Mead &Hunt

The Myths of Electrification & ZNE Case Studies

SAME Oklahoma

October 17, 2023

Renée Azerbegi
PE, LEED AP, CEM, WELL AP

National Sustainability Market Leader / Sustainability Business Unit Leader

1

Agenda

- Why Electrify
- Relevant Policies
- Four Myths of Electrification
- Case Studies
- Pathway to Electrify

Course length: 1 hour

Your course has been approved for AIA CES Course The Myths of Electrification & ZNE Case Studies (0005) for Mead & Hunt, Inc. **(400103380).** This course may be offered for AIA continuing education credits.

The course has also been reviewed and approved by GBCI for 1 CE Hour(s) with course ID **(0920026134).**

2

Learning Objectives

- Understand the benefits of building electrification as they relate to energy savings and emissions reductions and the full scope of electrifying buildings
- Be able to explain the myths of building electrification related to if it makes sense to electrify all types of buildings all at once across the country.
- Clarify the importance of and define beneficial building electrification which saves on all three of the following: energy, emissions and cost.
- Overcome barriers to building electrification by taking the first steps towards electrification planning.
- Provide case studies of zero net energy all electric buildings

3

Sustainability Group Markets & Services

EXPERTISE

- Commissioning
- Decarbonization Planning and Modeling
- Embodied Carbon and Daylight Analysis
- Energy Consulting
- Green Building Rating Systems
- Net Zero Energy and Carbon Consulting
- Resiliency Consulting
- Sustainability Consulting
- Sustainability Planning
- Sustainability Reporting

US Forest Service Laboratory
Corvallis, OR

NIST Building 1, Wings 3 and 6
Boulder, CO

The Cesar Chavez Memorial Building and Parking Garage
Denver, CO

GSA Los Angeles Courthouse
Los Angeles, CA

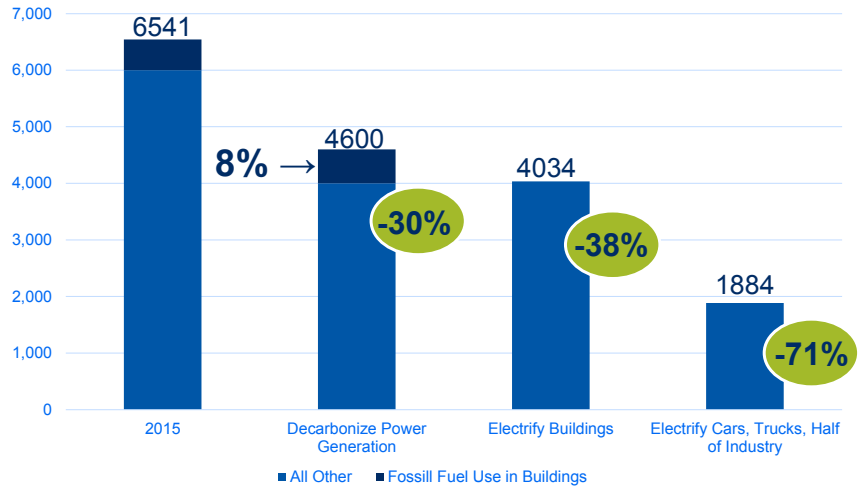
4

Why Electrify?

5

Scope of Emissions

US Economy-Wide Greenhouse Gas Emissions and Decarbonization Options, MT CO_2E[11]

