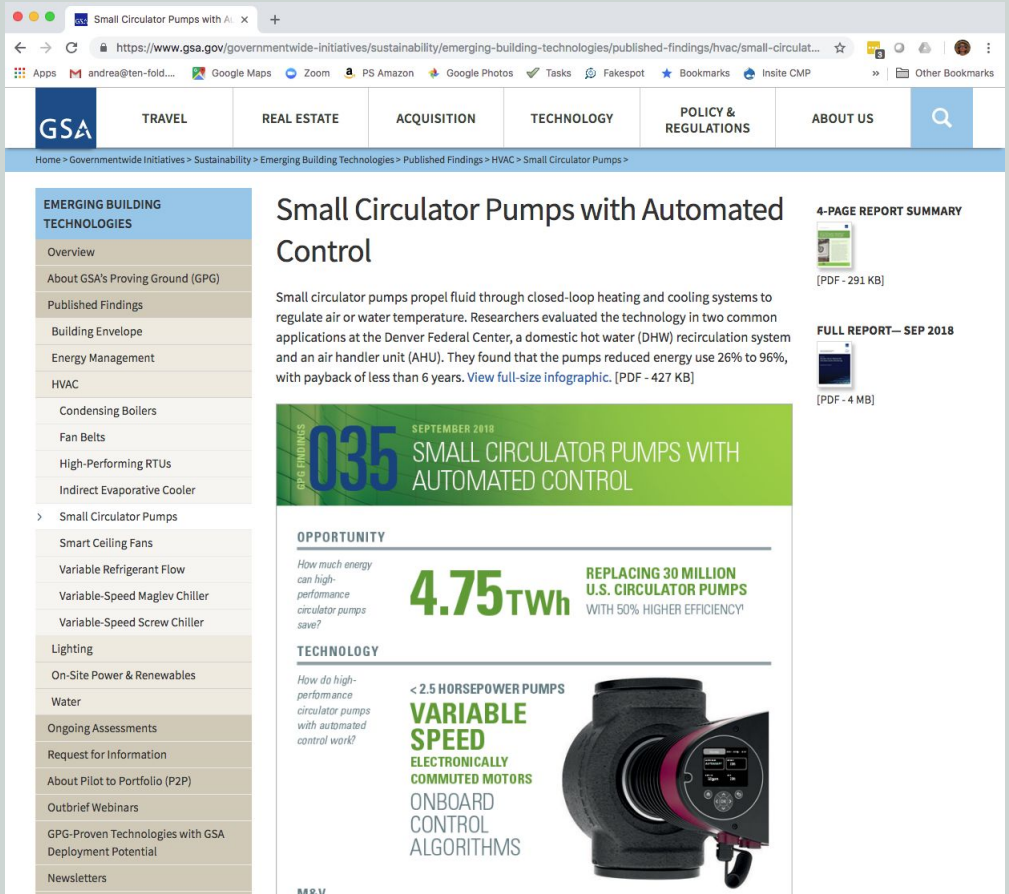
GPG Outbrief 16

Small Circulator Pumps with Automated Control

Emerging Building Technologies, GPG Program | U.S. General Services Administration | October 11, 2018

