Residential Electrification Introduction

Understanding Denver's Code Context

Eric Browning, CPD – Chief Building Official

Community Planning and Development & the Office of Climate Action, Sustainability, and Resiliency

Budget & Policy Committee

March 6, 2023

What is the Context of "Residential" in Today's Presentation?

- Building types regulated by the Denver Residential Code
  - ✓ Single Family Dwellings
  - ✓ Two Family Dwellings
  - ✓ Townhomes (rowhomes) built side-to-side

    - *('Residential' are <u>not</u> apartments, condos, or hotels regulated by the Denver Commercial Building Code)*

What's Already in Denver Residential Code & Energy Code Regarding Electrification?

- R404.4 - Electric Vehicle Ready Spaces - Including Infrastructure
  - Dedicated and labeled panel space
  - Conduit, Receptacles, & Wiring
- R404.5 – Electric Infrastructure – for Furnace, WH, Range & Dryer
  - Dedicated reserved panel spaces and 240 V receptacle w/ wiring or conduit
  - Minimum room volume for electric water heater
- R404.6 - Solar Ready Zones – Minimum 300 ft^2 plus infrastructure
  - Dedicated and labeled panel space
  - No obstructions on roof, free of shading

Possible Timelines, Phasing, and Questions

- It's easier/more cost effective to electrify from the start (new construction)
- How to address new construction vs. existing/renovations?
- Consider first incentivization (reduced fees, city rebates), then mandatory
- Phasing timeline:
  - New Construction first, then existing buildings
- Agencies need a year or more to update regulations with community involvement. Complexity is higher than adding language to the codes – there are ripple effects throughout the codes.
- Must consider cost and equity, especially with existing homes.