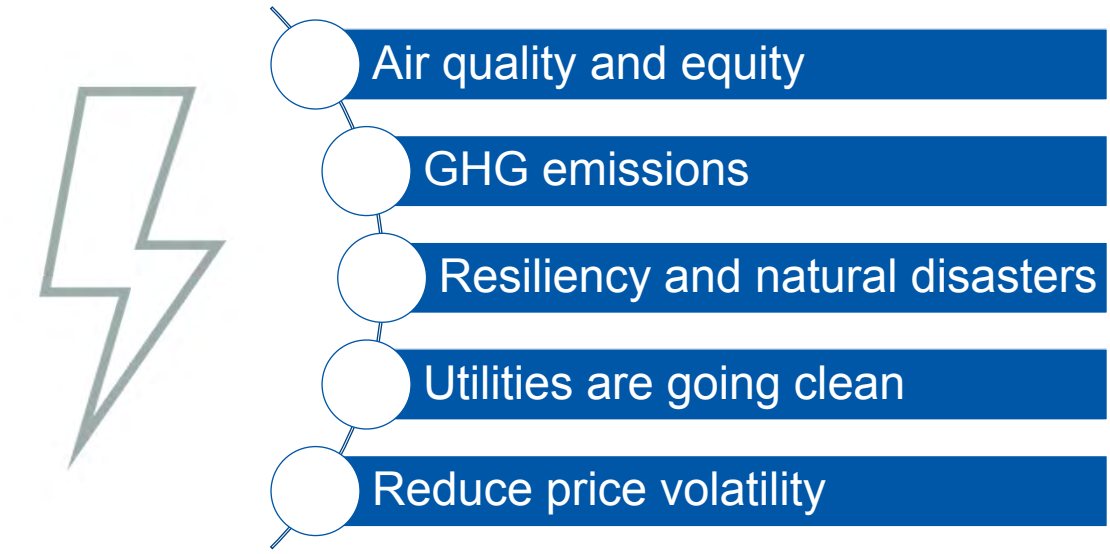


Source: RMI_Economics_of_Electrifying_Buildings_2018.pdf

Mead &Hunt

6

Why Electrify?



7

Relevant Policies

8

The Innovators

- New York (Local Law 97)
- Seattle (Energy Code)
- Massachusetts (CMR 780)
- California (2022 Zero Code)
- Denver (Net Zero Implementation Plan, All electric by 2027)
- Department of Defense (March 2023 Memorandum)

- Natural gas restrictions
- All electric buildings
- Carbon emissions

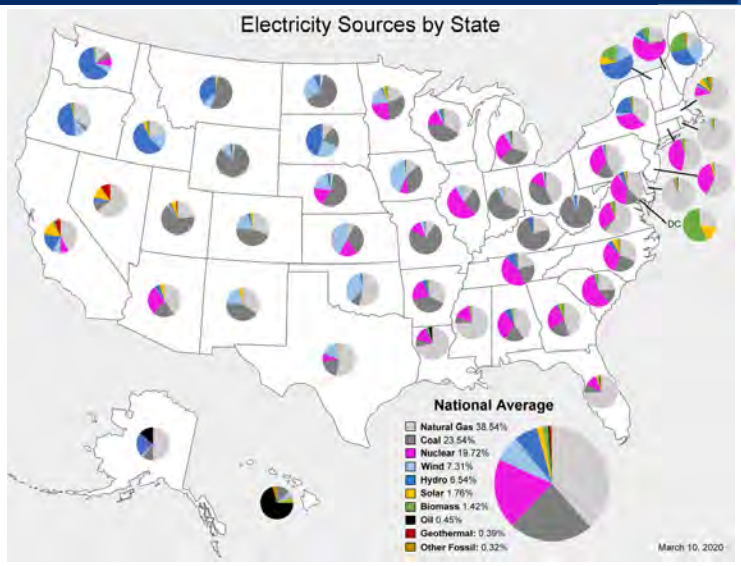
9

Myth #1

Let's electrify all of the U.S. now!

