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HEAT PUMP WATER HEATERS IN EVERY HOME? FORECASTING THE COSTS AND EMISSIONS IMPACTS AND LONG-TERM RESOURCE PLANNING IMPACTS

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IEPEC

Slide 1

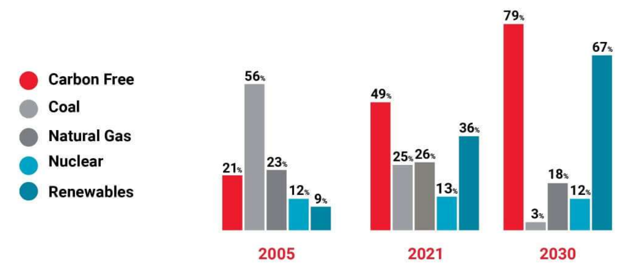
KR0 Was Ashly a co-author? She might appreciate having her name on here too.
Kasman, Robert, 2022-10-26T22:25:05.225

Introduction – Traditional DSM at a Crossroads

The changing landscape

Source: Guidehouse analysis 2022

KR0



2022 Xcel Energy Colorado DSM Potential Study, Residential Lighting; 2021 Xcel Energy Sustainability Report

Slide 2

KR0 I know the Guidehouse graphic is not part of your paper, but it doesn't ring true to me. We'll be at 88% efficiency saturation in 2 years?

Kasman, Robert, 2022-10-26T22:17:56.770

BBT0 0 I definitely agree there's room to disagree on the actual saturation levels here, but don't really want to focus on specific details, rather I'm really just trying to convey in our service territories we're seeing a plateauing and even declines in EE achievement (and forecast further declines). Our most recent Potential study is saying that many of our highest achieving end-uses (e.g., Res Lighting) are getting closer and closer to saturation. It would be nice if I had another similar graphic readily available that maybe showed the portfolio trends, but this what I have.

Boyle, Byron T, 2022-10-27T20:51:10.240

Introduction – DSM and Beneficial Electrification

Key Topics

Beneficial electrification[1] is coming, are we ready (and do we understand the impacts)?

This study aims to understand the BE impacts from residential HPWH including:

- Utility Cost-to-Serve versus Retail Rate
- Carbon Emissions
- Customer Costs
- Resource Planning Impacts

[1]The use of term "beneficial electrification" in this presentation refers to natural gas to electric fuel switching that should reduce costs, emissions, and improve the efficiency of the electric grid.

Slide 3

KR0 I always struggle with this term. Would be better to say "electrification" and leave off beneficial, IMO. That's what your research is trying to find out. When/where/for who are the benefits.
Kasman, Robert, 2022-10-26T22:20:57.856

BBT0 0 Adding the footnote addresses this to certain extent.
Boyle, Byron T, 2022-10-28T05:22:41.477

KR1 to...
Kasman, Robert, 2022-10-26T22:38:24.388

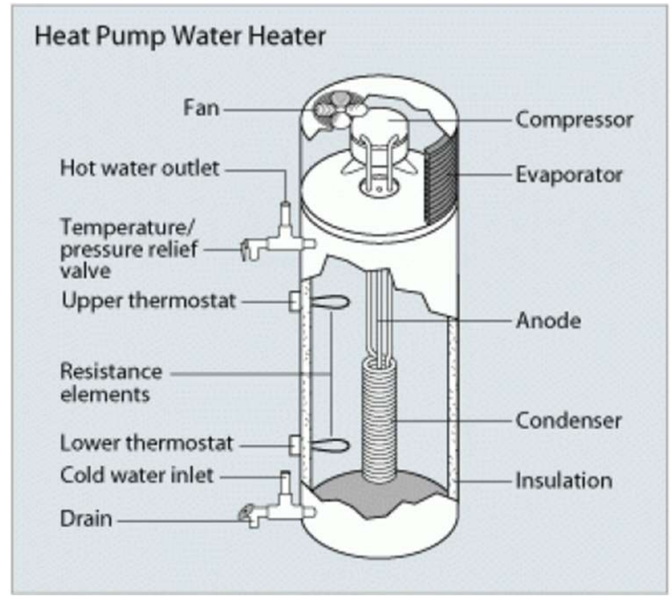
KR2 I see you define the term BE in your notes. I would suggest putting that on the slide as a footnote.
Kasman, Robert, 2022-10-26T22:42:35.549

