February 11, 2021

Will Seuffert
Executive Secretary
Minnesota Public Utilities Commission
121 7th Place East, Suite 350
St. Paul, MN 55101

RE: 2020-2034 Upper Midwest Integrated Resource Plan,
Docket No. E002/RP-19-368

Dear Mr. Seuffert:

I submit the following comments as a long-time shareholder (more than 60 years) of Northern States Power Company, now Xcel Energy, and as a part of Saint Paul 350.

Sincerely,
/s/ Tim Wulling
1495 Raymond Ave.
Saint Paul, MN 55108

Contents

Main points

The PUC must:

- Deny Xcel's proposed Sherco CC combined-cycle gas plant and deny rate recovery for it.
- Ensure retirement of fossil gas plants before 2050.
- Ensure that Xcel's projections allow for deep energy reductions in housing beyond the projection used in the high electrification sensitivity.
- Require Xcel to include incentives for cold-climate heat pumps for space heating to ensure high penetration.
- Require implementation of all avenues of Demand Response.
- Be aware of the increasing need for Demand Response and do not allow any programs that encourage whole-house tankless water heaters.
- Push Xcel to use excess renewable generation.
- Require Xcel to have a "low energy user" rate.
- Require Xcel to evaluate decoupling revenue from quantity of electricity sold.

Overriding necessity

The urgency of climate change requires elimination of the use of fossil fuels. We are past the time when fossil-fueled electric generation resources are a bridge to fossil-free. **Therefore, the PUC must deny rate-recovery for Xcel's proposed Sherco CC combined-cycle gas plant,** and, if within the PUC's jurisdiction, prohibit the construction of Sherco CC even without rate recovery.

The urgency of climate change requires that existing fossil-fueled generation resources be phased out as their ends of life occur but in all cases before 2050. Xcel is doing this in accelerating the retirement of coal power plants. **The PUC must ensure Xcel retires fossil gas plants before 2050 as well.**

The fundamental operation of the electric grid will change, from generation being adjusted to match customers' load, to customers' load being changed to match generation. This can be done without interrupting customers' activities much more than already occurs with Time-Of-Use rates, Critical Peak Pricing, tank water heaters, etc. Actually, grid-scale storage can be used to offset the some of the variability of renewable electricity, but, even so, fundamentally the grid will operate differently.

Renewable wind and solar resources have different characteristics from central electric power plants. The output of central power plants can be ramped up and down as needed to equal the amount of electricity customers use at any given time. Renewable energy cannot do that, because output from wind and solar resources change according to wind speed and sunshine.

The urgency of climate change also requires elimination of fossil fuels not only in electric generation but also of fossil gas in buildings and petroleum in transportation. Planning for electrification of these current uses of fossil fuels is a necessity.

Everything has become interconnected

Successful electrification depends on commitments from all sectors:

- Electric utilities aggressively eliminating fossil fuels from electric generation;
- The Public Utilities Commission including the cost of climate change to "...appropriately balance [public and private] interests in a manner that is 'consistent with the public interest.'"[1]
- The State of Minnesota implementing a building code that drastically, not incrementally, increases the energy performance of new buildings and of retrofits of existing buildings;
- Trades becoming familiar with practices needed with new building codes;
- Cities following through on aggressive carbon action plans with infrastructure for electric vehicle charging and with stringent building-energy codes, perhaps as conditions for tax breaks for new developments;
- The public choosing electric appliances and vehicles for low energy consumption and ability to adapt to when energy is available in a renewable electric system;
- Vehicle manufacturers producing electric vehicles;
- Equipment manufacturers switching combustion appliances to all electric;
- Industries transforming their processes to use renewable fuels that might include a fuel such as hydrogen produced with excess wind and solar generation;

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[1] Mission of Minnesota Public Utilities Commission, https://mn.gov/puc/about-us

- ✦ Governments, utilities, and other bodies providing financial incentives that help with those costs of electrification that do not readily pay for themselves;
- ✦ People adjusting behavior (clotheslines? public transportation?);
- ✦ Electric rate structures that reward using less electricity and using electricity when renewables resources are producing; and
- ✦ Gas utilities transforming themselves out of the business of fossil gas distribution.

None of these alone can ensure that electrification successfully meets the challenge of climate change. But any one alone, by inactivity, can ensure the challenge is not met.