10

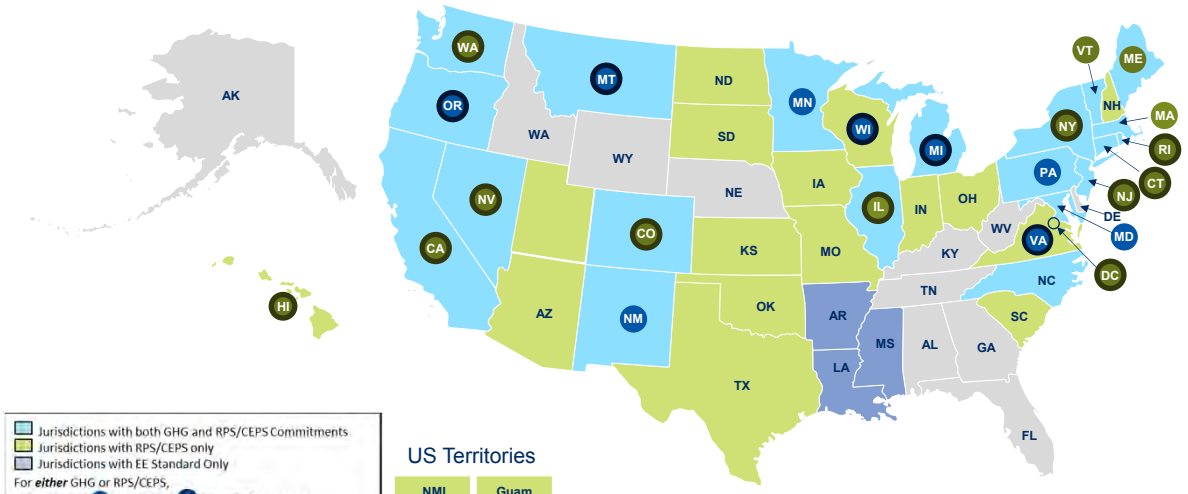
Power Mix by State



Source: U.S. Department of Energy, Alternative Fuels Data Center, "Electricity Sources and Emissions." Data accessed on March 10, 2020."

11

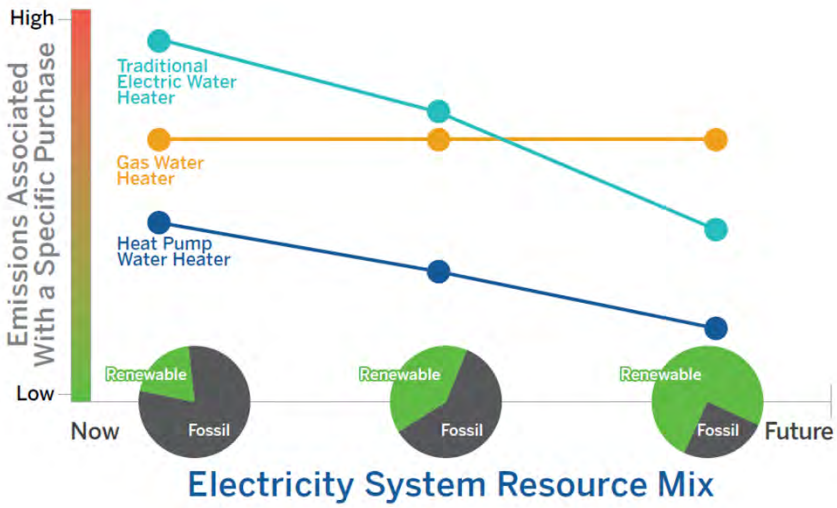
Clean Energy Policy Tracker



Clean Energy Policy Tracker - NARUC

12

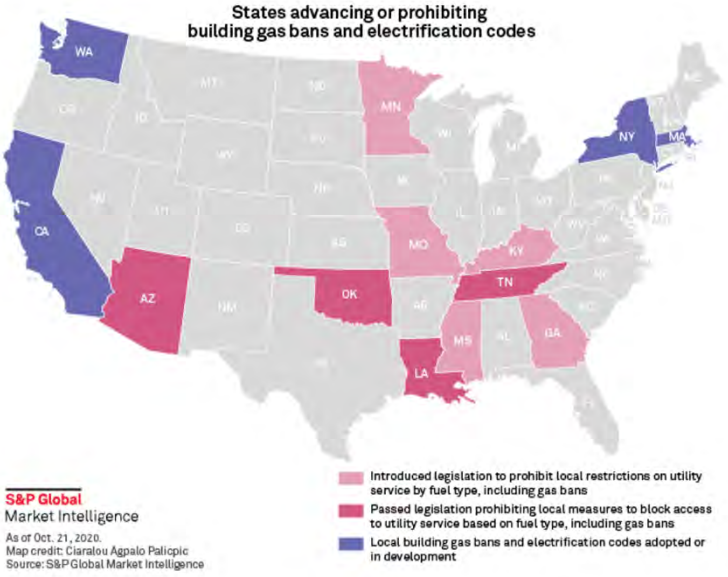
Emissions in Utility Mix vs Water Heating Options



Farnsworth, D., Shipley, J., Lazar, J., and Seidman, N. (2018, June). *Beneficial electrification: Ensuring electrification in the public interest.* Montpelier, VT: Regulatory Assistance Project.

