

# Zero Energy Healthcare

How Integrative Design Produced a Facility  
Operating Less than \$0.41/ SF/ Yr.



# How Zero Energy Buildings Fit into the Bigger Picture

? Why Change?

🧩 Pueblo Community Healthcare Clinic

📺 Results

🔄 How the team made it happen

♻️ What's next?



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# Learning Objectives

- **Understand industry terms** for measurement of building energy use
- **Learn about the process** applied to achieve Zero Energy certification
- **Increase knowledge** regarding goal setting, energy modeling and integrated design
- Understand how Zero Energy building strategies:
- **Reduce** the impact on the environment
- **Impact** the project's bottom line
- **Benefit** the communities they serve



# Why We Need Zero Energy Buildings



## “ Question

How much did global CO2 emissions drop in 2020 due to the pandemic (from 2019 levels)?

A) 21%

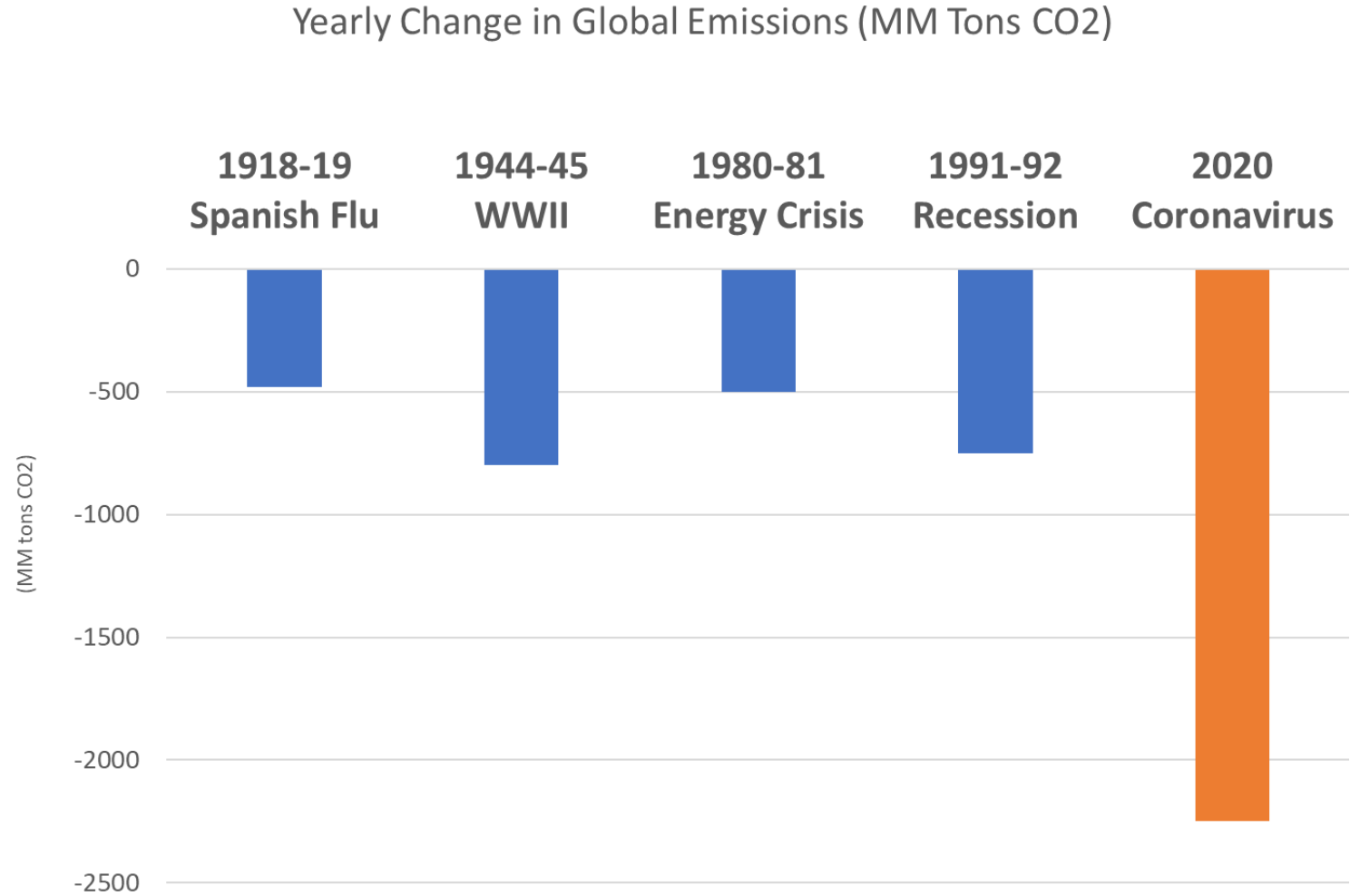
B) 65%

C) 6%

D) 96%

”

The world shut down  
and CO2 emissions  
only fell 6%!



## “ Question

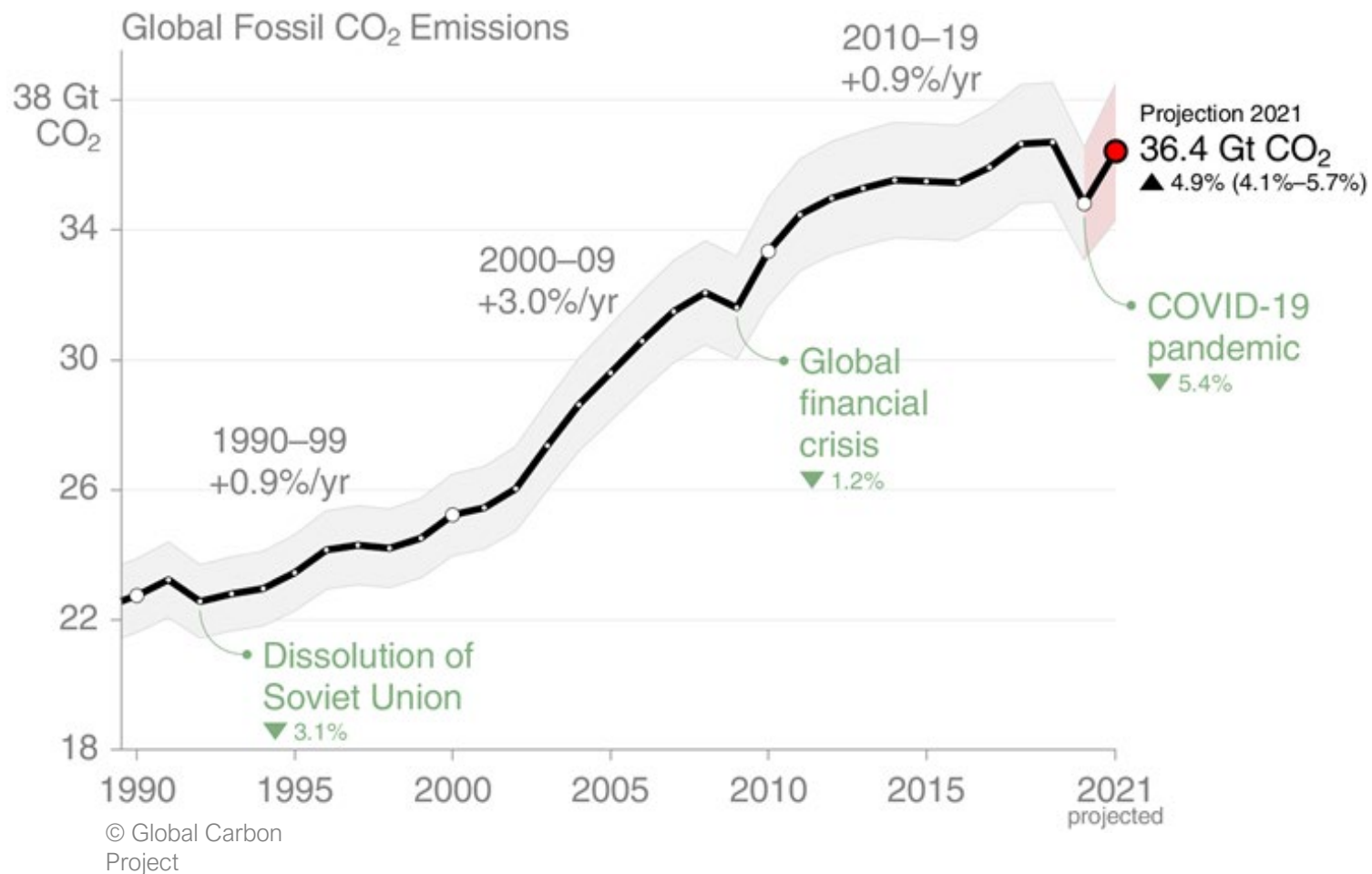
The reduced CO2 levels in 2020 are equivalent to the CO2 levels in:

