Powering our Future:
The Coal to Nuclear Opportunity

Monday, October 24

ANS Events

DOE Office of Nuclear Energy
Coal to Nuclear Transition

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A recent @Energy report finds that a substantial amount of coal capacity in the U.S. is amenable to converting to nuclear capacity – over 250 GW, which is more than double our existing nuclear capacity.

- Evaluating feasibility of coal to nuclear transition
- Working to deliver place-based solutions and ensure equitable energy transition
- Early analysis finds hundreds of coal power plant sites across the country could be converted to nuclear power plant sites
- Study shows energy communities could benefit from adding 650 permanent jobs, additional economic activity of $275 million, and 86% reduction in greenhouse gas emissions
- Communities and developers could leverage existing infrastructure and highly skilled workforce
- https://www.energy.gov/ne/articles/could-nations-coal-plant-sites-help-drive-clean-energy-transition

Opportunities for Coal Repowering with Advanced Nuclear

www.GoodEnergyCollective.org
Twitter: @GoodEnergyColl

Who We are

Good Energy Collective is a progressive think-tank that delivers policy and leadership on nuclear energy.

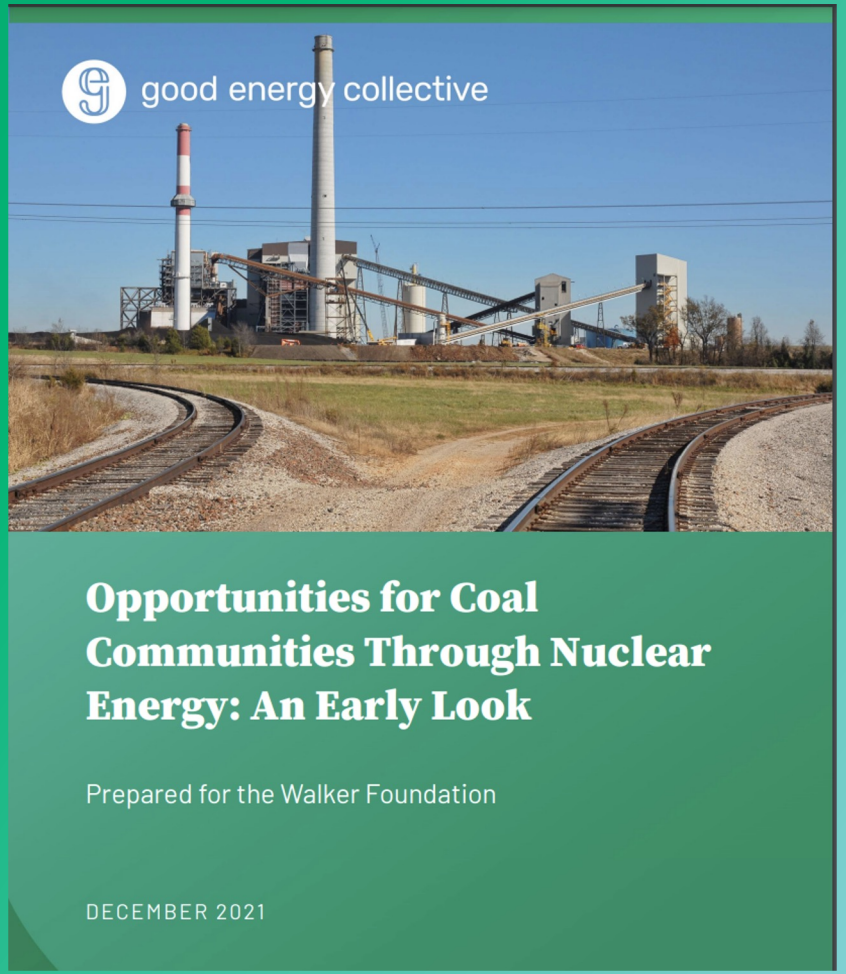
good energy collective

Our Interest in Coal-to-Nuclear Repowering

- "Just Transition" is key to progressive energy vision
- Study by UCS & UWUA, it would cost $33-$83 billion to provide a comprehensive set of supports to transition the ~90,000 people directly employed in the US coal industry
- Complications
  - Mismatch in job location
  - Mismatch in skills or required training
  - Reduced pay, benefits, or ability to join a union
  - Piecemeal state/federal approaches to sourcing new energy jobs

Jeremy Richardson and Lee Anderson. Supporting the Nation's Coal Workers and Communities in a Changing Energy Landscape. Union of Concerned Scientists (2021).