13

States Advancing or Prohibiting Gas Bans and Electrification Codes



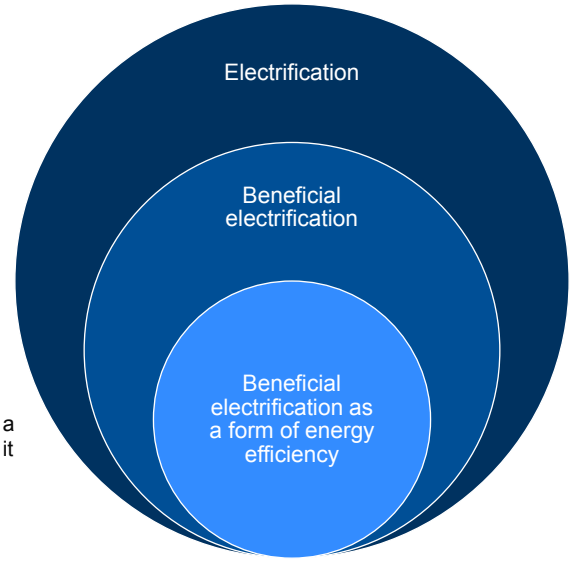
14

Myth #2

As long as it's electric, it's better!

15

Beneficial Electrification



"ACEEE sees electrification as a form of energy efficiency when it **saves energy (in total Btus), saves money, and reduces emissions."**

16

Efficiency First!

- New construction
  - Energy modeling
  - Energy usage and energy cost savings
  - **Life-cycle cost analysis**
  - Resource life-cycle cost analysis
  - **Triple bottom line analysis**

17

DOD Electrification Projects in the Works

- Tinker BACH Agile Hanger, Oklahoma City, OK (in JV w/Mason & Hanger)
- Florida Army National Guard Operational Readiness Training Complex (ORTC), Camp Blanding, FL (in JV w/TetraTech)
- New Mexico Army National Guard Rio Rancho FMS, Rio Rancho, NM
- Birmingham US Army Reserve Center (USARC), Birmingham, AL (sub to RSP Architects)

Tinker BACH Agile Hanger, Oklahoma City, OK (in JV w/Mason & Hanger)
Florida Army National Guard Operational Readiness Training Complex (ORTC), Camp Blanding, FL (in JV w/TetraTech)
New Mexico Army National Guard Rio Rancho FMS, Rio Rancho, NM
Birmingham US Army Reserve Center (USARC), Birmingham, AL (sub to RSP Architects)

Early design: Tinker BACH Agile Hanger

18

State of Colorado, Centennial Office Renovation Life Cycle Cost Analysis

LIFE CYCLE COST ALTERNATIVES	SYSTEM COMPONENT	DESCRIPTION	PRESENT VALUE
ALTERNATE 1	HVAC	OPT1 - VRF	$17,670,107
ALTERNATE 2	HVAC	OPT2 - FCU - BLR & CHLR	$11,378,479
ALTERNATE 3	HVAC	OPT3 - FCU - CHLR-HTR	$13,210,958

Centennial Building, Life-cycle cost analysis, Denver

OPT1 - VRF	COST	COST DESCRIPTION	COST TYPE	IF NONRECURRING THEN WHAT YEAR	IS COST ESTIMATION A FUTURE OR PRESENT COST	TEXT DESCRIPTION	PRESENT VALUE
INITIAL CAPITAL COST	$9,595,600	Construction	Nonrecurring	0	PRESENT	80 $/SF	$9,595,600
ENERGY COST - ELECTRIC	$173,096	Energy - Electric	Recurring			30 years of electric bills	$3,276,707
ENERGY COST - FUEL	$0	Energy - Fuel	Recurring			30 years of NGAS bills	$0
REPLACEMENT COST	$9,595,600	Replacement	Nonrecurring	20	PRESENT	Full system replacement costs	$9,595,600
ANNUAL MAINTENANCE COST	$0	Maintenance	Recurring			30 years of maintenance costs	$0
REMAINING LIFE OF THE EQUIPMENT	-$4,797,800	Salvage	Nonrecurring	30	PRESENT	10 years life remaining	-$4,797,800
UNIFORM PRESENT VALUE						**SUM**	**$17,670,107**

