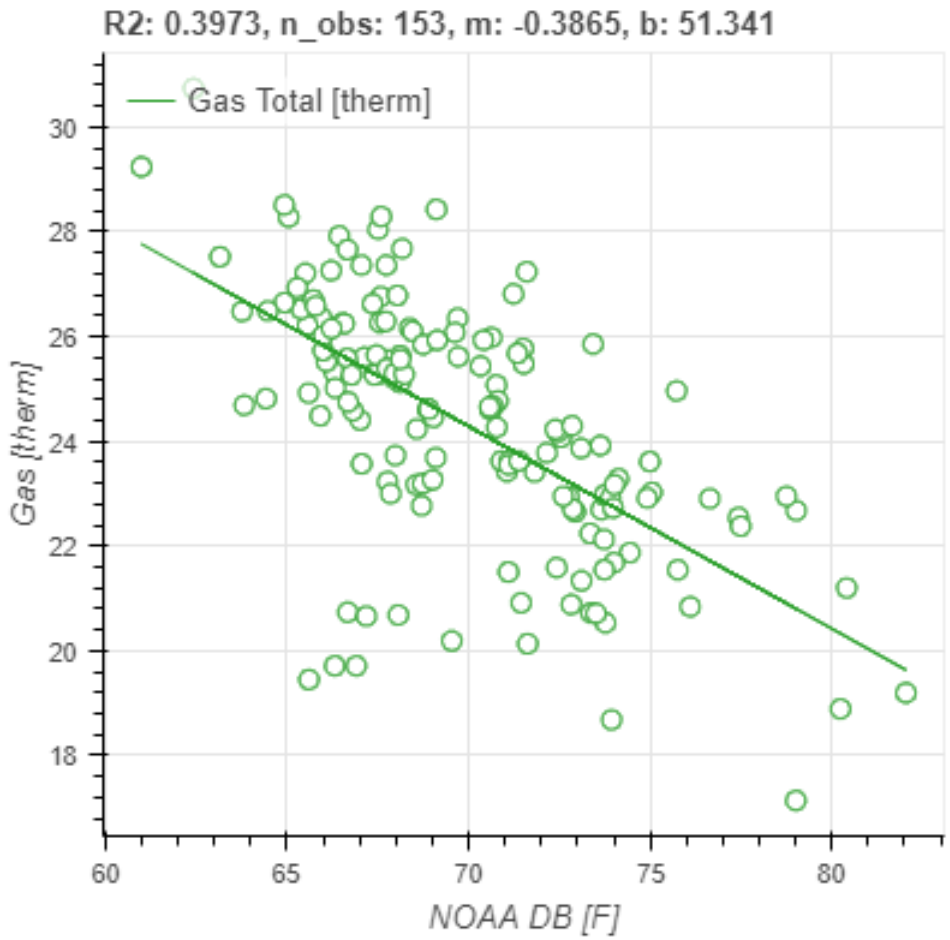
BASELINE M&V

Baseline EM&V Instrumentation



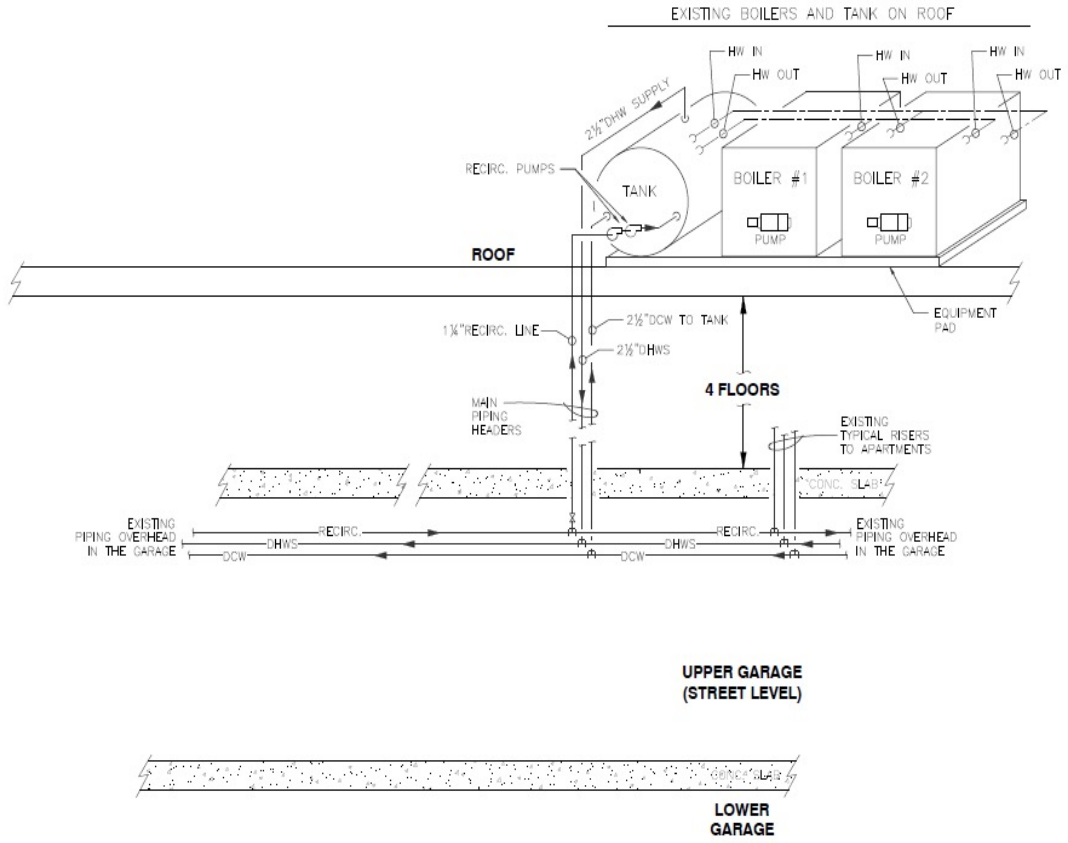
Baseline Water Heating Energy Use

- Baseline energy use estimated from gas and ambient temperature measurements shown in this plot (R2 not ideal)
- Annual therms used = 10,069 th/yr
- Annual Emissions from water heating = 111,810 lbs/yr of CO2
- Annual DHW gas cost = $10,069
- EM&V done by NegaWatt Consulting



