Central Heat Pump Water Heating Q2 2020

BDC Presents Series

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Agenda

- Heat Pump Water Heating
- Technology Innovation Roadmap
- Advanced Water Heating Initiative (AWHI)
- Heat Pump Water Heating Tool Development
- Prescriptive Heat Pump Water Heater Design California T24 Approved
- Packaged Plug and Play Water Heater Skids
- On the Horizon

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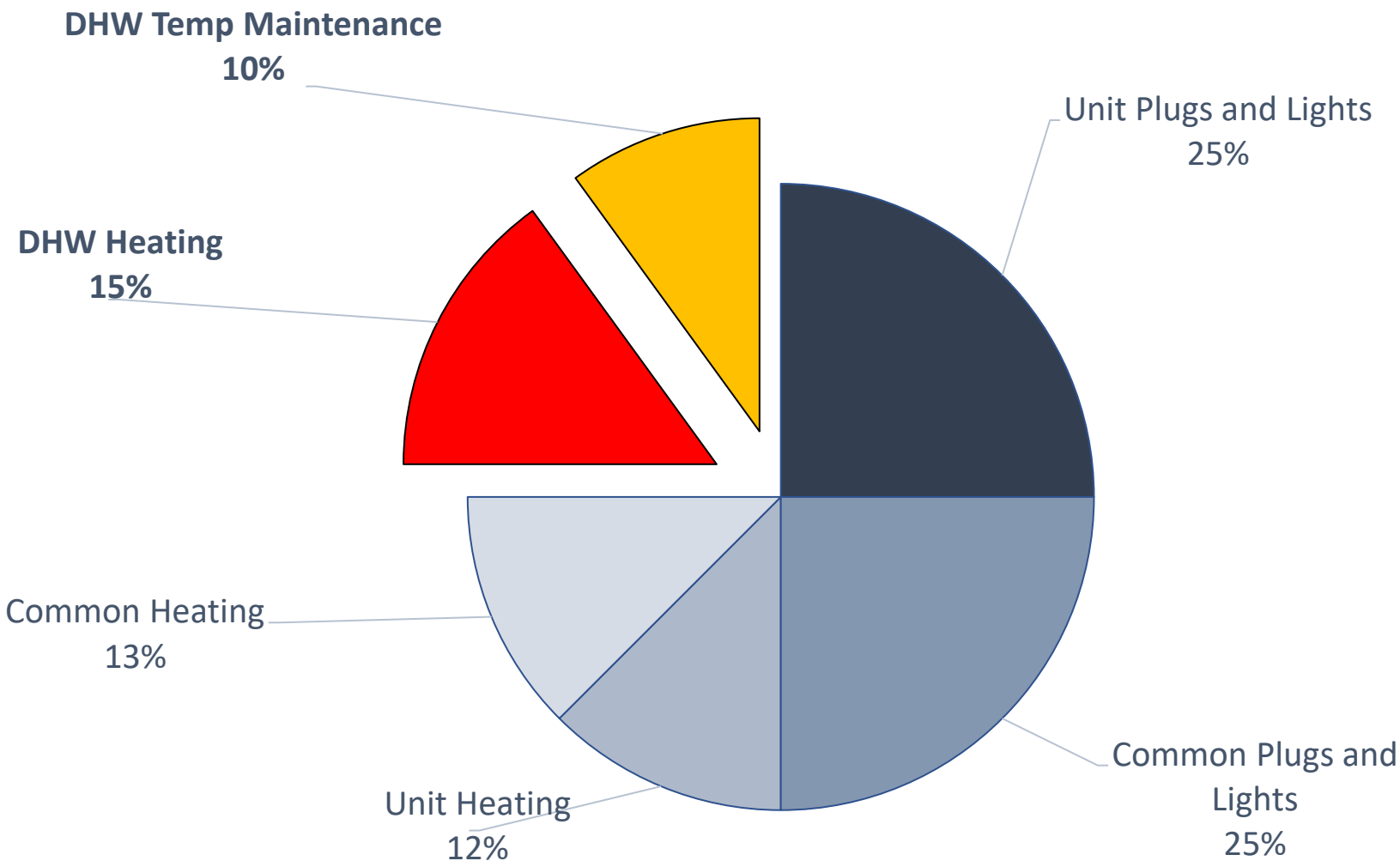
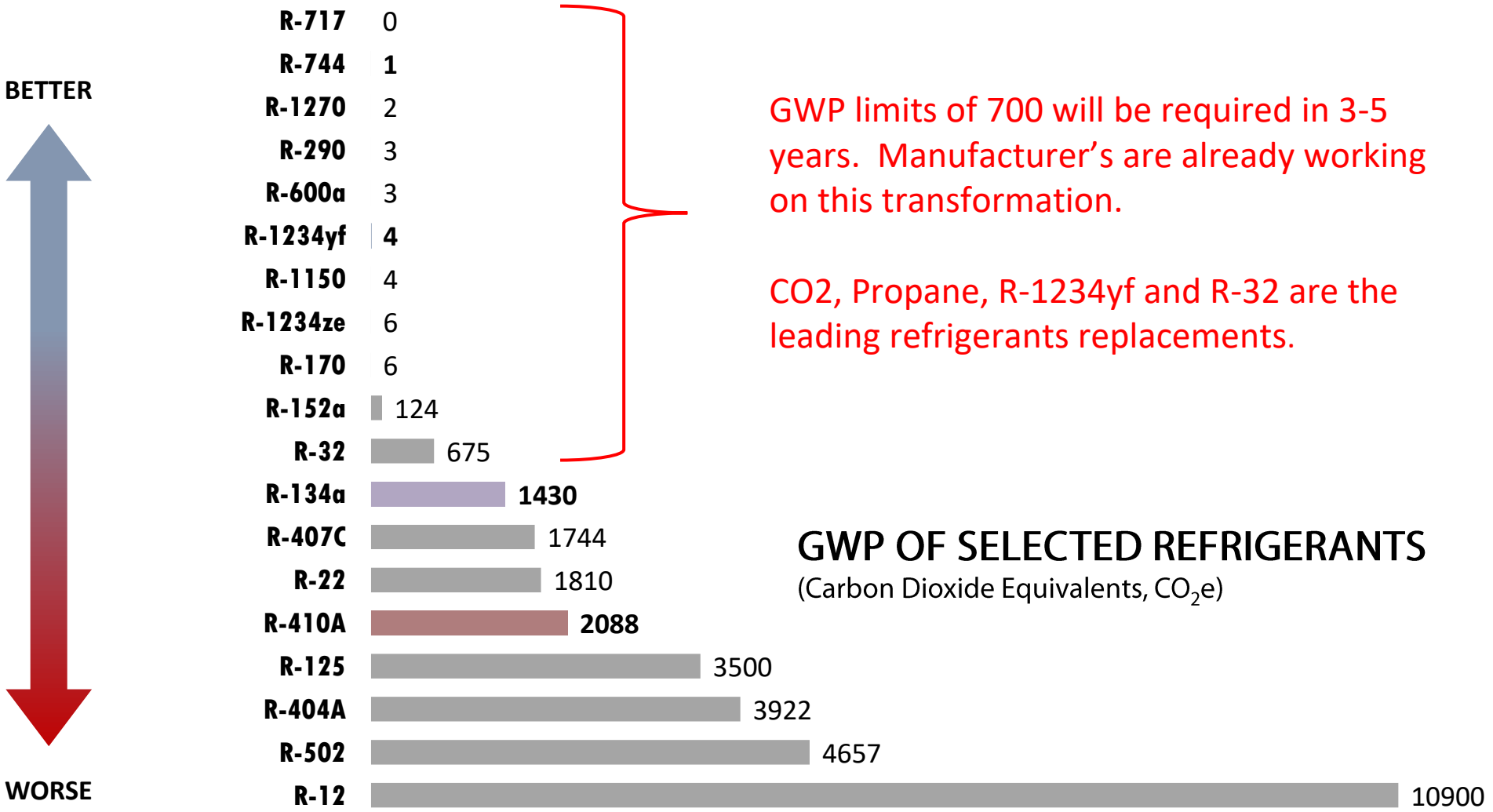
Heat Pump Water Heating Background

Multi-Family DHW Energy End Use %



Refrigerant Phase Out



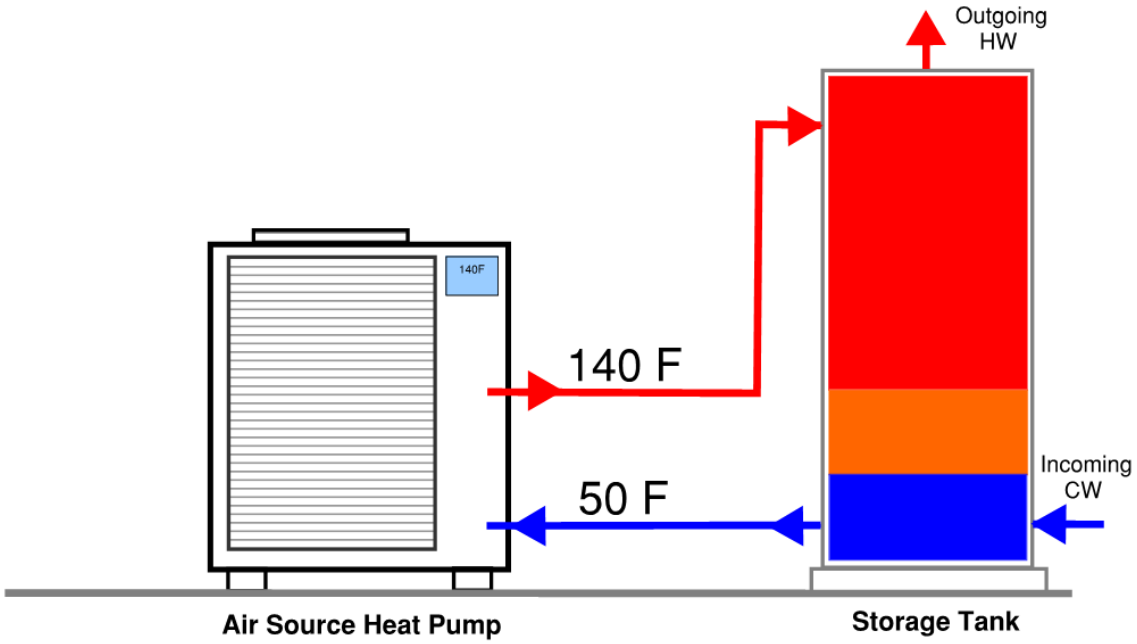
GWP limits of 700 will be required in 3-5 years. Manufacturer's are already working on this transformation.

CO2, Propane, R-1234yf and R-32 are the leading refrigerants replacements.