19

Airport- Triple Bottom Line Analysis

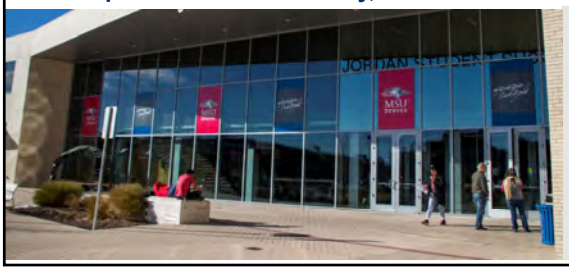
Score (1-5, 1 is best) Description	Owner Weighting Factor	Option 1 Traditional CUP, Water-Cooled Chillers, Natural Gas Boilers, Cooling Towers, Water Economizer	Option 2 Hybrid CUP - Geo-Exchange, Water-Cooled Chillers with Heat Recovery Chiller, Natural Gas Boilers, Cooling Towers, Water Economizer	Option 3 Air Cooled Heat Recovery Chillers, Electric Boilers	Option 4 Chiller-Heaters with Geo-Exchange	Option 5 Heat Recovery Chillers with Geo-Exchange
First Cost with Rebates	66%	2	4	2	4	5
Life Cycle Cost	100%	1	3	1	3	5
Annual Maintenance Costs	100%	5	5	3	1	1
Replacement Costs	100%	1	2	4	3	3
Expandability / Future Flexibility	100%	1	2	1	2	2
Energy Savings	100%	3	1	3	1	1
Water Conservation	66%	5	4	1	1	1
Community Impact / Perception	33%	5	3	4	3	3
Innovation	33%	5	4	4	3	3
Carbon/Greenhouse Gas Reductions	66%	4	1	3	1	1
CUP Footprint	33%	3	5	3	2	1
Score		22.6	22.9	19.6	16.6	18.9
Overall Ranking (1 is best)		**4**	**5**	**3**	**1**	**2**

20

Efficiency First!

- Existing building
  - Re/retro-commissioning
  - Energy audits
  - Renewable energy feasibility studies
  - Replacement vs. end-of-life

Metropolitan State University, Denver- Joint Student Success Building - Energy Audit and Retro-Cx Study



- Energy cost savings of $12,000 per year, not including lighting controls saving
- 13% of the annual utility spend for the building
- Most measures identified through the energy audit have a return on investment of less than one year

21

Federal Existing Building Energy projects

- South Dakota Army National Guard, SD
  - Energy audits of all facilities done every 4 years
- USFS Corvallis Laboratory, OR
  - Commissioning of 94k sf laboratory mechanical system upgrades
- GSA Los Angeles Courthouse, CA
  - Recommissioning of 600k sf LEED Platinum courthouse
- USFS Shadow Mountain Village, CO
  - Energy audits and infrared imaging of residences and vehicle maintenance buildings
- Readiness Center, Cedartown, GA