Electrification

Full electrification of buildings would add load of 46,000 GWh and electrification of transportation would add 46,000 GWh and would make the total electrified load four times NSP-MN's existing load. (See Table 1 below.)

Energy reductions of 34,000 GWh in building energy and 20,000 GWh in transportation energy can be obtained – without reductions in comfort or function – from the following:

- ✦ Space heating
  - ✦ High performance construction and retrofitting to Passive House standard
  - ✦ Heating and cooling with electric heat pumps, not electric resistance
- ✦ Water heating
  - ✦ Low-flow fixtures and efficient piping
  - ✦ Heat pump water heaters
- ✦ Lighting
  - ✦ Conversion to LED lighting (light emitting diode)
  - ✦ Tuning commercial lighting levels
- ✦ Appliances
  - ✦ Energy Star appliances
  - ✦ Commercial refrigeration efficiencies
- ✦ Light- and medium-duty vehicles
  - ✦ Conversion from internal combustion engines to electric vehicles
- ✦ Heavy-duty vehicles
  - ✦ Conversion of HDVs to electric seems difficult for such large loads. If conversion to hydrogen, the energy losses in producing hydrogen would *add* to HDV load.

This is not an exhaustive list. Energy reduction opportunities must be pursued wherever they are encountered. Another category is behavior change – more use of mass transit and less of personal vehicles, more use of clotheslines and less of clothes dryers, etc.

Table 1. NSP-MN Annual Load if Full Electrification Without Reductions

	Residential	Commercial	Industrial	Transpor-tation	Reference	Total of all sectors
EXISTING NSP-MN ELECTRIC (annual)						
Customers 2019	1,162,246 ea	133,069 ea	511 ea	1 ea	[note 1]	
Electric energy 2019	**8,550 GWh**	**13,034 GWh**	**8,128 GWh**	**26 GWh**	[note 1]	**29,738 GWh**
EXISTING NON-ELECTRIC ENERGY		**Commercial / industrial**				
Fossil gas / premise	18,557 kWh	176,250 kWh			Table 1.	
Fossil gas energy 2015	**21,567 GWh**	**23,544 GWh**				**45,111 GWh**
Vehicles energy / customer	23,790 kWh	140,153 kWh			[note 2]	
Vehicle energy	**27,649 GWh**	**18,722 GWh**			[note 2]	**46,371 GWh**
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Total of current annual energy	**57,767 GWh**	**63,427 GWh**		**26 GWh**		**121,220 GWh**
Ratio of TOTAL energy before electrification to ELECTRIC energy	6.8 : 1	3.0 : 1		1.0 : 1	Compared to CURRENT total ELECTRIC energy	4.1 : 1
2050 energy after full electrification with Energy Efficiency reductions						
Space heating reductions	-14,135 GWh	-11,579 GWh			Passive House, heat pumps	
Water heating reductions	-2,891 GWh	-1,831 GWh			Heat pumps	
Lighting reductions	-1,205	-1,542 GWh			Conversion to LED; tuning commercial lighting	
Appliances (including refrigeration)	-678 GWh	-464 GWh			Energy Star	
Total building energy reduction						**-34,324 GWh**
Vehicles, excluding heavy duty vehicles	-19,612 GWh	-5,064 GWh			Efficiency of electric vehicles over ICE	
Heavy duty vehicles		5,007 GWh			If hydrogen, additional energy to produce hydrogen	
Total vehicle energy reduction						**-19,668 GWh**
Total energy reductions	**-38,520 GWh**	**-15,472 GWh**		**0**		**-53,993 GWh**
Net ENERGY after reductions	19,246 GWh	47,955 GWh		26 GWh	If growth is due only to electrification	**67,227** GWh
Ratio of total energy after electrification with reductions to current ELECTRIC energy	2.3 : 1	2.3 : 1		1.0 : 1		2.3 : 1
Note 1.	IRP appendix N1, p.339 (p.465 of eDocket Document ID 20197-154051-07)					
2.	Vehicle energy includes only roadway vehicles, not aviation or marine					

Xcel's IRP provides data about numbers of electric customers and electric energy in NSP-MN territory. I have approximated corresponding data for fossil gas used in buildings by extrapolating data for Saint Paul provided by Xcel in its Partners in Energy report[2] (see Table 2). Table 3 breaks out the energy use in buildings. Transportation energy is estimated from various data from the U.S. Department of Transportation and the U.S. Energy Information Agency.