A good option for retiring coal plants?

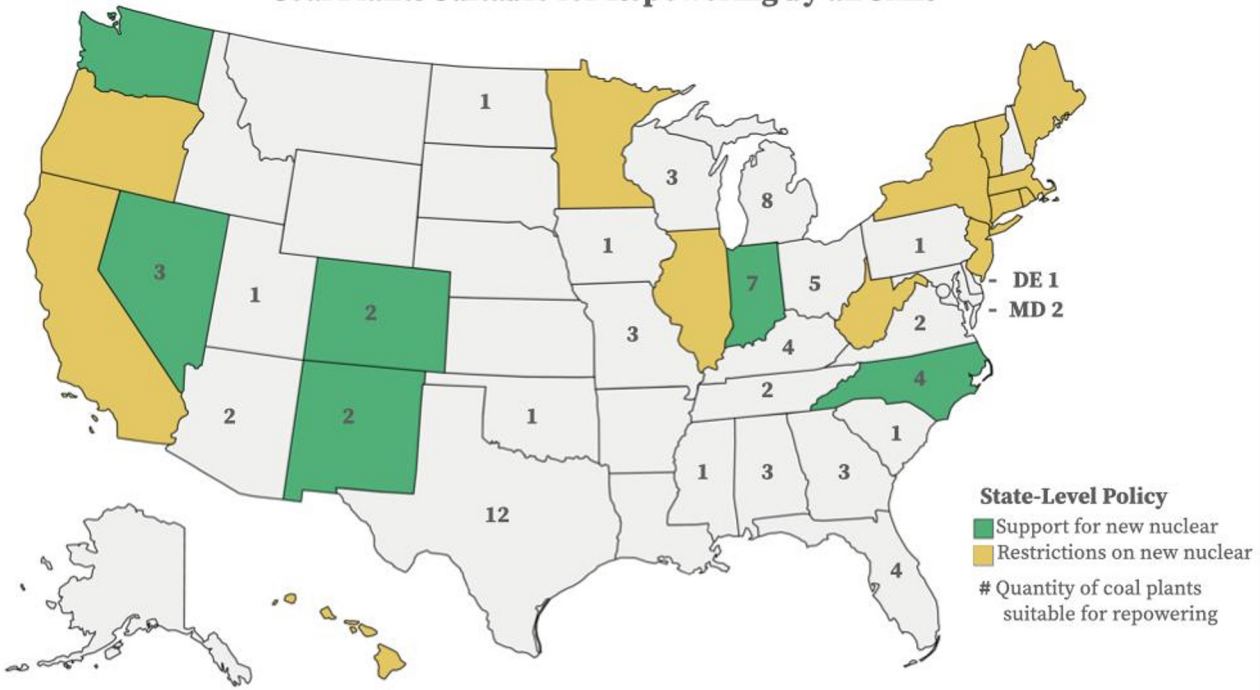


https://www.goodenergycollective.org/policy/coal-repowering

Methodology

- Fastest Path to Zero (FPtZ) database of 304 coal plants retired since 2010 or retiring before 2045
- Filtered out:
  - Active state policy restrictions against new nuclear plants
  - Safety hazards identified by FPTZ
  - Total nameplate capacity of less than 300 MWe; nameplate capacity per unit of greater than 1000 MWe

Coal Plants Suitable for Repowering by an SMR



Recommendations

Role for SMR vendors

- **Start early**
- Continue engaging with **NRC**
- Engage with the **utility, municipality,** or other owner/operator
- Identify local technical/community **colleges and universities**
- Identify whether a **community workforce organization** exists in the area
- Identify **state or local business councils** and **economic development groups**