GWP OF SELECTED REFRIGERANTS

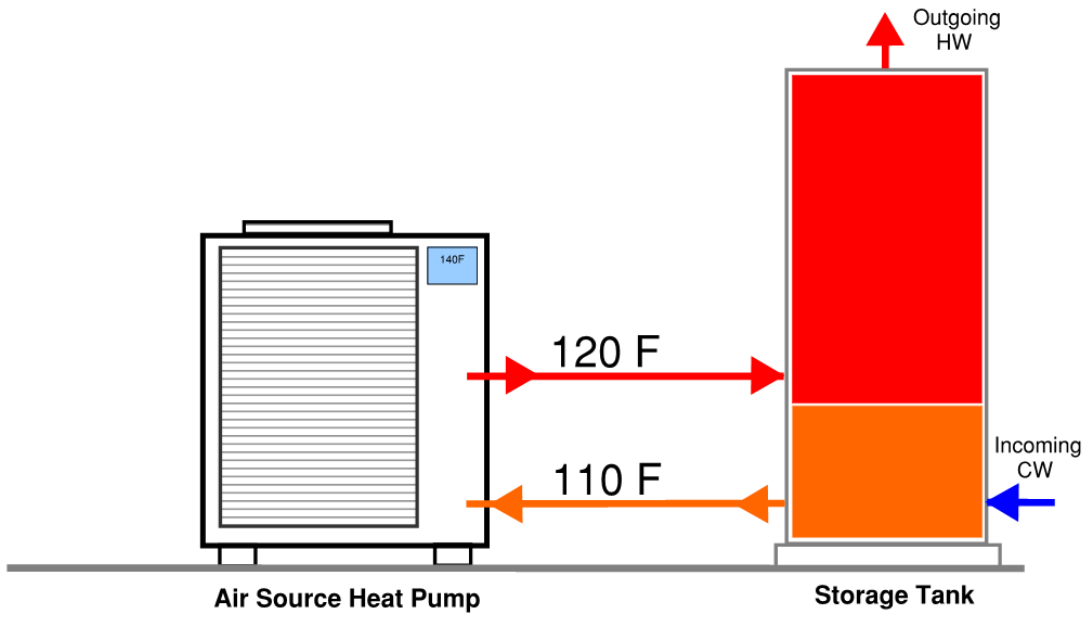
(Carbon Dioxide Equivalents, CO_2e)

Single and Multi-Pass



Single Pass

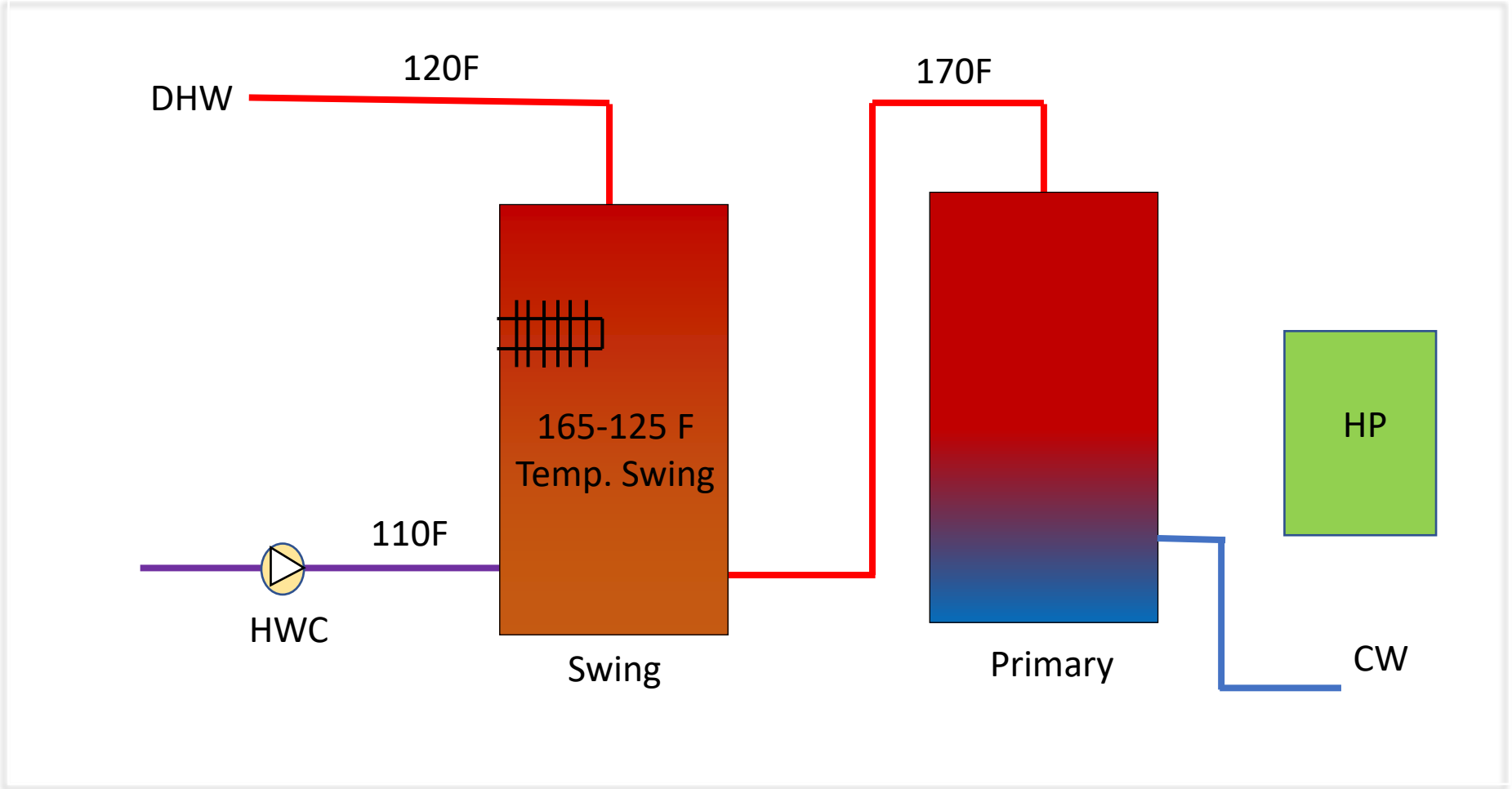
Heats up water to working temp in single pass