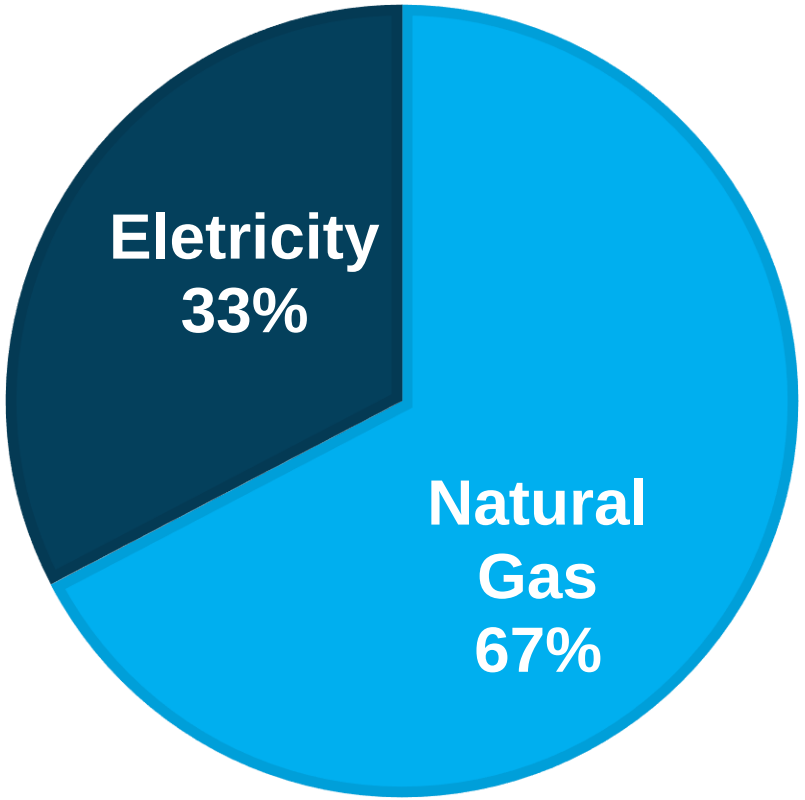
New Buildings Institute

Sean Denniston

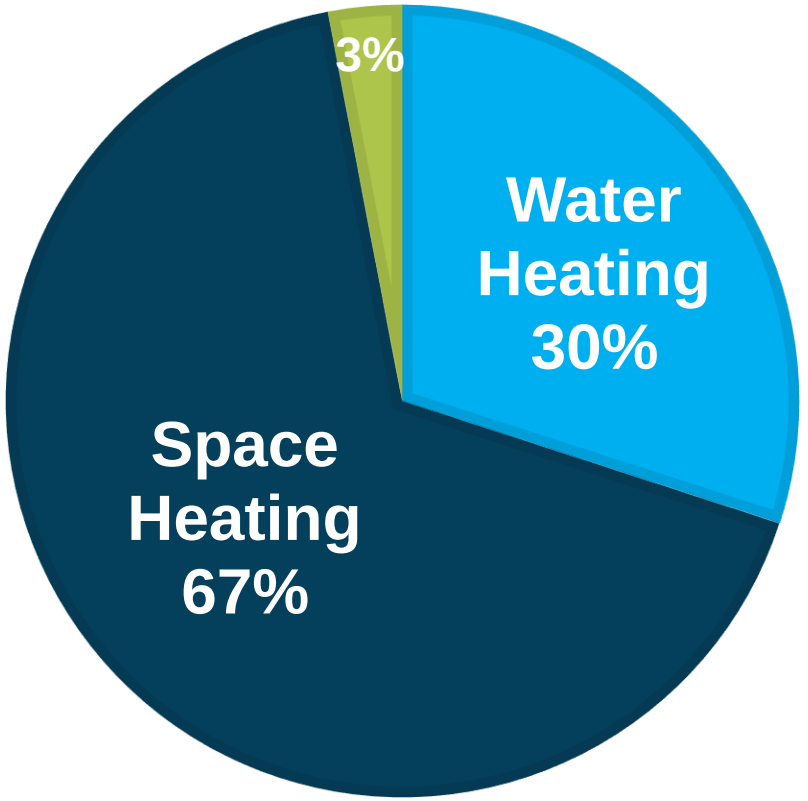
Senior Project Manager

Natural Gas Usage in Denver Buildings

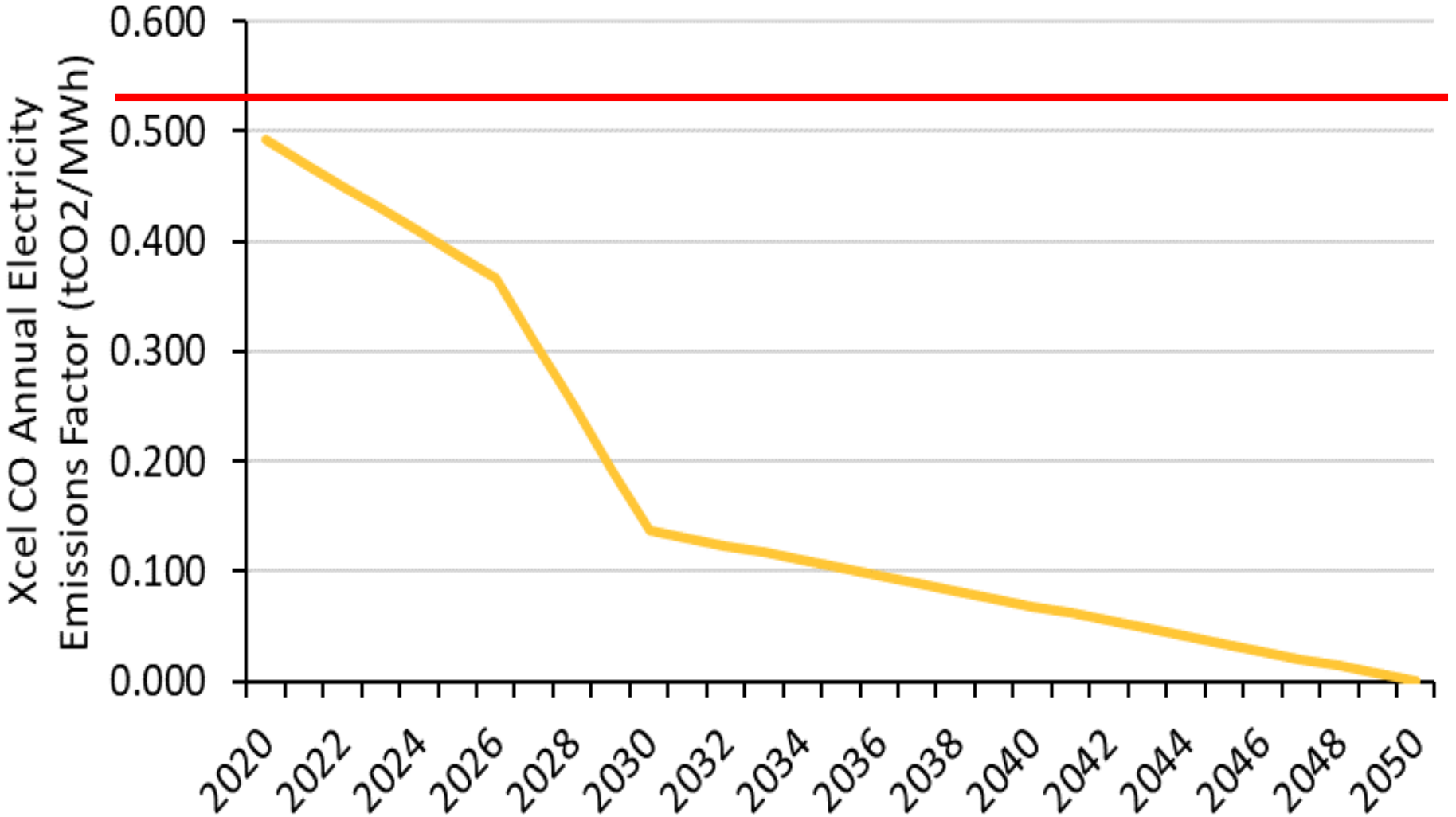
SF Total Energy Use



Gas Usage

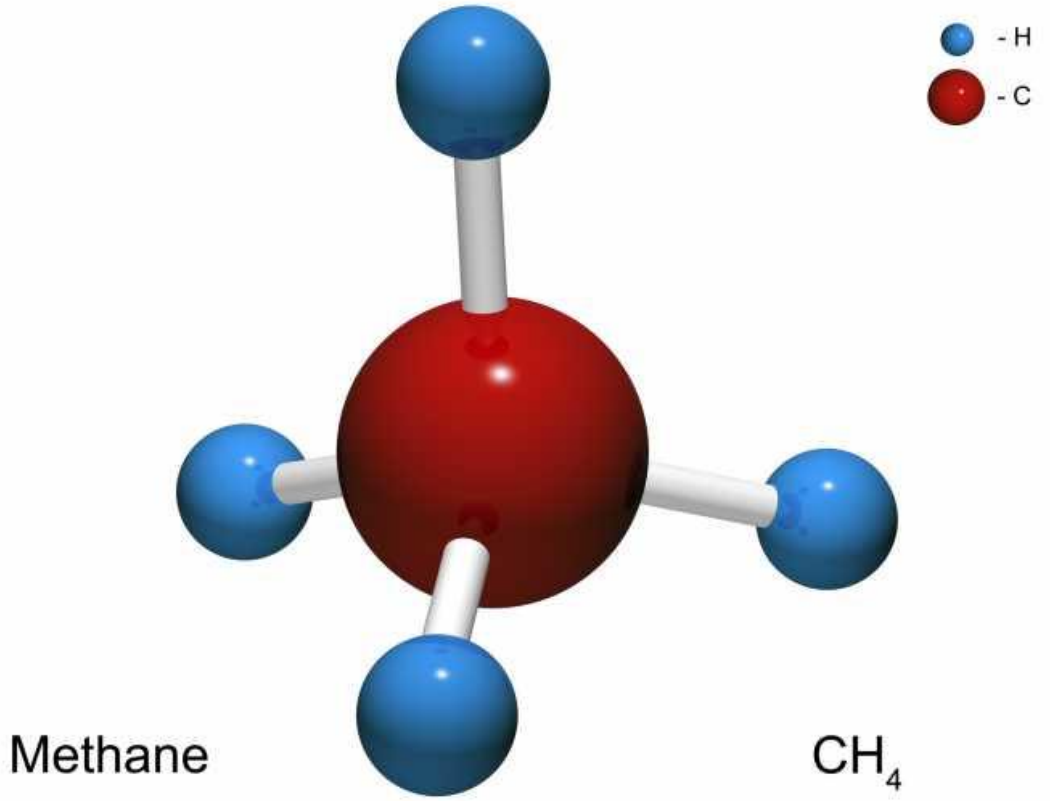


Impact of Natural Gas – CO2 Emissions

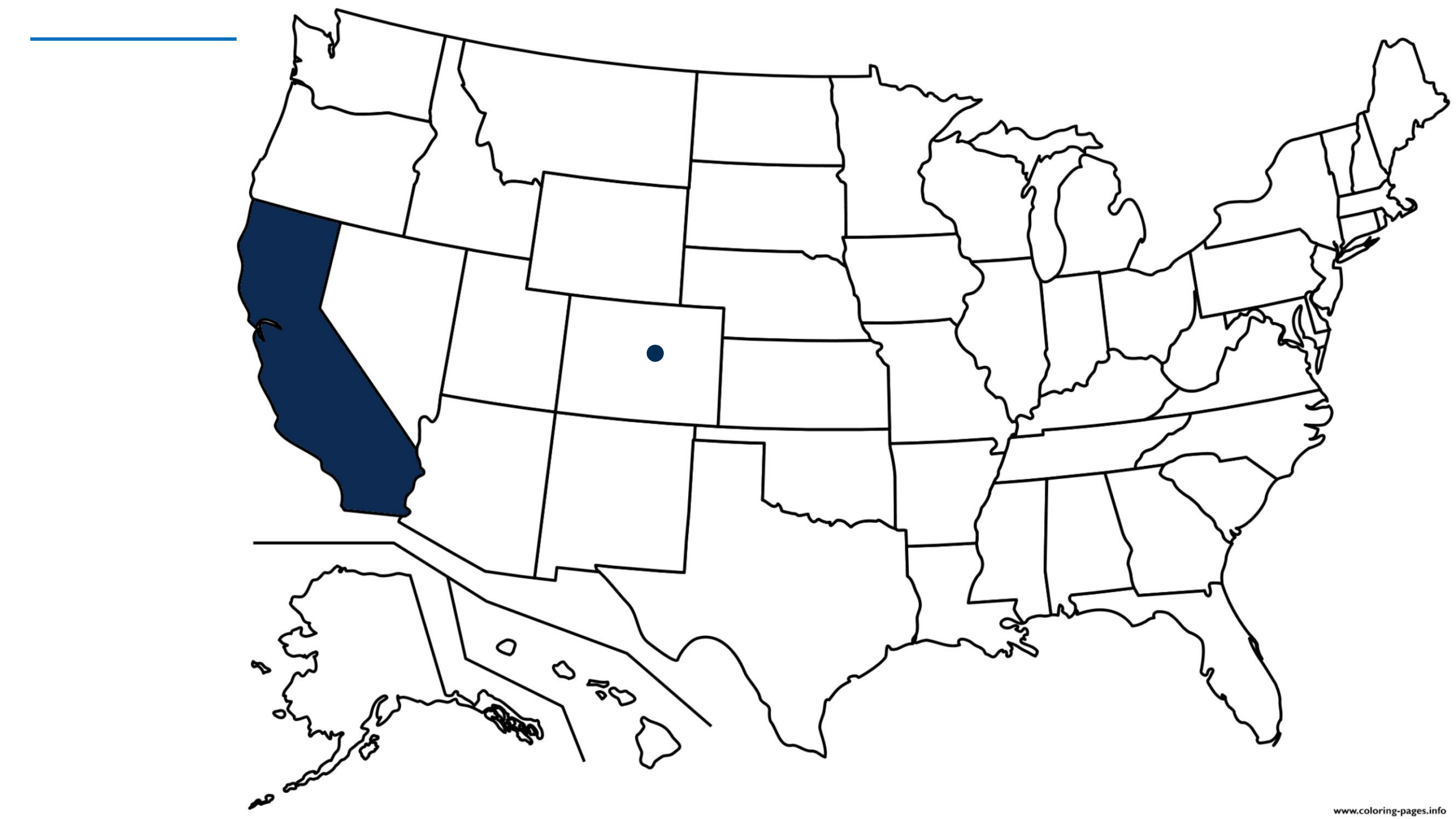


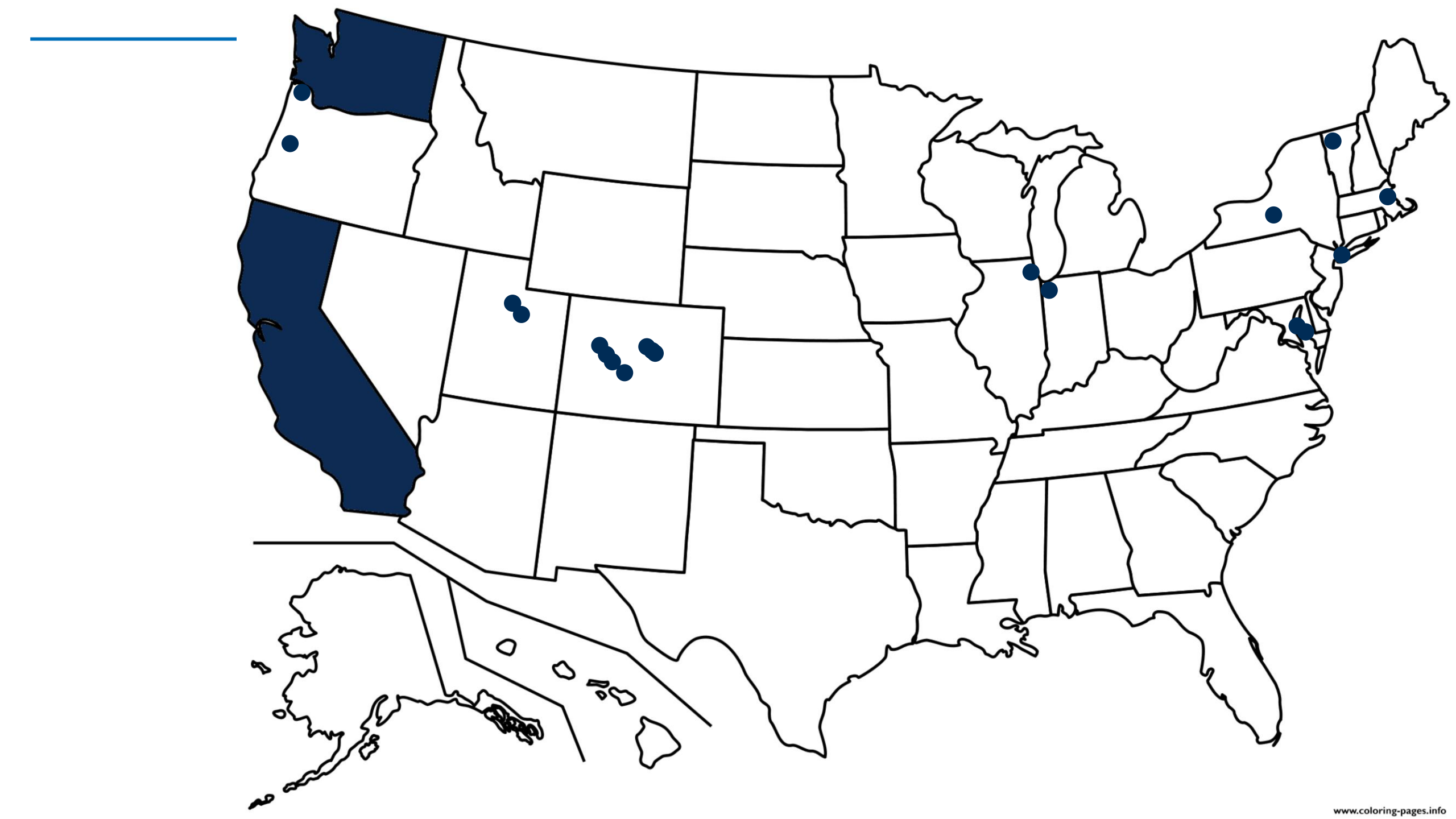
Impact of Natural Gas – Methane Emissions

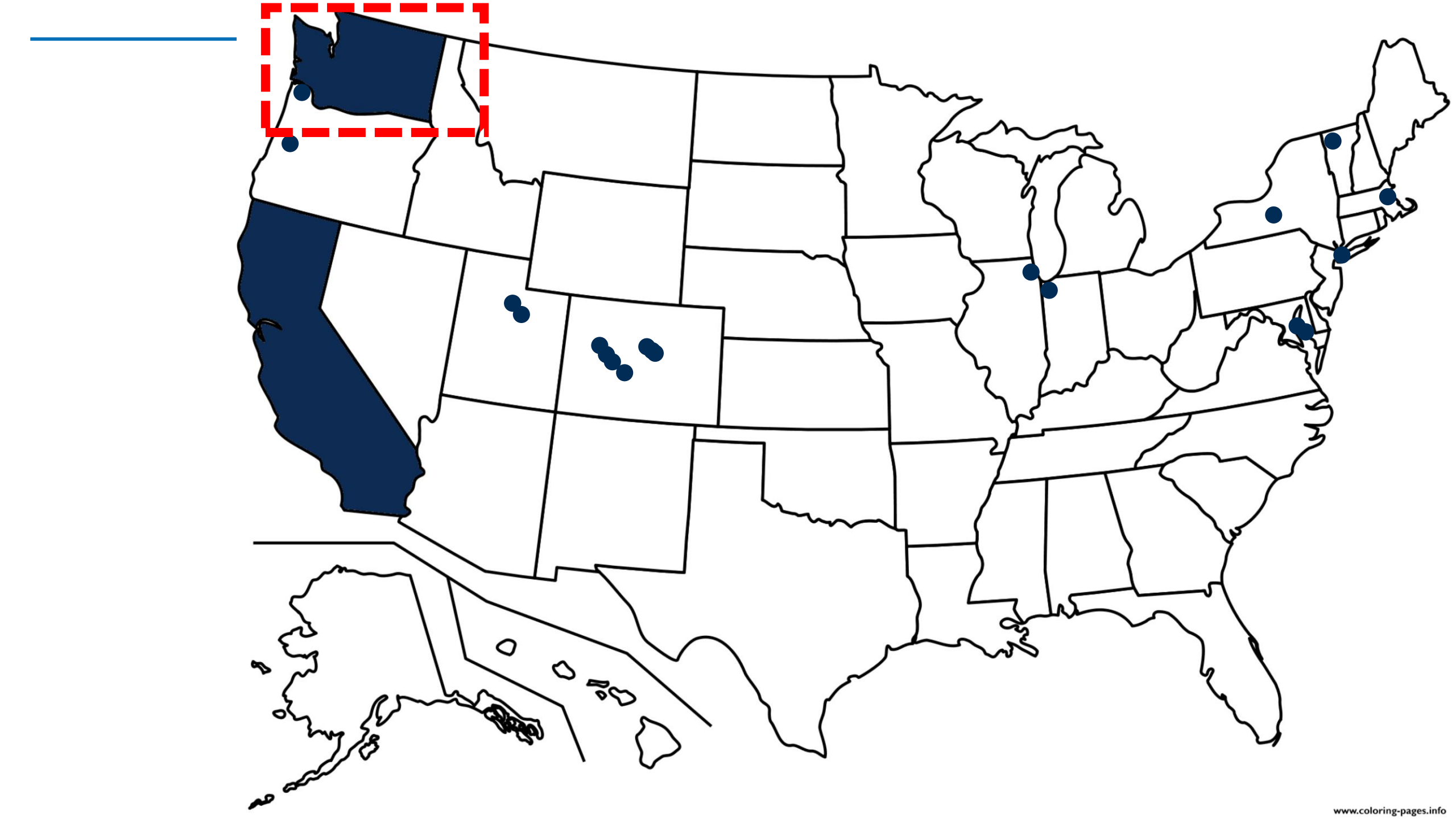
- Methane has 80x the climate impact of CO2
- 6% of methane emissions come from distribution
- 50% of distribution losses come from distribution mains
- 27% of distribution losses come from buildings



"Natural Gas Infrastructure Modernization Programs at Local Distribution Companies: Key Issues and Considerations." US DOE, Office of Energy Policy and Systems Analysis. Washington DC, 2017.

