2022-2027 Adjustable Speed Drives Interim Market Model Expert Panel Summary

June 2025

This summary documents the activities, process, and participants of the expert panel for BPA's 2022-2027 Adjustable Speed Drives (ASD) Interim Market Model and related market research. Panel activities described in this summary took place between April 2023 and January 2025.

ASD Market Research and Purpose of Expert Panel

The ASD market is a complex one that spans multiple sectors, segments, end uses, and applications. BPA maintains a quantitative market model to understand the energy consumption of standalone motor-driven equipment and track the impact ASDs have on Northwest energy consumption over time. To date, BPA has reported Momentum Savings from ASDs on industrial standalone pumps and fans.

In 2024, BPA expanded the model to include standalone commercial and industrial pumps and fans and developed a forecast of Momentum Savings from ASDs added to these systems during BPA's Energy Efficiency Action Plan period of 2022 to 2027. BPA refers to this current model iteration as the 2022-2027 ASD Interim Market Model and intends to update it in 2028 to finalize results for 2022-2027. Because of uncertainty around forecast results, BPA has not published materials related to the 2022-2027 ASD Interim Market Model. For more information on BPA's ASD market research and Momentum Savings, please contact Masumi Izawa, the BPA project lead, at mrizawa@bpa.gov or visit https://www.bpa.gov/energy-and-services/efficiency/market-research-and-momentum-savings/adjustable-speed-drives-market-research.

BPA contracted with DNV to facilitate a panel of independent experts and regional stakeholders to review and provide feedback throughout the development of the 2022-2027 ASD Interim Market Model and related market research. The goal of the expert panel process is to provide BPA with independent expert review and advice on their market research, methodologies, market model, and results. Additionally, the expert panel process ensures continuous engagement in BPA's market research from its stakeholders representing the Northwest Power and Conservation Council (Council), the Northwest Energy Efficiency Alliance (NEEA), the Regional Technical Forum (RTF), and internal BPA staff.

Overview of Panel Engagement Activities

This section summarizes panel activities that took place between April 2023 and January 2025 throughout the development of the 2022-2027 ASD Interim Market Model and related market research. A more detailed catalog of specific panelists engaged in each activity and meeting minutes for each working session are accessible at the end of this document. A copy of the comment tracker with panelist feedback and BPA's responses is available upon request.

ASD Expert Panel Kickoff Working Session on April 26, 2023: BPA engaged with the full panel to kick off the interim model development process and asked the panel to answer questions related to four topics: expanding the model scope to cover commercial pumps and fans as well as industrial, motor stock, operational data, and sales data. The panel's feedback helped inform BPA's model development plan.

Program Savings Desk Review in Jan. 2024: BPA asked questions to a targeted group of panelists knowledgeable about how ASD-related savings are tracked and counted in BPA's and NEEA's commercial/industrial programs. Panelist responses helped BPA confirm and/or decide on the program savings assumptions to use in the market model.

Unit Energy Consumption (UEC) Working Session on Jan. 31, 2024: BPA engaged with the full panel to review updates to the UEC equation and associated inputs and an analysis of new pump and fan operating data and discuss any red flags or opportunities for improvement in data sources or analysis approach. Additionally, BPA asked the panelists to respond to specific questions about the following topics: transmission efficiency, commercial pump operating hours, commercial fan operating hours, and load factor analysis. The panelists generally agreed with BPA's improvements to the UEC model inputs and asked questions about the metered data used in the load factor analysis. BPA provided more detailed descriptions of the three data sources used.

Stock Characterization Working Session on March 18, 2024: BPA engaged with the full panel to discuss how they are modeling motor horsepower stock in the region and to present their forecast of the drive saturation in the region from 2022 to 2027. The panelists were asked to respond to questions regarding the following topics: using gross output as regional scalar, embedded fan definition, industrial ASD saturation, commercial ASD saturation, fan motor size, and economic drivers. Several panelists pointed out the high forecasted ASD saturation in the industrial sector towards the end of the 2022-2027 period. Based on those observations, BPA reviewed its model calibration process and found a solution to adjust the forecast down slightly. BPA also made a small change to the commercial pump ASD saturation based on panelist feedback.

Interim Market Model Draft Results Working Session on May 21, 2024: BPA engaged with the full panel to present the interim model draft results and gain perspective and input from the panelists on the energy consumption forecast for pumps and fans, ASD savings forecast, BPA's characterization of the uncertainty in these forecasts, and the direction of future research. Based on the discussion during the meeting and panelist responses to specific questions, BPA decided to widen its uncertainty for ASD saturation on certain equipment. BPA provided the panelists with the updated uncertainty bounds as well as details on how that impacted their sensitivity analysis.

ASD Shipments Data Collection Kickoff Working Session on Jan. 16, 2025: BPA engaged with the full panel to discuss the data collection to inform the ASD saturation forecast and get panelist feedback on BPA's outreach plan. Additionally, the panelists were asked specific questions related to the list of priority distributors, contacts at priority distributors, anticipated challenges, and strategies to overcome those challenges. Panelists were also able to provide contact information, warm leads, and introductions.

Expert Panel Process

For each panel engagement, DNV first met with BPA to understand the research or modeling needs and identified the appropriate panelists. Then DNV scheduled the working session meeting or desk review, distributed materials, and facilitated the discussion and feedback response. Panelists were responsible for showing up to the working session, completing their desk review on time, and contributing critical feedback in a professional and respectful manner.

BPA and its research contractor documented all panelist feedback in a comment tracker and provided responses to the feedback received including any follow-through actions taken. For transparency, panelists received a copy of the comment tracker and meeting notes in a thank you email that DNV sent after activity completion.

Expert Panelists

The panel included experts and stakeholders with a diverse range of ASD knowledge and capacities. DNV recruited the independent expert panelists while BPA recruited regional stakeholders. BPA requested DNV to recruit independent experts that provide expertise on all elements of the market research.

- **Market/Industry Expert:** A market/industry subject-matter expert (SME) has a strong understanding of the markets where ASDs are present, including pumps, fans, air compressors, circulators, and material handling/processing. They know who the key market players are, what the market trends are, and how the supply chain typically works for ASDs and motors across sectors and applications. They are also familiar with different sources of motor or drive sales data, be up to date on motor-driven technology trends and codes and standards impacting ASD adoption and preferably have past "boots on the ground" experience working within motor-driven markets (e.g., have worked with/for a motor/drive manufacturer, distributor, program implementer, engineering firms, etc.).
- **Technology Expert:** A technology SME has engineering expertise and a strong understanding of how motor-driven technologies — including pumps, fans, air compressors, and other motor-driven process loads — work and how they work when their motors are paired with an ASD. A technology SME is knowledgeable of different types of ASDs, such as variable frequency drives and electronically commutated motors, and be up to date on motor-driven technology trends and codes and standards impacting ASD adoption. A technology SME understands how different technical specifications and installation conditions affect the ASD-paired motor's performance and energy consumption and how ASDs save energy in different applications and equipment operations. A technology SME is preferably

knowledgeable of current practices on replacing or upgrading motors (with and without an ASD), and the types of custom projects that involve ASDs.

- **Market Analysis Expert:** A market analysis SME is someone with experience using a mix of datasets such as sales data, regional building stock assessment data, utility program data and census data, and analyzing them for the broader regional market/population. The market analysis SME is well versed in assessing the representativeness and uncertainties of a sample dataset to determine whether and how to use it to make inferences on the population. The market analysis SME has knowledge of inputs, methods and outputs of stock turnover models and is preferably familiar with the Council's power plans and baseline methodologies.
- **Sampling/Statistical Expert:** A sampling/statistical SME has a strong understanding of sampling methods and techniques. They can review and provide feedback to BPA on sampling plans for primary data collection in a way that ensures the data are robust and representative of the population. They help inform BPA on the appropriate use of primary and secondary data sources, including appropriate uses of weights.
- **Regional Stakeholder**: Regional stakeholders are those from the Council, NEEA, RTF, or BPA that participated on behalf of their organization.

Table 1 shows the independent experts and regional stakeholders in the ASD expert panel.

Table 1. ASD Expert Panelists

Panelist Name	Expert Classification	Affiliation during Panel
Rob Boteler	Market/Industry Expert	Independent
Peter Gaydon	Market/Industry Expert	Hydraulic Institute
Kenneth Kuntz	Market/Industry Expert	Greenheck
Mike Wolf	Market/Industry Expert	Greenheck
Paul Lemar	Technical Expert	Resource Dynamics
David Morris	Technical Expert	RHT Energy
Prakash Rao	Market Analysis Expert	Independent
Todd Amundson	Regional Stakeholder	BPA
Kevin Smit	Regional Stakeholder	Council
Kristen Aramthanapon	Regional Stakeholder	NEEA
Nicole Dunbar	Regional Stakeholder	NEEA
Evan Hatteberg	Regional Stakeholder	NEEA
Ryan Firestone	Regional Stakeholder	RTF

Catalog of Panel Activities

The panel kicked off in April 2023 and ended in January 2025, completing a total of six panel engagement activities. Table 2 shows the full list of panel engagements, topics covered, and panelists involved. Appendix A provides the detailed meeting minutes to the working sessions. A copy of the comment tracker with panelist feedback and BPA's responses is available upon request.

Table 2. ASD Expert Panel Completed Activities

#	Review Type	Panel Engagement Period	Topics Reviewed	Independent Experts	Regional Stakeholders
1	Working Session	April 26, 2023	Interim model kickoff to introduce the team, present updates on the model scope, and discuss key model inputs.	Pete Gaydon, Mike Wolf, Paul Lemar, Dave Morris	Ryan Firestone, Evan Hatteberg, Nicky Dunbar
2	Desk Review	Jan. 2024	Custom project projections, deemed savings, NEEA savings, embedded horsepower, commercial UES, and commercial % of ASDs per technology/activity/practice.	None, targeted desk review	Todd Amundson, Eric Mullendore, Evan Hatteberg, TJ Sharkey
3	Working Session	Jan. 31, 2024	Unit energy consumption updates including transmission efficiency, operating hours, and load factors.	Pete Gaydon, Kenneth Kuntz, Dave Morris, Rob Boteler	Evan Hatteberg, Todd Amundson
4	Working Session	March 18, 2024	Stock characterization, in-service motor horsepower, and ASD saturation.	Pete Gaydon, Kenneth Kuntz, Dave Morris, Rob Boteler, Prakash Rao	Evan Hatteberg, Nicky Dunbar, Todd Amundson, Kevin Smit, Kristen Aramthanapon
5	Working Session	May 21, 2024	Interim market model draft results including review model basics, industrial and commercial model results, uncertainty, sensitivity, and future research.	Rob Boteler, Kenneth Kuntz, Dave Morris, Prakash Rao	Evan Hatteberg, Nicky Dunbar, Kristen Aramthanapon
6	Working Session	Jan. 16, 2025	Where data collection fits into the ASD model timeline, high-level project overview, how collected data will be used, details on specific data collected.	Rob Boteler, Pete Gaydon, Kenneth Kuntz, Paul Lemar, Dave Morris, Prakash Rao	Todd Amundson, Ryan Firestone, Kevin Smit, Evan Hatteberg, Nicky Dunbar, Kristen Aramthanapon

Appendix A: Working Session Meeting Minutes

The following contains the meeting minutes to all working sessions.

Working Session: ASD Expert Panel Kickoff – Apr. 26, 2023

Began recording meeting

ACTION ITEM – This highlights an action item for a panelist.

ACTION ITEM – This highlights an action item for BPA and/or Cadeo.

Attendees

BPA: Joan Wang, Todd Amundson

DNV: Tyler Mahone, Bridget Ransford, Lorre Rosen

Cadeo: Nate Baker

Panelists: Pete Gaydon (Hydraulic Institute), Mike Wolf (Greenheck Fans), Paul Lemar (Resource Dynamics), Dave Morris (RHT Energy), Ryan Firestone (Council/RTF), Rob Boteler (Independent/Confluence LLC), Evan Hatteberg (NEEA), Nicky Dunbar (NEEA)

Unable to attend: Prakash Rao (Independent), Kevin Smit (Council)

Working Session Agenda

The presentation will cover the following agenda:

- Introductions (15 min)
- Kickoff Meeting Goals (5 min)
- Background on BPA Market Modeling (10 min)
- New ASD Market Model Scope (25 min)
- Interim Model Game Plan (30 min)
- Timeline for Expert Panel Activities (10 min)

Kickoff Meeting Goals

Joan reviewed the goals for today's kickoff meeting. The primary goal is to re-engage the panel for the next iteration of the ASD market model.

The market model will help forecast energy consumption of pumps and fans in the northwest region. This will help BPA determine energy consumption and calculate ASD momentum savings, or ASD savings that occur in the market above the Council's Power Plan baseline without direct utility incentives or NEEA programs.

We want to:

- Introduce/reintroduce the team and expert panel
- Present updates on the model scope
- Discuss key model inputs to update
- Talk through timeline for expert panel engagement

BPA's Market Models serve multiple purposes:

- Quantify momentum savings
- Forecast energy consumption
- Consistently characterize market trends

Expert panelists serve as a resource to help the team develop a best-in-class model, through:

- Technical expertise and experience
- Creativity and open-mindedness
- Consistent commitment

Mike Wolf asked how BPA defines industrial fans and how that differs from commercial and residential fans? **Joan** said that Nate can address this question later in the meeting. *See page 8 for the response.*

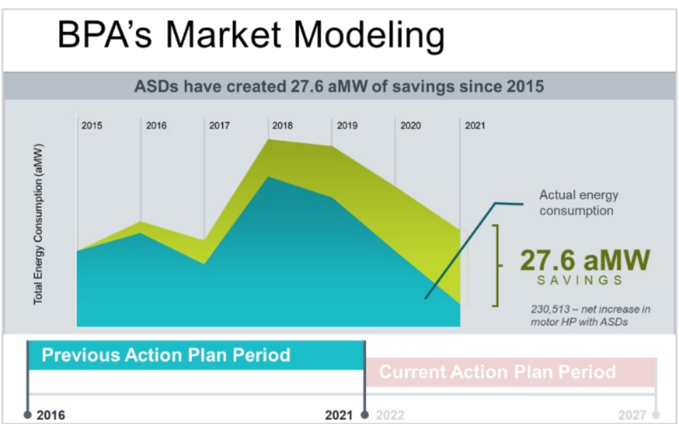
Background on BPA Market Modeling

Joan provided additional background on BPA's market modeling process.

BPA creates market models in six-year periods to align with:

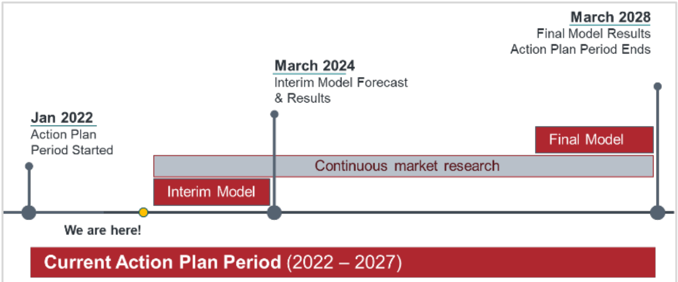
- Northwest Power and Conservation Council's Power Plan Action Plan Periods
- BPA's Energy Efficiency Action Plan Periods

BPA produces an action plan with target energy efficiency savings for a six-year period. The current plan covers 2022 through 2027. For the last Action Plan period (2016-2021), BPA was able to quantify about 27.6 average megawatt (aMW) savings from adding ASDs to industrial pumps and fans in the northwest region. For the current Action Plan period we have a longer time frame to work with which will benefit the new model.



There are two phases to modeling in the current period:

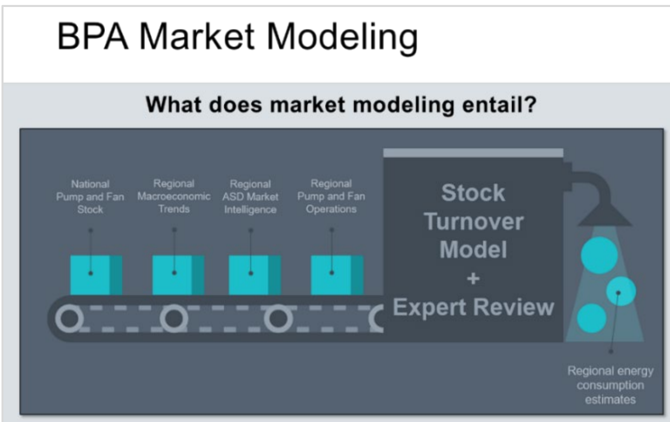
- Interim model: Produce a forecast of energy consumption and Momentum Savings for 2022-2027
- Final model: Produce final results and report Momentum Savings for 2022-2027



Joan noted that we are in a different place than where we were a year or two years ago. During the last action plan period we were trying to build a model, finalize savings, and get all the data all at once. We did all of that in two years. But now, we have a longer timeframe to work with. For the next 12 months, we will build the interim model to produce a reasonable, vetted forecast of savings, energy consumption, and trends. After March 2024, we will do additional market research and fill in the data gaps. BPA is going to tackle some hard questions up front, but we are in it for the long haul.

Nate added that we have a lot more runway to build and refine our model. With this extra time, we can be more forward thinking.

Tyler added that the panel is here to provide solutions and ideas on how to improve this process.



Joan noted that the image above outlines the methodologies the panel helped to develop for the last model. We looked at regional and national pump and fan stock information. We looked at regional macroeconomic trends to see how the industrial pump and stock changed year over year. We also gathered region-specific information about ASD sales that helped us model the saturation of ASD in the region and how that changed over the last six years. We also looked at regional ASD market intelligence and developed a database of regional pump and fan operational characteristics to help us reliably estimate energy consumption. You helped us develop the methodology and review a multi-page document to solidify model inputs. The expert review along the way helped us vet and calibrate our results. We have done all of that over the last two years.

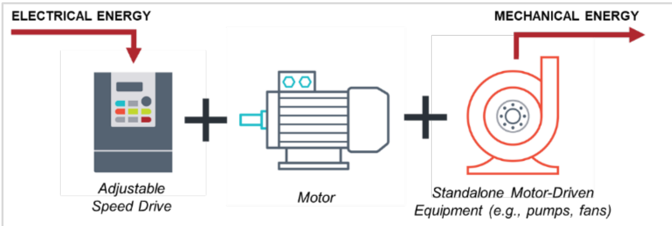
Joan added a reminder that we follow the four-question framework to develop all the market models. This framework is not specific to the ASD market model; this is the method we follow on all market models. We answer each question, in order to produce model results.

- What is the market?
- How big is the market?
- What are the total market savings?
- What are the program savings?

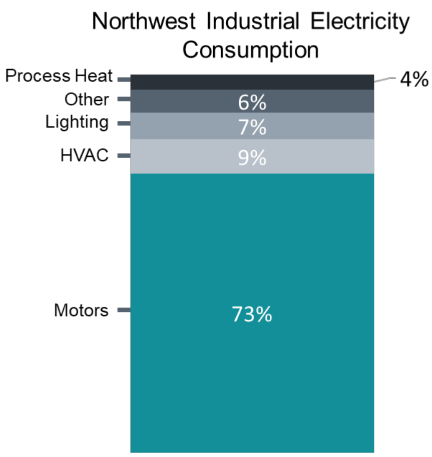
New ASD Market Model Scope

Before reviewing slides for this section of the meeting, **Nate** noted that we have a new component of the model, and we will be expanding the model scope to include more than just industrial pumps and fans. Nate started the discussion with a refresher about ASDs and why we are focusing on it.

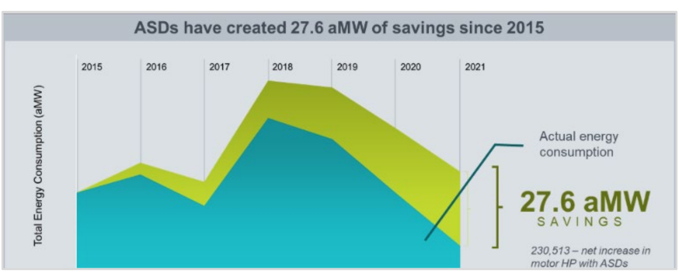
An *adjustable speed drive, or ASD*, is an electronic controller that allows a motor to spin at various speeds. This includes variable frequency drives, variable speed drives, and any motor technology that is inherently variable speed. Switch reluctance or ECMs that are a packaged unit that don't have a separate drive, but are variable speed, are lumped under the umbrella term "ASD". That does not include mechanical controls that allow for asynchronous rotation of the motor in driven equipment. We account for those in the model, but we are not considering them as ASD. That is, we don't calculate savings based on the application of those mechanical devices.



The other terminology we want to discuss is *standalone equipment*. We are focused on standalone equipment in this market model. Even though we are expanding our scope a little, we are still focused on standalone equipment or pumps and fans that are not embedded in larger built-up packaged units.



Why does BPA care about ASDs? We care about the energy savings potential that an ASD provides, especially on centrifugal equipment that follows the affinity laws and the cubic relationship between speed and power. We also care about the large amount of energy that is concentrated in these motor-driven products. The chart to the right shows that 73 percent of the electricity used in the industrial sector is concentrated in motors. Of that 71 percent, 31 percent is used in pumps and fans (not shown on the graph), and that equates to approximately 25 percent of industrial energy use in pumps and fans. That is a huge energy consumer, we identified ASDs as equipment having a big impact on the energy use of pumps and fans. That led to BPA developing the last market model. We identified ASDs as a big potential energy saver, and our model showed that there was a big difference in energy consumption due to the adoption of ASDs. We used that model to calculate energy consumption for the model period using a baseline case, which is this theoretical energy (shown in green below) that industrial pumps and fans would have consumed without the ASD adoption that occurred within the model period. It identified that ASDs saved 27.6 aMW. That is normalized to account for the fact that energy use fluctuates year over year in the industrial sector and we saw some interesting trends in 2020 and 2021 because of COVID. Our model allowed us to characterize COVID, but didn't adjust or impact the methodology for calculating savings.



Nate noted that we built the previous 2016-2021 market model to cover Industrial Pumps and Fans. The previous model calculated:

- Energy consumption
- ASD adoption
- ASD Program activity
- Momentum savings

For the new ASD market model, we have been investigating potential areas for model scope expansion. In the table below, the rows include the different sectors that motors cover, and columns represent different end uses. We looked at two potential groupings of these end uses.

First, we considered expanding within the industrial sector and developing an industrial motor market model, which would model not only pumps and fans, but also material handling and processing, air compressors, and refrigeration compressors and really diving into what motor energy use in the industrial sector looks like.

Sector	Motor End Uses							
	Pumps	Fans	Air Compressors	Material Processing	Material Handling	Refrigeration	Pollution Control	Other Motors
Industrial								
Commercial								
Agricultural								
Residential								

The second option was focusing on pumps and fans more detail. So instead of expanding within the sector, we would expand within the equipment to develop a commercial and commercial pump and fan market model.

Sector	Motor End Uses							
	Pumps	Fans	Air Compressors	Material Processing	Material Handling	Refrigeration	Pollution Control	Other Motors
Industrial								
Commercial								
Agricultural								
Residential								

We assessed both options, looked at pros and cons, and discussed the benefits and risks with each potential model scope.

Option 1 – Industrial Motors:

- Better understanding of industrial motors beyond pumps and fans
- Large potential savings opportunity
- Big uncertainty
- Very under-characterized

Option 2 – Commercial and Industrial Pumps and Fans:

- Near-full characterization of the equipment types
- Smaller potential savings
- Active programs
- Data collection needs are better understood
- Better characterized market

For industrial motors, we were very excited because there is a huge amount of energy consumption in the sector and big potential to provide insight into the industrial sector, that is historically less well characterized than the commercial or residential sector. There was a big opportunity there.

But the uncertainty in that scope option for industrial motors was too big. With it being under characterized, there is inherently more uncertainty in the size and characteristics of this industrial motors market. It was a hazy field when we looked at the currently available data. And beyond just the stock and characteristics of these motors, there was also more uncertainty in the energy savings potential.

We ended up choosing to focus on commercial and industrial pumps and fans. Program activity was a big driver. There is a lot of program activity in the Pacific Northwest around pumps and fans across the sectors.

The BPA market modeling team and the energy efficiency world in general has done a lot of investigation and characterization of ASDs on pumps and fans. There is less aggregated information on the energy savings for other motor-driven equipment that aren't pumps and fans. Most of the other equipment aren't variable torque, which means they don't see that cubic energy power to speed relationship and have less dramatic energy savings. That was another component of uncertainty that compounded on top of other ones and led us to focus more on expanding our model and digging deep on pumps and fans and characterizing the savings potential there.

Nate added that it's not to say that BPA is not interested in industrial motors. The hope is to structure our collection for industrial pump and fan operational and stock data, to help expand the knowledge of industrial motor use in general. But our scope for this model, we will plan to focus on commercial and industrial pumps and fans.

At this point, **Nate** opened the meeting up to discussion and asked the panelists if they had any thoughts, comments, or concerns about BPA's plan to expand into the commercial sector.

Rob asked when you talk about active programs, does that include DOE programs or regulations at the extended product level for pumps and fans.

Nate replied that the establishment of an energy conservation standard by DOE is something we considered mainly because that serves as another big source of information. Pumps and fans have been engaging with DOE and that results in building up of characterization for that market. When we talk about a better characterized or under-characterized market, the presence of a standard is one of the things that impacts it. The program that we will be characterizing in the market model when talk about program savings are energy efficiency incentive or market transformation programs.

Rob added that because DOE has been so engaged with fans and pumps, there must be a lot of available data…maybe not specific to the states we're looking at, but at a national level.

Nate added that the analyses that DOE performs for those standards were helpful when we developed the last model and served as a foundation for understanding the efficiency mix of the equipment and a comparison point for different operating characteristics. The standard gets incorporated into the data that informs the model.

Rob said he was surprised that we see smaller potential savings [for the commercial/industrial pumps/fans scope option compared to the industrial motors scope option]. On the industrial side, you have higher horsepower machines. And on the commercial side, you have more machines, but they are a lot lower horsepower which would be part of the argument for a smaller potential with the commercial industrial vs. just the broad industrial.

Nate acknowledged that Rob made an excellent point. It is both the size of the equipment and the fact that we are covering so many more end uses in industrial motors. Material processing and handling are huge energy consumers in the industrial motors end uses. This market model scope would cover those motors and that will increase potential savings. But the unknown factor of the savings potential from an ASD adds to the level of uncertainty.

Rob asked in either case, did we consider municipal? We don't consider water, wastewater, natural gas. That is not in the scope?

Nate replied that for industrial pumps and fans, this is a great point to answer Mike's earlier question about how we define the sectors. And how we define an industrial fan vs. a commercial fan. That definition is based on where that fan or pump is installed. How are we defining those sectors. During the last model, we used NAICS codes to define the industrial sector. The most recent update to the Power Plan included municipal water conveyance and municipal water treatment in the industrial sector. While we are not expanding the scope, the definition of industrial has expanded to include those municipal systems.

Tyler asked if Evan, Nicky, and Ryan had any thoughts on the expanded scope.

Nicky said that there is a lot happening on the federal level in relation to motors and there is a large need for understanding parts of the market that aren't well understood right now. In terms of industrial motors, where they are, what they're doing, etc., is a "topic of activity" right now.

Joan commented that Nicky made a great point and a reminder that similarly in the region, we might be getting to a path of developing a motor stock assessment study. BPA is working with NEEA to try to determine what that looks like. That will help with data that we will need for either of these modeling options. We desperately need an updated look at the region's industrial motor stock. Regardless of either path we take over the next six years, the BPA will continue to be interested in industrial motors and bolstering knowledge of motor stocks and the industrial sector. Hopefully, we will get to a place where we have much better knowledge of industrial motor stock and can contribute to the activity that is happening beyond the region.

Ryan, from the RTF's perspective, either path provides valuable information for the RTF. Focusing on pumps and fans makes sense since that is the direction that we've been going in. So, to learn more and have a better understanding of those markets sounds great. Of course, anything we learn about other industrial applications will be useful too.

Paul commented that he agrees with Joan that we desperately need an update on motor stock. On the last model, we were starting to extend an older DOE assessment on motors into this timeframe. We don't want to keep projecting older data set. With the longer timeframe, we have more luxury to investigate what's coming. In the commercial space, we do see a lot of standalone pumps for chilled water distribution and things like that. But for fans, most are embodied in air handlers. If that is not included because it's part of a piece of equipment, does this limit the scope too much?

Nate mentioned that we will be excluding embedded fans within commercial and they do represent a large portion of the fan stock. We will discuss more on this later, but NEEA's commercial building stock assessment does a really good job of characterizing the fan stock in commercial buildings. And we can identify those ventilation exhaust supply standalone fans.

Paul asked for clarification about municipal water conveyance and water treatment being included in the 2021 Plan, but is wastewater also included?

Nate said, yes, the segments included in the plan are water supply and either wastewater or sewage treatment.

Paul commented that 50-60 percent of their load is aeration (standalone blowers) and the rest of it, 20-30 percent of their total is almost all pumping. Pumps and fans in total are 80-90 percent of their load.

Nate moved on to the next slide and asked how does this change the way we are modeling the market? Expanding into the commercial sector impacts most facets of the model:

- Impact of Energy Code is prevalent in the commercial sector and much less prevalent in industrial.
- There are deemed programs in the Northwest that cover ASDs on pumps and fans in the commercial sector. In the industrial sector, those are all custom programs. We developed and

implemented the methodology for custom programs during the last model build, but we will have to develop a new methodology for deemed programs.

- There are different drivers of motor stock growth in the commercial and industrial sectors. We used gross output for different industries to model the change in motor horsepower in the industrial sector. And that is not really a macroeconomic trend we can use in the commercial sector. We will dive into how to model that commercial sector growth.
- There are different ASD sales patterns. ASDs are sold very differently in the industrial sector. We learned through data collection in 2021 and early 2022 that the industrial sector almost exclusively sees their drive sales through a separate supply chain. They are sold separately and paired at installation. Within the commercial sector, ASDs are sold both without equipment and with equipment that is packaged with a drive. We want to account for that. There are other differences that we will incorporate into our methodology.

One of the main high-level goals for this interim model is to build a framework that addresses and accounts for all those sector-specific nuances for the commercial sector. And then use that framework and the data that currently exists within the commercial sector along with our existing model to forecast the savings for this action plan period. We also want to start the process of developing data sources for the final model. And we very consciously used the term "start developing data sources" because there is a lot of information and data needed to constantly model the market. And that data takes time to identify, collect, and incorporate. We have five years to finalize this model, and we want to make sure that we are preparing and using our time wisely and setting ourselves up at the end of this interim model to collect the data that we need in the intervening years. So that when we start that final model development, we have the data that we need.

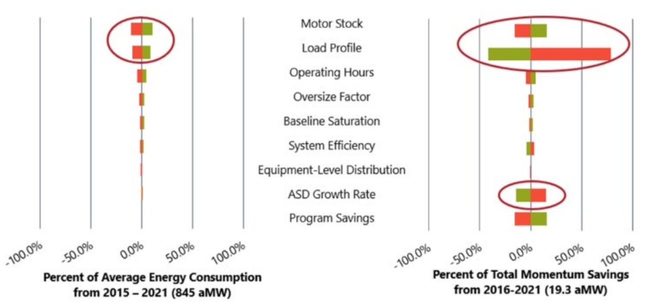
We took a brief, five-minute break at the meeting's one-hour mark.

Nate continued by discussing the goals for the interim modeling period, which include:

- Build a framework for the commercial sector
- Develop a savings forecast for the model
- Start the process of developing data sources for the final model

By the end of the interim model, we want to have a well-informed forecast and a solid plan for finishing data collection and modeling by March 2028.

Interim Model Game Plan



We are starting by investigating the model's most uncertain components. The graph below is the result of the sensitivity analysis that we collected on the model results from the last model. We did this analysis to understand where the biggest points of uncertainty existed in the model and in the different inputs we had.

The three biggest drivers of uncertainty are motor stock, load profile (operating information), and ASD growth rate, which we are going aim to characterize in this action plan period through ASD sales.

Item	Industrial	Commercial
Data Needs	Recent, regional motor stock information	NEEA Commercial Building Stock Assessment (CBSA)
Activities	***Near Term:*** Identify and aggregate any existing facility/building audit data	
	Long-term: Motor-driven Product Stock Assessment	***Long-term:*** Provide input/support on future CBSA

The stock of motors is the biggest driver of uncertainty in energy consumption. For momentum savings, the biggest driver was load profile along with motor stock and ASD sales. Program savings was large as well, but we spent time focusing on why it was large. While it is a big factor in this sensitivity analysis, there wasn't a lot of uncertainly around why the bar is the size it is

Motor Stock

On motor stock, **Nate** noted that we will be talking about the industrial and commercial sectors separately because we will use different data for each sector. For the commercial sector, NEEA's most recent CBSA includes information on motor-driven equipment, which can serve to inform the motor stock. They collect information on the pumps present in buildings and the size of those pumps, similarly for fans. They also have enough information to identify embedded vs. standalone fans.

The goal from a long-term perspective is to provide input and support to NEEA in collecting this information again in the upcoming CBSA. In the near term, we will incorporate the information they have from the previous CBSA.

For industrial, it is a little more complicated. The model uses motor stock information from the motor system market assessment to characterize motor horsepower. That data is national in scope. By the end of this action plan period, it will have been collected almost 10 years prior. That study was conducted in 2018 and published in 2020-2021. Once we are at the end of this action plan period in 2028, we will be almost 10 years beyond the collection point. And that, along with it being a nation characterization of stock means that the modeling team is focused on finding or developing a more recent, region-specific data source. As Joan mentioned earlier, a motor-driven product stock assessment is in discussion within the region. That is a long-term goal; it will take a lot of engagement from PBA and work from NEEA.

In the near-term, the plan is to identify and aggregate existing building audit data. We have been brainstorming ways to aggregate existing data to inform motor stock. We currently don't have a regional characterization of industrial motor horsepower.