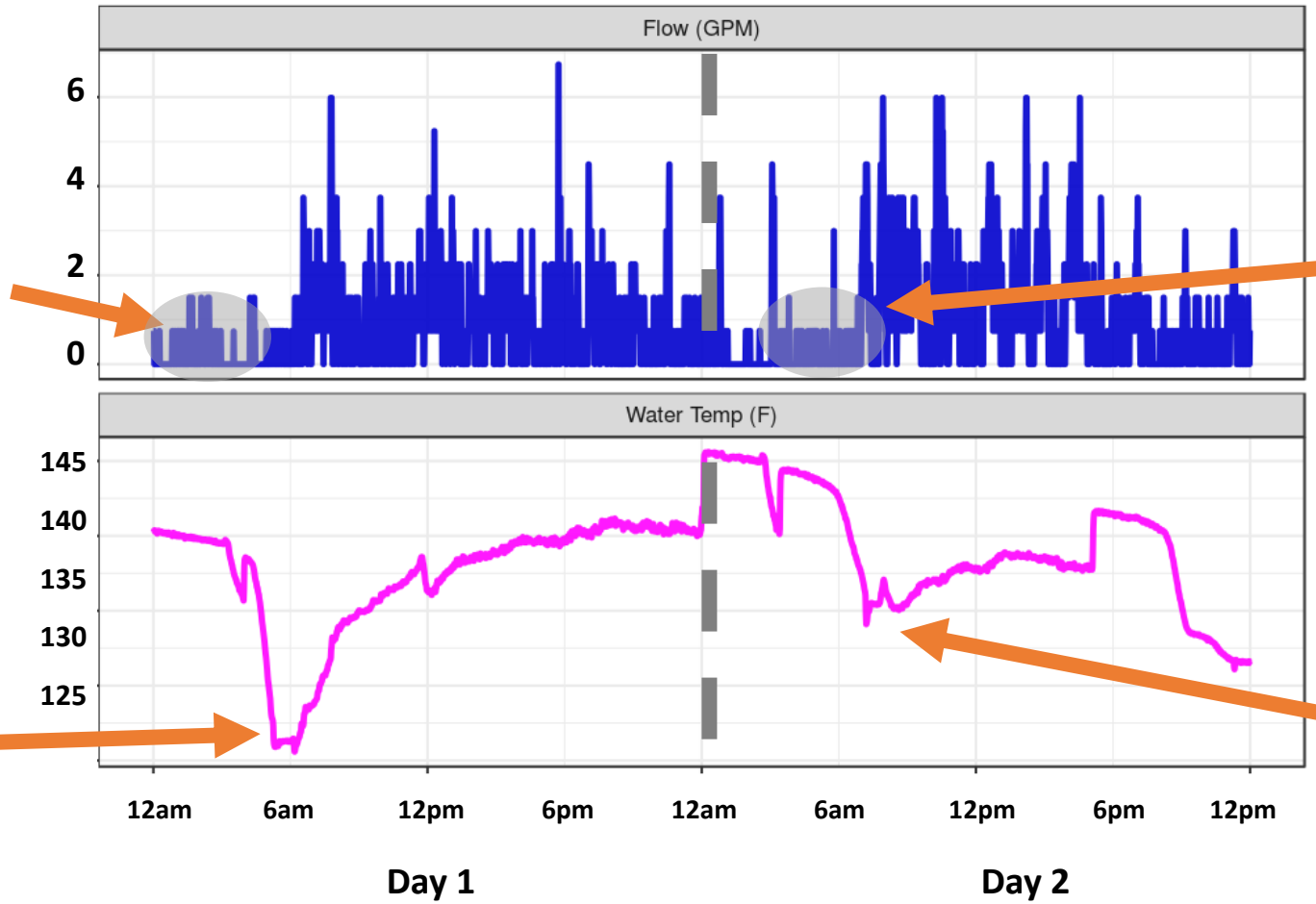
Multi-Pass

Heats up water to working temp in multiple pass

Loop or Swing Tank with Single Pass



Swing Tank with Single Pass



Low overnight hot water use

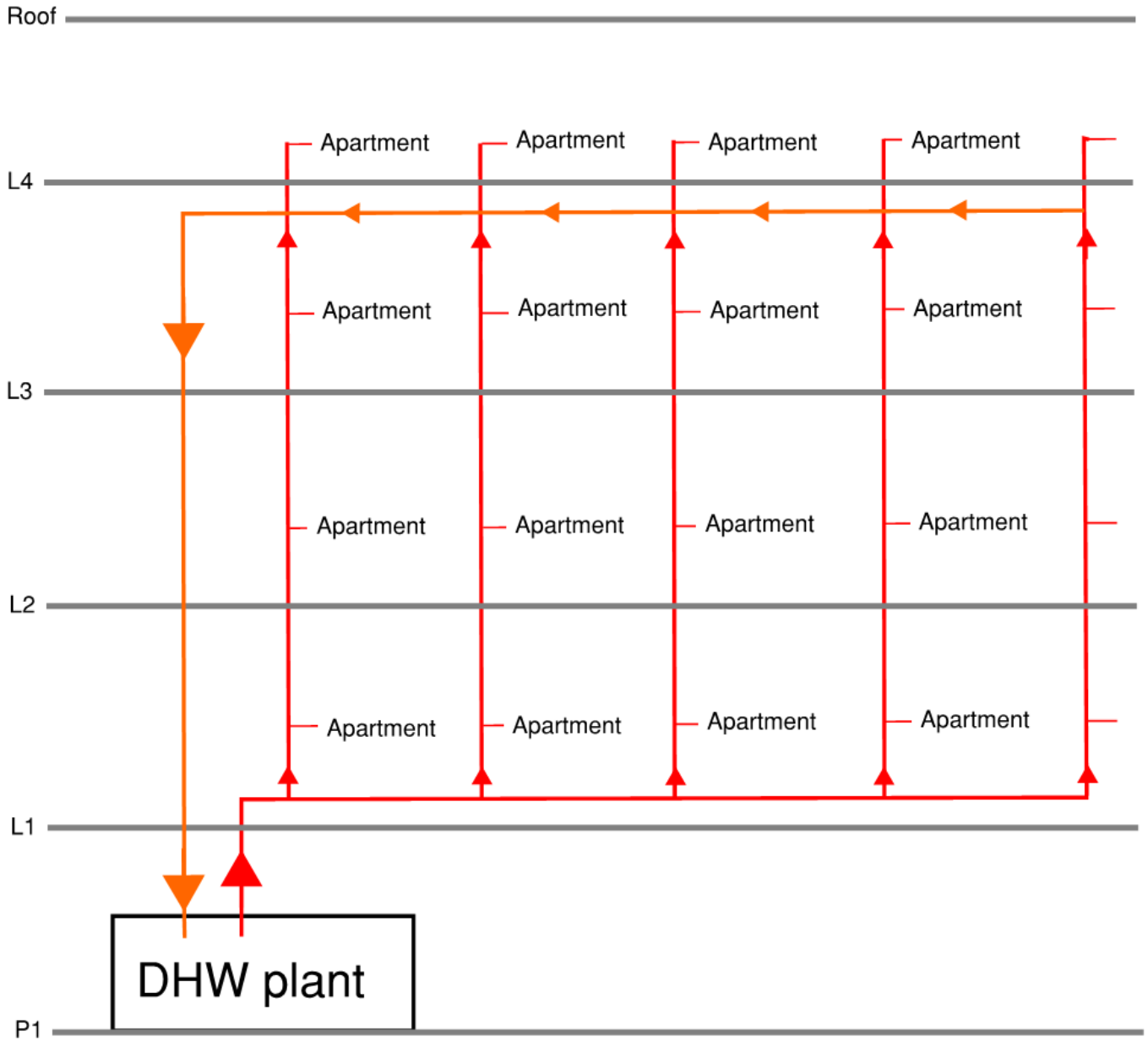
High (enough) overnight hot water use

Swing temperature drops

Helps keep temperature up

2 Loads in any Central HPWH system

- Primary Heating:
  - Heating water for use
  - Making cold water hot
  - 16-22 gal DHW/pp/day
- Temperature Maintenance:
  - Reheating water due to energy losses in the distribution system
  - Keeping hot pipe hot.
  - 40-120 W/Apt.



High Level Strategic Goals (3-5 Year)

- Heat Pumps are Standard Practice in New Construction and =Retrofit
- Deliver COP of 3.0 for HPWH
- Use Low-GWP Refrigerants (GWP<10)
- Plug-and-Play
- Cost Effective
- Reliable and Redundant systems
- Ability to Load Shift

Advanced Water Heating Initiative (AWHI)

Advanced Water Heating Initiative (AWHI)

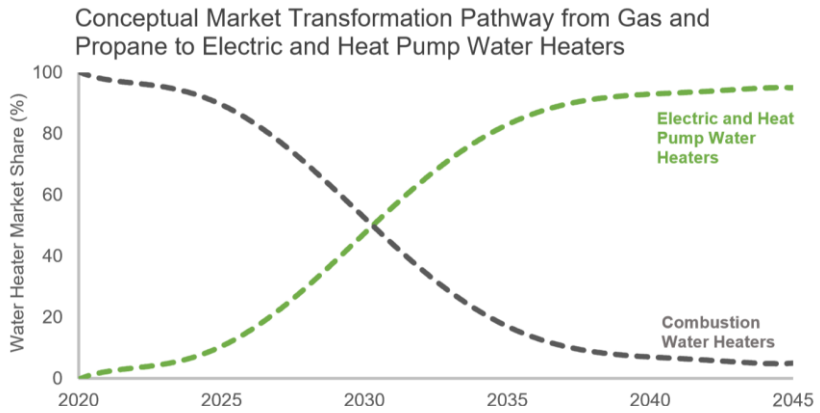
Current Advanced Water Heating Intiative Members:

1. Association for Energy Affordability
2. BC Hydro
3. Beyond Efficiency
4. Bonneville Power Adminstration (BPA)
5. Bradford White Water Heaters
6. Building Decarbonization Coalition
7. California Energy Commission (CEC)
8. Carbon Free Silicon Valley
9. California Public Utilities Commission (CPUC)
10. East Bay Community Energy
11. Ecotope
12. Efficiency First CA
13. Energy Solutions
14. Electric Power Research Institute (EPRI)
15. GE Appliances
16. Grasteu Associates
17. Guttmann & Blaevoet's
18. HTP Comfort Solutions LLC
19. HWR
20. Laars Heating Systems
21. Larson Energy Research
22. Los Angeles Dept. of Water & Power (LADWP)
23. New Buildings Institute (NBI)
24. Northwest Energy Efficiency Alliance (NEEA)
25. National Renewable Energy Lab (NREL)
26. National Resources Defense Council (NRDC)
27. Nyle
28. Pacific Gas & Electric (PG&E)
29. People's Self Help Housing Corp
30. Redwood Energy
31. Repcor Plumbing
32. Rheem
33. Sacramento Municipal Utility District (SMUD)
34. Sanden
35. Silicon Valley Clean Energy
36. Southern California Edison (SCE)
37. StopWaste
38. Skycentrics
39. Turnbull Energy

BUILDING DECARBONIZATION COALITION

nbi new buildings institute

2020 Working Groups
1. **120V Unitary HPWHs**
2. **240V Unitary HPWHs**
3. **Central HPWHs**
4. **Connectivity and Controls**



AWHI's Market Transformation Approach

The collaborators on the Advanced Water Heating Initiative range from manufacturers, to efficiency advocates to utilities and others interested in increasing the market share for these products. They are working to build better awareness among consumers and understanding of the product value. In addition, AWHI is helping installers and builders understand the opportunities for specifying HPWHs and is supporting the supply chain to break down the barriers preventing HPWHs from market adoption.

Specific objectives of the AWHI include:

- Provide alignment in the design, marketing and messaging efforts for a coordinated effort surrounding HPWHs which will assure the manufacturing industry to invest more in this technology.
- Support utilities with efficiency program offerings. Programs will provide strategic utility investments in heat pump water heating market chain development and program incentives in order to catalyze overall market transformation.
- Bring all the key stakeholders i.e. policy makers, program administrators, utilities, manufacturers, installers, industry experts, etc. together to share their experience and learn from each other in order to move the market in the same direction.

To achieve these ends, the AWHI consortium has established four working groups that are focused on market deployment of 120V unitary HPWHs, 240V unitary HPWHs, Central HPWHs, and connectivity and controls of all units.

2020 Working Groups
1. **120V Unitary HPWHs**
2. **240V Unitary HPWHs**
3. **Central HPWHs**
4. **Connectivity and Controls**

The initiative and the working groups rely on the support and contributions from our members. How can heat pump water heaters support your service territory, project, or jurisdiction? Join the initiative, participate in a working group, or support the initiative directly to help us shape the future of the heat pump water heater market.

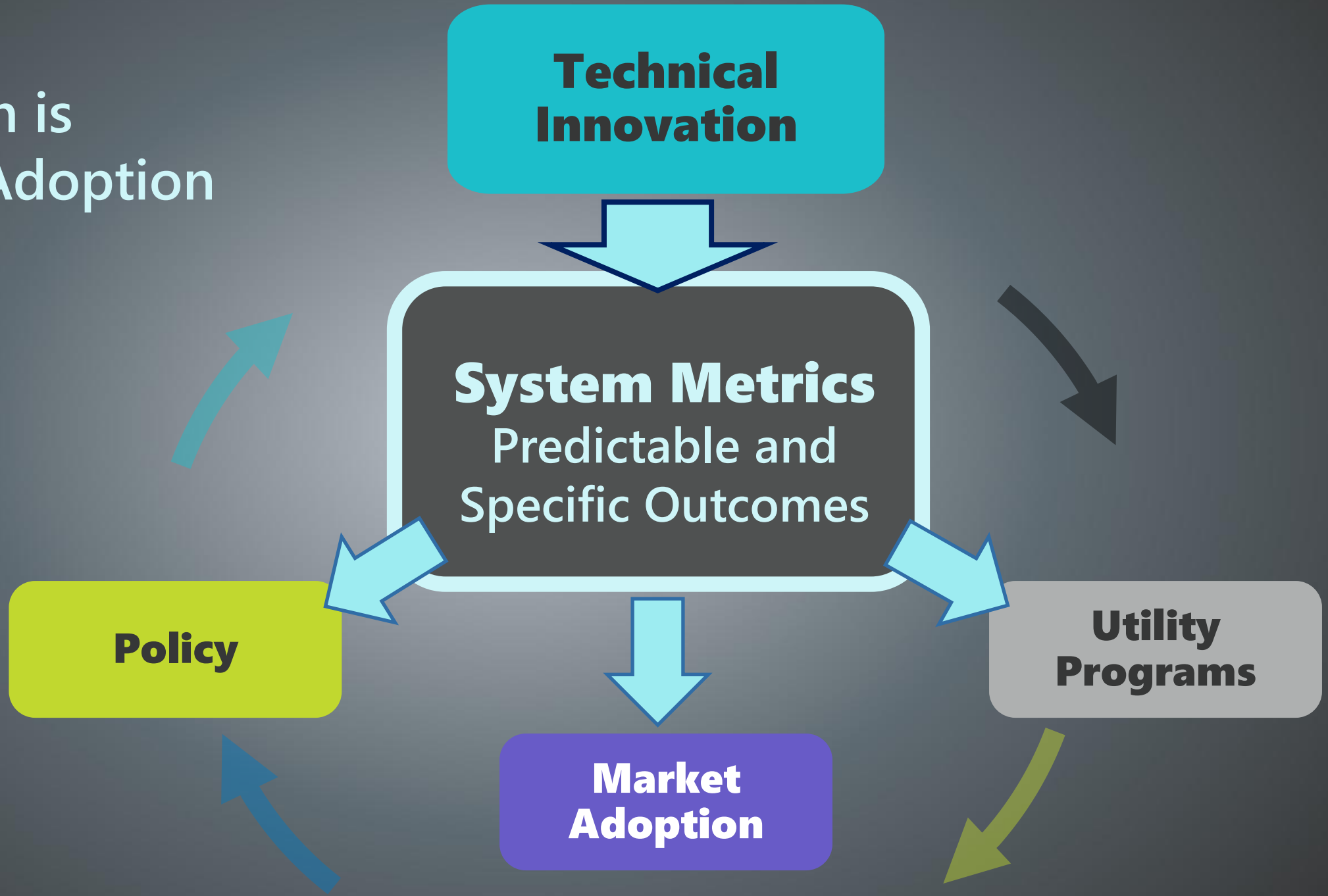
Join us! To learn more, or to join the Advanced Water Heating Initiaitive or a working group, contact Amruta Khanolkar, NBI project manager, at amruta@newbuildings.org. Sign up to get the latest news by email.