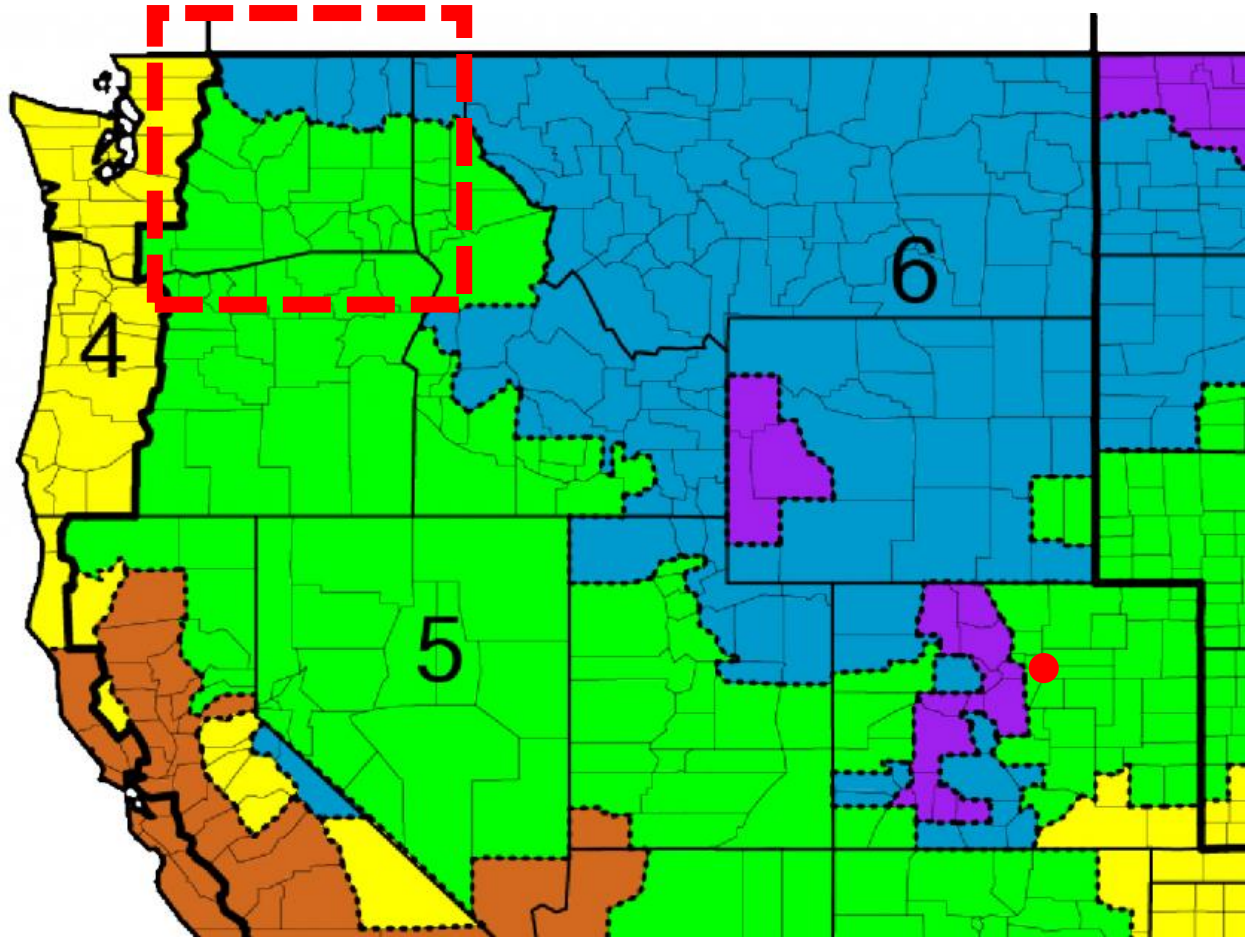






Why Washington

- WA state has ambitious climate goals like Denver
- Eastern WA is a similar climate to Denver (CZ 5B)
- WA codes are based on the I-Codes like Denver



WA Strategy: Heat Pumps

2021 Commercial Code

- Heat Pumps required for space heating
- Heat Pumps requires for 50% of water heating capacity

2021 Residential Code

- Heat Pumps required for space and water heating in SF

History

WASHINGTON STATE
ENERGY CODE - RESIDENTIAL
2018 EDITION

CHAPTER 51-11C WAC

WASHINGTON STATE BUILDING CODE COUNCIL

EFFECTIVE JULY 1, 2020

History

WASHINGTON STATE
ENERGY CODE - RESIDENTIAL
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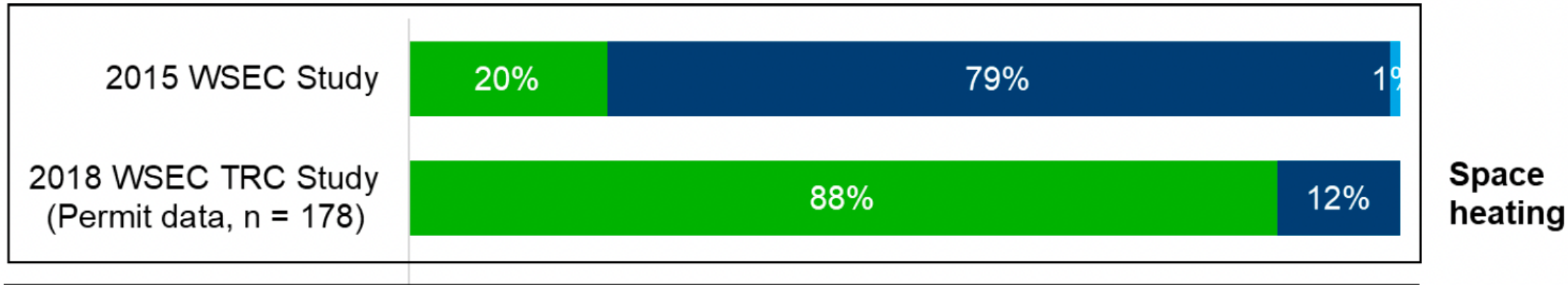
WASHINGTON STATE BUILDING CODE COUNCIL

EFFECTIVE JULY 1, 2020

TABLE R406.2
FUEL NORMALIZATION CREDITS

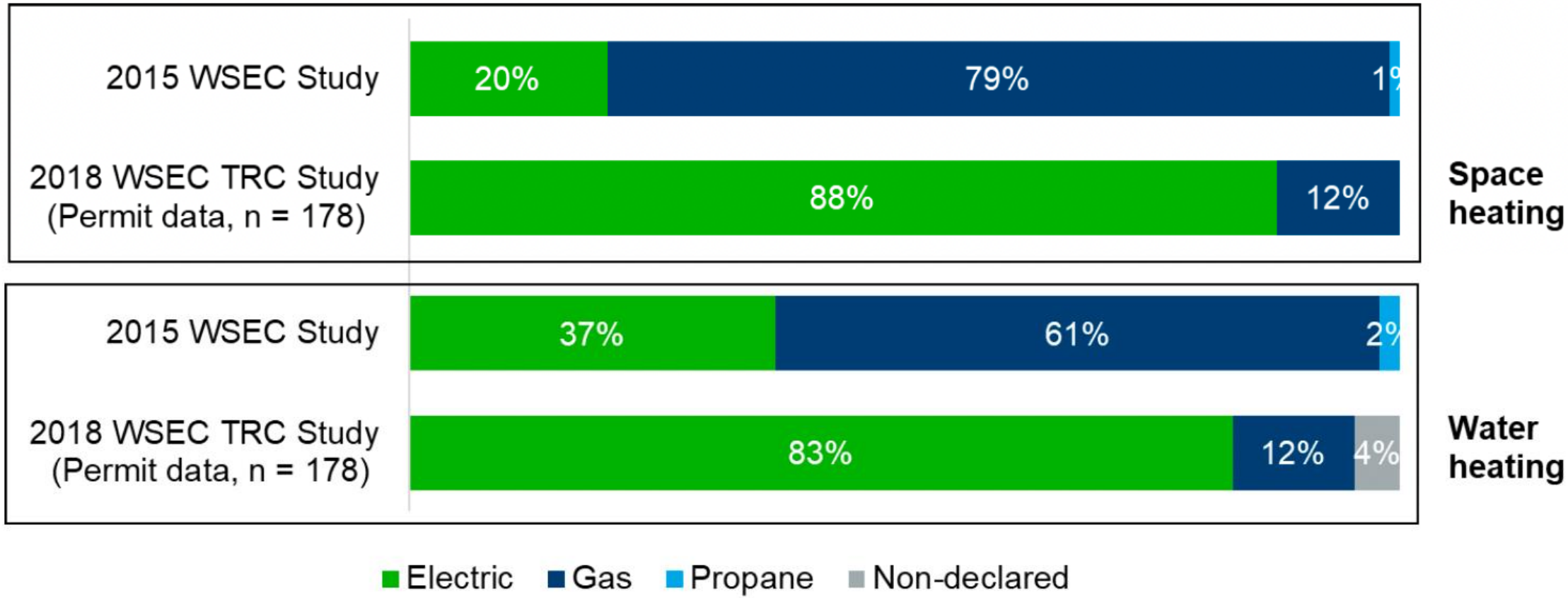
System Type	Description of Primary Heating Source	Credits	
		All Other	Group R-2
1	Combustion heating equipment meeting minimum federal efficiency standards for the equipment listed in Table C403.3.2(4) or C403.3.2(5)	0	0
2	For an initial heating system using a heat pump that meets federal standards for the equipment listed in Table C403.3.2(1)C or C403.3.2(2) **or** Air to water heat pump units that are configured to provide both heating and cooling and are rated in accordance with AHRI 550/590	1.0	1.0
3	For heating system based on electric resistance only (either forced air or Zonal)	-1.0	-1.0
4	For heating system based on electric resistance with a ductless mini-split heat pump system in accordance with Section R403.7.1 including the exception	0.5	N/A
5	All other heating systems	-1	-0.5

Figure 5. Fuel Choice for Space Heating and Water Heating



Source: NEEA. “Washington Residential Post-Code Market Research Report”

Figure 5. Fuel Choice for Space Heating and Water Heating



Source: NEEA. “Washington Residential Post-Code Market Research Report”

Thank You!

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nbi new buildings institute

www.newbuildings.org

Town of Crested Butte

Mel Yemma

Long-Range Planner

All Electric Building Codes

The Crested Butte Case Study

Denver City Council Meeting | March 6, 2023

Mel Yemma, AICP, Long-Range Planner, Town of Crested Butte

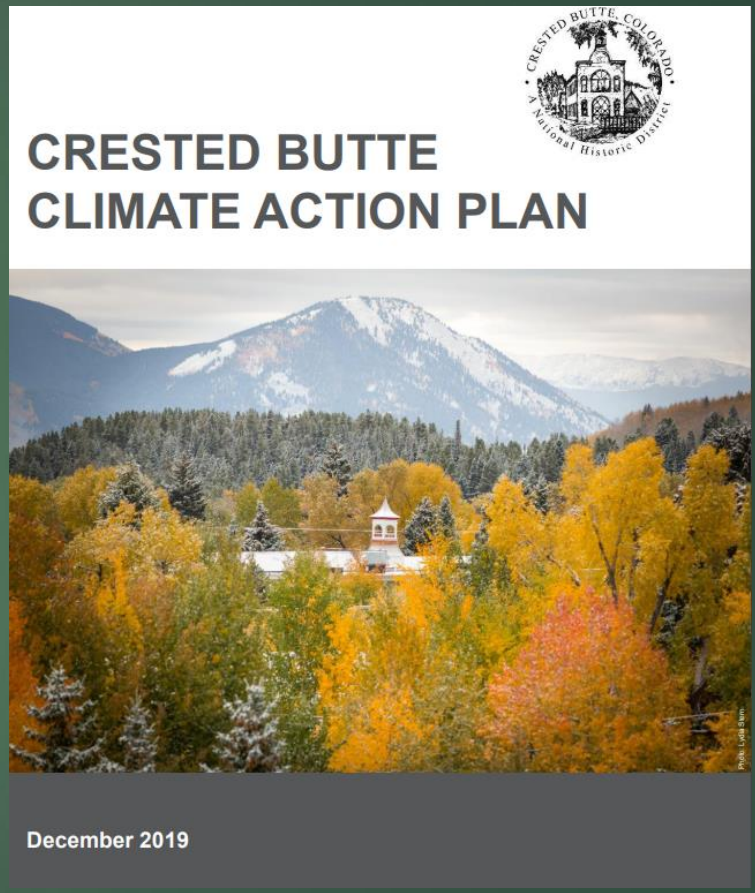
The Foundation

Short-Term Goals: Reduce Greenhouse Gas emissions of Town operations by 50% and the community at-large by 25%, by 2023

Long-Term Aspiration: Work towards becoming a net-zero community by 2030

Building Energy Use Chapter: Adopt above code standards and consider electrification policy

Another impetus: **Tri-State will reduce their GHG emissions by 80% by 2030** (approved ERP)



The Process

Feb - April

Research & Analysis

May - June

Public, Building Community, and Town Council Outreach

July - Aug

Adoption Process through Ordinance

Jan 2023

Effective Enforcement

Crested Butte 2021 Building Code (Residential)

New Construction

- Zero Energy Ready Home (ZERH) Certification
  - Includes solar ready provisions
- Electric Vehicle (EV) ready
- **Electric required**

Level III Remodels

- Home energy assessment
- EV ready
- **Electric ready**

Electrification: The Big Questions

- Does it work in this climate?
- Is electricity less carbon intensive than natural gas?
- Is it cost effective?
- Does our grid have the capacity? What about redundancy?
- How is it going now?

Does it work in this climate?

