

High Performance Circulator (HPC) Pumps



CALIFORNIA
TECHNICAL FORUM

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Presentation Overview



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Objective: Review Cal TF & CPUC comments from 9/26/16 presentation and seek approval of final workshop

- Short Measure Review -
 - What is the measure?
 - What is the market?
 - What is the energy savings opportunity at stake?
- 9/26/16 Cal TF Questions & Answers
- Measure Case Field Study

Measure Description

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Base Case

Market Standard Pumping System

- None or Valve Controller
- No VFD
- Standard Induction Type Motor
- Wet End Pump



Grundfos UP 15-29 SU/LC

Measure Case

High Performance Circulator Pump

- Integrated “Self-Optimizing” Control Scheme
- Integrated VFD
- Electrically Commutated Motor (ECM, BLPM)
- Highly Efficient Wet End Pump

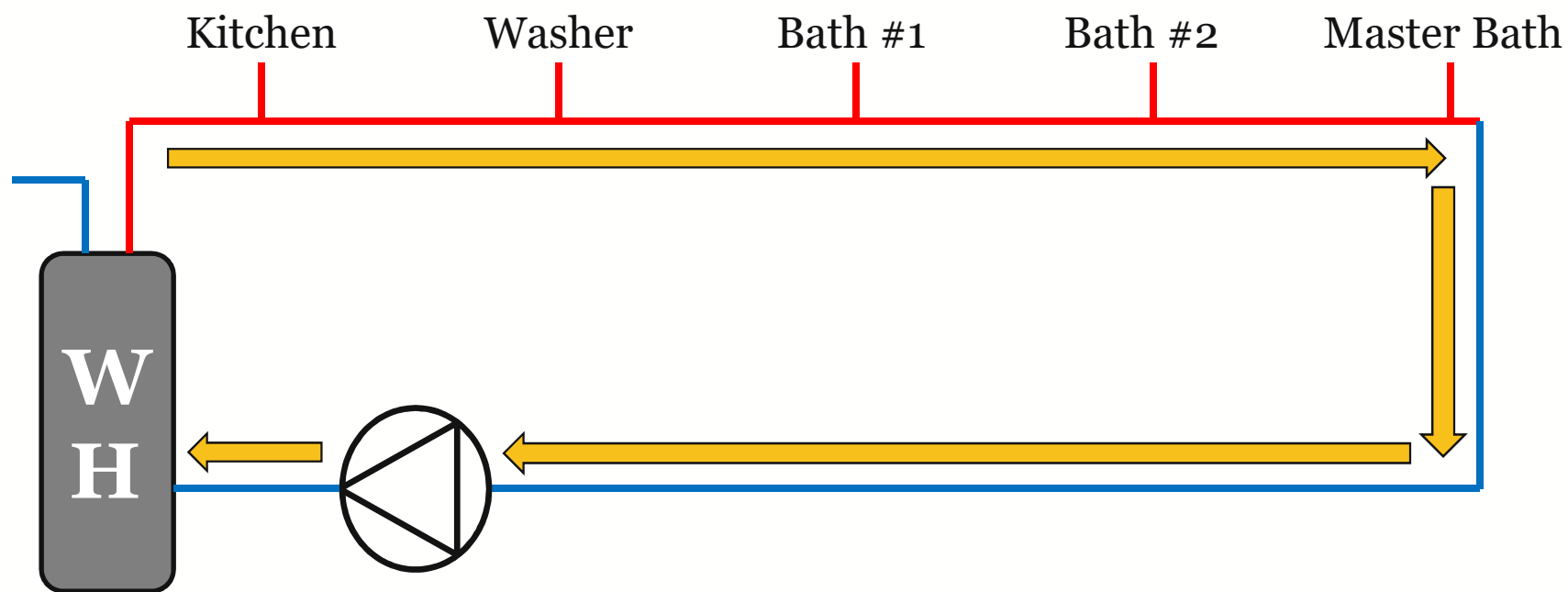


Grundfos Alpha 15-55 SF/LC

Measure Application

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Domestic Hot Water Recirculation