A) 1957 B) 1985 C) 2012 D) 1996

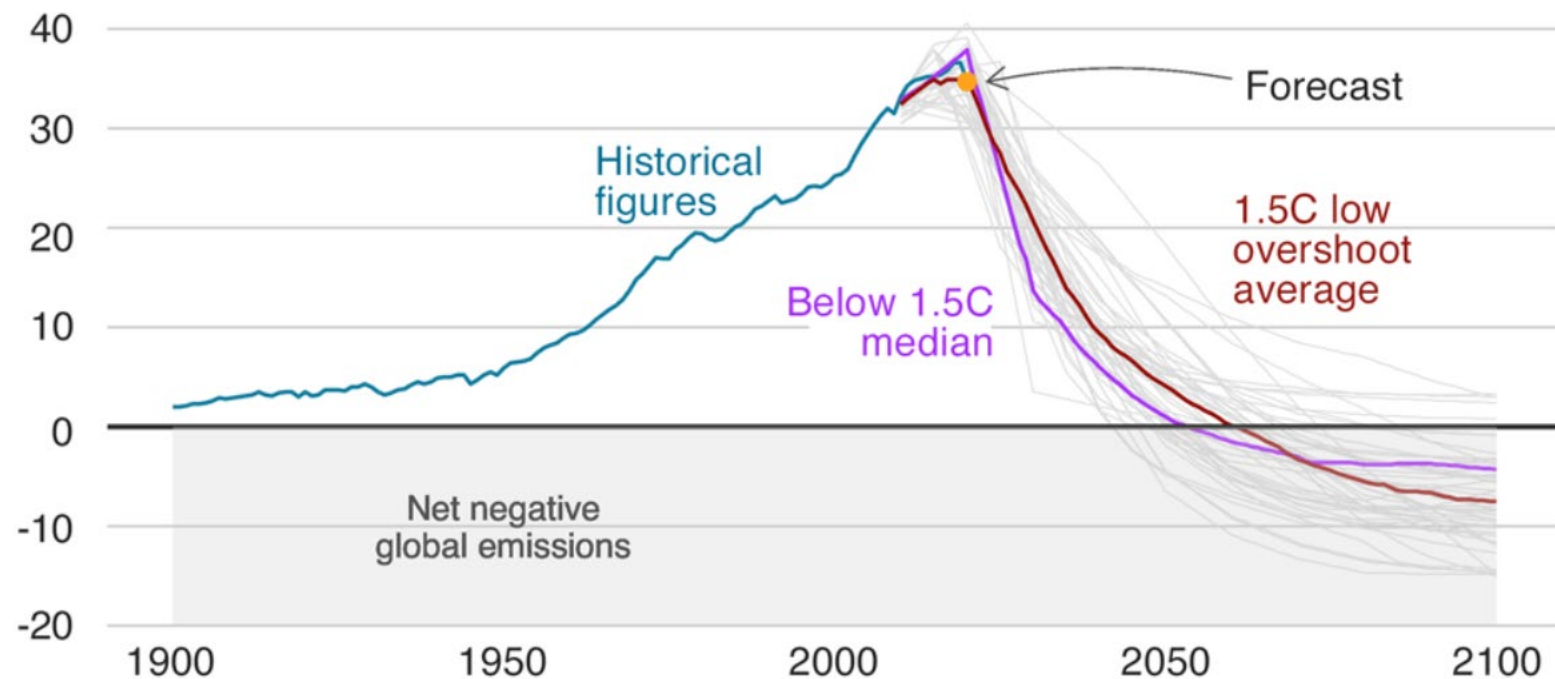
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The world needs to drop CO2 levels similar to the 2020 Pandemic

To achieve 1.5 C° (Paris Climate Agreement)



CO2 emissions must immediately decrease and reach net-negative by 2050 to keep global temperature rise to 1.5°C



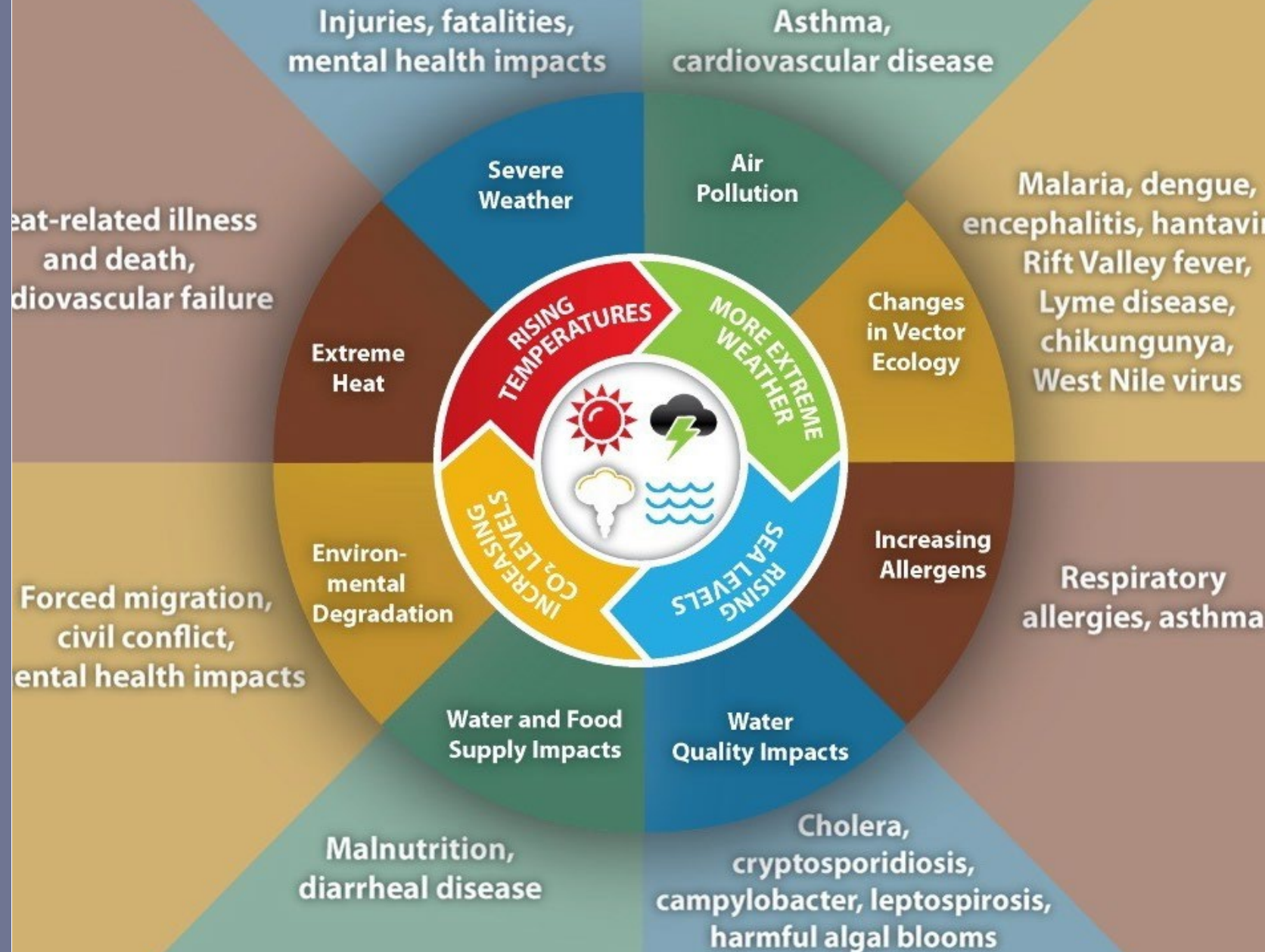
Source: Glen Peters, IAMC, IIASA



**What is healthcare's responsibility?**

# Impact of Climate Change on Human Health

Healthcare contributes over 10% of US greenhouse gas emissions. That's equal to 141 coal-fired power plants per year.