GPG-035 Small Circulator Pumps @ gsa.gov/gpg

- Infographic
- 4-page Findings
- Full Report
- Additional Resources



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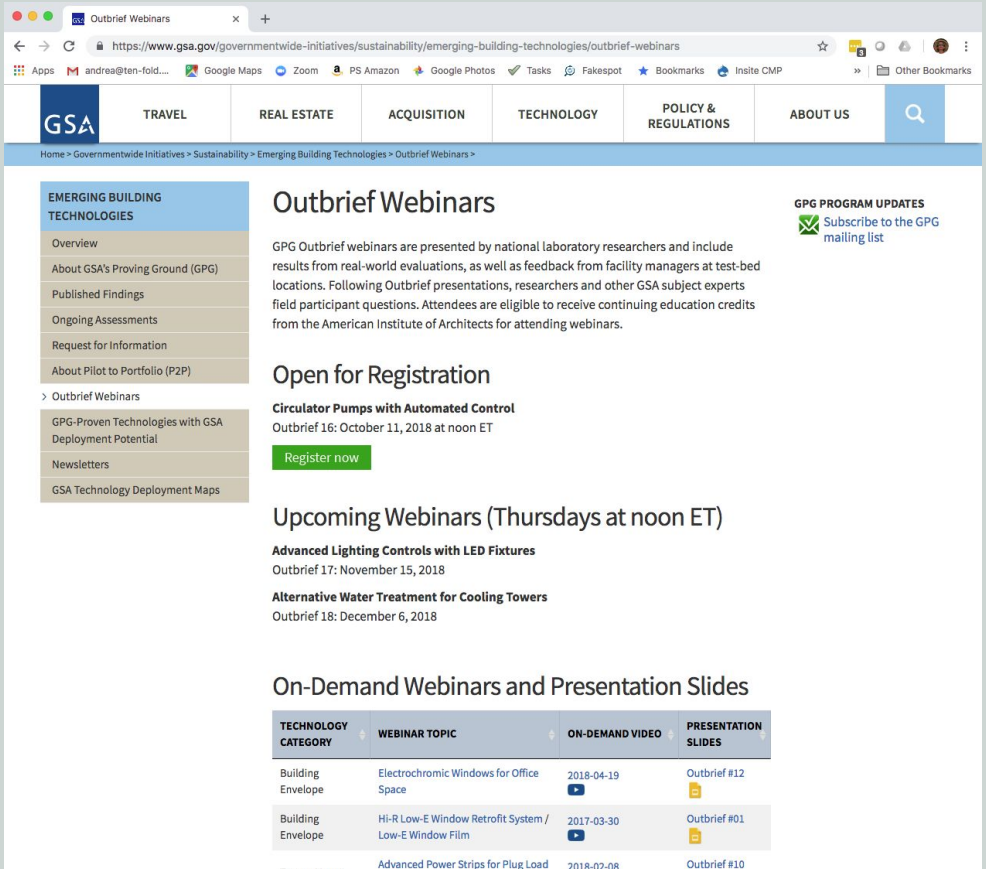

Upcoming 2018 GPG Outbriefs—Thursdays, 12 PM ET

Nov 15 Advanced Lighting Controls with LED

Dec 06 Alternative Water Treatment for Cooling Towers

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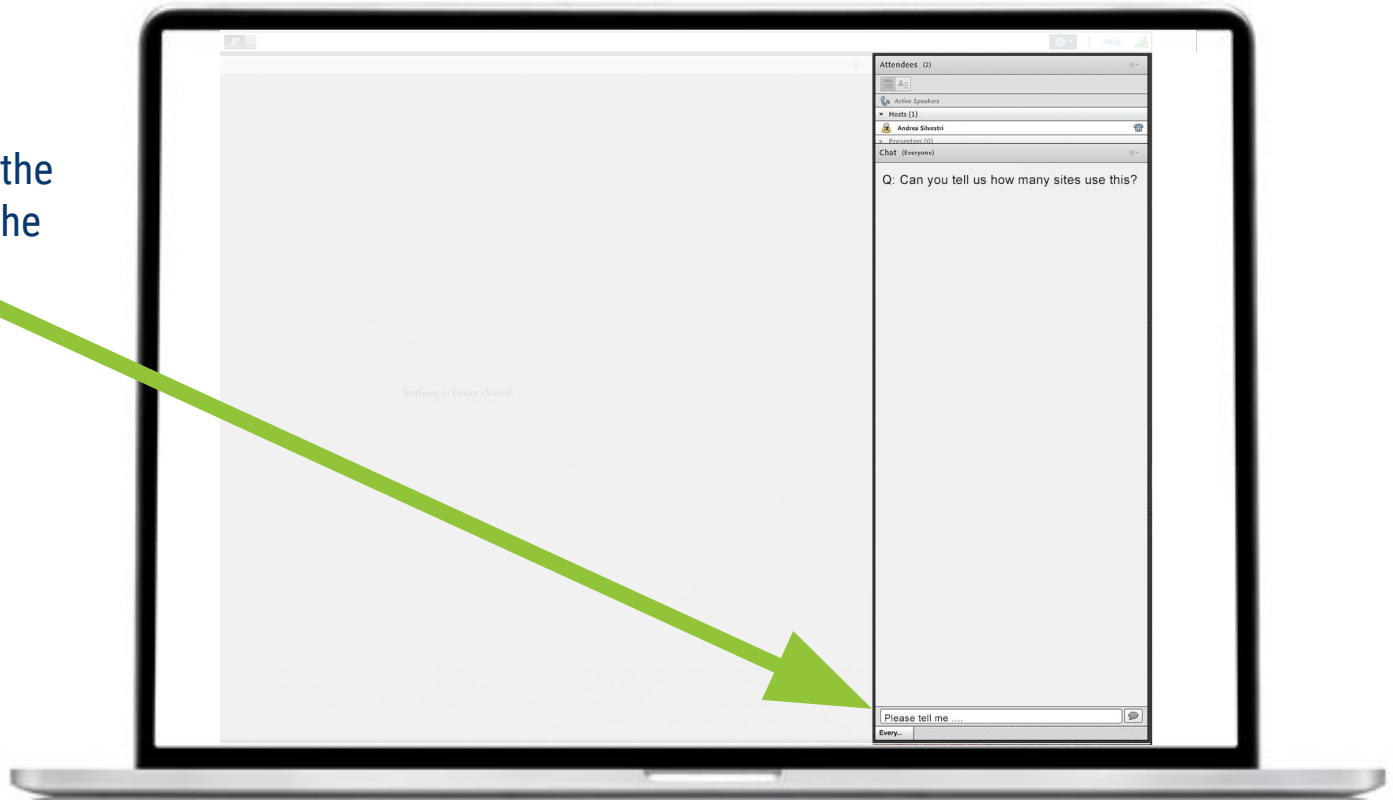