KR0

Methodology – Water Heating Assumptions

Lots of Scenarios to Consider

<table>
<tr><th>Technology Type</th><th>Water Heater Location</th><th>Control Strategy</th><th>Tank Size (gallon)</th><th>Energy Factor</th></tr>
<tr><td>Natural Gas
Federal Min. Efficiency</td><td>N/A</td><td>None</td><td>66</td><td>0.60</td></tr>
<tr><td>Electric Resistance</td><td>N/A</td><td>None</td><td>66</td><td>0.95</td></tr>
<tr><td rowspan="3">Electric Heat Pump</td><td>Unconditioned</td><td rowspan="3">None</td><td rowspan="3">66</td><td rowspan="3">3.50</td></tr>
<tr><td>Conditioned; electric heat</td></tr>
<tr><td>Conditioned; natural gas heat</td></tr>
<tr><td>Electric Heat Pump</td><td>Conditioned; electric heat</td><td>Load shifting</td><td>66</td><td>3.50</td></tr>
</table>



Assumptions
13-year water heater lifetime
3-bedroom, single-family home in CO/MN
Non-load shifting tank temperature set to 120 F

Image Source: https://www.energy.gov/sites/default/files/styles/embed_image_large_480px_width_/public/2021-11/heat_pump_water_heat.gif?itok=0u2WxUGq

Slide 4

KR0 I think table 2 in your paper is great. Listeners don't have to understand everything, but it's very insightful to appreciate all the different scenarios that need to be considered. For example, it's not obvious at all that space heating fuel type is a factor for HPWH costs and benefits modeling.

Kasman, Robert, 2022-10-26T22:24:00.522

BBT0 0 I pulled in the paper figure.

Boyle, Byron T, 2022-10-28T05:01:30.868

Methodology – Cost Considerations
From the Utility and Customer Perspectives

Based on recently filed Xcel Energy DSM/Resource Plans in CO*

Utility Costs

- Avoided Marginal Energy
- Avoided Generation Capacity
- Avoided T&D Capacity
- Natural Gas Commodity Cost

Customer Costs

- Retail Electric and Natural Gas Costs
- Equipment Costs

*Paper covers impacts in Xcel's Colorado and Minnesota service territory.

Methodology – Control Strategy
Loadshapes and Load Shifting

Uncontrolled – load determined by usage

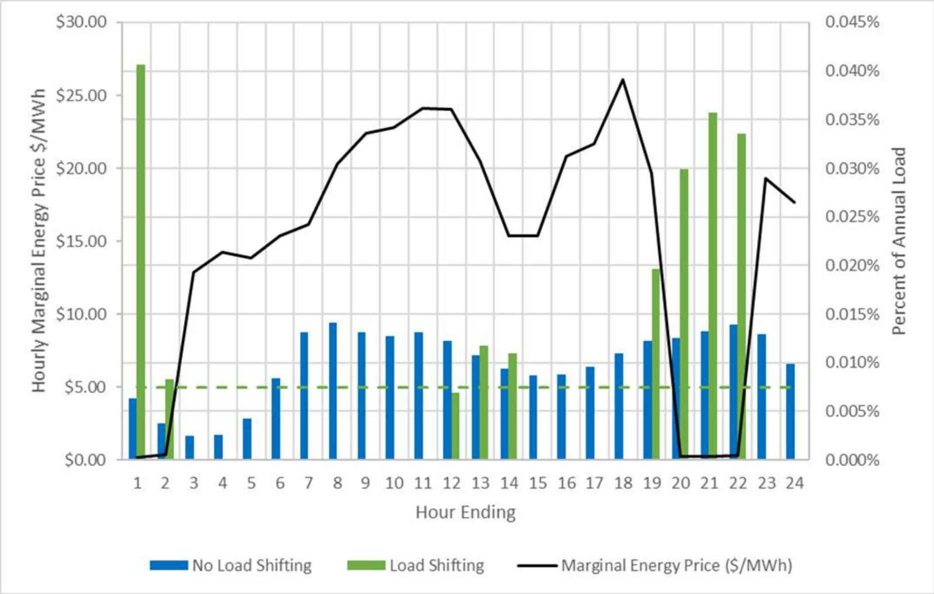
Controlled – load determined by usage, but can also respond to control signals to vary load