BPA – Central Heat Pump Working Group Lead (AWHI)

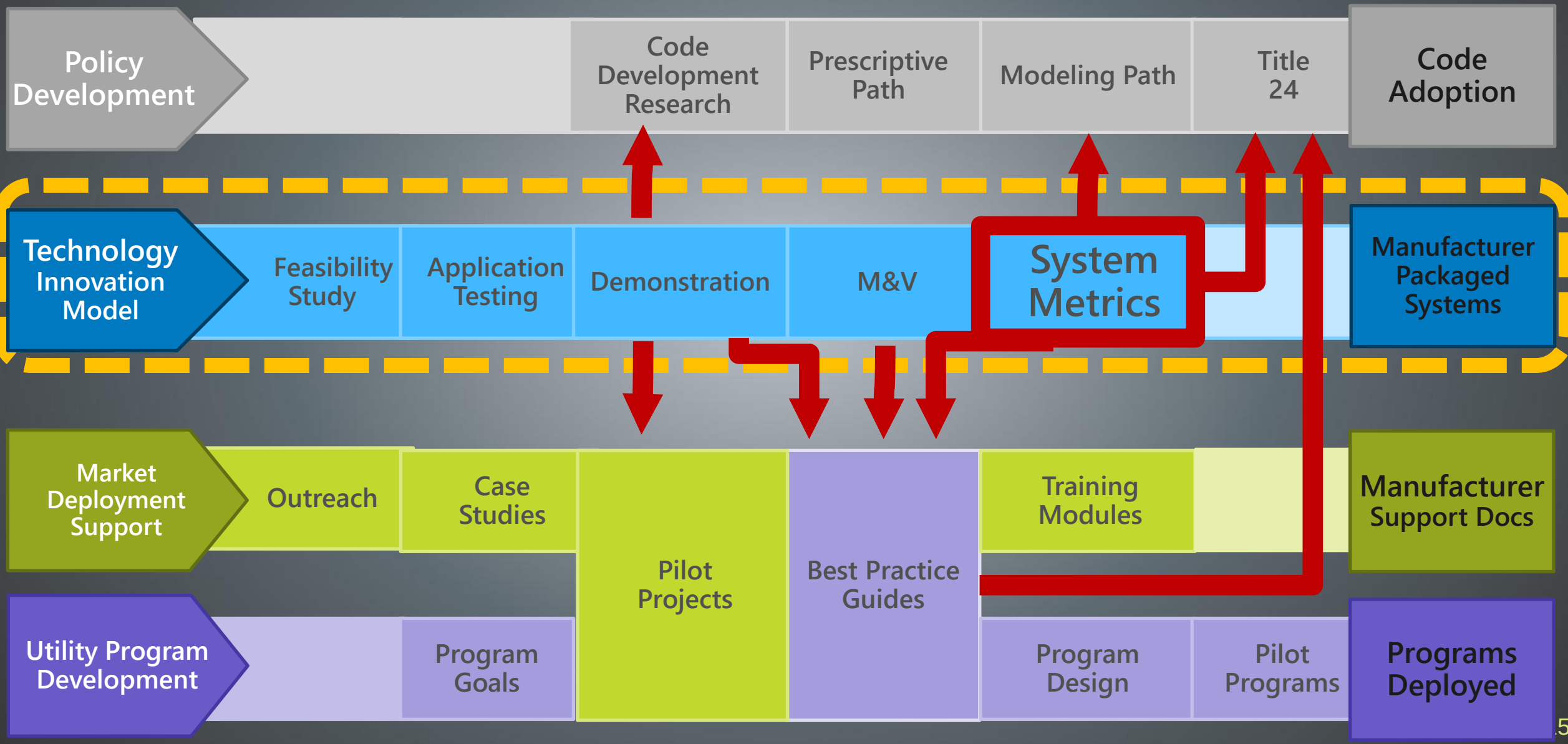
The shorter term tactical goals are:

- Use Technology Innovation Model to support development of new products, support incorporation of existing products in the market, and push industry to fully integrated plug-and-play solutions – away from custom engineering to support rapid wide-scale adoption.
- Expand communication between all parties working in this field and improve coordination, standardization of language and metrics, and coordinated funding for priorities.
- Expand CBECC-RES simulation tool to allow for additional available HPWH technologies (Colmac and Nyle single-pass are next)
- Expand CBECC-RES tool to allow for multi-pass configurations and equipment
- Use existing high GWP refrigerant equipment as bridge while low GWP equipment is developed and brought into the market.
- Use PG&E test lab to test impact of wide range of installation variables – especially associated with handling of hot water recirculation and controls settings
- Create open source free sizing tool for HPWHs with support for designing for load shifting
- Advocate for expanded research on temperature maintenance system losses and load shapes for range of commercial applications.

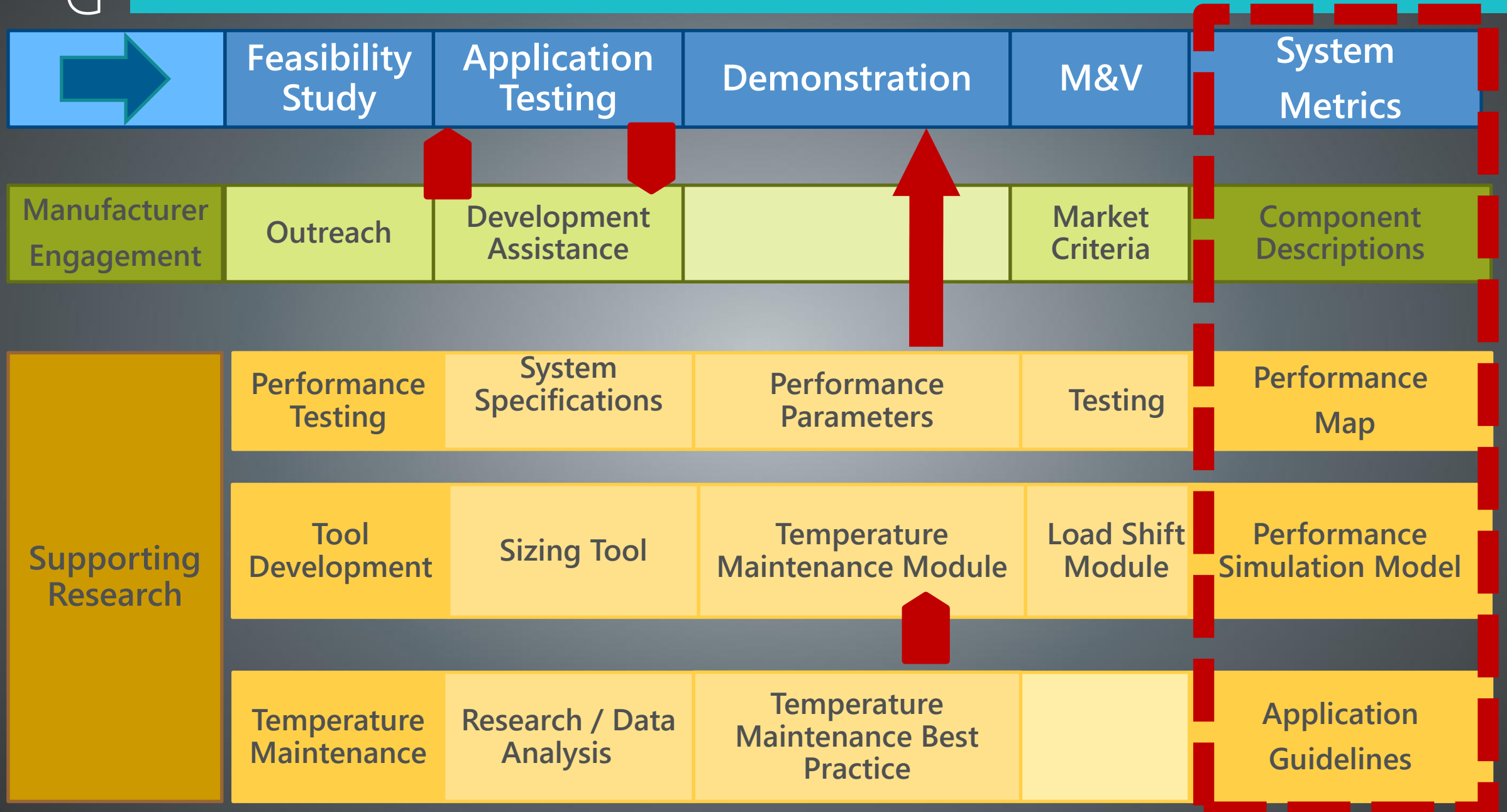
Technical Information is Critical to Adoption Pathways



Parallel Development Paths



Technology Innovation Model (TIM)



Current Heat Pump Options for Central Hot Water Heating

- Ganged up 134a Integrated Res. Units (Rheem, AO Smith, etc.)
- Sanden CO2 Ganged Up Prescriptive Design
- Colmac 134a Single Pass Central HPWH and Controls
- Nyle 134a Single Pass Central HPWH and Controls
- Multi-Pass 410a Products (Colmac, Nyle, Aermec)
- Mitsubishi CO2 in pilot testing phase of the TIM

HPWH Tool Development

Central HPWH Sizing Tool - "HPWHuLater"

Expected September, 2020

HPWHuLater - Multifamily Central HPWH Sizing Tool (Beta Proof of Concept)

Select the Demand Type

Market Rate with Low Flow Fixtures (20 GPD per person)

Advanced Options ☑

Or Input GPD per Person

22 Range: 18 - 46 GPD Per Person

Are the Apartments Individually Metered?

Yes

Choose Input Method:

Number of People and Number of Apartments

Number of Units		
Qty	Unit	Occupancy Rate
8	Studio	1.4
8	1 BR	1.7
12	2 BR	2.6
5	3 BR	3.1
2	4+ BR	4.2

Number of People and Number of Apartments	
100.1	Number of People
65	Number of Apartments
100.1	People Calculated
65	Apartment Calculated

Enter Design Temperatures

150	°F Primary Storage Temperature
50	°F Minimum Cold Water Supply Temperature
120	°F Hot Water Supply Temperature to Occupants
24	°F Design Air Temperature (Coldest Air Temperature Expected for the Sanden to Expeirence)

Primary Storage Size

Minimum Storage:	688	Gal
Storage Tank Size:	250	Gal
Number of Storage Tanks:	3	
Total Storage:	750	Gal

Look up by primary storage volume (Gal):

487 Gallons

Primary Heating Size

Heating Capacity:	6.1	Tons	14.7	Tons for Primary
Number of Sandens:	6	Units	13	Units

Temperature Maintenance

Storage Volume:	442	Gal
Heating Capacity:	1.7	Tons or
	5.9	kW

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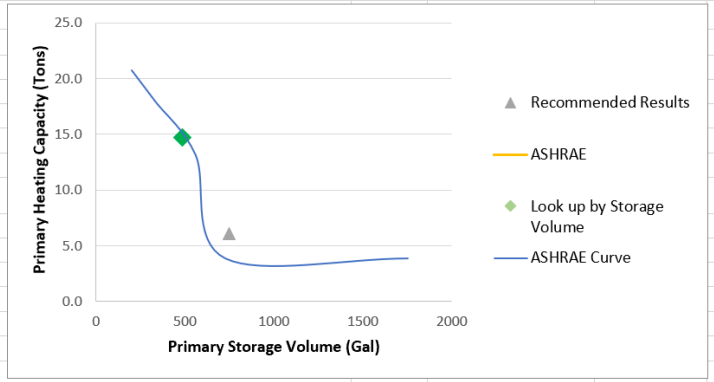
Advanced Options