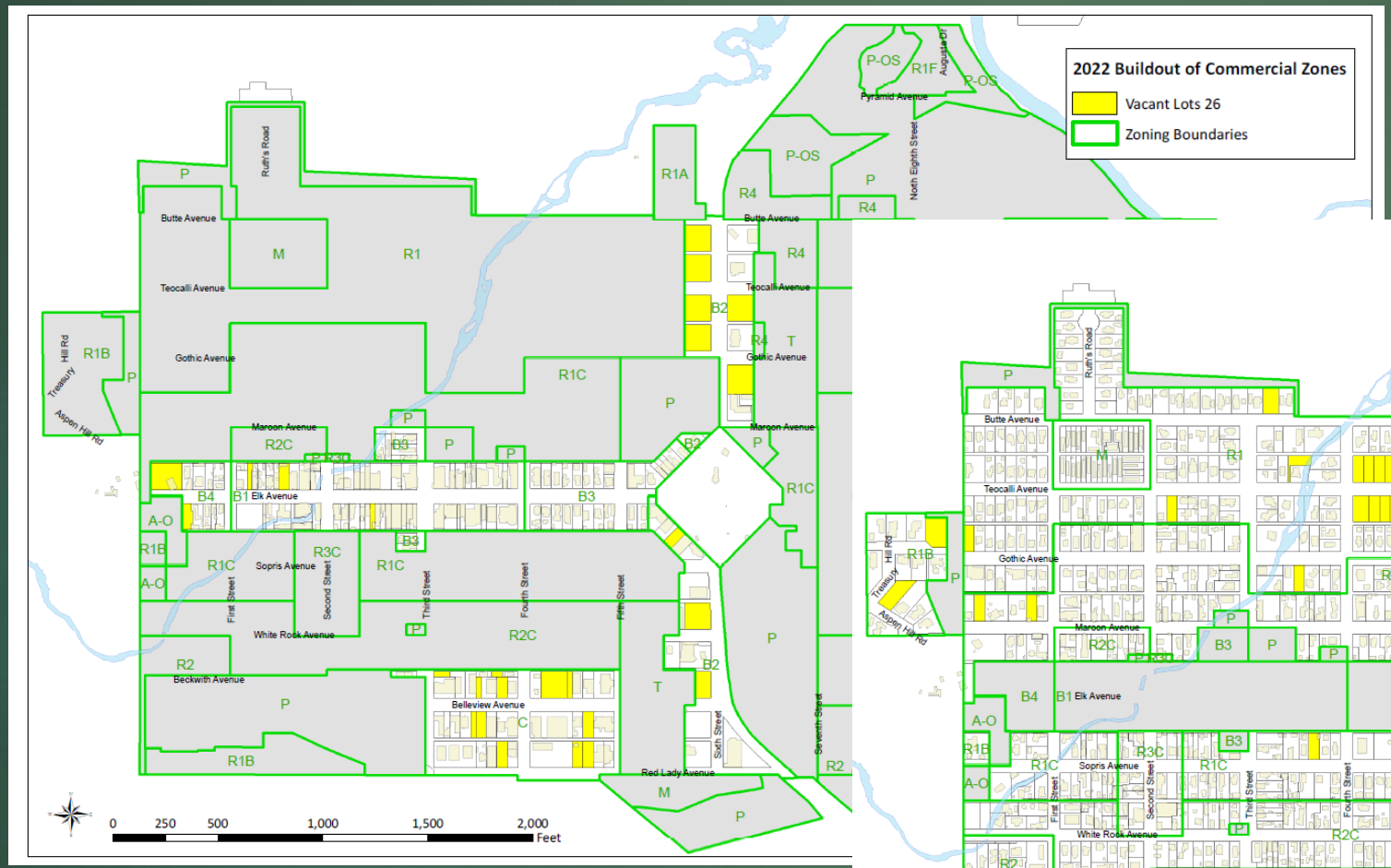
Is electricity actually less carbon intensive than natural gas?

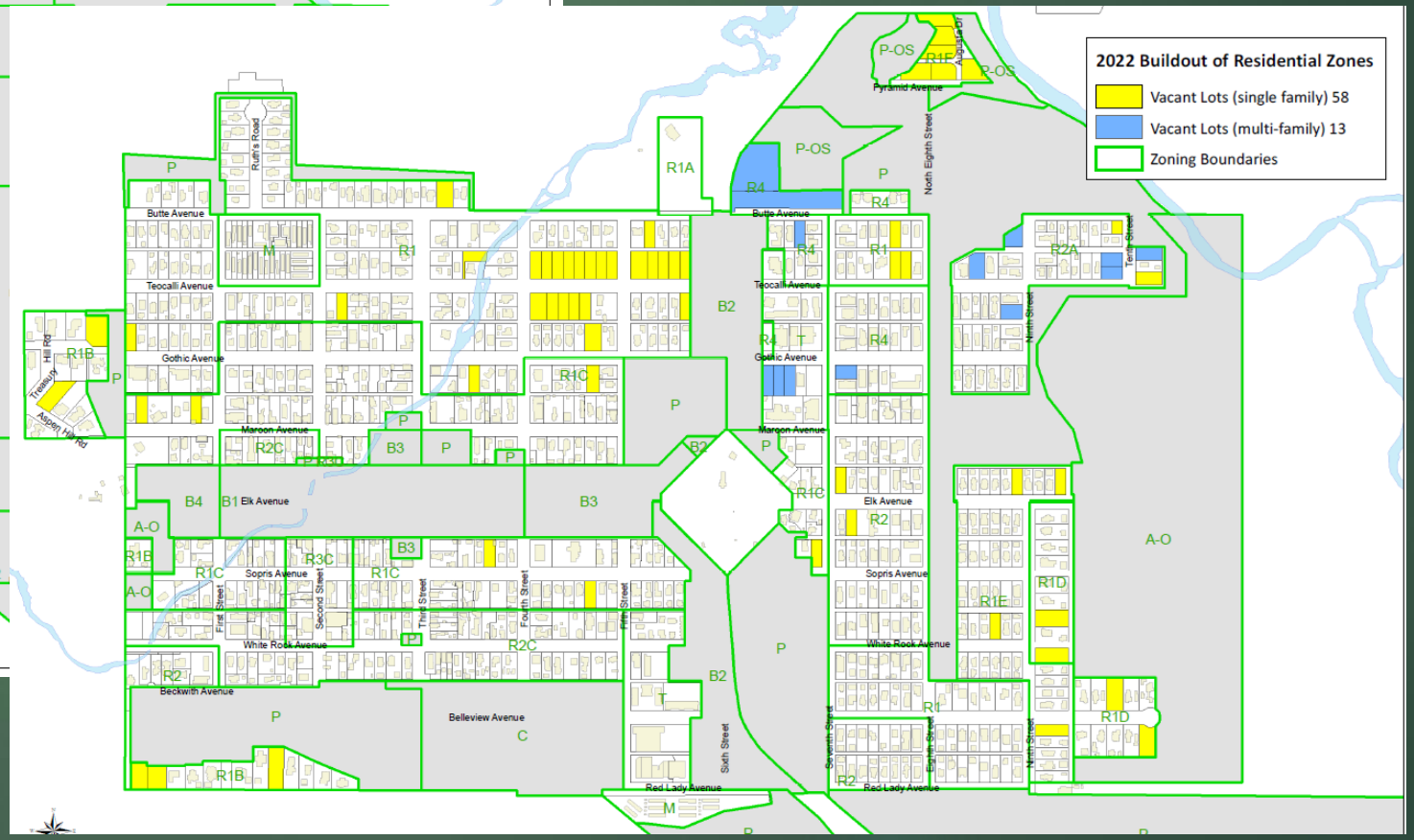
GHG Emissions Calculations for 3,000 sq ft home	Natural gas heating, hot water heating, and appliances	Electric heating, hot water heating, and appliances
Annual GHG Emissions from Energy Usage *(today's grid)*	37,242 lbs. carbon (18.6 tons)	33,082 lbs. carbon (16.5 tons)
Scenario: GHG Emissions (expected 2030 grid)	28,863 lbs. carbon (14.4 tons)	7,982 lbs. carbon (4 tons)
Scenario: GHG emissions with 10 kW solar (today's grid)	26,198 lbs. carbon (13.1 tons)	9,880 lbs. Carbon (4.9 tons)
Scenario: GHG emissions with 10 kW solar (2030 grid)	26,198 lbs. carbon (13.1 tons)	2,382 lbs. carbon (1.2 tons)

Is it cost effective?

	Natural Gas	Electric
HVAC Costs	**95% Efficient Gas Boiler**	**Cold-Climate Heat Pump with Hydronic Heat**
Equipment Cost	$3,500	$16,000 *(2 heat pumps based on size and energy usage)*
Available Rebates	*$300*	*$4,800*
Total Cost After Rebate	$3,200	$11,200
Energy Star Water Heater Costs	**Gas Water Heater**	**Heat Pump Water Heater**
Installed Cost	$1,500	$2,500
Available Rebates		*$740*
Total Cost After Rebate	$1,500	$1,760
Stove/Range	**Gas Stove**	**Electric Induction Stove**
Cost*	$3,200	$3,200
Available Rebates		$500 *($350 + 25% additional off purchase price up to $150)*
Total Cost After Rebate	$3,200	$2,700
Infrastructure Costs	**Gas Equipment**	**Electric Equipment**
Electrical modification		$500
Gas connection & piping	$12,600 *($2,100 gas line to house, $10,500 internal piping and ventilation)*	
Total Installation/Equipment Costs	**$20,500**	**$16,160**
Annual Energy Costs		
Calculated Annual Energy Costs	$2,008	$2,722
Scenario: Annual Energy Costs (with 10 kW of solar)	$1,099 *(off-setting lighting and other appliances)*	$813 *(off-setting heating, hot water heating, lighting, and appliances)*

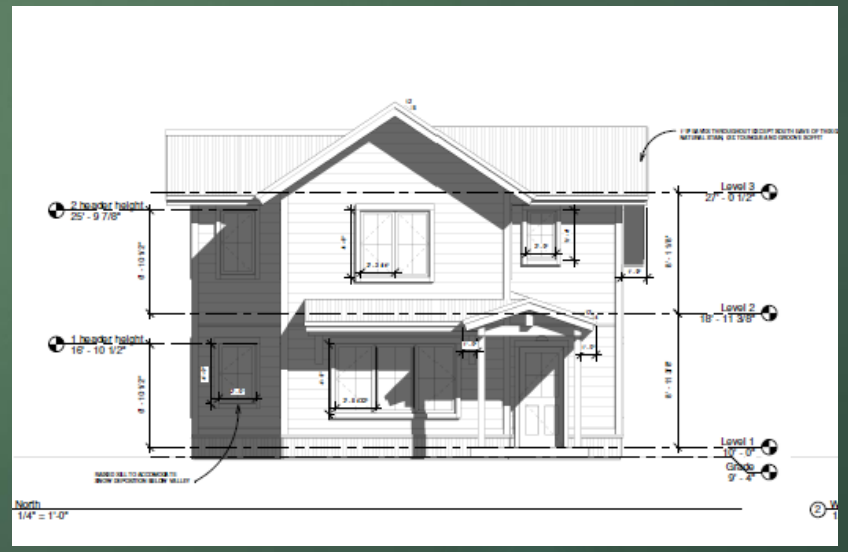
Do we have capacity? What if there is an outage?





How's it going so far?

- Projects coming in ranging from free market single family homes to affordable multi-family, duplex, triplex quad
- Overall positive perception
- Using Town housing projects as case studies to build capacity among contractors and work through hurdles



