

Extraordinary Circumstances and Plans Demand Extraordinary Care in Approval. 21A-0141E

Gas: Save 100s of Millions and Improve Capability by Upgrade Old vs Buy New High Renewables/Storage, and WEIS Change Everything

CORRECTED (bottom page 10, top page 11) 12/6/23

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Introduction

Just as Xcel's 120-day report was extraordinarily late because this plan was exceptionally complex to produce and model, the extraordinary circumstances, uncertainties, and costs demand extraordinary review by the PUC and others. I request the PUC delay final deliberation and decisions for 3 months on Xcel's exceptionally expensive plan to allow further public and PUC review including a new public hearing.

My comments will be in 3 main sections:

- Hybrids: The conversion to hybrids for the 172 MWs of gas turbines instead of retirement was not considered in the all-source solicitation as the RFP and Xcel's appetite for profit are focused on new generation not upgrade. See Hybrids below.
- WEIS: Just as high renewables/storage change everything, moving to WEIS is changing almost everything. WEIS started on 4/1/23. To fully understand the changes requires ideally a year's data, though having the 3 worst months of winter data would probably suffice – hence my recommendation for a 3-month delay.
- Choice of new generation is absolutely critical to minimizing stranded assets. The public does not know enough about what Xcel's planned new generation is to comment properly. Must run is bad. Spin is bad. Steam is bad. Slow start/stop is bad. High minimum MWs are bad. Heat rate matters little. These issues were not called out clearly in the Xcel's plan.

If the Pawnee conversion has a high cost, has slow start/stops, high minimum MWs, and given the tiny runtime of Xcel's Cherokee 4 coal to gas conversion in the Denver Metro area, the Pawnee conversion should be relooked at even though it has a CPCN.

Since Xcel makes more guaranteed profit by investing more money, it is imperative that EVERY alternative for lower cost generation be explored in depth and in public.

Convert Existing Gas CTs to Hybrids Instead of New Generation

Think of Hybrid Gas Turbines (HGT) as firm spinning reserves with 90% less spin.

Take an existing CT, add local mostly dedicated storage that shares the CT's interconnect, and you get an HGT for less than a ¼ the cost of new generation. ¹

HGT advantages are:

- Faster response and more flexibility than Aeroderivative Turbines.
- In CAISO and perhaps other areas of the US HGTs count as spinning reserves and regulation (ramps, VARs, etc) even when not spinning. CAISO also allows HGTs for black start.
- FERC allows storage added to existing generation to use a fast-track interconnection process.
- Reliability is as good or better than the original CT because the HGT can run either just the CT, just the battery, or both and can switch on the fly.
- Like a plug-in hybrid car, e.g., a Prius Prime, adding a relatively small battery to a far larger gasoline engine provides much improved efficiency, reliability, and reduced fuel use and pollution.
- More than 4 GW of mostly gas + Li-ion storage hybrids were operating at the end of 2022 in the US. ²

¹ Cost of HGT conversion.

² <https://emp.lbl.gov/online-hybrid-and-energy-storage-projects> More than 4 GWs Gas installed in the US - click maps choose only fossil + gas and Li-Ion battery and add up the different installed systems. Note 29 projects operating and proposed at the end of 2022 by clicking the "Hybrid Projects" button. This represents a total of "6.6 GW of capacity" - scroll down on the same web page.

- These enhanced capabilities for conversion of existing CTs are about ¼ the cost of new. For example, roughly \$15 M per 50 MW CT³ vs. at least \$60 M for a new 50 MW CT.

For example, Wellhead⁴ converted an existing 50 MW Peaker CT for Marin Clean Energy in 2023. Data from April 1 - July 31, 2022, compared to April - July 2003 (before and after) shows **reductions** in:⁵

- Starts of 62%
- Hours of 86%
- Gas of 90%

Reductions in starts, hours, and gas use vastly reduce maintenance costs and pollution, and will extend the life of older CTs.