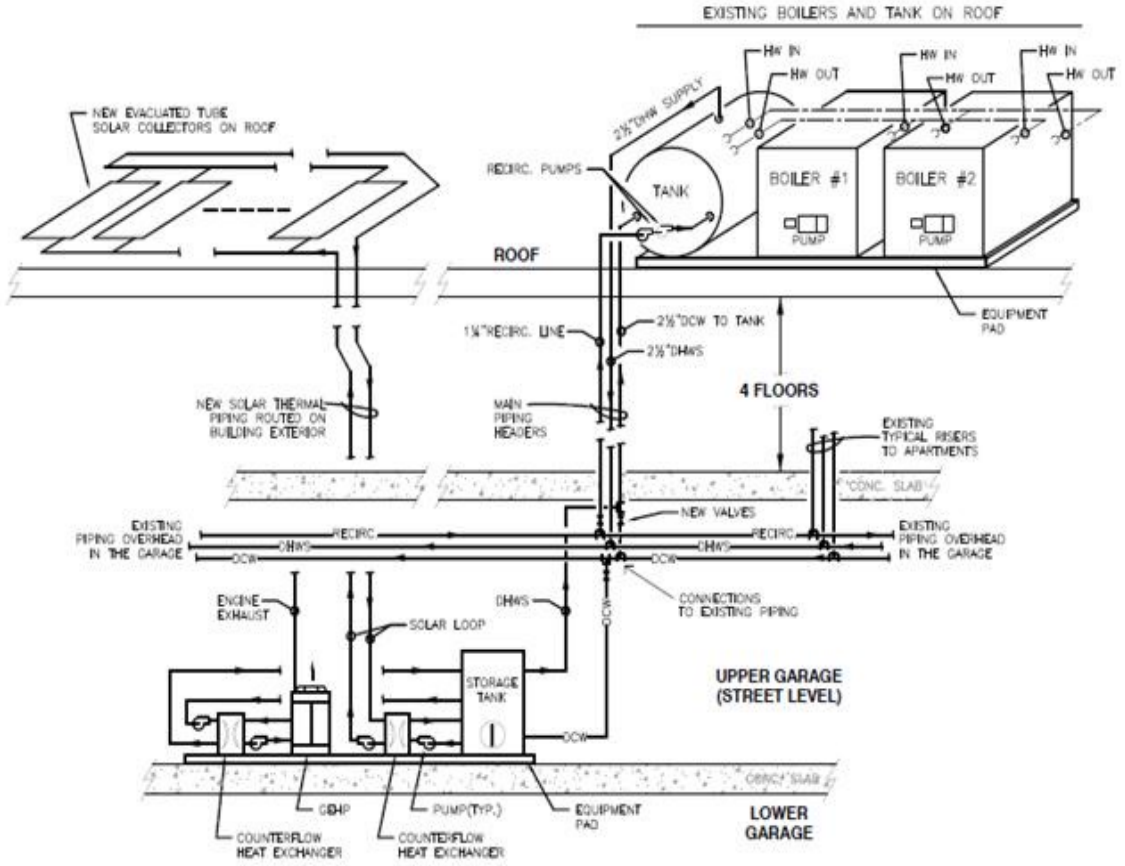
SYSTEM DESIGN

DESIGN – Existing DHW Schematic



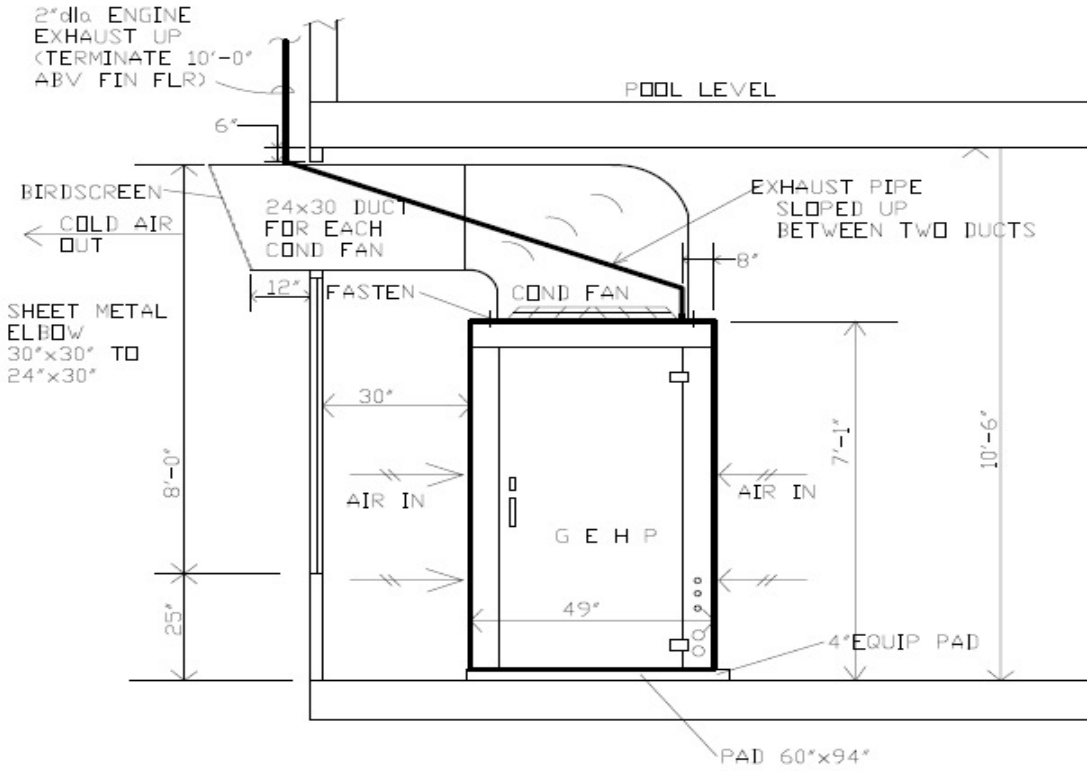
PARK WEST APARTMENTS, LOS ANGELES
EXISTING DOMESTIC HOT WATER SYSTEM SCHEMATIC