[2] Xcel Energy's Partners in Energy draft report, "Saint Paul's Path to Carbon Neutrality: *Buildings Sector,"* June 2017, pp.19-20.

Table 2. St. Paul Fossil Gas energy

Table EE-1a. Fossil Gas Energy						
	Residential		**Commercial / industrial**		**Combined**	
Premises, percentage	**89%**		**11%**		100%	
Premises, quantity	112,612	ea	13,918	ea	**126,530**	ea
Fossil gas energy						
Fossil gas	**46%**		**54%**		100%	
Fossil gas	71,300,000	therm	83,700,000	therm	**155,000,000**	**therm**
Fossil gas – in GWh	2,090	GWh	2,453	GWh		
Fossil gas / premise	18,557	kWh	176,250	kWh		
Bold, shaded data above are 2015 data from Xcel Energy's Partners in Energy draft report "Saint Paul's Path to Carbon Neutrality: *Buildings Sector,"* June 2017, pp.19-20.						

Table 3. Building Energy Breakdown

	RESIDENTIAL						Commercial					
	Fraction		**Energy before reductions**				**Fraction**		**Energy before reductions**			
Total current BUILDING energy			30,117	GWh [1]	Electricity + fossil gas				44,706	GWh [1]	Electricity + fossil gas	
Energy uses												
Space heating & cooling	**55%**	[2]	**16,564**	**GWh**	Space heating fuel breakdown		**37%**	[5]	**16,541**	**GWh**		
Electric space heating	2%		523	GWh	3%	[3]						
Fossil gas space heating	53%		16,042	GWh	97%	[3]						
Water heating	**15%**	[2]	**4,518**	**GWh**	Water heating fuel breakdown		**7%**	[5]	**3,129**	**GWh**		
Electric water heating	5%		1,355	GWh	30%	[4]						
Fossil gas water heating	11%		3,162	GWh	70%							
Lighting	**10%**	[2]	**3,012**	**GWh**			**14%**	[5]	**6,080**	**GWh**		
Appliances/refrigeration	**15%**	[2]	**4,518**	**GWh**	Appliances		**7%**	[5]	**2,995**	**GWh**	Refrigeration	
Electronics	**5%**	[2]	**1,506**	**GWh**								

Notes

1. Table 1
2. Indicated percentages are from *Home Energy Guide*, MN Commerce Department, 2018, p.1, https://mn.gov/commerce-stat/pdfs/home-energy-guide.pdf
3. In 2018, average of 35,181 residential NSP-MN customers (3%) of average of 1,114,777 total residential NSP-MN customers had electric space heating. IRP appendix N1, p.373 (file p.499)
4. Colburn, Ken, "Beneficial Electrification," 2017 Energy Issues Summit, Minnesota Rural Electric Association, slide 16, https://www.raponline.org/wp-content/uploads/2017/08/rap_colburn_mrea_eis_beneficial_electrification_2017_aug_10.pd
5. Indicated percentages are from Buildings Energy Data Book 2011, U.S. Dept of Energy, Office of Efficiency and Renewable Energy, p.3-2. https://openei.org/doe-opendata/dataset/buildings-energy-data-book/resource/3edf59d2-32be-458b-bd4c-796b3e14bc65

My calculations are imprecise and incomplete. For example, in the absence of data on the extent of gas distribution, extrapolation of Saint Paul gas data to all of NSP-MN could be in question if NSP-MN's gas territory is less than its electric territory. However, my calculations show the general magnitude of the challenge. Before quadrupling the electric load, the reductions I've shown limit electrification's load increase to double. Other steps are available to stop using unnecessary energy and further reduce the load increase caused by electrification.