Introduction

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Webinar Agenda

- Introduction (5 minutes)
  Jay Fine, Project Manager, Emerging Building Technologies
- Small Circulator Pumps with Automated Control (15 minutes)
  Jesse Dean, National Renewable Energy Laboratory
- On-the-ground Feedback R8, Denver Federal Center (10 minutes)
  Tyler Cooper, GSA Region 8
- Q & A (20 minutes)

Emerging Building Technologies' two programs—GSA Proving Ground (GPG) and Pilot to Portfolio (P2P)—enable GSA to make sound investment decisions in next-generation building technologies based on their real-world performance

GPG-035

Small Circulator Pumps with Automated Control

General Services Administration
Public Buildings Service

GSA

GPG-035 | SEPTEMBER 2018

SMALL CIRCULATOR PUMPS WITH AUTOMATED CONTROL

Energy Savings and Positive Return-on-Investment from Two Applications

Because most small circulator pumps (< 2.5 horsepower) operate at a constant speed and use very little energy, they have typically been overlooked for energy efficiency upgrades. With over 30 million circulator pumps installed in U.S. commercial buildings, however, the opportunity for savings is significant. GSA's Proving Ground (GPG) program commissioned the National Renewable Energy Laboratory (NREL) to evaluate new high-performance variable-speed circulator pumps with automated control that adjust pump speed to meet changing demand. NREL researchers evaluated the new pumps' performance in two common applications: a domestic hot water (DHW) recirculation system and an air handler unit (AHU)—both at the Denver Federal Center (DFC), in Denver Colorado. When the new high-performance variable-speed circulator pumps were attached to the DHW system and compared with market-standard constant-speed baseline pumps, energy savings were between 90% and 96%. A savings of only 26% was achieved with the new AHU pump, because it was compared with a more efficient baseline pump. When compared with a

Measurement & Verification

Jesse Dean
Senior Research Engineer, M.S., CEM
National Renewable Energy Laboratory

Opportunity

4.75TWh

REPLACING 30 MILLION U.S. CIRCULATOR PUMPS

WITH 50% HIGHER EFFICIENCY

Over 90% of the currently installed circulator pumps in the U.S. are constant volume pumps powered by standard induction motors

https://www.epri.com/#/pages/product/000000003002001762/

High-Performance Circulator Pump

DWH Recirculation Pumps, Small Hot Water and Chilled Water Pumps

- 2.5 HP or smaller
- EC motor
- Local and remote monitoring: temperature, speed, flow, power, head energy, BTU, history
- Built-in control modes
  - Constant speed
  - Constant pressure
  - Proportional pressure
  - Constant temperature
  - AUTOADAPT
  - FLOWADAPT
- Reduced maintenance