DESIGN – Proposed DHW Schematic



PARK WEST APARTMENTS, LOS ANGELES
DOMESTIC HOT WATER SYSTEM SCHEMATIC

DESIGN – GEHP Air Flow Management

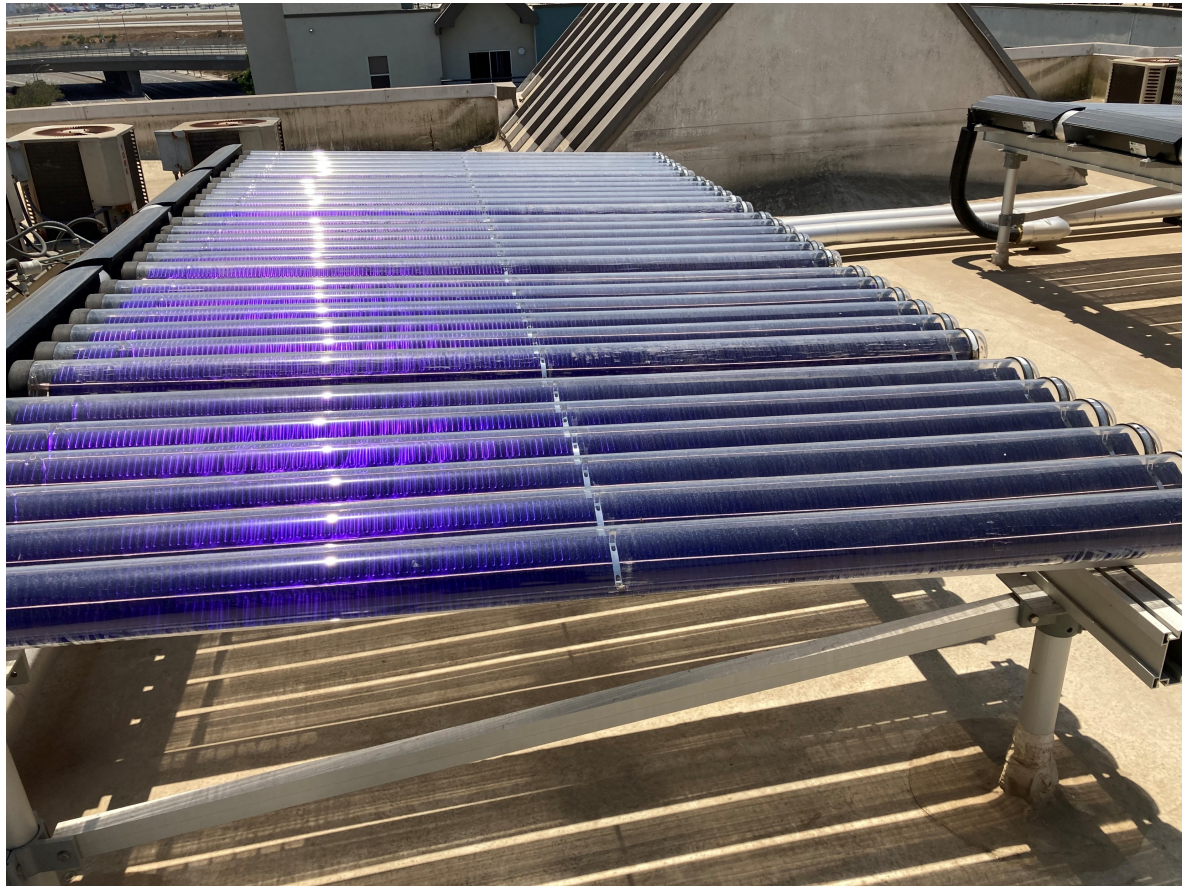


GEHP ELEVATION SHOWNING
AIR FLOW MANAGEMENT
SCALE 1/2"=1'-0"