Role for coal-closure communities

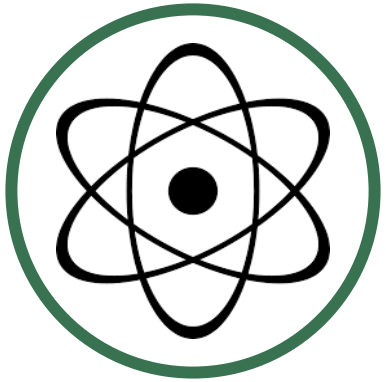
- **Start early**
- Identify potential **utility partners**
- Exploring whether and where possibilities may already exist to facilitate **transitional training**


energy
Clean • Safe • Secure • Affordable

The Makings of a New Energy Era

Environmental Consciousness

Breakthrough Technology



Political Alignment

Unprecedented Convergence

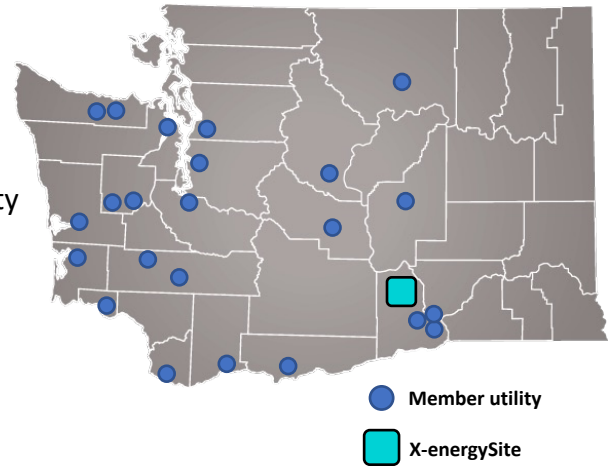
Advanced Reactor Demonstration Program – 2027

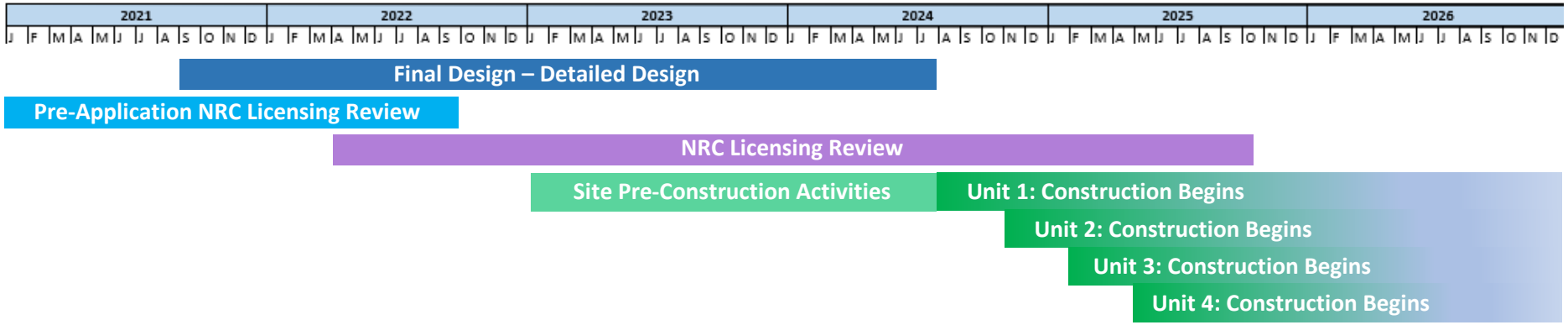
Advanced Reactor Demonstration Project

- In May 2020, the Department of Energy announced the Advanced Reactor Demonstration Program (ARDP)
- X-energy and TerraPower were selected as program winners in October 2020
- Program designed as a public-private partnership:
  - Government provides winning bids with 50% cost share for first-of-a-kind advanced nuclear plant
  - Plant must be commercial (*not* demonstration)
  - ✓ Government motive? Kick-start advanced nuclear industry
- X-energy partnered with Energy Northwest, a top-tier customer
- **ARDP supports a 320MW plant (4 modules), plus a TRISO fuel manufacturing facility**

Energy Northwest

- Membership includes 28 public power utilities, including 23 of Washington state's 29 public utility districts.
- **State law mandates zero carbon grid by 2045, with limited additional upside in Washington state for renewables.**
- EN is a public agency with tax-advantaged capital access.