Table 31 of Xcel's 120-day plan shows 172 MWs of CT capacity to be retired.

I asked Wellhead to review Xcel's long list of concerns about those older turbines in the paragraph above Table 31. My key question: **Would an EGT upgrade be cost-effective vs. buying new capacity for Xcel's older turbines?**

Brian Norris and other members of Wellhead's team reviewed the units listed for retirement. (Brian is Wellhead's Business Development Manager. Quotes are used with permission. Brian welcomes calls and questions at 816-213-2519.

bnorris@wellhead.com)

Brian emailed me:

"In general, we believe the EGT®⁶ hybrid could enhance most of the units by allowing BESS⁷ capacity to reduce wear and tear on the combustion turbine units. A BESS and proprietary hybrid controls would reduce run time of the CTG's and when the CTG does run it is allowed to sit at an

³ \$15 M from my communication with Brian Norris at Wellhead and from <https://www.enmax.com/news-events/news/canadas-first-hybrid-electric-gas-turbine>

⁴ Wellhead Power eXchange, part of Wellhead Electric Co., using Wellhead's Hybrid Electric Gas Turbine (EGT) that was co-developed with General Electric.

⁵ 2023 <https://www.powermag.com/hybrid-plant-provides-a-cleaner-power-solution/>

⁶ Enhanced Gas Turbine EGT® (note: EGT is registered).

⁷ Battery Energy Storage System (BESS)

optimized output while the BESS provides the fast regulation response needed.

Simply put, adding batteries and integrated controls reduces wear and tear on the CTG's. The CTG will likely run much less once hybridized. Most of the new capital is spent on a BESS. Maintenance on the CTG is still required but since the run times and starts are reduced with hybridization, the life of the CTG is extended.

The EGT® is worth further consideration by Xcel. Even if they decide to go all new, hybridizing all new CTG with BESS would reduce their runtime and lead to lower maintenance cost and much lower overall emissions while providing black start emergency backup.”

EPRI

Xcel is a member of the Electric Power Research Institute (EPRI). EPRI issued a report in 2021 on Hybridized Gas Turbine Plus Battery Energy Storage Systems Technology Benefits and Application Barriers.⁸

EPRI was quite enthusiastic about HGTs:

“...the very large fleet of existing gas turbines worldwide can be better utilized (repurposed) for the evolving grid changes needed to adapt to growing renewable capacity and reduced GHG emission targets...”

...by use of hybridized gas turbines.

More from EPRI's report:

“FERC Order 845A also enables generation owners to add energy storage to an existing generation facility, and if the generation owner has surplus interconnection capacity, it can request a fast-track interconnection

⁸ EPRI report on Hybridized Gas Turbines and BESS
<https://restservice.epri.com/publicdownload/000000003002022317/0/Product>

process to utilize the surplus without reentering the interconnection queue.”

And

“Hybridizing existing resources is an answer to the growing grid challenge of plenty of capacity, but not the right kind of capacity. “

Finally, I found Figure 1 on Page 3 of EPRI’s report to be very helpful in understanding HGTs.

<https://restservice.epri.com/publicdownload/000000003002022317/0/Product>

The PUC should order Xcel to publicly review the option of converting existing gas generation to hybrid gas turbines to save \$100s of millions in cost over new gas generation.⁹

WEIS Changes Everything

Xcel and other utilities in Colorado have joined the Western Electricity Imbalance Service (WEIS). WEIS started dispatching most of Colorado’s generation fleet on 4/1/2023 and literally overnight changed the operation for generators that aren’t must run with a high minimum run capacity.

WEIS was intended to and has reduced curtailment of renewables.