POST INSTALLATION PHOTOS

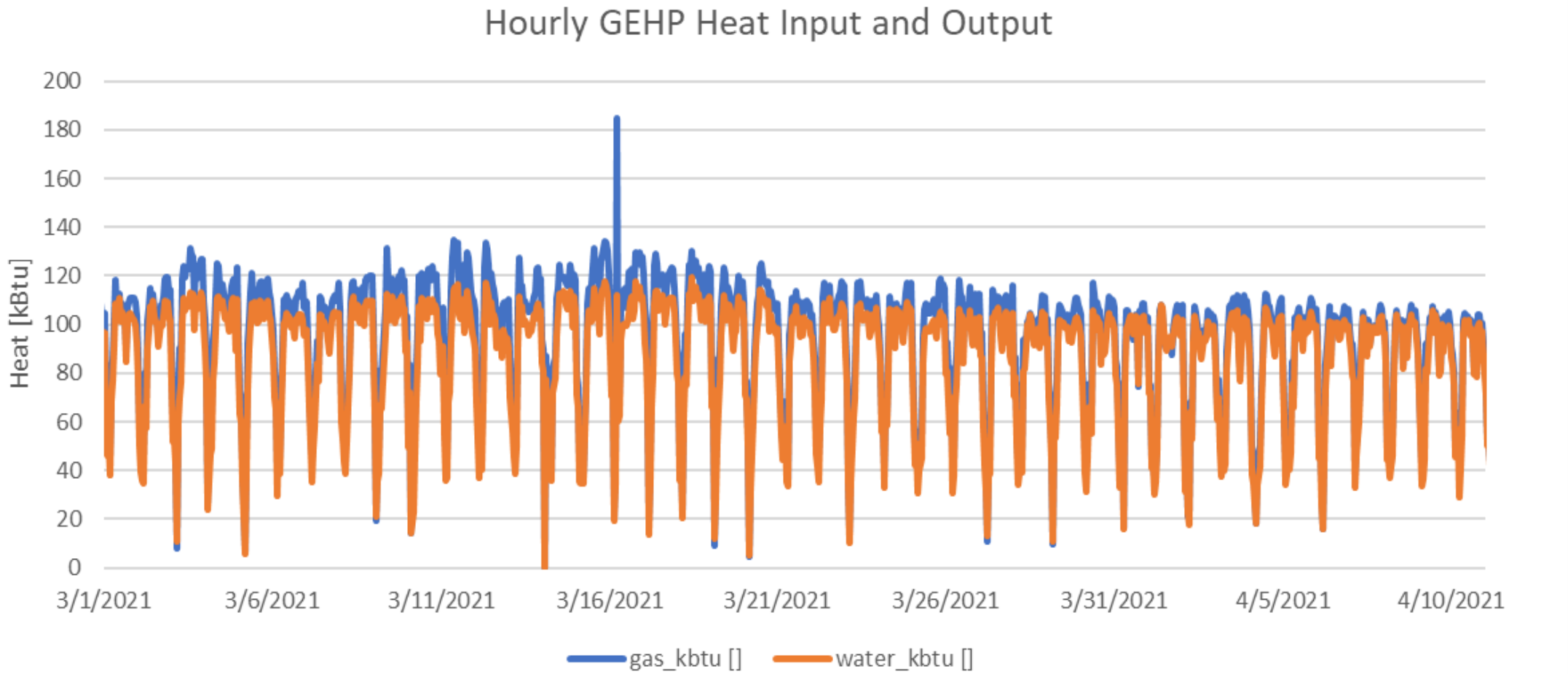
- Following pages illustrate equipment installation through photographs