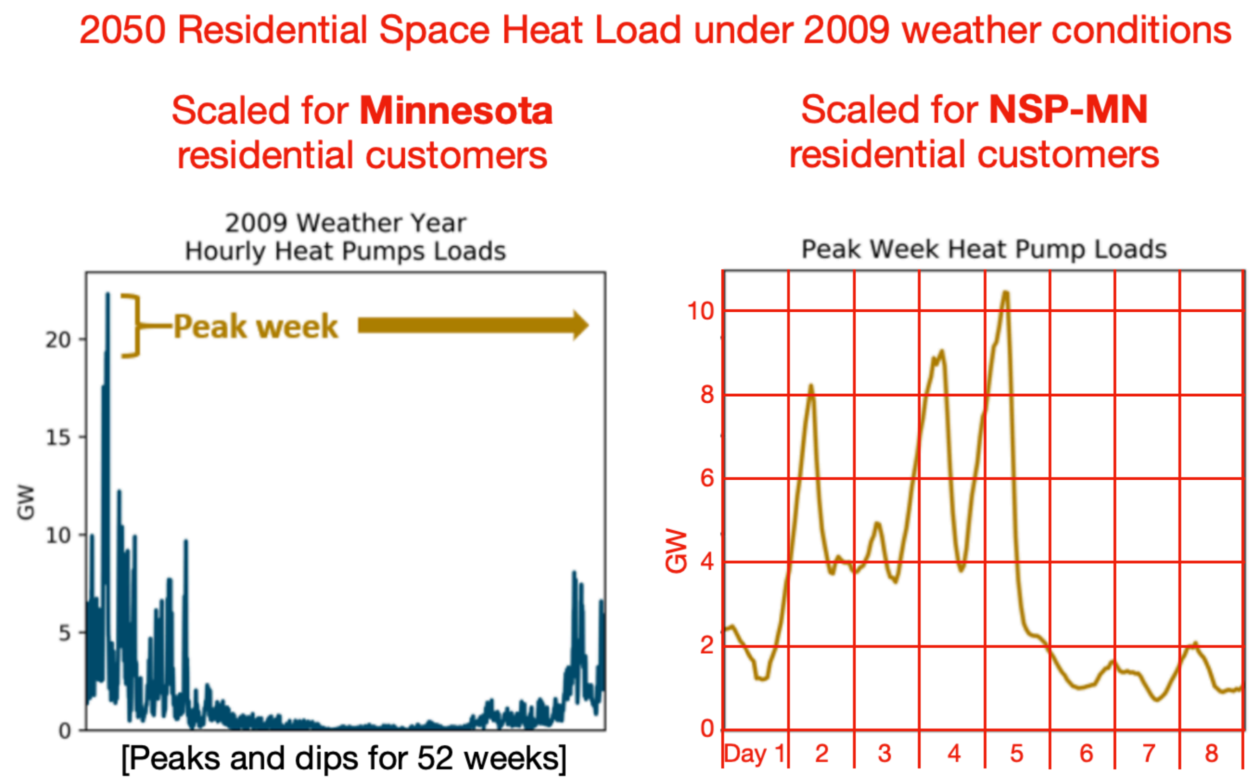
An example of unnecessary energy use is having a 60 Watt light bulb produce 800 Lumens of light when an LED can do it with 7 Watts. As another example, the efficiency of an electric motor enables moving a car with less electric energy than the gasoline energy required for an internal combustion engine. Reducing energy this way does not reduce comfort or function.

Space heating

Electrified space heating and severe winter weather will create a winter peak load bigger than the summer peak. This, combined with lower winter solar production and possible curtailment of wind production at very low temperatures, will stress the grid. So the first thing to do for the grid is to reduce buildings' heat less.

Xcel's case for its reliability requirement includes the example of the severe weather of January-February 2009, combined with projected heat pump penetration of 2050, to demonstrate the future with winter peaks larger than current summer peaks. Figure 6 of IRP appendix F4[3] is reproduced here with my additions in red.

3 Figure 6, IRP Appendix F4: High Electrification Scenario Description, p.15 (p.334 of eDocket Document ID 20197-154051-01)



Several things must be noted to keep the example in the context of the current IRP.

- The original figure is scaled for all of Minnesota with a peak of 22.4 GW. When scaled for NSP-MN's fraction of Minnesota,[4] the peak is 10.4 GW. The figure assumes high penetration of cold-climate air-source heat pumps.
- The peak week curve could be reduced by 50% (by my calculations and estimations) for a peak of about 5 GW, if new construction starting in 2022 would meet the Passive House standard, if a significant fraction of existing residences were retrofitted to be near Passive House by 2050, and if remaining existing residences were brought up to their existing potential.
- The peaks could be mitigated further with smart thermostats and thermal storage (described below).

