# Fan/Blower Efficiency Evaluation

Avista's approach

Andy Paul | December 5, 2024

# About Avista

**Avista Electric and Natural Gas Service Areas**


- Investor-owned utility involved in energy production, transmission and distribution
- 418,000 electricity customers (WA, ID)
- 382,000 natural gas customers (WA, ID, OR)
- 30,000 square miles of service territory
- Celebrating 135 years of service

# Andrew Paul Bio

- 13+ years in Energy Efficiency
- BSME, Washington State University
- MSCE, University of Washington
- MBA, Gonzaga
- PE (ME & EE) WA, ID, and CA
- Certified Energy Manager (CEM)
- Certified Measurement & Verification Professional (CMVP)

# AGENDA

- Avista DSM Overview
- Two pathways for rebates/incentives
- Site-Specific projects intro
- Site-Specific Project example types
- Site-Specific projects process
- FEI Intro
- Q & A

# About Avista Demand Side Management (DSM) i.e., why we do it

- DSM Tariff Rider provides approx. $30M in annual funding for energy efficiency programs
- Reduction of approximately 10% of retail loads in recent years, or about 120 aMW or two small/medium generating stations.
- Must meet state-mandated energy reduction targets.
- Become a trusted energy partner with our customers and help them meet/exceed energy/cost carbon reduction goals in the form of both expertise and monetary incentives.

# 2 Pathways for Possible Avista rebates/incentives specific to fans/blowers (Prescriptive & Site-Specific)

- Prescriptive (PSC)
  - https://www.myavista.com/energy-savings/energy-saving-programs-services-for-your-business/rebates-washington
  - Rebate $ given upon the purchase of energy efficient equipment. This is more of a “cookie cutter” approach for both common and proven efficiency upgrades.
  - Relatively simple and fast process for Avista customers.
  - Refer to program eligibility and guidelines.

# Prescriptive rebates/incentives specific to fans/blowers

- Prescriptive
  - HVAC Fan VFD (retrofit ONLY)
  - Will be discontinued for 2025

**Table A – Fan or Pump Application Codes**

| CODE | APPLICATION | CODE | APPLICATION |
|---|---|---|---|
| SFA | SUPPLY FAN OR SUPPLY AIR HANDLER | FWP | BOILER FEED WATER PUMP |
| SFP | SUPPLY FAN ON VAV PACKAGED OR ROOFTOP HVAC UNIT | CTP | COOLING TOWER PUMP |
| RFA | RETURN FAN OF RETURN AIR HANDLER | CHWP | CHILLED WATER PUMP |
| RFP | RETURN FAN ON VAV PACKAGED OR ROOFTOP HVAC UNIT | COWP | CONDENSING WATER PUMP |
| BEF | BUILDING EXHAUST FAN | OTHER | PLEASE SPECIFY IN TABLE C |

**Table B – VFD Incentive per HP of Designed Primary Motor Load**

| TYPE OF VFD | MAXIMUM $ PER HP |
|---|---|
| VFD FANS | $200 |
| VFD COOLING PUMP ONLY | $200 |
| VFD HEATING PUMP ONLY OR COMBINED HEATING AND COOLING PUMP | $200 |

# AVISTA Site-Site Specific Projects

- Eligibility
  - Must be and Avista electric customer
  - **Must initiate the project with Avista prior to the purchase of any equipment! Contact your friendly and knowledgeable Avista Account Executive!!!**
  - If you don't know your Avista AE…

**https://www.myavista.com/energy-savings/energy-saving-programs-services-for-your-business/get-personalized-help**

# AVISTA Site-Site Specific Projects, cont'd

- Project must meet our SPB requirements (currently between 0 and 15 years).
- Potential (electric) incentive is $0.26/kWh saved up to 70% of the eligible project cost ($0.23/kWh in ID).
- Most projects must follow a strict evaluation, measurement, and verification (EM&V) protocol. Details and requirements may vary among projects, most will involve IPMVP Option B.
- New construction/end-of-life (incremental cost) or full retrofit.