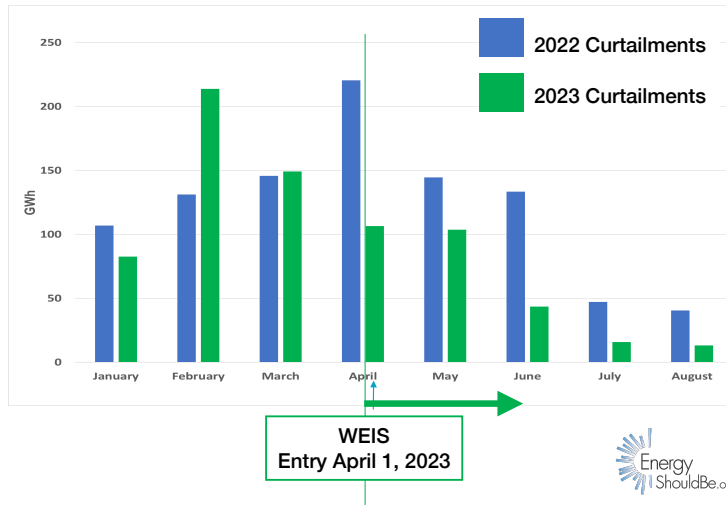
⁹ Note: Ken Regelson and EnergyShouldBe.org are not related to Wellhead in any way other than they were willing to answer my questions about HGTs.

WEIS - A Big Change for Xcel Colorado (PSCo)

Xcel 09.22.23 Curtailment Stakeholder Meeting.pdf with minor additions by EnergyShouldBe.org

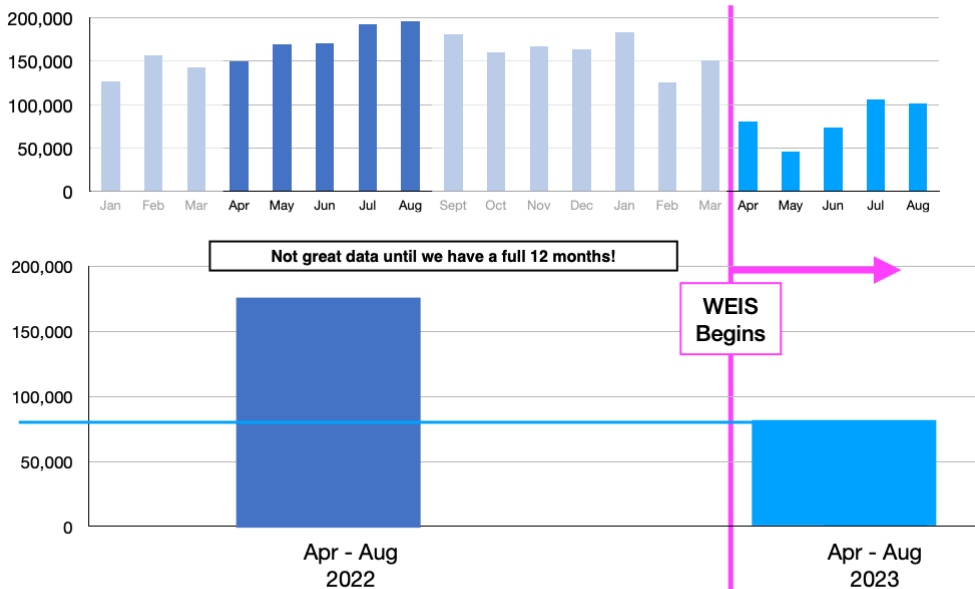
Curtailment in Context - WEIS Experience

Curtailments as a percentage of Potential Production are down 48% YoY since joining WEIS in April



Most Colorado grid aware folks understood that the generation mix would change. One surprising change is the reduction in monthly generation of Platte River Power Authority's 280 MW Rawhide coal plant to about half of its previous monthly generation.

WEIS - A Big Change for PRPA's Rawhide 1 Coal Plant



Slide: Data from Department of the Energy's Energy Information Agency (EIA) Form 923. Utilities report total monthly generation by power plant to EIA which summarizes them into yearly spreadsheets. There is about a 3 month lag before a month's data shows up on EIA's website.