The PUC must ensure that Xcel's projections allow for deep energy reductions in housing beyond the weatherization mentioned in the high electrification sensitivity.

Building codes are the primary way to reduce heat loss, and the adoption of the Passive House standard would bring about a large reduction in space heating load. It needs to be applied to new construction quickly. The marginal extra cost of more insulation, attention to detail, and heat recovery ventilation is offset some by smaller heating and cooling equipment. Occupants benefit

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[4] 1,149,958 NSP-MN residential customers in 2018, IRP appendix N1, p.312 (p.438 of eDocket Document ID 20197-154051-07). 2,477,753 MN housing units on July 1, 2019, U.S. Census Bureau, https://www.census.gov/quickfacts/fact/table/MN,US/HSG010219

from greater comfort, better indoor air quality, and lower energy cost than with standard construction.

Retrofitting existing buildings toward Passive House is much more difficult and costly than for new construction. It involves external insulation and new siding, among other things. For some houses with complex shapes will just be too difficult. For these, blowing insulation into the walls, adding insulation to the attic, and maybe adding basement and/or roof insulation will still make a significant difference.

Unfortunately, the PUC has little control over building codes but will be much affected by them as space heating is electrified. However, the **PUC can require Xcel to include incentives for cold-climate heat pumps for space heating to ensure high penetration.**

Loss of performance advantage compared to electric resistance heating at very cold temperatures is a problem with air-source heat pumps. In contrast, ground-source heat pumps retain their performance at all winter temperatures. As building electrification occurs, one study[5] considers replacing gas lines city block by city block with boreholes and a pump for delivering tempered water to heat pumps in houses, forming block-size mini-district heating and cooling. This avoids the low temperature disadvantage of air-source heat pumps, while offering a way for the gas utility to transform its business away from fossil fuels. I think **the PUC should require Xcel's gas utility to consider such a transformation**, although that is not part of the IRP proceeding.

Smart thermostats that respond to the grid through Advanced Metering Infrastructure offer another Demand Response possibility. Xcel could give customers options to let the grid lower their thermostat setting a specified amount during winter peaks and increase them during summer peaks. Different incentives could be offered for changes of 1°F, 2°F, or even 5°F. A high performance Passive House would lose temperature very slowly even in very cold winter, enabling it to ride through night-time or longer low temperatures. Also, the grid could raise the thermostat setting a degree or two to raise the room temperature before a cold weather event so the house might coast through more of the cold spell.

Residential space heating Demand Response is also possible with thermal storage in ceramic bricks. For decades, room units with electric resistance heating have existed to heat the bricks at night with lower Time-Of-Use electric rates.[6] With electrification, energy from the grid would be stored whenever during the day or night renewable energy is available and delivered as heat to the room without loading the grid when grid energy is less available.

The PUC should require Xcel to expand incentives for grid connections to smart thermostats and for residential thermal storage for space heating.

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5 Figure I-2, GEO MICRO DISTRICT Feasibility Study, heet / Burohappold Engineering, p.8. https://heetma.org/energy-shift/geomicrodistrict-feasibility-study

6 Electric thermal storage, Steffes, https://www.steffes.com/electric-thermal-storage

The PUC must require implementation of all avenues of Demand Response.

Xcel pointed out an extreme winter weather occurrence in which renewable generation was extremely low.[7] A way to help counteract such conditions would be to optimize some grid-scale solar arrays for winter production, using a steeper tilt angle. This would intercept more insolation as well as increase snow shedding. **The PUC should require Xcel to evaluate the effect of winter solar optimization on winter peak demand.**

Demand Response – water heating

An electric tank water heater is a good example of how storage enables customer to draw hot water at a different time from when electricity is drawn from the grid to heat the water. What is needed with the new, renewable electric grid is for the electricity use to depend not only on the tank temperature but also upon the availability of electricity – in other words, Demand Response. Storage – whether thermal as with a water heater or electric as a battery – can decouple the time energy benefits a customer from the time the grid supplies the energy, allowing optimal timing for each.