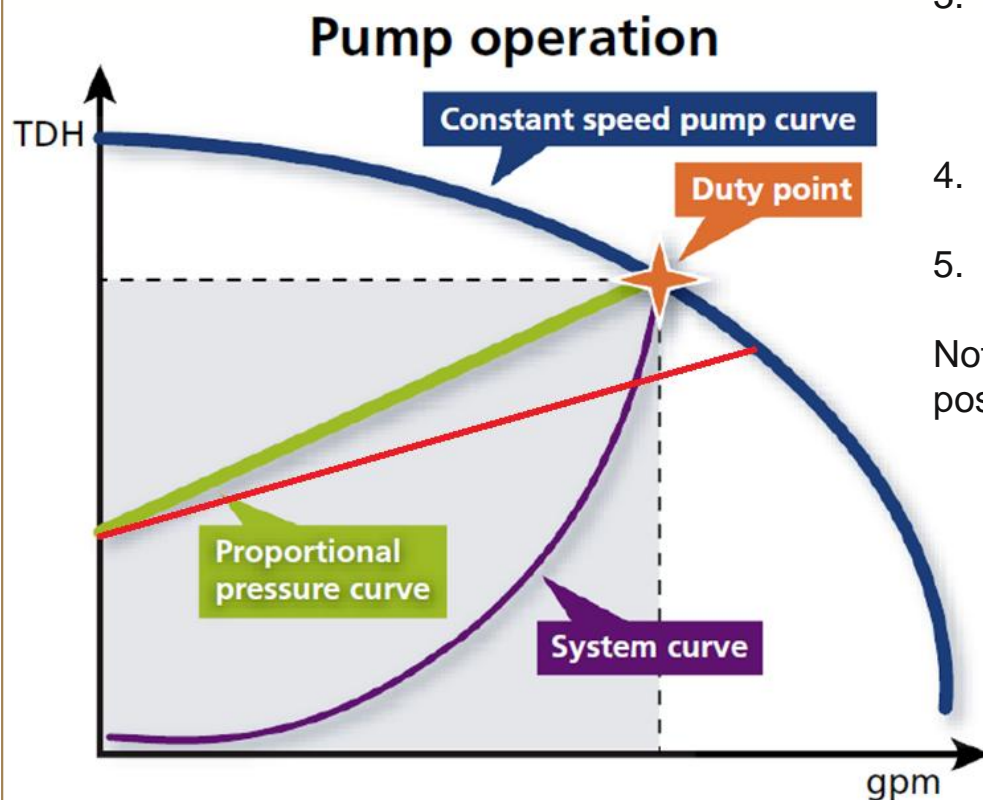
AutoAdapt Right-Sizing Method

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Example:

1. Begins at green proportional pressure line.
2. Settles on the left end green line in SS operation
3. If the required flow is more than the current intersection point of the system curve and green proportional pressure line. A new proportional pressure curve is created.
4. Pump now operates on the red proportional pressure curve
5. Settles to the left end of the red line to minimum flow required at SS operation

Note: there is a minimum head requirement that limits position on the curve along with minimum required flow



$$P(Hl) = \frac{Q(gpm) * TDH(ft)}{3960 * \eta_{pump} * \eta_{motor}}$$

Source: Putnam, Stephen. "Optimizing Unitary Pumping Solutions." *Consulting-Specifying Engineer*. February 2017: pg 52-57.

Measure Details

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- **Units:**

- kW & kWh Savings/ Pump (based on running watts)

- **Measure Application and Delivery Type**

- Replace on Burnout - ROB – Upstream (direct to wholesale distributors)

- **Eligibility**

- Climate Zones: All (not climate zone dependent)
- Building Types: Residential/Multi-Family

- **Target Market**

- Residential hot water recirculation systems in CA
 - ✦ Target the retrofit/ replacement market

- **Market Potential, 26-120 Watt Market:**

- Annual Estimated GWh savings opportunity: >14 GWh



Grundfos Alpha 15-55 SF/LC

Measure Details



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- **Measure Costs**

- Baseline cost: \$231 Pump Cost + \$300 Installation Cost = \$531 Total Cost
- Measure cost: \$336 Pump Cost + \$300 Installation Cost = \$636 Total Cost
- Incremental cost: \$105