Our working hypothesis is that we want to use facility audit data to understand the motor horsepower for both pumps and fans in different industries within the region. Utilities collect this information for programs and characterize a facility's energy use based on it. Our thought was, first, that we could use of this data to serve as a corroboration or calibration point for the national data that we are currently using because the data was collected robustly and could serve as a regional point to tie or calibrate that data. The second use of the data could be to show what we know about that motor stock and to find out what information do facilities collect or track that they provided in this audits that a motor-driven stock assessment would be able to collect to help inform any data collection tools or the scope of a full-scale industrial motor-driven stock assessment. The initial goal would not be to develop a representative sample with this method during this period, but to serve as another point of reference for a model input. The interim modeling period is about a year long, so we wouldn't have time to collect a representative sample and do a bunch of extrapolations or weightings to create a statistically representative assessment through the utility audit forms. The goal would be to provide another point of reference for any model input.

Nate then asked the panel the following question.

Question for the Panel: Do you know of any sources of building/facility audit data that we could use to inform the motor stock in the Pacific Northwest? If so, do you have contact information?

Paul commented that the audits he has been involved in will break down the energy use into certain areas and the efficiency measures may highlight the horsepower of the measure. But there is usually not a facility inventory of motors by size range in an audit because it is not a productive use of time. You might be able to garner some anecdotal information, but it may not be enough to build the model.

Nate confirmed that we would get energy use information, and we could use that for a comparison point against the product of our model because the model results produce energy consumption information, but not necessarily stock information.

Paul said you might be able to get the amount of energy use that is motor driven, but I don't think it would give you a complete assessment of inventory.

Todd agreed with **Paul** and said that many audits will focus on processes and systems and there could be some useful information like motor horsepower provided, but it will miss the lower exhaust fans and things of that nature. But he does think that in strategic energy management, there are energy scan reports where you might get a little more detail down to horsepower per system process and HVAC, and that might be worth investigating.

Rob suggested carrying out a study like Prakash did where we look at example facilities in a variety of categories and then use a resource like an ISA (Industrial Supply Association) organization to do an audit with our own guidelines. Then we can extrapolate from a handful of factual audits.

Tyler reminded everyone that we will be sending a list of the question from today's meeting to the panelists so they can provide more detailed responses and information.

Nate continued the discussion by moving on to the next topic: operational data.

Operational Data

Operating characteristics define the model's UEC value and can be big drivers of uncertainty:

- Load Profile: Largest driver of uncertainty in ASD savings
- Operating Hours: Third largest driver of uncertainty in energy consumption
- Metered energy consumption: used as a comparison point for model results

Load profiles are the largest driver of uncertainty in ASD savings because the savings mechanism of an ASD is so dependent on the load points that a pump or fan spends its time. We grouped the operating characteristics together b/c we want to improve all that we can. Often, collecting one will allow us to characterize others. For example, collecting information on load profile can be from metered energy consumption from a pump or fan.

In the near term, BPA is focused on incorporating commercial operating data into the model framework that we build out. There are RTF measures that characterize the energy savings for commercial pumps and fans and there is the data that DOE pulls together. There is a base of information for this commercial equipment, but we have similar uncertainties with load profile within the commercial sector. Because the plan is not to collect any of the operational data ourselves, we are reliant on other sources for that data. We know the info takes a lot of time to collect and even longer to get to a critical mass to use in the model. We want to start a process to identify the data that we have and the data gaps that exist.

Nate then asked the panel the following question.

Question for the Panel: Do you know of any sources of operational data or potential methods for collecting pump/fan operating information?

Paul added that one data source BPA should consult is the IAC database of measures for the industrial sector. They are not going to give you comprehensive sets for each facility, but for the measures they evaluate, they not only characterize operating hours, but also the duty cycle. The data is kind of anecdotal, but they have several assessments for the centers in that footprint.

Nate asked if Paul knows if they have any additional beyond what is publicly available on their website.

Paul said the written reports have much greater detail and quantitative information that probably does not get into the database. You could even request IAC data for specific facilities.

Nate then moved on to discuss sales data.

Sales Data

To characterize the full market of ASD sales we need information from both the equipment (fan and pump) market and the drive market. The goal here is sales data collection. This is a big one for BPA because sales data collection in industrial is difficult and it's a big lift for BPA market research and for individuals and organizations that we're collecting data from. We want to dedicate a lot of our time as an expert panel to focus on sales data collection. We want to set ourselves up for success so that when we do go out and collect data, we collect enough data that we can use it in the model and have a broader impact with that data collection.

Equipment	Sector	Equipment Sales Data	Drive Sales Data
Pumps	Commercial	X	X
	Industrial		X
Fans	Commercial	X	X
	Industrial		X

Nate then reviewed the matrix. Our initial step is coordinating with organizations that are conducting or in the process of starting any data collection in these markets. Earlier we mentioned the program activities that are happening in this sector and NEEA is a big force in that work. They have the Extended Motor Products (XMP) program that they have been running for a couple of years that is focused on commercial pumps and VFDs on those pumps. We want to make sure we're coordinating with them and the efficient fans team at NEEA and being conscientious about outreach and data collection and making sure that we're collaborating in this process.

Our biggest data gap is drive sales data. We have experience, knowledge, and insight into equipment sales data collection and data collection process. What we are hoping for now is twofold. One, we are asking if anyone on this call has insight into where in the supply chain the information on the equipment that ASDs are installed with lives. It is one thing to know that an ASD is sold, it's another to know where it is sold to, but it's a totally different thing to know what piece of equipment it's sold on. Because they aren't sold with the equipment in industrial, we are in the process of identifying where that installation component in known. Our initial thought is that it will be known at the installing contractor, but will it be known further up the supply chain like at the distributor level?

Second, is there anyone on the call who has contacts in the ASD supply chain: drive manufacturers, salespersons for drive manufacturers or distributors, or installing contractors that work with ASDs. Our goal with these contacts is to discuss what information is known at the level you work at in the supply chain, and we want to make sure we discuss data availability and ensure that any data collection plan is reasonable to implement within the market. We want to make sure that we don't start on a data collection effort and then finding out that a key data point isn't known, or it's only known in a specific data form that we can't use. We want to have a full picture of the data and where it lives within the supply chain.

Question for the Panel: Would you be able to provide contact information for any drive manufacturers, drive sales personnel, or drive installing contractors?

Nicky said that she probably has a couple of contacts for drives that she can pass to BPA. She added that for fan sales data, that will be a tricky thing. NEEA is beginning a fans program, and they are struggling to access sales data from various partners due to sensitivity around market privacy. That is a current barrier that NEEA is facing.

Paul mentioned that Siemens claims to be the largest manufacturer and seller of medium-voltage VFDs in North America and that he might be able to get the Siemens contact info. He can ask. If you look at smaller, 1-50 horsepower Schneider Electric model, Schneider will market through the local distributor.

Rob noted that most motor and drive manufacturers report their sales to National Electrical Manufacturers Association (NEMA), but they don't report their sales information geographically by region. It might be worth a conversation with Don Levins who runs that organization within NEMA to see what interest level there might be with the two manufacturing groups to see how difficult it would be to report that data by region. Rob said that we would check it out.

Joan and **Tyler** thanked the panel and then Tyler moved on to discuss the timeline and next steps.

Timeline for Expert Panel Activities

We want to be strategic about our Expert Panel Engagement and leverage different types of panel sessions:

- Large engagement: Large working sessions with pre-work, discussion, and follow up questions
- Medium engagement: Desk review with no meeting
- Small engagement: Targeted outreach to discuss a specific model component

There will be three main topics for the Expert Panel:

- Data collection
  - Small engagements to plan and scope any data collection
  - Medium Desk Reviews of data collection tools
- Model inputs
  - Large session to discuss methodology
  - Medium engagements to review model inputs
- Draft results
  - Large session to review and discuss results

Summary Table

<table>
<tr><th colspan="2">Topic</th><th>Tentative Timing</th><th>Description</th></tr>
<tr><td colspan="2">Model Methodology (large)</td><td>July 2023</td><td>Working Session to discuss and refine model methodology</td></tr>
<tr><td rowspan="3">Model Input Review (medium)</td><td>Updated UECs</td><td>September 2023</td><td rowspan="3">Desk Review of the model input workbooks. Expert Panel to provide input and feedback on data sources and analysis.</td></tr>
<tr><td>Stock Characterization</td><td>October 2023</td></tr>
<tr><td>Program Savings</td><td>Dec 2023</td></tr>
<tr><td colspan="2">ASD/Equipment Sales Data Collection Plan (medium)</td><td>Q4 2023</td><td>Desk Review of Data Collection Plan</td></tr>
<tr><td colspan="2">Model Results (large)</td><td>March/April 2024</td><td>Working Session and Desk Review of the interim model results</td></tr>
</table>

Working Session: Unit Energy Consumption – Jan. 31, 2024

ACTION ITEM – This highlights an action item for a panelist.

ACTION ITEM – This highlights an action item for BPA and/or Cadeo.

Attendees

BPA: Joan Wang, Bonnie Watson

DNV: Tyler Mahone, Lorre Rosen

Cadeo: Nathan Baker, Cory Luker

Panelists: Pete Gaydon (Hydraulic Institute), Kenneth Kuntz (Greenheck Fans), Dave Morris (RHT Energy), Rob Boteler (Independent/Confluence LLC), Evan Hatteberg (NEEA), Todd Amundson (BPA)

Unable to attend: Paul Lemar (Resource Dynamics), Ryan Firestone (RTF), Nicky Dunbar (NEEA), Kevin Smit (Council)

Working Session Agenda

The presentation will cover the following agenda:

- Introductions & Recap (5 min)
- Goal of this Meeting (5 min)
- Review Model Basics (10 min)
- UEC Model Input Updates
    - Transmission Efficiency (5 min)
    - Operating Hours (20 min)
    - Load Factors (35 min)
- Wrap Up and Next Steps (10 min)

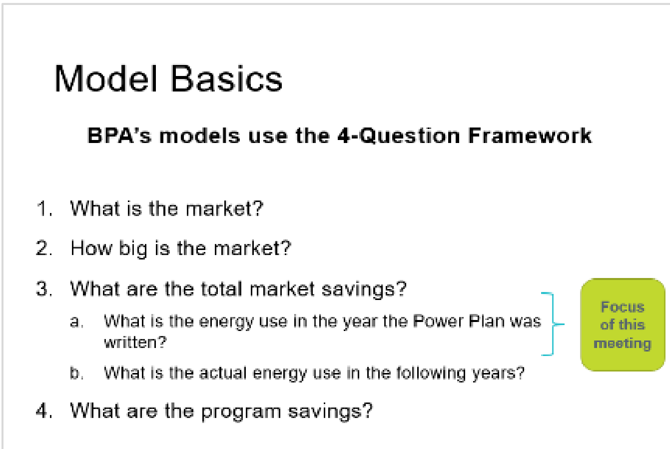
Introductions, Recap, Meeting Goal

Tyler led the panel through introductions, including our new panelist, Ken Kuntz.

Joan provided a brief overview and recap. Since our kickoff for the interim model last spring, we have a lot of model updates and then hopefully we will wrap up everything that we want to do for the interim model by the middle of the year. You can expect a lot more expert panel engagements, both working sessions and desk reviews, in the coming months. What we have been doing for the past year is updating this model to cover the next six years, years 2022 to 2027. We also made a big decision to expand the scope of the model to include commercial pumps and fans. Some of these years are in the future, what we want to get out of the interim model this year is a forecast of energy consumption and savings over the 6-year time period. We are going into that forecasting territory where we do not have the data for some things yet, but we are going to work with you to hopefully come up with the best forecast that we can.

The goals of this meeting are to review updates to the UEC equation and associated inputs and an analysis of new pump and fan operating data and discuss any red flags or opportunities for improvement in data sources or analysis approach.

Model Basics



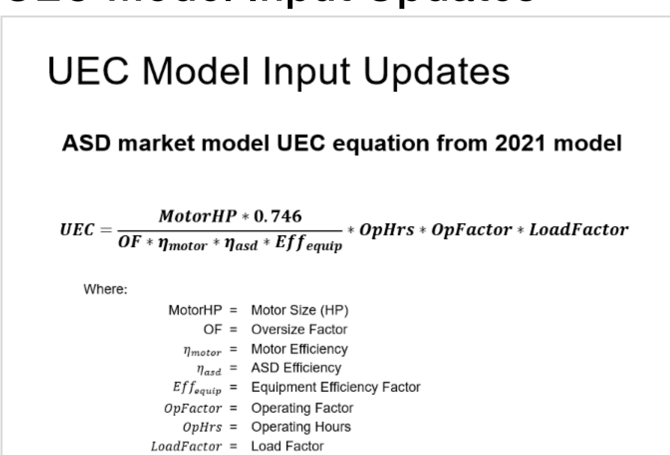
Nathan reviewed the basics of BPA's model.

The first question focuses on defining the scope of the model. As Joan mentioned, we are covering commercial and industrial pumps and fans. The second question looks at how big the market is. For the ASD model, our units are number of motor horsepower. We calculate the number of motor horsepower in the Pacific Northwest in each year. Question three is the question that we are going to focus on during this meeting. What are the total market savings. The focus of this meeting is the first sub question: what is the energy use of equipment in the region? We use unit energy consumption (UEC) to calculate that energy consumption. The fourth question is what are the program savings? In answering all of these questions, it allows us to calculate energy consumption and look at the savings impact that ASDs have had over the time period.

For the ASD model, we have seven model dimensions to characterize energy consumption. Each unique combination of these dimensions represents a group of motor horsepower that have similar energy consumption patterns. The model calculates a separate unit energy consumption value for each unique cell. When we calculate the number of motor horsepower in the region, we also attribute those motor horsepower to these same cells to understand the energy consumption of those motor horsepower and then the sum of all of those cells represents the total market in the region.

Nathan continued. We are not calculating the energy consumption of any one actual pump or fan. We are looking at the market in the Northwest as a whole. We are using average values for variables like operating hours or load factor, which means that we are calculating the average UEC for the pumps and fans that fall into that cell, and it does not represent the actual energy consumption of any one use.

UEC Model Input Updates

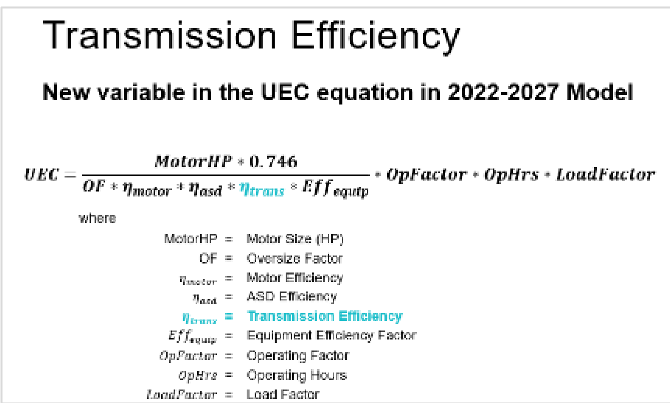


Nathan continued. As a refresher, this is the equation that we used in the 2021 model. Our calculation of kilowatt hours per year for a given system is based on multiplying the average input power by the operating hours. These variables here are what allows us to do that.

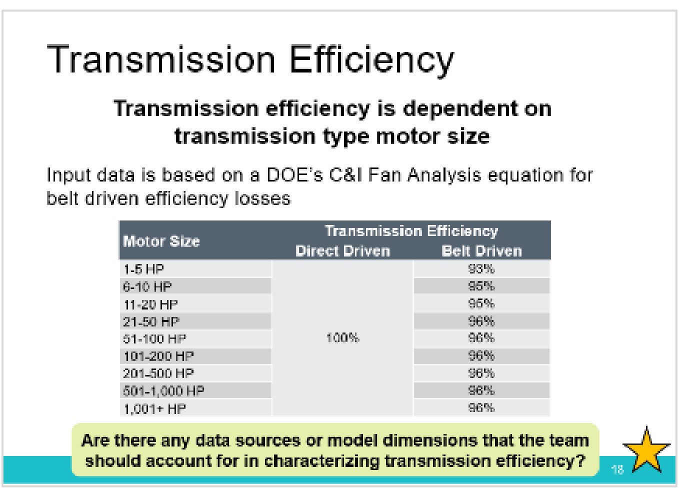
We include motor horsepower to understand the size of the of the equipment and this 0.746 is a unit conversion value. We also include an oversize factor to account for the fact that in the field, designers and installers, either out of caution or simply necessity, oversize motors beyond the needs of the system. We also have these different component efficiencies that account for the efficiency of the equipment, the motor, and the efficiency of the controller. We have an operating hours factor, the amount of time that the that the pump or fan is operating in a year. We have an operating factor that aligns the modeled power draw through this equation with metered data. We used a database of metered data to calculate that operating factor. We compared our calculated values to that database and then used this to adjust based on real-world data. And then this final factor is the load factor, and it accounts for the average power output of a system relative to its nominal horsepower over the course of the year. This load factor is the variable that we got a whole bunch of new data for that Joan mentioned at the beginning of the presentation.

Nathan continued. A quick summary of the changes to the UEC equation and input. There are three main changes. The first one is that we added a new variable. We added “transmission efficiency” to account for the losses between the motor and the motor-driven equipment mainly in regard to belt-driven fans to account for the losses within those systems. Next, we brought developed new operating hour inputs for the new building types in the expanded model: 10 commercial building and the wastewater and water supply facility type and the cement facility type. Previously, cement was just included under miscellaneous and now we are separating and creating its own category. The last update is what I mentioned before. We have new data to inform our load factors, so we are going to be spending a lot of time talking through that analysis.

Transmission Efficiency



Cory continued. On the slide, you see the same UEC equation that we showed before, but there is a new variable. It is a new component efficiency variable for transmission losses, and it considers the efficiency losses between the motor and the motor-driven equipment. This is the only update that we made to the actual UEC equation. All of the other changes are going to affect the inputs to these existing variables.



Cory continued. Transmission efficiency is dependent on a new dimension called transmission type and the size of the motor. This transmission type dimension is either categorized as direct-driven or belt-driven and there are only transmission efficiency losses if the system is belt driven. If the system is direct driven, then it is a direct connection between the motor and the equipment. So, there would not be any efficiency losses. This input data is based off of the Department of Energy’s (DOE) commercial industrial fan analysis equation for belt-driven efficiency losses, and their values vary by motor size. We also vary our efficiency losses by motor size, and you will see that this update is going to increase energy consumption of belt-driven fans by anywhere from four to seven percent. And because both ASD systems and non-ASD systems would have or not have the same transmission type, there is going to be a negligible impact on ASD savings. A minor adjustment to that overall impact on the model, but worth acknowledging. It is also good to note that our stock assessment research indicates that belt-driven equipment is really prevalent in fans, particularly in the commercial sector. But belt driven pumps are rarely installed, if ever.

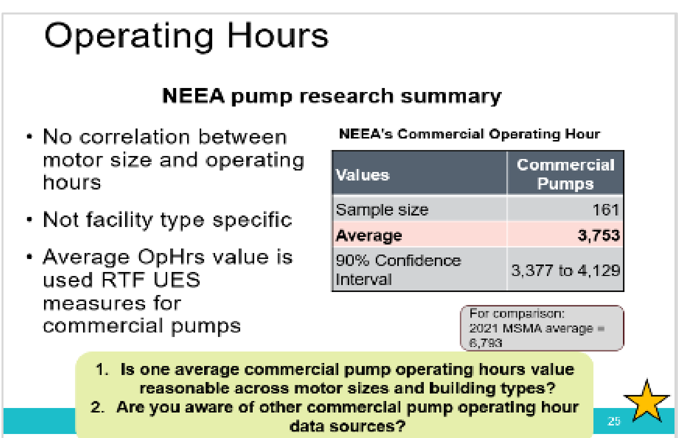
Ken agreed with the information being presented. I think the DOE is actually using the Air Movement and Control Association (AMCA) equation for transmission efficiency. And just off the top of my head, it looks like your percentages are pretty much spot on…higher belt drive loss on the lower horsepower models and then less of an impact on the higher horsepower models. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) also did a research project exactly on belt drive losses. They did that through AMCA, but I believe you have probably got it modelled correctly. But obviously, there is the ASHRAE research project out there that you can verify with.

Operating Hours

Cory continued. In the 2021 model, operating hours relied on the Northwest Industrial Motor Database. This is an industrial-only database. It is specific to the Pacific Northwest, and it contains more than 200,000 motor or pumps and fans. We could get operating hour correlated to both motor size and facility type in that database. In this new model, we have expanded our scope to include commercial sector facility types and introduced two new industrial facility types: 1) water and wastewater and 2) cement facility types. We have had to consider new data sources for operating hours.

Commercial Pumps

Cory continued. We will start with commercial pumps. The team identified NEEA pump research as the best available resource for commercial pump annual operating data. This resource comprises field data collected on the energy consumption of commercial pumps, and it contains meter data from more than 161 pumps in the Pacific Northwest. Additionally, it is the basis for the Regional Technical Forum's (RTF) current commercial pump unite energy savings (UES) measure. The RTF is the Northwest entity that produces/validates analyses and data supporting energy efficiency measures offered by many utilities. We also looked at DOE's 2021 Motor System Market Assessment (MSMA). This is a national assessment with a large sample size of motors considered. However, all operating data, be it load factor or operating hours, was based off of survey responses. They essentially asked participants to give a rough estimate of what the operating hours for pumps were. Despite having the MSMA having a larger sample size, the team opted to use the NEEA data because it is regional, it is based off of meter data, and it has a decent sample size for the commercial sector.



Cory continued. This shows a summary of the NEEA's pumps research, NEEA's pumps research did have information on motor size, but it did not show any correlation between commercial pump operating hours and motor size. The data set did not distinguish pumps by facility type. As a result, we do not define separate commercial pump operating hours based on motor size or facility type. We are just using a single value for all commercial pumps. This is consistent with the RTF UES measure for commercial pumps, which uses the same average value of 3,753 as the operating hour for all commercial pumps regardless of size, install location, or application. I have also included the MSMA average, which is substantially higher. But the fact that the NEEA data is regional and that the quality of the data we have from NEEA and the tightness of the confidence interval from the data set makes us more confident in the operating hours from NEEA.

Rob said that he agreed with Cory. I think the NEEA data is more accurate. **Dave** added. Based on my experience on energy studies, I would definitely have more confidence in the 3,750 value. It seems more reasonable and reflects what I have seen in in my experience.

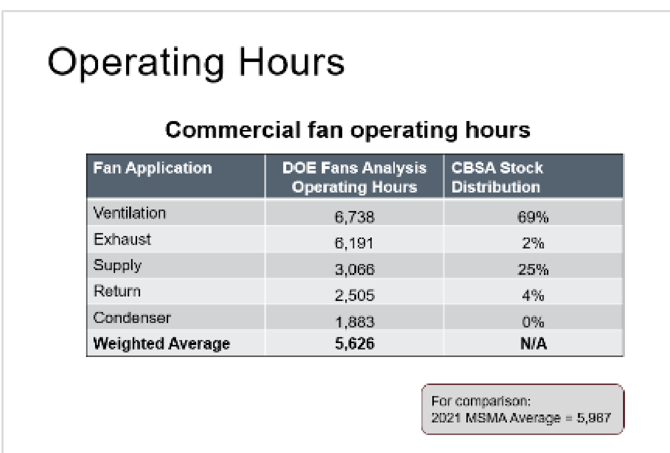
Tyler reminded the panel. The second question here, is anybody aware of other commercial pump operating our data sources that might be useful to compare against or potentially look into? **Dave** responded that Energy Trust has a lot of data on commercial operations. I don't know if that data is available, but it would be worth checking out through the Energy Trust of Oregon. **Pete** mentioned that the DOE had assumed operating hours that were different than MSMA, it was part of the regulation for commercial HVAC and domestic hot water. Perhaps what I am now thinking about is that we may actually leverage the NEEA numbers in what we did.

Nathan added that future data sources are definitely something we want to know about because we could plan to include it at that time.

Commercial Fans

Cory moved on to discuss fans. We have two commercial fan operating hour data sources. The first data source is DOE C&I Fans 2016 analysis. There is a new Notice of Proposed Rulemaking that just came out for fans in January, but we have not incorporated that here because it came out just a couple weeks ago after we developed this workbook. This 2016 analysis uses energy modeling data, and it is not specific to motor size or facility type, but they do provide separate values based off of different applications. They have different average operating hours for ventilation, exhaust supply return, and condenser fans. This is the data that the RTF uses for its commercial fan measures as well.

Again, we looked at the 2021 MSMA, same things apply: national in scope and large sample size. But based off of survey response information, we opted to use the DOE commercial industrial fan analysis because it is being used by the RTF UES measures and is based off of modeling, rather than survey responses.


Operating Hours

Commercial fan operating hours

Fan Application	DOE Fans Analysis Operating Hours	CBSA Stock Distribution
Ventilation	6,738	69%
Exhaust	6,191	2%
Supply	3,066	25%
Return	2,505	4%
Condenser	1,883	0%
Weighted Average	**5,626**	**N/A**

For comparison:
2021 MSMA Average = 5,987

Cory continued. DOE has these fan operating hours broken out by fan application. And we know from our stock distribution that comes from the CBSA, what percent of fan applications exist in our model. So, we could take a weighted average of these values to calculate an average operating hour for all commercial fans in our ASD market model. We got a value of 5,626, which is pretty close to the MSMA average of 5,967. I will note that while the RTF values use the DOE C&I fans analysis data, their value is a bit different. They just take a direct average of the ventilation and exhaust fans, and it gets you 6,500.

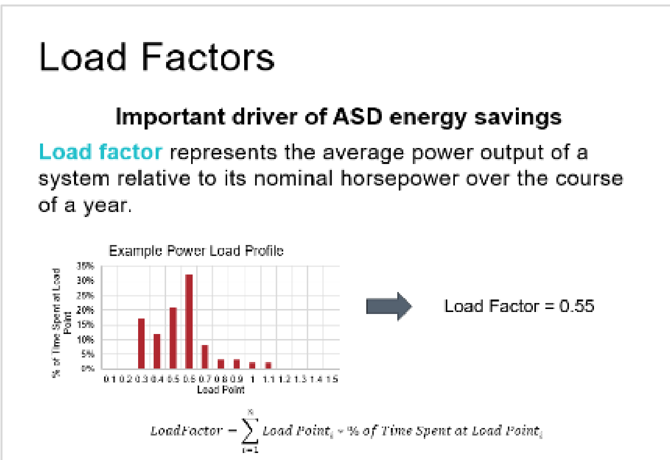
Nathan added. I will provide a little context on the stock distribution that we are seeing right here. You can see that that our scope for this model is really concentrated on ventilation and supply. To provide some context for that, a large number of fans in the commercial sector are embedded in HVAC equipment. Fans is part of that built up HVAC equipment that is rated with an efficiency metric of its own, and we have not included those in this scope. We are only looking at standalone fans or fans that are not included in packaged HVAC equipment that has its own efficiency metric.

Ken said that these numbers surprised him a little bit. I know when we generally make assumptions on commercial fan usage, we are usually going 10 hours a day, 5 days a week and that puts you closer to 2,400 hours per year. So, about half of that. I'm not saying your numbers are wrong, I am just saying that is what we are doing. And we are also looking at standalone and not packaged or embedded equipment. So, interesting conversion.

Nathan added. That is really good context in comparison, and it may be worth with us following up either after this call or via e-mail on that and identifying either sources or information to potentially see if we need to adjust this number to account for anything or adjust.

Load Factors

Load Factor Overview



Cory moved on to discuss load factors. We have a lot of new load profile data in this model that is going to affect our load factors. And since load factors are the driver of ASD energy savings in this model, it is pretty important, and we have dedicated this entire section to discussing this new analysis. I want to explore what the concept of load factor is in our model. It is a word that can be defined in multiple ways depending on who's talking about it. In our case, load factor represents the average power input of a system relative to the nominal horsepower or the nominal power over the course of the year. And the nominal power signifies the full load power of the equipment. After accounting for component efficiency losses, it is calculated as the sum product of load points and percent of time spent at each load point. We also define load types in our model. We have constant load systems and variable load systems. We define a constant load system as a system where 90 percent or more of the time is spent at a single load point. It is essentially operating at a constant value over the course of the year with a little bit of wiggle room. And then a variable load system would be the remainder of the systems. Here we see that the system operates between 0.3 and 1.1 of its nominal power input and spending around 30 percent of its time at a load point of 0.6. And when we take the sum product of those values, we get a load factor of 0.55.

Rob asked if this replicates what we did with the with the NEMA standard for a power index? We do not have as many load points, that’s for sure. Typically, we only have four load points, but is this trying to accomplish really the same metric as what we did with the NEMA standard does?

Nathan replied. Yes, it is trying to do the same thing in terms of characterizing where a piece of equipment is spending its operating time in terms of its power draw. But here we had a whole bunch of data, and it was detailed enough that we were able to establish it at 10 percent bins. So, it is just a little bit more granular but the same idea.

Rob replied. In the motor coalition that Nicky is a member of, the PI is being adjusted to agree more with the European standards. I have not been paying a lot of attention to it, but I believe it is going to expand beyond the four points to maybe seven or eight. I just wonder if it is the right thing to do to come up with a new metric if there is going to be an ANSI standard. The PI is an ANSI standard. It would not be good to consider the PI as an energy load factor.

Nathan added. We are not regulating or stamping anything with this disaggregation. We have a bunch of new operational data from the field about measured pump and fan operation, so we are just using this breakout to calculate the load factor as an input to the UEC equation. Depending on where the PI metric goes with regulation, it could be something that we could incorporate into the equation as a variable in the future if it is adopted in time for the 2027 model. But at this point, we are just using these load factors to characterize the energy consumption of each system that we have been looking at.

Joan followed. I think what our model is trying to do is most accurately calculate the total energy consumption of these systems in the Northwest. In order to do that, we obviously do not know details about every or any single system, right? So, when we are trying to get data such as load profiles and load factor, we are trying to get as much data as we can at the most detailed and granular level and, hopefully, as representative of the region as we can so that we can still calculate a total energy consumption that is as accurate as we can possibly get. And that is a very different purpose than what metrics and regulations are trying to get: maybe somewhere in between assigning an easy, but also accurate enough metric on a single system. I think we are looking at the same thing but from very different perspectives here.

Rob agreed. You are right. The PI is going to be modeled in your own unit specific; it is not going to be an aggregate like that.

Cory added. I will also say that this information is new information on where these pumps and fans actually operate and could actually potentially feed into the weighting of this PI metric in the future as we learn more about what that typical system looks like, which is really what PI is after.

New Load Factor Data

Cory continued. Going back to after we developed the 2021 model, we identified load factor inputs as an area of high uncertainty. We had limited data and that resulting uncertainty on load profile had a large impact on the model results. Over the last year to address this gap, the team identified three data sources containing metered power data from more than 400 motor driven systems. And then we used that data and introduced a new methodology for calculating load factors and then also assessed average load factors to pinpoint opportunities to improve our existing inputs. Previously, our model relied on flow load profile data, and we had to use a power load relationship, which is essentially a curve that tells you for a given flow what the expected power is, to convert those flow load profiles to power before calculating load factors. Our new method eliminates this intermediate step since all our raw data is inherently based on power, so we do not have to use that transformation.

Load Factors

New data available for load factors

Old Load Factor Data

The team used metered and modeled **flow** data from one data source

System Type	# of Systems
Commercial Pumps	N/A
Commercial Fans	N/A
Industrial Pumps	11
Industrial Fans	0
Total	**11**

New Load Factor Data

The team collected metered **power** data from three separate sources.

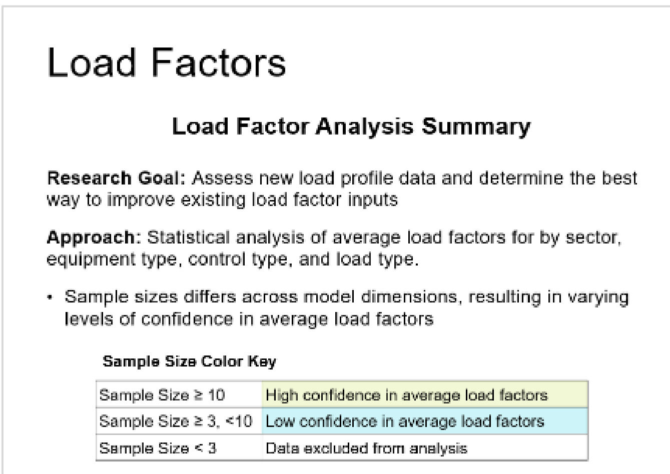
System Type	# of Systems
Commercial Pumps	145
Commercial Fans	46
Industrial Pumps	166
Industrial Fans	54
Total	**411**

Cory continued. This slide compares the old data to the new data. In the old data, what we had was metered flow data from 11 industrial pumps and the rest utilized DOE energy models. The DOE commercial industrial pump and fan rulemakings had flow load profiles for both pumps and fans that was based off of energy modelling. So, we did not really have any good raw data, which is where that uncertainty was coming from and represented a significant data gap in the ASD model. To address this gap, we collected from three different data sources more than 400 systems, which is a bit different from pumps and fans. We have about 300 pumps evenly split between the commercial and industrial sector and about 100 fans also evenly split between the commercial and industrial sector. The first data source was 132 commercial industrial pump data from NEEA pumps research. The second was leveraging previously collected measurement and versification (M&V) data from 51 of BPA's custom projects. The last data source came from some work that is going with California IOUs and 2050

Partners: from a big data mining effort on their custom M&V projects, they aggregated their findings and sent us load profiles for 357 commercial industrial pumps and fans. A huge thank you to these organizations for collecting this data and making it available to us. This is a huge increase in the information available and really helps our model.

Nathan added. This data can inform other things like the weighting for PI metric or other investigations that are happening about the operation of these motor-driven systems. And the nice thing is, we are talking about metered power data (not flow) and so all the data can be combined and used as a singular data source and be built upon. The more information we get, the more confident we get in terms of the operating characteristics of these systems.

New Load Factor Analysis



Cory continued. Now we are going to dive into the load factor analysis. Our goal here was to assess new load profile data and determine the best way to improve existing load factor inputs. To do this, we took statistical analysis of average load factors by different model dimensions. We looked at differences by sector, equipment type, control type (ASD controlled systems versus non-ASD controlled systems) and also load type (which is constant load versus variable load systems). And to facilitate and make sure that we had robust comparisons, we focused our attention on cases where we had a minimum of 10 systems within the same sector equipped with the same equipment attributed to the same control type and load type. Those are going to be highlighted green on the upcoming slides. We also considered cases where we might not have as much data. Cases where we have got three to nine systems, those are color-coded blue. Just to remind you that while we are seeing some average results, perhaps the limited data set is not telling us the full story. And then when you have less than three systems, those cases were excluded from the analysis just because there is just not enough data to determine an average value. Which is a reminder that in this model, we are looking at average load profiles, not only one load profile for a given system.