Department of Health & Human Services (HHS) is urging health systems to commit to reducing greenhouse gas (GHG) emissions:

**50%**  
by 2030

**Net zero**  
by 2050

# Climate Change & Health

The NEW ENGLAND  
JOURNAL of MEDICINE

January 17, 2019

## The Imperative for Climate Action to Protect Health

Andy Haines, M.D., and Kristie Ebi, M.P.H., Ph.D.

**C**LIMATE CHANGE IS ALREADY ADVERSELY AFFECTING HUMAN HEALTH and health systems,<sup>1,2</sup> and projected climate change is expected to alter the geographic range and burden of a variety of climate-sensitive health outcomes and to affect the functioning of public health and health care systems. If no additional actions are taken, then over the coming decades, substantial increases in morbidity and mortality are expected in association with a range of health outcomes, including heat-related illnesses, illnesses caused by poor air quality, undernutrition from reduced food quality and security, and selected vectorborne diseases in some locations; at the same time, worker productivity is expected to decrease, particularly at low latitudes.<sup>3,4</sup> Vulnerable populations and regions will be differentially affected, with expected increases in poverty and

# Health Care Industry Emissions

## Health Care System to Reckon with the Human Costs of Climate Change Health Affairs

October 16, 2019

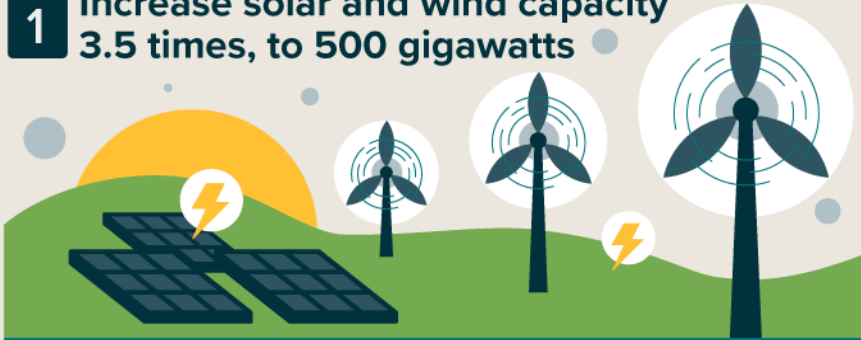
### The Health Care Industry Paradox

Health care institutions are some of the biggest culprits in climate change. The US health care sector singlehandedly produces about 10 percent of the nation's total annual carbon emissions; in 2011 alone it pumped out 655 million metric tons of carbon dioxide and other greenhouse gases (GHGs). Collectively, it is the 13th-largest producer (1) of carbon dioxide worldwide. A 2018 study estimated that, annually, GHG emissions from large US health care organizations took 123,000 to 381,000 years off of the total life expectancy of the US population. It seems paradoxical that institutions dedicated to healing would play a major role in jeopardizing human health. Yet, health care organizations lag behind every other economic sector in sustainability reporting, a practice that is common among large businesses; more than 78 percent of the S&P 500 issued public reports about environmental stewardship in 2018. Even as the business world embraces greater transparency and accountability regarding climate change, most health care organizations have failed to follow suit.

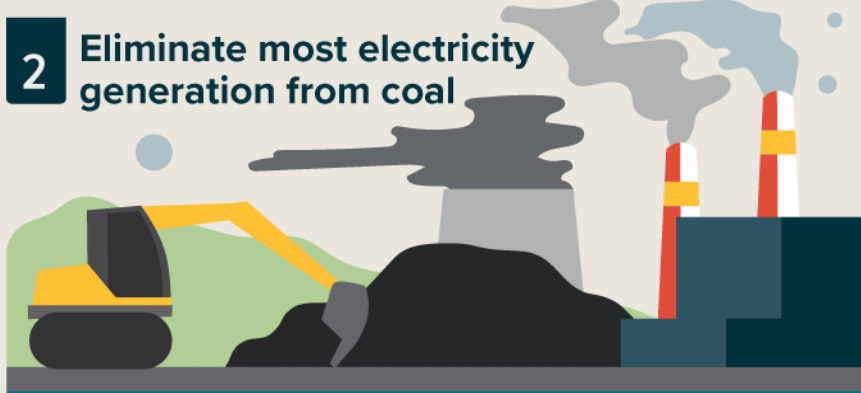
# Getting to Net-Zero Carbon Emissions by 2050

## 8 actions needed by 2030

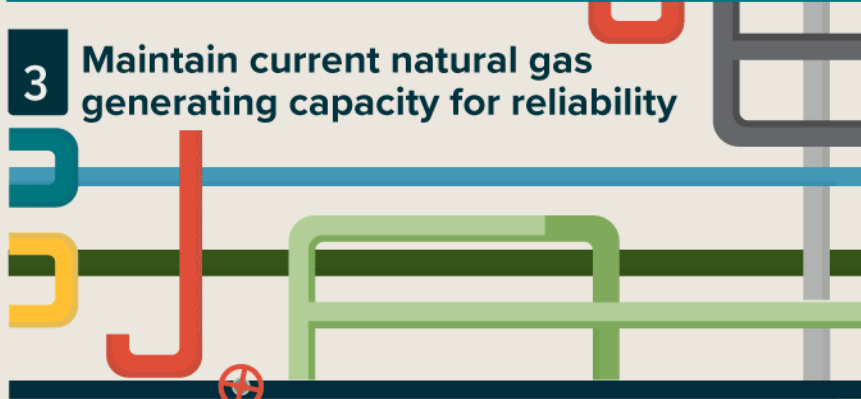
**1** Increase solar and wind capacity 3.5 times, to 500 gigawatts



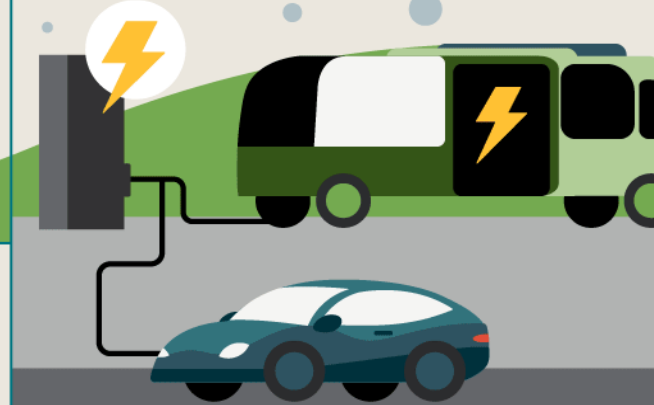
**2** Eliminate most electricity generation from coal



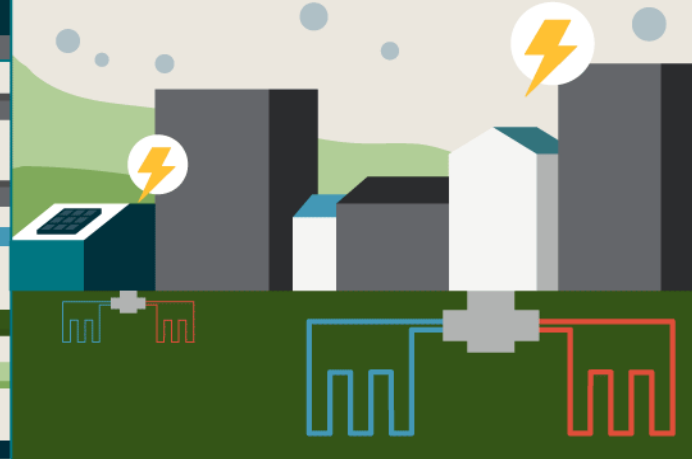
**3** Maintain current natural gas generating capacity for reliability