- **EUL**

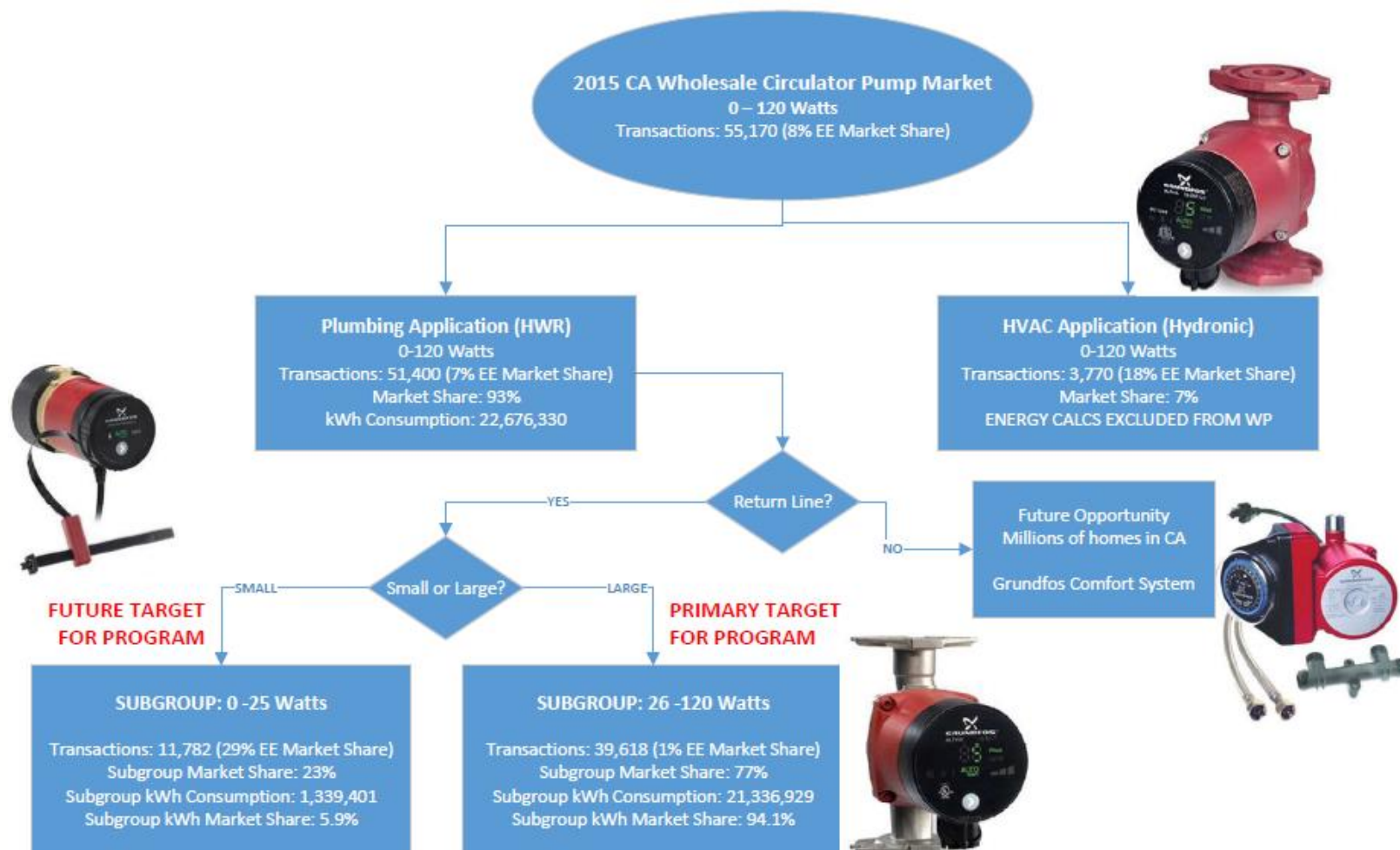
- 15 Years per DEER EUL for circulator pumps for the commercial sector.

- **NTG**

- **IOU** → All-Default ≤ 2yrs Source: **0.70**
- **POU** → Calculated NTG from Grundfos market knowledge of wholesale channel sales and Efficiency Vermont HPCP program uptake: **0.875**
 - ✦ Further calculation details for the POU value is explained in later slides

What is the Existing CA Market

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Existing CA Market Stance?

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- Contractors are the decision makers for pump selection
 - “Like-for-like” replacement
 - Engineers size in a “safety factor”
 - Upsize pump if like-size not readily available
- Lack of knowledge and time to correctly size a pump
 - Unable to do effectively for retrofit applications
- Cost (NOT EFFICIENCY) is primary deciding factor for pump selection
 - Pump to make it through warranty period without callback

RESULT... Cycle of continually oversizing circulator pumps that are inefficient, but are utilized because they cost less!