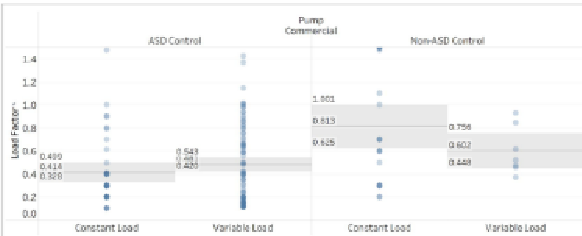
Pete asked a question. Can you remind me again what the load factor definition is based on? Is it power? **Nathan** responded. Yes. If you have a load factor of 1, you are essentially operating at the nominal horsepower of the unit after considering component efficiency bosses. So, it is like full load. If you are at 0.5, then you are at 50 percent of that and we are talking in power. **Cory** added. As opposed to flow.

Nathan responded. One thing to touch on before we jump into the analysis is this approach. In the 2021 model, we had different load factors by control type AND by load type. With constant load systems having a higher load factor and variable load systems having a lower load factor because they operate more variably based on the model load profiles that we had from DOE. **Cory** added. Those were identified as the key variables that could cause significant change in load factors.

Rob added. Nate, you could end up on the load type with a constant load with a load factor of 0.75 because the system is running 100 percent of the time at 75 percent load? **Nate** replied. Exactly…or 100 percent of the time at 50 percent load would still be considered a constant load system.

Commercial Pump Load Factors

Commercial Pump Load Factors



Load Type	Control Type	Count	Average Load Factor
Constant Load	ASD Control	36	0.41
Variable Load	ASD Control	81	0.48
Constant Load	Non-ASD Control	21	0.81
Variable Load	Non-ASD Control	7	0.60

Cory continued. For commercial pumps we collected load factors for 145 commercial pumps, and these are represented by individual data points on this graph, and then the increasing opacity of the blue dots indicates where multiple systems share the same load factor. The gray boxes are bound by the 90 percent confidence intervals for the average load factor. Centered in those gray boxes is the actual average load factor.

We can see for the ASD controlled systems on the left, these systems exhibit lower load factors compared to the non-ASD controlled systems, which aligns with our expected power consumption reduction benefits of ASDs. But that does not mean that every single ASD system is doing better than every single non-ASD controlled system. It is just on average, when we look at a large number of systems, they use less energy.

Additionally, we see that the constant load and the variable load average load factors are quite similar. They are within their 90 percent confidence intervals and the same is true for the non-ASD controlled systems. Although, it is worth noting that we have only got seven variable load non-ASD controlled systems. It is hard to make a concrete assessment about variation and load type for these non-ASD controlled commercial pumps.

Pete asked a question. If the dot is darker, that represents that there are multiple samples with the load factor? **Cory** said yes, that is correct. This is an aggregate of all three data sources. We ran a similar analysis on individual data sources, which we will talk about a little later. For this high-level summary, we have got all data from all data sources compiled together.

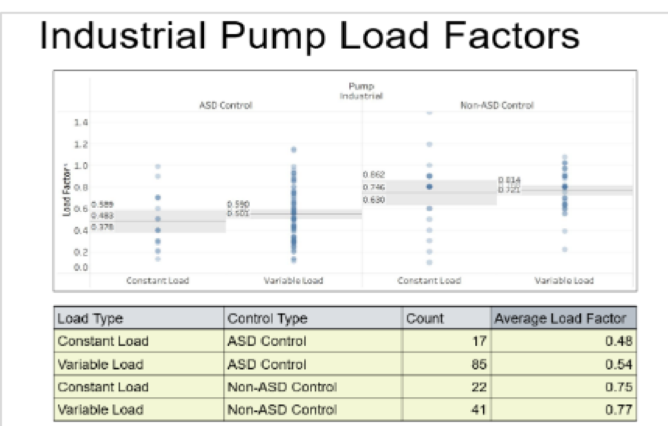
Nathan added. What jumped out to me in this plot was that we see a similar range across almost all of these disaggregations in terms of load factor, whether it is constant load or variable load. When we looked at that average, at least for the ASD control systems, I was surprised to see that the constant load factor was actually lower than the variable load factor. They are 0.07 apart and the 90 percent confidence intervals overlap a fair bit, so they are very similar. But that difference jumped out as surprising when we were looking at this analysis. **Joan** added. To keep looking at that, for the constant load, ASD control, commercial pumps in the first category, the darker dots show there are relatively more systems that are operating most of their time at a pretty low point. That is why you got, on average, pretty low load factors.

Pete said that looking at this, I am trying to figure out why a constant load pump would have an ASD at that low of a load factor. It seems like it would be a grossly oversized piece of equipment for the actual utility and would not be the most efficient way to do it. I was surprised by that. **Ken** asked if that is a case of where they might be sizing for an emergency condition or for future expansion and they do not want to replace it. I am thinking about where they put in a bigger fan for a university or laboratory research. And they know where they are going to expand to the future, they do not want to replace the fan. Would that be the same thing on pumps? **Nathan** replied that that is what we were thinking, or it could be that the pump was sized correctly to start with and then the system load decreased. Maybe it is a commercial building that is no longer fully occupied because nobody's working in offices anymore or they planned for a bigger system or an expansion that did not happen. But we are similarly seeing those same constant load systems operating with no ASD down in the 0.2-0.4 range. There are less of them, but they are occurring over there as well. And so, it is surprising to see them down there. It could just be that in reality the most efficient option would be to replace the pump with a smaller pump. But that takes time and money and maybe the ASD is a way to do that without replacing the equipment.

Rob added. We could have a conversation with one of my former pump customers that does a lot of smaller circulator type pumps. I do not know if he would be down with a load factor of 0.41, but it would be down pretty low. In the commercial applications, they size them for the daily operation of a building. But then in the peak of the summer when they have weddings or something at a hotel, the number jumps way up. But then it goes back down after the event is over. **Cory** added. I want to reiterate one other point really quick as a reminder that we are talking in terms of power. So, .4 power of the nominal power would not be .4 of the flow. You are probably already down to .4 when you're at maybe .6 or something. **Pete** said that it probably depends on the system. What Rob was describing would probably fall into the variable load category, not the constant load category. **Rob** said no, I was thinking of Armstrong pump where they set it at one level, and it runs there 90 percent of the time. And then they have an event in the building, and they change it for a few hours, but it does not vary throughout the day. It is pretty much set up at a constant load. **Pete** added. Maybe I would have to review the definition of variable and constant load for this study then. **Nathan** said that we are using 90 percent of operating hours at one load point to define a constant mode. A constant load system would, depending on how long those events are, fall into that category. **Joan** added. Ideally, this is out of an entire year. But depending on the availability of the meter data, I guess it is predominantly 1 month, or 3 month data. **Cory** said there is no such thing as people, or at least for these M&V assessments, they are not doing assessments over an entire year. They collect one month or three months of data and then they extrapolate that to the entire year, and we do too. **Joan** added. In Rob's case, it changed significantly in the summer. Depending on when the metering is done, the resulting load factor might not capture this variation.

Todd asked if the data sources used for this analysis were BPA and California Public Utilities Commission (CPUC), would all these counts here be kind of post-project data, like the install of the VFD or maybe an efficient pump? **Nathan** said that the data includes post install of drives, but it also includes M&V projects that did not include the installation of a drive. They could have installed a more efficient pump or a more efficient motor. And it includes data from NEEA's pump research, which was not solely focused on project data. It included a lot of externally monitored system data. So, we have a variety of utility and non-utility projects in the data sources.

Industrial Pump Load Factors

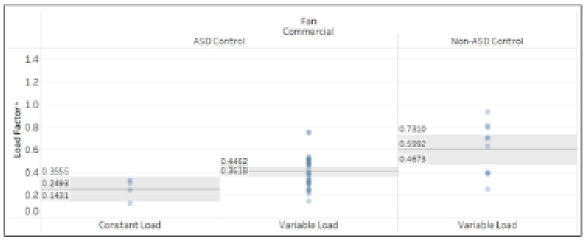


Load Type	Control Type	Count	Average Load Factor
Constant Load	ASD Control	17	0.48
Variable Load	ASD Control	85	0.54
Constant Load	Non-ASD Control	22	0.75
Variable Load	Non-ASD Control	41	0.77

Cory continued. So, for industrial pumps, we calculated load factors for 165 industrial pumps. In this case, we have got large sample sizes for all load type and control type permutations. Again, we see that the ASD controlled systems are exhibiting lower load factors compared to their non-ASD controlled system counterparts. Also, we see that there is again this lack of variation in load factors based on load type. The average load factors differ by only six percentage points for the ASD-controlled systems and only two percentage points for the non-ASD controlled systems, which are both well within the confidence intervals. This is probably our sample where we have the most data, and we see these two trends that we will continue to see throughout this work.

Commercial Fan Load Factors

Commercial Fan Load Factors

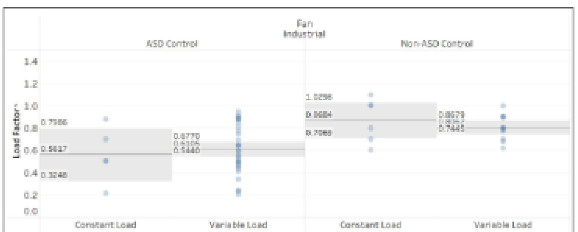


Load Type	Control Type	Count	Average Load Factor
Constant Load	ASD Control	4	0.25
Variable Load	ASD Control	32	0.40
Constant Load	Non-ASD Control	0	-
Variable Load	Non-ASD Control	10	0.60

Cory continued. We have less data for commercial fans. We have only got 46 commercial fans in our data set right now and it is concentrated in those variable load systems. We do not even have a constant load non-ASD controlled commercial fan. That does not mean that they don't exist, it just means that they are not in our data set. But we do see that the ASD-controlled systems have on average lower load factors than the non-ASD controlled systems. But we really can't draw any other conclusions given the limited data for the constant load systems.

Industrial Fan Load Factors

Industrial Fan Load Factors



Load Type	Control Type	Count	Average Load Factor
Constant Load	ASD Control	5	0.56
Variable Load	ASD Control	30	0.61
Constant Load	Non-ASD Control	7	0.87
Variable Load	Non-ASD Control	12	0.80

Cory continued. We have 54 industrial fans, which is a similar sample size to our commercial fans, but they are a little more distributed into the constant load systems in our data set. Again, we see that same finding of ASD systems exhibiting lower energy consumption and then we also see similarity in load factors between load types. For the ASD-controlled case, we see that the variable load systems are slightly higher than constant load, whereas the opposite holds true for non-ASD cases. We think that similarity and lack of directionality reinforces this overarching trend that load factors remain independent of load type.

Load Factor Key Findings

Load Factors

Load Factor Key Findings

- Load factor doesn't vary by load type
  - Constant load and variable load systems, linked to the same equipment, sector, and control type, tend to demonstrate **similar average load factors.**
- ASD-controlled systems consistently operated at **lower average load factors** than their non-ASD-controlled counterparts.

Reactions? Questions?

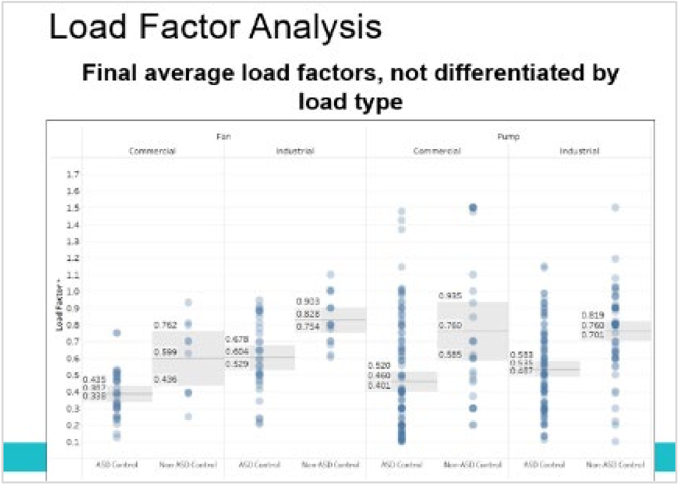
Cory continued. We observed that load factor does not appear to be dependent on load type. In all high-confidence cases, there were more than 10 samples. The average load factors for constant load and variable load systems fell within the 90 percent confident intervals. Additionally, for the majority of the low-confidence cases, the same was true and there was not really a consistent directionality trend either. As a result, I will just say that that was our surprising finding that we want to discuss with the expert panel. And then the other finding, which is great because it confirms the reason why we are all using ASDs and why we are putting together this model, is that in every instance ASD-controlled systems consistently operated at significantly lower average load factors than their non-ASD counterparts, which affirms that energy savings impact of ASD systems in real world operations. On the next slide, we have combined all data so that load factor is not dependent on load type. We are only looking at average load factors by sector, equipment type, and control type. And we have got essentially an average load factor for every commercial or industrial pump and fan that is either an ASD or a non-ASD controlled system. And that is a big change to how we had done it in the past where it was dependent on load type.

Dave added. I have done a lot of energy studies on industrial fans and pumps and comparing the constant load and variable load systems. I am actually not surprised that they fall within the average because with the affinity laws working, small turn downs result in large energy savings. And a lot of the projects where we conduct M&V at the end to verify the project savings, they do tend to average out similarly for a percent savings, whether it is an adjustable variable load system or a constant load system. I have not really thought about it that way but looking at your data and comparing it to what I have done in the past, I do believe it and it does seem very reasonable.

Ken added. I think we are all happy. The ASD-controlled systems operate in a lower average load factor. That is not a real shock. I guess that is the direction we all thought this would go. I am a little surprised that the load factor does not vary by the load type. Maybe the pump guys have more experience, but I have seen this on the fan side. They will get the ASD, and then they set it and forget it, whether it is a constant load or a variable load. I am wondering if that is the case, and they are not really taking advantage of the adjustable capability of the drive itself. Is that a possibility. **Nathan** responded. That is something that we saw in in the stock data that we have. NEEA does a stock assessment of the commercial sector every five years and they looked at ASDs the last time that they did that assessment. They did not look at load type: constant load or variable load. But they did look at the at the variable frequency drive (VFD) and track what setting it was in. Was it off, was it on and set manual to 100 percent, was it on auto so that it could be changed, or was it set to a value less than 100 percent. And we saw ASDs in the field in all three or all four of those different categories. It is definitely something that is seen happening out in the Northwest.

Pete asked a question. I have a general question about the data set. Was the additional data that was received mostly from M&V, from efficiency programs? They are adding VFDs, and they are metering it after the VFD has been added. Was that the data source for this? **Cory** replied. We will talk a little bit about some assessments to see if there was bias in the data that we did in a bit. But I will say that that yes, there is a handful of data that is exactly that. It is VFD efficiency upgrades, and we have the post data for it. But we also have two data sources where that is certainly not the case. It is just any efficiency upgrade associated with a pump or fan system. It could be an ASD, could be an efficient pump or fan, or it could be a motor improvement. The data is not exclusively VFD improvement projects. We looked at all the data sources individually and saw the same trends. **Nathan** added. What Cory was talking about was the California M&V projects. I can speak to the NEEA pumps research projects or the systems that we pulled for this research: there are some in here that are exactly what you described Pete. But the majority of the systems that are included in here are just a pump operation monitored outside of a utility program. We got it through a source that did not undergo either a motor upgrade or an ASD installation. **Joan** added to the chat window. In our follow-up, we can include a more detailed description of the samples by type (post-installed ASD equipment or randomly selected for monitoring, or pre-installation equipment, etc.)

Final Load Factor Model Inputs



Cory continued. This is the same data that we looked at before, but it is now not differentiated by load types. So now we are just showing it by sector, equipment type, and ASD vs. non-ASD control: you can see that in each case, the ASD-controlled systems have significantly lower load factors, and it is just a compelling graph to see that difference.

Load Factors

Load Factors in 2021 Model vs. 2022-2027 Model

Sector	Equipment	Load Type	2021 Model Non-ASD Control	2021 Model ASD Control	2022-2027 Model Non-ASD Control	2022-2027 Model ASD Control
Industrial	Pump	Constant	44%	34%	76%	53%
		Variable	79%	43%		
Industrial	Fan	Constant	89%	71%	83%	60%
		Variable	95%	37%		
Commercial	Pump	Constant	N/A	N/A	76%	46%
		Variable	N/A	N/A		
Commercial	Fan	Constant	N/A	N/A	60%	39%
		Variable	N/A	N/A		

Cory continued. These new load factors are the average values that you saw on the previous graph, now compared with what we had in the 2021 model. We see the 2021 model had varying values for the constant and variable loads, but now we see that there is only a single value for each sector, equipment and control type. Also, the 2021 model did not have commercial data, so that is why we have the “N/As” in those columns.

Load Factors

% ASD Savings in 2021 Model vs. 2022-2027 Model

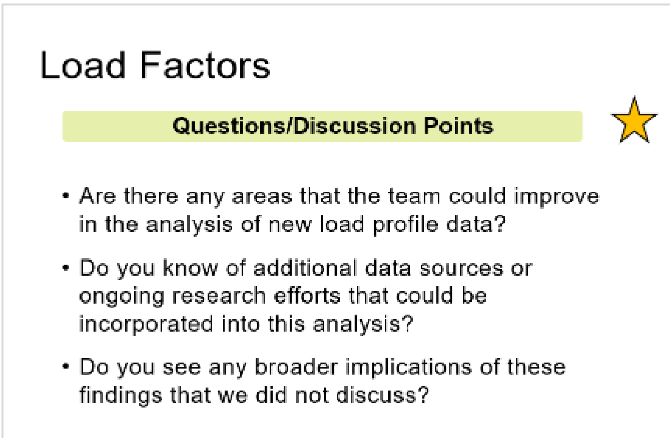
Sector	Equipment	Load Type	2021 Model % ASD Savings	2022-2027 Model % ASD Savings
Industrial	Pump	Constant	10%	22%
		Variable	36%	
Industrial	Fan	Constant	28%	23%
		Variable	58%	
Commercial	Pump	Constant	N/A	30%
		Variable	N/A	
Commercial	Fan	Constant	N/A	21%
		Variable	N/A	

Cory continued. The difference between an ASD control load factor and a non-ASD control load factor is our modeled savings for this ASD market model. You can see that the old saving values again are differentiated by load factor, the new ones are not. It is interesting that all of the savings by sector and equipment type are pretty similar between 20 and 30 percent, which was just an interesting finding that came out of this research.

Cory continued. We talked a little bit about this already, but we investigated different components that may have impacted or biased these findings. We have confirmed that the key findings occurred across all three different data sources. As Nate mentioned earlier, we are using data that is not just associated with the ASD programs. The NEEA data is from pump operating monitoring outside of programs and the California IOU data includes M&V files for programs that do not involve the drive.

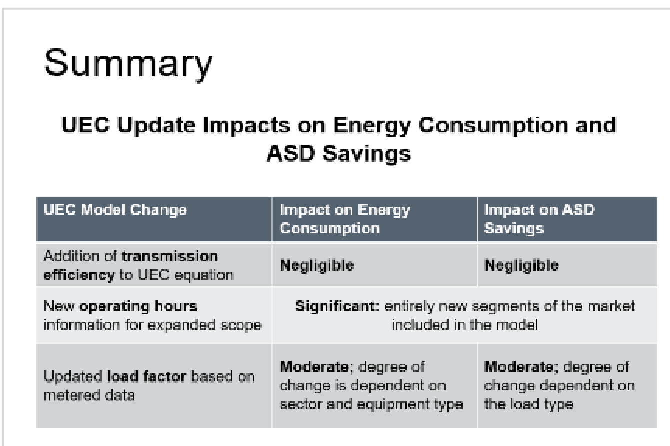
The last bias analysis that we did is on the definition of constant versus variable load. We selected 90 percent of the time at a single load point as the definition for constant load because it gives us a good amount of time at a single operating point, but we modified that to see if that would impact the results on load type. We varied the definition up to 95 percent of the time and down to 80 percent of the time and saw little to no impact on observable trends that we discussed earlier. That gave us good confidence in the idea that load factors are not dependent on load type.

Expert Panel Questions



Joan said that given where we are on time, we will read these questions and discuss them with the panel now, but we will also email these questions out to the panel for additional responses, comments, etc.

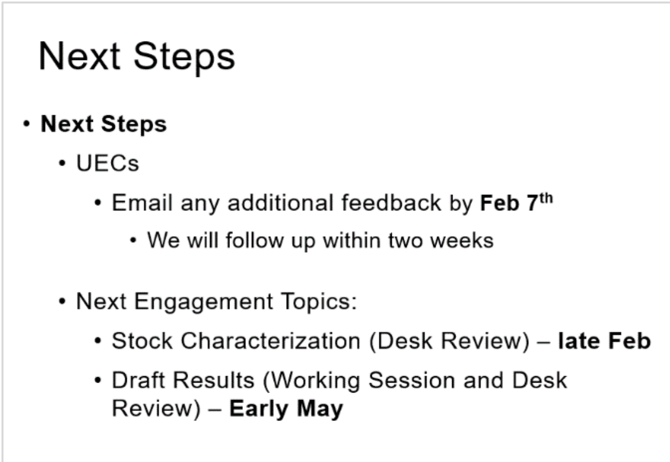
Wrap Up and Next Steps



UEC Model Change	Impact on Energy Consumption	Impact on ASD Savings
Addition of **transmission efficiency** to UEC equation	**Negligible**	**Negligible**
New **operating hours** information for expanded scope	**Significant:** entirely new segments of the market included in the model	
Updated **load factor** based on metered data	**Moderate;** degree of change is dependent on sector and equipment type	**Moderate;** degree of change dependent on the load type

Nathan added. This slide is just a summary of those three model changes that Cory walked us through and the impact that they have on the energy consumption and savings that our model calculates. For the addition of transmission efficiency into the UEC equation, it has a negligible impact on both of those.

Our new operating hours will have a significant impact on both energy consumption and ASD savings mainly because we are adding entirely new segments of the market into the model. We are adding the entire commercial sector and two new industrial segments into our model, and it will increase how much we are saving and the energy consumption we are modeling. And then for load factor, we included moderate impact for both energy consumption and savings mainly because the impact is dependent on where the motor horsepower is installed in the region. For example, for variable load industrial pumps, it will decrease that percent savings. But for constant load systems, it will increase because we are using one average, and the impact is moderate.



Tyler reviewed the next steps.

In the chat window, **Joan** thanked the panelists. I appreciate that the panelists not only gave us great feedback, but you also backed it up with the "why" or "how" ... SUPER HELPFUL. Thanks everyone.

Working Session: Stock Characterization – Mar. 18, 2024

ACTION ITEM – This highlights an action item for a panelist.

ACTION ITEM – This highlights an action item for BPA and/or Cadeo.

Attendees

BPA: Joan Wang

DNV: Tyler Mahone, Lorre Rosen

Cadeo: Nathan Baker

Panelists: Pete Gaydon (Hydraulic Institute), Kenneth Kuntz (Greenheck Fans), Dave Morris (RHT Energy), Rob Boteler (Independent), Prakash Rao (Independent), Evan Hatteberg (NEEA), Todd Amundson (BPA), Nicky Dunbar (NEEA), Kevin Smit (Council), Kristen Aramthanapon (NEEA)

Unable to attend: Ryan Firestone (Council/RTF) *, Paul Lemar (Resource Dynamics)

** While Ryan did not attend the working session, he reviewed the slides and materials and provided feedback.*

Working Session Agenda

The presentation will cover the following agenda:

- Introductions & Goals (5 min)
- Stock Characterization Basics (15 min)
- In-Service Motor HP (40 min)
  - Industrial
  - Commercial
- ASD Saturation (20 min)
  - Industrial
  - Commercial
- Wrap Up and Next Steps (10 min)

Introductions and Meeting Goals

Tyler introduced the presenters and panelists.

Joan reviewed the goals of the meeting, which is to review and discuss:

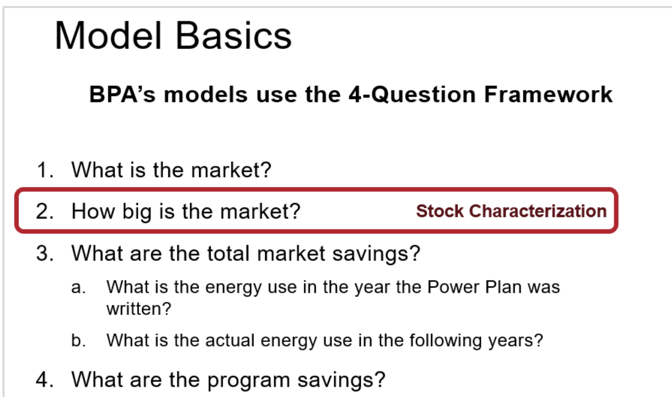
Data sources and methods used in:

- Motor stock calculation
- ASD saturation forecast
- Outcomes of our analysis
- Reasonableness of the forecasted values

What we are going to talk about today is how we are modeling the motor horsepower (HP) stock in the region. This is something we did previously with the industrial ASD model with industrial pump and fan motor stock. For this model, we are doing the same thing for the years 2022 to 2027; we are adding commercial as well. There is a little bit of forecasting involved. Though the methodology of how we calculate motor stock has not changed much from the previous model. But since we are adding a new sector and updating the model with better and newer data sources, we want to walk through the available data sources and how we are using them.

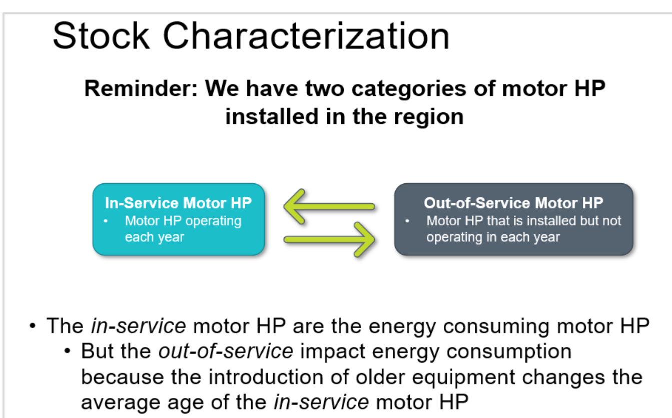
Even more importantly, we are going to talk about our forecast of the drive saturation in the region from 2022 to 2027. This is a big driver of savings in the model, and it is a forecast for a number of years, so this is a key area where we want to vet our forecast with this panel. We are going to reopen the model in 2027 and 2028 when all the years are done and update it with actual data.

Stock Characterization Basics



Nathan reviewed BPA's four-question framework used for all of their market models. The first question is focused on defining the scope of the model. The scope for our model here is commercial and industrial standalone pumps and fans. The second question is how big the market is, which focuses on how we determine the number of units in the region in each year. For our model, the units are motor HP as opposed to looking at individual pumps and fans, so that the impact that large pumps or really large fans have on energy consumption is accounted for. The third question is what the total market savings are. This is a question where UECs come into play, which we talked about during our last discussion. Question 4 is about program savings.

Today, we are going to talk about how we calculate the market size, in Question 2. In our last meeting we talked about UECs. The product of those UECs—that we calculate for each individual cell or combination of model dimensions—and our stock characterization (which is the number of motor HP that falls into those cells) is the energy consumption in the model. Calculating energy consumption is one of the main outcomes of the model.



Nathan continued. Here is a quick reminder of how we account for motor stocks. We use two different categories of motor HP: in-service and out-of-service. Motor HP in-service represents the motor HP that are operating in each year. Out-of-service represents motor HP that is installed in the region but is not consuming energy. These would be backup systems or motor HP on production lines that are not operating. As the model calculates the stock, motor HP can move from in-service HP to out-of-service and back as the years progress. Our model accounts for the fact that motor HP could potentially not consume energy in one year but then consume it in the next year.

Stock Characterization

Equation for calculating Motor Stock

$$InstalledMotorHP_{t,f,e} = \underbrace{\left(MotorIntensity_{f,e} * EconomicDriver_{t,f}\right)}_{\text{In service motor HP}} + OOSHP_{t,f,e} - Retirements_{t,f,e} + NewSales_{t,f,e}$$

InstalledMotorHP	=	Total installed motor HP (motor HP)
Motor Intensity	=	In-service motor HP Rate (motor HP/gross output or motor HP/sq ft)
Economic Driver	=	Annual regional gross output or Commercial Floorspace (million 2012$ or sq ft)
OOSHP	=	Out-of-service motor HP (motor HP)
Retirements	=	Annual retirements (motor HP)
New Sales	=	Annual sales (motor HP)
t	=	Year
f	=	Facility type (e.g., Transportation, Hospital)
e	=	Equipment type (pump or fan)

Nathan continued. This equation shows all of the components of the installed motor HP and how we calculate it each year in the region.

Rob asked a question. When you say total installed HP in this equation, are we talking about the nameplate HP or are we de-rating it for motors that are operating below their nameplate HP. **Nathan** replied that this is nameplate motor HP. **Rob** added. Is there any place in the equation where we do the actual calculation and consider that the majority of motors are running considerably below nameplate HP? **Nathan** responded. We do not account for it in our stock characterization. What we are doing here is counting those nameplate motor HP. But when we assign an energy consumption value to those motor HP, that is where we do that discounting to account for the fact that oftentimes, they operate below nameplate motor HP.

Nathan continued. There are four different components associated with this equation. The first one highlighted with the red bracket is the in-service motor HP; they are the energy consuming motor HP. Then there is the out-of-service HP, the retirements and new sales. Retirements are calculated using a standard estimate of the retirement rates; it is “1” divided by the lifetime of the equipment. New sales are calculated as an output of the model and our out-of-service HP is calculated through stock turnover logic that is dependent on the other variables in the equation.

Calculating In-Service Motor HP

ISHP is dependent on two variables

- To calculate motor HP, we need:
  - An **annual economic driver** representative of change in the facility type over time
  - **Motor intensity**, or the rate at which motor HP is used in a facility type

$$Motor\ Intensity = \left(\frac{Stock\ of\ Motor\ HP}{Economic\ Driver}\right)$$

Nathan continued. In this meeting, we are going to focus on the in-service HP because it is the energy consuming motor HP, and it is a value that we calculate directly for each year in the model. Calculating in-service HP is dependent on two variables. The first is an economic driver, or an annual value that is representative of how a different facility type in a specific sector changes over time, how it grows or contracts. The second variable is motor intensity, which is the amount of motor HP required to serve one unit of the annual economic driver. If you look at that equation, in-service HP equals the product of that annual economic driver multiplied by motor intensity, with motor intensity being calculated as the stock of motor HP in a year divided by the value of the economic driver for that year.

Calculating In-Service Motor HP

Example of ISHP Calculation

Value	Year 2021	2022	2023	2024	2025	2026	2027
Gross Output (million $)	1,223	1,251	1,265	1,280	1,312	1,307	1,330
Motor Intensity (motor HP/ million $)				15.36			
Annual ISHP	**18,785**	**19,215**	**19,430**	**19,661**	**20,152**	**20,076**	**20,429**

Nathan continued. In this table-based example (with made up numbers), our economic driver in the industrial sector is gross output in millions of dollars for each year in the model, as shown in the first row. We also have motor intensity in the form of motor HP per millions of dollars of gross output. Then we multiply the gross output in each year by the motor intensity and calculate the in-service motor HP in each year of the model. This assumes that motor intensity is constant over the model, which is an assumption that we used in our last model. It is based on the fact that while demands for motor HP change year to year, the amount of motor HP needed to serve a specific unit does not.

Ken asked Nathan to remind him again about how we differentiate the commercial and the industrial markets. I am assuming it is not by HP size. **Nathan** said that we have different facility types for the different sectors. For the industrial sector, we are looking at manufacturing facility types. We use different three-digit North American Industry Classification System (NAICS) codes to identify 13 different industrial facility types. For the commercial sector, we are looking at different commercial building types, (e.g., hospital, resident hospital or residential care, office space) and we have 10 different building types that we use to identify the commercial sector. **Ken** said, “So, it does not depend on the type of fan or pump or HP size. It is really the facility that it goes in. **Nathan** confirmed. Correct, it is the facility it is installed in.

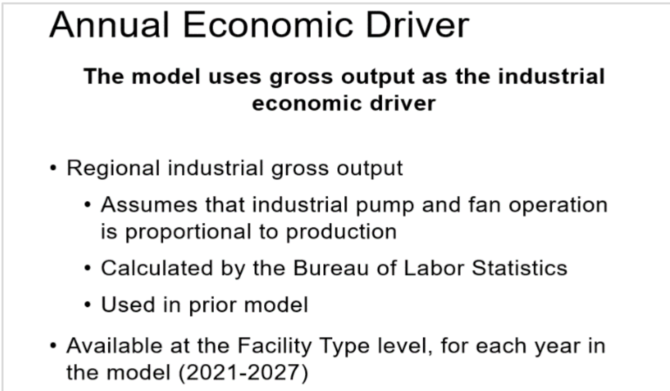
Prakash asked a question. I think you had 15.36 hp/$M. It's pretty exact and wonder if a range would be better representative of the confidence in the number? **Joan** responded. Thanks for the question, Prakash. The slide's numbers are all examples for illustrative purpose only. Nathan's going over what we actually use in the model, which are exact numbers. **Prakash** added: especially given the difficulty in accurately/precisely pegging a HP to an economic/productivity metric. I think you are out to 2 decimal places. It is 15.36 HP per $1,000,000 and that is kind of significant digits-wise. That seems like you are reporting a much higher level of accuracy than I think any one of us would think is correct. If you reported something like 14 to 16 or something like that and then did ranges and bounds, that might better bracket sort where we are at especially because dollar per GDP is just as flawed as anything else I can think of. In the MSMA, we use HP per employee which isn’t necessarily any better.

Joan said we do conduct model calibration later on (not covered today) where we will compare our modeled motor stock with other external sources to see if any adjustments are warranted. We will also conduct a sensitivity analysis where we can test any uncertainty. **Joan** asked Prakash if he could offer some guidance on if and how we may want to use a range so that we could test the sensitivity of our motor HP stock forecast to this economic metric. **Prakash** responded. Doing a sensitivity analysis would help you understand which variables in your assumptions are the most persnickety and need to be hammered in. It might even start to allow you to get into some sort of confidence interval range with some of those results.