**4** Increase zero-emission vehicle sales share to 50%



**5** Increase sales share of building heat pumps to 50%



**6** All new buildings and appliances meet strict energy efficiency goals



**7** R&D for carbon capture, sequestration, and carbon-neutral fuels



**8** Build electricity transmission and pipelines for carbon dioxide and hydrogen gas.



# Zero Energy Buildings – What Are They?



**Sustainable  
Design**

+



**Energy  
Efficiency**

+



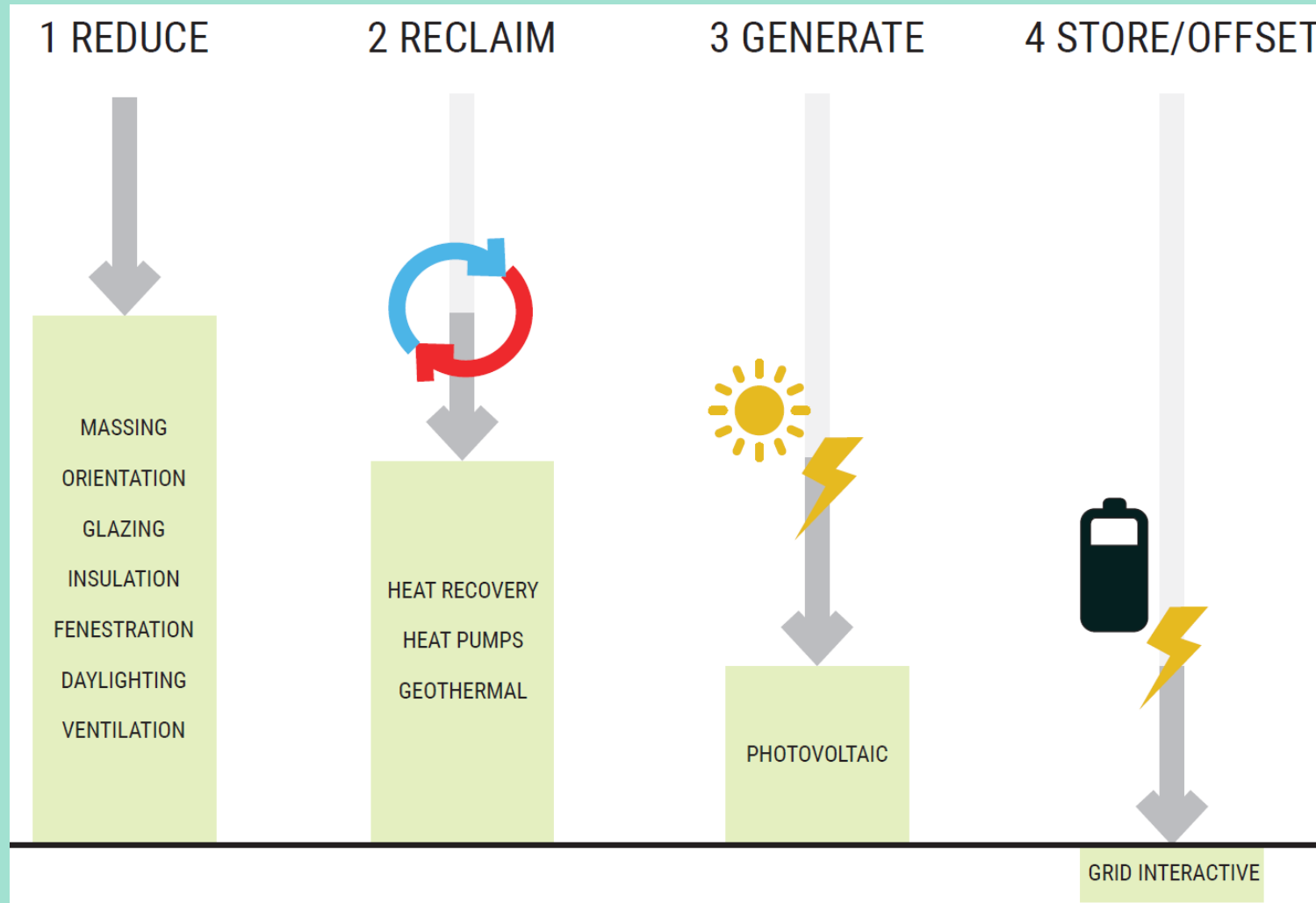
**Renewable  
Energy**

=



**Zero  
Energy  
Potential**

# Zero Energy Buildings – What Are They?



“ **Question**

**How many verified zero energy buildings are in the US?**

**A) 5    B) 160    C) 746    D) 2,567**

”



# 160

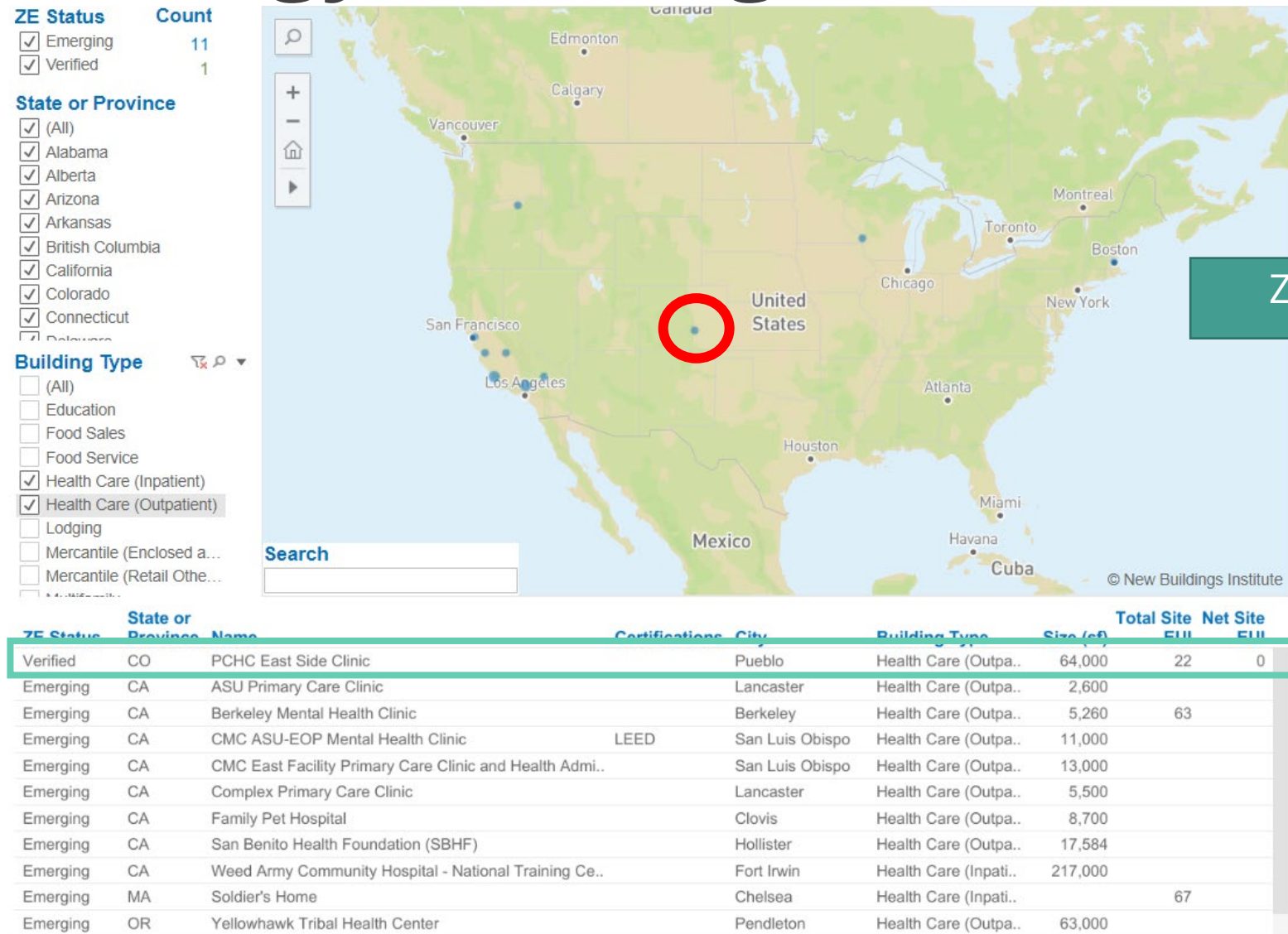
**Verified Zero Energy Buildings in USA**