Marginal Energy Price Load Shift

Pre-heats tank during low-price energy

Afternoon Peak Demand Load Shift

Curtails load during peak load events



Customer Equipment and Retail Costs KR1

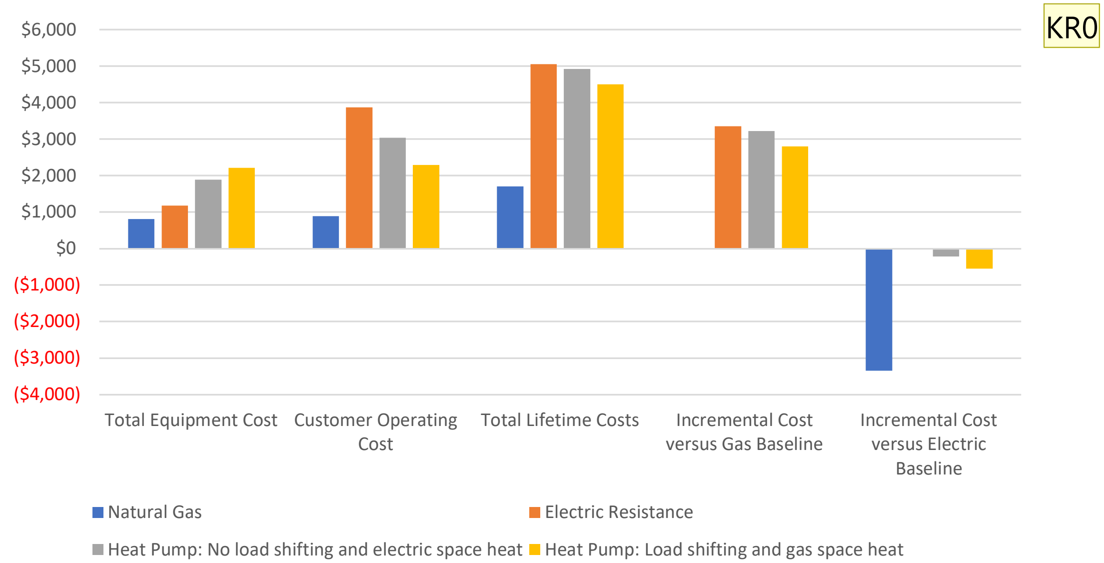
Customer Baseline Equipment Makes a BIG Difference

Electric Resistance Baseline

Heat pumps provide cost savings compared to electric resistance water heater

Natural Gas Water Heater Baseline

Customers face substantial costs switching from natural gas to a heat pump



Dollar amounts represent lifetime NPV totals

Slide 7

KR0 Very interesting results. I presume some customers don't have access to gas or they'd be using it. Do the ERWH customers generally have propane?
Kasman, Robert, 2022-10-26T22:28:39.771

BBT0 0 For sure, some are stuck with propane, sometimes it's building owners installing a "cheaper" water heater, since they're not paying the utility bill. Sometimes it just a house with just electricity and that doubling of upfront equipment cost is enough to drive the choice to install the more inefficient option.
Boyle, Byron T, 2022-10-28T05:43:07.431