2027
4 Units Operating

Transitioning from Coal to Nuclear

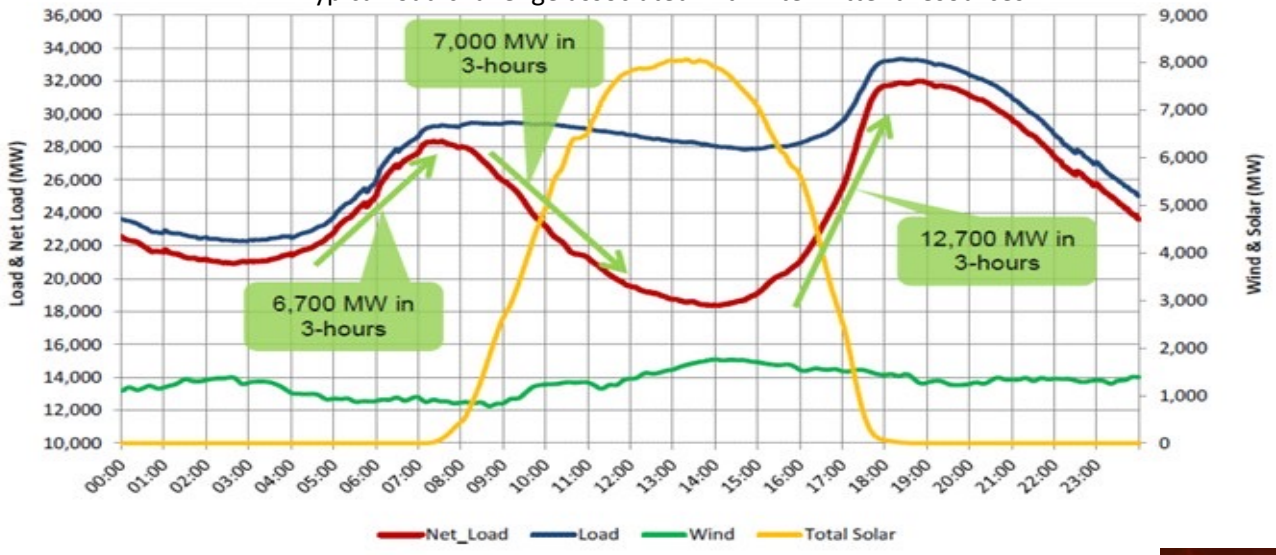
Advantages	Challenges	Comments
Coal plants like nuclear plants have been cornerstones of communities providing well-paying jobs and large tax revenues	Coal plants are generally sited closer to communities and may have other industrial neighbors	This is a change from traditional LWR's that are generally sited far away from community center HOWEVER Converting coal sites to nuclear helps stabilize communities that would have otherwise lost a significant economic backbone
Adv. Reactors with an EPZ at the site boundary allows developers to take advantage of these sites	Creates challenges around acceptance and the social license to build	We are assessing the regional socio-economic impact on a 4-pack standard deployment with Frostburg State University – Maryland Energy Administration Grant
Leverage site characterization data Coal sites with meteorological data and some geo-technical data can help speed up site characterization needed for NRC license	Greenfield sites or sites with no environmental data can add at least a year to the NRC licensing process	Each site has different parameters and characteristics that need to be evaluated individually, based on size, environmental factors, and environmental information needed for licensing
Feasibility studies need to assess the current infrastructure and if it can be reused with the nuclear design: Admin buildings Water intake Switchyard	Re-use of the infrastructure will be dependent on the age of the equipment and also how closely the output size matches Ex: Switchyard – If the current plant is only 200 MW and you put in a 320 MW plant the switchyard is now undersized for the power output and the project does not have sufficient grid interconnection capacity rights	Every site has its specific facilities and infrastructure that must be evaluated based on both the particular site, size of plant and specific reactor and its characteristics

Ideal for Pairing with Renewables and Industrial Applications

(1) Right-sized power output

The reactor size of 200MWt (80MWe) has been designed to address the largest possible market providing a good fit for replacement of existing carbon-based heat sources such as coal and gas.