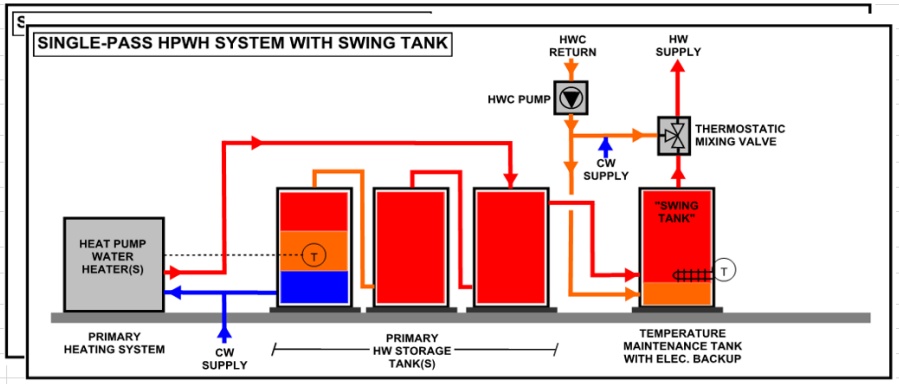
Water Heater Characteristics

Parameter	Input	Recommended Values	Units
% Of Useable Primary Storage Volume	0.8	0.8 - 1.0	
Max Daily Compressor Run Hours	16	12 - 16	hours
Defrost Factor	0.9	0.9	

Recirculation Loop Losses

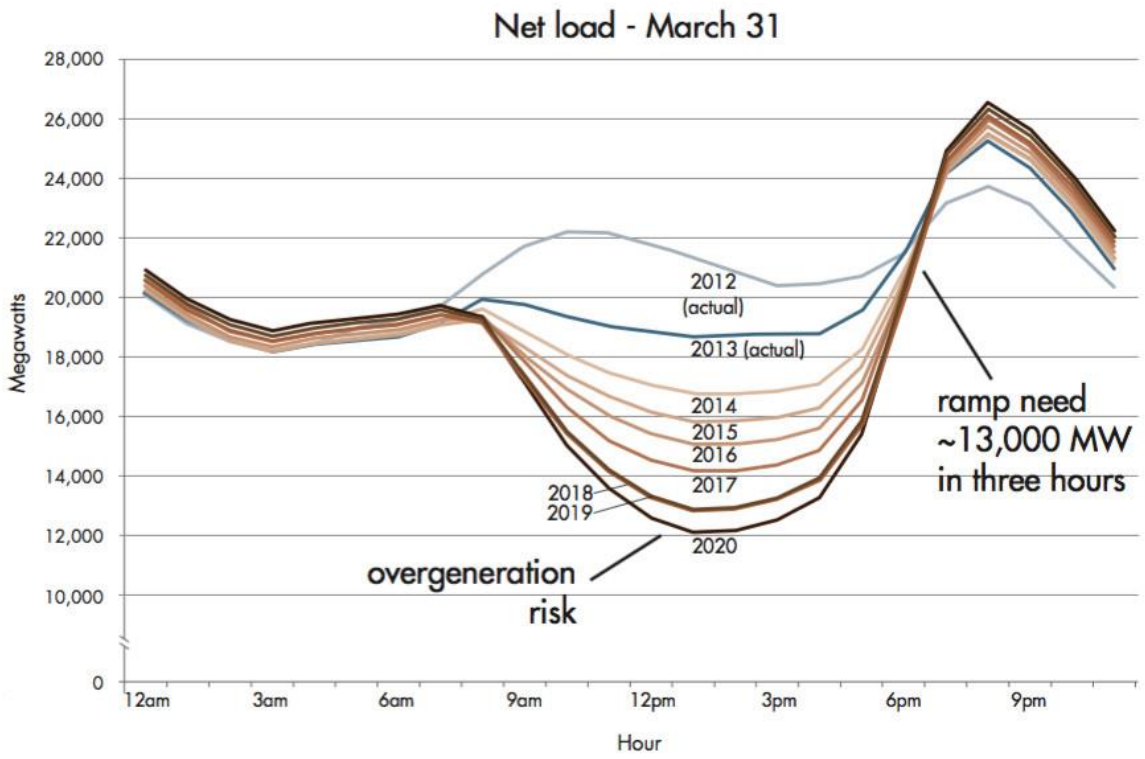
Parameter	Input	Recommended Values	Units
Recirculation Loop Heat Loss Rate	90	70 - 120	W/apt
Swing Tank Resistance Turn On Temperature	122	120 - 125	°F
Nightly No Draw Span	5	3 - 8	Hours

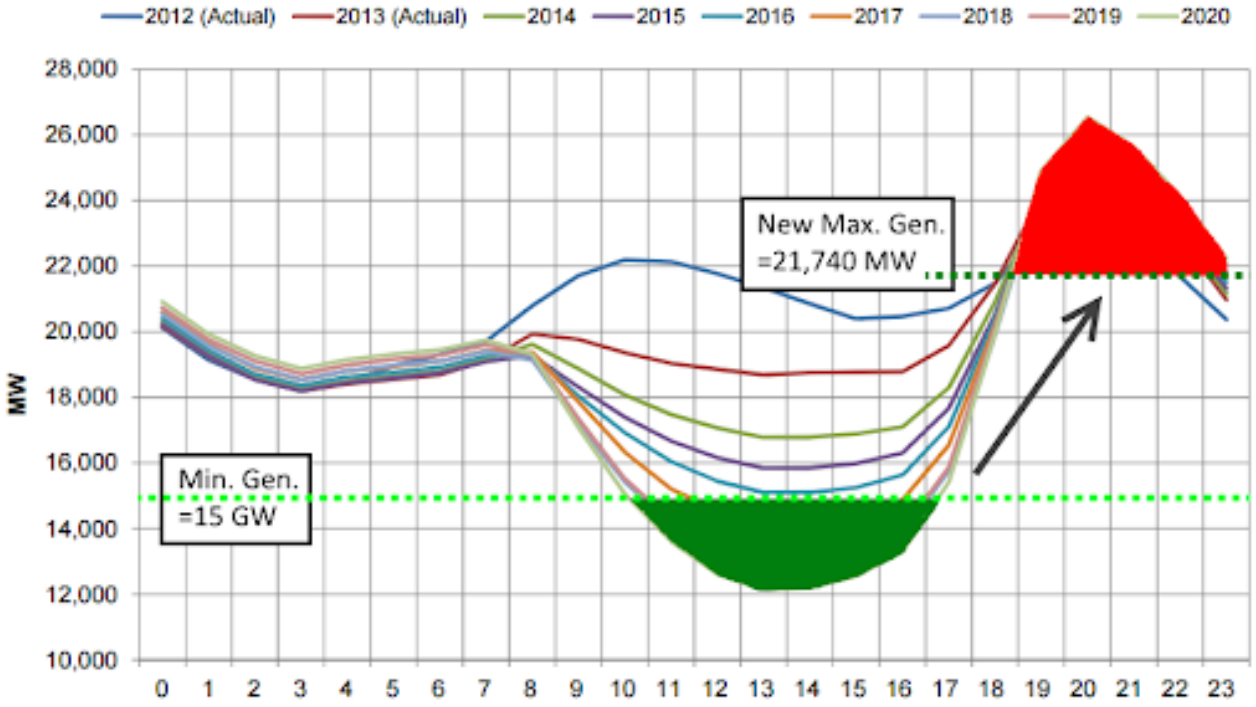




Load Shift Sizing and Modeling

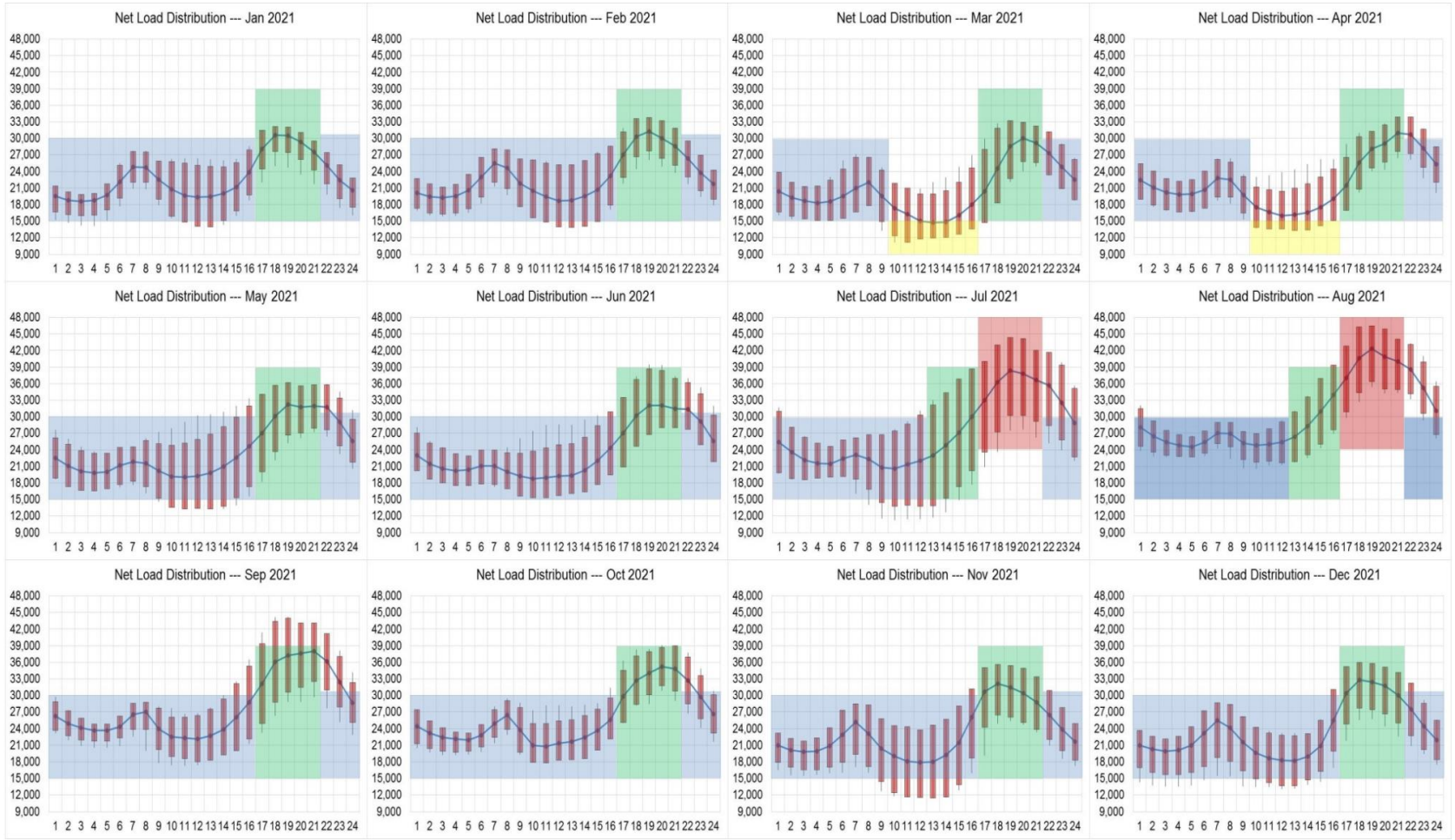
Figure 2: The duck curve shows steep ramping needs and overgeneration risk