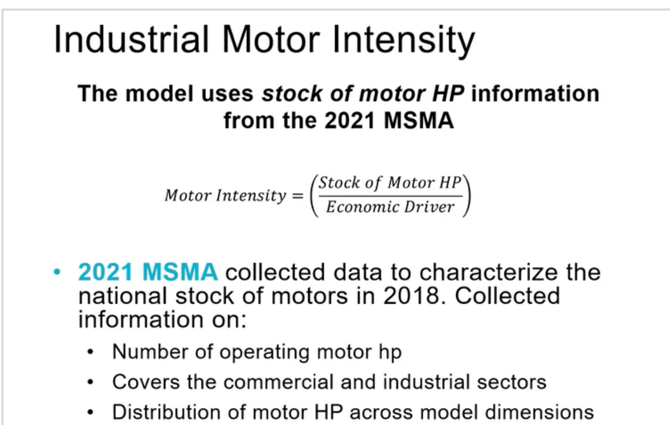
Nathan added. Thank you for flagging that. We made up that value on this slide for illustrative purpose, but it does highlight something that we had not been intentional about, which is those significant digits. I think that is something that we will go back and review and make sure that we are consistent and intentional about how we establish them.

Joan asked Nathan. I am curious, do you know off the top of your head if the Bureau of Economic Analysis (or whoever) put out the forecast for gross output if they characterize the uncertainty in their forecast? **Nathan** replied. I do not know specifically about the gross output values. I know the MSMA characterizes their uncertainty in the motor stock values and we use those uncertainty bounds as inputs into that sensitivity analysis to understand that uncertainty. **Joan** added. I think it would be worth looking into how the people that produce the forecast talk about uncertainty and consider modeling that in our sensitivity analysis.

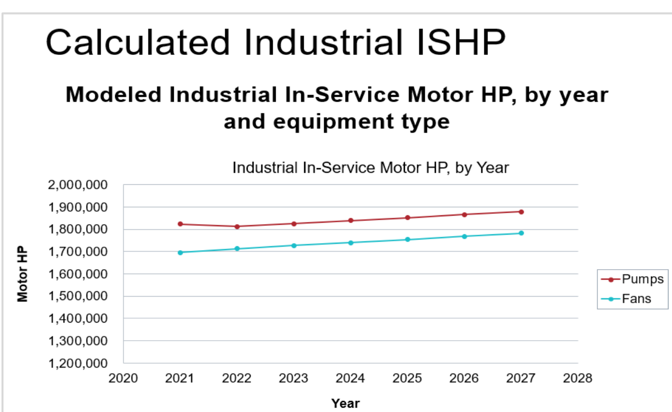
Industrial In-Service Motor HP



Nathan continued. For the industrial annual economic driver, we use gross output, which is the dollar value of the product of an industry. This is the same economic driver that we used in the last model. We reviewed three different economic drivers (the gross output, the number of operating facilities, and employment) and identified that that gross output was the most representative of changes in motor operation. The Bureau of Labor Statistics and Bureau of Economic Analysis publish data on national gross output, but they do not provide it at the state level. So, we scaled national gross output for each facility type to the Pacific Northwest using national and state-level gross domestic product (GDP) information. We did not use GDP directly because it does not account for intermediaries, and we felt like gross output was more directly tied to production. That allowed us to generate a facility-type level regional gross output value for each year in the model from 2021 through 2027 and future years of that value are forecasted. One of the main forecasting variables in our model is this annual economic driver.

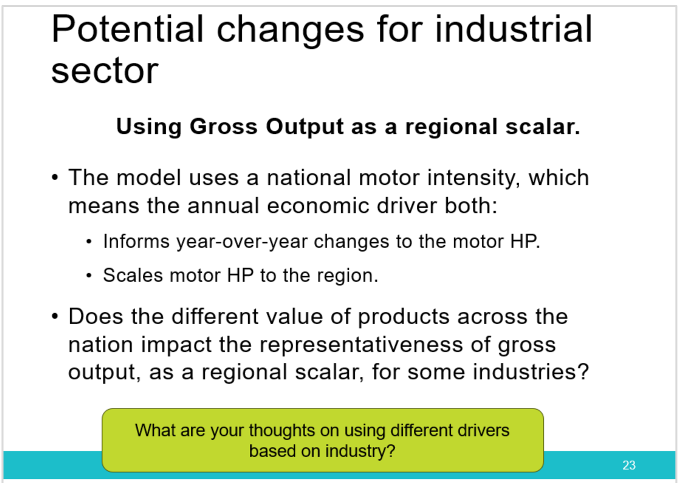


Nathan continued. For industrial motor intensity, we use the motor stock information from the 2021 MSMA to understand the numerator of this value. The MSMA collected information on the national number of motor HP in each facility type in 2018 for both the commercial and industrial sectors. The Northwest Energy Efficiency Alliance (NEEA) has plans in the next 5-year business plan to collect region-specific information on motor stock in the industrial sector, which means that hopefully we will have an updated region specific data source for our final market model. But right now, we are using the MSMA's national value. Using that national motor HP value means that we are assuming that the national motor intensity is representative of the region, meaning the motor intensity or motor HP per gross output in the Pacific Northwest is consistent with the national value. We used that same assumption from our previous model.



Nathan continued. Those are the two inputs to in-service motor HP, and we used them to calculate an annual motor stock value for pumps and fans. This chart shows the industrial in-service motor HP for each year with pumps in red and fans in blue. We are showing very similar numbers for motor stock between those two equipment types, with fans being less than 10 percent lower than pumps. This shows our methodology (and the gross output forecast data) is not forecasting wild swings in motor HP year over year. From 2021 to 2022 you can see a decrease in the number of in-service motor HP pumps, but not one in fans. That is driven by the fact that we saw contractions of specific industries in that year that were very pump intensive but not very fan intensive.

Ken asked a question. It seems like a pretty consistent slope for the years that you have projected, and I wonder how that correlates with construction indices (e.g., the Dodge Forecast on construction). I know about the commercial side, but I am not sure about the industrial side. I am wondering if your equation aligns with any of those indices. **Nathan** replied. These years are forecasted. We developed this in 2023, so 2023 to 2027 is forecasted based on the Bureau of Economic Analysis forecasting the change in gross output on a three-digit NAICS code level for the industrial sector. For the commercial sector, we actually forecast using Dodge construction data.



Nathan mentioned that we used gross output as the annual economic driver for the industrial sector because we identified it as being the most directly tied to changes in production. But because we only have national motor intensities for each facility type (not regional), we are assuming that the economic driver for the industrial sector not only informs year-over-year changes to the motor HP, but it also scales motor HP to the region.

And as we were digging into the representativeness of gross output, not as an economic driver in terms of year-over-year change, but as a scalar to the region, we had a couple concerns that the different monetary value associated with products within the same industry across the nation may impact the suitability of gross output as a scalar. The value associated with the region's product in a specific industry may be dramatically different from the national average. The biggest example of this is transportation. The Northwest has a large concentration of airline parts and production. The value associated with airline production is higher than other transportation manufacturing industries. For example, Boeing is going to produce a higher value product than a Toyota or Ford plant. That made us wonder if for every industry, gross output is the most representative scalar or if taking an industry-specific approach and looking at each industry and identifying if employment or number of facilities is a better value to use. For this current model iteration, we will be using gross output, which is what we used in the last model and is used by other organizations in estimating energy consumption changes in the industrial sector. But we are researching the potential of doing that facility-type level investigation in the future. **Kristen** commented. I imagine employment may not be accurately representative as automation advances. **Rob** agreed with Kristen. I think the gross output is far better than employment. **Prakash** added. On that last one, we did try to look at the MSMA data compared to the early 2000s to see if we saw any differences due to automation. We expected we would, but we did not see anything. So, I do not know which would be better to go with.

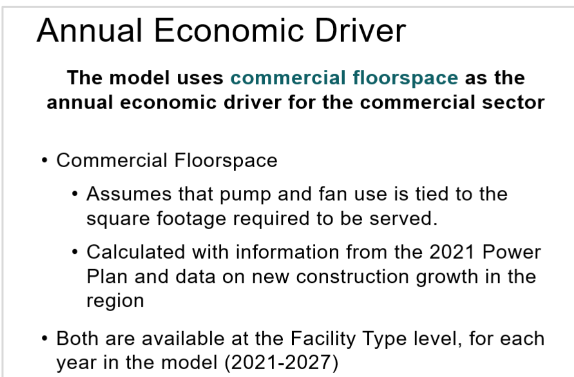
Prakash continued. But back to Nathan's question. I wonder if you don't have to go into different drivers for every single industry. Some industries are common in how they use motors, such as HVAC or conveying. Select industries might have huge grinding or pulping motors. Maybe pick some sectors that you think are unique or sector-specific motor uses and then dive deeper there. But I do not think you need to do it for all 20 or more three-digit NAICS codes. I think you could bucket 75 percent of them and then go ahead with just a single metric. **Todd** also agreed with Prakash. It seems if different industrial segments / facility types can be categorized, then yes. If not all, perhaps the others can be called 'general' and use gross output.

Nathan added. Last time we developed this model we did a similar comparison to see if there were dramatic differences in the number of motor HP in in the facilities by NAICS code and the confidence bands overlapped and were very similar.

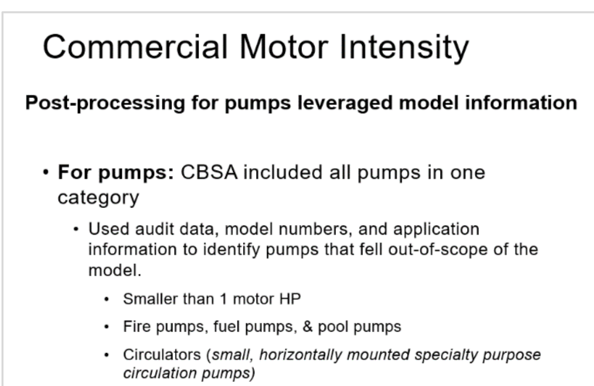
Kristen added. I also wonder if inputs can/should be considered, in the event that side products and waste is not accounted for in outputs? **Nathan** responded. The dollar value of the gross output accounts for intermediaries in terms of the values. That is one of the reasons we chose that versus GDP.

Dave mentioned that due to EPA regulations driving emissions, he is seeing a lot of desk collection projects for wood products. That would be fan projects to get rid of HP to reduce a pressure drop by installing clean side fans and bag houses over cyclones. There might be a slow change on the wood product side for fan use as a reduction based on output just because of the EPA. **Nathan** said that there might be a shift in motor intensity in that sector.

Commercial In-Service Motor HP



Nathan continued. For the commercial sector, we use commercial floor space as the economic driver. This assumes that pump and fan operation is tied to the square footage the equipment serves. We felt that was a reasonable assumption as commercial pumps and fans mainly serve building services like HVAC systems or water heating systems. BPA also models the commercial HVAC and non-residential lighting markets; both of those models also use commercial floor space in estimating commercial energy consumption like the 2021 Power Plan. The commercial floor space values that we use are facility-type specific and forecasted using the best available information and vetted through the expert panel that BPA has for their commercial HVAC model. For commercial motor intensity, we identified two sources of data for the single-year estimate of motor HP in the commercial sector. One was the 2021 MSMA. The second one is NEEA's 2019 CBSA, which is regional and is conducted every five years. We chose the CBSA because it is region specific.



Nathan continued. While CBSA does represent the best available data in terms of the estimate of motor stock, fan and pump motor HP are not the focus of that study, so we had to do some processing of the published CBSA data to make sure the pumps and fans that we were including were in the scope of our model. For pumps, we used the CBSA's audit information, which included motor size, model names and numbers, and application information to identify pumps that fell in versus out of scope. We excluded pumps that are smaller than 1 motor HP; fire pumps, pool pumps, and fuel pumps; and circulators that are small horizontally mounted circulation pumps. We followed the DOE's definition of pump versus circulator, which led us to exclude circulator pumps. A lot of this processing relied on the model names and numbers that NEEA collected.

Commercial Motor Intensity

Post-processing for pumps leveraged model information

2019 CBSA Pump Stock

Pump Group	Number of Pumps	Number of Motor HP
In Scope	25,644	339,310
Out of Scope	85,180	238,240
Total	**110,825**	**577,550**

- Out-of-Scope pumps are much smaller (on average)
  - Aligns with expectation, as we excluded <1 motor HP

Nathan continued. This table shows the pump motor HP that was collected in the CBSA in terms of whether it is in scope or out of scope. One thing this highlights is that there are more out of scope pumps versus in scope pumps, but less out of scope pump motor HP than in scope pump motor HP. That made sense to us, because a large portion of those out-of-scope pumps are small, less than 1 motor HP pumps. They are going to register as one pump but less than 1 motor HP.

Commercial Motor Intensity

The model uses facility-type level motor HP to calculate motor intensity

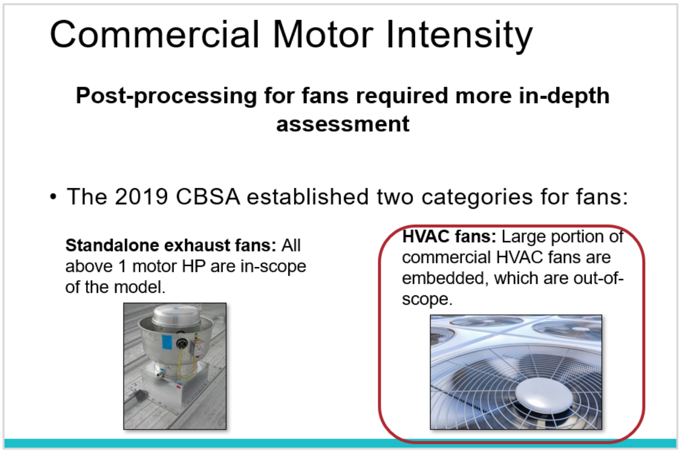
Facility Type	Calculated Motor HP, 2019
Assembly	7,720
Grocery	-
Hospital	76,235
Lodging	48,230
Office	121,471
Other	25,059
Residential Care	1,289
Restaurant	-
Retail/Service	-
School	59,306
Total	339,310

We use motor HP by facility type to calculate commercial motor intensity. You can see that offices and hospitals are the largest, which makes sense because they are often the largest buildings with the biggest systems. Another thing to note is that grocery, restaurants, and retail services are currently not showing any motor HP within our scope. That does not mean they do not have any pumps in them, just that they are served by much smaller pumps that are not in the scope of this model.

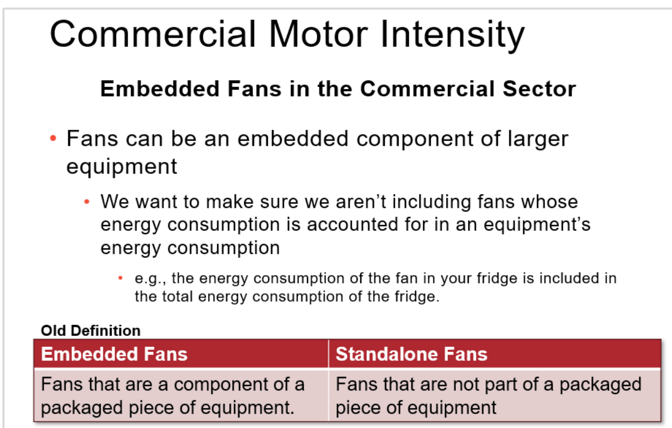
Pete asked. Regarding the rationale between in and out of scope, I understand being aligned with the DOE's HP range, but what is the rational for not considering the circulators if you have an estimate for it? **Nathan** replied that NEEA has a market transformation program that includes commercial and residential circulators which covers the entire commercial circulator market. So, we decided to leave commercial circulators out of the ASD market model altogether.

Prakash said that the grocery store not having calculated HP was surprising. I wonder if that is because you are looking at fans and pumps. In some segments, the chiller might be something to think about. Hospitals are another one that would bump that number up. And with restaurant exhaust fans, I think we saw a bunch of those in the MSMA but maybe they are too small. **Nathan** clarified that this slide shows pump motor HP only. But there are chillers, and we do see fan motor HP in every facility type with things like exhaust fans.

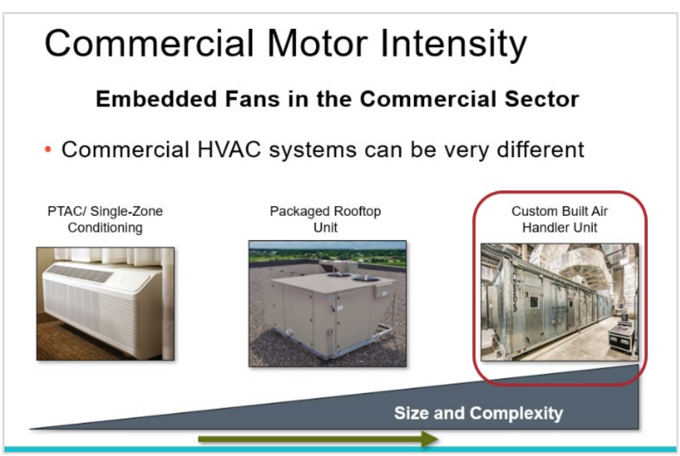
Kristen asked for clarification. On this slide, could you say the hospital facility type has a calculated motor HP intensity of roughly 76,000? Could you give me one more example sentence of exactly what the motor intensity means? Is that the sum of all the motor HP that is in there or is that an assigned value? **Nathan** replied this is just a point estimate in 2019 of the motor HP that the CBSA observed and extrapolated to be representative of the region [i.e. the numerator of the commercial motor intensity variable]. So, for hospitals, the CBSA data tells us there are 76,000 in-scope motor HP installed in hospitals in the region in 2019.



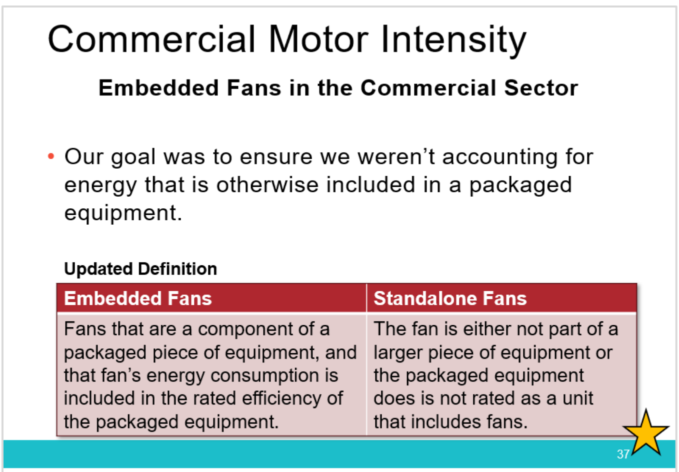
Nathan said that the post-processing for fans was a lot more in depth. CBSA has fans separated into two different categories: standalone exhaust fans and HVAC fans, which is where the complexity comes in because our model only looks at standalone fans and a large portion of commercial HVAC fans are embedded fans. I want to spend some time talking through our investigation of HVAC fans and how we are defining embedded fans. I want to start by saying this topic is something that manufacturers, regulators, and program designers have been grappling with for a long time. What we are going to discuss here is how we consider these fans with respect to this model. This is not a definition of embedded fans that is universal, and it would be great to get your insights, reactions, and potential refinements. There are definitely gaps in how this definition would be applied to a regulation or something outside the context of what we are modeling.



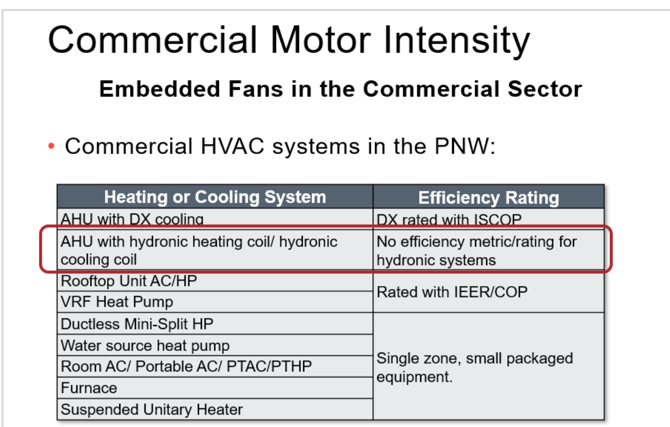
Nathan continued. Fans can either be their own piece of equipment like roof ventilators or exhaust fans or as a component in a larger piece of built-up equipment. In the latter case, often times the energy consumption of those component fans is included in the energy consumption of the larger piece of equipment. The example that I like to use is a refrigerator. Everybody's refrigerator has a fan, but you would always include the energy consumption of that fan in the consumption of the refrigerator. This definition uses a physical perspective (how it is installed in the field with respect to other equipment) to define if it is embedded or not. When we look at commercial HVAC systems, we want to make sure that we are not double counting fan energy consumption that is also counted as part of that packaged equipment. Our old definition of embedded fans is shown on this slide. If it is a fan that is part of a packaged piece of equipment, we consider it embedded. If it is a fan that is not part of a packaged piece of equipment, we consider it standalone.



Nathan continued. As we dove into commercial HVAC fans, we realized that definition was too simplistic because commercial HVAC systems range wildly from small single-zone conditioning units in hotel rooms to larger multi-zone systems and custom built air handler units. That old definition did a really good job of characterizing the simpler smaller systems, but how these larger custom built air handlers are designed created some complexity to just using a package versus not-package definition. From conversations with HVAC specialists, we learned that field-erected HVAC systems were more common in larger buildings in the past, but they are not common now. Even the really large built-up systems that the biggest commercial buildings have are assembled in a factory and shipped to the site. That means most commercial HVAC systems would fall under that “package” category of equipment. Which means that under the old definition, all of the fans in these HVAC systems would be considered embedded fans. This presents a problem because if these larger custom units use hydronic heating and cooling, there is not a package rating for those large air handlers that includes the efficiency of those component parts. They do not have a package metric in the same way that your AC would have like a seasonal energy efficiency ratio (SEER) or heating seasonal performance factor (HSPF). The large hydronic heating/cooling do not have those package metrics because the air handler does not produce any of the thermal energy. Often it is a central boiler or a central chiller system that heats or cools the fluid and then circulates it up to the air handler. That means that a packaged metric is not called for because the main energy consuming components that are within that unit are just the fans or the actuators that control the dampers. That means there are fans whose energy consumption is not included as part of a packaged HVAC metric, so should be considered standalone fans. But based on our old definition, are still considered embedded fans.

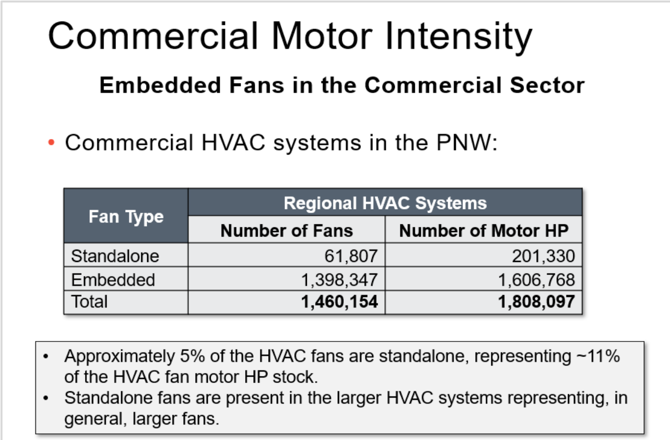


Nathan continued. We changed our definition to account for the fan energy consumption that is not included in packaged equipment metrics. Our definition for an embedded fan is now a fan that is part of a packaged piece of equipment where that equipment's efficiency rating accounts for the fan’s energy consumption. Conversely, a standalone fan is either not part of a packaged piece of equipment or the packaged equipment does not have a metric that accounts for the fan’s energy consumption.



Nathan continued. When we apply the definition to commercial HVAC systems, there is one type of system that we are considering as having standalone fans. This table from the CBSA shows all the heating and cooling systems and the efficiency metrics associated with it. Air handler units with a hydronic heating coil or cooling coil are the systems that we have identified as having standalone fans. It is those large air handler units without a package metric.

Ken said that it sounds like if the equipment has been regulated, we would consider it embedded. If it is not regulated, the fan would be considered standalone? **Nathan** replied. Yes, regulated or with a specific metric that the energy code uses. So, regulated from a standards or code perspective. **Ken** added. So, then an American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) code would apply too? **Nathan** said that was correct.

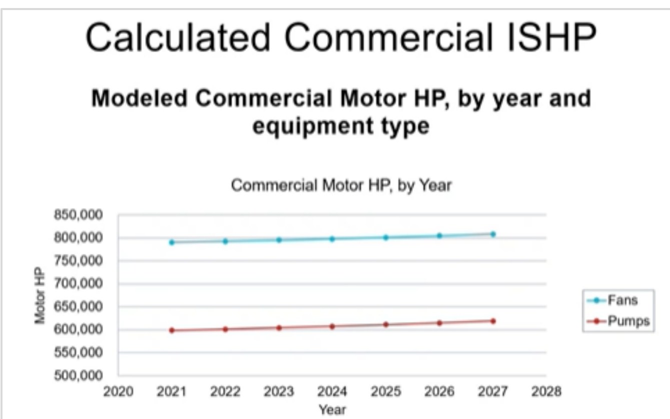


Fan Type	Regional HVAC Systems	
	Number of Fans	Number of Motor HP
Standalone	61,807	201,330
Embedded	1,398,347	1,606,768
Total	**1,460,154**	**1,808,097**

Nathan continued. This is the result from the CBSA in terms of the number of fan motor HP. We see a similar trend here to what we saw with pumps where the percentage that is in scope when looked at from a motor HP perspective is larger than when we look at it from a number of fans perspective. That makes sense because standalone fans are only in those large air handler systems that are not regulated and not covered by an efficiency metric. The fans would be larger.

Ken said that he is a little surprised about the distribution. The DOE recently produced their Technical Support document. I think they had a different percentage, a little more even, but certainly heavily skewed towards the embedded. I am curious if you compare those values. **Nathan** said no because we developed this stock characterization before they published their most recent report at the beginning of 2024. I would expect that difference would be driven by definition. How DOE defines embedded versus standalone might be a little bit different.

Rob asked. Are you telling me that it is 200,000 HP for 61,000 standalone fans? So, the average HP is like 3 HP? Does that make sense? I thought we were looking at huge fans. **Ken** replied. That sounds about right. As a as a fan manufacturer, our sweet spot is around 3-5 HP. I am not saying we have the whole industry, but that does not sound way far off. **Nathan** responded. Good thing to flag. We will make sure that we make that comparison and that we look at the distribution of fan sizes.

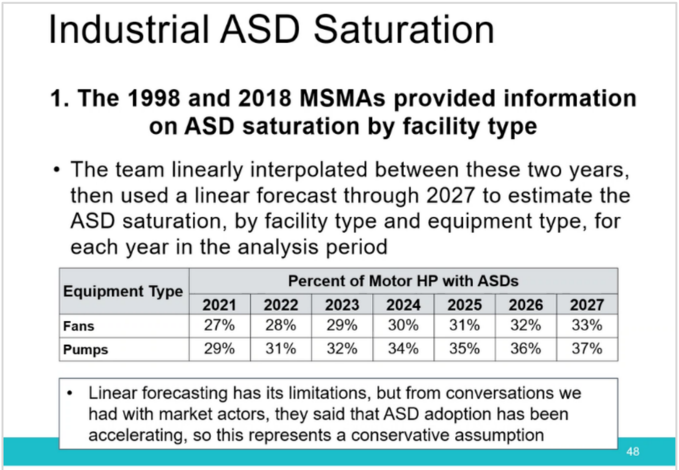


Nathan continued. Earlier, we talked about the calculation for commercial in-service HP. This is the result of that calculation. As with the industrial sector, you do not see a lot of fluctuation in in-service motor HP. Trends are a little more sensitive at the facility-type-level, but at the sector-level, it is pretty consistent growth informed by the annual economic driver.

ASD Saturation

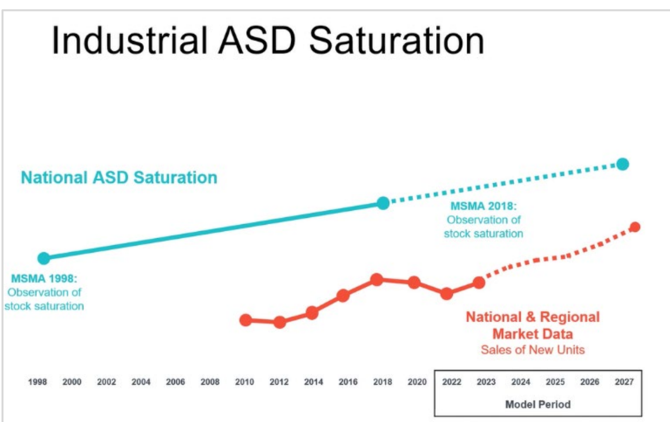
Nathan continued. ASD saturation is a big component of our model; it drives our energy savings and in this interim model we have to forecast ASD saturation. We will be calculating it in the final model, but right now it is a forecast.

Industrial ASD Saturation



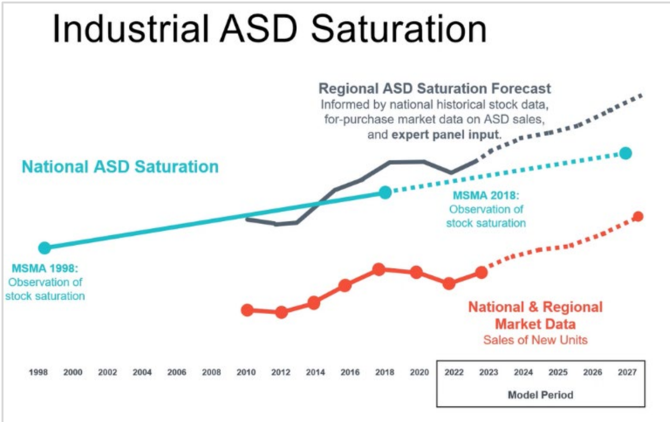
Nathan continued. At a high level, we used a three-step process, which is the same process that we used last time. The first step is to calculate the national ASD saturation of ASDs in each year using the two MSMAs and then we use for-purchase ASD market data to compare the trend in sales between the nation and the Pacific Northwest. The third step is getting expert input to corroborate or inform any adjustments that saturation. In the first step of calculating the national ASD saturation using the two MSMAs, we did linear interpolation between 1998 and 2018 and then a linear forecast out to 2027. We are using this as the national ASD saturation and acknowledging that it has limitations. We are doing a linear forecast, and the last data point we have is three years before our model starts.

We did some market actor interviews to understand how ASD adoption is changing. All the feedback we got from those interviews was that ASD adoption has been increasing and will continue to increase. So, we felt that a linear forecast was a conservative assumption of what ASD saturation at the national level would look like in the next five or six years. We are calculating 27 and 29 percent of motor HPs have ASDs for fans and pumps respectively in 2021. That would grow over the course of the model period to 33 percent for fans and 37 percent for pumps in 2027.

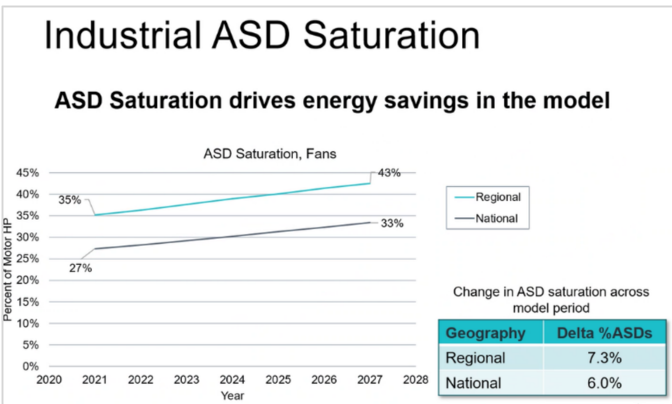


Nathan continued. This is a graphic that looks at national ASD saturation forecasted through to 2027. And then we have for-purchase market data on the national and regional number of ASDs sold in the industrial sector from 2010 through 2027. This data set is from a company called Global Market Insights. We use that same data in the old model, and we got an updated set of that for purchase market data. During the process, we reviewed their methodology, as well as other organizations that collect and produce similar estimates, to determine that this would be the best source for looking at how sales of ASDs change both year over year and from regional to national because we were able to get it at a state and national level.

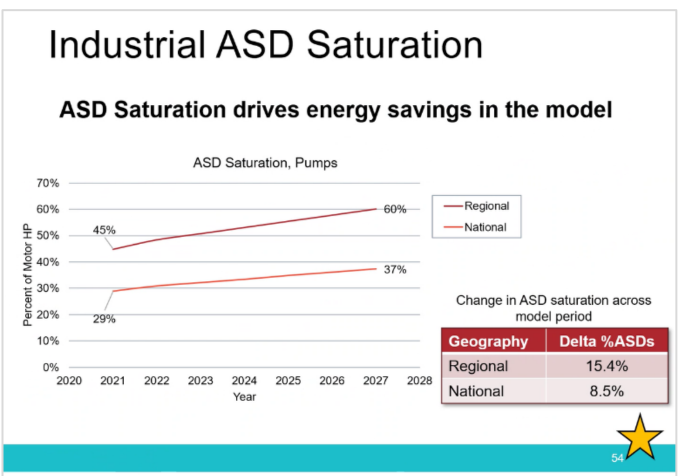
That data, when you compare the region regional sales to national sales, shows that regional ASD sales have been disproportionately larger when compared to the region’s industrial sector than the nation's. We are using motor HP in the nation versus in the region as representative of the industrial sector. That showed us that ASD sales have been higher in the region.



Nathan continued. Using that difference in sales relative to the industrial sector, the team was able to adjust the model's calculated annual ASD sales starting in 2010 because that is the furthest back that we have data to account for this regional increase in ASD sales. We used that regional increase to calculate a regionally adjusted ASD saturation in this gray line that is informed by the differences shown in that red line and then forecast it out through the model.