KR1 This slide seems to be more about incremental costs
Kasman, Robert, 2022-10-26T22:39:38.885

KR0

Utility Cost-to-Serve and Retail Costs

Rate Structure Makes a BIG Difference

Differences in electric and natural gas retail rate structures are a key barrier

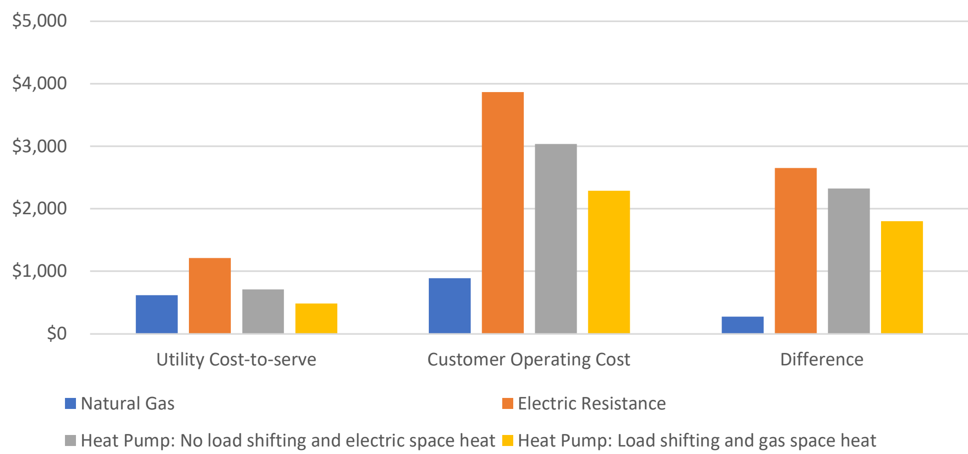
Retail Cost Divergence

Heat pump retail costs are more than 300% higher than the utility cost-to-serve, while only about 40% for natural gas

Narrowing the Gap

Specifically designed rates

Upfront and ongoing incentive



Dollar amounts represent lifetime NPV totals

IEPEC

Slide 8

KR0 If I understand this correctly, the third chart on the right "cost-to-serve difference" is just the mathematical difference of the first too. It would be clearer if it was simply labeled "difference".

Kasman, Robert, 2022-10-26T22:30:29.583

CO2 Emissions

Electric System Emissions Dictate Savings Potential

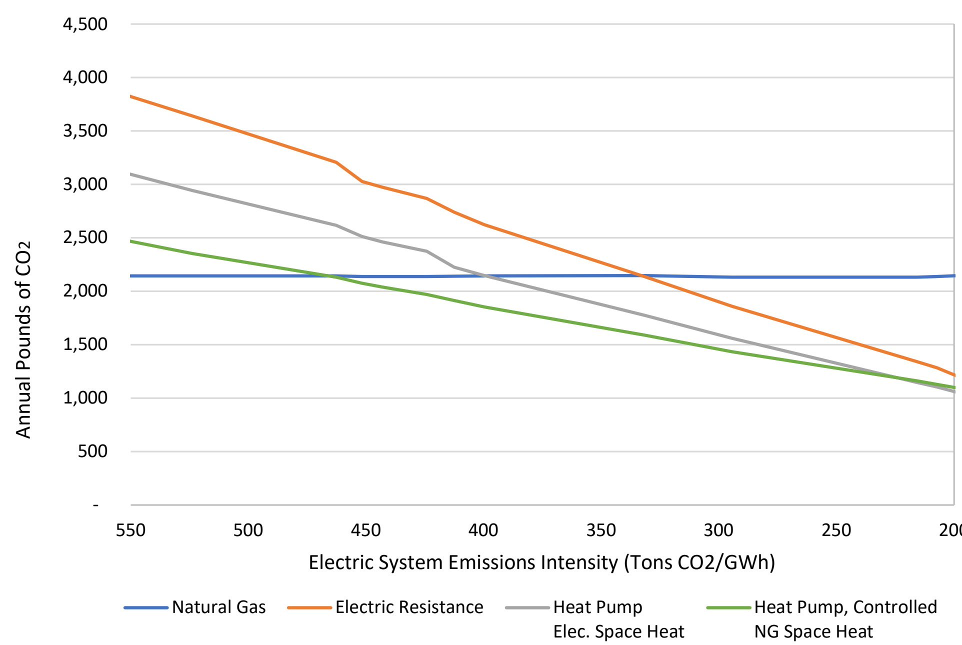
Heat pump water heaters have the potential to generate substantial lifetime emissions reductions compared to natural gas water heaters