Since WEIS is difficult or maybe impossible to get energy production for a single unit, to create the above chart I had to resort to EIA Form 923 data.¹⁰

As Colorado has required very high levels of renewables, it is quite surprising that the utility players in WEIS's market do not know what the percentage of clean vs. dirty energy they get when they purchase from WEIS. Clearly this must be fixed to understand what WEIS's impact is.

What other surprising results can we expect from WEIS when we can actually see the generation mix by generator we can only guess at. And guessing when data should exist can be extraordinarily expensive.

I believe the PUC should compel WEIS to publish on the web detailed hourly operational data by generator and what renewable mix is delivered so that the public may understand what its impact is.

In a High Renewables/Storage Future, Fossil Generators that “Must Run”, Spin, Use Steam, Have Slow Starts, and High Minimum MWs are bad and displace renewables. Heat Rate Doesn’t Matter Much

Xcel and other utilities acknowledge that renewables need highly flexible generation to match the quick changes in production that nature gives us.

And while Xcel's Plan recognizes this some of the time, other times the understanding of what this means seems to be lacking or is not spelled out in the 120-day plan.

In a high renewable future:

- Fossil generators that must run are bad because they displace renewables and require renewable curtailment.

¹⁰ Data from Department of the Energy's Energy Information Agency (EIA) Form 923 2022 and 2023. Utilities report total monthly generation by power plant to EIA which summarizes them into yearly spreadsheets. There is about a 3 month lag before a month's data shows up on EIA's website.

- Fossil generators that spin (e.g., for regulation) do so by using gas. If they must stay spinning for regulation or capacity reasons, they burn more gas/fuel than if spin wasn't needed (e.g., hybrid gas battery systems can provide regulation and capacity with no spin). Spin displaces renewables.
- Generators that use steam in Colorado are generally quite large. Steam generators gain fuel efficiency by being extremely hot and by using cooling water that is quite cold in comparison. This mix of extreme hot and cool must be started very slowly and carefully to avoid damage to the steam generator. This slows down steam generator's ability to ramp quickly and makes them quite slow to start. Steam generators have generally been used for providing baseload. It has been apparent for more than a decade that baseload generation is incompatible with variable renewables.¹¹
- Any generator that starts slowly must be run a lot of time when it is not needed which wastes fuel and displaces renewables. In addition, slow starters will be difficult to start in time to provide the kind of firm capacity that transmission and generation failures and abrupt renewable generation changes require. Coal fired power plants and gas conversions of coal plants have very long startups - often several days. The steam generator parts of combined cycle gas plants take 12 hours or more to start.
- Generators that can't be turned down to run at very low capacity will waste fuel and displace renewables.

Large New Gas Plants

It is unclear if the large gas plants that Xcel's wants to buy have very small minimum capacities and are made up of one or two large generators or multiple independent small generators. Multiple small generators each with very small minimum capacities allows flexible dispatch and minimum displacement of renewables.

For example, for Xcel's proposed new 400 MW gas generator, there could be one 400 MW shaft (generator), two 200 MW generators, or eight 50 MW generators.

¹¹ For example, see my 3-minute 2012 video To Allow More Renewables, Baseload Coal and Nuclear Must Go.
<https://www.youtube.com/watch?v=deWtgphdJIM>

All add up to 400 MW. As the smallest minimum run I've found is 5%, 400 MW is 20 MW minimum, 8 50 MW generators have a minimum of 2.5 MW as the generators can be dispatched individually.

The PUC should require small discrete generators (say 8 50 MW generators to make 400 MWs) with small minimum capacities for new gas generation. This prevents long runs of polluting and expensive gas. As HGTs provide reductions in spin, they could be considered as well. Other configurations may work as well – say 2 50 MW and 300 MW generators. Modeling needs to be performed to determine the optimum mix.