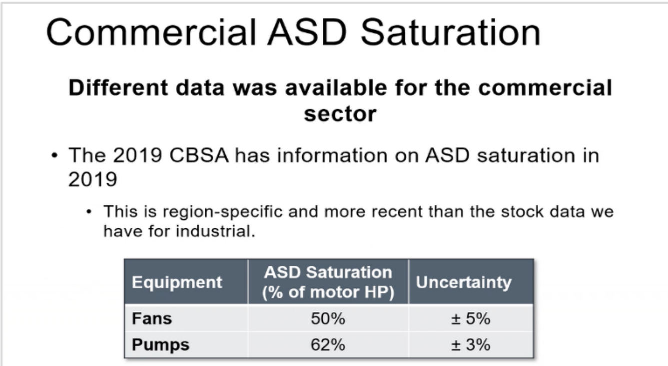


Nathan continued. This is the regional fan saturation (blue line) compared to the nation (gray line). You can see that it is a higher ASD saturation in the Northwest. You can also see that the rate of change in the ASD saturation is about one percent higher, looking at the delta across the model period, than it is in the nation. With this interim model and updated data, we see that the ASD saturation is less than what we previously calculated in our model in 2021.

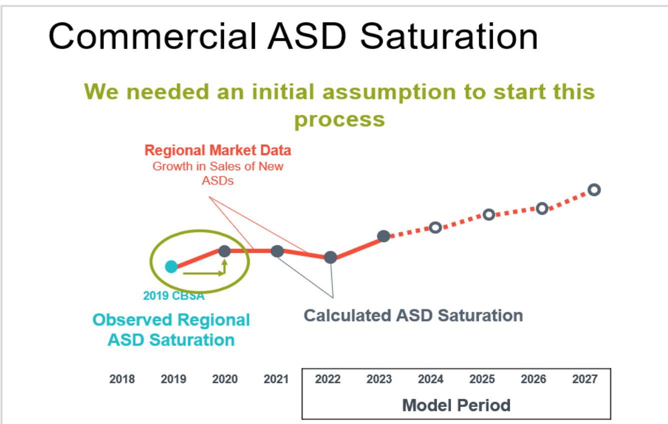


Nathan continued. For pumps, you can see that similarly there is also a stepwise higher ASD saturation in the region. The rate of change in the Northwest is a lot higher than the rate of change nationally. Based on this forecast, ASDs are being adopted about twice as fast in the Pacific Northwest than they are nationally.

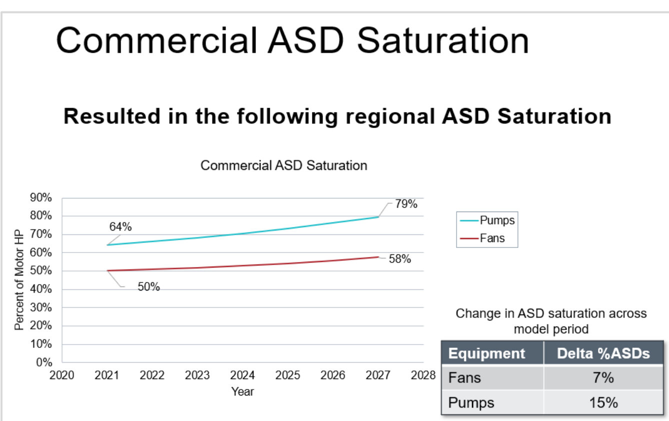
Commercial ASD Saturation



Nathan continued. We have a really good regional data source in the commercial sector, the CBSA, which informed the motor HP for the commercial sector for pumps and fans. We are using that information from 2019 as the starting place for our methodology and will talk through what that looks like from a diagram perspective.

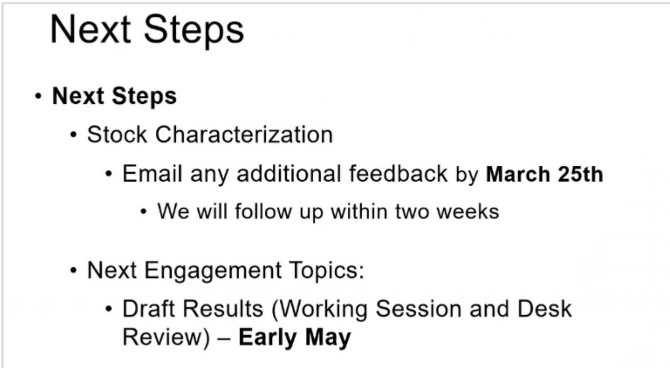


Nathan continued. For our methodology, we start with that single point of commercial ASD saturation in 2019, and we are pretty confident in it because of its observed regional ASD saturation. As the years progress, we use the growth in ASD sales from that same for-purchase market data from GMI to calculate the new sales of ASDs in the region. That allows us to calculate the stock and ASD saturation in the subsequent year and then repeat that process for all subsequent years. We build on previous sales and saturation to calculate the next year's values. We do that until we have values for each year in the model. The dashed lines represent forecasted values, but we use the same methodology for those years. The one complication with this process is that because we are using growth in ASD sales in each year as an input, we need an initial value of ASD sales to start this process. So, we need an initial year-over-year change in ASD saturation from 2019 to 2020, and we make an assumption that the year-over-year average change in the industrial ASD saturation is representative of the commercial sector. That assumption in the first year allows us to start the calculation process.



Nathan continued. These are the results of that methodology. With that initial assumption of the commercial sector and industrial sector, we are pretty confident in the magnitude of the starting values and that pumps are being adopted at a faster pace than fans.

Next Steps



Tyler discussed the next steps and the workbook of questions that we will distribute to the expert panelists.

Working Session: Interim Market Model Draft Results – May 21, 2024

ACTION ITEM – This highlights an action item for a panelist.

ACTION ITEM – This highlights an action item for BPA and/or Cadeo.

Attendees

BPA: Joan Wang

DNV: Tyler Mahone, Lorre Rosen

Cadeo: Nathan Baker, Cory Luker

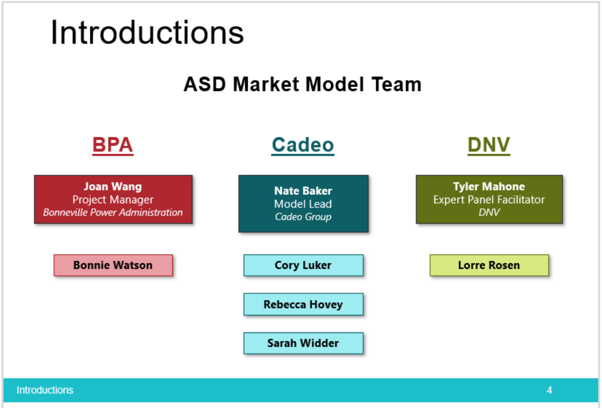
Invited Panelists	Affiliation	Attended	Did Not Attend
Rob Boteler	Independent	☒	☐
Pete Gaydon	Hydraulic Institute	☐	☒
Kenneth Kuntz	Greenheck	☒	☐
Paul Lemar	Resource Dynamics	☐	☒
Dave Morris	RHT Energy	☒	☐
Prakash Rao	Independent	☒	☐
Todd Amundson	BPA	☐	☒
Ryan Firestone	RTF	☐	☒
Kevin Smit	Council	☐	☒
Evan Hatteberg	NEEA	☒	☐
Nicole Dunbar	NEEA	☒	☐
Kristen Aramthanapon	NEEA	☒	☐

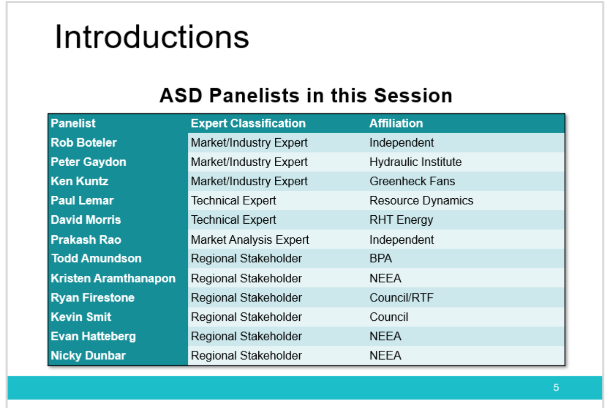
Working Session Agenda

The presentation will cover the following agenda:

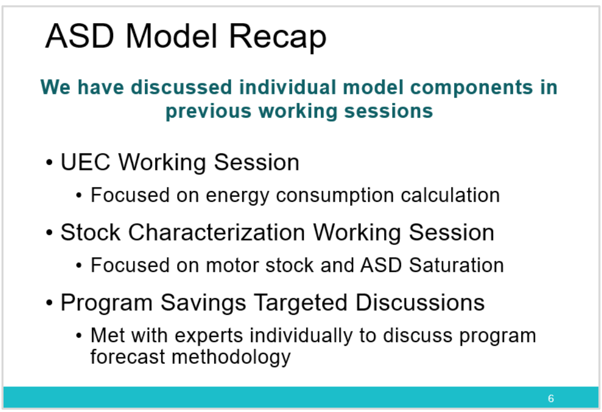
- Introductions, Recap, and Goals (5 min)
- Review Model Basics (10 min)
    - Calculating Results
- Industrial Model Results (35 min)
    - Forecasts of Energy Consumption, ASD Saturation, and Energy Savings
- Commercial Model Results (25 min)
    - Forecasts of Energy Consumption, ASD Saturation, and Energy Savings
- BREAK (10 min)
- Uncertainty, Sensitivity, and Future Research (30 min)
- Wrap Up and Next Steps (5 min)

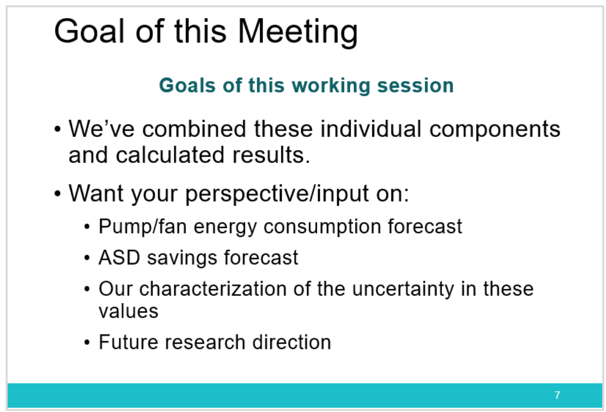
Introductions





Tyler introduced the panel.

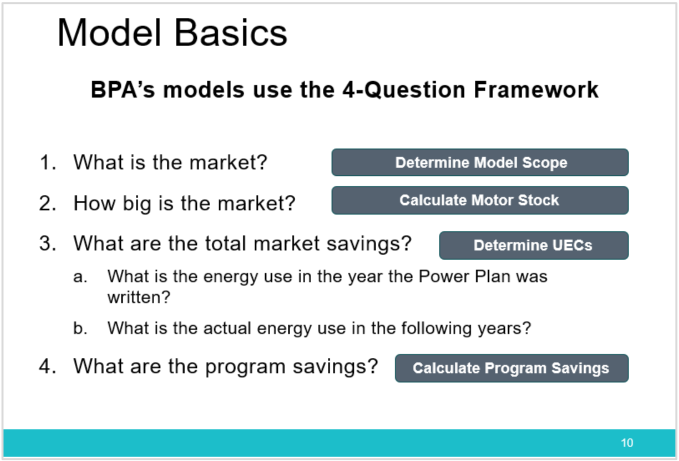




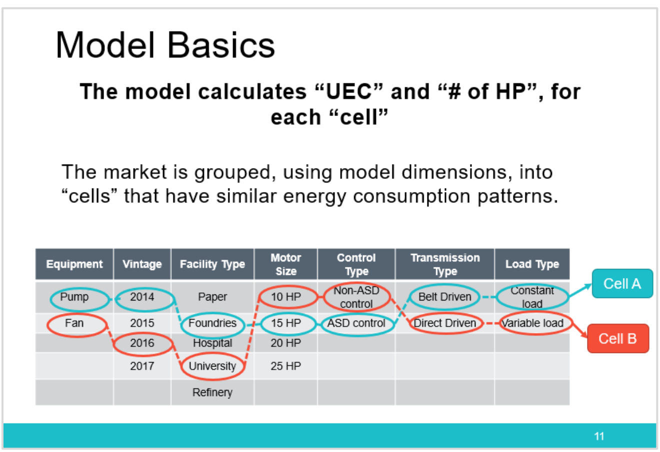
Joan provided a recap of the ASD market model and discussed the goals of this meeting. All the information we are sharing with you today is a forecast, and we want to get your opinion on the high-level direction of our pump and fan energy consumption forecast. More importantly, we want to know where you think the biggest uncertainty lies in our forecast. We all know and acknowledge that there is uncertainty in these values. We still have a couple more years of research we can do to reduce the uncertainty in some of our inputs, and we will get actual data to turn this forecast into actual results in a few years. So, we want to hear from you about where you think we have uncertainty in the results and where you think we should spend time researching in the next couple of years.

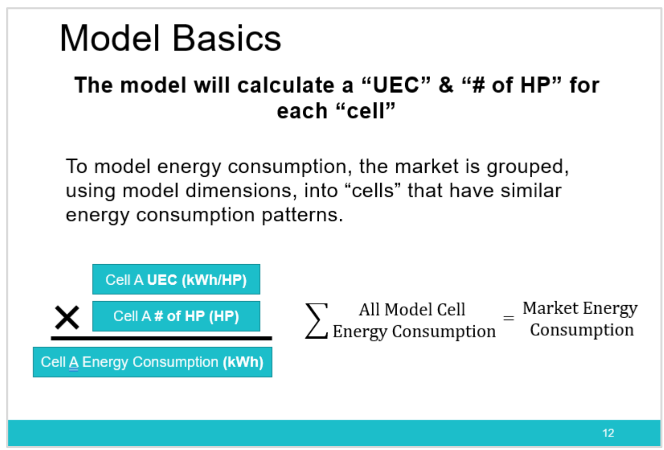
Review Model Basics

Calculating Results



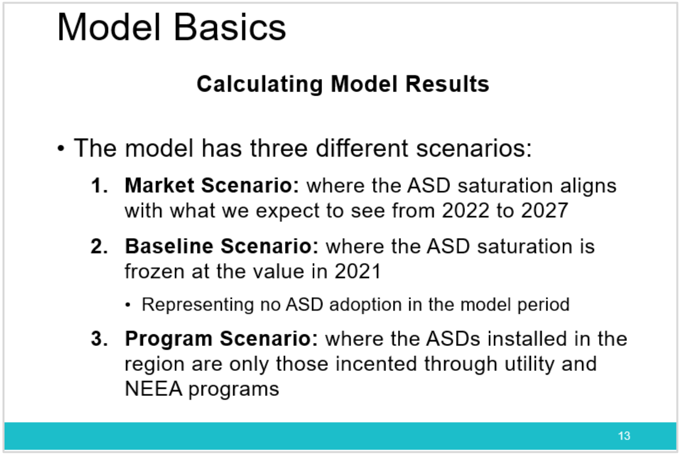
Nathan reviewed BPA's 4-question framework. The previous expert panel working sessions have aligned with this framework. And each of these questions serves as an input into calculating model results. For us, "calculating model results" means calculating the energy consumption of commercial industrial pumps and fans and calculating the energy savings created through the adoption of ASDs since 2021. We have forecasted the growth of each sector as well as increases in ASD saturation and, in this section of the presentation, we will walk through how we calculate energy savings.



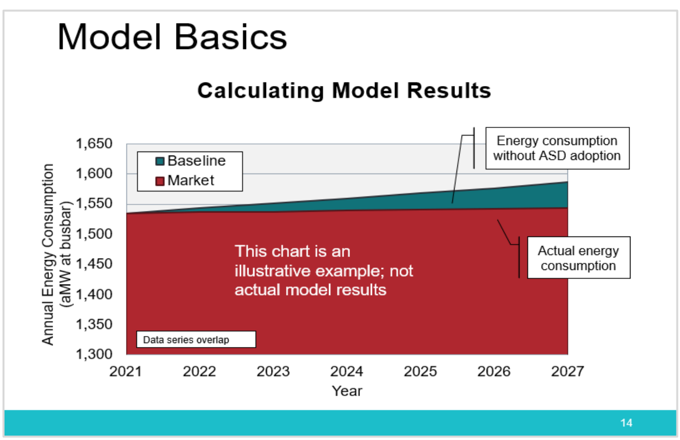


Nathan reviewed the basics of the model. The model uses cells or unique model dimensions to segment the market. Each model cell has a unique unit energy consumption (UEC). Each unique combination of these model dimensions has energy consumption in kilowatt hours per motor horsepower associated with it. We also use model cells to identify the distribution of motor horsepower. Along with the UEC, each cell also has a number of motor horsepower associated with it. If you take that UEC and multiply it by the number of horsepower associated with that cell, it gives you a kWh value, which is the energy consumption of the motor horsepower in that cell. Adding up all the model cells in the model for a given year gives you the energy consumption in that year. That means that the distribution of motor horsepower across these cells has the ability to impact energy consumption. More motor horsepower in cells that that are representative of no ASD control are going to consume more energy than those with ASD control. Conversely, if motor horsepower were concentrated in cells with ASDs, the energy consumption would be less.

Rob asked a question. When you are calculating the kilowatt hours, where did you plug in hours of operation, is that part of the calculation? **Nathan** replied. It is. We use these different market dimensions to identify different inputs into the UEC equation. Sector, equipment type, and facility type impact the operating hours. **Rob** added. Did those hours come from NEEA's research? **Nathan** replied. Yes, we reviewed a lot of different sources to identify operating hours. That was one of the main foci of our UEC working session. We aggregated all of those inputs and then just developed a list of UECs that align with hundreds of thousands of different unique combinations of these different market dimensions.



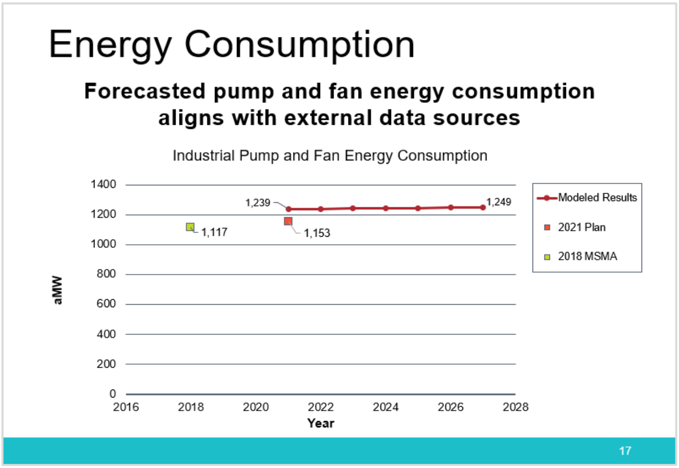
Nathan continued. We have three different scenarios where we develop distributions of motor horsepower for to understand the impact on energy consumption. The first market scenario is where ASD saturation is what we expect to see during the model. We purchased some data and viewed that from a regional lens to develop an ASD saturation that we forecasted throughout the analysis period. We apply that distribution of motor horsepower to calculate the market scenario. At a high level, that is what we expect to happen. The other two scenarios are counterfactual. They do not actually happen, but it allows us to compare that market scenario to different scenarios of ASD adoption. The first counterfactual scenarios are baseline. We assume that the ASD saturation is frozen at the value in the baseline year for the model, 2021. This scenario represents a world where ASD saturation remains flat over the analysis and does not increase at all. This allows us to ask, by 2027, how much has energy consumption changed due to the adoption of ASDs since that baseline year? In the third scenario, we assume that the only ASDs sold in the region since 2021 were those that are incentivized through utility programs. That allows us to understand the impact that utility programs are having on the adoption of ASDs in in the Pacific Northwest. That also means that the ASD saturation for this scenario falls between the previous two. Because our baseline is flat, the ASD saturation for the baseline is flat. ASD saturation for the market is higher than that and program scenarios fall somewhere in between those two.



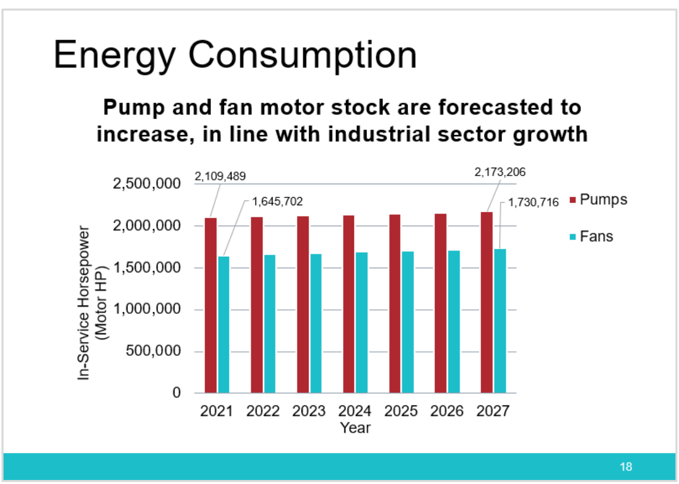
Nathan continued. We have provided a chart that just shows the highest level aggregation of our actual model results to illustrate the scenarios I described. You can see the baseline energy consumption calculated with the baseline scenario is steadily increasing over the model. Energy consumption with the ASD saturation that we predict to actually occur is a much flatter line. It is increasing a little bit, but it is much flatter. The difference between the baseline energy consumption and the market energy consumption represents the savings that are created by the adoption of ASDs in the region. Going one step further, the program scenario allows us to understand what portion of these savings is created directly by utilities and what portion is created through momentum within the market, which is driven by previous adoption and previous program activity making ASDs more prevalent in the region. **Dave** asked a question. When you talk about the program scenario for utility and NEEA programs, does that include utility programs such as Energy Trust that are not a direct utility program, but are kind of one step removed from it? **Nathan** replied. Yes, It includes any program savings that are reported to the Northwest Power and Conservation Council through the Regional Conservation Progress Report, which includes Energy Trust. **Prakash** asked. Can you remind me what sectors are included in commercial? Specifically, are you looking at data centers as part of your projection? **Nathan** replied. Data centers are not included. We are looking at commercial buildings, it does not include data centers and industrial does not include direct-served industries such as aluminum smelting.

Industrial Model Results

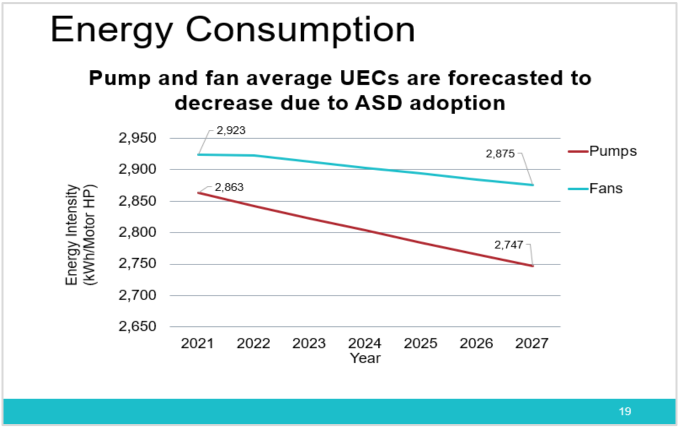
Forecasts of Energy Consumption



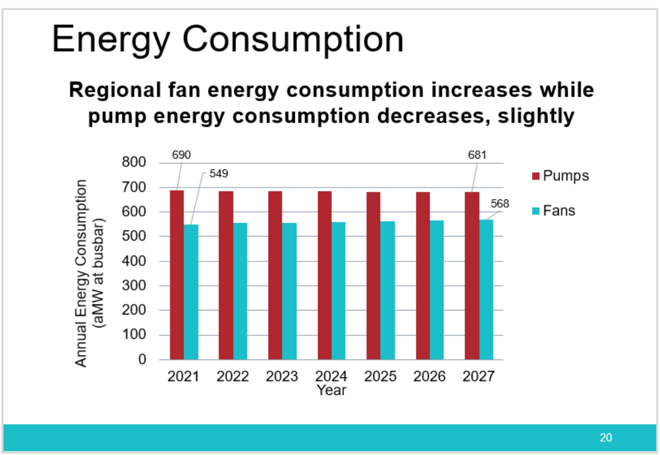
Nathan continued. For energy consumption, we are looking at just the high-level pump and fan energy consumption over the course of the model. The red line shows combined pump and fan energy consumption. Over the analysis, we show a slight increase in energy consumption from 2021 to 2027. We also included two external comparison points for our model. The first one is the estimate of pump and fan energy consumption from the 2021 Power Plan. The second, in green, shows 2018 power consumption from the Motor Systems Market Assessment (MSMA). We used that data along with a scaling factor for the region to scale the pump fan energy consumption to represent the Northwest. What you can see is that all three differently calculated values are within 10 percent of each other, which made us really confident in in the values that we are calculating. Looking more in depth at the comparison between the MSMA and the model of results are motor intensity. The motor horsepower per gross output uses data from the MSMA. It is not surprising that our values are similar. What this shows is that the UECs that we are calculating and applying to the motor stock in our model align with those values even though they were developed using very different methodologies. Ours are really granular, calculated from a bottom-up approach that is region-specific.

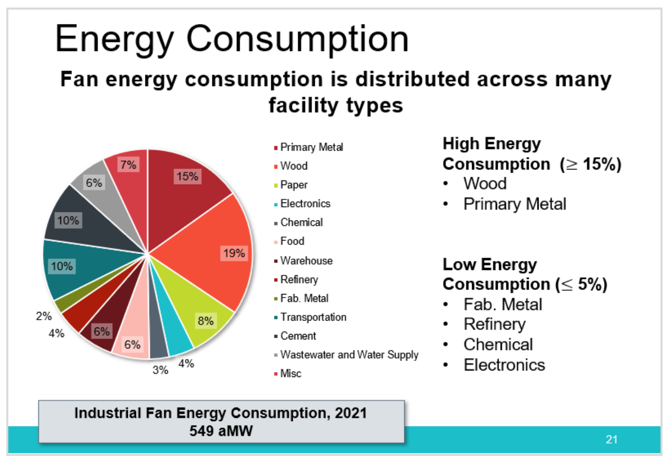


Nathan continued. This bar chart shows the motor stock for pumps in red and fans in blue. This is not necessarily energy consumption, but it is one of the two values that our model calculates to develop energy consumption, motor horsepower, and then UECs. If you look at motor horsepower, you can see pumps have a lot more motor horsepower than fans, about 500,000 more pump motor horsepower in the region than fan motor horsepower. This is a little bit different from our last model, where the values between equipment were more aligned. The difference is driven by a couple of key differences between this model and the previous model that we developed to cover 2016-2021. The first difference is that this model includes water supply and wastewater treatment facility types. Previously, we had not considered that as part of the industrial sector. Unsurprisingly, those facility types are very pump intensive. That increased the number of motor horsepower in pumps that we include in our model. The second driver is that in our past model, we underrepresented the transportation industry. There was a segment of the transportation industry that we had not included, and now we are accounting for a more realistic presence of that industry. The transportation industry is large relative to other areas in the country because historically, companies like Boeing have been based out of the Northwest. Zooming out from that detailed comparison between pumps and fans, you can see that we are modeling motor stock as increasing for both pumps and fans over the model. That is driven by an increase in the industrial sector gross output. We forecast gross output to increase by about one percent each year and that creates an increase in in motor horsepower. This is one component of the energy consumption calculation.

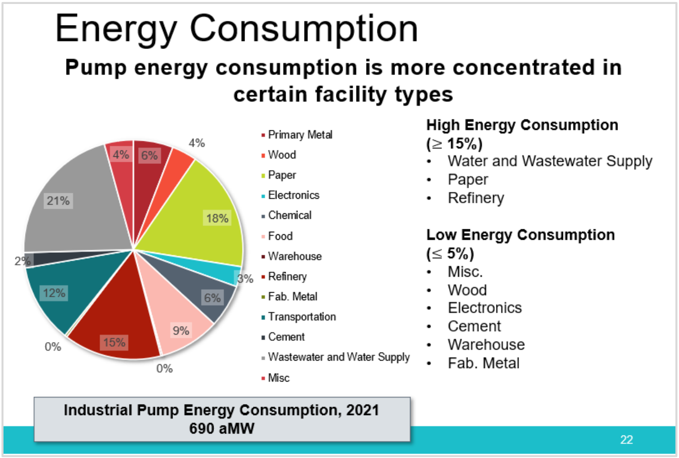


Nathan continued. The second component is UECs, and we are showing the average UEC within the model in each year of the analysis. Between 2021-2027 for both pumps and fans, the average UEC is decreasing. This decrease is driven by an increase in ASD adoption model throughout the analysis. The average pump UEC is forecasted to decrease by a little more than 100 kilowatt hours per year between 2021-2027. The average fan UEC is expected to decrease a little less than 100 kilowatt hours per year. We have installed pumps and fans increasing over the model. But we have the average annual energy consumption decreasing. When we multiply those two values together to get the high-level energy consumption, what we are seeing is a slight decrease in energy consumption for pumps and a slight increase in energy consumption for fans. That difference in directionality is driven by the difference in slope in these lines. We have the same growth rate for gross output between pumps and fans. But we have a steeper decrease in UECs over the analysis, which is showing up in energy consumption as a slight decrease for pumps.

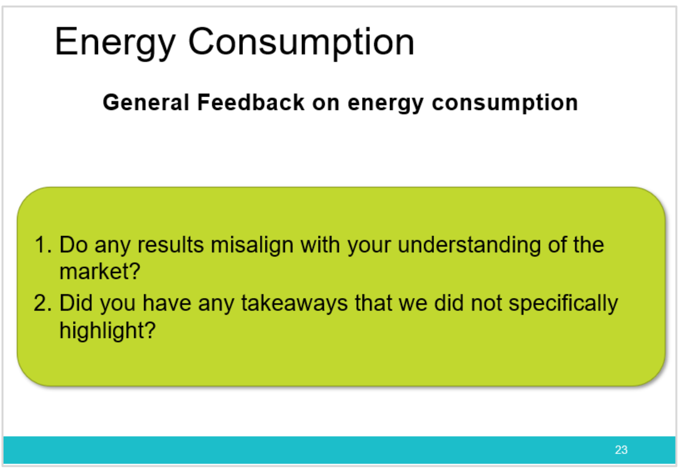




Nathan continued. This is a high-level look at pump and fan energy consumption; the next couple of slides dive into energy consumption at the facility type level. We looked at 13 industrial facility types. The total pie chart is the total energy consumption in 2021, and we separated that into 13 wedges representative of the size. We are using 2021, because in our forecast, there is not a big difference between the distribution across facility types in 2021 versus 2027. For fans, there is not much concentration in any one facility type. In industrial, we do have two industries that have the most fan energy consumption: wood and primary metal. But both of these are less than 20 percent of the energy consumption. We also have four industries with very low fan energy consumption, less than 5 percent fabricated metal, refinery, chemical industries, and electronics. At a macro level, we did not see any trends that were unexpected.



Nathan continued. We saw similar trends, or lack of interesting trends, in pump energy consumption at the facility type level. Water treatment and wastewater supply, paper, and refineries were the largest energy consumers, which is not surprising. Thise industries all have a lot of pumps. There are more lower consuming pump energy facility types, but none are dramatically lower than we would expect. The distribution aligns with our previous understanding of energy consumption and facility size.

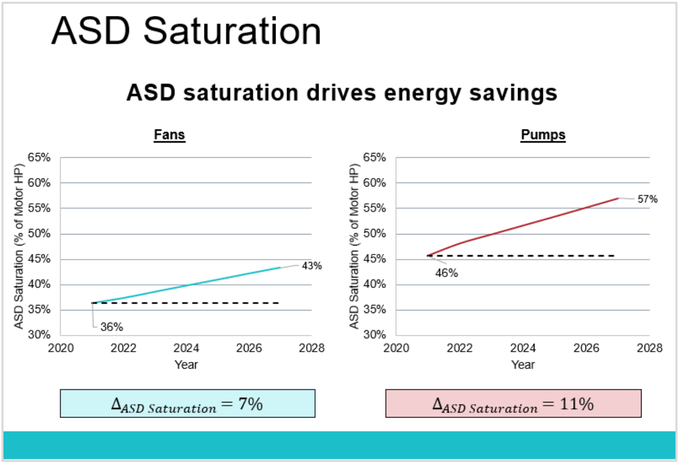


Prakash asked a question. There is nothing alarming related to your first question. But looking at the slope of the lines for pumps and fans, the pumps line is steeper than the fans. Why would that be when ASD adoption might be similar or the same across the two? **Nathan** replied. We are modeling greater ASD adoption in pumps as opposed to fans, and that is what is driving the steeper slope for pumps. **Prakash** added. Your point is that pump and fan energy consumption go up but is offset by ASD. So, it is kind of balanced. but when you express the energy savings, it would be cool to express it as what it would be minus what it is with ASD. So, it is not really flat, right? ASDs save a lot of energy. It is not critical, but I think just from the benefits of ASD, comparing it to what would be minus what it is with ASDs would be beneficial. **Nathan** replied. That is a great callout. We have slides that compare to the counterfactual baseline scenario, as if those ASDs had not been adopted.

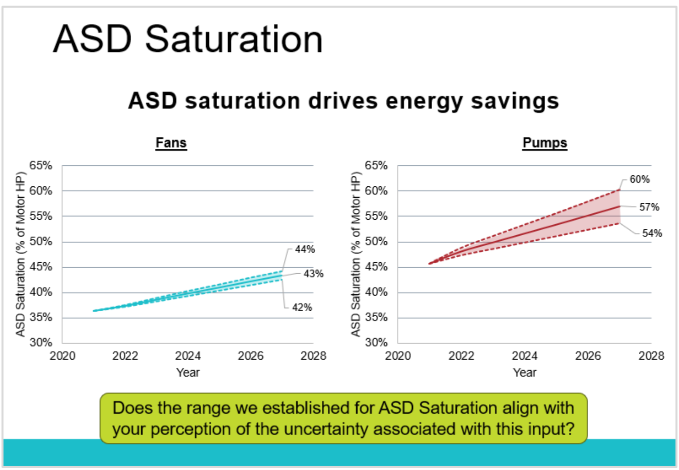
Rob asked a question. On the fan market pie chart, you made the comment that on the water/ wastewater you had less use of fans by definition. Did we include high-pressure blowers because wastewater uses a lot of high-pressure blowers? But I do not know if they fall out of our definition or not. **Nathan** said that is a good thing for us to look into. **Rob** added that they are usually high-powered.