# 591

**Emerging Zero Energy Buildings in USA**

*Source: NBI (New Building Institute)*

# Zero Energy Buildings in Healthcare



Source: NBI (New Building Institute)

# Zero Energy Process and the Results



# New East Side Clinic

- New construction - 63,896 SF
- Community Health Center, FQHC
- Serving Pueblo's East Side
- 52 exam rooms with shell space for expansion to 78
- Full range of medical services: dental, lab, pharmacy, and behavioral health



**6.25%**

over the cost of  
traditional construction

**18-year**

payback (baseline)

**7.8-year**

payback  
(replaced facility)



# Goal Setting



**50%**  
energy reduction



**2x**  
code-required  
thermal insulation

**\$45K**

estimated annual  
energy cost savings



280 kW (total) PV arrays



Pursuing Zero Energy  
verification

# Building Energy Use

## What We Measured

Energy Utilization Index (EUI) = kBtu/SF/Yr

OR

How much energy you're using per SF per year

# Building was Designed to Save \$45,000/ year

	Baseline Building	This Project, As Designed
<b>EUI</b>	52 kBtu/SF/yr	24.6 kBtu/SF/yr
<b>Energy Cost</b>	\$104,960/yr	\$60,562/yr (without PV)
<b>Renewables</b>	NA	<ul style="list-style-type: none"><li>› PV Energy Reduction: \$31,255/yr</li><li>› One-time energy grant: \$122,522</li></ul>

Note: avg Colorado benchmark for MOB's is 106 kbtu/sf/yr from state reporting data

# Results – How the Building Is Actually Performing

Savings over the building this replaced (2018 \$)



\$192,767

Savings compared to baseline Colorado Ave Clinic (2022)



\$103,135

EUI for this building



22.55

# Results – How Much Will the Utilities Cost?

	Comparable Energy Efficient Building	Building this Replaced	PCHC
Energy Cost	\$2.03	\$3.48	\$0.415/sf/yr

\$0.324/sf/yr After rebate applied to other buildings in portfolio!

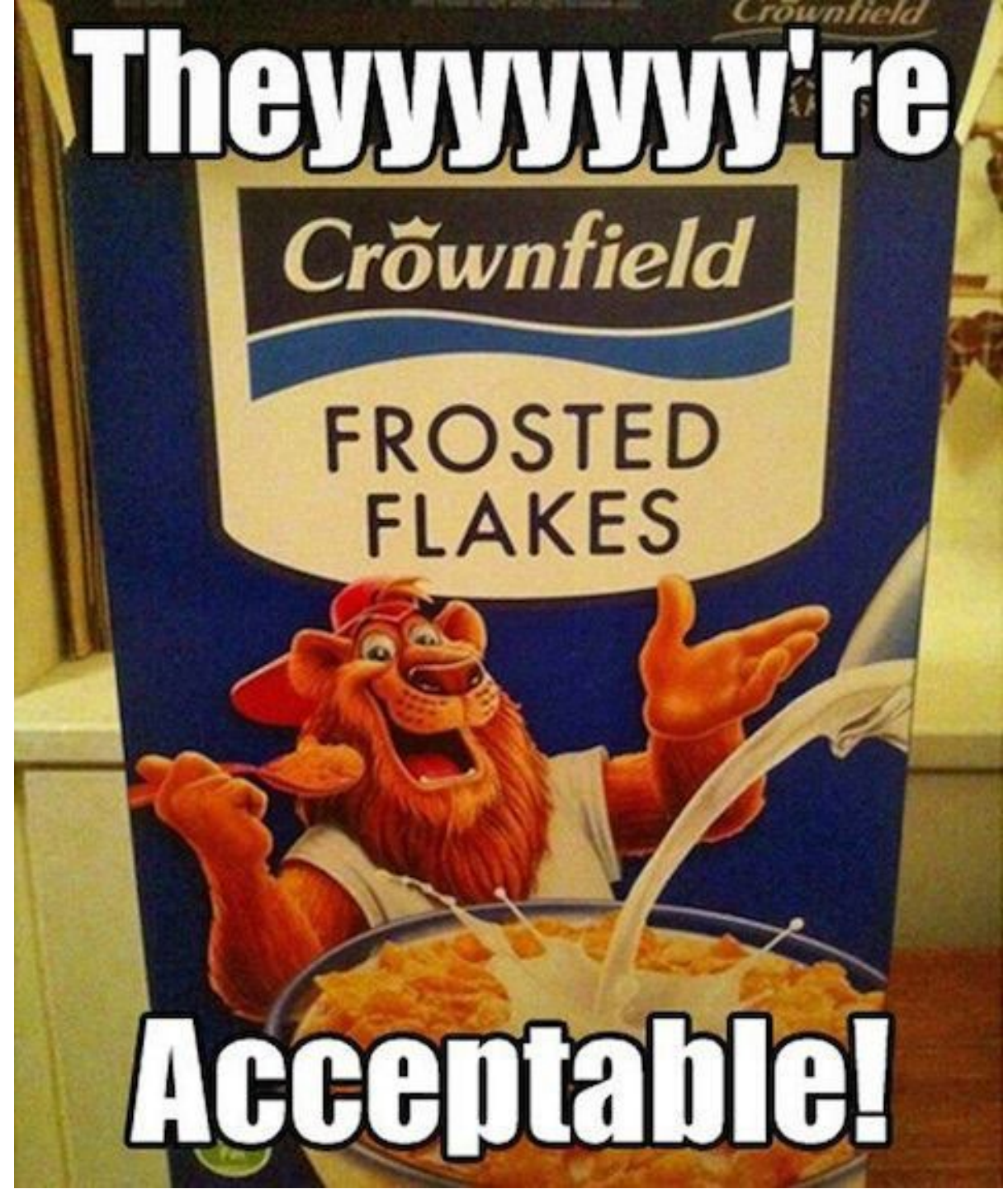
# How Did Our Team Do This?



# Generic Keys to Success

All project teams claim to:

- Set clear goals
- Start early
- Collaborate
- Get Owner buy-in
- Educate
- Define expectations
- Measure & verify



# Key Element #1: Understanding

Really Understand how  
the Owner uses the  
building

- Location
- Functional use
- Energy baseline
- Culture



## Key Element #2: Executive Sponsorship

Concern for  
polluting the  
communities that  
PCHC is trying to  
make more healthy.



Board  
Vision

Community  
Vision

Business  
Case

- A Federally Qualified Health Center (FQHC) serving the poor and underserved in Pueblo since 1983.
- 27,000 clients with 125,000 visits (pre-pandemic), providing medical, behavioral health, dental services, and pharmacy. Historic annual growth of 5-6%.
- Pueblo's East Side identified as area of greatest need. Plans to build replacement began in 2017.