The grid services that a tank water heater provides can be increased by heating the water above the desired tap temperature and attaching a mixing valve to moderate the temperature of the water delivered to the tap. The mixing valve introduces enough cold water to bring the higher temperature tank water down to the temperature wanted at the tap. With Advanced Metering Infrastructure, the grid can raise the tank temperature to use surplus renewable energy or let the temperature go lower when demand on the grid is high. The temperature might be allowed as high as 160°F but never lower than some chosen temperature above the desired tap temperature.

The combined load of a large number of water heaters could provide a grid resource in the following ways:[8]

- ✦ Peak shave – curtailed a few hours on a few days of the year;
- ✦ Thermal storage – curtailed daily when demand is high;
- ✦ Fast response – used daily for frequency regulation while heating water off-peak.

In grid terminology, fast response would provide an ancillary service.

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[7] "Table 1: Hourly Wind and Solar Capacity Factors February 5, 2019," IRP Appendix J2: Reliability Requirement, p.16 (p.334 of eDocket Document ID 20197-154051-03).

[8] "The Hidden Battery: Opportunities in Electric Water Heating," The Brattle Group, 2015, pp.5-6. https://rpsc.energy.gov/tech-solutions/technologies/heat-pump-water-heater/resources/hidden-battery-opportunities-electric-water-heating

Demand Response trade-off with Energy Efficiency

As Demand Response and Energy Efficiency increase, some situations will arise requiring a trade-off between the two. Water heaters are an example.

First, whole-house water heaters can be either tank or tankless. Although insulated, a heated tank slowly loses heat. Avoiding that loss, a tankless water heater is somewhat more efficient. However, when hot water is drawn from a tankless heater, it is a large electric load drawn from the grid drawn when the customer wants hot water regardless of how heavily the grid is loaded. My gas tankless water heater provides an example of a tankless water heater's load. Its maximum rate of energy consumption is three times that of my furnace. An electric tankless water heater burdens peak loads; it cannot be used for Demand Response. **The PUC must be aware of the increasing need for Demand Response and not allow any programs that encourage whole-house tankless water heaters.**

Second, an electric tank water heater has either electric resistance heating or a heat pump. The heat pump is significantly more efficient but more complicated and costly. Is the simplicity and lower cost of the resistance water heater – combined with more grid services – more advantageous than the energy savings of the heat pump? **The PUC should require Xcel to evaluate this before providing customer incentives one way or the other.**

Renewables and storage

Renewable resources must be increased. Xcel is doing this. Xcel has expanded renewables significantly and has been a leader in the use of wind energy. Xcel is concerned that increased wind and solar penetration reduces their capacity factors.[9] However, the extra capacity does not have to go unused. It could be stored – in electric batteries, or in grid-scale thermal storage for later use by steam generators.[10] It could produce hydrogen, maybe for use in heavy-duty vehicles. **The PUC must push Xcel to use excess renewable generation through technologies that delay the use of the excess generation to times when electricity is not in excess (i.e., storage) and through the possible production of alternate fuels whether used for transportation or for later power generation.**

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[9] "III. High Levels of Renewables Result in Declining Capacity Values," IRP Appendix J2, p.8, (p.326 of eDocket Document ID 20197-154051-03).

[10] "Energy storage: Recharging the energy transition," Siemens Gamesa, https://www.siemensgamesa.com/en-int/explore/innovations/energy-storage-on-the-rise

Rate structures

The PUC should require Xcel to have a "low energy user" rate for residential customers using less than some predetermined amount per month. I recall, I think correctly, that Northern State Power at one time had a financial incentive for residential customers who stayed under 300 kWh per month. Such a rate should be structured to help ease the energy burden of low-income households.

Rate structures are such that Xcel's revenues increase when it sells more electricity. However, higher loads strain generating capacity and add pressure for more carbon-emitting generation. To counter this **the PUC must require Xcel to evaluate decoupling revenue from quantity of electricity sold.** "Shifting toward performance-based regulation, which rewards utilities for outcomes instead of further capital investment, can go beyond just removing the disincentive to invest and can align utilities' earnings opportunities with decarbonization."[11]

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[11] "With the Shift Toward Electrification, Decoupling Remains Key for Driving Decarbonization," blog, Regulatory Assistance Project, p.4. https://www.raponline.org/blog/with-the-shift-toward-electrification-decoupling-remains-key-for-driving-decarbonization