Load Shift Sizing and Modeling

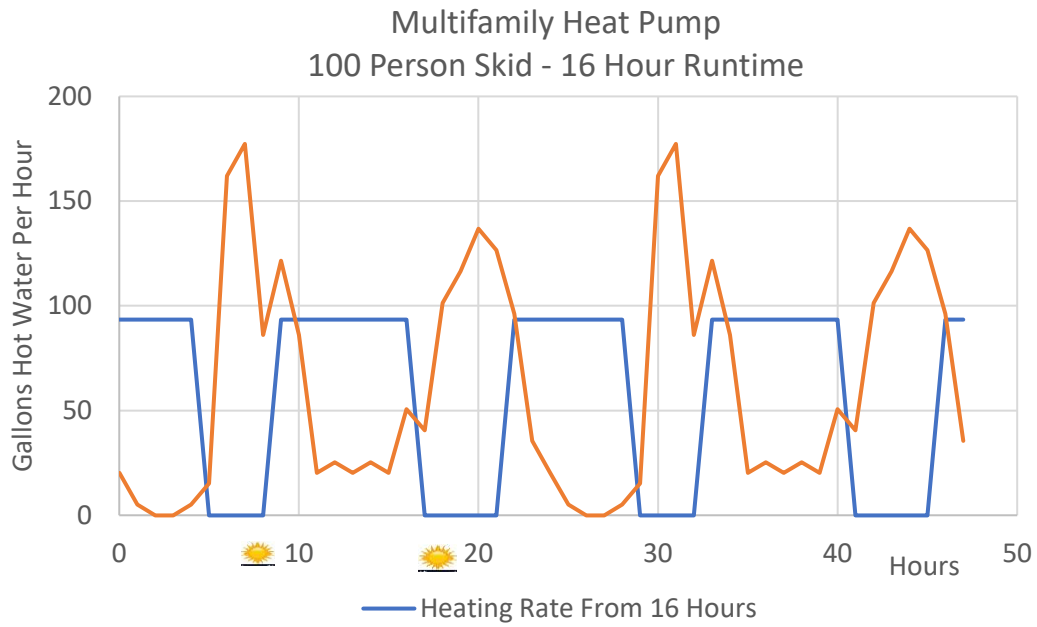
Forecast 2021 WeekDAY Monthly Net Load Distribution

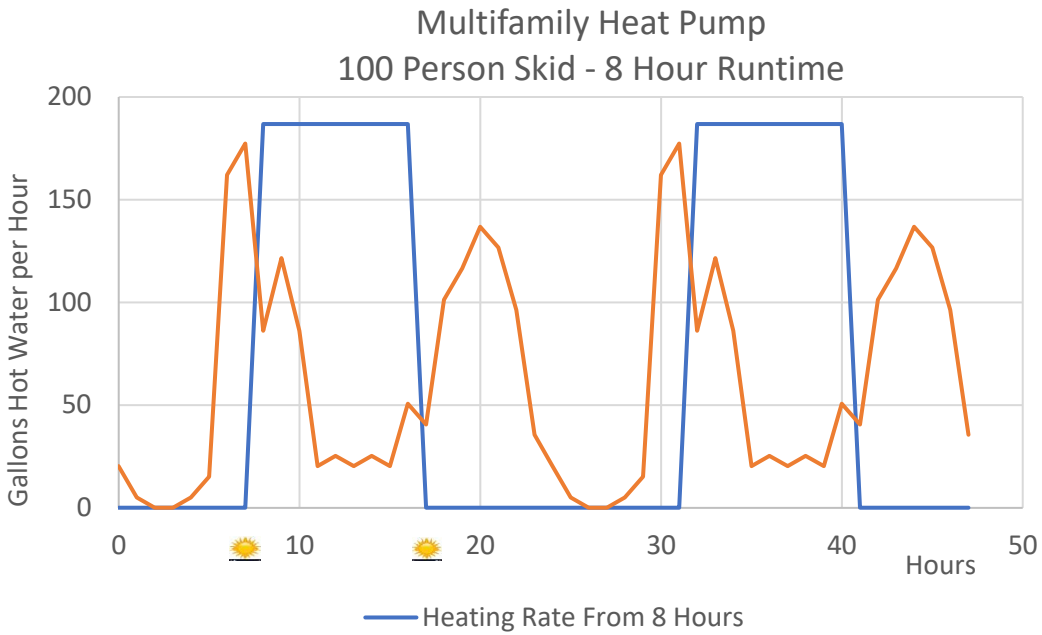


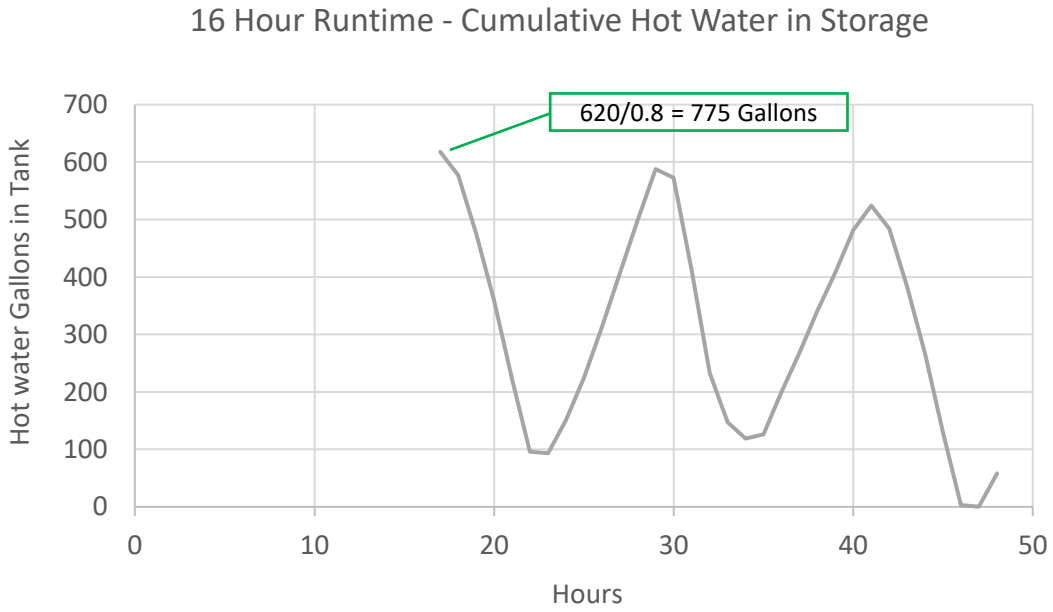
http://www.caiso.com/Documents/CaliforniaISO_Time_UsePeriodAnalysis.pdf