Image source: Grundfos

Comparison to Standard Pumps

Market Standard

EC motor with variable speed vs. induction

10% to 20% electricity savings*

Optimized impeller

10% to 15% hydraulic savings*

Grundfos Magna3

Built-in control algorithms and nighttime setback

Up to 65% savings*

Image source and savings estimates: Grundfos

Measurement & Verification

Monitored Performance in Two Buildings within the Denver Federal Center

Building 810
Air Handler Unit Pump

Building 67
Domestic Hot Water Recirculation Pumps

Technology for test-bed measurement and verification provided by Grundfos

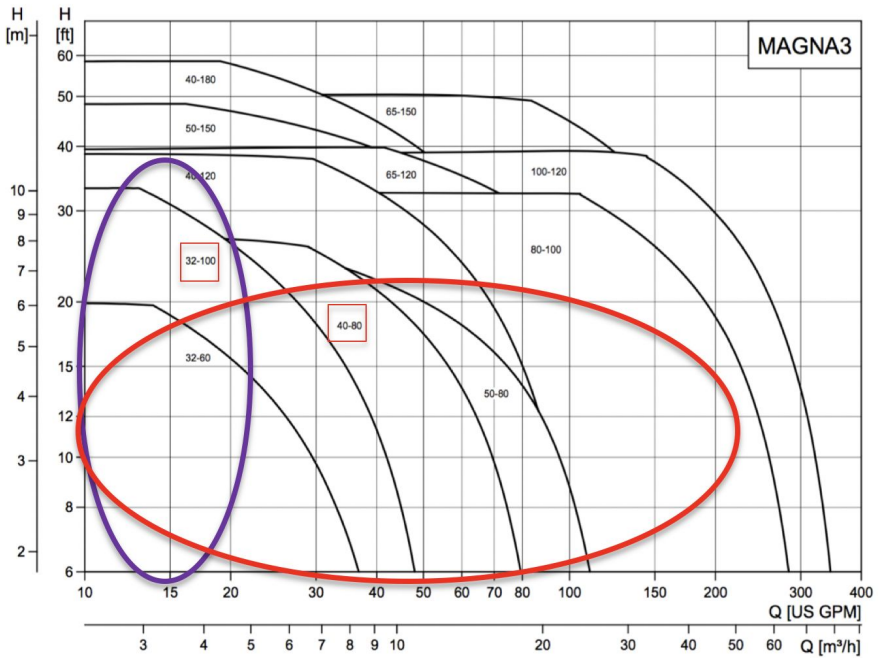
High-Performance Circulator Pump Size

Two Smallest Pumps Tested

With such small pumps, any reduction in O&M significantly impacts economics

Purple oval—
DHW recirc pump typical operating range

Red oval—
HHW or CW pump typical operating range



Domestic Hot Water Pump Tests

DHW Loop #1: 8 hr/weekdays

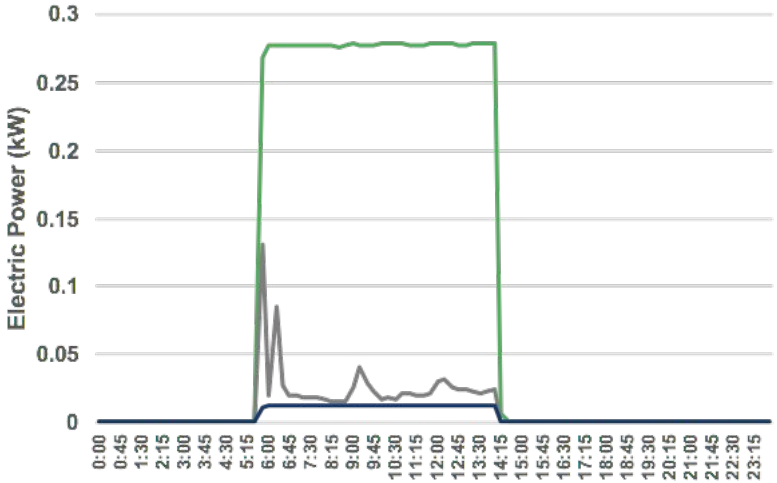
Characteristic	DHWP-1 Baseline	DHWP-1 HPCP (40-80)	DHWP-1 HPCP (32-100)
Pump Size	¼ HP	0.37 HP	¼ HP
Duty Point Power (watts)	280	157	77
Wire-to-Water Efficiency	8.2%	14.5%	30.1%
Area Served	1st Floor Cafeteria	1st Floor Cafeteria	1st Floor Cafeteria
Control Modes Tested	–	AutoAdapt & Constant Temp	Constant Temp

DHW Loop #2: 11 hr/weekdays

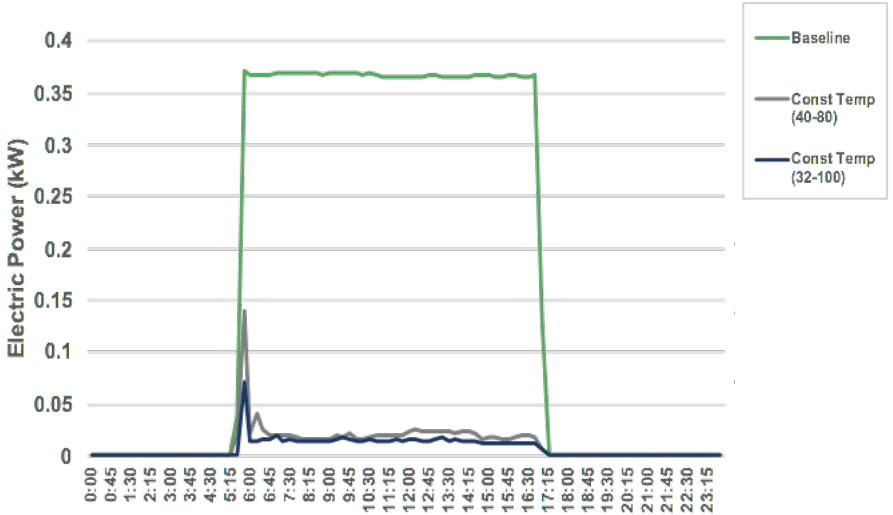
Characteristic	DHWP-2 Baseline	DHWP-2 HPCP (40-80)	DHWP-2 HPCP (32-100)
Pump Size	½ HP	0.37 HP	¼ HP
Duty Point Power (watts)	370	176	97
Wire-to-Water Efficiency	Unknown	23.9%	44.3%
Area Served	Floors 2–8	Floors 2–8	Floors 2–8
Control Modes Tested	–	AutoAdapt & Constant Temp	Constant Temp