Typical load challenge associated with intermittent resources



(2) Flexible power delivery

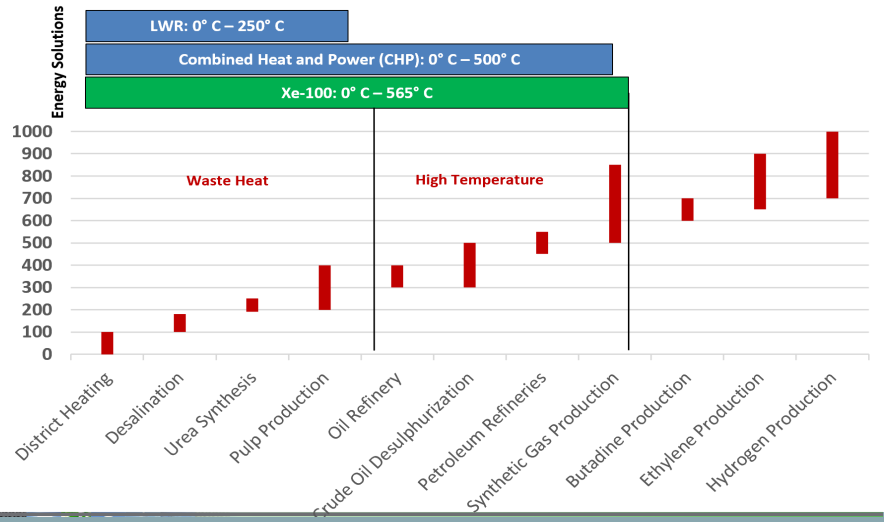
- Designed to be capable of fast and efficient load following. Load-follow with a reactor power ramp rate, up or down, of 5% per minute between 40% and 100% power.
- Ideal for utilities with renewables on their grid.

(3) Broad range of applications

Designed to be independent of the end use makes our solution deployable for electricity and many other process heat applications, such as:

- Hydrogen production;
- Petrochemical processing;
- Desalination; and
- District heating.

The Xe-100 can do both simultaneously or switch between applications.



Energy Density for Nuclear Makes It a Desirable Choice

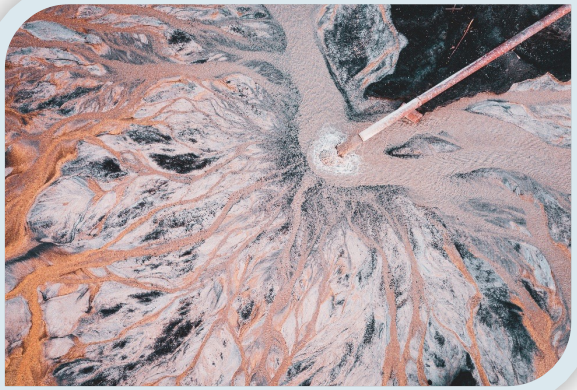
1 pebble:
7g with 15.5% wt
Low Enriched Uranium