Colorado Energy Office

Keith Hay

Senior Director of Policy

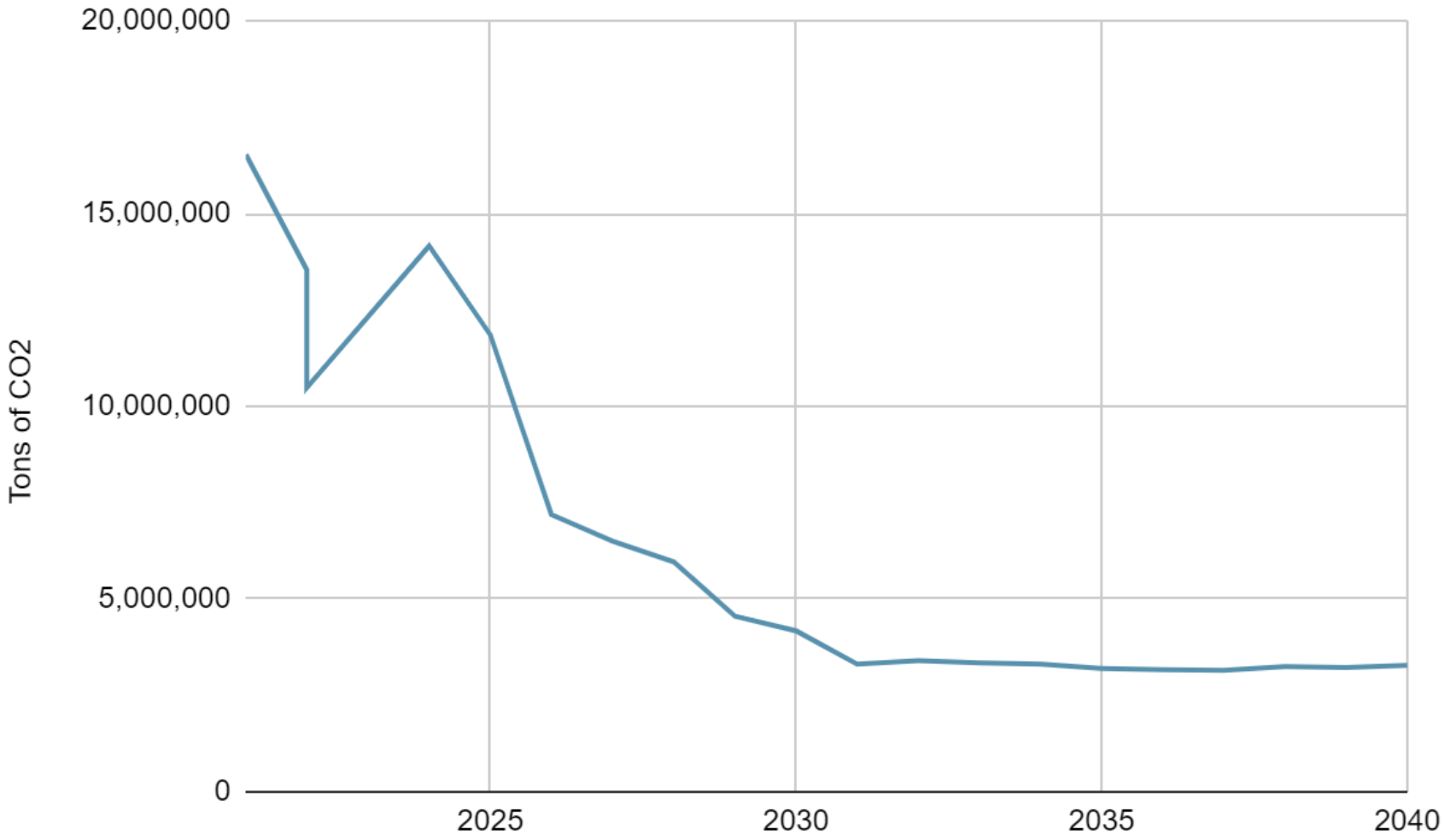
Colorado Building Energy Programs

March 6, 2023

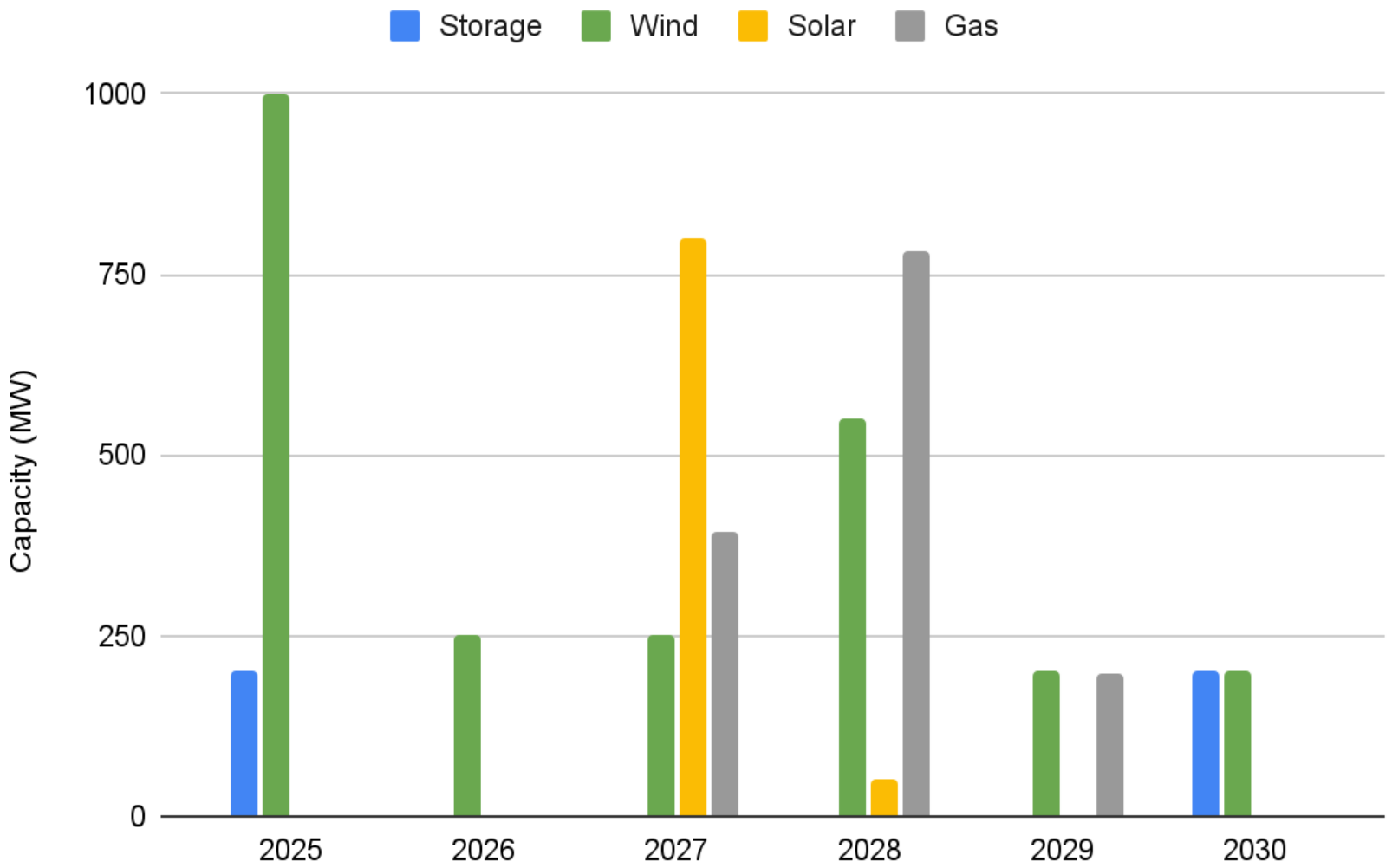
COLORADO
Energy Office

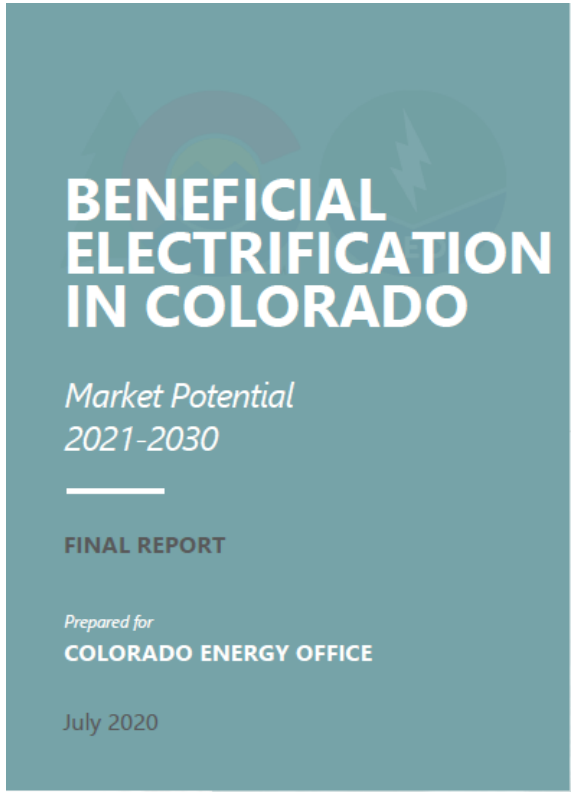
Colorado Energy Office: Mission & Vision

Xcel Energy Carbon Emissions Reductions



Xcel Energy - Forecasted New Capacity





	NATURAL GAS SALES	
Potential Scenario	2025 Reduction	2030 Reduction
Technical Potential	24%	47%
Economic Potential	13%	31%
High Electrification	1.6%	6.2%
Moderate Electrification	1.1%	3.3%

CEO Study of Gas and Building Decarbonization

What are the impacts and trade-offs of various long-term approaches to meeting State emissions reduction targets from space and water heating in residential and commercial applications?

How Much Money is Potentially Available Per Project?

Type of Home Energy Project	Household Income (HHI) below 80% Area Median Income (AMI)*	HHI between 80% and 150% AMI	HHI above 150% AMI
Efficiency project with at least 20% predicted energy savings**	80% of project costs up to $4,000	50% of project costs up to $2,000 (max of $200k for a multifamily building)	
Efficiency project with at least 35% predicted energy savings**	80% of project costs up to $8,000	50% of project costs up to $4,000 (max of $400k for a multifamily building)	
Home electrification project qualified technologies	100% of project costs up to $14,000	50% of project costs up to $14,000	Not eligible
	ENERGY STAR electric heat pump water heater: Up to $1,750		
	ENERGY STAR electric heat pump for space heating & cooling: Up to $8,000		
	ENERGY STAR electric heat pump clothes dryer: Up to $840		
	ENERGY STAR electric stove, cooktop, range, or oven: Up to $840		
	Electric load service center: Up to $4,000		
	Electric wiring: Up to $2,500		
	Insulation, air sealing, and ventilation: Up to $1,600		

*Look up AMI for your area: https://www.huduser.gov/portal/datasets/il.html#2022_query
**Other rebate amounts (roughly within these ranges) may be available if efficiency rebate rates are determined through measured performance.
Source: U.S. Department of Energy, Office of State & Community Energy Programs

Tax Credits Available for New All-Electric Homes

Equipment Type	**Available Tax Credit**
Geothermal Heat Pump	30% of total cost
Solar thermal for water heating	30% of total cost
Home Energy Performance Standard	**Available Tax Credit**
Energy Star Certified Home - highly efficient home	Up to $2,500 per single family duplex, or townhome Up to $500 per dwelling unit in a multifamily building
Zero Energy Ready Certified Home* - home that is so efficient that onsite renewable energy can offset energy use	Up to $5,000 per single family, duplex, or townhome Up to $1,000 per dwelling unit in a multifamily building

*Does not technically require all-electric construction, but is very difficult to achieve in mixed fuel buildings

energyoffice.colorado.gov

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COLORADO
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METUS

Shawn LeMons

Performance Construction Manager

DENVER
CLIMATE ACTION, SUSTAINABILITY & RESILIENCY

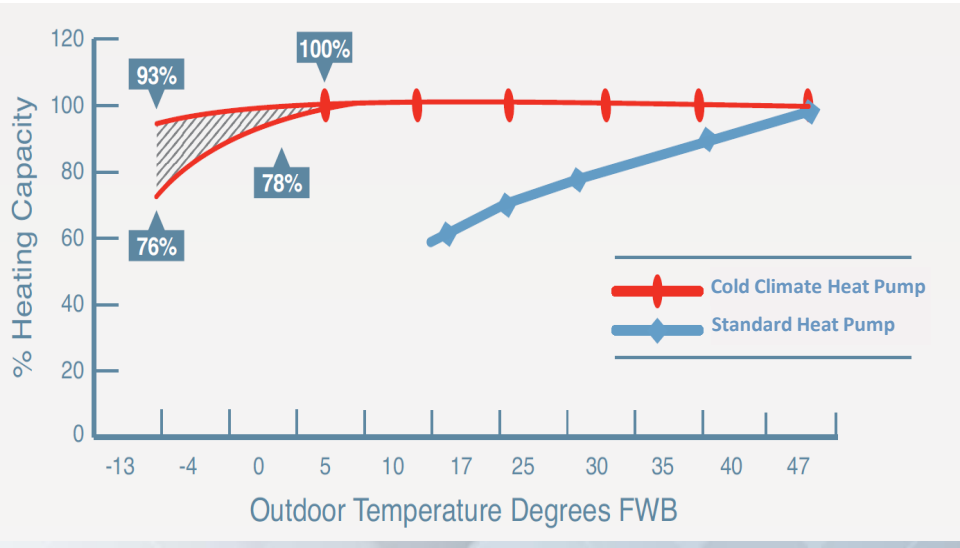
Cold Climate ASHPs – They Actually Work

Feb. 21, 2023

Shawn LeMons

Performance Construction Mgr, METUS

(Former BPI, IECC, RESNET, LEED, PHIUS, Thermography)