Coal Legacy Plants

All the concerns about backup fossil generation in this section have either already come to pass or will soon. Any fossil generation that can't nimbly and completely move out of the way displaces renewables.

Coal legacy plants, both coal-fired generation and possibly gas fired conversions of coal plants, have an additional cost problem. Coal plants need large numbers of staff both for 3 shifts and for one or two shifts a day. Xcel's staff costs for coal plants appears to be highly confidential information. PRPA is much less secretive and shows that 280 MW of capacity in their single coal plant has \$37 M per year of non-fuel costs – much of that for staff. This compares to just \$7 M¹² per year for PRPA's fleet of 5 CTs totaling 388 MWs.

As inevitably the amount of run time of high staffing costs of coal legacy drops because of renewables and the cost of displacement of renewables by those plants, coal legacy generation will have extremely high costs per MWh. If they are fairly priced in the marketplace, this should lead to a very quick death spiral.

The PUC should investigate shutting down Comanche 3 much more rapidly than Xcel's planned 2031 retirement to save ratepayers \$10s of millions.

¹² 2024 proposed budget P 50 <https://www.prpa.org/wp-content/uploads/2023/09/09.28.2023-Platte-River-Board-of-Directors-meeting-packet-ELECTRONIC.pdf>

Fossil Runtime Matters

In a high renewables/storage future, backup generators will be run at very low percentages. In modeling 2030, Platte River Power Authority says their backup generators will not run above 5%. Xcel's modeling says that all their peaking generators will run at much less than 1%.

The following chart from Xcel (copied from Leslie Glustrom's comments) shows annual percentage runtimes for Xcel's gas fleet.

Figure LWG (120 Day Comments)-11 **Projected Capacity Factors for PSCo Gas Combustion Turbines**

From AKJ-2, Revision 2, Page 122, Hearing Exhibit 101, Proceeding 21A-0141E

Pink font from the source document--AKJ-2, Revision 2, showing numbers changed by PSCo

Hearing Exhibit 101, Attachment AKJ-2_Technical Appendix, Rev. 2
Proceeding No. 21A-0141E
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Facility Name & Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Ft. St. Vrain 4	14.0%	15.5%	15.6%	12.9%	10.1%	16.6%	17.5%	20.2%	25.8%	25.2%
Rocky Mt. Energy Center 1	31.9%	34.6%	41.1%	36.0%	27.3%	32.3%	33.4%	38.9%	40.7%	40.6%
Rocky Mt. Energy Center 2	9.0%	9.6%	19.0%	18.1%	16.6%	22.2%	21.7%	25.3%	30.3%	29.1%
Rocky Mt. Energy Center 3	14.3%	15.4%	22.0%	19.0%	14.8%	18.2%	18.2%	21.5%	26.7%	26.1%
GAS COMBUSTION TURBINE UNITS										
Alamosa 1	0.29%	0.25%	0.04%	0.15%	0.03%	0.01%				-
Alamosa 2	0.34%	0.25%	0.04%	0.18%	0.03%	0.03%				-
Blue Spruce 1	0.40%	0.29%	0.29%	0.73%	0.41%	0.70%	0.14%	0.07%	0.02%	0.07%
Blue Spruce 2	1.03%	0.58%	0.79%	1.21%	0.70%	1.57%	0.22%	0.08%	0.03%	0.14%
Fruita 1	0.05%	0.02%	0.02%	0.03%	0.04%	0.02%				-
Ft. Lupton 1	0.00%	0.18%	0.00%	0.00%	0.03%	0.00%				-
Ft. Lupton 2	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%				-
Ft. St. Vrain 5	0.53%	0.46%	0.42%	0.62%	0.37%	1.22%	0.41%	0.10%	0.04%	0.14%
Ft. St. Vrain 6	0.26%	0.19%	0.30%	0.31%	0.27%	0.88%	0.24%	0.10%	0.03%	0.12%
Manchief 11	0.25%	0.10%	0.09%	0.11%	0.12%	0.05%	0.04%	0.01%	0.01%	0.01%
Manchief 12	0.25%	0.10%	0.09%	0.11%	0.12%	0.05%	0.04%	0.01%	0.01%	0.01%
Valmont 6	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%				-
Valmont 7	0.01%	0.00%	0.02%	0.03%	0.02%	0.04%	0.03%	0.18%	0.40%	0.46%
Valmont 8	0.01%	0.00%	0.02%	0.03%	0.02%	0.04%	0.03%	0.18%	0.40%	0.46%
Cherokee 4	2.25%	0.00%	0.45%	0.92%	0.00%	0.24%	#DIV/0!			-