SOLUTION...

An HPCP with integrated controls and VFD that will “right-size” itself to the specific application into which it is installed, armed with utility incentives in an upstream program, it becomes the most cost effective for contractors to install.

SOLUTION to CA Market Stance?

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Pump Wet End: Stainless Steel for OPEN (plumbing) applications, Cast Iron for CLOSED (HVAC) applications, 6-1/2" flange-to-flange (standard)

Integrated VFD: VFD built directly into the pump, allows for self-optimization ability

Self-Optimizing: Algorithm dictates pumps performance and right-sizes for the specific application into which it is installed

Control Modes: Single button allows changing to seven different control modes. AUTOAdapt is default setting. Active mode is lit.

UNITARY SOLUTION: The Grundfos Alpha is a unitary solution. This means that it is a “plug and pump solution”. Out of the box, the Alpha has the wet end pump, integrated VFD and self –optimizing ability. There is no need for external equipment in order to gain energy savings. Installation takes no additional time, expense or complication as compared to the current market standard.

Out of the box, the Alpha will run in AUTOAdapt, immediately optimizing its performance and coaching contractors to utilize this control feature.

How much energy will an HPCP save?



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Market Standard



UP 15-29 SU/LC

Max Watts: 87 Watts
Typical Running Watts: 84.2
kW: 0.084
kWh/ Yr: 541

HPCP



Alpha 15-55 SF/LC

Wattage Range: 5-45 Watts
Average Field Test Running
Watts after 7 days¹: 26.7
kW: 0.027
kWh/ Yr: 172

kW Savings/Pump: 0.056

kWh Savings per year/Pump: 370 (68.3% Savings)²

1 – A running wattage of 12.1 was originally carried based on engineering calculations. This has been conservatively revised to reflect average results in the Alpha field test that were installed for an average of only 7 days. Grundfos expects this number to decrease as the AutoAdapt controls have time to adapt to the system.

2 - Assumed: 6,427 Running Hours/ Year

Questions from 9/22/16 Cal TF Presentation



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1. Baseline Determination: What is the typical pump that is being replaced in single family residences (SFR)?
2. Hours of Operation: What are the typical hours of operation for DWH recirculation pumps in CA, primarily in SFR?
3. What is the instantaneous and sustained power draw compared to steady-state (SS) operation?
4. EUL: What is the EUL of the new unit and replaced unit?
5. Measure Type/Delivery/Rebate: Confirm the proposed methods.
6. Net-to-Gross: Clarify the proposed NTG compared with the default DEER hours

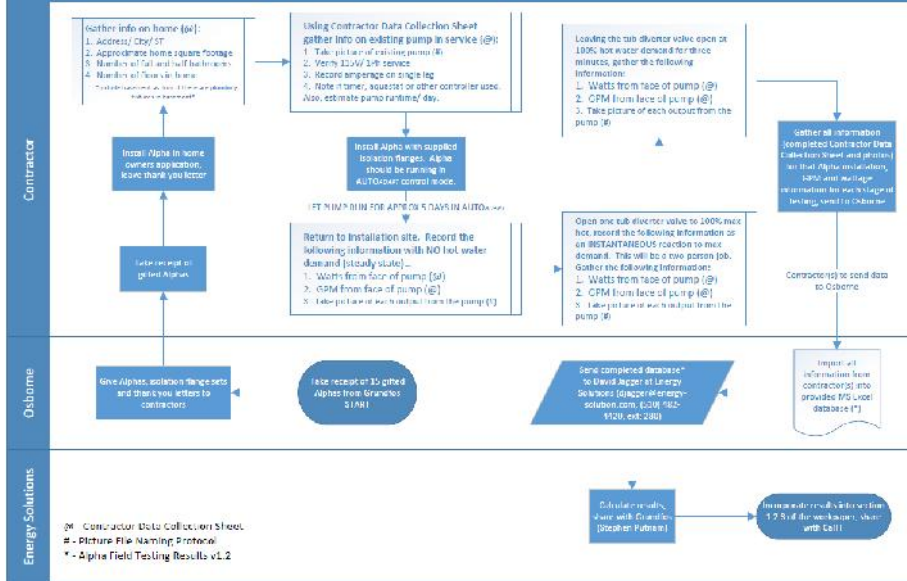
Alpha (Measure Pump) Field Study



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California Technical Forum – HPCP CA Residential HWR Market Analysis