27.4 MWh

=

2.66 metric tons of coal

8.0 metric tons of CO_2



~ 0.8 metric tons of ash

Reference: https://www.eia.gov/tools/faqs/faq.cfm?id=667&t=2

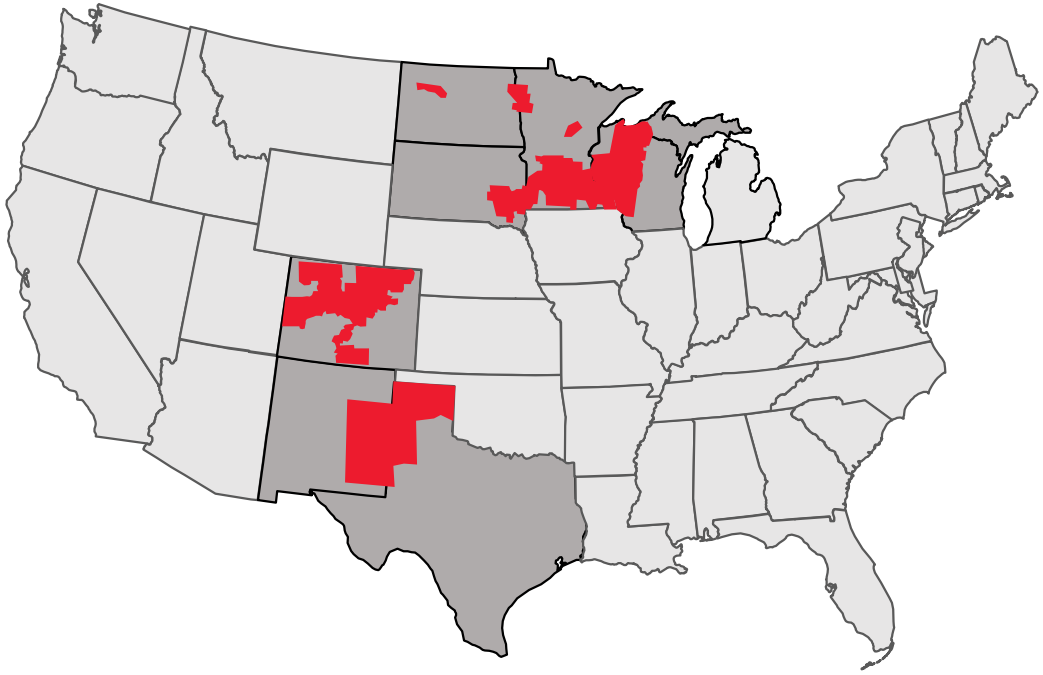
Power of the Pebble

ANS Webinar
Coal to Nuclear

Xcel Energy
October 2022

Patrick Burke
VP Nuclear Strategy

Xcel Energy



Serving eight states

3.7 million electricity customers

2.1 million natural gas customers

Nationally recognized leader:

Wind energy

Energy efficiency

Carbon emissions reductions

Innovative technology

Storm restoration

2020 Data

Xcel Energy's Two Nuclear Generating Plants

Prairie Island

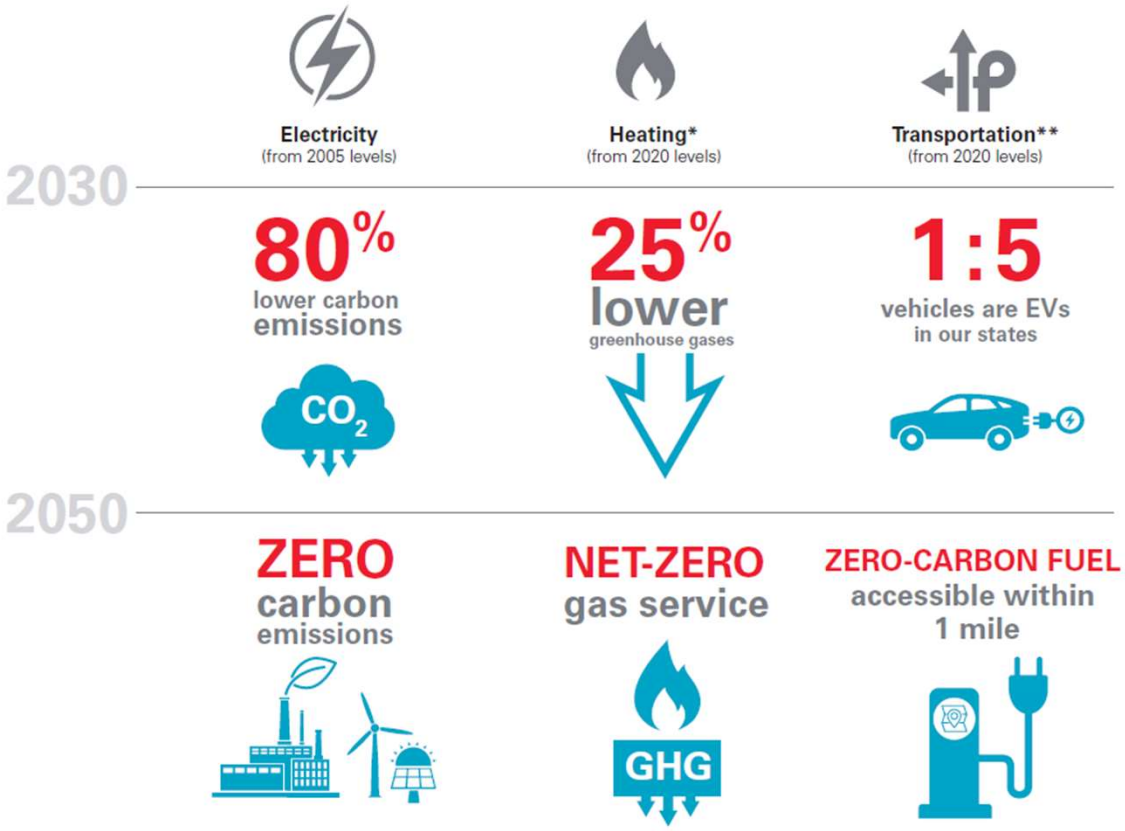
- 2 pressurized water reactors
- Unit 1 (1973); Unit 2(1974)
- Licensed through 2033/2034
- 1,100 MW
- 800 Employees; 1,000 more during refueling

Monticello

- 1 Boiling water reactor (1971)
- Licensed through 2030
- 671 MW
- 650 employees; 800 more during refueling

Net-Zero Energy Provider by 2050

Goals that cover all the ways our customers use energy



*Spans natural gas supply, distribution and customer use

**Includes the Xcel Energy fleet; zero-carbon fuel is electricity or other clean energy

Leading the Clean Energy Transition

2005

21% Carbon-free

Nuclear, Wind, Solar and Other Renewables

Coal and Natural Gas

2021

49% Carbon-free

Nuclear, Wind, Solar and Other Renewables

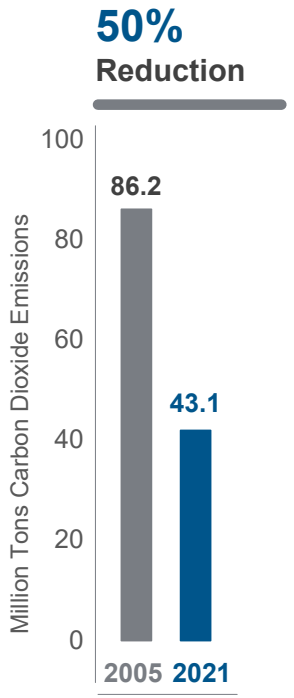
Coal and Natural Gas

2030 Estimate

79% Carbon-free

Nuclear, Wind, Solar and Other Renewables

Coal and Natural Gas



Coal Transition Plan

- Announced plant retirements
  - Hayden 2 in 2027
  - Hayden 1 in 2028
  - Craig 1 in 2025*
  - Craig 2 in 2028*
- Other actions through CEP
  - Pawnee conversion to natural gas by 2026
  - Comanche 3 to retire by 2031; reduce operations 2025
- Workforce transition and community assistance plans for host communities

* Public Service has a 9.8% ownership share in both Craig 1 and 2
**Comanche 1 to retire in 2022 and Comanche 2 in 2025 per the Colorado Energy Plan

NuScale Technology and Xcel Energy

- Explore feasibility of Xcel Energy serving as plant operator for NuScale reactors
- Creates framework for negotiated agreements on how Xcel Energy and NuScale might work together.
- Xcel Energy is providing services related to certification and developing plans for serving as plant operator.