GSA Courthouse, Retro-Cx, Los Angeles

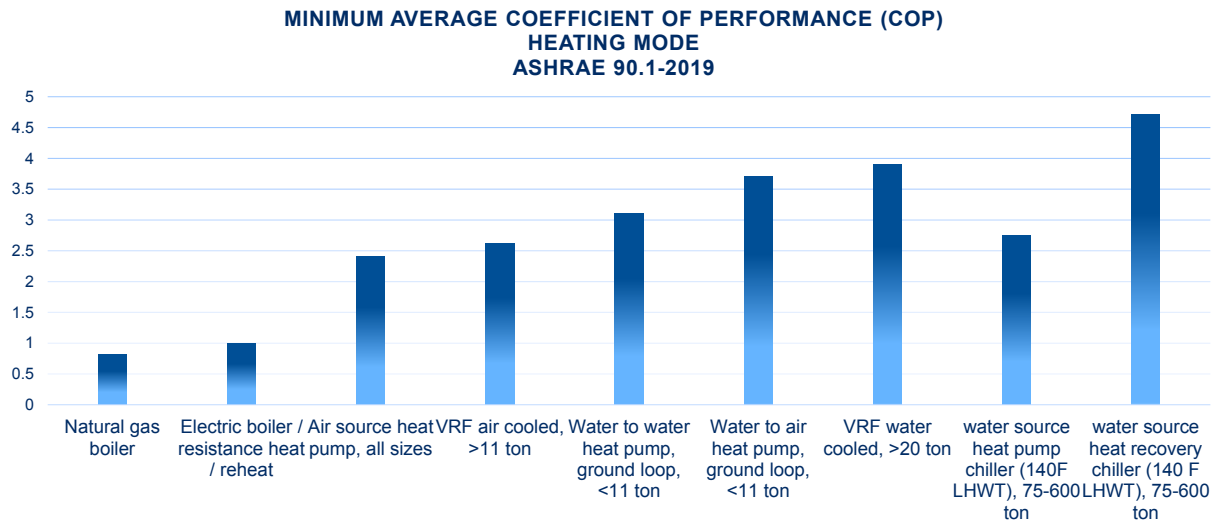
22

Myth #3

My campus or building is too big!

23

Electrifying Large Buildings

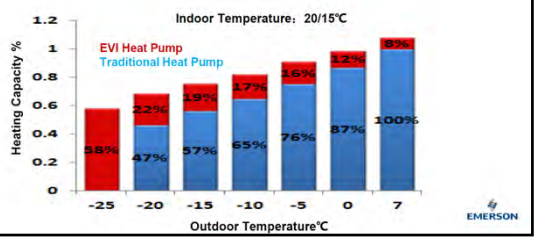


24

Electrifying Large Buildings

- Key considerations:
  - Electrical service capacity
  - Back up heat in cold climates
  - Cold climate heat pumps
  - Supply of large heat pumps
  - Operating cost
  - Thermal storage
  - High hot water demanding buildings
  - Refrigerant types

Source: Trane.com



25

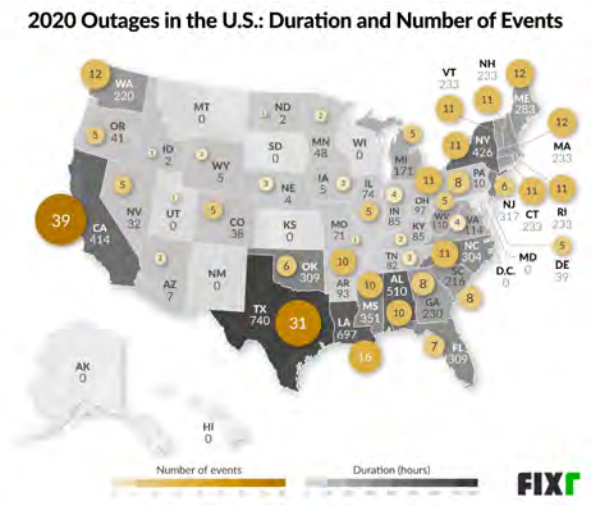
Myth #4

Going 100% electric is best!

26

Grid Reliability and Energy Sources

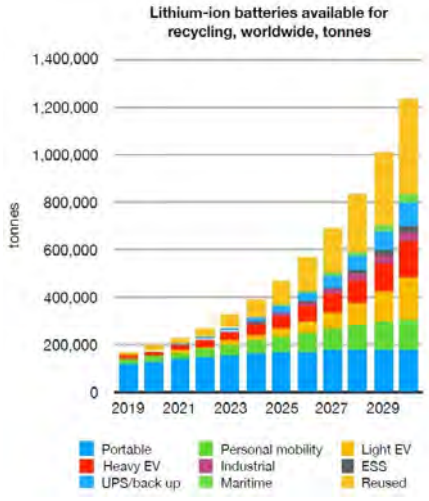
- Singe source of energy vs. multiple sources
- Microgrids
- Solar PV + batteries
  - Demand (kW)
  - Energy (kWh)
  - Time of use rates



27

Considerations for Batteries

- Cost vs. hours of backup vs. generators
- Limited material supply
- End-of-life management
- States with:
  - No Net Metering
  - Unreliable Power
  - Favorable Rate Structures



Source: Circular Energy Storage

28

Electric Vehicle Considerations

- Cold weather performance
- Level vs. time plugged in
- Metering to charge users
- Electric capacity

Levels	Cost Range	Charge Time	Electric Capacity	Voltage
Level 1	$200	8-12 hrs	1.2 – 1.8 kW	120 V AC
Level 2	$500-$1000	4-8 hrs	3.6 – 22 kW	240 V AC
Level 3 or DC Fast Charger	$20,000+	20-30 min	50 kW +	480-1000 V AC

Source: plug in america

29

Vehicle to Grid (V2G) for Resiliency

GREEN MOUNTAIN POWER

GMP Energy Bundle

Whole-home energy transformation simplified. Super-convenient energy independence and resiliency all bundled into one predictable, flat monthly price. Solar, battery storage, grid energy and an optional EV!