# Site-Specific rebates/incentives specific to fans/blowers

- Again, sometimes referred to as “custom”.
- HVAC – (typically) retrofit only (2025). WA Energy Code 2021 C403.2.4 requires VFD on all HVAC fans >=5.0HP (2018 code was 7.5HP) and does NOT apply to refrigeration systems.
- Will likely require a post EEM measurement & verification (M&V).

# Some Project Examples for Site-Specific HVAC

- Bolt-on VFDs – probably the most common EEM (again, retrofit only).
- Net HP reduction – reduced CFM demand, system modification resulting in reduced SP, etc.
- Filter MERV rating modifications (maybe).
- Evaporative cooling to replace mechanical cooling in favorable OSA conditions. This can (and should) be used in conjunction with rpm control and space/environmental conditions.
- Etc.

# Evaporative cooling/fan wall example (although this example would be considered “process”)

# Non-HVAC Applications - Specific Examples

- Commercial
  - Building supply & exhaust (again, retrofit add-ons only)
  - Parking garage ventilation
  - Destratification, LSHV (HVAC? Sort of)
- Industrial Process (NC or retrofit)
  - Combustion air & Exhaust
  - Dust collection
  - General Manufacturing
  - Product drying
  - Material conveyance
  - Etc.

# Direct Drive vs Belt Drive

- Direct Drive

- Belt Drive

# EEM: VFD Project Evaluations (fixed-speed BASELINE)

- Will typically involve spot power measurements and a data monitoring (length of time will vary).

- Baseline usage will be calculated at follows:

$$kW = \frac{V * A * \sqrt{3} * pf}{1000}$$

- If…I must estimate…

$$\text{kW} = \frac{\%mtr\ load * nameplate\ HP * 0.746}{\eta_{mtr} * \eta_{drive}}$$

or by using the familiar fluid-to-power equation (if only fan data is known)…

$$BHP = \frac{cfm * inwg}{6356 * \eta_{fan}}$$

- Typically, I estimate 80% motor load, 90% for the motor efficiency, approx. 50% fan eff. for small fans, 75% for large fans (ASHRAE, or use mfgr. fan performance data if available), and drive eff. depends on the wire-to-air drive components. Time permitting, I will walk you through a fan performance table at the end of this presentation.

# EEM: VFD PRELIMINARY Project Evaluations (fixed-speed retrofits)

- Upgrade estimate using affinity laws:

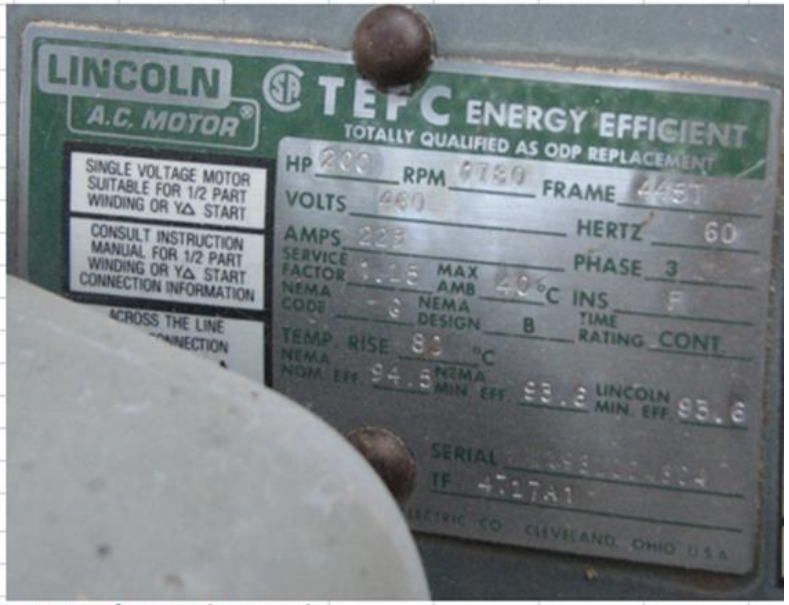
$$HP_2 = HP_1 \left( \frac{RPM_2}{RPM_1} \right)^{2.6}$$

- Note: An affinity exponent of 2.6 is used instead of 3 to more accurately include system compound inefficiencies (this will vary among organizations, usually ranging between 2.2 and 2.7).

- Adjustments for air density, temperature, etc.