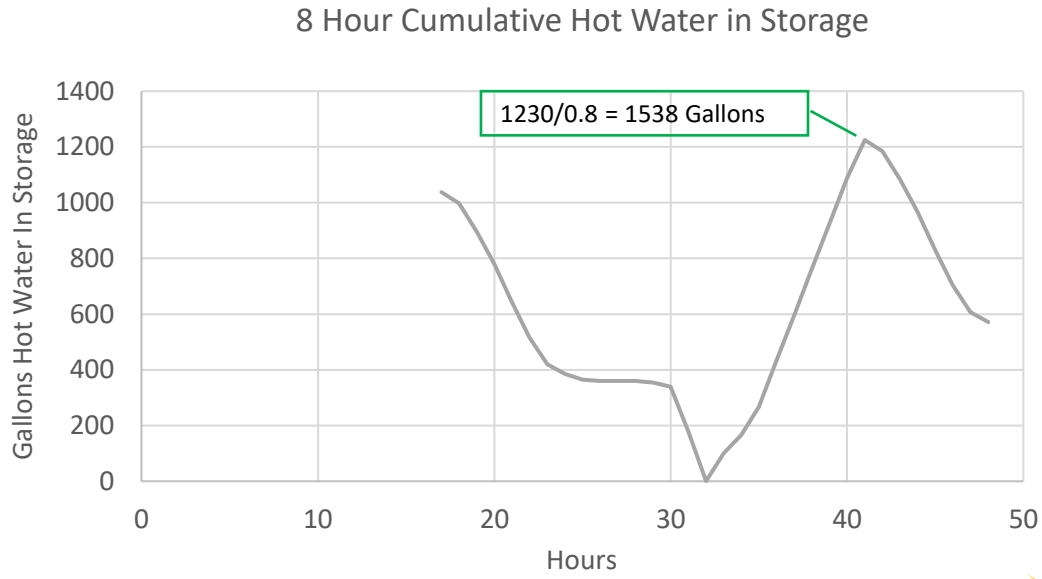
Load Shift Sizing and Modeling

Grid Harmonization









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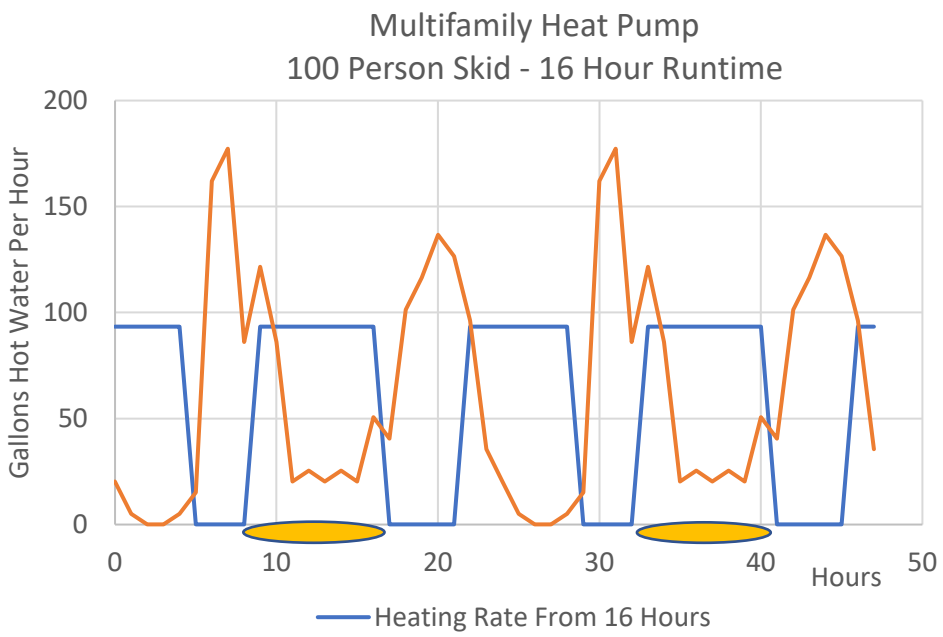
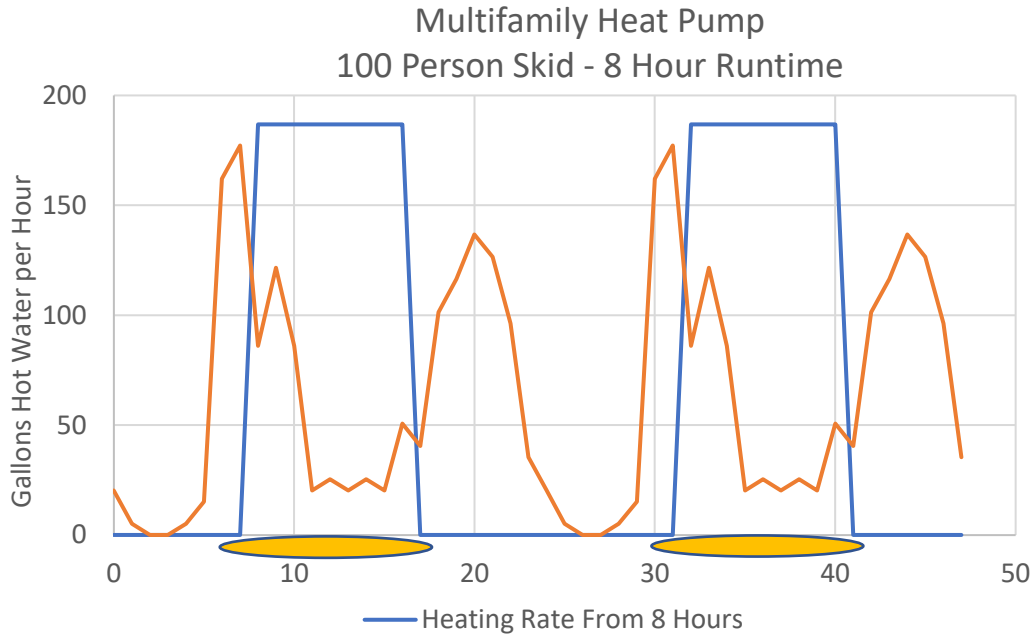
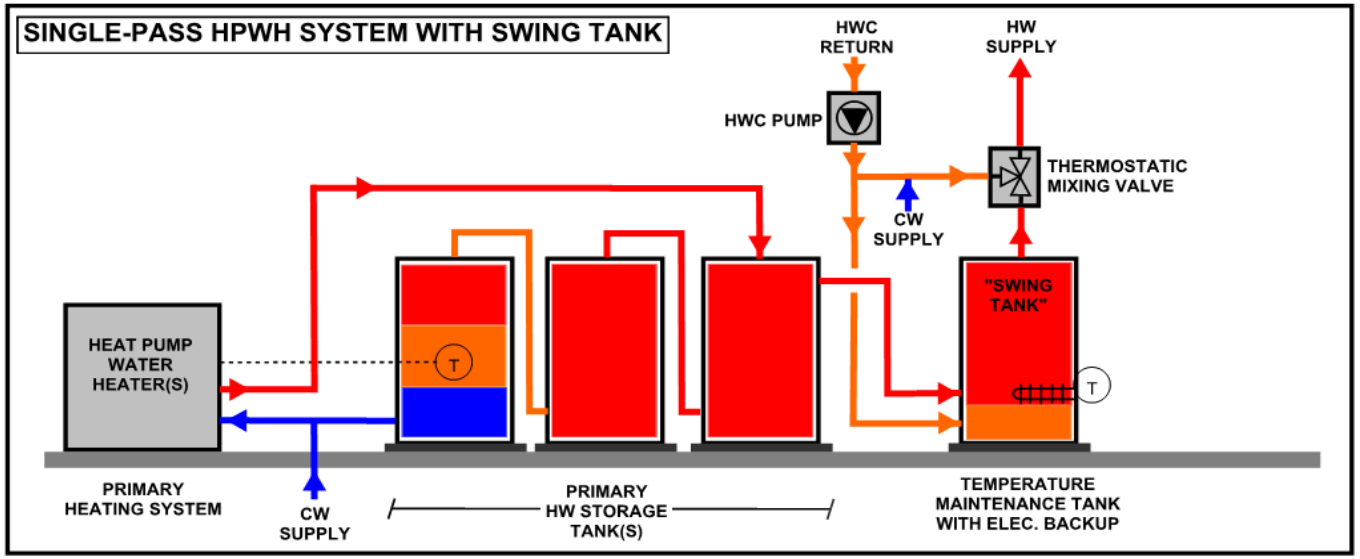
Load Shift Sizing and Modeling





100 Person Skid Sizing

	Tons	Storage	kW	Watts/apt
16 Hrs	6.1	775	6.6	120
8 Hrs	12.1	1538	13.2	240



Prescriptive Central Heat Pump Water Heating Design

Prescriptive Central Heat Pump

Docket Number: 19-BSTD-01
Project Title: 2019 Alternative Calculation Method Reference Manuals and Compliance Software Tools
TN Number: 231318
Title: Excecutive Director Determination Pursuant to Section 1501(c)8C for Central Heat Punmp Water Heating System
Description:
Filer: Danny Tam
Organization: California Energy Commission
Role: Commission Staff
Submission Date: 12/26/2019 9:43:32 AM
Docketed Date: 12/26/2019
Subject(s):
Submission Type: Document
Page(s): 7

Temporary solution to allow central heat pump water heaters in Title 24 compliance software while the policy/software changes in CBEC RES/COMM are being developed.

ECOTOPE

Prescriptive Central Heat Pump Specification

"Executive Director Determination Pursuant to Section 1501(c)8C for Central Heat Pump Water Heating Systems",

Controls Required to Power on/off heat pumps and send alarms on failure

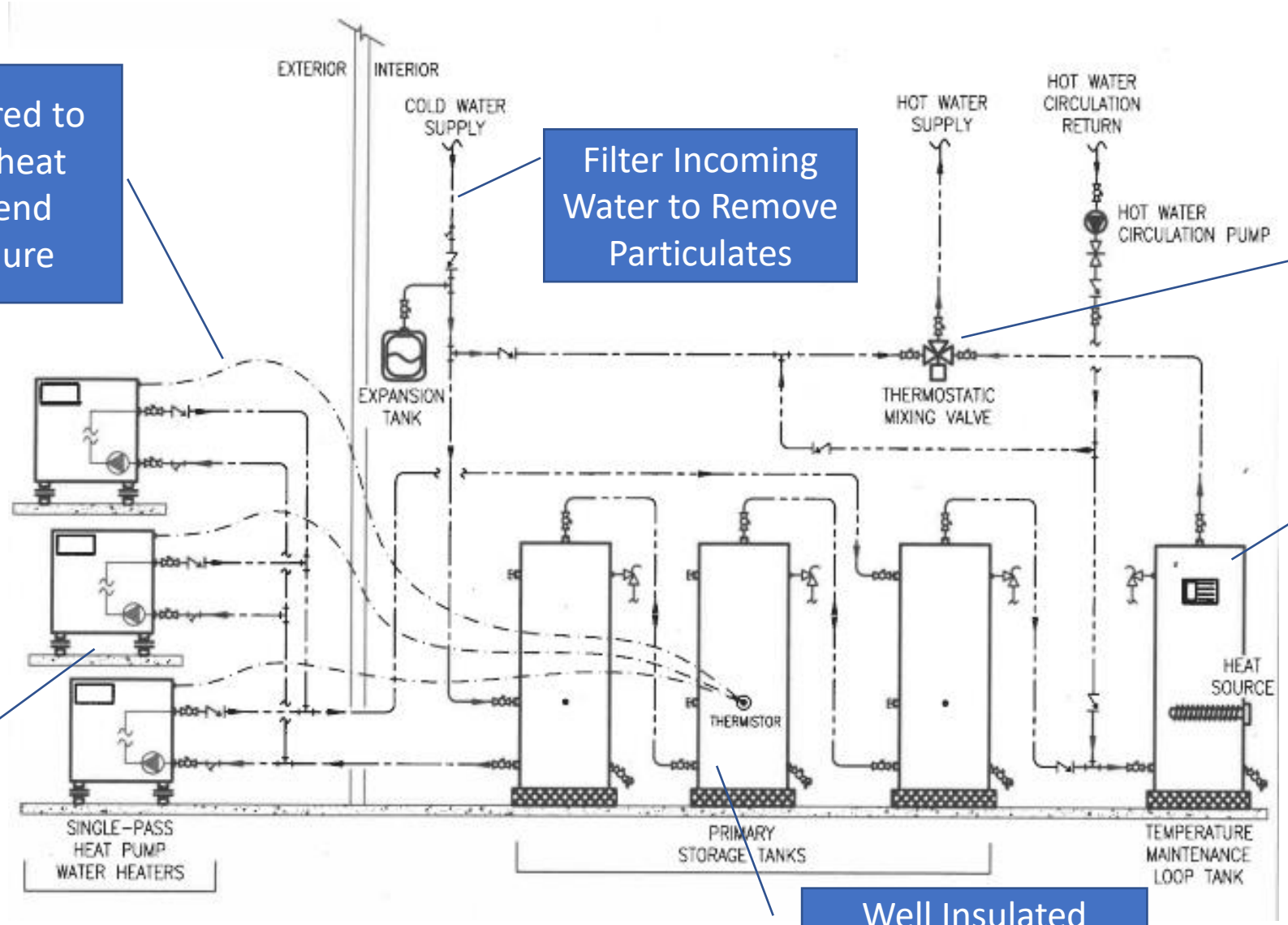
Filter Incoming Water to Remove Particulates

Electronic Thermostatic Mixing Valve

Swing Tank or Loop Tank sizing critical to system performance

Follow Manufacturer Recommendations for Heat Pump Installation

Well Insulated Storage (R-22) on R-10 Pad



Prescriptive Sizing

5. System Sizing

   a. The number of HPWH compressors shall be no less than calculated by Equation 6.1. (Each compressor heating capacity assumed to provide 15,400 BTU/hr)

      Equation 6.1 Compressor(s) = (0.037 * Bedrooms) + (0.106 * Dwelling Units)

   b. The primary storage capacity shall be no less than shown by Equation 6.2.