DHWP Results

DHWP #1 Daily Average Elec Power



DHWP #2 Daily Average Elec Power



DHWP Measured Energy Savings

DHWP Savings Estimate

	DHWP-1			DHWP-2		
	Baseline	Constant Temp. (Model 40-80)	Constant Temp. (Model 32-100)	Baseline	Constant Temp. (Model 40-80)	Constant Temp. (Model 32-100)
Weekday Total Power (kWh)	2.36	0.23	0.10	4.18	0.26	0.18
Max. Power (watts)	281	136	12	373	143	72
Weekday Savings (%)	–	90%	96%	–	94%	96%
Annual Savings (kWh)	–	554	587	–	1,017	1,039

DHWP Payback at End-of-Life Replacement

Higher Flow Rates Combined with Smaller Pump Sizes Offered the Best ROI

	% Savings	Annual Energy Savings (kWh/yr)	Annual Energy Cost Savings @ 0.11 kWh ($)	Annual O&M Savings ($)	Incremental Cost ($) over market standard pump	Simple Payback	Savings-to-Investment Ratio (SIR)
DHWP #1: ¼ HP, 77 watts (duty point) **Baseline:** ¼ HP, 280 watts (duty point)	96%	587 kW	$65	$75	$575	4.1	3.6
DHWP #2: ¼ HP, 97 watts (duty point) **Baseline:** ½ HP, 370 watts (duty point)	96%	1,039 kW	$114	$75	$575	3.0	4.9

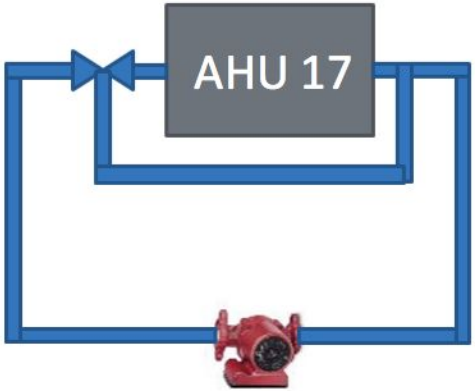
Heating Hot Water Circulator Pump Test

Simultaneous Monitoring for 3 Months

Baseline Grundfos

New ½ HP constant speed pump

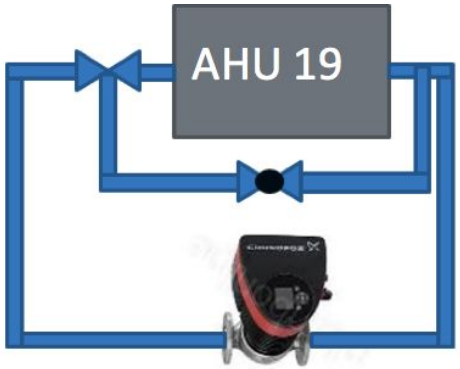
3-way valve controls flow through AHU



Grundfos Magna3

Automated flow control

Bypass valve closed



AHU Heating Hot Water Results

- Operation problems invalidated 2016-17 data
- AHUs serve different loads making a direct comparison difficult
- AHU19 had low heating runtimes and sometimes switched to cooling during the middle of the day
- Savings were estimated by applying the baseline pump power to the AHU19 pump runtimes

AHU Measured Energy Savings

	AHU-17 Baseline Grundfos	AHU-19 Grundfos Magna 3, 0-10-V-DC Control
Max. Power (watts)	221.6	204.0
On-Peak Avg (kWh/day)	0.144	0.093
Off-Peak Avg (kWh/day)	0.728	0.550
On-Peak Savings (%)	–	35%
Off-Peak Savings (%)	–	24%
Overall Savings (%)	–	25.7%