## Fan/Blower CFM, Velocity, and Energy Analysis

| | | | |
|---|---|---|---|
| **Fan Motor Measured Data** | | | |
| Motor HP | **HP** | 200 | |
| Motor Voltage | **V** | 480 | |
| Motor Amperage | **A** | 223 | |
| Motor Efficiency | **%** | 93.6% | |
| Motor Power Factor | **%** | 85% | est |
| **Motor Power (electric)** | **kW** | 157.59 | |
| | | | |
| Fan Brake kW | **BkW** | 147.5 | |
| Fan Brake HP | **BHP** | 197.7 | |
| Motor Speed | **RPM** | 1780 | |
| Fan Speed | **RPM** | 818 | |
| **System Data** | | | |
| Duct Type (Round? Rectangular?, etc.) | | Round | |
| Duct Size | **in** | 36 | |
| Duct Size | **in** | | |
| Duct Size (Round) | **ft²** | 7.07 | |
| Flow Rate (Clarke Perf. Tables MH 90*) | **CFM** | 32868 | |
| Air Velocity | **FPM** | 4650 | |
| Desired Velocity | **FPM** | 4000 | 4000 fpm minimum for particle removal |
| Velocity Reduction Ratio | **pct** | 86.0% | Note: This approximately agrees with post-EEM panel reading of 55 Hz |
| **Energy Savings Analysis** | | | |
| VFD Affinity Exponent | | 2.6 | * Clarke Performance Tables for MH-90 centrifugal fan with |
| Proposed Flow Rate | **CFM** | 28274 | 37 in inlet dia., 64 3/8 wheel dia., 818 wheel rpm, and 14 in. SP) |
| Proposed Motor Power | **kW** | 106.5 | |
| Annual Hours of Operation | **hr** | 2080 | |
| Baseline Energy Usage | **kWh** | 327784.9 | |
| Proposed Energy Usage (Estimated) | **kWh** | 221614.7 | |
| **Annual Energy Savings (Estimated)** | **kWh** | **106170.2** | |
| | | | |
| **Demand Reduction** | **kW** | **51.0** | |



# BE CAREFUL WHEN RETROFITTING BELT DRIVES!!!

- Check with manufacturer specifications (both the belt and the fan/driver).
- V-belt speed should run between 1000 and 5000 ft/min. Outside of this range may result in equipment damage (premature belt wear, bearing damage, sheave damage, or worse). Easily calculated with sheave ratios.
- Most literature says 4000 ft/min is ideal for V-belts, most cross-sections.
- Remember, even a slight speed reduction will result in a significant energy reduction.

# Site-Specific Projects Closeout…

- These types of project will be subject to a post-installation inspection and will likely be M&V’d.
- Length of the performance period may vary depending on the application.
- Project will be re-evaluated at the end of the performance period and any necessary adjustments will be made (weather, production metrics, etc.)

# Site-Specific Projects Closeout cont'd

- Most modern VFDs have the data collection capability needed to perform the final evaluation…
- Most will report avg running Hz, avg running kW, cumulative kWh (sometimes cannot be reset), total run-hours, etc. I can work with any two of these. Otherwise, the kWh will be data- logged/extrapolated in the traditional way.
- Final EEM kWh usage is compared to the original baseline and…
- Final incentive payment (if any) is usually sent within two weeks.

# The Future? Fan Energy Index (FEI)

- What is it and does it replace Fan Energy Grade (FEG)?
- The (very) short answer is that it is basically a comparison of the energy usage between a specified standalone fan/array and a conceptual “reference fan” at a certain operating point (cfm, and pressure) as calculated per AMCA 208. And yes, it does replace the former FEG.
- Operating point: TP or SP depending on fan/impeller type, air density, cfm.
- Avista will likely adopt a minimum baseline FEI requirement of 1.0 in accordance with ASHRAE 90.1 for site-specific projects. The compliant range for fans AND arrays is FEI >=1.0, 0.95 for VAV systems in the United States (ceiling fans are exempt along with embedded and other fans under certain criteria).
- Not difficult to work with, however there are some technical and regulatory nuances here (I can go into if needed).