Heat Pump Savings

50% fewer lifetime emissions compared to natural gas

Low Carbon Grid

Leads to large emissions savings even for inefficient technologies like electric resistance



Slide 9

KR0 This needs a legend.
Kasman, Robert, 2022-10-26T22:30:52.831

KR1 I think this is a best practice for conference presentations: putting the key takeaway of each slide in the subtitle. (People get easily lost and distracted.) Some other slides would benefit from this practice.
Kasman, Robert, 2022-10-26T22:32:05.974

BBT1 0 Thanks for the tip, I tried to update several that were missing or not very informative.
Boyle, Byron T, 2022-10-28T05:32:33.556

KR2 the
Kasman, Robert, 2022-10-26T22:40:07.626

Resource Planning Impacts

Annual Incremental Electrification Load - Inputs

What are the impacts to the electric system from large-scale growth in residential beneficial electric load?

Low Electrification Scenario

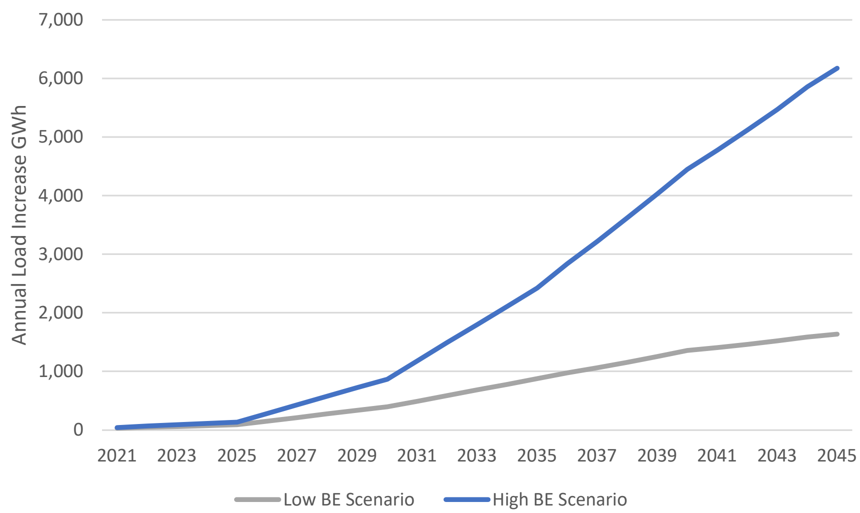
20% of Xcel Energy served households have electric heat by 2045

4% of annual system load by 2045

High Electrification Scenario

70% of Xcel Energy served households have electric heat by 2045

14% of annual system load by 2045



Resource Planning – Capacity Expansion Plan

Beneficial Electrification - Induces System Generation Change

PSCo Base Case Exp (No BE)	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total
Storage	-	-	-	200	-	-	-	-	200	100	-	500
Wind	-	-	-	1,000	-	150	650	150	350	100	300	2,700
Solar	-	-	-	-	-	600	100	0	850	0	0	1,550
CT	-	-	-	-	392	196	588	-	-	-	392	1,568
Recip (Internal Combustion)	-	-	-	-	-	-	-	100	-	-	-	100
CC	-	-	-	-	-	-	-	-	-	-	-	-
Distributed Solar	126	792	232	899	342	1,012	475	1,163	643	1,302	785	7,771
Total	**-**	**-**	**-**	**1,200**	**392**	**946**	**1,335**	**247**	**1,397**	**192**	**684**	**6,393**