AHU Economic Performance—Evaluated at End-of-Life Replacement

Very Little Run-time 4/hrs a Day

	% Savings	Annual Energy Savings (kWh/yr)	Annual Energy Cost Savings @ 0.11 kWh ($)	Annual O&M Savings ($)	Incremental Cost ($) over market standard pump	Simple Payback	Savings-to-Investment Ratio (SIR)
AHU 19 : 0.36 HP, 186 watts (duty point) **Baseline:** ½ HP, 223 watts (duty point) 4 hrs/day run-time	26%	45 kW	$5	$75	$500	6.3	2.4
AHU 19: 0.36 HP, 186 watts (duty point) **Baseline:** ½ HP, 330 watts (duty point) 20 hrs/day run-time	60%	688 kW	$76	$75	$500	3.3	4.5

Value in Pre-Programmed Control Sequences

- Constant return-water temperature control mode with pump's internal temperature sensor best for DHW pumps
- Control modes internal to the pump or simple 0-10-V DC from BAS recommended for small heating system pumps
- AutoAdapt mode does not work well when pumps are oversized or operating on the lower end of the pump curve

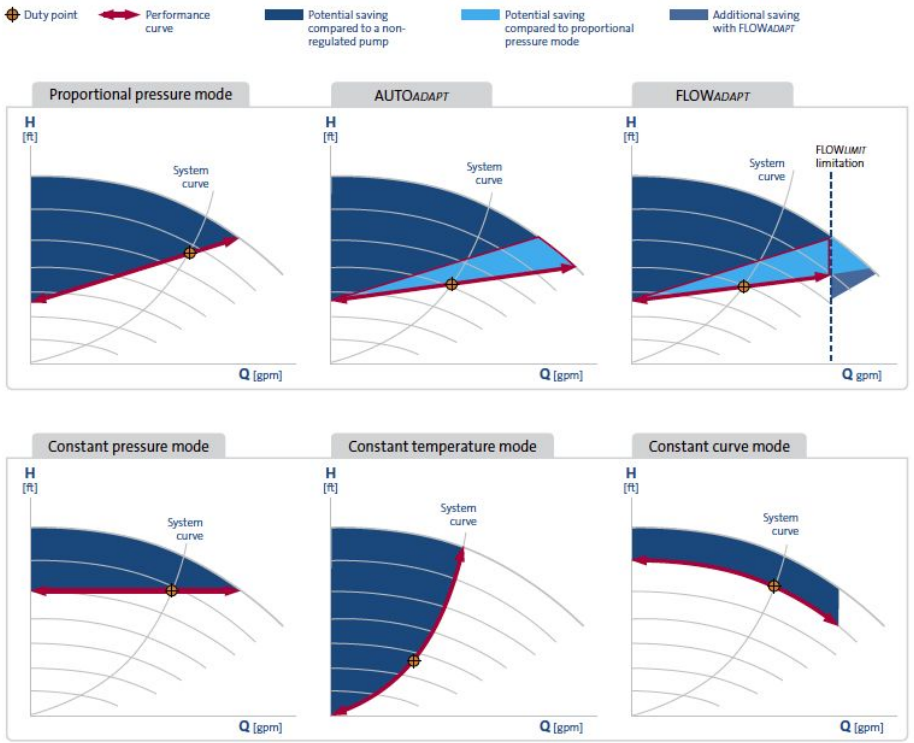


Image source: Grundfos

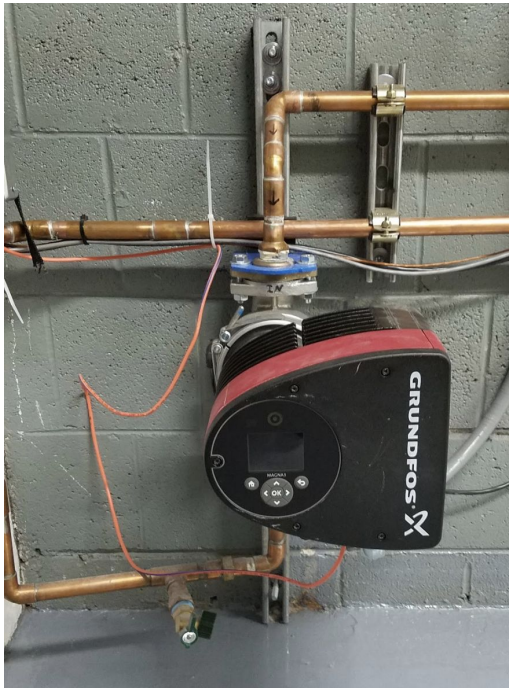
Lessons Learned

Convert 3-way Bypass Valves to 2-way Valves

At a minimum, the flow through the bypass loop must be closed for the pumps to operate correctly.