Kristen added in the chat: I am just taking notice that the chemical industry is not such a huge consumer of pump energy. The pumps team has been looking into this industry a bit (for our interest in ANSI/ASME pumps), so this is slightly disappointing. But I guess it's also not shocking since I assume there is less of this industry in the region, compared to others. **Nathan** replied to Kristen. That is something we can look into.

ASD Saturation



Nathan continued. In the last working session, we talked about ASD saturation and what we were calculating as a regional saturation. We made some adjustments based on your feedback. What we are showing here is our modeled ASD saturation and how we are modeling it growing between 2021 and 2027 for fans and for pumps. We also included the percent change. This 11 percent being greater than seven percent is really what is driving that steeper red line that in our average UECs. The colored lines are our model of ASD saturation, and the black dotted lines are the baseline ASD saturation. We assume that no ASDs are adopted beyond what is already in the market in 2021. In our baseline scenario, we hold ASD saturation constant at this black line level. Then we calculate the energy consumption in the baseline scenario and in the market scenario, and the difference is the savings created by ASDs.



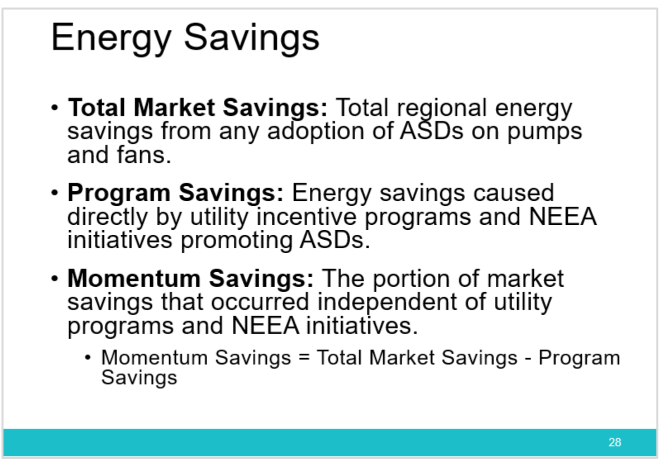
Nathan continued. In our stock characterization working session, we presented our regionally adjusted ASD saturation values. We talked through the process of purchasing market data that was forecasted out through 2027 and using that to adjust a national ASD saturation forecast to be regionally representative to account for the increased sale of ASDs that the purchased market data showed was occurring in the Northwest. That produced this upper dotted line for pumps and fans. The feedback that we got from this group was that those values were probably higher than what we could expect to see in terms of ASD saturation, but not out of the realm of possibility. In general, participants agreed that our regional ASD adoption would be higher than the nation because we have such historic program activity, which has influenced and promoted ASD adoption for a long time. The lower dotted line for pumps and for fans is that national ASD adoption saturation. We reviewed your feedback and looked at what we were previously considering including in the model, and we asked ourselves if it is realistic to assume that the highest range of ASD saturation will occur in the forecast. Maybe it will happen, but it is probably more realistic that it will fall somewhere in between our regionally adjusted ASD saturation and the nationally adjusted ASD saturation. So, we set those as realistic low and high limits to what we are modeling ASD saturation as, and we are using those as bounds in our sensitivity analysis and as an input to the model. We cut that range in half and used the midway point in each year between those two, the high and the low values, as our base case ASD saturation that we are putting into the model. Compared to what we talked about in our during the stock characterization working session, now we are showing less growth in ASD saturation over the analysis. It is much more pronounced for pumps than it is for fans. We are showing a lot bigger difference in regional adoption when compared to national adoption for pumps than we are for fans.
Prakash noted. For fans and maybe pumps too, I would expect a larger range, particularly out to 2028. We do not know industry growth, barriers to ASD adoption, and electricity rates. But I would expect uncertainty ranges in the 20-ish percentile. I know if it is 43 percent ± eight percent, nine percent

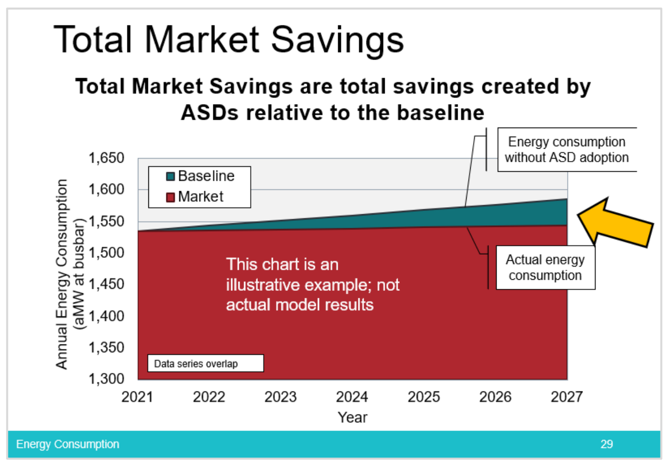
uncertainty ranges. Pumps are looking a little bit more in line, but I expect it to be a little bigger. But this is just my gut reaction; I have not poured through the numbers.

Rob asked. When you say saturation, you are talking about the actual installed base, you are not talking about units being sold per year, right? **Nathan** said that is correct. **Rob** continued. To get to 60 percent saturation with pumps, which is a huge number of new units sold every year. The driver here is the DOE regulations for pumps that are already in place for the for the water pumps. As of this week in the commercial markets, the circulators are going to come into play in four years. But the manufacturers are going to start their conversion sooner. The number of units sold with ASD is going to continue to grow dramatically. But when I look at this and I see 60 percent saturation in the installed base, that seems like an awfully big number.

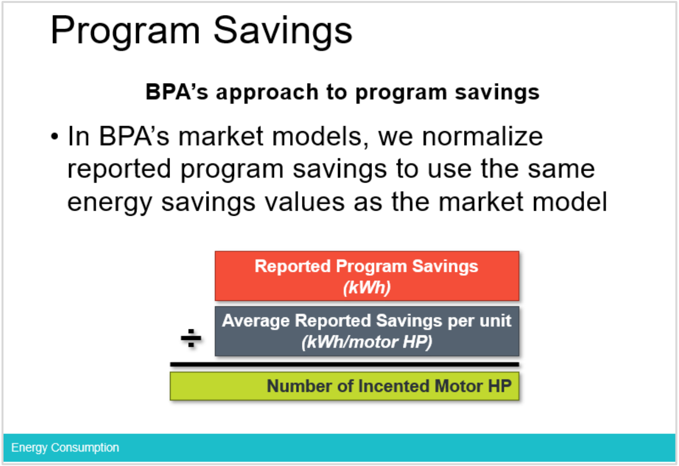
Joan asked. So, based on what is going on in the market and also thinking specifically about the Northwest, you think that a lot of the new pumps are going to have ASDs on them. If you forget about where the saturation is starting or landing on the chart, but if you look more at the change in the saturation year by year, does that more align with what you know about ASDs being added to the market? These are all based on data that go from far back compared to 2022. We have good data showing that the region's industrial pump market is ahead in terms of stock saturation of ASDs. What do you think about the change in that saturation during these years? **Rob replied.** I need go back and look at the previous charts before I answer that.

Energy Savings

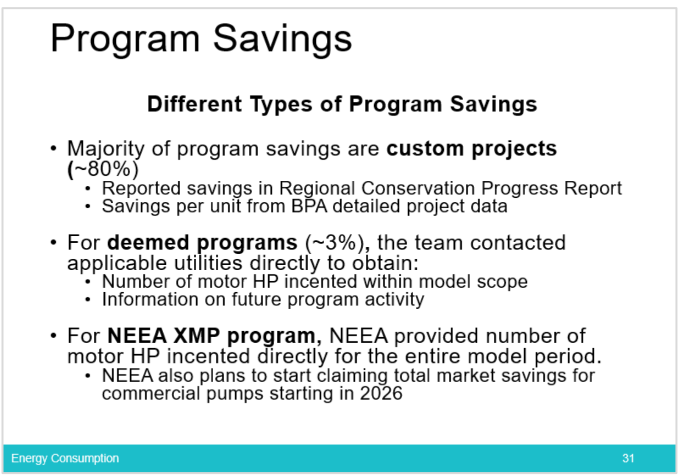




Nathan continued. The actual red energy consumption line is energy consumption with actual forecasted ASD adoption incorporated. The blue line is energy consumption without any ASD adoption. The differential is the energy savings created by increasing ASD adoption, which gives us total market savings. One of the things that we need to be able to calculate is the program savings that are occurring. What percentage of these total market savings are program savings?

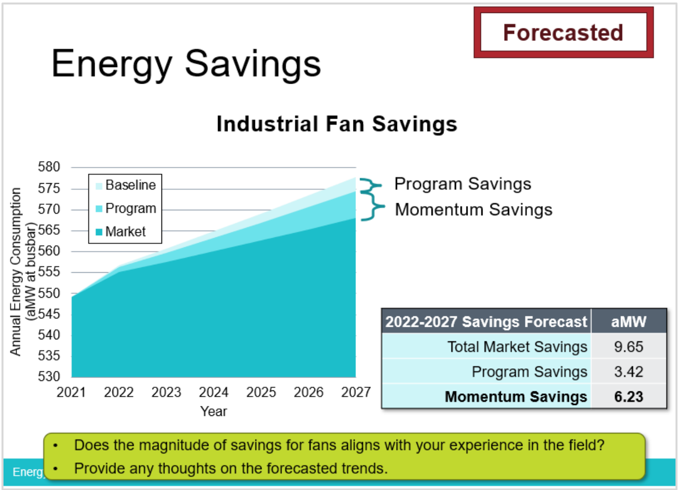


Nathan continued. We normalize reported program savings to a consistent baseline and then apply it to our model in terms of the units that our model is calculated in, which is incented motor horsepower. We start by identifying the program savings in kilowatt hours within our scope (the red box). We use the Council's regional conservation progress report to do this, which is where all the savings in the region are reported. We used that report, along with information on where those programs are applied, to calculate ASD-related savings. Then we divide that by a unit savings value. Within all of those programs, how much energy does one motor horsepower save to calculate the motor horsepower in the region? The average unit energy savings (UES) value (in gray) is specific to programs because the assumptions that go into a program may be a little bit different than the assumptions that go into our model. Programs may use different operating hours or a different load profile value to calculate the pump or fan than the energy savings that our model does. We want to make sure that we compare apples to apples. So, we use a program-specific UES to calculate number of incentive motor horsepower, which allows us to then apply those motor horsepower to the model to understand the impacts that program incentive motor horsepower has on regional ASD adoption.

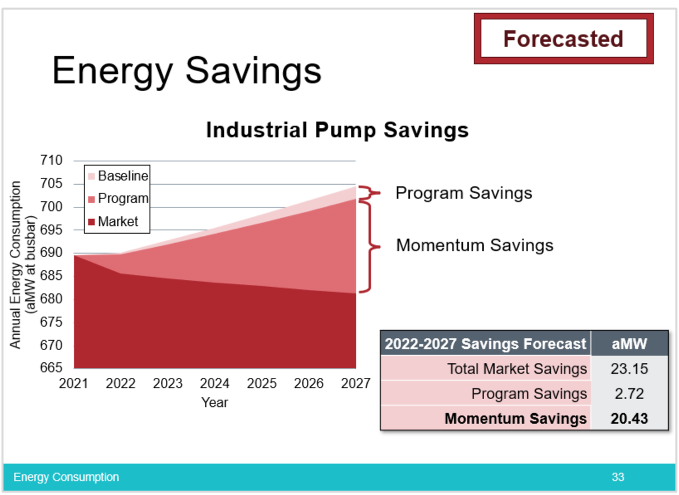


Nathan continued. There are three different types of program savings that we include in our model for custom programs. They make up about 80 percent of the total savings that we model in the market. For commercial and industrial, the percent is much higher. Specific to industrial, almost all of the industrial savings are custom, but at a high level, it is about 80 percent of the total. We use the regional conservation progress report and the detailed BPA program data to do the calculation that we just showed in the last slide for deemed programs. We were able to contact the utilities that run deemed ASD programs. They sent us information on the number of motor horsepower that they incented and their expectations around future program activity. So, we have a much more direct value of the number of incented motor horsepower for deemed.

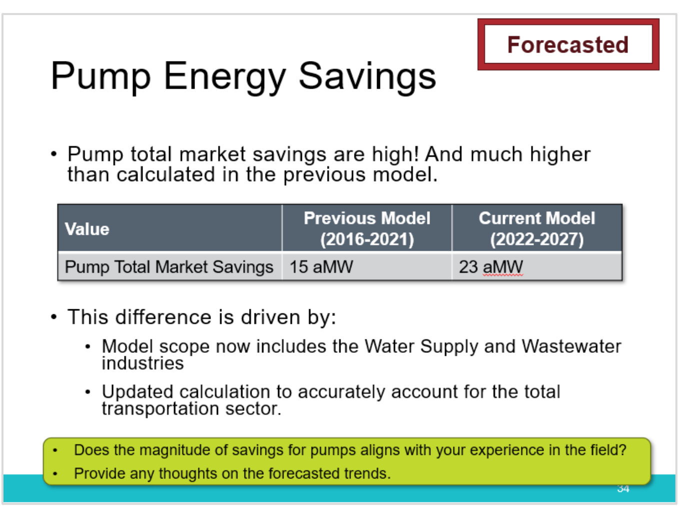
NEEA's XMP program covers the application of ASDs on pumps within our scope and NEEA was able to provide the number of directly incented motor horsepower forecasted throughout the region. There is also the potential for NEEA to claim total market savings for commercial pumps; and we estimated that it would start in 2026. This is a forecast that is subject to change, but we wanted to account for that in impacting commercial program savings that are being generated. So, that is the assumption that our model uses.



Nathan continued. The dark blue wedge is the energy consumption that we are modeling with the ASD adoption that we forecast will occur. The lightest blue line is the baseline energy consumption or the energy consumption that would have occurred had ASD adoption not increased from the 2021 value. The line in the middle delineates program savings: ASDs installed via utility programs versus ASDs installed outside of utility programs due to the momentum created within the market. We are seeing that there are a little less than 10 average megawatts of energy saved on industrial fans due to the adoption of ASDs. A little bit over 1/3 of that is program savings (about 3.5 average megawatts) and the remaining 2/3 is momentum savings for ASDs adopted outside of programs. **Dave** noted. I am surprised that that program savings is not a larger chunk of the total savings just because of how the incentive programs work. I would have expected them to be more balanced. Seems like it would be a lot closer than it is.



Nathan continued. The big difference in this chart compared to the last is that we are showing a lot more industrial pump savings compared to fans. In total, we have about 23 average megawatts of total market savings with a similar absolute value of program savings of about 3 average megawatts of program savings for industrial pumps. That shows about 20 average megawatts of momentum savings occurring in the region. This much larger value is much higher than we were expecting. We investigated these values and what is driving them.



Nathan continued. Not only is it a lot bigger than fans, but it is also a lot bigger than the value that we calculated in our previous model. If you look at this table in our previous model, we were calculating about 15 average megawatts of savings in 2016 through 2021. Currently, we are calculating about 50 percent more than that or 23 average megawatts for the current model. That difference is driven by the two factors: the inclusion of the water supply and wastewater industries and the updated calculation to include the entire transportation sector increased the total size of the pump market a lot in this model. It drove an increase in energy savings. The differential between program savings and momentum savings is driven by the fact that there is not a large amount of program activity associated with those industries. Program activity stayed similar to our previous model, but our total market size increased.

Rob asked. Is the impact of DOE regulation included in the momentum category? **Nathan** replied that we are not accounting for the impact of increases in efficiency of pumps in the savings, so we are accounting for increases in pump efficiency in our energy consumption. But that change is reflected in all three scenarios. We are not including DOE savings created by standards or by codes in the commercial sector in either program or momentum. With these models, we are trying to characterize the impact outside of the adoption of codes and standards. **Joan** added. They were accounted for in the baseline already. **Nathan** added. Yes, we account for the impact that they have on baseline energy consumption. Any increase in efficiency due to standards or code is characterized there. But we are not creating wedge in this in this chart that represents those savings.

Prakash asked a question. The chart shows that you are going from 690 to 705, right? And then you have program savings at 5 and the momentum savings is 20. Should it be the other way around? Isn’t the market going down? **Nathan** replied. The market is going down and this represents actual ASD adoption. This is where we are applying that increase in ASD adoption by 11 percent. That drove energy consumption down from 690 to about what would this be 682/683. We are modeling what we think will happen with continued ASD adoption. Conversely, the light line is what the model shows if no new ASDs were installed in the region. If our ASD saturation from 2021 stayed constant, we would see the number of motor horsepower increasing in the region year over year. If we do not adopt any more ASDs, energy consumption is going to climb. **Prakash** added. That makes sense.

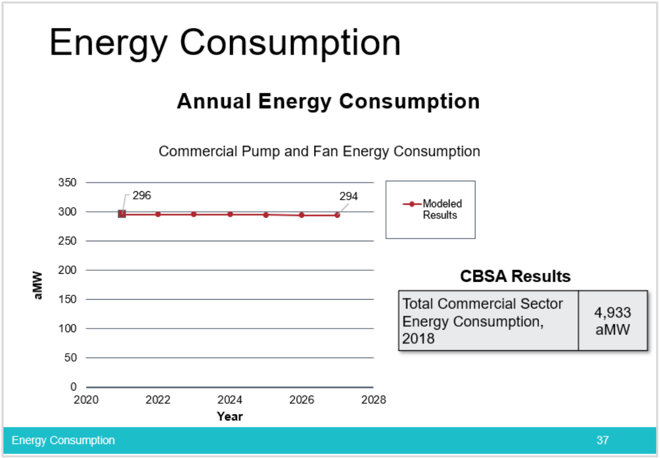
Dave added. The momentum and program savings seem unbalanced. The wastewater plants that were included are very active in the utility-based savings programs, and I am just not seeing them adopting ASDs without using utility programs. **Nathan** said that is a good flag, and we can add that to our future research. **Joan** added. I love that you provided examples. Are you specifically thinking of the water/wastewater industry? **Dave** replied. Yes. The water and wastewater industry has been very active in utility programs.

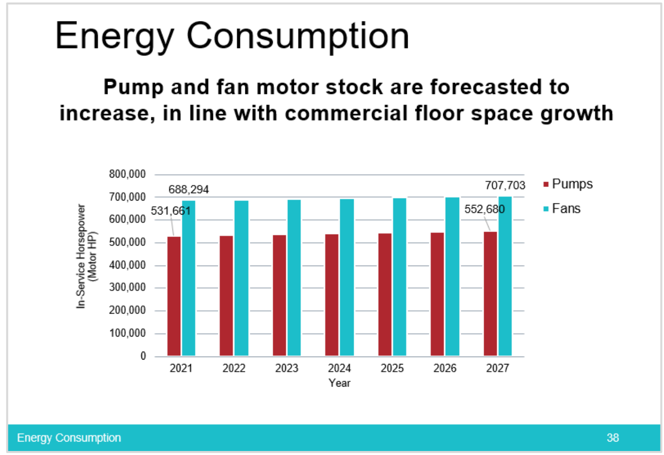
Joan added. That helps us dig in more specifically. I just want to offer a couple of things because we are going to look at the similar thing for commercial as well. The slide that Nate showed on industrial pumps is probably the biggest finding: that we are modeling a lot of non-program incented ASD adoption. If you think about how our model works, that is really driven by whatever we are modeling in terms of the overall ASD saturation forecast. We feel really confident about how we have captured all the program savings that are in the region. Think about why you might see a huge chunk of momentum savings. It is really the difference between what we are modeling with programs and what we are forecasting in the market. I think about non-program incented savings as a product of previous program accomplishments because that is what drives the momentum in the market — to adopt efficient practices like drives that may not need that program incentive. We will find out in three years if this forecast is reasonably accurate. There has been a lot of previous program activity in the market that may be driving that momentum in the non-program incented space.

Joan added in the chat: Side follow-up for Dave on industrial pump savings: you are right that Water/Wastewater have large program activity (it has the biggest # of program-incented motor HP), and program accounts for about a quarter of total ASD activity in this facility type (which is a big portion compared to other facility types). There are lots of industrial facility types that have almost no program activity: Water/Wastewater, Paper, Food, and Chemical are really the four industrial facility types that have good program activity in the region. I hope these detail help, and I look forward to additional feedback!

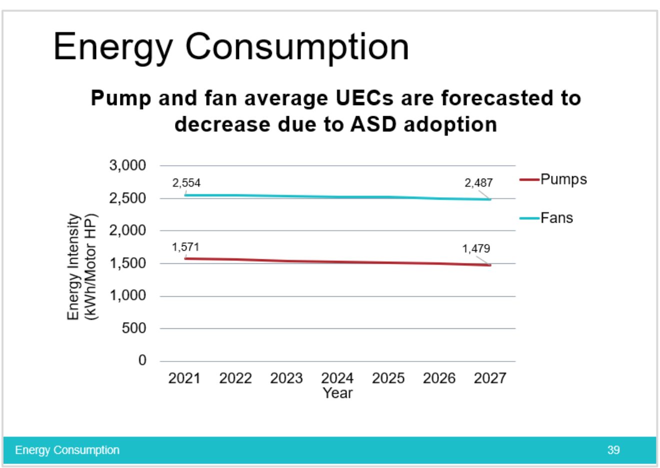
Commercial Model Results

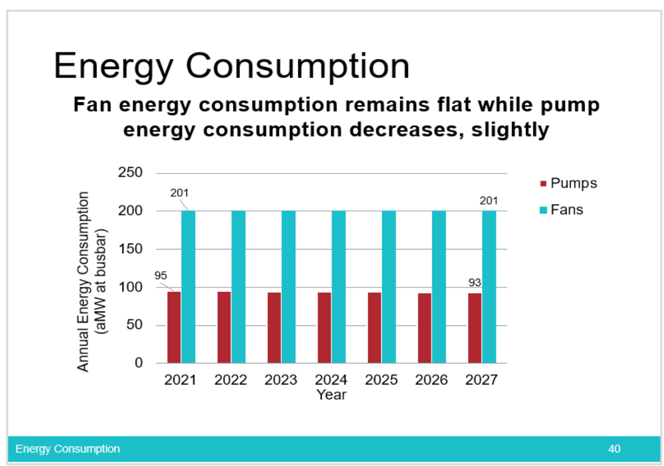
Energy Consumption Forecast



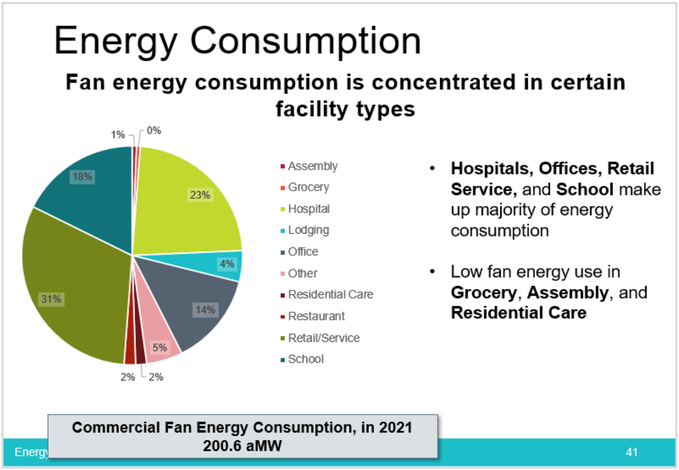


Nathan continued. This is the motor stock that we are modeling for commercial pumps and fans. We are using the same color scheme: pumps are red, fans are blue. We are showing that both pumps and fans are increasing slightly, similar industrial. This increase is driven by the increase that we are seeing in our forecasted commercial floor space values. We are showing more commercial fan motor horsepower than pump motor horsepower, which is inverted from the industrial sector. We had more pump motor horsepower in the industrial sector, but in speaking with commercial HVAC experts program people that are heavily involved in BPA's program as well as in modeling the commercial market, they agreed that this difference makes sense. They also said that fans are a huge energy consumer in commercial HVAC. There is a lot of fan motor horsepower. If we were to include all the commercial HVAC fans, that difference would probably be even bigger. But as a reminder for our scope, we are excluding fans below 1 motor horsepower and fans that are packaged in HVAC equipment. That has its own efficiency metric. We are only including standalone fans, e.g., exhaust fans that are not part of a larger system or fans installed in large built-up air handlers. It is a limited fan scope. But even with that limited fan scope, we are seeing more motor horsepower than pumps.

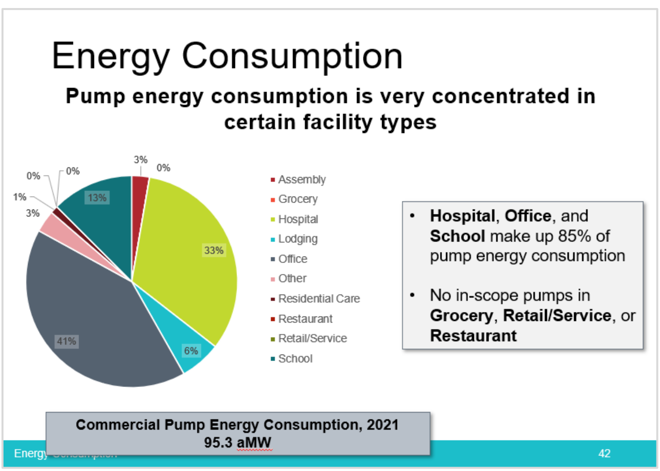


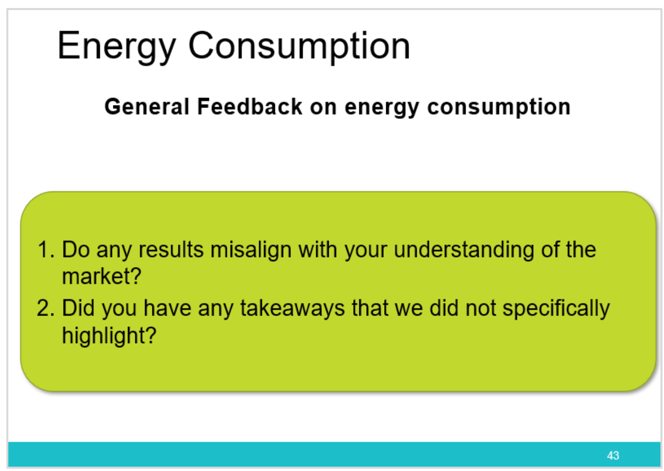


Nathan continued. This line chart shows the average UEC for commercial and pumps. This is where we see similar trends between pumps and fans as we saw in industrial, but a little bit steeper for pumps than we had for fans and fans have a higher average UEC in general. The bar chart shows energy consumption for pumps and fans in each year, which is about double the energy consumption for fans as we have for pumps. That higher UEC coupled with the greater motor horsepower is really exaggerating the difference between fan energy consumption and pump energy consumption. We wanted to confirm if that was correct. In talking with the commercial HVAC specialists, we learned that this finding aligns with their expectations. One of the big drivers of energy consumption in commercial buildings is moving air through conditioning systems.



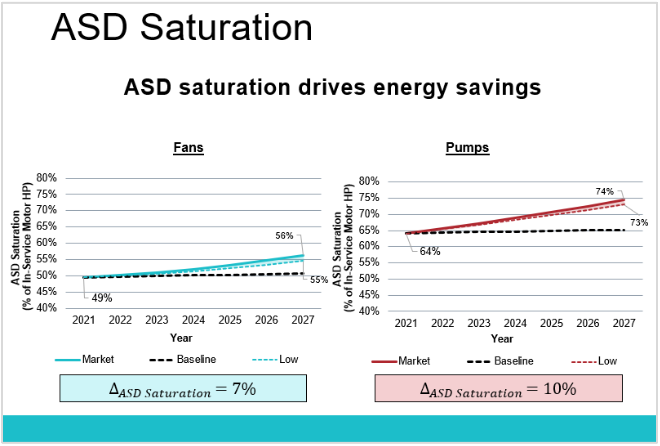
Nathan continued. These pie charts are a little more interesting than in industrial because we have some heavy concentrations of energy consumption. For fans, we have three industries that are really driving energy consumption. About 75 percent of the fan energy consumption is falling into hospitals, schools, and retail or service buildings. In the conversations where we were confirming these results, the specialists that we talked to noted that this concentration makes a lot of sense. Hospitals and schools have outdoor air ventilation requirements that mean those facilities are going to consume more energy per square foot than other facility types. Retail and service do not have similar requirements. But it is such a broad facility type that it includes a lot of motor horsepower. Retail and service can often be smaller buildings. Each of the smaller buildings will have dedicated exhaust and you are going to get fewer economies of scale than you would see in larger buildings with those standalone exhaust systems. That impacts the number of motor horsepower seen in those facility types.

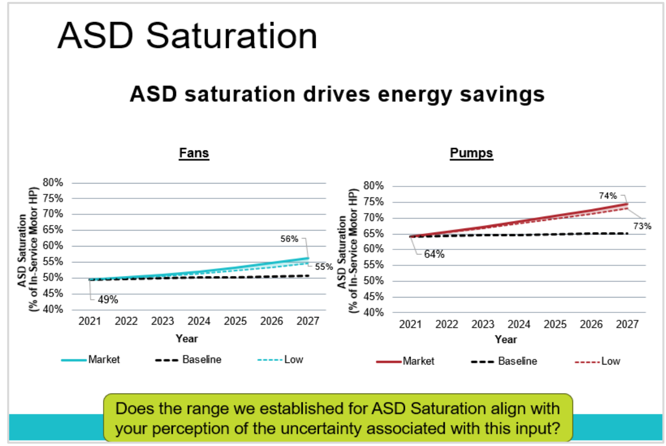




Nathan continued. Pump energy consumption is even more concentrated by facility type. We see 40 percent in office buildings and 33 percent in hospitals. Schools have about 13 percent, but the combination of those two make up 85 percent of the pump energy consumption and our scope only covers clean water pumps above 1 horsepower. To justify installing these, you are usually going to have larger systems that require the flows that those pumps serve. Smaller buildings are going to have smaller pumps. More often, they are going to have small circulating pumps or fractional pumps that fall outside of the scope of this model. What really highlights that is the fact that our model is currently showing no in-scope pumps in grocery, retail and service, or in restaurants. That is not to say that there are no pumps in those systems, but those buildings are not usually large enough to justify having large, dedicated clean water pumps above 1 horsepower. They are going to be served by fractional circulators or fractional horsepower pumps.

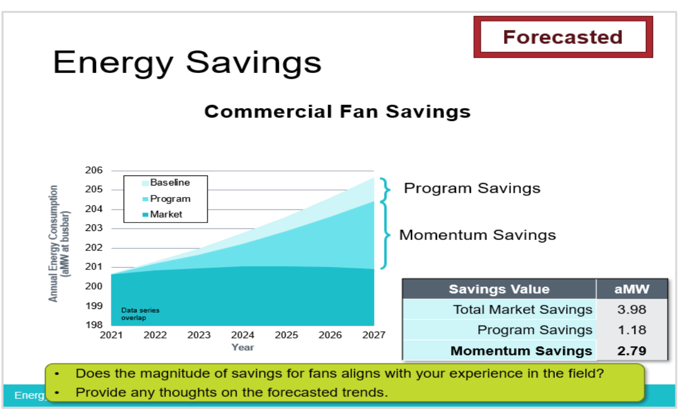
ASD Saturation Forecast



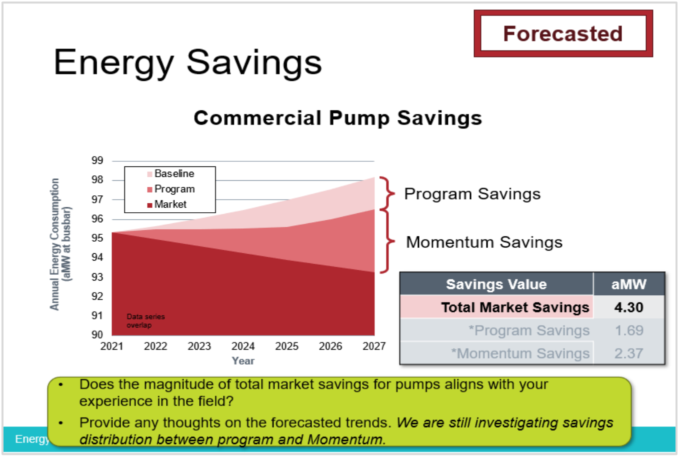


Nathan continued. We are talking about this variable specifically because it really is the one that is driving our calculation of energy savings, and it has a big impact on energy consumption. We are seeing a similar delta ASD saturation in fans and pumps as we did in industrial, about seven percent for fans, 10 percent for pumps. In our conversation during the stock characterization working session, pump ASD saturation went up to about 79 percent and we got feedback from multiple panelists that this seemed really high and that 75 percent was a value that seemed a more realistic point at which ASD saturation would reach. We made a couple of adjustments based on their feedback. Incorporating those comments meant that our ASD saturation changed to align well with the feedback. We adjusted it down to 74 percent and that delta ASD saturation is a little lower than when we last looked at the range of ASD saturation that we are including in our uncertainty. Based on the feedback, we decided to set that solid line market scenario as our high value. We felt that was realistic and we did not want to model it any higher than what we were currently modeling. To set the low end sensitivity, we decreased the year-over-year change in ASD saturation by 25 percent. The growth rate decreased by 25 percent in each year, which produced this lower-end ASD saturation as shown in the dotted line.

Energy Forecast Savings

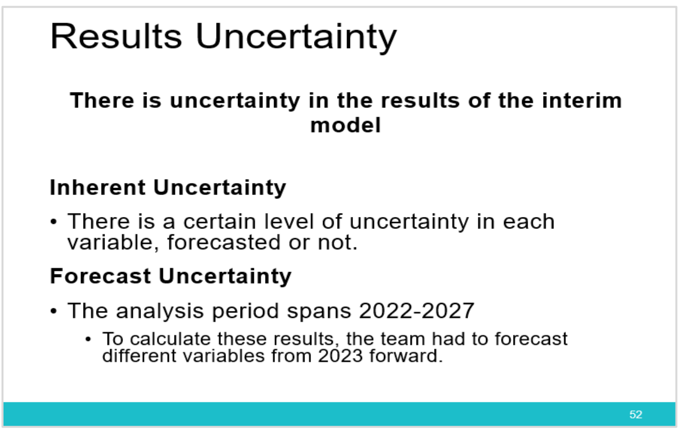


Nathan continued. For this one, the scale has changed. Even though the size of the chart is the same, we are showing less savings in commercial than we were showing in fans. It is about 4 average megawatts for fans in commercial than compared to the 10 that we were showing in industrial. About 1 average megawatts is programs and 2.8 is momentum. This is a similar distribution to industrial between program and momentum.