What Heat Pumps Do

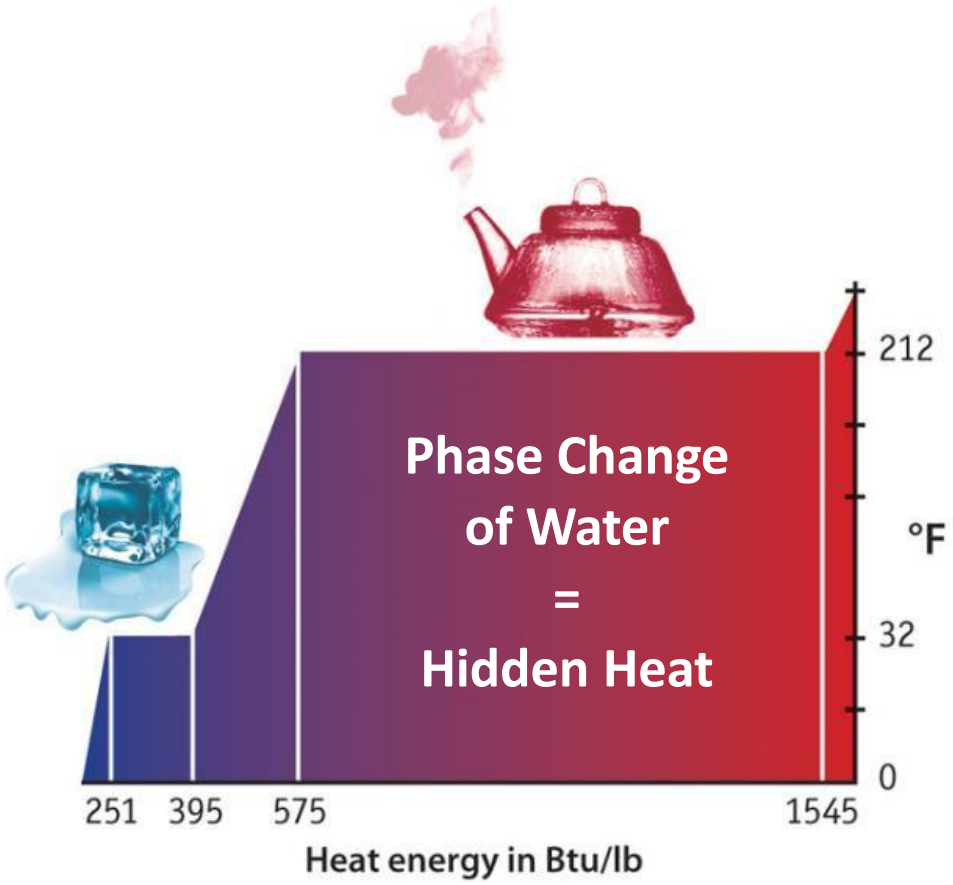
They pump heat to <u>where you want it.</u>

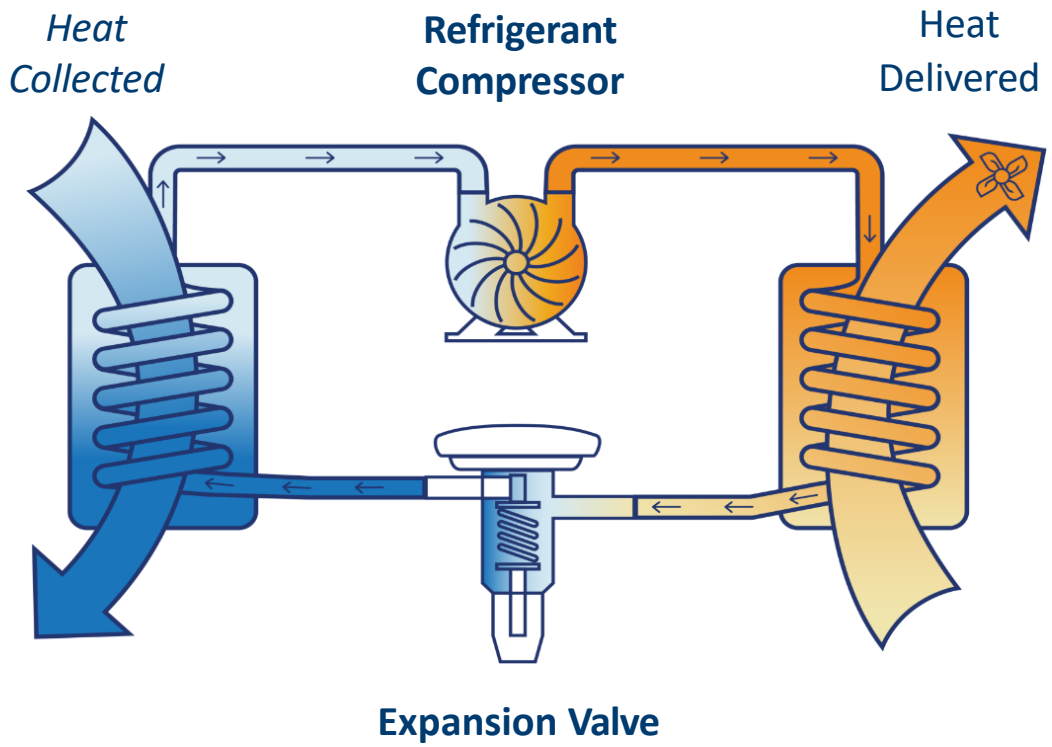
Summer / Cooling

Winter / Heating

How Heat Pumps Work

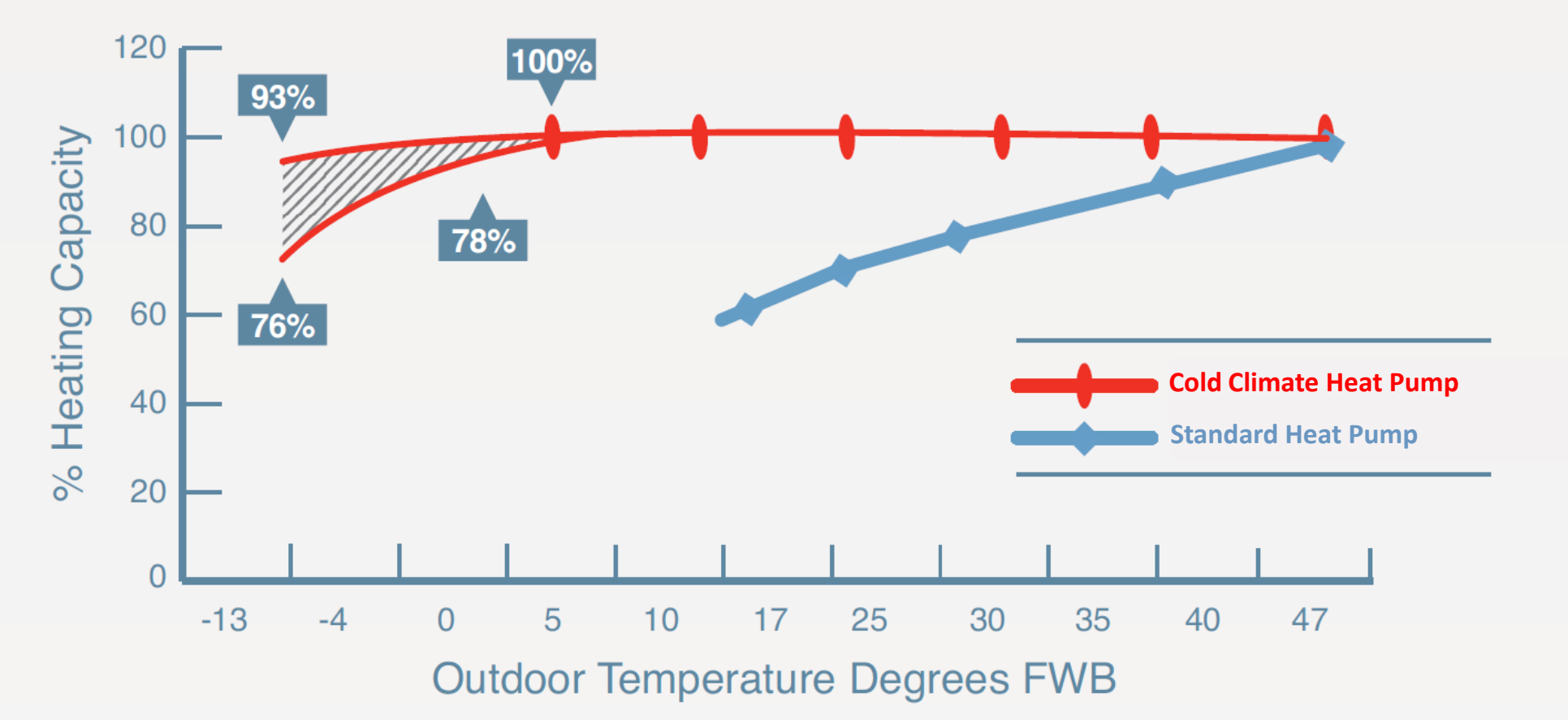
Heat pumps use <u>phase change of refrigerants.</u>





Cold Climate Heat Pumps

Cold climate heat pumps are <u>purpose-built for cold weather</u>

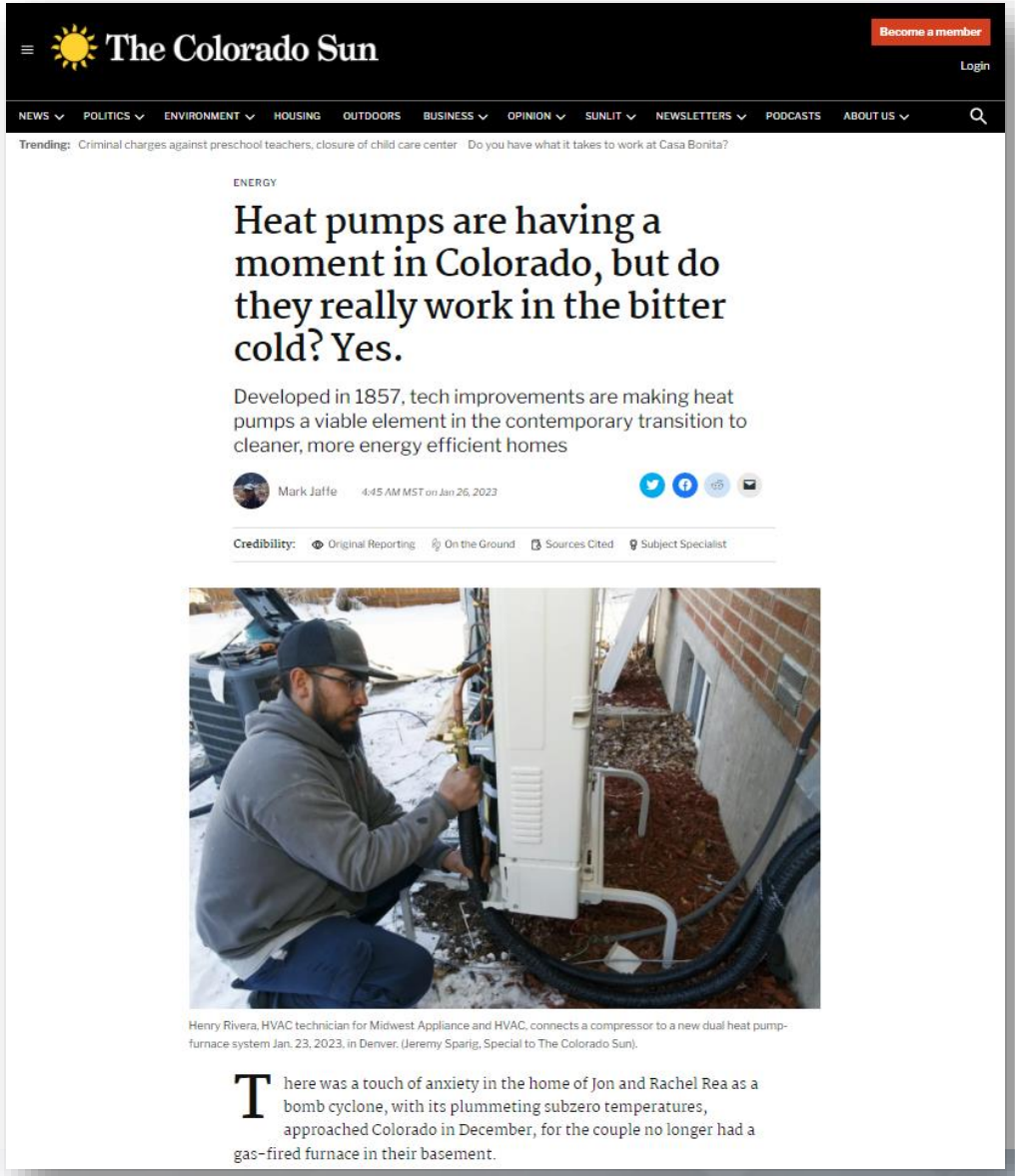


The Right Product for the Project

The temperature in Boulder on the night of Dec. 22 fell to 18 below.

“Overall, it was just another day,” Jon Rea said. “It was not much of an event.”

The heat pump was working nearly full-time during the cold snap, but the house remained comfortable, Rea said.



The Colorado Sun

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Trending: Criminal charges against preschool teachers, closure of child care center Do you have what it takes to work at Casa Bonita?

ENERGY

Heat pumps are having a moment in Colorado, but do they really work in the bitter cold? Yes.