Ilios
HEWH-500-AS

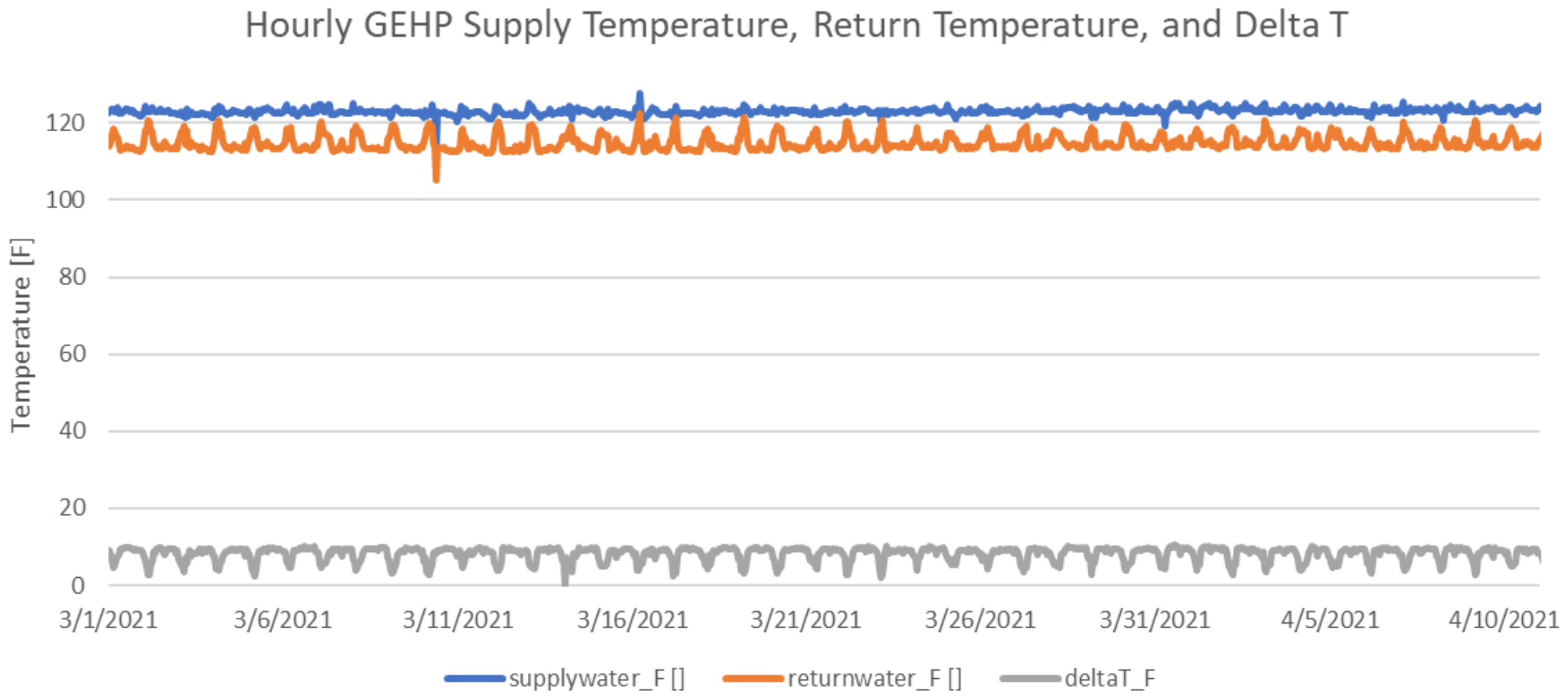


Post-Installation M&V

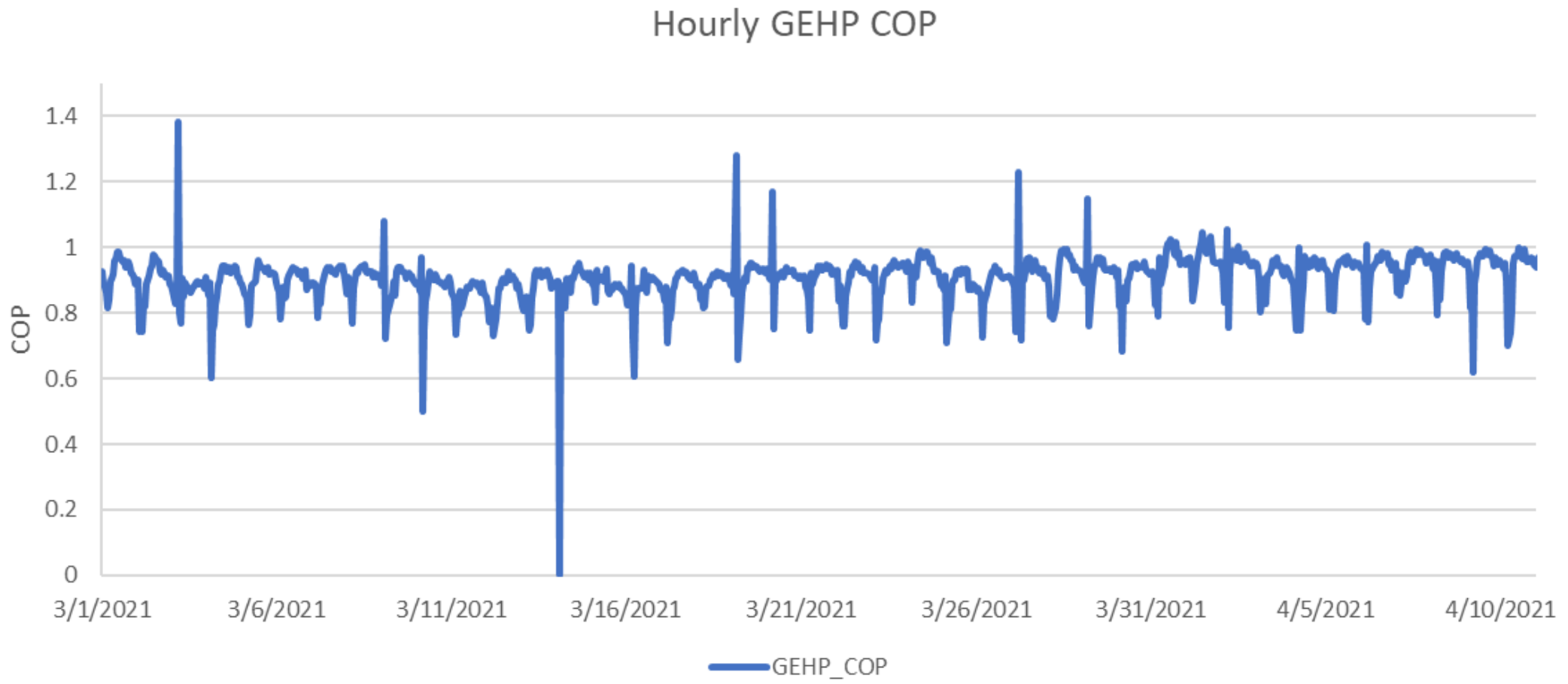
GEHP Heat Input and Output



GEHP Temperatures



GEHP COP


Hourly GEHP COP
COP
1.4
1.2
1
0.8
0.6
0.4
0.2
0
3/1/2021
3/6/2021
3/11/2021
3/16/2021
3/21/2021
3/26/2021
3/31/2021
4/5/2021
4/10/2021
GEHP_COP