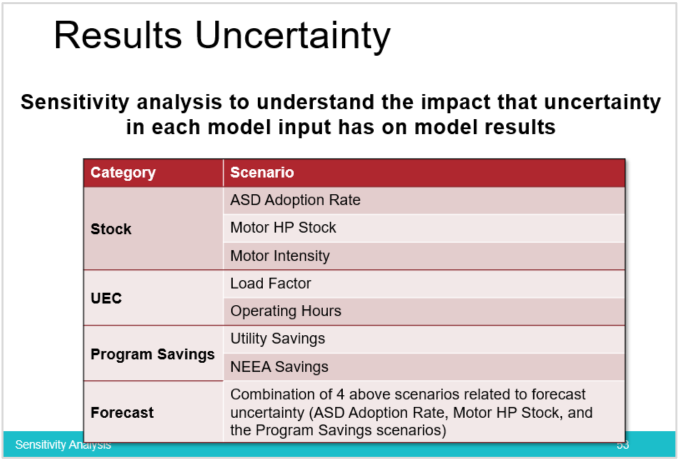


Nathan continued. For commercial pumps, we are not showing the big total market savings that we were showing in industrial. For commercial, we have a really similar total market savings value for commercial pumps as we do for commercial fans, about 4.3. And we have grayed out program savings and momentum savings. We still have these values in here, but in finalizing the results, we identified a couple trends that did not quite align with our expectation. There is a possibility that this distribution will change. In providing feedback on these charts, the goal would be to get feedback on the magnitude of savings that we are showing in commercial pumps as opposed to the distribution between program and momentum.

Uncertainty, Sensitivity, and Future Research



Nathan continued. The uncertainty with each model variable drove our sensitivity analysis and the findings from that sensitivity analysis are what informed where we are prioritizing our future research. In this section, we are going to talk through all three of them somewhat sequentially with the understanding that kind of they cascade into one another. To start off, we are going to review the two different types of uncertainty that we characterize in our model. The first is inherent uncertainty, which is uncertainty that exists in the data that we are using in the model. Even if it were 2028 and all our data was collected in the past, those data sources would have error bounds associated with them or uncertainty associated with those data sets. It exists in all data and is not necessarily bad. It is just something that you want to make sure that you are characterizing. Our goal is to decrease it as much as possible by using the best available data or using region-specific information. What we want to prioritize doing is understanding what it is, minimizing it, and characterizing its impact. The second is forecasted uncertainty, which is the uncertainty associated with the fact that we are four years out from the end of our model. That means that there are a lot of things that could change. Industries could grow and shrink; there could be economic issues. Four years from the end of our last market model, there is no way that we could have predicted COVID, which had a big impact on our model. Forecasted uncertainty is inherent in the forecast, the forecasting, and the results that we are using here. We want to accurately quantify what that uncertainty is. When we talk about future research, we are going to tie it back to whether those future research activities are aimed at addressing and decreasing inherent uncertainty or are focused on resolving that forecasted uncertainty around using forecasted data.



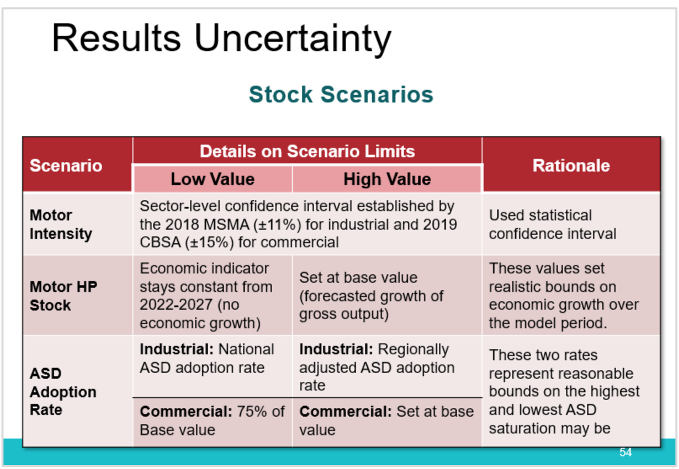
Results Uncertainty

Sensitivity analysis to understand the impact that uncertainty in each model input has on model results

Category	Scenario
Stock	ASD Adoption Rate
	Motor HP Stock
	Motor Intensity
UEC	Load Factor
	Operating Hours
Program Savings	Utility Savings
	NEEA Savings
Forecast	Combination of 4 above scenarios related to forecast uncertainty (ASD Adoption Rate, Motor HP Stock, and the Program Savings scenarios)

Sensitivity Analysis 53

Nathan continued. To understand uncertainty, we developed a sensitivity analysis and established high and low values on different variables that impacted energy consumption and savings. We developed eight scenarios covering the three main model inputs: stock, UEC and program savings. Then we developed a forecasted sensitivity scenario that combined all four scenarios that used forecasted variables: ASD saturation, ASD adoption rate, motor horsepower, and stock program savings. We looked at the compounding impact of the uncertainty in our forecast to understand a realistic range of what the highest and lowest that savings could be. For some of these, the data had statistical uncertainty associated with it. We established the bounds for the sensitivity analysis using those statistics. For others, we did not have it. For those, we established what we saw as a realistic bound based on our experience and judgement. The next couple of slides are broken up by category.



Results Uncertainty

Stock Scenarios

Scenario	Details on Scenario Limits: Low Value	Details on Scenario Limits: High Value	Rationale
Motor Intensity	Sector-level confidence interval established by the 2018 MSMA (±11%) for industrial and 2019 CBSA (±15%) for commercial		Used statistical confidence interval
Motor HP Stock	Economic indicator stays constant from 2022-2027 (no economic growth)	Set at base value (forecasted growth of gross output)	These values set realistic bounds on economic growth over the model period.
ASD Adoption Rate	**Industrial:** National ASD adoption rate	**Industrial:** Regionally adjusted ASD adoption rate	These two rates represent reasonable bounds on the highest and lowest ASD saturation may be
	Commercial: 75% of Base value	**Commercial:** Set at base value	

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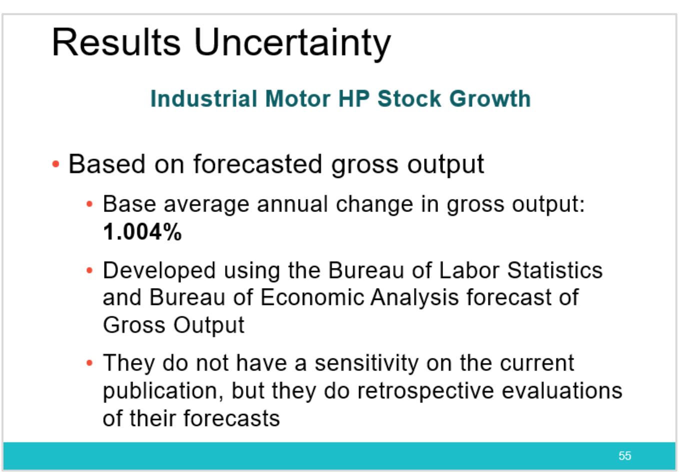
Nathan continued. For our three stock scenarios, we varied motor horsepower per gross output, or motor horsepower per commercial square foot, based on the confidence interval published in the data sources that we used. We used the motor systems market assessment (MSMA) for industrial, we used the 2019 CBSA for commercial, and we used the sector-level confidence interval that that was published for both of those. For ASD adoption rate, we vetted those values through the expert panel and received great feedback on how we are representing the uncertainty and the range of those bounds. The third one is motor horsepower stock. As a reminder, we have an economic driver that changes year over year and that gets multiplied by that static motor intensity to calculate motor horsepower in each year. The change in our forecast is driven by the forecasted economic indicator.



Results Uncertainty

Industrial Motor HP Stock Growth

- Based on forecasted gross output
  - Base average annual change in gross output: **1.004%**
  - Developed using the Bureau of Labor Statistics and Bureau of Economic Analysis forecast of Gross Output
  - They do not have a sensitivity on the current publication, but they do retrospective evaluations of their forecasts

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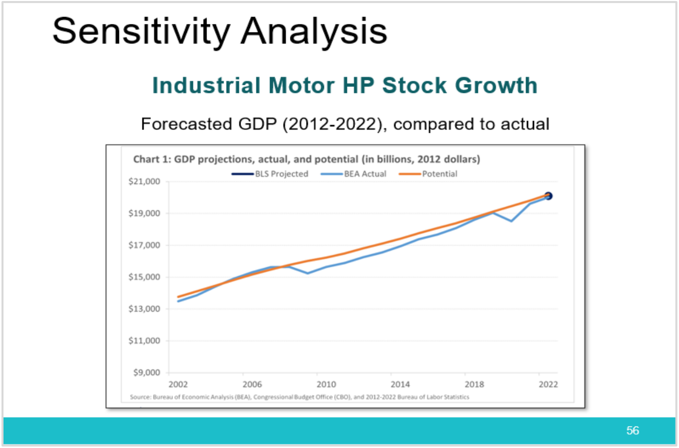
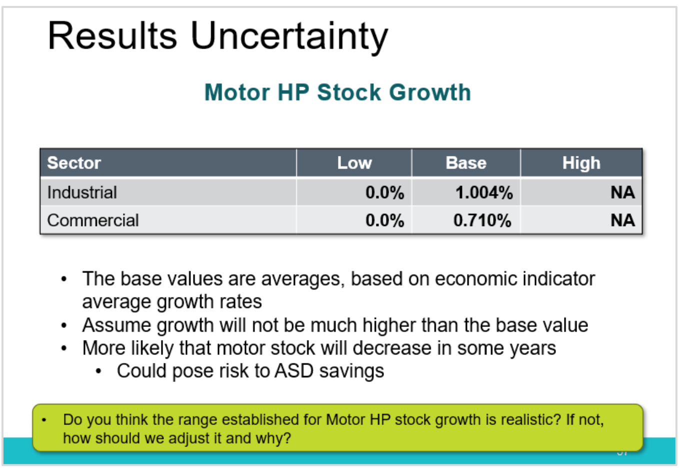
Nathan continued. For industrial motor horsepower, in the standard model (base case), the average annual change in gross output is 1.004 percent year over year. This was developed using information from the Bureau of Labor Statistics and the Bureau of Economic Analysis who forecast gross output, but they do not publish a sensitivity. They do not publish what their certainty associated with those values are, but they do retrospective evaluations on their forecast. So, they look back every 10 years to see how their forecast aligns with reality.



Nathan continued. We looked at the previous retrospective, and we are showing it in this chart. The orange line is forecasted potential, and the blue line is what actually happened. You can see between 2004 and 2008, it was a little bit higher than their forecast and then decreased. It creates a saw tooth pattern where it almost reaches the forecasted value and then drops a little bit and then does that again over the next 10 years. Our takeaway is that their average growth rate seems to be pretty accurate because that is where they end up over the long term, the average growth rate. **Prakash** asked if this is for the U.S. or just the Northwest. **Nathan** replied that this is for the U.S. We do not have this information at the state level.



Nathan continued. For our sensitivity analysis, we set the base value as those averages based on the economic indicator average growth rates. If we look at the base value and then the high scenario and low scenario, our base value is 1.004 percent for industrial and .seven percent for commercial. That .seven percent is from the growth in commercial square footage over the analysis. That is how we established the base. Looking at a high versus low scenario, we felt it was unrealistic to model a high scenario because, in those sawtooth patterns, it was pretty uncommon for that growth rate to be higher than that average line. It usually hit that line and then would sawtooth back down. So, we set the high value as equivalent to the base value. For the growth in our low scenario, what we wanted to model was either decreased or flat sector growth in each scenario. Because we saw some pretty big turmoil and decrease with COVID in 2020-2021, we thought that it was unrealistic to model it as decreasing motor horsepower stock. But we did want to understand what impact a constant motor horsepower growth would have on our energy consumption. The low case assumes that there is no commercial or industrial sector growth and that is held constant across the model. **Prakash** commented. The DOE has an annual energy outlook out to 2030, and you could look at their projection for electricity consumption. You can get machine drive energy consumption from the Manufacturing Energy Consumption Survey (MECS). And then maybe get a third data point to see if the electricity projection for machine drives aligns with a one percent per year growth rate or if it is different. That would be a direct energy projection comparison and might also give confidence in using GDP as the growth rate. **Nathan** added. Conversely, there is the Commercial Buildings Energy Consumption Survey (CBECS) we could look at for commercial.

Sensitivity Analysis

UEC Scenarios

Scenario	Details on Scenario Limits: Low Value	Details on Scenario Limits: High Value	Rationale
Operating Hours	**Industrial pumps/fans:** 90% confidence interval from NW Motor Database. **Commercial pumps:** NEEA Pumps Research.		Used statistical confidence interval
	Commercial fans: Doubled industrial fans' confidence interval for commercial fans		Less data for commercial fans
Load Factor	Cadeo-developed 90% confidence interval – calculated confidence in difference in means from BPA and CA IOU pump and fan load factor data.		Provides a measure of variability based on real-world operational data

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Nathan continued. For load factor, we developed 90 percent confidence intervals using the difference in means from our BPA and California pump and fan load factor data. In our UEC working session, we talked in detail about how we calculated our load factors. We have a lot more physical data that we are using to calculate load factors for this model. That allowed us to calculate a statistical confidence interval using those data as opposed to using estimates of what we would expect our uncertainty to be, which is what we did last time. For operating hours for industrial pumps and fans, we use the 90 percent confidence interval calculated from the Northwest Motor Database. That is the data set that we used to calculate industrial pump and fan energy consumption, which has hundreds of data points. For commercial pumps, NEEA conducted pumps research in 2019 that characterized operating hours and provided confidence interval. We used that value for commercial pumps and for commercial fans. We had a lot less data for commercial fans on operating hours. So, we doubled the 90 percent confidence interval that we calculated for industrial fans and applied it to commercial fan operating hours. That was a little bit driven by less statistics and more by wanting not to undercut the uncertainty associated with commercial fans. We also based it on an uncertainty value associated with fans.

Results Uncertainty

Program Scenarios

Scenario	Details on Scenario Limits: Low Value	Details on Scenario Limits: High Value	Rationale
Program Savings	41% more program HP	23% less program HP	Combined the high/low values of 4 different variables within program savings.
NEEA Savings	Same as Base	Assumes NEEA does not claim total market savings for commercial pumps in 2026/2027	NEEA's forecast for the base case is a best-case scenario; the high value represents lower NEEA savings.

Note: For program variables, low values result in less momentum savings, high values result in more momentum savings

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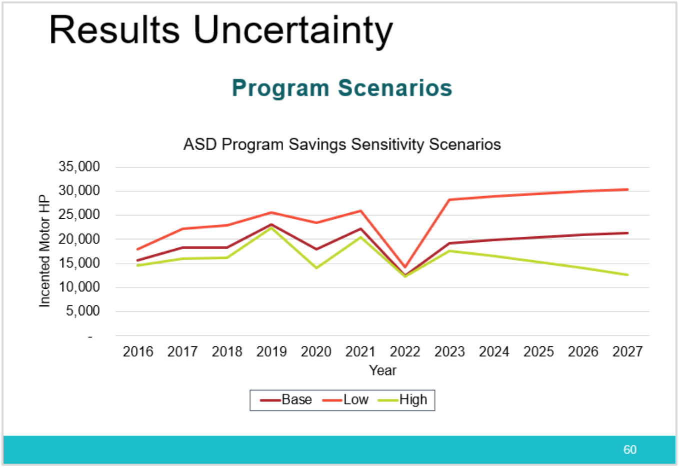
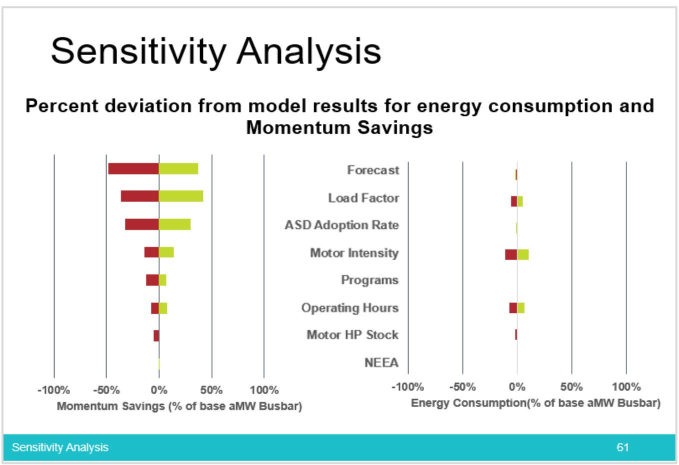
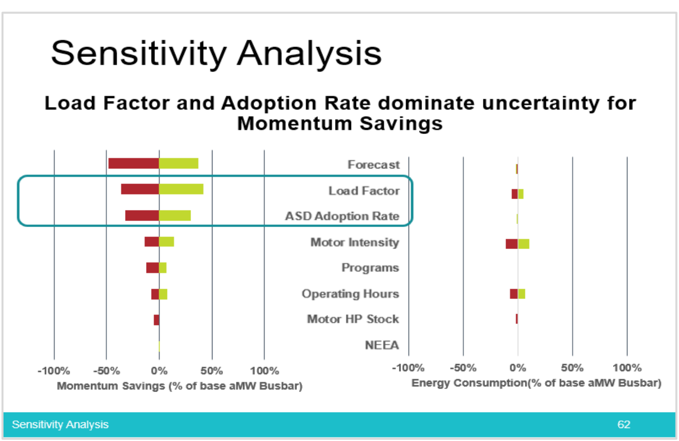
Nathan continued. The third category of sensitivity scenarios were for program savings, which had two different components. One is just our forecast of program savings. We made certain assumptions in our program savings workbook that were either more conservative or more liberal depending on the assumption that we made. We solicited expert input to land on a value for that component. In our high and low values, we varied to the highest possible and lowest possible value for that specific component. Those different variables are the percent of motors that fall in scope, the percent of programs that that we know have ASDs, and the projected growth of program savings.



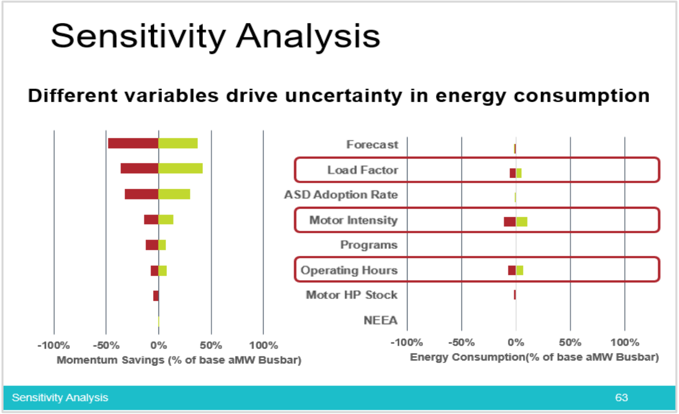
Nathan continued. This graph shows our ASD program savings sensitivity scenarios. Our base case is the red line; it is the number of motor horsepower incented in each. The green line is the high scenario representing high momentum savings. Our low scenario is the highest program savings. This is what we are projecting in terms of program savings in every year of our analysis. We get a pretty big range in those three values by the time we get out to 2027. That aligns with about 41 percent more program horsepower in our low scenario and 23 percent fewer program motor horsepower in our high momentum savings scenario. We established all those scenarios and then reran our model eight or nine times to understand the impact that the high and low values had on energy consumption and momentum savings.



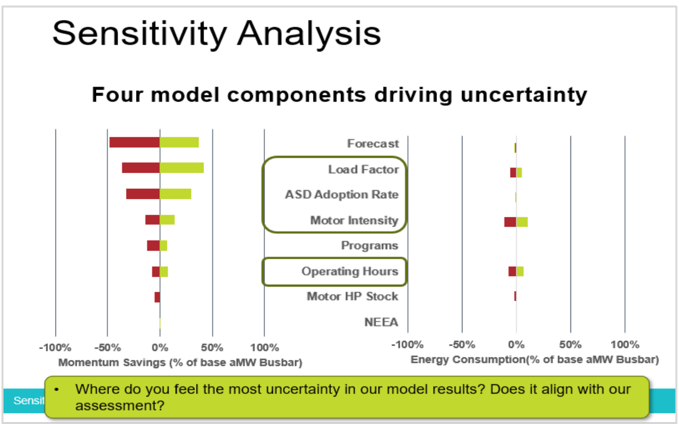
Nathan continued. Here are the results of our sensitivity analysis. The 0 percent line is the baseline energy consumption calculated using all our baseline values. Then we calculated the low scenario where we have low momentum savings and the high scenario where we have high momentum savings. This chart shows the percent deviation from that baseline value. At the top, we have the combined forecast scenario. We combined the variables that were forecasted to show the impact of the compounding uncertainty. Below the "Forecast" bar, we have each individual scenario. This chart highlights two different things. One, uncertainty has a much bigger impact on the results for momentum savings than it does on energy consumption. For the high and low values, even though the changes are the same, calculating momentum savings shows a much bigger difference than in calculating energy consumption. Two, the drivers of uncertainty for momentum savings are different than the drivers of uncertainty for energy consumption. The big drivers for momentum are load factor and ASD adoption rate, which align pretty well with what expected.



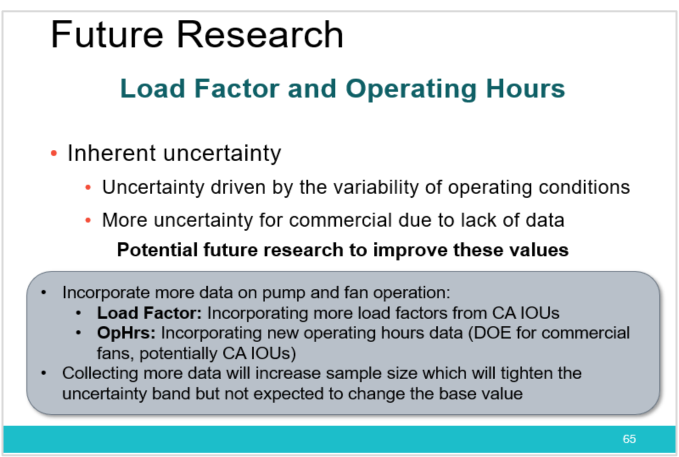
Nathan continued. Load factor is how effectively a pump or fan meets a specific load, and the adoption of ASDs directly impacts that load factor. Conversely, ASD adoption rate is essentially the number of new ASDs installed in the region. As we increase or decrease that, it has a direct impact on momentum savings. Those two are the biggest drivers for momentum savings, but load factor, motor intensity, and operating hours are the biggest drivers of uncertainty for energy consumption.



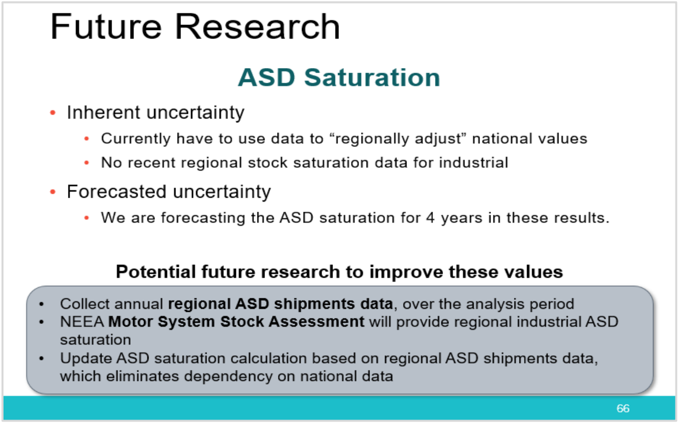
Nathan continued. Operating hours is a direct addition or subtraction to that calculation of kilowatt hours and motor intensity. As you increase or decrease motor intensity, you are directly increasing or decreasing the number of motor horsepower in the region, which is going to have a proportional impact on energy consumption.



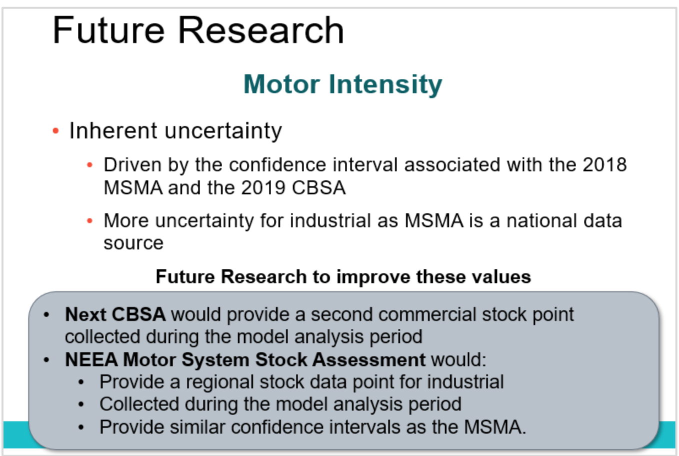
Nathan continued. We identified load factor, ASD adoption rate, motor intensity, and operating hours as the main components driving our uncertainty. We left “forecast” out because this is a combination of multiple individuals and sensitivity scenarios. Program savings does have an impact on momentum, but it is smaller than the three biggest variables and has little to no impact on energy consumption. **Dave** asked. One thing I noticed this year with program savings is that Energy Trust of Oregon dramatically increased their incentive rates. They are up to $0.45 per kWh, up to 90 percent of the eligible project cost. That has an extremely large effect on our programs for driving increase an in the number of projects. I do not think that would show up in your data and it might be something to look at. **Nathan** said that it is a great flag. That would not show up in our forecast. That is something for us to keep our eye on.



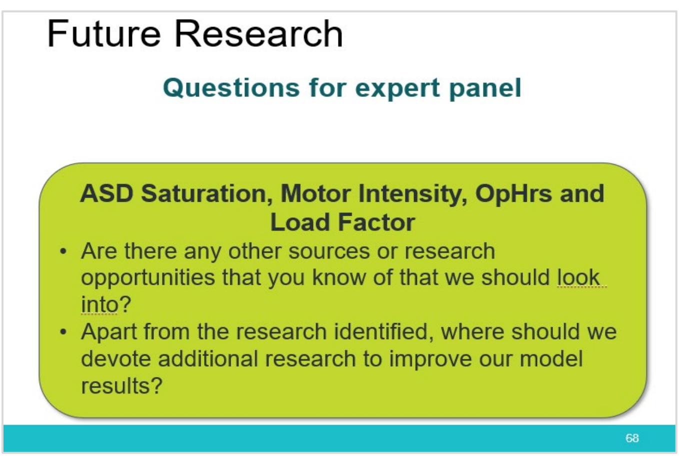
Nathan continued. Our future research is focused on four areas of uncertainty. The first is load factor and operating hours. We group these together because the data sources and research that we would do is similar for both. The uncertainty that exists for these two is inherent uncertainty. No matter what, we are going to have uncertainty in these values. We have more uncertainty in commercial versus industrial simply due to a lack of data. What we want to do is prioritize potential future research to increase the amount of information that we have in forming load factor and operating hours. We may incorporate more load factors from the California IOU data set. For operating hours, the DOE has a new energy conservation standard that will have information on fan operating hours. There is also the potential to include California IOU data to calculate operating hours. Collecting more data will increase our sample size, which will allow us to tighten that range of uncertainty.



Nathan continued. We do not expect it to have a huge impact or change in our base values for ASD saturation. There is both inherent and forecasted uncertainty associated with this data point. We have forecasted uncertainty because we are forecasting ASD saturation four years into the future. For our inherent uncertainty, we are using data that we are regionally adjusting, and we do not have a recent regional stock data point for industrial. So, BPA is prioritizing two research tasks to improve these values. The first is collecting annual regional ASD shipment data. This year, the BPA will start reaching out to distributors to collect information on the number of ASDs that they are selling in the Northwest. The second is a motor system stock assessment. NEEA is planning to implement one of these in their next business plan, which will provide a regional industrial ASD saturation value that we can use as a starting place specific to the Pacific Northwest to understand ASD saturation. This also allows us to decrease our dependency on national and for-purchase market data that is not region specific.

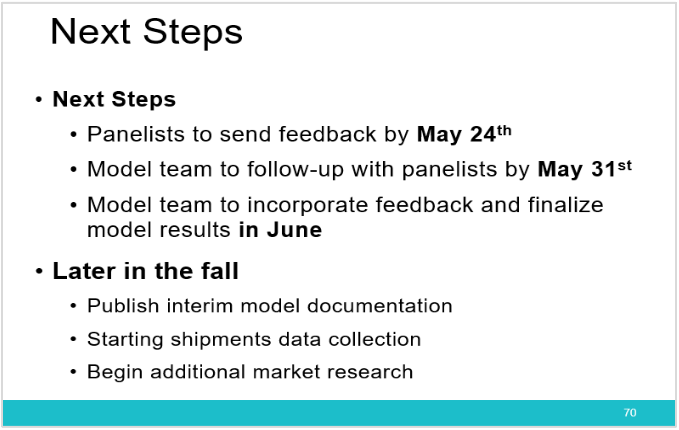


Nathan continued. There is inherent uncertainty in motor intensity. We are using either the CBSA or MSMA to calculate motor intensity. By the time we get to the end of this analysis, we will be almost 10 years away from those data points. Our future research will focus on the commercial sector ensuring that the CBSA includes the same level of commercial motor stock characterization as it did in 2019. For the industrial sector, the MSMA would provide a regional stock data point for industrial and would be collected during our model analysis. It would also provide a way for us to calculate confidence intervals similar to how the MSMA calculates confidence intervals.



Nathan continued. These are the last questions for the panel. Are there any other sources of data or research opportunities that you guys know of that we should either look into or potentially look at developing as a good resource for our market model? And where should we develop additional research to improve our model results?

Wrap Up and Next Steps



Tyler discussed the next steps.

Working Session: ASD Shipments Data Collection Kickoff – Jan. 16, 2025

ACTION ITEM – This highlights an action item for a panelist.

ACTION ITEM – This highlights an action item for BPA and/or Cadeo.

Attendees

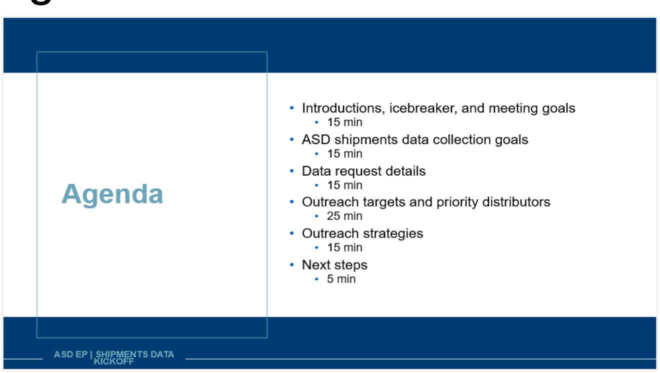
BPA: Joan Wang

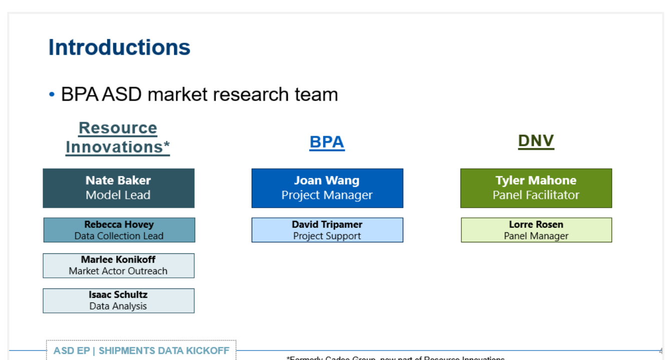
DNV: Tyler Mahone, Lorre Rosen

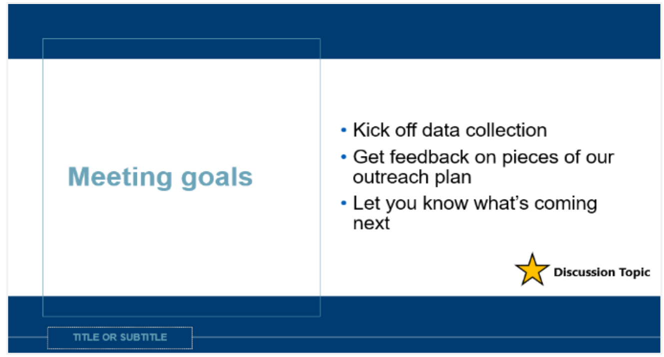
Cadeo: Nathan Baker, Rebecca Hovey

Invited Panelists	Affiliation	Attended	Did Not Attend
Rob Boteler	Independent	☒	☐
Pete Gaydon	Hydraulic Institute	☒	☐
Kenneth Kuntz	Greenheck	☒	☐
Paul Lemar	Resource Dynamics	☐	☒
Dave Morris	RHT Energy	☒	☐
Prakash Rao	Independent	☒	☐
Todd Amundson	BPA	☒	☐
Ryan Firestone	RTF	☒	☐
Kevin Smit	Council	☐	☒
Evan Hatteberg	NEEA	☒	☐
Nicole Dunbar	NEEA	☐	☒
Kristen Aramthanapon	NEEA	☒	☐

Agenda and Introductions

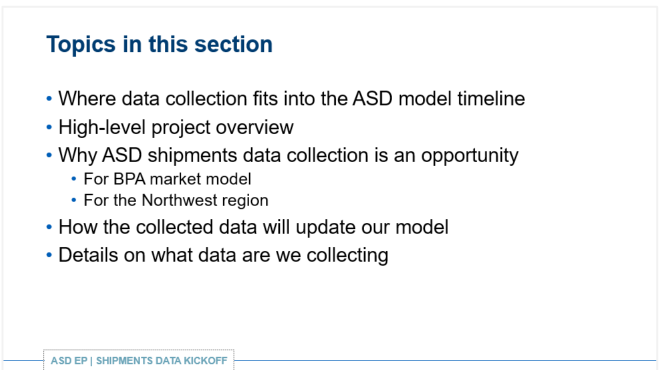


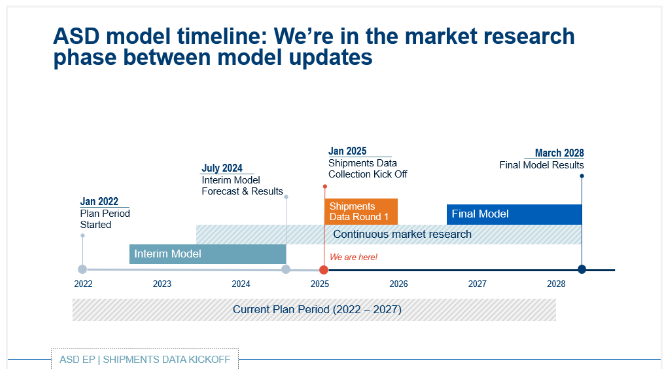


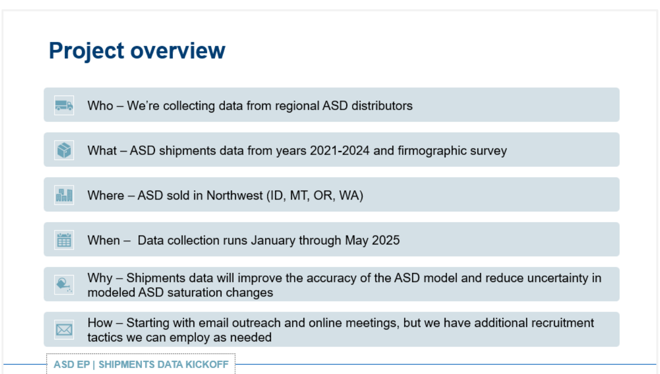


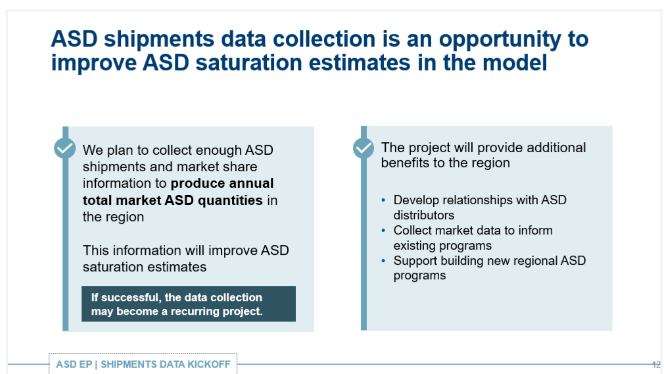
Tyler went over the agenda for today's expert panel, introduced the team, and reviewed meeting goals.