Pueblo  
Community  
Health Center

# Zero Energy

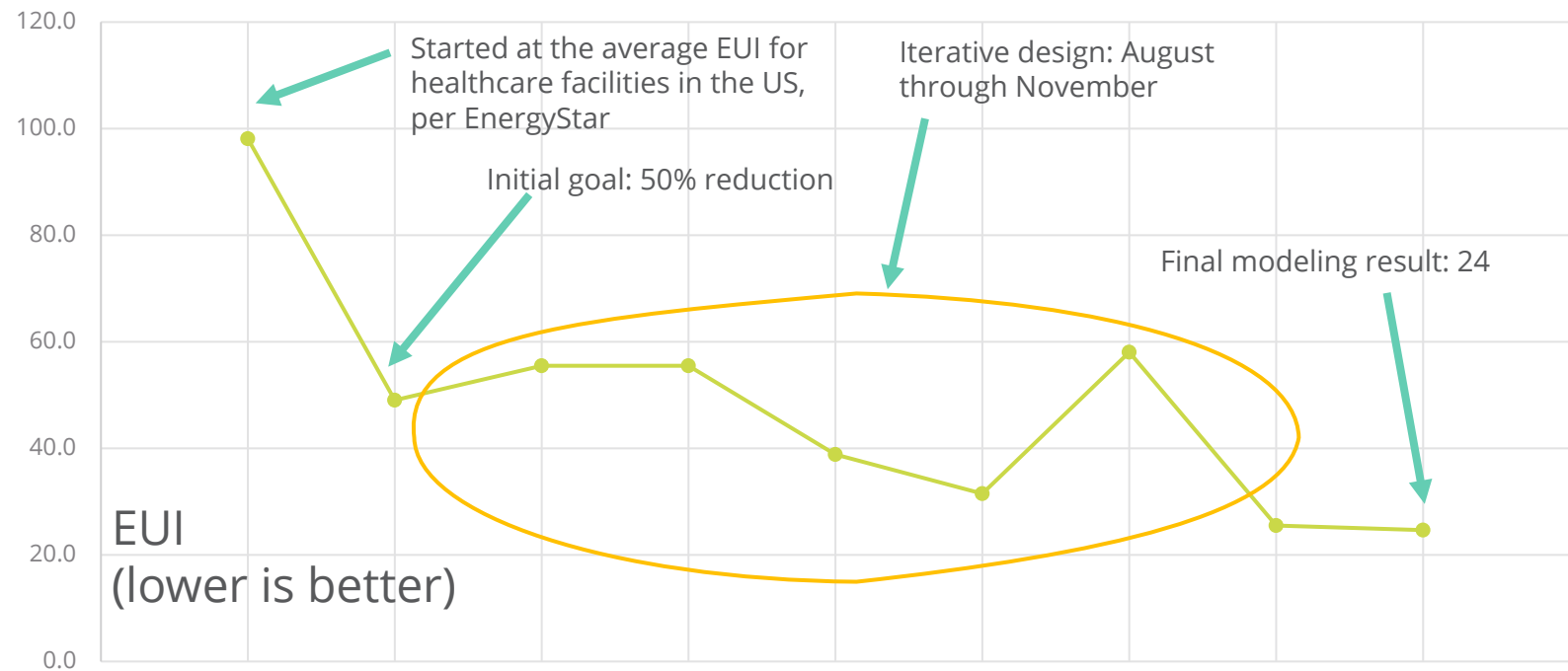
- **Practical Zero Energy**
- **Verification not certification**
- **12 months of operational data (utility bills)**

**nbi** new buildings  
institute

# Benchmarking to Baseline



## Site EUI through early design



# Project Timeline



## PRE-DESIGN

- Master Plan Refresh
- Community Focus Groups
- User Groups
- Sustainability / Zero Energy Charrette
- 3P Events ( Programming, Exam Room Mock-Ups)



## SCHEMATIC DESIGN

- Development Plan / Site Amendments
- Site Plan
- Floor Plans
- Elevations
- Sustainability / Zero Energy Road Map



## DESIGN DEVELOPMENT

- Development of the Design
- Product Selections
- Draft Specifications
- Sustainability / Zero Energy Road Map



## CONSTRUCTION DOCUMENTS

- Finished Drawing Set
- Fully Coordinated Specifications
- Sustainability / Zero Energy Road Map

# Clearly Document Lock In Expectations

DESCRIPTION	ASHRAE 90.1 2013 BASELINE PERFORMANCE REQUIREMENTS	INITIAL DESIGN GOALS	AS DESIGNED PERFORMANCE CHARACTERISTICS
<b>Building Envelope</b>			
Wall Construction	21% Window to Wall Ratio Mass: Overall U-Value - 0.09 , Overall R-value - 11.4 Wood Framed: Overall U-value - 0.051, Overall R-value - 20, Steel Framed: Overall U value = 0.055, Overall R value = 18.2	Steel Framed: R-23 (Note find that in our climate going above and beyond with wall insulation sees diminishing returns in the R-22-23 range for buildings with A/C)	Brick over stud wall, 3" Polyiso insulation, Fluid applied air and moisture barrier, 6" Metal stud with 2" SPF - R-25 total
Roof Assembly	Insulation Entirely above Deck: Overall U value = 0.032, Overall R value = 30, Attic and other: Overall U-value - 0.021, Overall R-value - 49	Insulation entirely above deck: R-60 (In our experience 50-60 is good target)	Fully Adered TPO with 10" Polyiso Insulation, 1.5" Metal Roof Deck - R-60 total
	Mass: U-value= 0.057, R-14.6 Steel Framed: U-value= 0.055, R-18.2		Unheated 4" slab-on-grade, rigid R-10 insulation, R-16.2 at perimeter

DESCRIPTION	COLORADO CLINIC EQUIPMENT ELECTRICAL REQUIREMENTS	INITIAL DESIGN GOALS	AS DESIGNED PERFORMANCE CHARACTERISTICS
<b>Internal Loads</b>			
Equipment Loads	1.1 W/SF	Doors: Unheated F-0.520	Alpen Fiberglass Windows - U-value: 0.21
Server Room			
AutoClaves			
Ice-Makers			
Washer/Dryers			
Dishwashers			

RESPONSIBLE PARTY	DESCRIPTION	ASHRAE 90.1 2013 BASELINE PERFORMANCE REQUIREMENTS	LIGHTING FOOTCANDLE RECOMMENDATIONS	AS DESIGNED PERFORMANCE CHARACTERISTICS
<b>Interior Lighting and Electrical Loads</b>				
	Office	0.82 W/SF	10-15-20	0.58
	Patient Rooms	0.62 W/SF	5-7, 5-10	0.71
				<b>0.42 W/SF Average</b>

RESPONSIBLE PARTY	ASHRAE 90.1 2013 BASELINE PERFORMANCE REQUIREMENTS	INITIAL DESIGN GOALS	AS DESIGNED PERFORMANCE CHARACTERISTICS
Electrical Engineer	<b>Exterior Lighting</b>		
	600W base allow		
	Main Entries 20 W		
	Other doors 20 W		
	Entry Canopies 0		
	Walkways < 10' w		
	Walkways > 10' w		
	Stairways 1.0W/SF		
	Landscaping - 0		
	Parking Areas 0		
	Daylight controls		
		<b>HVAC Equipment</b>	
	Building Heating System	Packaged VAV w/ Reheat, hot-water fossil fuel boiler heating, 80% thermal efficiency	COP=4.0/4.4 COP=4.0
	Building Cooling System	Packaged VAV w/ Reheat, DX cooling, economizer w/ high limit shutoff at 75°F, 11.0 IEER	GSHPs (ClimateMaster TE049 or WaterFurnace Envision^2 Compact 038 w/ECM motors) Part/Full: EER=19.3/27.4 GSHPs (ClimateMaster TE Series or WaterFurnace Envision^2 Compact Series w/ECM motors) EER=19.3
	<b>Plumbing Equipment</b>		
	Plumbing Fixtures	Standard Water Use	Efficient Water Use Standard Water Use for clinical, water efficient fixtures for all public use fixtures.
	Domestic Water Heater	80% Eff, gas storage	Electric water heater to eliminate on-site combustion De-superheater to use excess heat produced by GSHP system for domestic water heating, supplemented by electric water heater.
	<b>Ventilation</b>		
	Ventilation Method	Mechanical	Mechanical ventilation with Energy Recovery Dedicated outside air system with energy recovery wheel, 80% effectiveness.

# Key Element #3: Involve Everyone In Energy Goals

- Gave 30% energy reduction goals to each designer (envelope, lighting, HVAC)
- Achieved 50%+
- Iterative review of modeling results

SITE ENERGY USE (KBTUS)	ENVELOPE IMPROVEMENTS (WALL AND ROOF PLUS WINDOWS)	LIGHTING UPGRADES (WITH ENVELOPE IMPROVEMENTS)	GROUND SOURCE HEAT PUMP SYSTEM (WITH LIGHTING AND ENVELOPE IMPROVEMENTS)
Lighting (Interior)	615,852	298,820	298,820
Lighting (Exterior)	21,683	15,178	15,178
Plug/Process Loads (Electrical)	577,542	577,542	577,542
HVAC - Pumps	17,422	18,026	76,712
HVAC - Fans	349,866	321,257	198,302
HVAC - Electrical (Cooling)	251,553	215,376	143,577
HVAC - Electrical (Heating)	0	0	108,041
<b>Electrical Subtotal Site Energy</b>	<b>1,833,919</b>	<b>1,446,198</b>	<b>1,418,172</b>
HVAC (Thermal-Heating)	403,406	463,561	0
DHW (Thermal)	165,597	165,597	0
<b>Thermal Htg Subtotal Site Energy</b>	<b>569,003</b>	<b>629,158</b>	<b>0</b>
<b>Total Site Energy</b>	<b>2,402,922</b>	<b>2,075,356</b>	<b>1,418,172</b>
<b>Calculated Site EUI (kBTU/SF/Year)</b>	<b>37.4</b>	<b>32.3</b>	<b>22.1</b>
<b>Modelled Incremental Energy Savings* =</b>	<b>934,857</b>	<b>1,262,423</b>	<b>1,919,608</b>
<b>Modelled % Savings =</b>	<b>28%</b>	<b>38%</b>	<b>58%</b>
<b>Energy Cost</b>			
Electrical Cost	\$76,323.71	\$60,187.61	\$59,021.22
Natural Gas Cost	\$3,470.92	\$3,837.86	\$-
<b>Total Cost</b>	<b>\$79,794.63</b>	<b>\$64,025.48</b>	<b>\$59,021.22</b>
Cost Savings* =	\$14,608.53	\$30,377.68	\$35,381.93
Proposed % Savings =	15%	32%	37%