      Equation 6.2 Primary Storage = 80 gallons * number of compressors

Loop Tank Sizing Table

Number of Dwelling Units	Minimum Capacity (Gallons)
1 - 7	40
8 - 11	80
12 – 23	96
24 – 47	168
48 – 95	288
96 and greater	480

Example Prescriptive Sizing: Market Rate – 60 Units, 90 Bedrooms

ECOTOPE

Heat Pump Sizing

(.037)*90 + (.106)*60 = **9.7 compressors**

9.7 compressors *15,400 btu/hr = 149,226 btu/hr = **12.1 Tons**

Primary Storage

9.7*80 gal = **775 gallons at 120F**

= 620 gallons at 150 F

Loop "Swing" Tank Storage:

60 units from table is 288 Gallons of storage

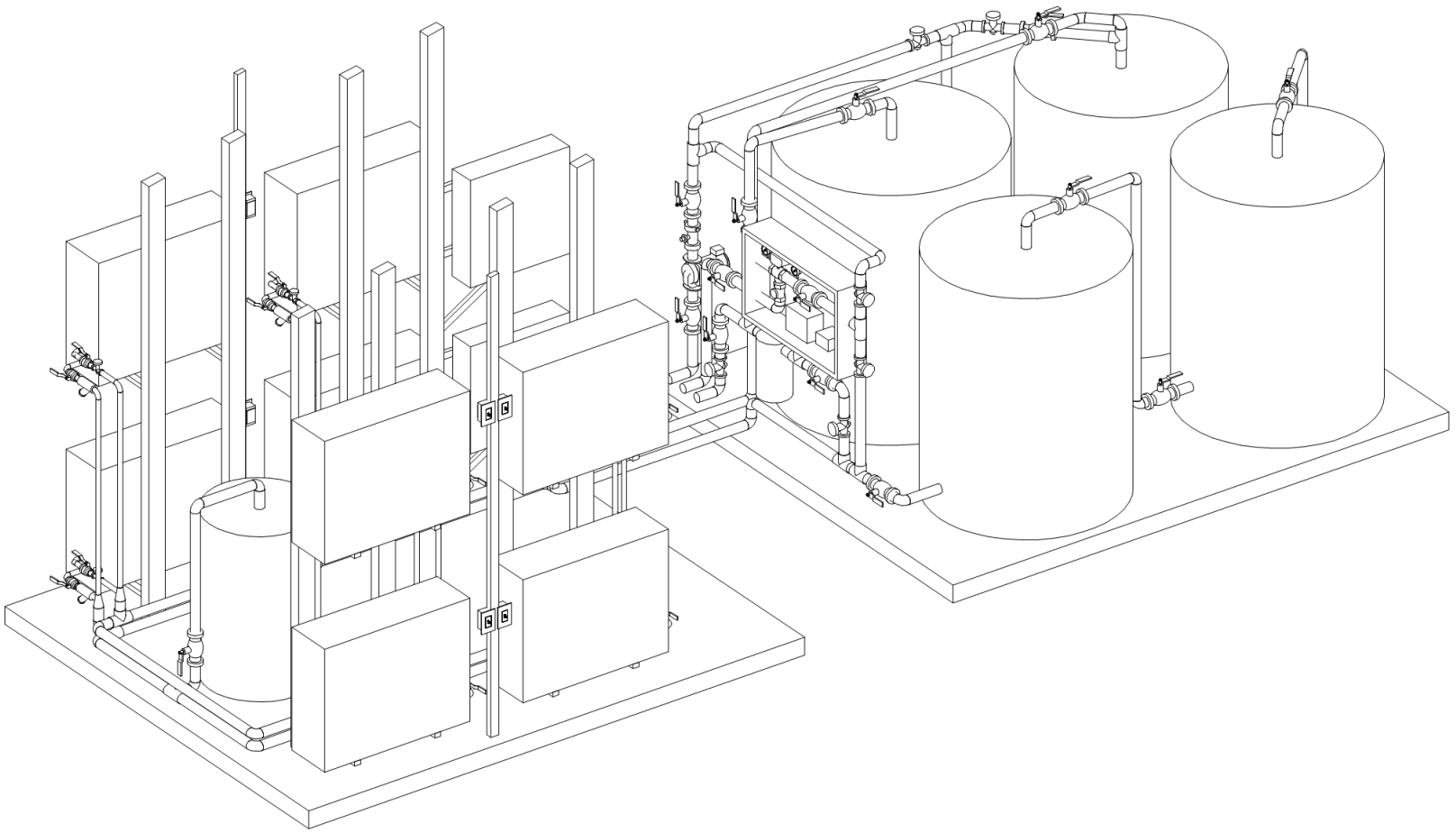
Loop "Swing" Tank Backup Heat:

Temperature Maintenance Load ~ 100W/Apt = **6kW**

System Backup Power – (TM Load * 2.5) = **15kW**

Plug and Play DHW Skid Development

Manufacturer Plug and Play Packages Development



100 Person, Load Shift Capable, Plug and Play Sanden Skid for Menlo Park Apartment Projects (840 units)

- Working with Manufacturer to develop standardized packages around number of people served (25, 50, 75, 100 people)
- Crane up to roof, mount to stanchions plug in water lines, electrical lines, internet and ready to go.
- System will be configured around a skid of storage and a skid of heat pumps and controls.
- Controls add on for Monitoring, M&V systems and DDC connection
- Load Shift Capable
- COP 3.5 (Annual)

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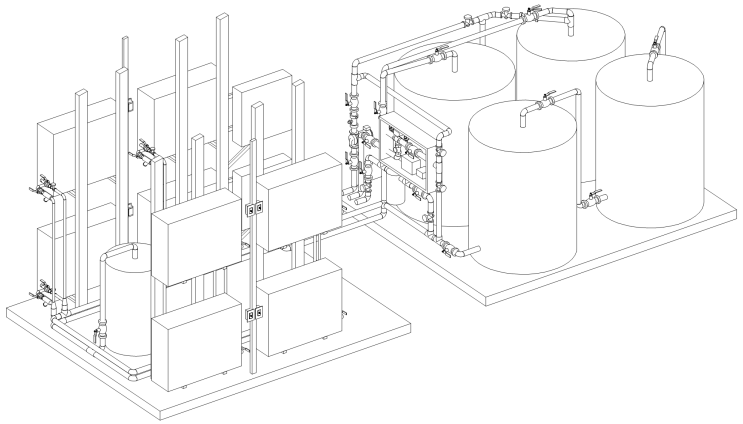
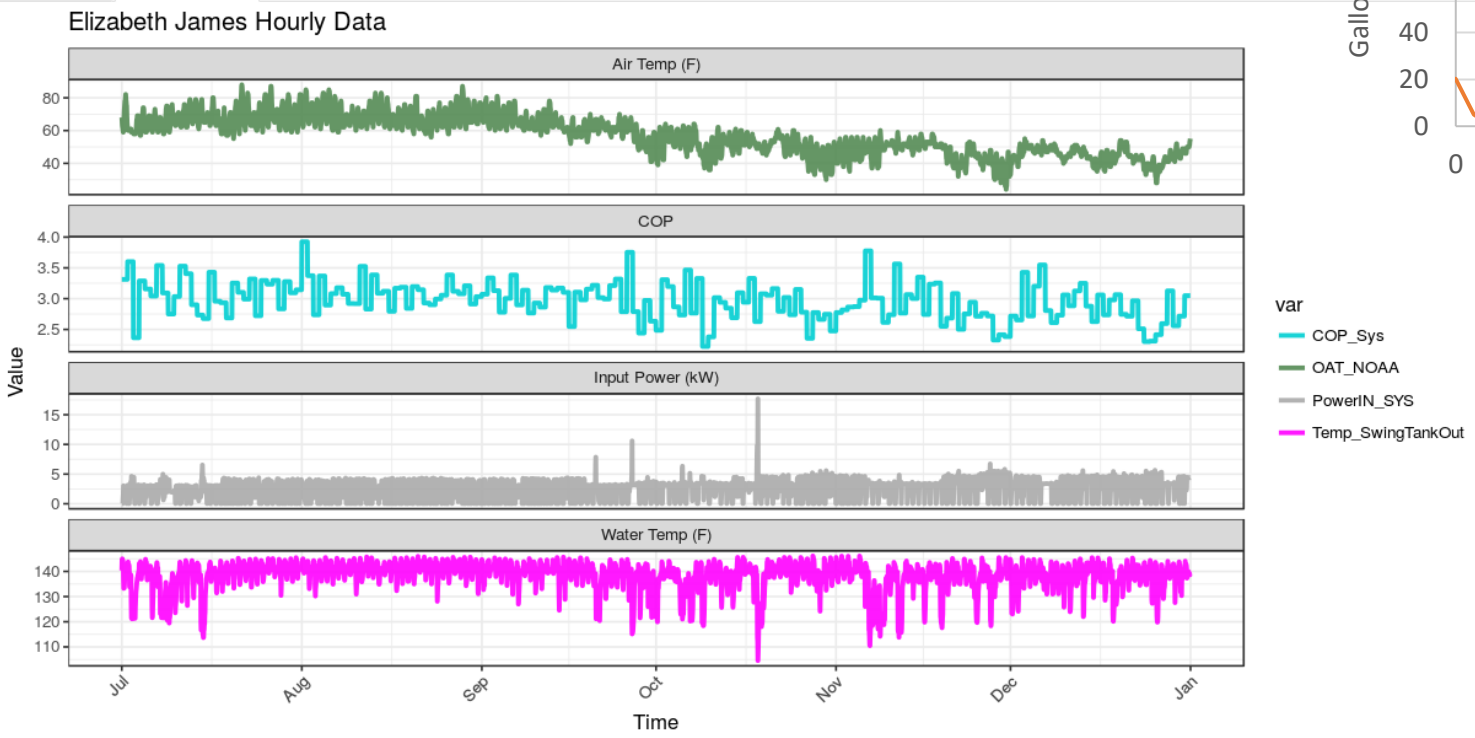
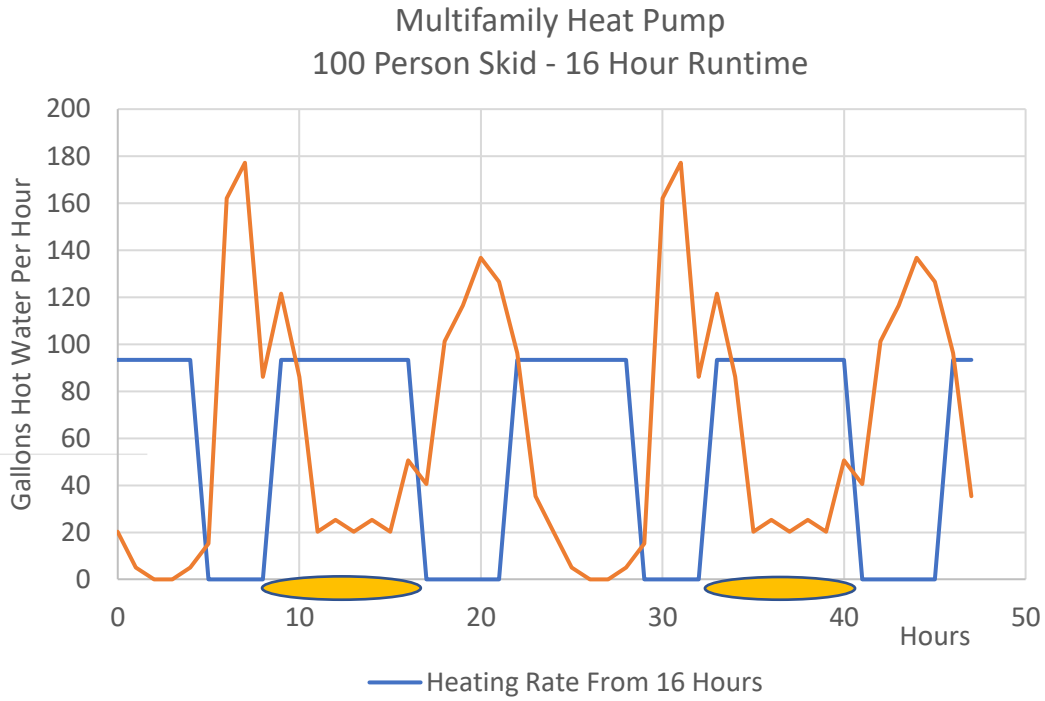
Manufacturer Plug and Play Packages Development



Raw Data | Hourly Means | Daily Means | Hourly Shapes | Variable Definitions | About





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ECOTOPE

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Ecotope counteracts the climate crisis with research-proven engineering and visionary leadership; we drive the building industry toward transformative and scalable low-carbon solutions, informed by four decades of learning and technical innovation. Our clients seek holistic designs that optimize energy efficiency and are in harmony with the future grid.