Goals of Data Collection





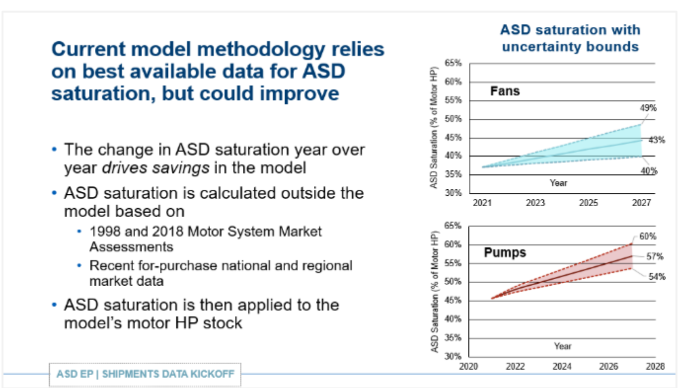




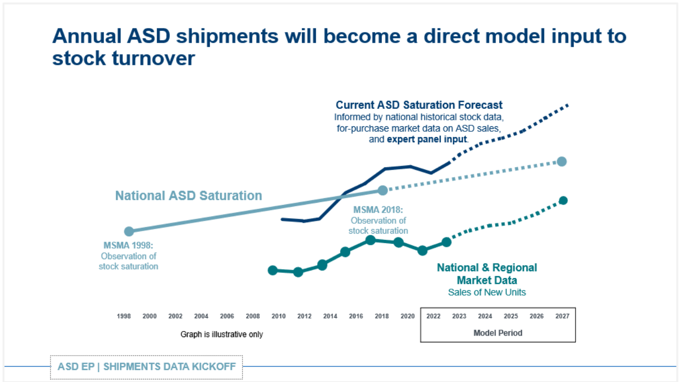
Joan reviewed the goals of data collection and provided a high-level overview of the new data collection project and provided background context. This data collection will be of value both for our market modeling research, the broader Northwest region, and maybe even beyond the region. Our collected data will also help improve our existing ASD model. In June 2024, we wrapped up our interim model where we tried to forecast the ASD landscape in the region specifically for commercial and industrial pumps and fans for 2022-2027. We will finalize the model in late 2027. From now until 2027, we are doing continuous market research for prioritized pieces of research that we think are valuable to improve the final model. One of those things is collecting ASD shipments data in the region. I think we are the only ones in the Northwest region trying to collect annual drive shipment data from regional distributors. We did a pilot effort a year ago to talk to regional distributors to see if they have the kind of data that we are seeking in terms of granularity, if that data is readily available, etc. We received positive feedback from this group of market actors. Now, we are launching a full-scale effort. We also considered other types of market actors where we could collect drive shipment data from, one of which is drive manufacturers. One difficulty of that is pinpointing the location that the drives are sold to if we go straight to the manufacturers. Another, more detailed route is going to the installers. That would prove to be significantly more burdensome given the much larger population. We think that targeting regional drive distributors is a good way to get the needed data within a reasonable scope. We are trying to collect annual shipments data from 2021-2024. We are also collecting data from a survey where we are asking market actors to tell us what they estimate is the portion of their shipments out of the total drive market in the region. That market coverage estimate is really important. We will be collecting this data for several months as it takes time to get to the right market actor, the right contact, build relationships, and work with them on this complex data request. By late spring, we will start analyzing the data and come back to this expert panel to propose how we are analyzing the data.

Prakash asked. I want to confirm the sectors you are interested in. Is it manufacturing? **Joan** replied. Yes. We are trying to cover commercial and industrial pumps and fans. That includes manufacturing and commercial. We have also done a little prep work to make sure this sampling or outreach target segment is by sector and equipment type. We feel pretty good about that because when talking to drive distributors, it seems like that is how they are organized. If we ask them if they sell drives that eventually go into manufacturing or industrial or commercial pumps and fans, they can give us a clear answer.

Joan continued. So, how are these drive shipments data going to help improve our ASD saturation estimates? We acknowledge that we are not going to get all regional drive distributors to give us their shipments data. We know that whatever data we collect is going to only cover a portion of the market. Given that fact, we are also trying to collect from those that participate in this effort what they think is their firm's share of the market and so that we can marry the data that they give us and the details of that data with their market share estimates. That way, we can compare everything that they can give us to get an estimate of the total market drive quantities in the region that we feel confident in. If this project is successful and if there is appetite from those group of market actors, we are planning to make this a recurring project. Then we can start building a trend line to see how this estimate changes over time. Another important benefit to this project is getting an opportunity to build direct relationships with these distributors. We will be partnering the Northwest Energy Efficiency Alliance (NEEA) on this effort. The goal is for the data that we collect to also give real-time market intelligence to our existing regional utility programs.

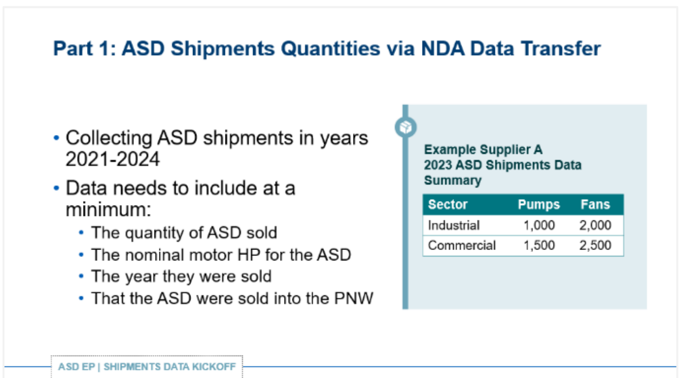


Joan continued. The charts on the right show the forecast of ASD saturation we produced from the interim model and reviewed with you in the middle of 2024. The lines in the middle show our best estimate of the ASD saturation forecast. We have uncertainty bound around the middle lines. We vetted these lines with you and asked for your feedback to make sure this is realistic and to see if there is any additional data we could collect to update and improve the model. The hope is that with more region-specific and real-time data that the uncertainty bound that we are showing around these lines start getting smaller and smaller. With this new data collection effort, we are trying to replace using this combination of best available data with an even better data source that is more regional specific, more real time and hopefully more accurate.

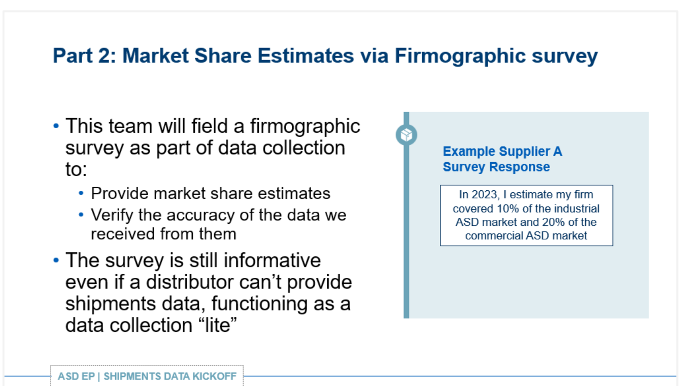


Joan continued. This shows a combination of several different data sources combined with panel input. The input to the model has been that drive saturation, the percent of the motor stock that has a drive. If we can get good annual total estimates of drive shipments data, then those quantities will become the direct model input. Then, the model will be able to produce updated drive saturations.

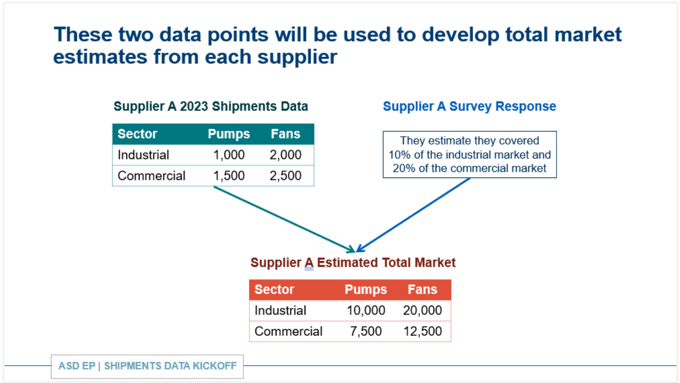
Data Request



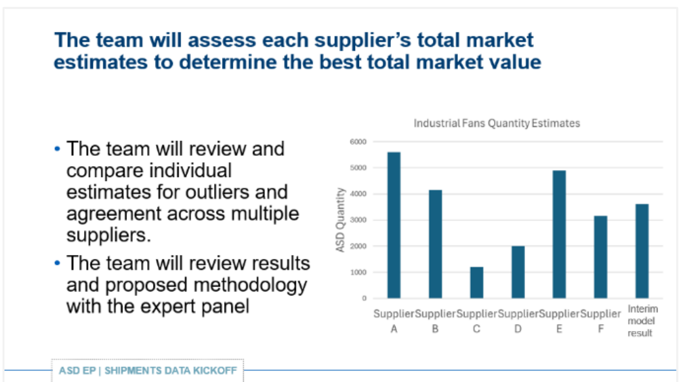
Rebecca discussed the details of the data requests. There are two key pieces of information that we are collecting through this data collection effort. The first one is the actual ASD shipments quantities. This might be an Excel data file with the quantities of ASDs and their associated characteristics. We are showing a very simplified table of what we might get from each participating distributor or supplier. We have the minimum requirements that we need to get from each participant in order for the data to be useful. We will also ask additional questions about any segment relevant to our model such as facility type and sector. We are planning to ask each participant to supply data from 2021-2024. Because this is sensitive information, we plan to set up a non-disclosure agreement (NDA) with every participant to assure them of our data handling practices. In addition to the shipments data, we will also ask each participant to provide written responses to other questions (e.g., how many ASD do you sell annually, what percent of your ASD shipments are in each sector and equipment type, or what percent of the total Northwest ASD market do you cover).



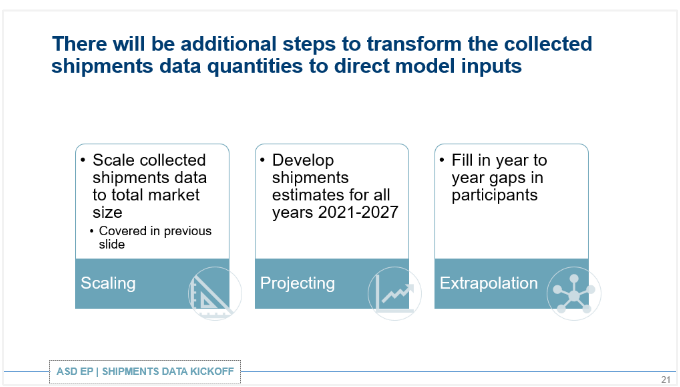
Rebecca continued. This information will help us get to that total market estimate. But it is also a key quality control (QC) effort because someone might export files from their internal tracking system and then not realize that they missed an entire sector or an entire state. When we have that written response, we can run a check against the data provided. It will be easier for us to catch some quality issues earlier in the process. The written survey can also help us with some regional specific distributions by sector and equipment type. The survey provides a way for us to get that information if they do not track it specifically with the line items in their shipments data. The survey is a key piece of our data collection effort, and it would still be useful to get someone to give us a survey response even if they could not provide the detailed data set.



Rebecca continued. This is an example of how these two pieces of information could work together to get us a total market estimate. We have an individual distributor's shipments information that we get from them directly and we have their survey response on how much they estimate their market share is. For industrial fans, supplier A has 2,000 ASD shipments per year, and they also estimate that they cover 10 percent of the industrial market. We could take those two data points together to show that they estimate the total market in the Northwest is 20,000 industrial ASD going to fans. When we have collected all that information, we will compare each person's total market estimate against each other to parse out some trends or agreement between them and use that as our final estimate.



Rebecca provided another example using fake data. Once we have the total market estimates based on individual information, we can compare across each other and compare to the information we already have, primarily our interim model result for sales each year. In this example, there is not really clear agreement. Ideally everyone's estimate would be around the same point and corroborate our previous model results. But we anticipate that there will be some outliers, and we may need to take an average with our final market total market value. We will have to wait and see what data we get and then make decisions based on the quality of data. We plan to circle back with the expert panel on our proposed approach for getting to the total market value.



Rebecca continued. We know there are a couple other transformations we will need to make to the raw collected data before getting the final input into our model. We know that scaling will be tricky. We are proactively collecting information to help us do this piece of the data transformation. But we will also need to do some projections. Our market model runs through 2027, which is in the future, so we have to project the shipments into the future years based on external data sources. But over time, if this is a successful annual effort, we will gather enough information that we can probably create a projection based on our own collected data set. The next step is using extrapolation. Even though we are requesting four years of data, some distributors might give us only two years. And then in an annual effort, some people might participate in some years and not others. We have an extrapolation process to fill in the gaps in individual distributors' data between year to year, which is something we do on other data collection efforts.

Rob asked. We are only surveying ASDs that are sold as ASDs. So, if I am a distributor and I build a pump skid with a motor, a control, and a pump, that is not reported in this survey? **Rebecca** replied. We have detailed notes when you are filling out the survey that an ASD is anything that can vary the motor speed. So, a smart pump counts as an ASD. We are not collecting pumps specifically, but an electronically commutated motor (ECM) counts as an ASD and should be included. A standalone drive is an ASD and should also be included. If you had a packaged pump and drive and motor together, that would also count as an ASD. We are asking them to provide that information.

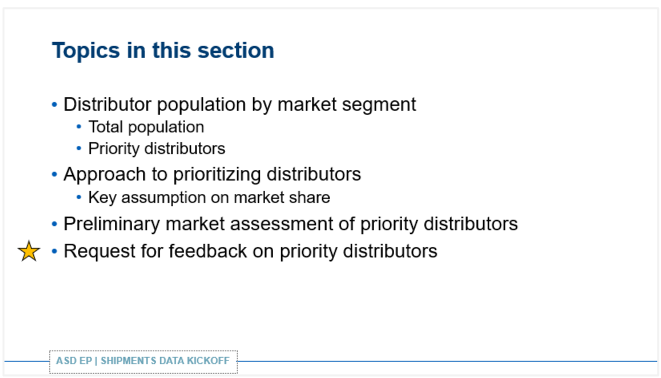
Rob added. And it remains the industrial and commercial market, now that we added the commercial. One assumption I see with this is that your distributor class has a lot of information available. With the Electrical Apparatus Service Association (EASA) members, some of them are very small and they may not have significant resources. It is not a matter of them not wanting to provide the information. I think we are going to have to figure out ways for them to dig through files and historic information efficiently. I am not sure that it is going to be easy for them to do. **Rebecca** replied. We did try this with a few people last year to get a sense for what kind of data exports regional distributors would be able to provide. The people we talked to indicated that they would be able to give us exports for this level of detail. Everyone's systems are going to be different. While I hope they will use our template exactly, I am sure everyone's formats will be a bit different. They will need some cleaning, and we might need to work more closely with some people to get what we need, and account for how long that request is going to take.

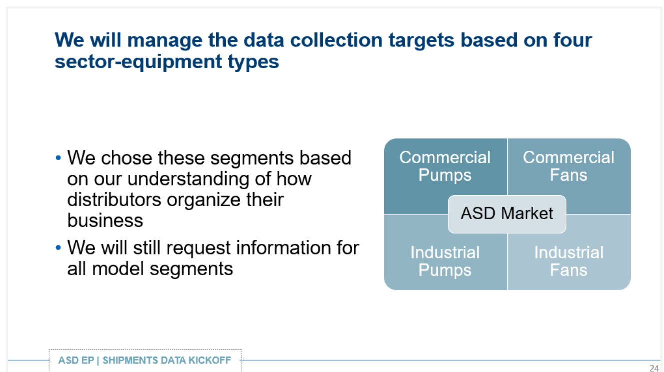
Rob asked. Have you already had a conversation with the 11 members of the list and are they willing to participate? **Rebecca** replied. Not all 11, we reached out to six of them last year. For some people, we had a warm lead. But some were just identified, and we are starting from scratch on those relationships. **Rob** added. The other thing that struck me is that only one of the organizations on that list is an EASA member. There are 40 EASA shops in the Pacific Northwest. A year or two ago, Nate and I talked to Paul Rossiter, the president of EASA, about this project and got some information about the work his company does in the Pacific Northwest. EASA would certainly be interested to review this with us at some point and offer support on the best way to reach additional members. **Rebecca** replied. We looked at their Pacific Northwest participants and considered them for our population that we are contacting. But they might not have made it on to our top ten list based on the criteria for who we are targeting. EASA is on our list, and we are considering them as an opportunity to pitch our data collection effort to them. We might follow up with Rob afterwards if we want to talk Paul Rossiter directly.

Ken asked. It appears your model assumes that most ASDs are coming through distributors. I wonder if there was any consideration or concern for ASDs that may be coming through original equipment manufacturers (OEMs) or other channels that did not go through a distributor. **Rebecca** replied. We thought about the Graingers of the world. Through our preliminary outreach, we are expecting that they will be harder to get in touch with and get the data specifically for this region. But they are still on our list of someone that we will reach out to. **Nate** added. I can speak to the portion of the market that goes through pump or fan OEMs. We have done some market mapping on different channels of how ASDs get into the market. We actually did some research a couple years ago to try and collect data on ASDs through pump and fan manufacturers. We learned that it is a very small number. It is a single digit percentage of the ASDs that are making it into the market are flowing through those equipment manufacturers, at least at the size that we are looking at which is above 1 horsepower.

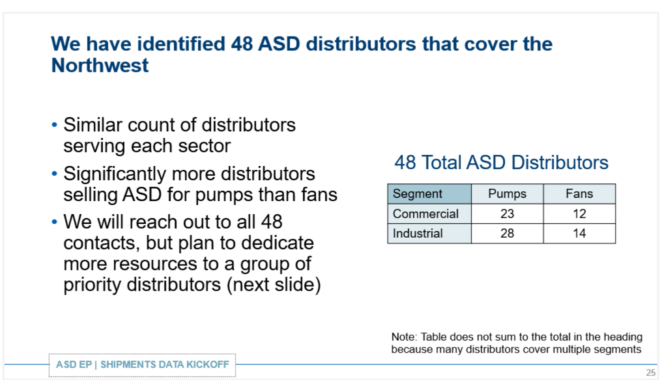
Prakash asked. What is the incentive for the distributor to fill this out? Are you targeting specific people? **Rebecca** replied. Yes, we are offering an incentive. We have $1,000 monetary incentive for the person providing us the data to thank them for their time. We are also planning to provide a custom market report that shows their place compared to the anonymous total group to provide market insights. Money is great, but that sort of market information might be more valuable as an incentive in the long run. **Joan** added. We think that our partnership with Kristen at NEEA on this outreach will also help a lot. Part of the incentive is giving the distributor an opportunity to be at the forefront of potentially driving towards future programmatic incentives or opportunities. Having that seat at the table and being able to have direct conversations with regional programs is something they might care more about, maybe even more than the data stipend. The data stipend is important though because this is our first round of data collection and we are asking for not only the previous year's data, but also some historical years. It can be tricky to figure out and the stipend makes sense in terms of thanking them for their time. Our assumption is that we need to have an actual conversation with each distributor to understand how we can make this as easy as possible for them. **Nate** added. Based on our preliminary outreach, we have found that there are some specific titles that we are aiming to talk to. What we want is somebody who sees the value in participating in a program like this, somebody who can drive this forward and champion it at an organization. Because at most organizations, even the small ones, it is going to take at least one or two people to be involved to say yes to getting that data. **Prakash** added. It is also important to find someone who has been there for a while too, someone with institutional knowledge. **Nate** added. That is very important for those firmographic questions. We want somebody who has knowledge of that company's shipments over the course of multiple years and context of the market that they operate in.

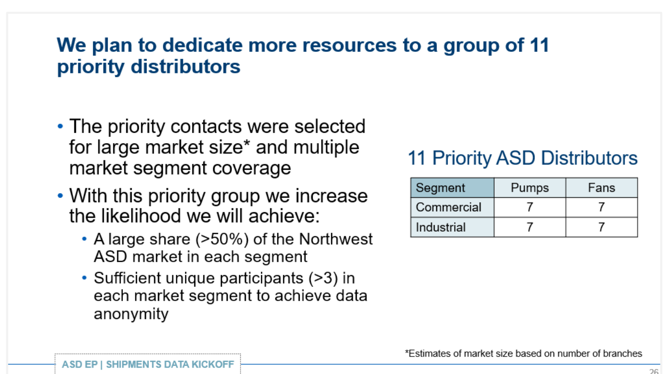
Outreach Targets and Priority Distributors





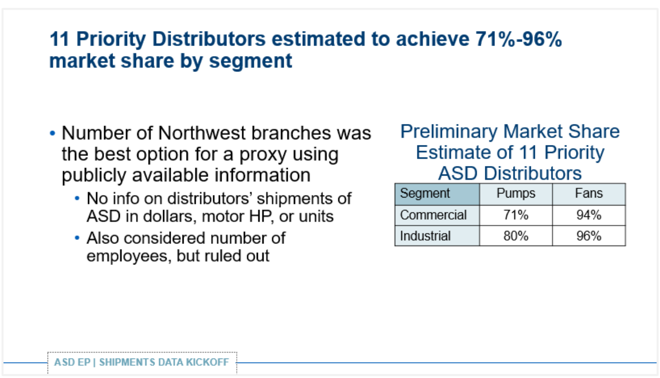
Rebecca continued. When we think about our market of the ASD's sold in the Northwest, we want to subdivide it to help us manage our data collection effort. We thought about it from the perspective of segments of our market model, which includes sector equipment type, state, motor, horsepower, bin, and facility type. Based on our preliminary outreach, we decided to organize it into four sector equipment types as our four main market segments. We still plan to request information on every model segment, such as facility type, sold to location, motor horsepower bin, etc., but that is not how we are directing our outreach effort.



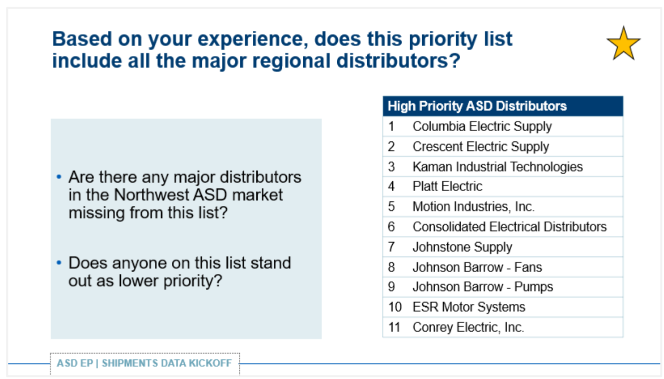


Rebecca continued. We have a list of 48 ASD distributors that are selling drives into the Northwest. This table is a summary of the coverage by those four segments and values are a unique count of ASD distributors. It does not add up to 48 because a lot of the distributors will cover more than one segment. We used some online sources of industry trade associations like the EASA trade group to identify ASD distributors in the Northwest. Then we looked at ASD manufacturers' websites to find additional distributors. Overall, we found that there was a similar number of distributors for each sector. But we also found that there are roughly twice as many people distributing ASDs for pumps than for fans. Forty-eight is a lot and we have a finite amount of resources, so we created a group of priority distributors so we can spend more time and effort on the people that are the most important for our data collection goals. What we are trying to achieve in this data collection effort is to have a large market share—more than half of the market of ASDs in the Northwest for each segment. We also need to meet some data anonymity requirements. We want to make sure we have at least three unique participants in each segment so that we can share the aggregated data. The reason we picked the priority contacts is for these two reasons: 1) we want someone that has a large market size and 2) they cover multiple segments. We have selected seven contacts per segment, which made it onto a total list of 11.

We wanted to pick people that had a large market share, but we do not have market share by distributor. We could not find that in the publicly available information. We have estimates of total drives to the region by our market segments, but we do not have them by distributor. In the meantime, we used a proxy to help us develop this preliminary list of priority people. We used branches in the Northwest for that distributor's business as the proxy for how large their business was. We also considered the number of employees.

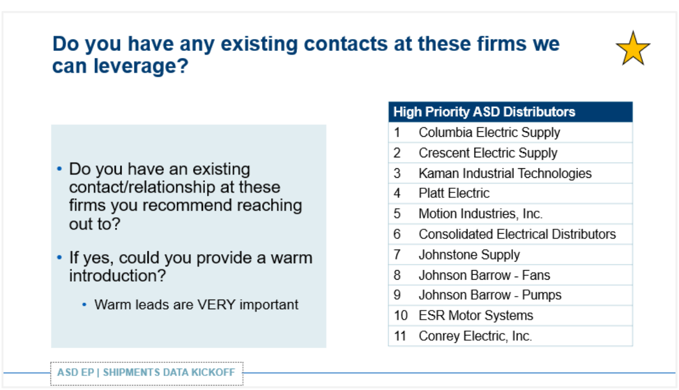


Segment	Pumps	Fans
Commercial	71%	94%
Industrial	80%	96%



High Priority ASD Distributors	
1	Columbia Electric Supply
2	Crescent Electric Supply
3	Kaman Industrial Technologies
4	Platt Electric
5	Motion Industries, Inc.
6	Consolidated Electrical Distributors
7	Johnstone Supply
8	Johnson Barrow - Fans
9	Johnson Barrow - Pumps
10	ESR Motor Systems
11	Conrey Electric, Inc.

Rebecca continued. Using the Northwest branches, we estimate that we can achieve between 71 to 96 percent of the market for each segment, but that feels high. We acknowledge that using branches like this is an imperfect proxy for market share, but it is a starting place. We plan to refine the estimates of market share once we start getting the data from distributors; market share is a key question in our firmographic survey. We also ask them for distributor recommendations.



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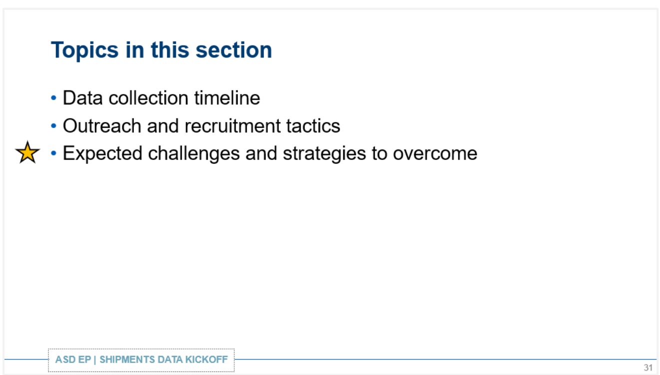
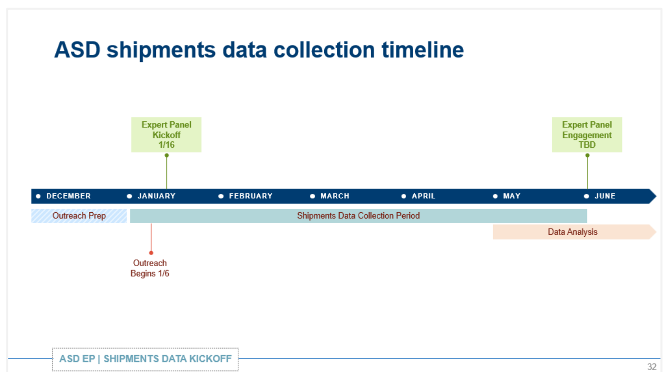
Rebecca continued. This is the list of 11 priority distributors we have created that we think have a large market share and cover multiple segments, but we want to get feedback from the panel. Does this list include all the major distributors? Is there anyone that you think is missing from this list based on your experience with the Northwest market or someone on this list that seems out of place and should not be given such a high priority? **Rob** said. Going through this list with Paul at EASA will be a good idea. **Kristen** asked. Are you saying that these are the 11 and they all have different branches, so it is more like 50 different groups? Looking at Johnson Barrow, they are split up into different groups. They have their fans and the pump sections, but I think they have a general drives section as well. **Rebecca** added. This is how we tracked it when we developed the list. Johnson and Barrow was split into fans and pumps. Maybe that makes more sense to just think of them as one organization once we have reached out to someone. But if there is one person that would be the right person to talk to for drive shipments to fans versus pumps, we would be thinking about it that way. They do have multiple branches and that's why we picked them. This is just our starting place, but especially with this priority group, we want to push for a meeting to understand their business, what information they can give us in what format, or even if we are talking to the right person. For example, we know we want to talk to Columbia, but once we get in that meeting, we might learn that they have four regional branches, and we need data from four different places. We will learn more about how their business is organized during that initial meeting.

Todd added (in the chat window). Apsco, Beckwith and Kuffel, Northwest Pumps, Xylem Pumps, HD Fowler, Olympus Controls Corp, Arrow Speed Controls and Automation, Applied Industrial Technologies, even Grainger come to mind. **Joan** asked if Todd could describe the group that he listed and where and how would be the best way to contact them? **Todd** replied. I can reach out to program implementers and get contact information for the companies listed. I have seen custom project completion reports with them as distributors of variable frequency drives (VFDs) for pump and fan projects. I can follow up with you on that.

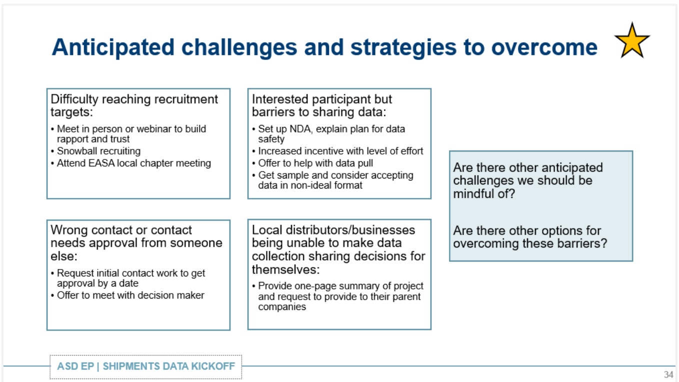
Joan added. These data collection projects are hard. Our team has worked on several of these data collection projects with NEEA over time and we have slowly built up relationships. It is not going to happen overnight. It took us more than five years to get from maybe 20 percent of the HVAC market to close to 80 percent of the market. Trying to get this off the ground in the very first attempt, warm leads or at least an email address to a real person would be so helpful.

Outreach Strategies





Rebecca continued. Looking at our data collection effort, we are actually planning to recruit people and collect data from participants over the next five or six months. Today is our kickoff with the expert panel and we have already started outreach to some distributors. But there is definitely time to pivot and work with more specific contacts if you have them. We have a couple different approaches and phases to our collection efforts over the next six months. Then we will start assessing the data and creating summaries starting in May. We will likely want to meet with the panel again to discuss our proposed approach to the data transformations and get your feedback on the data analysis. We have the priority distributor targets we reviewed in the last section. We want to partner with NEEA in our outreach materials and in our meetings to show a united, regional front. This will also show that multiple organizations are interested in this information and there is value in this effort for all of us. Tactics 3 and 4 are both about periodic assessments to check data quality and that our overall approach is working. We will consider whether we need to make any adjustments to do something different with recruitment or push for in-person meetings. And we already talked about the monetary incentive and the customized report. **Rob** said. Within the Northwest service area, there are a number of utilities that have energy programs. Have you reached out to them and asked if they would share distributor contacts with you. For example, Excel Energy has a very active program. **Rebecca** replied. Yes, we are definitely planning to leverage BPA's contacts, but that is a good idea.



Rebecca continued. Here are some of those anticipated challenges that we are expecting and how we are currently thinking about ways to overcome those challenges. Are there other challenges that we should be mindful of? If you have other tactics like Rob just had for overcoming these barriers, we welcome that feedback. **Rob** added that the EASA convention is in Nashville on July 20 this year. If you want to meet dozens of motor and drive manufacturers, that is the place to be. **Prakash** said that there is a motors and drive conference in Tallahassee in February.

Next Steps