BAS Integration Increases Installed Costs

Use the pump's pre-programmed internal control modes and rely on the BAS for on/off control.

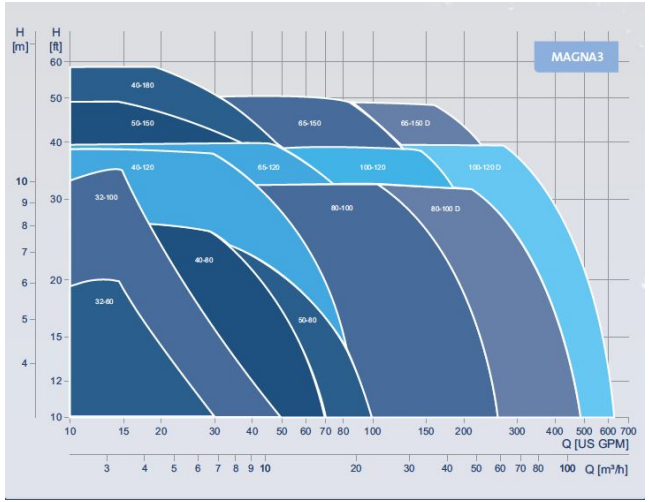


Correctly Size the Pump

Oversized Pumps Save Energy but are Not as Cost-effective

Use one of these methods to size smaller constant-volume pumps:

- Determine pipe sizes and lengths and then calculate actual head loss from the pipes to estimate flow (GPM) and head required for the pump.
- Observe supply and return temperature differentials to make an educated guess about the existing pump's suitability. For example, if the Delta-T is extremely small (2°F to 5°F), the pump is most likely too large.

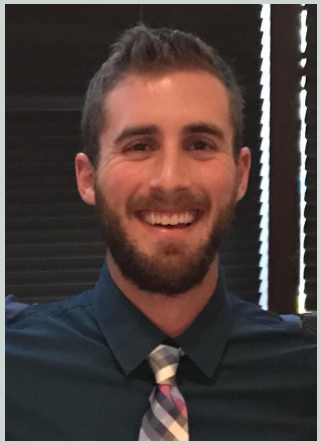


Deployment for Small Circulator Pumps

End-of-life Replacement

- DHW recirculation pumps with > 40 hours a week operation
- Heating hot water & chilled water pumps with > 10 hours a day operation
  - Pumps serving multiple heating coils have greater energy savings
  - Convert 3-way valve bypass to 2-way valves
- GSHP circulator pumps with > 40 hours a week operation

GSA Feedback—Denver Federal Center



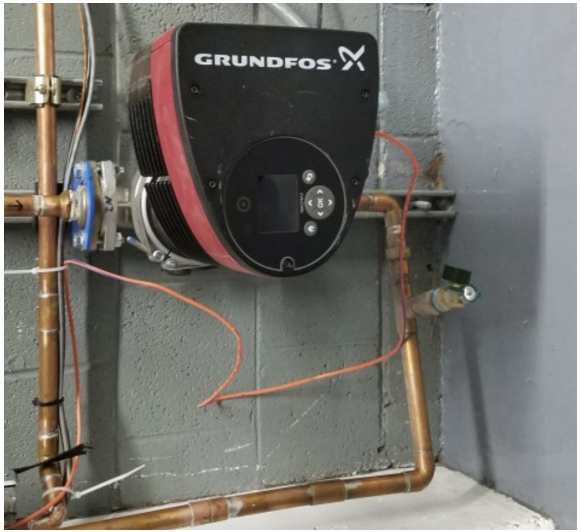
Tyler Cooper
Supervisory Energy PM
GSA Region 8

Installation

Like-for-like Replacement

Minimal additional work if you don't add points to the BAS, which for such small pumps we wouldn't recommend

Baseline: Armstrong ½ HP



Replacement: Magna ¼ HP

Controls Programming

Minimal Additional Work

- Can select control mode from the pump head. Very fast if you know which mode to select
- Easy to test different control modes because you have real-time power readings
- Local and remote monitoring was valuable
- Smart-phone application is available but not tested