V 1.2



Contractor Data Collection Sheet

California Technical Forum - HPCP Field Test

Contractor: _____ Phone: _____
Installer: _____ Email: _____

Installation Date: _____

Home Information:

Address Line 1 _____ Approx SF of Home _____
Address Line 2 _____ Number of Full Baths _____
City _____ Number of Half Baths _____
ST _____ Number of Floors _____
Zip _____ *Include basement as a floor ONLY if there are plumbing fixtures in the basement*

Existing Pump Info: (Take picture of pump in place PRIOR to removal, see file naming protocol)

Manufacturer _____ Control Type (Circle One) _____
Model _____ NONE Timer Aquastat T + A
Voltage _____ If Timer - Running Hours/ Day _____
Amp Reading _____

Install provided Grundfos Alpha, operate in AUTOADAPT mode (default mode at start up)

Return to site approximately 5 days after Alpha install

Step 1: Steady State Performance

Date _____

Record the following from face of Alpha...

GPM _____ With all hot and cold water fixtures closed, please record the following outputs from the face of the provided Grundfos Alpha pump. Please take pictures of both readings from the pump, naming in accordance with protocol.
Watts _____

Step 2: Instantaneous Demand Performance

Record the following from face of Alpha...

GPM _____ This will require two people. Open all tub diverter valves to 100% hot water demand and record the INSTANT reaction of GPM and Watts from the face of the Grundfos Alpha. Please take pictures of both readings from the pump, naming in accordance with protocol.
Watts _____

Step 3: Sustained Demand Performance

Record the following from face of Alpha...

GPM _____ After the tub diverter valve(s) have been left open for 3 minutes from step 2, record the SUSTAINED reaction of GPM and Watts from the face of the Grundfos Alpha. Please take pictures of both readings from the pump, naming in accordance with protocol.
Watts _____

Surveyed Single Family Residence (SFR) Characteristics - 13 Residences

	ft ²	Num of Floors	Num of Bathrooms	Length of Installation (Days)
Average	5,424	2.1	3.2	6.9
Min	2,400	1	2	4
Max	13,820	3	6	15

Qualifier: Existing pumps information is conservative.

- Installers were instructed to reach out to customers to install Alpha pumps free of cost. Not in response to service calls.
- Existing pump details are more representative of ER.
- Conservative estimates for ROB program as ER assumes newer pumps are replaced which are typically more advanced/efficient.

Question 1. Baseline Determination

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1. Baseline Determination: What is the typical pump that is being replaced?
 1. Grundfos transactional history through the wholesale market:
 - The proposed base case pump is the UP 15-29 model as this model represents the most popular model sold into the CA market in 2014 & 2015
 - The nameplate power of this model, 87 watts w/ 115V, represents the vast majority of the sales in 2014 & 2015.
 2. Field survey results show a mix of specific models and a mix of sizes but the base case wattage is the most popular and is a good representation of surveyed products:

*Alpha field test existing pump
nameplate power*

Power (W)	Units
~25	1
~90	9
~180	2
~245	1

Question 2. Hours of Operation

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2. Hours of Operation: What are the typical hours of operation for DWH recirculation pumps in CA?

DOE ASRAC weighted values

Control Type	Sector	Fraction of Consumers	HPY	Notes
No Control	Residential	50%	8,760	Constant Operation
	Commercial			
Timer	Residential	25%	7,300	50% @ 24/7 & 50% @ 16hrs/day
	Commercial		6,570	50% @ 24/7 & 50% @ 12hrs/day
Aquastat	Residential	20%	1,095	3 hrs/day
	Commercial			
On Demand	Residential	5%	61	10 min/day ¹
	Commercial		122	20 min/day ¹

1 - Assuming that circulators operate for 30 seconds for each demand "push"
Note: Assuming operating hours do not vary by region

Field survey results

Control Type	Units	% of Pumps Found ²	Operating Hours ¹
No Controls:	4	31%	8,760
Timer w/ Hours:	3	23%	5,645
Timer w/o Hours:	2	15%	8,760
Aquastat:	4	31%	1,095
On Demand:	0	0%	0