# Photo-Voltaic Array

Target =

**448,000 kWh/yr**

Actual Produced =

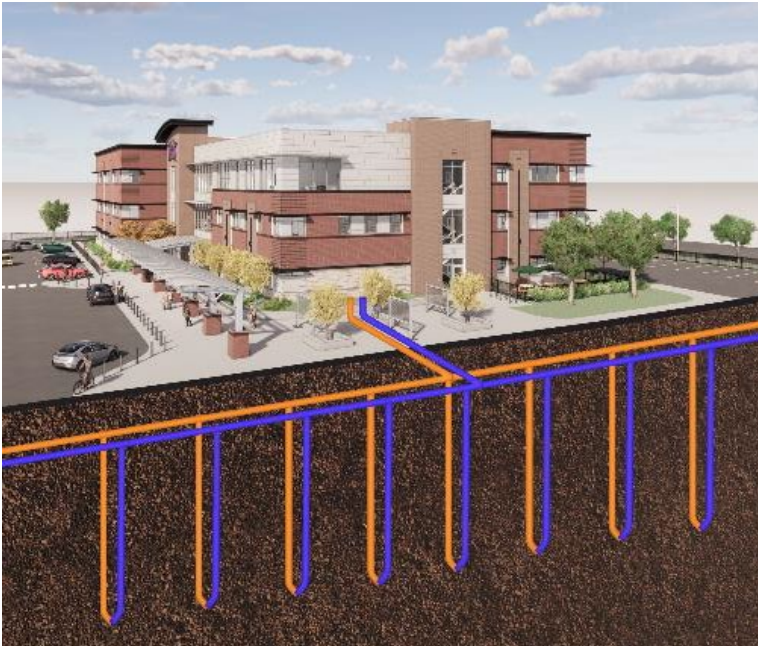
**449,280 kWh/yr**

## ENERGY MODEL RESULTS & EXPECTED ENERGY USE (2 OF 2)

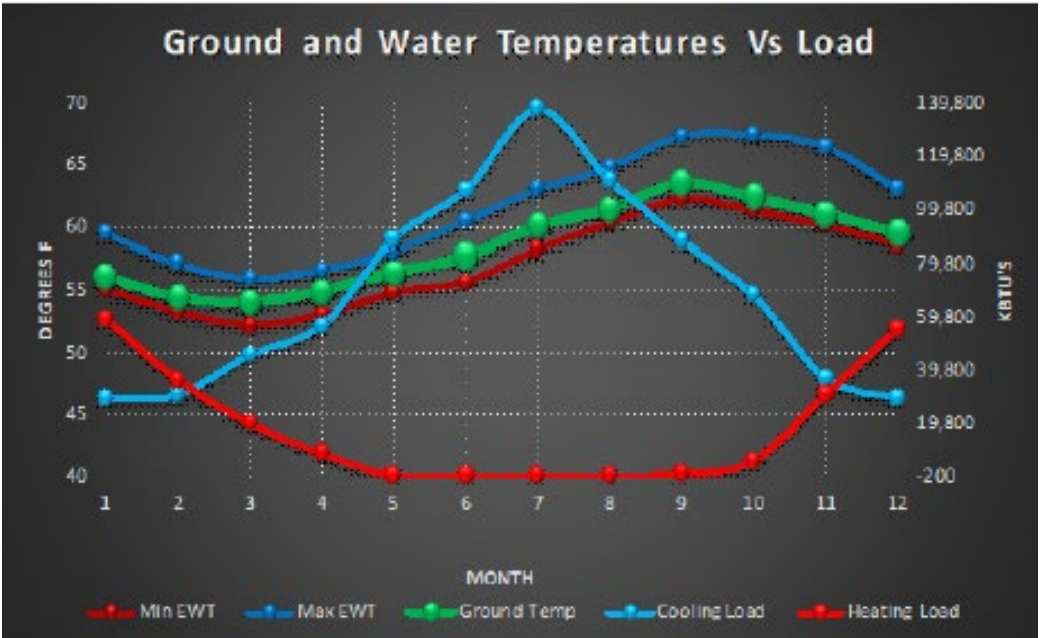
ENERGY PRODUCTION	11/4/2019 2013 APPENDIX G BASELINE HAP MODEL	6/12/2020 ENERGY MODEL AS- DESIGNED
Photovoltaic - Site Energy production (kbtuh/yr)	2,538,528	1,528,576
Photovoltaic - Array Size (KW)	465	280
<b>Total PV Energy Production Required- Site</b>	<b>2,518,280</b>	<b>1,416,776</b>
<b>Total PV Energy Production Required - Source</b>	<b>7,932,582</b>	<b>4,462,846</b>
<b>Net Zero Status (Total Source Energy - Total Source Total Source Energy Production &lt; or = 0)</b>	<b>-63,781</b>	<b>-352,169</b>
<b>Net Zero Source EUI</b>	<b>-1</b>	<b>-6</b>



# Ground Source Heat Pumps



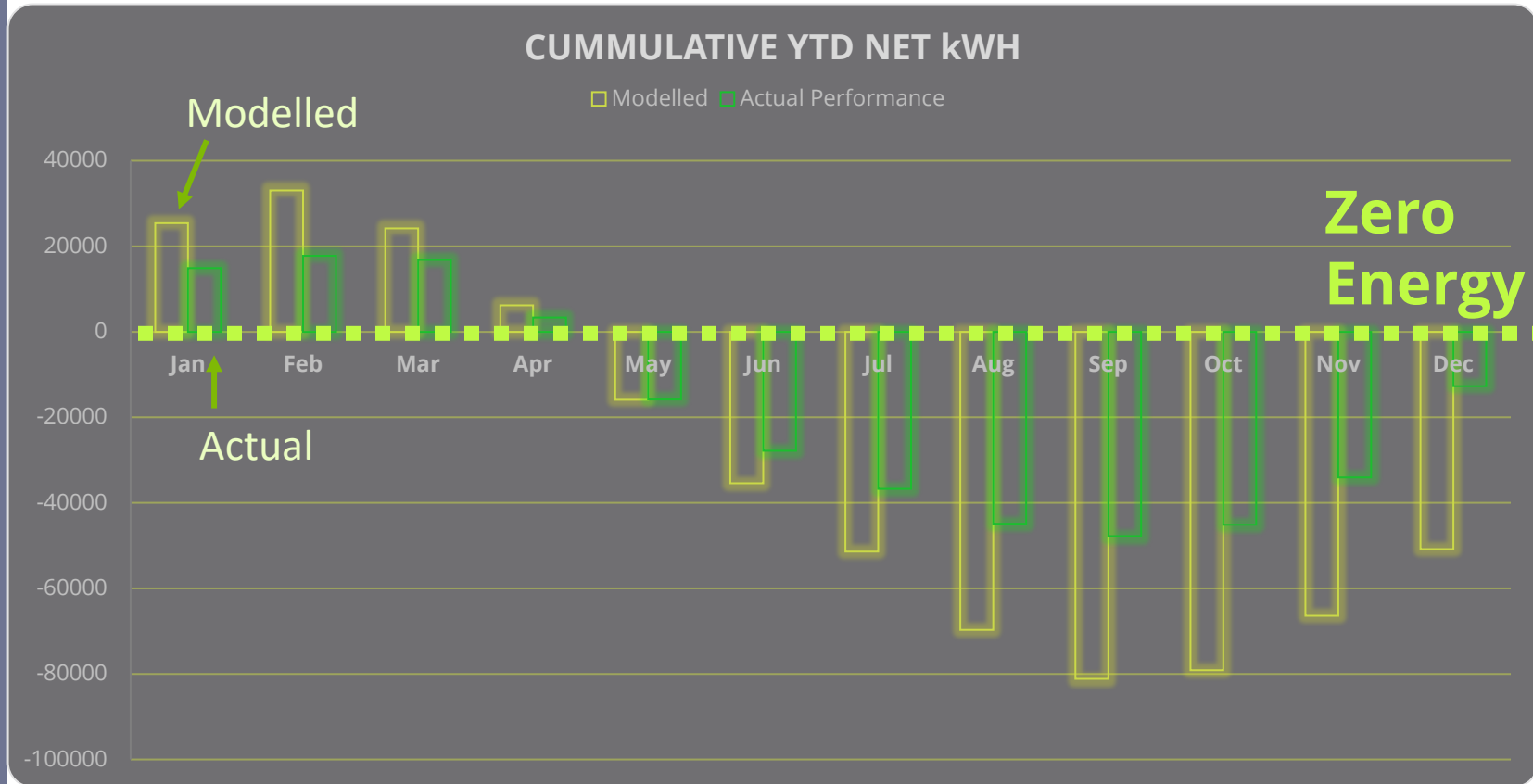
GROUND SOURCE HEAT EXCHANGE SCHEDULE	INITIAL VALUES
Total Bores/GPM	32 Bores/190 GPM
U-Bend Depth from Bottom of Header Trench	500'
Min. Grout Thermal Conductivity	0.9 Btu/hour-FT-°F
Soil Thermal Conductivity	1.2 Btu/hour-FT-°F
Soil Thermal Diffusivity (Estimated)	1.30 ft <sup>2</sup> /day
Undisturbed Soil Temperature	54 °F
Fluid	Potable Water, 15% PG
Min/Max Entering Water Temperature	40/80 °F
Min/Max Leaving Water Temperature	30/90 °F
U-Bend Material	1-1/4" HDPE SDR 11
Peak Cooling/AEFLH	62.5 tons/1300 hours
Peak Heating/AEFLH	60,000 kBtu/1040 hours