Developed in 1857, tech improvements are making heat pumps a viable element in the contemporary transition to cleaner, more energy efficient homes

Mark Jaffe 4:45 AM MST on Jan 26, 2023

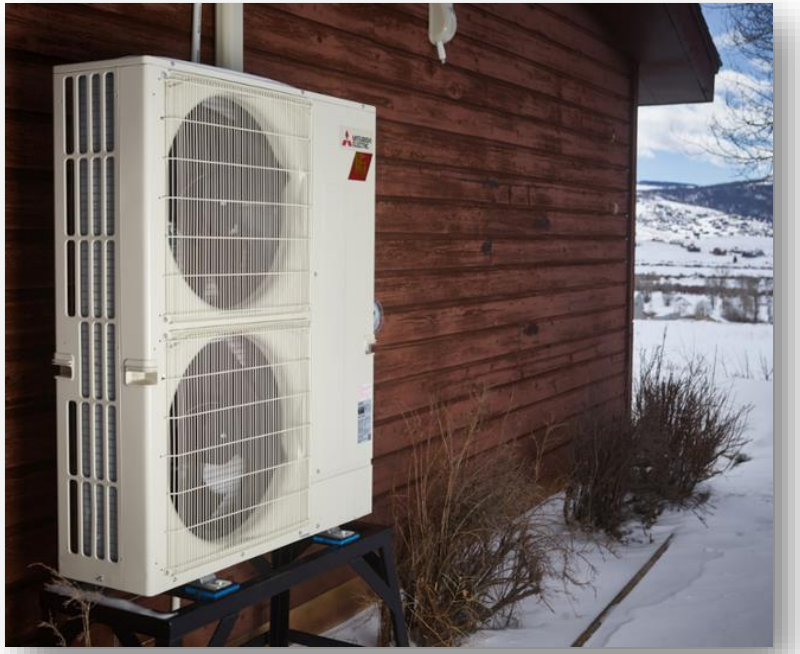
Credibility: Original Reporting On the Ground Sources Cited Subject Specialist

Henry Rivera, HVAC technician for Midwest Appliance and HVAC, connects a compressor to a new dual heat pump-furnace system Jan. 23, 2023, in Denver. (Jeremy Sparig, Special to The Colorado Sun).

There was a touch of anxiety in the home of Jon and Rachel Rea as a bomb cyclone, with its plummeting subzero temperatures, approached Colorado in December, for the couple no longer had a gas-fired furnace in their basement.

https://coloradosun.com/2023/01/26/heat-pumps-work-colorado/

“Heat pumps work when its cold”



Joe P’s home
Fraser, CO (8,600 ft elevation)
Installed 2015
“Operates below -30°F”

Joe & Kristen’s home
Fraser, CO (8,800 ft elevation)
Installed 2020
“Haven’t needed backup heat”

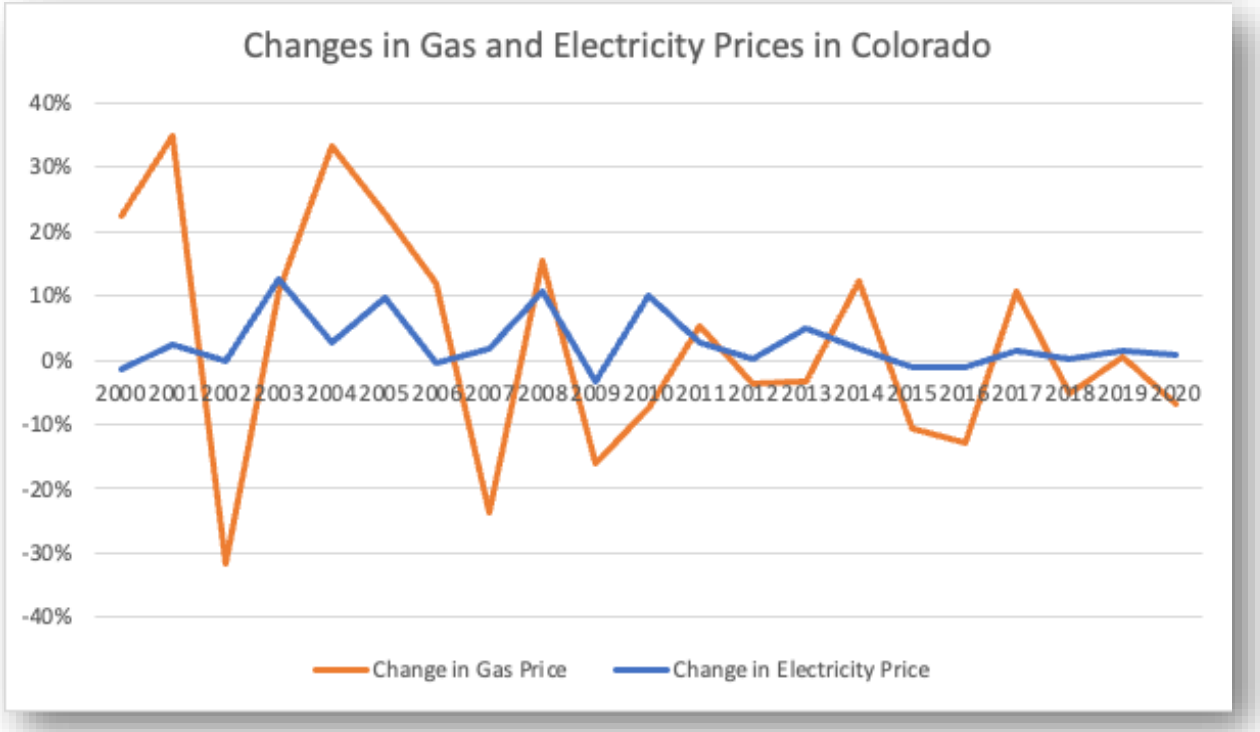
“Heat pumps work when its cold”

Greg Follet
Fish Builders of Colorado
Salida, CO
7,600 ft elevation

“The temperature according to my truck was -22 °F.
I was amazed to walk in and find it to be very comfortable inside.”

Energy Costs Volatility

US EIA



Shawn's January Bills

Nat Gas Rates (no fixed fees)

2021 $52 / 94 Therms = **$0.56** / Therm

2022 $17 / 18 Therms = **$0.97** / Therm (heat pump)

2023 $28 / 21 Therms = **$1.35** / Therm

141% increase

Electric Rates (no fixed fees)

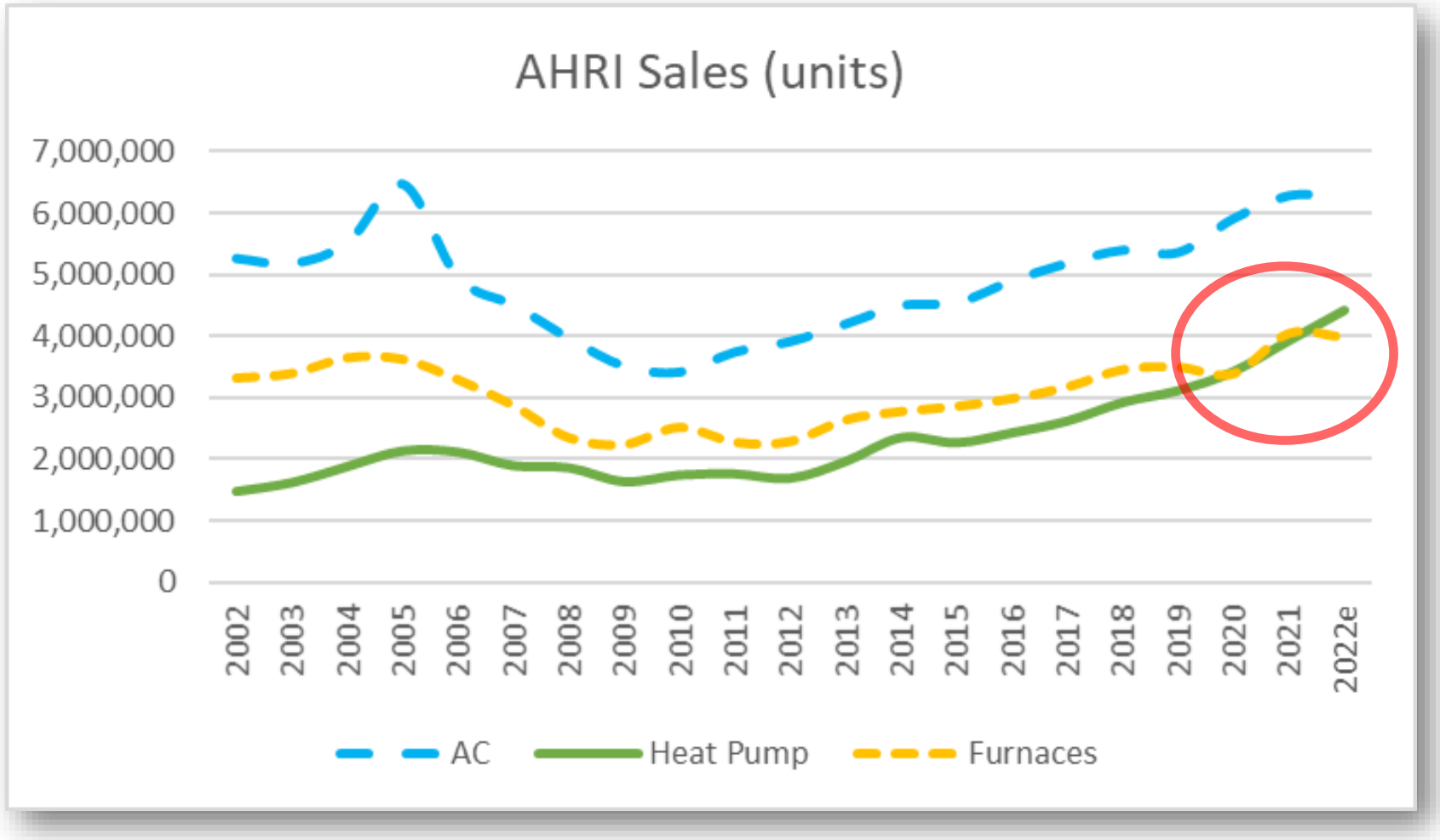
2021 $23 / 196 kWh = $0.115 / kWh

2022 $117 / 962 kWh = $0.121 / kWh (heat pump)

2023 $237 / 1635 kWh = $0.145 / kWh (EV)

26% increase

Heat Pumps Overtake Furnaces



Heat Pump Inflection Point

https://www.ahrinet.org/analytics/statistics/monthly-shipments

Big Changes in 14 Years

1935

10%
Farms with Electricity

1949

70%
Farms with Electricity

Industry Needs Clarity and Consistency

Professionals need long-term program reliability to build their businesses

Building Professionals – Staff up & tool up
IRA related Skilled trades – Career pathways and guidance
Manufacturers & Distributors – Provide the right product and field support

Thank you for all you do!

Shawn LeMons
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720-648-0505

Diverge Homes

Nick Jacobs, President

DIVERGE HOMES

Nick Jacobs
President
Diverge Homes

Agenda

1. About Diverge Homes
2. Catalyst for Building All-Electric Homes
3. Business Case
4. Q & A

March 3, 2023

PHOTO BY NIKUNJ SINGH ON UNSPLASH

DIVERGE HOMES

Who We Are

Mission-Based Homebuilder

- Rebuild American Small Towns
- Reduce Suburban Sprawl
- Build New & Sell to Owners

Founded 2016, Lafayette CO

$6M-$10M Annual Revenues

110+ Units in 5-Year Pipeline

Our Catalyst for All-Electric Homebuilding

December 30th, 2021

<u>Diverge Mission</u>
After Marshall Fire

1. All-Electrification
2. Custom/Client-Facing Building

Diverge is now 100% All-Electric Homebuilder

Changing to All-Electric

	Big Changes $ or Culture	No Material Change*
ENERGY STAR® NextGen All-Electric	Mechanicals Electrical Systems Appliance (Range) Solar PV	Foundation Framing Techniques Insulation Lighting & Plumb 35+ Other Cost Categories

Subcontractor Costs
Comparison to 2021 IECC Gas Install

Prior to Credits, Incentives & Other Deducts Assumptions: SFH 2,200 Above Grade Livable Area Margin of Error +/- 5%		
HVAC	Air Source Heat Pump Cool/Heat	$13,485 (40%)
Plumbing	Air Source Heat Pump Water Heating	$1,000 (10%)
Electrical	Xcel Service Upgrade 200A-300A	$2,452 (n/a)
	Electrical Smart Panel 200A w/1 L2 Charger	$4,000
	Avoid Gas Infrastructure	- $650 Reduced
Kitchen	Induction Range	$450 to $2,200 (10%)

Cost Increase

$17,500 to $25,000

What the Marshall Fire taught re: Electrification

1. Owners like cleaner air inside their home.
2. Owners will invest in improving the environment outside their home.
3. Owners want lower utility bills.
4. Losing electric power doesn't mean losing heat.
5. A back-up generator running a gas furnace spends more than if running a heat-pump
6. Solar panels are the perfect back-up generator!