1 - As Aquastat operating hours are unknown. The ASRAC working group agreed upon number of 3 hrs/day or 1,095 hrs/yr was carried

2 - Values are rounded to nearest whole number

Comparison of weighted average operating hours

Source	Weighted Operating Hours (hrs/yr)
Field Survey:	5,683
DOE ASRAC Number Carried:	6,427
Variation:	11.6%

Question 3. Instantaneous and Sustained Demand

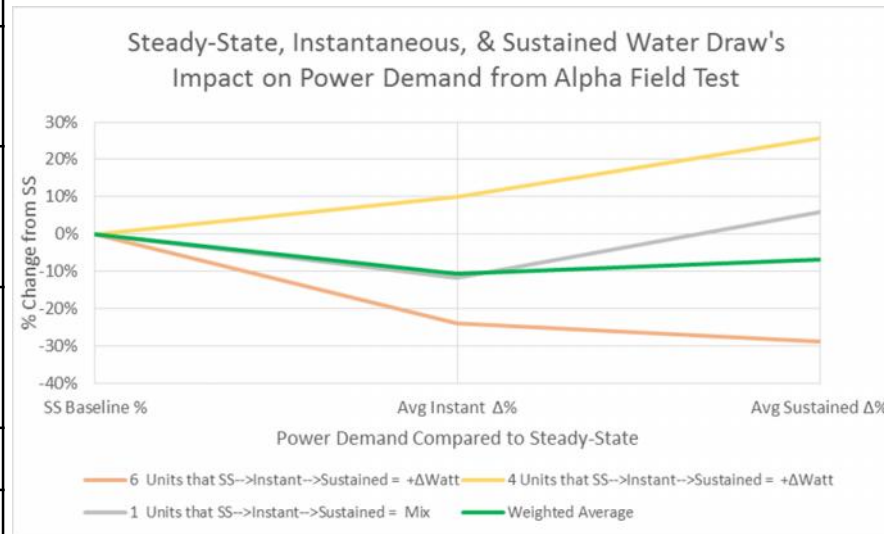
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3. What is the instantaneous and sustained demand draw compared to steady-state (SS) operation?

- In practice the power demand should decrease with water demand because of pump location in the system – downstream of the faucets. However:

Field test Results power demand from SS, instantaneous, and sustained water demand

	# of units	Power Demand		
		Avg SS (W) ¹	Avg Instant Δ%	Avg Sustained Δ%
Number of residences where flow and demand decreased with instant and sustained water demand	8	25.1	-24%	-29%
Number of residences where flow and demand increased with instant and sustained water demand	4	32.3	10%	26%
Mix of increase and decrease	1	17.0	-12%	6%
Weighted Average		26.7	-10.7%	-6.9%



1 - SS power demand will continue to decrease as the pump continues to find the most efficiency proportional pressure curve for the system

Note: Negative Δ% represent a decrease in flow or power demand

Question 4. Effective Useful Life (EUL)

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4. EUL: What is the EUL of the new unit and replaced unit?
- 15 years from DEER – we initially considered 20 as this was carried by HPCP Efficiency Vermont, but this was dropped.

EUL_ID	Description	EUL_Yrs	RUL_Yrs	Sector	BldgType	BldgLoc	VersionSrc	LastMod	TechType	Status
Motors-pump	Water Loop Pumps	15	5	Com	Any	Any	D08 v2.05	2/4/2014	PumpMtr	Standard

Source – DEE Resource 2014 EUL Tables - EUL_ID Motors-pump for Water Loop Pumps. Accessed 2/12/2017 - http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

Question 5. Measure Type/Delivery/Rebate

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5. Confirm the proposed measure type, delivery method, and rebate level:
 1. Measure Type: Replace-on-burnout (ROB)
 2. Upstream/distributor level: Encourage stocking & upselling
 3. Rebate: Equal to the IMC of \$105

Question 6. Net-to-Gross (NTG)

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Currently Carrying

Default 0.7 for all products with no DEER NTG and in a program for ≤ 2 years

Proposed

1. 2014 \rightarrow 2015 annual growth rate of HPCP is 46.6%
2. 1,167% EV HPCP Sales Increase pre to post program
3. Result in NTG of **0.875**