# QUESTIONS?

# THANK YOU!!!

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# PERFORMANCE TABLES — No. 90 - No. 100 - No. 110

# MH TYPE

**INLET DIAMETER — 37" O.D.** | **WHEEL DIAMETER — 64 3/8"** | **WHEEL CIRCUMFERENCE — 16.85 FT.**

## No. 90

| CFM | OV | 4" SP | | 5" SP | | 6" SP | | 7" SP | | 8" SP | | 10" SP | | 12" SP | | 14" SP | | 16" SP | | 18" SP | | 20" SP | | 22" SP | | 24" SP | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RPM | BHP | RPM | BHP | RPM | BHP | RPM | BHP | RPM | BHP | RPM | BHP | RPM | BHP | RPM | BHP | RPM | BHP | RPM | BHP | RPM | BHP | RPM | BHP | RPM | BHP |
| 8964 | 1200 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10458 | 1400 | 409 | 9.82 | | | | | | | | | | | | | | | | | | | | | | | | |
| 11952 | 1600 | 412 | 10.92 | 458 | 13.98 | | | | | | | | | | | | | | | | | | | | | | |
| 13446 | 1800 | 418 | 12.33 | 460 | 15.35 | 502 | 18.78 | | | | | | | | | | | | | | | | | | | | |
| 14940 | 2000 | 425 | 13.86 | 467 | 17.11 | 505 | 20.45 | 543 | 24.18 | 580 | 28.01 | | | | | | | | | | | | | | | | |
| 16434 | 2200 | 432 | 15.51 | 474 | 19.05 | 512 | 22.59 | 547 | 26.21 | 581 | 30.14 | | | | | | | | | | | | | | | | |
| 17928 | 2400 | 439 | 17.25 | 481 | 21.05 | 518 | 24.92 | 554 | 28.79 | 587 | 32.69 | 650 | 41.41 | | | | | | | | | | | | | | |
| 19422 | 2600 | 446 | 19.11 | 488 | 23.19 | 525 | 27.30 | 560 | 31.51 | 593 | 35.69 | 653 | 44.29 | 711 | 53.99 | 766 | 63.86 | | | | | | | | | | |
| 20916 | 2800 | 454 | 21.10 | 495 | 25.44 | 532 | 29.85 | 567 | 34.28 | 600 | 38.80 | 659 | 47.83 | 714 | 57.29 | 768 | 67.89 | 820 | 78.54 | | | | | | | | |
| 22410 | 3000 | 462 | 23.22 | 503 | 27.84 | 540 | 32.53 | 574 | 37.26 | 607 | 42.00 | 666 | 51.70 | 720 | 61.43 | 771 | 71.67 | 822 | 83.08 | 870 | 94.55 | | | | | | |
| 23904 | 3200 | 469 | 25.46 | 510 | 30.37 | 547 | 35.33 | 581 | 40.33 | 614 | 45.41 | 673 | 55.49 | 727 | 65.91 | 777 | 76.35 | 824 | 87.38 | 872 | 99.55 | 917 | 111.87 | 960 | 123.66 | | |
| 25398 | 3400 | 477 | 27.83 | 518 | 33.08 | 555 | 38.31 | 589 | 43.58 | 621 | 48.90 | 680 | 59.66 | 733 | 70.63 | 783 | 81.59 | 830 | 92.65 | 874 | 104.44 | 919 | 117.27 | 963 | 130.45 | 1004 | 143.17 |
| 26892 | 3600 | 485 | 30.30 | 526 | 35.92 | 563 | 41.42 | 597 | 46.98 | 628 | 52.56 | 687 | 63.93 | 740 | 75.27 | 790 | 87.05 | 836 | 98.62 | 880 | 110.33 | 922 | 122.82 | 964 | 136.20 | 1006 | 150.26 |
| 28386 | 3800 | 493 | 32.93 | 533 | 38.88 | 570 | 44.74 | 604 | 50.55 | 636 | 56.45 | 694 | 68.31 | 747 | 80.29 | 796 | 92.32 | 843 | 104.80 | 886 | 117.04 | 928 | 129.43 | 967 | 142.52 | 1008 | 156.33 |