The Marshall Fire incentives proved the carrot is far mightier than the stick.

Thank You
Q & A

DIVERGE HOMES

National Jewish Health

Jim Crooks

National Jewish Health®

Gas Appliances, Indoor Air Quality, and Health

James L. Crooks, Ph.D., M.S.
Associate Professor, National Jewish Health
Clinical Associate Professor, Colorado School of Public Health

National Jewish Health®

Pollutants in gas itself

- Methane (GHG)
- Benzene (carcinogen)
- Other Hazardous Air Pollutants known to be toxic (toluene, hexane, heptane, cyclohexane…)

Pollutants produced by burning gas

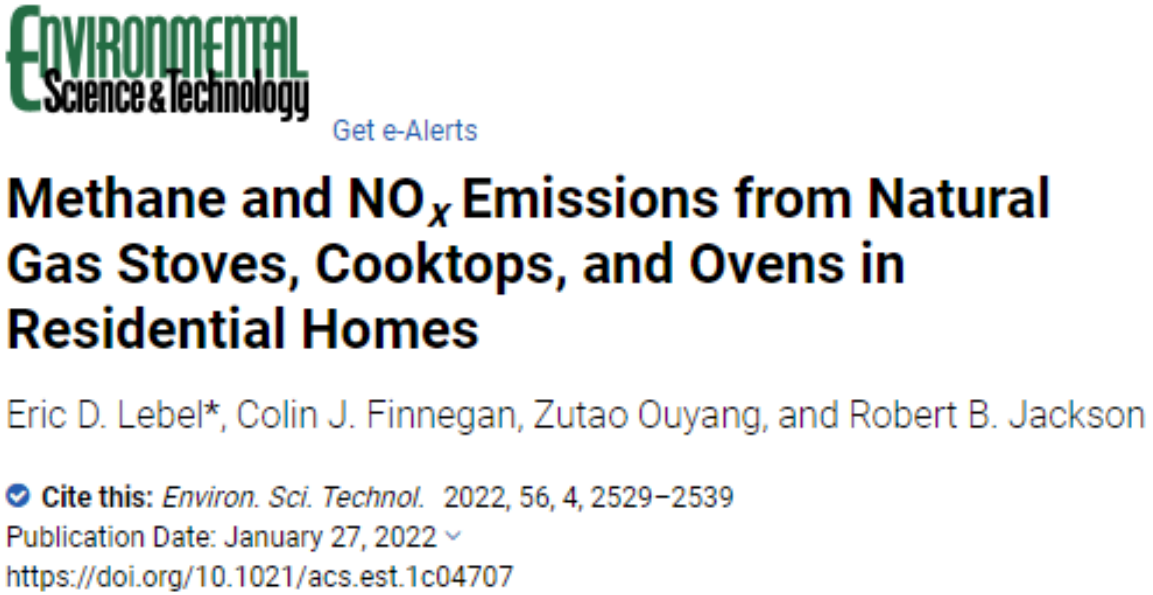
- Carbon dioxide (GHG)
- Nitrogen oxides (causes respiratory symptoms)
- Carbon monoxide

Drew R. Michanowicz, Archana Dayalu, Curtis L. Nordgaard, Jonathan J. Buonocore, Molly W. Fairchild, Robert Ackley, Jessica E. Schiff, Abbie Liu, Nathan G. Phillips, Audrey Schulman, Zeyneb Magavi, and John D. Spengler. *Environmental Science & Technology* **2022** *56* (14), 10258-10268. DOI: 10.1021/acs.est.1c08298

National Jewish Health®

Gas stoves leak even when not in use and have a significant greenhouse gas foot print

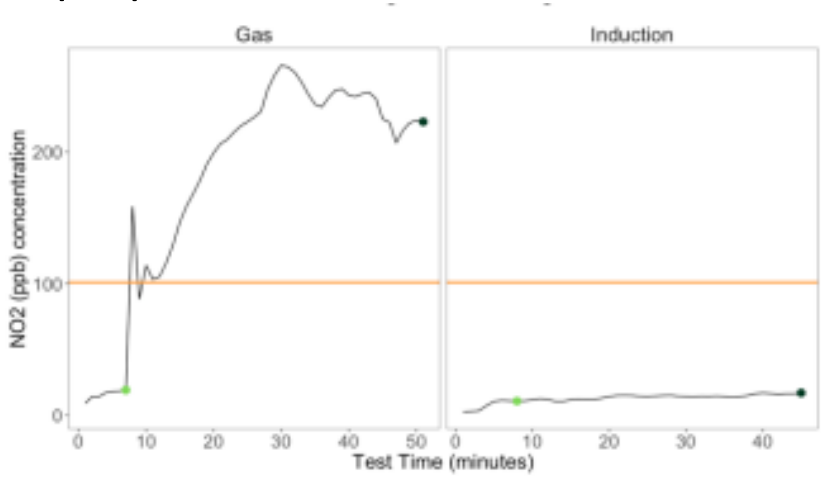
- Over 24 hours, ¾ of methane was emitted when the appliance **was turned off**.
- Extrapolating up to the whole U.S., methane from gas stoves would have the carbon footprint of 500,000 cars.
- Gas stove use also produced levels of nitrogen oxides well above EPA outdoor limits when proper ventilation was not used.



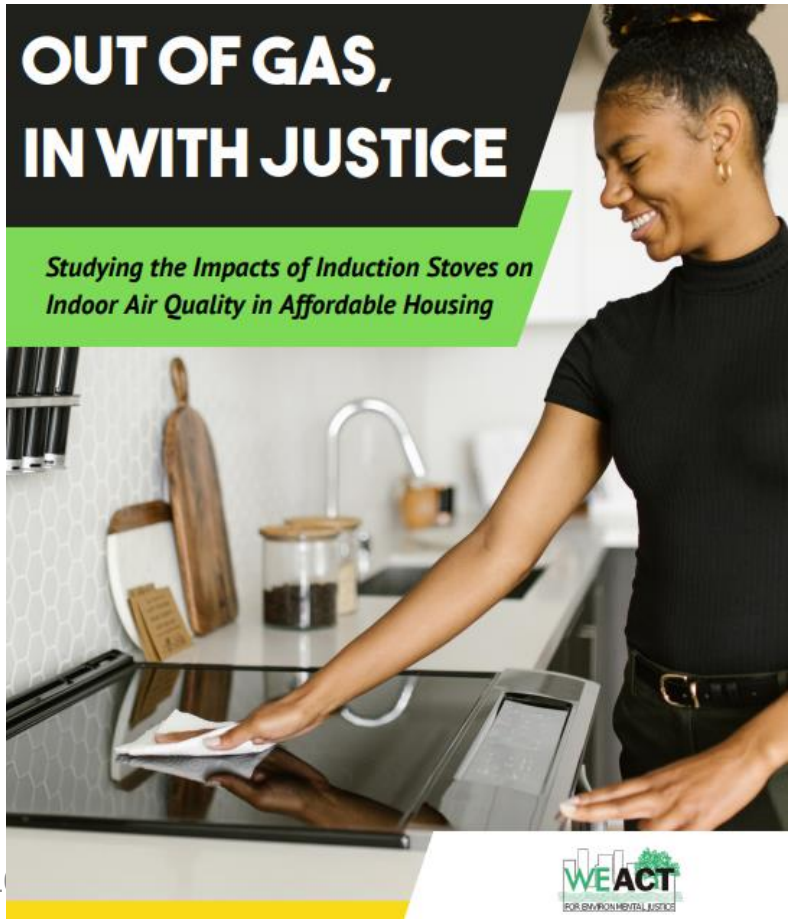
National Jewish Health®

Air pollution is higher in affordable housing units with gas stoves compared to those with induction stoves

- Nitrogen dioxide concentrations in kitchens with gas stoves were on average 190% higher than in kitchens with induction stoves during meal preparation.



- Over 24 hours, households with induction stoves experienced 35% lower nitrogen dioxide concentrations compared to those using gas stoves.



National Jewish Health®

Gas appliances are linked to asthma in children

- Having gas appliances in the home was associated with a 32% increased risk of asthma among children living in the home.

Meta-analysis of the effects of indoor nitrogen dioxide and gas cooking on asthma and wheeze in children FREE

Weiwei Lin, Bert Brunekreef, Ulrike Gehring ✉

International Journal of Epidemiology, Volume 42, Issue 6, December 2013, Pages 1724–1737, https://doi.org/10.1093/ije/dyt150

National Jewish Health®

Gas stoves are estimated to be responsible for many childhood asthma cases

- Approximately 12.7% of U.S. childhood asthma cases are attributed to gas stoves in the home.
- In Colorado, the estimate is 10.8% of asthma cases.

Population Attributable Fraction of Gas Stoves and Childhood Asthma in the United States

by Talor Gruenwald [1,†], Brady A. Seals [1,*], Luke D. Knibbs [2,3] and H. Dean Hosgood III [4]

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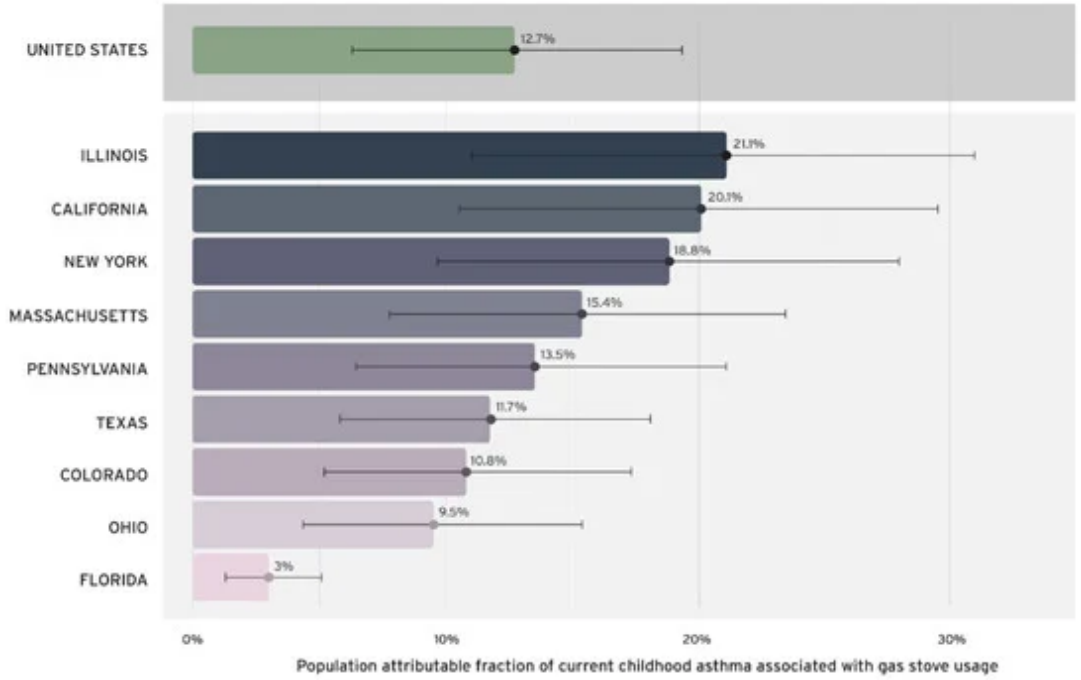
Int. J. Environ. Res. Public Health **2023**, *20*(1), 75; https://doi.org/10.3390/ijerph20010075



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The role of ventilation

- Ventilation helps prevent harm, but…

- Ventilation does nothing to reduce greenhouse gases.
- Not every kitchen has a ventilation fan.
- Not every kitchen fan ventilates effectively.
- People often don’t run the ventilation fan.
- Some pollution is released when the stove is off, when residents usually don’t run the fan.
- Kitchen ventilation may not help mitigate harm from gas furnaces, boilers, or water heaters.

Thank you!

Appendix of Additional Information

What's Already in Denver Commercial Building Code & Energy Code Today?

(Mandatory Partial Electrification Starting January 1, 2024)

- C403.2.4 – Electric for Space Heating
- C403.2.5 – Electric for Service Water Heating

- Already Effective as of March 1, 2023 - Parity of Permitting Process for:
  - C503.3.3 - Gas/Electric for Space Heating
  - C503.4.1 - Gas/Electric for Service Water Heating

CASR New Building Electrification Incentive Program

Design Support: partial funding for drawing sets and as-built drawings that can be reviewed by Denver builders to help inform how electrification can work for their projects

Pilot Projects: partial funding for builders or property owners interested in leveraging city funds to help a new building project be built all-electric

Equity Focus: 50% of the pilot project funds will be prioritized for affordable housing or otherwise serve or benefit equity priority buildings in Denver. Denver-based and/or MWBE firms and organizations are especially encouraged to apply for incentives.