Grundfos Market Knowledge

HPCP market growth $\sim 46.6\%$

Program extrapolation from Efficiency Vermont HPCP

	Pre-Program	1st Year Post-Program Implementation				2nd Year Post-Program Implementation			
	HPCP Sales ²	HPCP Sales ²	Annual Growth Rate ³	Natural Market Sales	Program Influenced Sales	HPCP Sales ⁴	Annual Growth Rate ³	Natural Market Sales	Program Influenced Sales
Efficiency Vermont HPCP 2013 \rightarrow 2015:	300	3,800	1,167%			4,874	28%		
California HPCP 2015 \rightarrow 2017:	277	3,509	1,167%	406	3,103	4,501	28%	595	3,906

2 - Efficiency Vermont 2014 Annual Report - <https://www.efficiencyvermont.com/Media/Default/docs/plans-reports-highlights/2014/efficiency-vermont-annual-report-2014.pdf>

3 - Assuming identical annual growth rate from Efficiency Vermont and the CA market

4 - *Swimming to Midstream: New Residential HVAC Program Model*. Bickel Et al. 2016 ACEEE Summer Study on Energy Efficiency in Buildings

NTG calculation

	Projected 2016	Projected 2017	Totals
Net Potential Savings (kWh Saving/Year):	1,146,691	1,443,472	2,590,163
Gross Potential Savings (kWh Saving/Year):	1,296,760	1,663,356	2,960,116
NTG⁵:	0.884	0.868	0.875

5 - Calculations assume natural HPCP market growth continues at 2014-2015 rates & HPCP sales increase by same % as Efficiency Vermont HPCP

2/23/17 Q & A



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- Any Additional Questions?

Additional Resources



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Annual kWh Saving Potential in California

CA Wholesale Circulator Market (Up to 120 Watts)							
Plumbing (HWR): 51,400		93.2% <i>Focus of Workpaper - Energy Calcs Based On This Market Application</i>					
Hydronic (HVAC): 3,770		6.8% <i>Market Application is EXCLUDED From Energy Calculations</i>					
TOTAL: 55,170		Qty Pumps Transacted/ Yr					
MARKET SEGMENT - UP TO 25 WATTS - PLUMBING MARKET			MARKET SEGMENT - 26 - 120 WATTS - PLUMBING MARKET				
% of CA Market: 22.9%			% of CA Market: 77.1%				
Market Qty: 11,782			Market Qty: 39,618				
Market Standard (Up to 25 Watts)		Efficient Option (Up to 25 Watts)		Market Standard (26 - 120 Watts)		Efficient Option (26 - 120 Watts)	
Market Segment: 70.6%		Market Segment: 29.4%		Market Segment: 99.3%		Market Segment: 0.7%	
UP 15-10 B5/TLC (P/N: 59896215)		Comfort PM Auto		UP 15-29 SU/LC (P/N: 59896776)		Alpha 15-55 SF/LC	
Max Watts: 25		UP 10-16 A PM BU/LC (P/N: 98420224)		Max Watts: 87		(P/N: 59896834)	
% Max Watts: 97%		Max Watts: 8.5		% Max Watts: 97%		Steady State Watts: 26.7	
Running Watts: 24.25		kW 0.009		Running Watts: 84.2		kW 0.027	
kW 0.024		Running Hours/ Day: 4		kW 0.084			
Running Hours/ Yr: 6427		Running Hours/ Yr: 1460		Running Hours/ Yr: 6427		Running Hours/ Day: 6427	
kWh/ Yr/ Pump: 156		kWh/ Yr/ Pump: 12.4		kWh/ Yr/ Pump: 541		kWh/ Yr/ Pump: 172	
		kWh Savings/ Pump: 143				kWh Savings/ Pump: 370	
Existing Market (Qty): 8,318		Existing Market (Qty): 3,464		Existing Market (Qty): 39,341		Existing Market (Qty): 277	
Existing Market kWh/ Yr: 1,296,414		Existing Market kWh/ Yr: 42,987		Existing Market kWh/ Yr: 21,289,339		Existing Market kWh/ Yr: 47,589	
Existing CA Market kWh: 1,339,401				Existing CA Market kWh: 21,336,929			
Total Existing CA Market kWh: 22,676,330							
Transformed Market Potential			Market Conversion Rate: 100%				
Market Standard (Up to 25 Watts)		Efficient Option (Up to 25 Watts)		Market Standard (26 - 120 Watts)		Efficient Option (26 - 120 Watts)	
Qty Pumps Transacted: 0		Qty Pumps Transacted: 11,782		Qty Pumps Transacted: 0		Qty Pumps Transacted: 39,618	
kWh: 0		kWh: 146,215		kWh: 0		kWh: 6,798,484	
Transformed CA Market kWh: 146,215				Transformed CA Market kWh: 6,798,484			
Total Transformed CA Market kWh: 6,944,699							
kWh Savings by Market Conversion Rate for 26-120 Watt Market							
25%: 3,634,549 16%				75%: 10,904,016 48%			
50%: 7,269,098 32%				100%: 14,538,565 64%			