| 29880 | 4000 | 501 | 35.72 | 541 | 41.96 | 578 | 48.22 | 612 | 54.34 | 644 | 60.50 | 701 | 72.85 | 754 | 85.49 | 804 | 98.15 | 849 | 110.92 | 893 | 123.93 | 934 | 136.86 | 973 | 149.93 | 1011 | 163.59 |
| 31374 | 4200 | 509 | 38.64 | 549 | 45.20 | 586 | 51.76 | 620 | 58.25 | 651 | 64.73 | 709 | 77.68 | 762 | 90.80 | 810 | 104.13 | 856 | 117.33 | 899 | 130.95 | 940 | 144.48 | 980 | 158.10 | 1017 | 171.84 |
| 32868 | 4400 | 517 | 41.78 | 557 | 48.63 | 594 | 55.49 | 627 | 62.40 | 659 | 69.15 | 717 | 82.70 | 769 | 96.29 | 818 | 110.10 | 863 | 124.05 | 906 | 137.95 | 947 | 152.36 | 986 | 166.45 | 1024 | 180.76 |
| 34362 | 4600 | 525 | 45.14 | 565 | 52.24 | 601 | 59.40 | 635 | 66.60 | 667 | 73.80 | 725 | 87.78 | 777 | 102.08 | 825 | 116.49 | 870 | 130.97 | 913 | 145.48 | 954 | 160.03 | 993 | 175.17 | 1030 | 189.88 |
| 35856 | 4800 | 534 | 48.71 | 573 | 56.05 | 609 | 63.50 | 643 | 71.01 | 674 | 78.53 | 732 | 93.33 | 784 | 108.11 | 833 | 122.98 | 878 | 138.02 | 920 | 153.25 | 961 | 168.39 | 1000 | 183.52 | 1037 | 199.39 |
| 37350 | 5000 | 543 | 52.52 | 581 | 60.04 | 617 | 67.81 | 651 | 75.59 | 682 | 83.42 | 740 | 98.92 | 792 | 114.20 | 840 | 129.74 | 885 | 145.33 | 927 | 160.93 | 968 | 176.93 | 1007 | 192.70 | | |
| 38844 | 5200 | 552 | 56.55 | 590 | 64.32 | 625 | 72.31 | 658 | 80.40 | 690 | 88.53 | 748 | 104.80 | 800 | 120.76 | 848 | 136.78 | 893 | 152.89 | 935 | 169.17 | 975 | 185.50 | 1014 | 202.00 | | |
| 40338 | 5400 | • | • | 599 | 68.85 | 633 | 77.03 | 667 | 85.43 | 698 | 93.83 | 755 | 110.72 | 808 | 127.43 | 856 | 143.89 | 901 | 160.68 | 942 | 177.40 | 982 | 194.38 | 1021 | 211.46 | | |
| 41832 | 5600 | • | • | 608 | 73.63 | 642 | 82.05 | 675 | 90.67 | 705 | 99.39 | 763 | 116.89 | 815 | 134.37 | 863 | 151.55 | 908 | 168.78 | 950 | 186.01 | 990 | 203.54 | 1028 | 221.11 | | |
| 43326 | 5800 | • | • | 617 | 78.67 | 651 | 87.30 | 683 | 96.16 | 714 | 105.18 | 771 | 123.29 | 823 | 141.47 | 871 | 159.27 | 916 | 176.87 | 958 | 195.00 | 998 | 213.02 | 1036 | 231.18 | | |
| 44820 | 6000 | • | • | 626 | 84.00 | 660 | 92.88 | 691 | 101.92 | 722 | 111.19 | 779 | 129.88 | 831 | 148.64 | 879 | 167.30 | 924 | 185.73 | 965 | 204.20 | 1005 | 222.71 | | | | |
| 46314 | 6200 | • | • | 635 | 89.58 | 669 | 98.69 | 700 | 107.95 | 730 | 117.47 | 786 | 136.75 | 839 | 156.12 | 886 | 175.55 | 931 | 194.57 | 973 | 213.45 | 1013 | 232.78 | | | | |
| 47808 | 6400 | • | • | 645 | 95.61 | 678 | 104.88 | 709 | 114.39 | 738 | 124.04 | 795 | 143.86 | 846 | 163.85 | 894 | 183.83 | 939 | 203.71 | 981 | 223.38 | 1021 | 242.99 | | | | |



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