PSCo BE Scenario 1 Expansion	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total
Storage	-	-	-	300	-	-	-	-	50	100	50	500
Wind	-	-	-	1,000	200	100	700	200	400	100	300	3,000
Solar	-	-	-	-	50	500	50	0	750	(0)	0	1,350
CT	-	-	-	-	-	784	392	196	-	-	392	1,764
Recip (Internal Combustion)	-	-	-	-	-	-	-	-	-	-	-	-
CC	-	-	-	-	-	-	-	-	-	-	-	-
Distributed Solar	126	792	232	899	342	1,012	475	1,163	643	1,302	785	7,771
Total	**-**	**-**	**-**	**1,300**	**250**	**1,384**	**1,139**	**393**	**1,197**	**193**	**735**	**6,592**

Delta Base Case and Scenario 1 Expansion	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total
Storage	-	-	-	100	-	-	-	-	(150)	-	50	**-**
Wind	-	-	-	-	200	(50)	50	50	50	-	-	**300**
Solar	-	-	-	-	50	(100)	(50)	(0)	(100)	(0)	(0)	**(200)**
CT	-	-	-	-	(392)	588	(196)	196	-	-	-	**196**
Recip (Internal Combustion)	-	-	-	-	-	-	-	(100)	-	-	-	**(100)**
CC	-	-	-	-	-	-	-	-	-	-	-	**-**
Distributed Solar	-	-	-	-	-	-	-	-	-	-	-	**-**
Total	**-**	**-**	**-**	**100**	**(142)**	**438**	**(196)**	**146**	**(200)**	**1**	**51**	**199**

Slide 11

KR0 Not very clear to me what the takeaway is from this slide. Why would solar go down with electrification?
Kasman, Robert, 2022-10-26T22:35:27.943

BBT0 0 The takeaway here is that these types of BE loads are different enough from the system load that they drive greater adoption of renewables (in this case it's wind) than if we were just looking at the typical capacity expansion plan based on the system resource plan. These results suggest that resource planning modeling to determine the change in generation assets built to serve BE loads should be considered when evaluating the impacts of BE technologies.

Acknowledging to a certain extent that these expansion plans are "black boxes" pinpointing why one resource is selected over another is not always easy to do, but I think here the results do seem logical.

Heat pump loads (both for space heat and water heat) don't align very well with solar, since most of the load is early morning or evening (warming up the house in the morning, the morning shower, evening space heat as the outdoor temps decline, etc.). Also, the heat pumps aren't driving an increase of load during hot midday hours, because air conditioners are already accounted for in the base case scenarios - the additional heat pump load is just replacing existing load (not adding more) so the cooling load is similar or slightly less (than the base case) assuming the HPs are a bit more efficient.

The HP load does align a lot better with our wind resources and the EnCompass results seem to indicate that building more wind capacity (at the expense of solar) is a better option. The CT is also growing since wind is not dispatchable and additional peaking capacity would be needed to deal with the additional BE load.
Boyle, Byron T, 2022-10-27T21:48:20.829

Resource Planning - Results
Emissions and Cost-to-Serve Impacts

The results vary significantly from strongly supporting the expectation of renewable generation sources serving the increased load from electrification to not.