Project M&V Summary of Findings

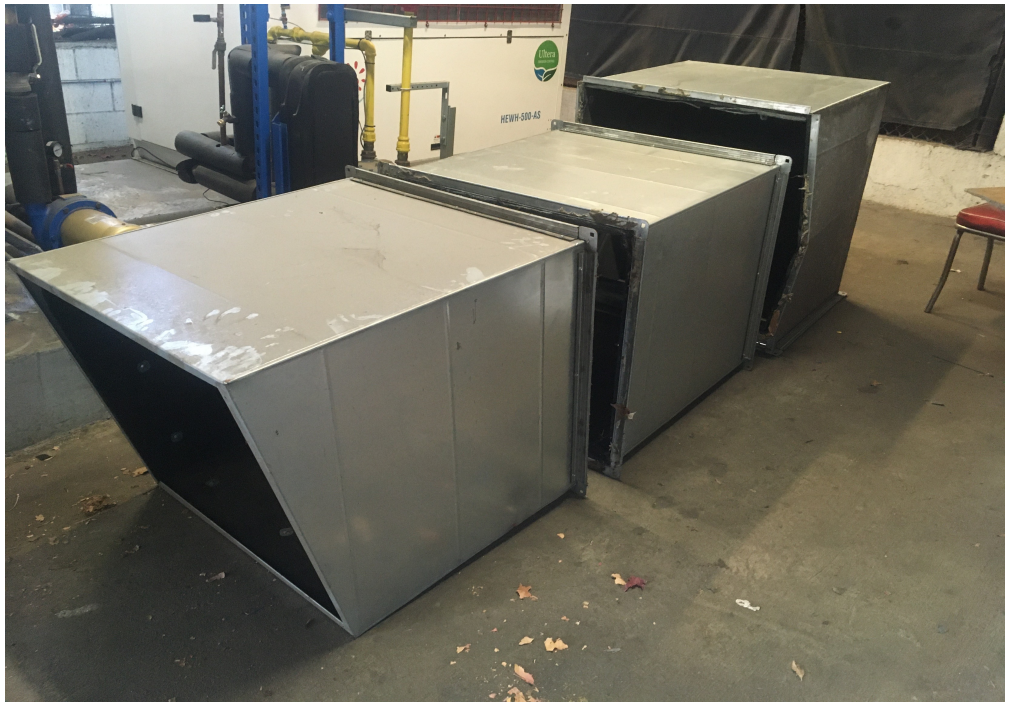
- The GEHP is successfully providing heat as shown by the steady delta T of about 10 F.
- The COP is lower than expected but it is trending higher. This may be due to minor differences in the DHW load.
- We expect that adding booster fans will improve the COP
- Solar and Energx controller performance has not been properly mapped – activities has been focused on troubleshooting GEHP performance
- Detailed M&V report on GEHP, Solar Thermal and Energx Controller performance will be available once project study is completed

Project Experience

Project Experience – GEHP Performance

- GEHP performance has been a challenge since the installation experienced reduced air flow through the evaporator coils
- Air flow measurements with Tecogen present showed that the fans were delivering half of the 22,000 cfm as required by Tecogen
- When the ducts were removed, the air flow improved to about 14,000 cfm still not enough and measured COP was around 1.0
- With just 34 inches between top of unit and garage ceiling, the exhaust fans are not capable of delivering the required cfm
- A solution is to re-install the ducts with in-line booster fans to get the required air flow across the coils
- As project funds were depleted, Energx requested SoCalGas ETP funding to get the project over this final hurdle
- SoCalGas agreed to fund this second phase of the project

Project Experience – GEHP Performance



Project Experience

- It is a complex project that requires a lot of coordination
- Several delays occurred - site change by Equity, approvals by CEC
- Site equipment location was a challenge and because of GEHP noise and emissions consideration. Took several site visits
- Equipment with GEHP, storage tank, heat exchangers and pumps require adequate space and space is a premium in existing high-end apartment complex
- Unusually long design phase-required Los Angeles Department of Building Services (LADOBS) review and approval of plans
- Months of delay due to COVID inactivity

NEXT STEPS – Phase II

- Project received additional funding from SoCalGas ETP
- Energx/Mission Aire to begin installing booster fans in ducts to increase air flow through evaporator coils
- Continue post-install M&V
- Complete project M&V and submit final report by March, 2022

Technology Transfer Activities

After completion of project study, the following activities are planned:

- Develop Presentation Materials on the project for Energy Commission- sponsored conference/workshop(s)
- Take High Quality Digital Photographs of the project for publishing
- Develop a technology transfer plan for the CEC with Fact Sheet
- Participate in technology transfer activities such as presentations in energy symposiums and forums (ESC, ESource, ACEEE, CEE)
- Publish articles in scientific journals

This project is funded by the California Energy Commission's Public Interest Energy Research (PIER) program.

For more information, contact Mr. Amir Ehyai at Amir.Ehyai@energy.ca.gov

The project final report will be uploaded to CEC Website and the ETCC website

Thank You

Q & A