1 % means 90 hours (8760 hours per year times 1%).

0.1% means 9 hours.

~~0.4%~~ 0.04% means 3.5 hours.

~~0.1%~~ 0.01% means less than an hour.

It hard to conceive that purchasing new gas turbines for these tiny runtimes makes any sense – that there aren’t better, cheaper alternatives than \$100s of millions for new gas and billions for transmission for such tiny time frames.

The PUC should require Xcel to justify all their new generation in the face of such tiny runtimes. For example, it can’t be sensible to replace Alamosa’s gas plants with new gas plants that are projected to run less than 0.03% (~~less than 20 minutes~~ **about 2 1/2 hours**) per year.

But Heat Rate doesn’t matter much anymore.

Heat rate measures the efficiency of fuel burning generators and is measured in BTUs/kWh. As the percentage of the time that a generator is run increases, somewhere above say 20%, heat rate matters a lot because of the cost of the fuel. Utilities no longer need to consider heat rate much as they buy new units.

At 1% operation per year (90 hours), the difference between the most modern aeroderivative fossil generator’s heat rate of 8500¹³ btu/kWh and a 51-year-old CT in the Northeast 18,000¹⁴ btu/kWh can be easily calculated.

For a 50 MW plant and gas cost of \$5 per MMBTU (high)
50 MW * 1% * 8760 hours/year = ~ 4,400 MWh/year
8,500 btu/kWh costs about \$ 0.2 M/year
18,000 btu/kWh costs about \$ 0.4 M/year¹⁵

So more than doubling the heat rate at 1% operation is a roughly \$200,000 per year increase in fuel cost. This is insignificant in the overall costs of capital upgrades and the overall costs we pay to Xcel.

¹³ <https://www.ge.com/gas-power/products/gas-turbines/lm6000>

¹⁴ Xcel treats heat rate as highly confidential. 18,000 btu/kWh is from page 39 of <https://www.cleangroup.org/wp-content/uploads/The-Peaker-Problem.pdf>

¹⁵ The math is

8500 BTU/KWh * 1000 kWh/MWh * 5 \$/MMBTU * 4400 MWh / 1000000 BTU/MMBTU = ~ 0.2 \$ M / year
18000 BTU/KWh * 1000 kWh/MWh * 5 \$/MMBTU * 4400 MWh / 1000000 BTU/MMBTU = ~ 0.4 \$ M / year

The PUC should order Xcel to publicly publish all information on fossil generation – no more highly confidential.

The PUC should order Xcel to specifically seek out generation that should be lower cost that maximizes flexibility but doesn't need to minimize heat rate.

Pawnee Coal to Gas Conversion

The PUC should revoke Xcel's CPCN if the Pawnee conversion from coal to gas does not make substantial changes to the existing coal equipment to allow much more rapid starts, more flexible ramping, and the ability to run at a much lower minimum capacity (MWs) than the 200 MWs that are currently listed for the coal plant. As this conversion has a CPCN, this needs extraordinary PUC action.

Furthermore, in looking at the above chart, Cherokee 4, Xcel's previous coal to gas conversion, is running insignificant amounts of time – 2% or less (180 hours per year) down to zero %. And yet Cherokee 4 is in the Denver Metro Area which Xcel says needs massive new generation and transmission. This makes no sense.