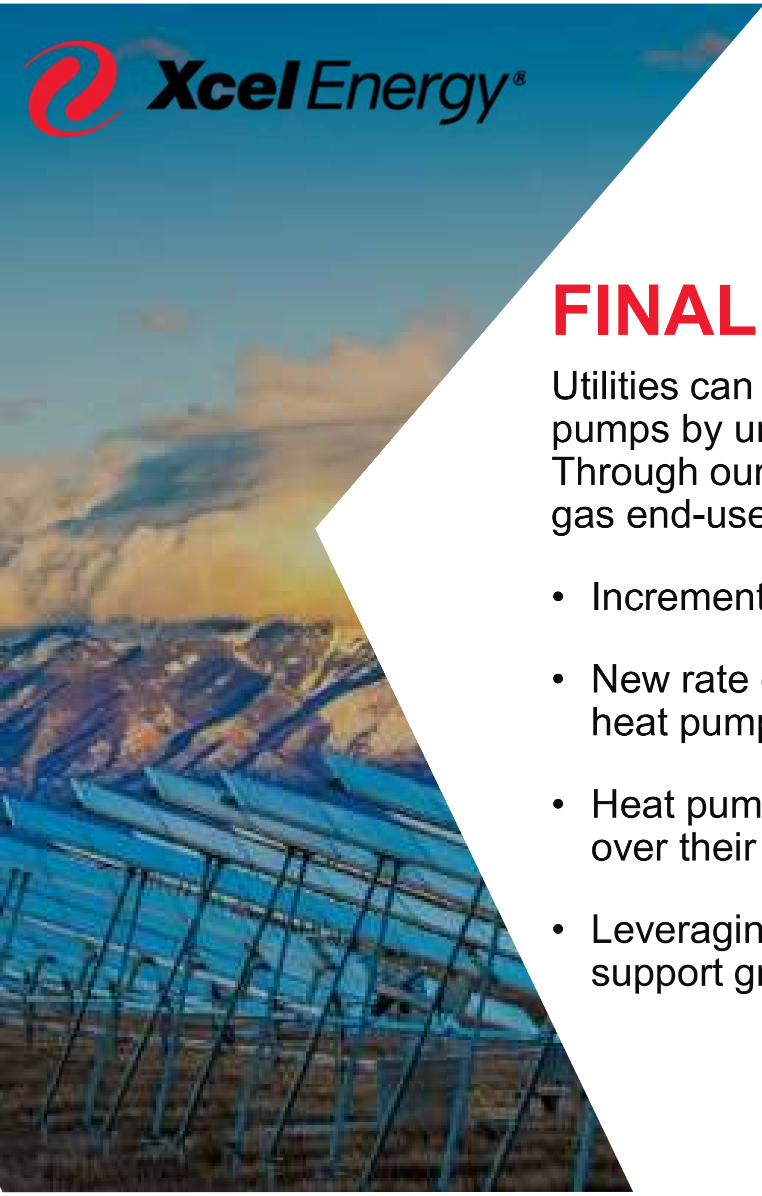
	Marginal emissions intensity (Tons/GWh)		Marginal cost-to-serve ($/MWh)	
Scenario	2024	2021-2032 Avg	2024	2021-2032 Avg
Low BE Scenario	412	-157	$24.14	$55.93
High BE Scenario	447	216	$21.86	$28.61
Approved DSM Plan	443	364	$23.78	$27.44

Low BE Scenario

Increased renewable generation capacity that produce more energy than the increase in load – leading to negative incremental emissions

High BE Scenario

Similar to baseline results



FINAL COMMENTS

Utilities can play a key role in raising customer interest and market adoption of heat pumps by understanding the barriers to adoption that are within their control. Through our study we identified barriers, benefits, and insights to electrifying natural gas end-uses including the following:

- Incremental customer cost can be a significant barrier to adoption for heat pumps
- New rate designs can better reflect the incremental utility cost-to-serve electric heat pump technologies
- Heat pump water heaters installed today can result in large emissions savings over their lifetime compared to natural gas water heaters
- Leveraging new BE load and programs may help shift system load enough to support greater renewable generation capacity across the country.

IEPEC

Slide 13

KR0 in

Kasman, Robert, 2022-10-26T22:43:44.770

KR1 pick singular or plural for this sentence

Kasman, Robert, 2022-10-26T22:44:37.632