Questions/comments from 1/28/2016 Cal TF



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- How was running wattage Calculated?
- Have additional independent reviewers:
 - Clarify demand savings from SS wattage and not nameplate
 - Clarify operating hours, assuming 8,760 for the entire market is a stretch
 - Are labor costs included in the IMC?
 - What is the EUL? Need sources
 - What is the NTG? Need sources
- What is the estimated residential ROB market?
- Include a more technical description of AutoAdapt technology
 - What is the expected installation rate based on annual sales?

How was running wattage calculated?



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Market Standard: Able to pull power curve internally, wattage reflects best efficiency point (BEP: 10 GPM @ 5' TDH) of 84.2 Watts

HPCP Option: Assumed a 4' per second velocity (best practice) in a ½" return line would yield a 2.45 PM. Based on the AUTOAdapt control curve, the resulting head would be approximately 5.5'. Power curves are published for the Grundfos Alpha and at 2.45 GPM @ 5.5' TDH the Alpha consumes 12.1 watts of power.

Reviewer's Comments / Revisions



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- Reviewers

- Gary Fernstrom, David Jagger, Chad Worth, Tim Melloch

At a Glance Summary:

- ✓ Peak Demand Reduction (kW/unit) – originally was based off nameplate. Therefore submittal data was used.
 - BASE CASE: wattage consumption at BEP = **84.2 watts**
 - MEASURE CASE: Assuming ½" return line on HWR and a 4' per second velocity, the flow = 2.45 GPM. AutoAdapt = TDH at 5.5'. Running watts for 2.45 GPM @ 5.5' TDH is **12.1 watts**
- ✓ Energy Savings (kWh/unit) – originally assumed 8,760 running hours/year
 - Reference DOE rulemaking from circulator pump workgroup which uses a weighted average of pumps that are running with no controller, no timers employed, aquastats employed and on-demand. Now using 6,427.

Reviewer's Comments / Revisions



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At a Glance Summary cont...

- ✓ Labor Cost included in measure cost?
 - It was discussed if the measure cost should include installation if ROB and it was determined that it should.
- ✓ Expected Useful Life
 - Debated between 15 and 20 years; settled on 15 years based off DEER EUL for ECM circulator pumps
- ✓ Net to Gross
- ✓ Grundfos calculated 92.5; however, based off feedback decided to publish DEER of .70 per CAL TF recommendations. While calling out market data would suggest as well as other NTG values across the US.

Reviewer's Comments / Revisions



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- ✓ 1.1 Estimated Residential ROB Market Discussion
 - Combined 2 measures to estimate market potential.
- ✓ 1.1 Technical Description
 - ✓ AutoAdapt: detection of system pressure changes
 - ✦ Reviewers wanted better understanding of the technology when the faucet is flowing versus when it was not.
- ✓ 1.2.1.3 In-Service Rate / First Year Installation Rate
 - Assumed installation rate close to 100%. The Alpha serves the market well due to its ability to right-size, thus providing a single pump solution to vast majority of installation opportunities.
- ✓ 2.1 & 2.2 Baseline by Measure Application Type
 - Baseline
 - ✦ First: refers to the first baseline period which in the case of ROB is the only baseline period. If it was ER we would assume a “first” and “second” baseline.

Reviewer's Comments / Revisions



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✓ 2.2.3 Peak kW

- There was a discussion on using the DOE running hours (6,427/ Yr) or 8,760/ Yr. Decided to go with 8,760 based on Grundfos market knowledge.

✓ 3.1 Base Cases (Costs)

- Data was questions as to weather it included brass and stainless DHW circulators – it includes both installed in HWR applications in CA.

✓ Appendix: CA Circulator Wholesale Market Landscape Analysis and Explanation of *AutoAdapt* Functionality