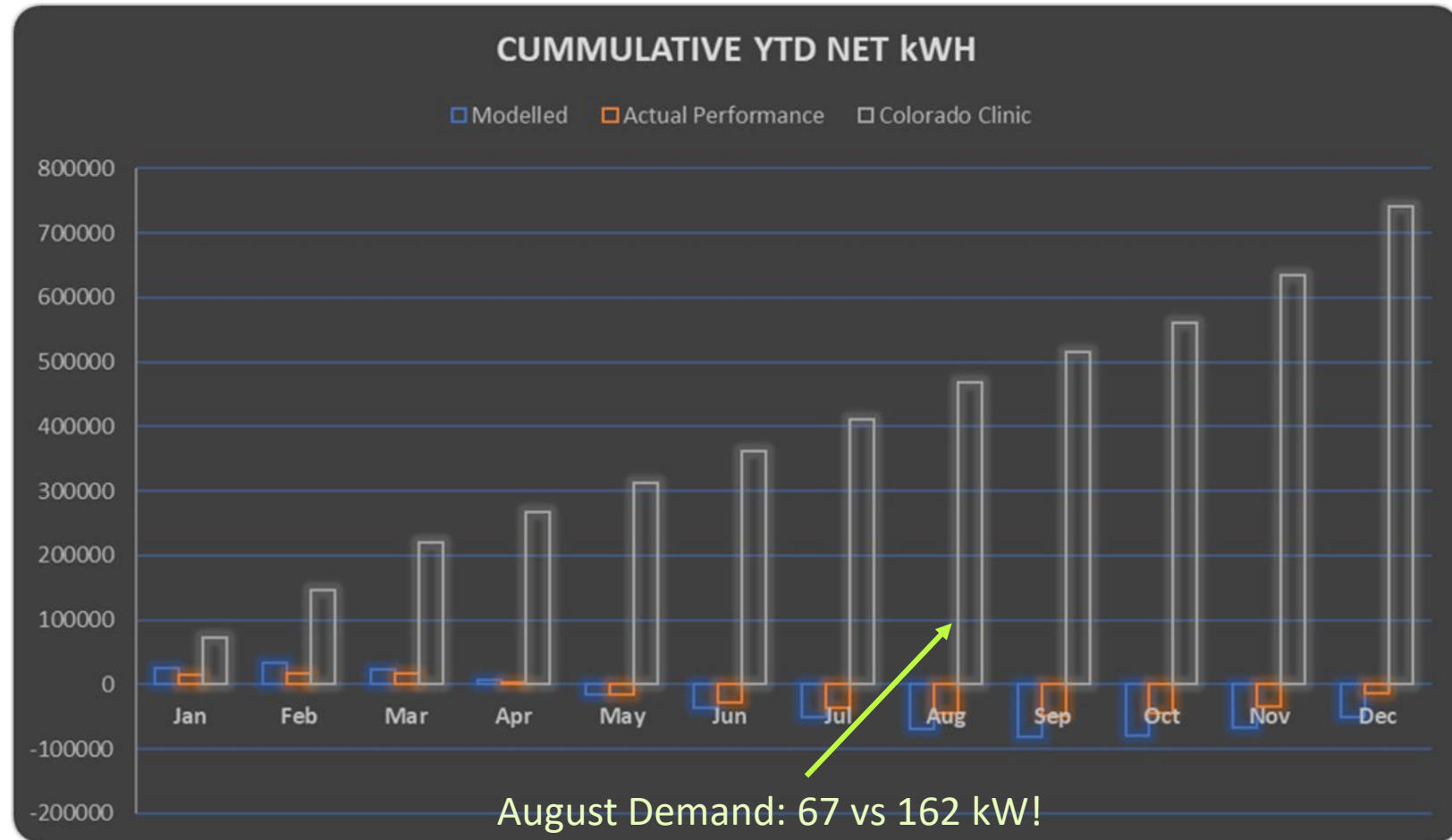
# Simplified, Smaller Mechanical Room



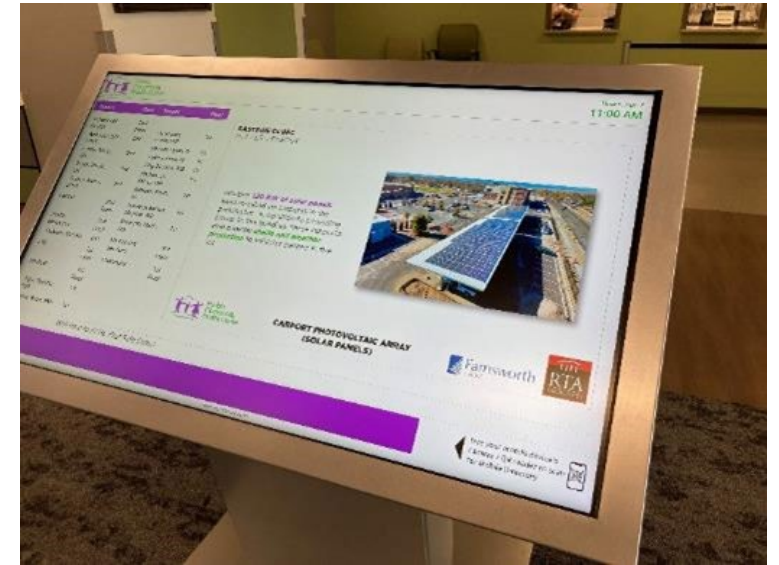
# Key Element #4: Actually Do Post-Occupancy Measurement & Verification



**Key Element**  
**#4: Measurement & Verification-**  
**Cumulative**  
**comparison to**  
**baseline facility**



# Key Element #5: Continuous Training



# Key Takeaways

- Owner buy-in
- Team dynamics with a “what if?” attitude
- Zero Energy doesn't have to be complicated or expensive
- Think total life-cycle costs of building
- Think community impact





# Thank you!

Any questions?

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Corey Chinn  
Jeff Boyer

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