The PUC needs to require Xcel to fully and publicly justify with costs and modeling the need for a slow, inflexible generator and show why gas-Pawnee isn't going to be just another stranded asset in a few years that will slow the pace of moving to renewables and storage.

In addition, the PUC needs to be certain that Xcel's \$2 B increase in Transmission for the Denver Metro Area is justified considering Cherokee 4's insignificant runtime. The PUC should open a new full docket to consider Xcel's Transmission planning.

Conclusion

First, a special thank you to Xcel, many intervenors, and the PUC Commissioners and Staff for an extraordinary change to our energy future.

This extraordinary plan demands an extraordinary review before approval by the PUC.

I believe Xcel's all source solicitation emphasized new capacity and did not seek out cost-effective alternatives that provide enhanced reliability and performance of existing resources at vastly lower cost than new such as hybridizing old CTs. With more than 4 GWs of existing conversion HGTs in the US, and with FERC and CAISO specific allowance and support for HGTs, there is no reason other than profit for Xcel to not upgrade their older CTs rather than retiring them.

I believe that not just high renewables, but WEIS have changed everything. High renewables has been modeled and commented on extensively. But WEIS has not. We know that the renewables Xcel has proposed will be used properly. For the sake of making certain the billions of dollars Xcel wants to invest in new fossil and transmission capital is well spent, most of a year of fully exposed WEIS data including hourly generation by generator must be considered.

I believe that with renewables now or soon accounting for more than 50% of total generation, any investment in fossil generation needs to be optimized to maximize the use of renewables. "Must run", spin, using steam, having slow starts, and high minimum capacity (MWs) are bad and displace renewables. Only heat rate doesn't matter much.

The PUC should:

1. Order Xcel to publicly review the option of converting existing gas generation to hybrid gas turbines to save millions in cost over new gas generation.
2. Delay approval of the 120-day plan for 3 months to allow nearly a full year of WEIS data and the extraordinary costs of this plan to be fully considered. This should include a new public hearing now that the full plan is being understood.
3. Order WEIS to openly publish current and historical hourly generation by generator and publish realtime and historical renewable/fossil generation mixes so that Colorado utilities may know how clean the energy they buy is.
4. Order Xcel to justify their new and converted generation considering WEIS operations.

5. Order an extraordinary review of Xcel's investments including conversion investments to be sure they all maximize, not displace, renewables.
6. Order Xcel to consider new generation that are small discrete generators (say 8 50 MW generators to make 400 MWs) to maximize renewables use.
7. Investigate shutting down Comanche 3 much more rapidly than Xcel's planned 2031 retirement to save ratepayers \$10s of millions because staff costs do not decrease significantly as a coal plants hours of operation decrease. This makes running Comanche 3 at lower than full capacity very expensive.
8. Require Xcel to justify all their new generation in the face of tiny runtimes of existing gas generators – runtimes less than 1% or even 0.03% (90 hours to 20 minutes per year).
9. Order Xcel to publicly publish all information on fossil generation – no more highly confidential – because as a monopoly they have no competition and because the costs for gas generation have shrunk as gas use is shrinking.
10. Order Xcel to specifically seek out generation that should be lower cost that maximizes flexibility but doesn't need to minimize heat rate.
11. Revoke or delay Xcel's CPCN if the Pawnee conversion from coal to gas does not make substantial changes to the existing coal equipment to allow much more rapid starts, more flexible ramping, and the ability to run at a much lower minimum capacity. In addition, Xcel must justify the need for Pawnee at all given the tiny runtimes of their previous coal to gas conversion – Cherokee 4.
12. The PUC should open a new full docket to consider Xcel's Transmission planning considering the extreme \$2+ billion cost, Cherokee 4's tiny runtime even though it is in the supposedly highly constrained Denver Metro area, and almost no information in the plan justifying or explaining the need for that level of investment.

Comments submitted 12/5/23.

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