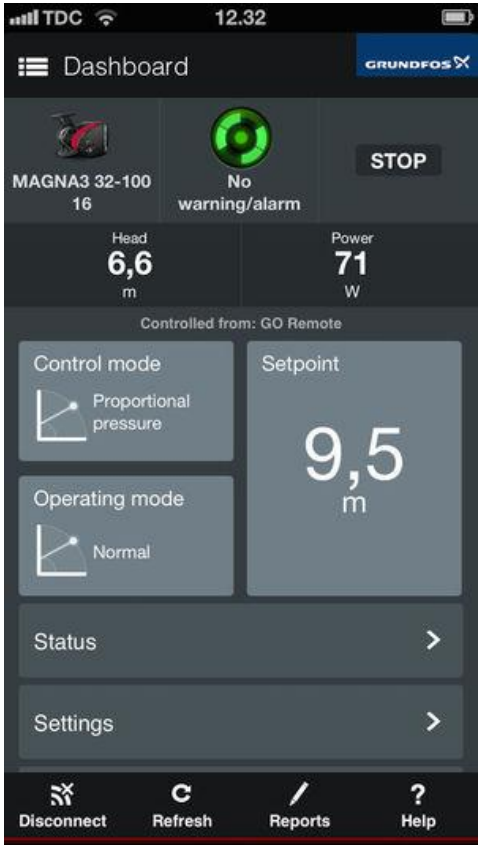


Image source: Grundfos

Operations & Maintenance

Annual Review of Pump Energy Recommended

- Reviewing real-time power readings can identify if there are blockages in the system
- Maintenance may be reduced with other new pumps as well

MORE

OPERATIONAL VISIBILITY

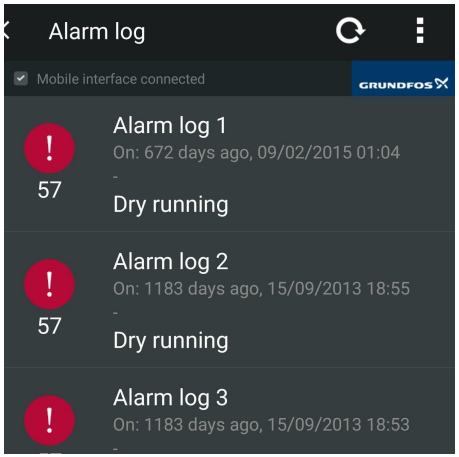
and reduced maintenance, no greasing of bearings or replacing pump seals

Image source: Grundfos

Considerations

Building Issues

- Direction on flow was not labelled so pump was installed backwards
- Retro-commissioning BAS, problems getting pumps to respond



Pump Issues

- Communication error more likely to happen with Model 30-100 (¼ HP) pump
- Power factor improved for Model 42-80 pump, worse for Model 30-100 at low pump speeds
- Mobile access not cleared through GSA IT-Security

Image source: Grundfos

Recommendation

Replace Small Pumps at End-of-life with High-performing Pumps

Some discretion on AHUs to know if there is adequate run time. AHU pumps only save energy when they are being used.

Image source: Grundfos

Q & A

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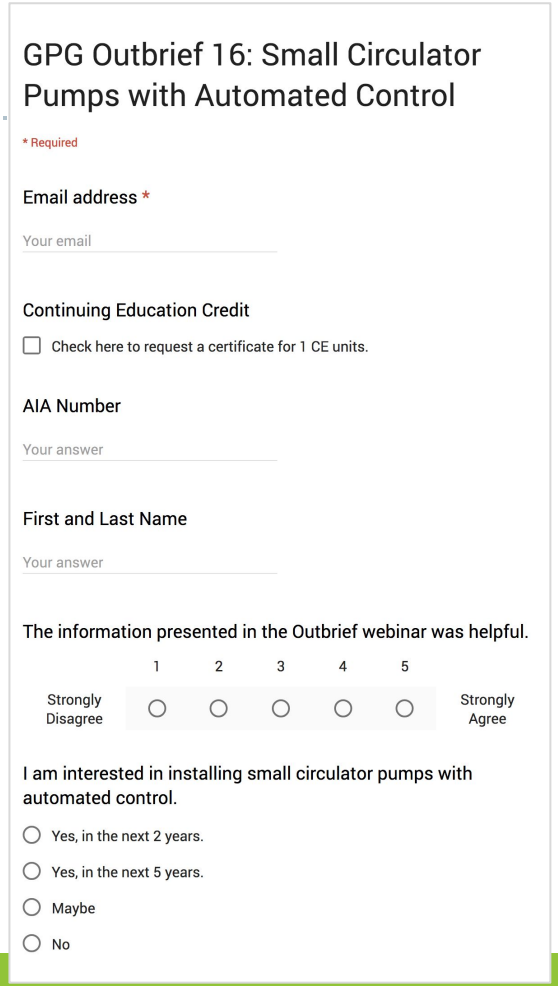

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Your answer

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Your answer

The information presented in the Outbrief webinar was helpful.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I am interested in installing small circulator pumps with automated control.

- ○ Yes, in the next 2 years.
- ○ Yes, in the next 5 years.
- ○ Maybe
- ○ No

Thank you

For more information: gsa.gov/GPG

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