Green Mountain Power and Concorde Monitor, David Brooks, 7/21/2018

30

ZNE/All Electric & Decarbonization Case Studies

31

University of Colorado, Anschutz Campus, Campus Safety Bldg.

Rendering by Anderson Mason Dale Architects

27,900 sf

ZNE Features

- Heat pumps with chilled water return loop as heat recovery from campus utility plant
- High efficiency roof
- Ultra low lighting power density
- All electric

32

Design by Fentress Architects

Energy Use Intensity (EUI) Summary

Modeled (Site)	33.0 kBtu/sf
Actual Operation (2020 data)	30.9 kBtu/sf
With On-site Solar (2020 data)	-4.8 kBtu/sf

Contra Costa County Administration Bldg.

71,000 sf

ZNE Features:

- High efficiency hot water and chilled water plants
- Heat pump boilers to provide heating hot water
- Heat pump chillers to provide heating hot water and chiller water
- All electric

33

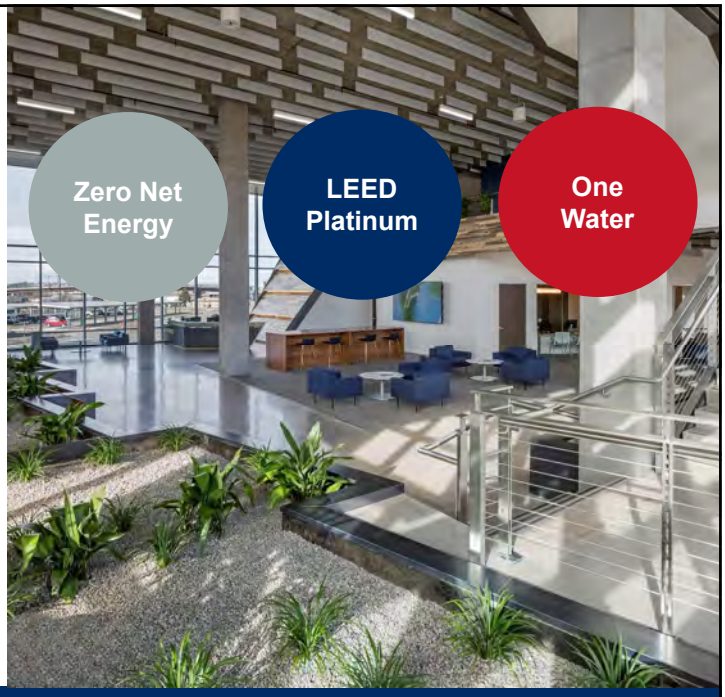
Denver Water Administration Bldg.

186,000 sf

ZNE Features:

- Radiant heating/cooling slab
- Ultra high efficiency central plant with heat pumps, heat recovery, thermal storage
- Dedicated outside air system
- Triple pane glazing
- All electric

Design by Stantec



34

Existing Facility Decarbonization Plan

- ASHRAE Level 2 Energy Audit
- Photovoltaic Feasibility
- **Electrification Building Planning**
- **Electric Vehicle Planning**
- Daylight Study
- Universal Design Analysis

Rochester International Airport, Decarbonization and Universal Design Plan, Rochester, MN

35

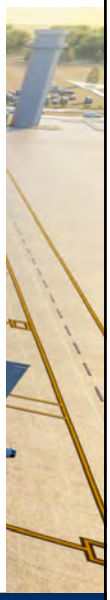
New Building Decarbonization Design
Appleton International Airport (ATW) – Operational Carbon

Geo-exchange loop with heat recovery chillers

Chilled beams with energy recovery ventilation

Solar PV array and all-electric HVAC

High performance envelope



36

New Building Decarbonization Design
Appleton International Airport (ATW) - Refrigerants

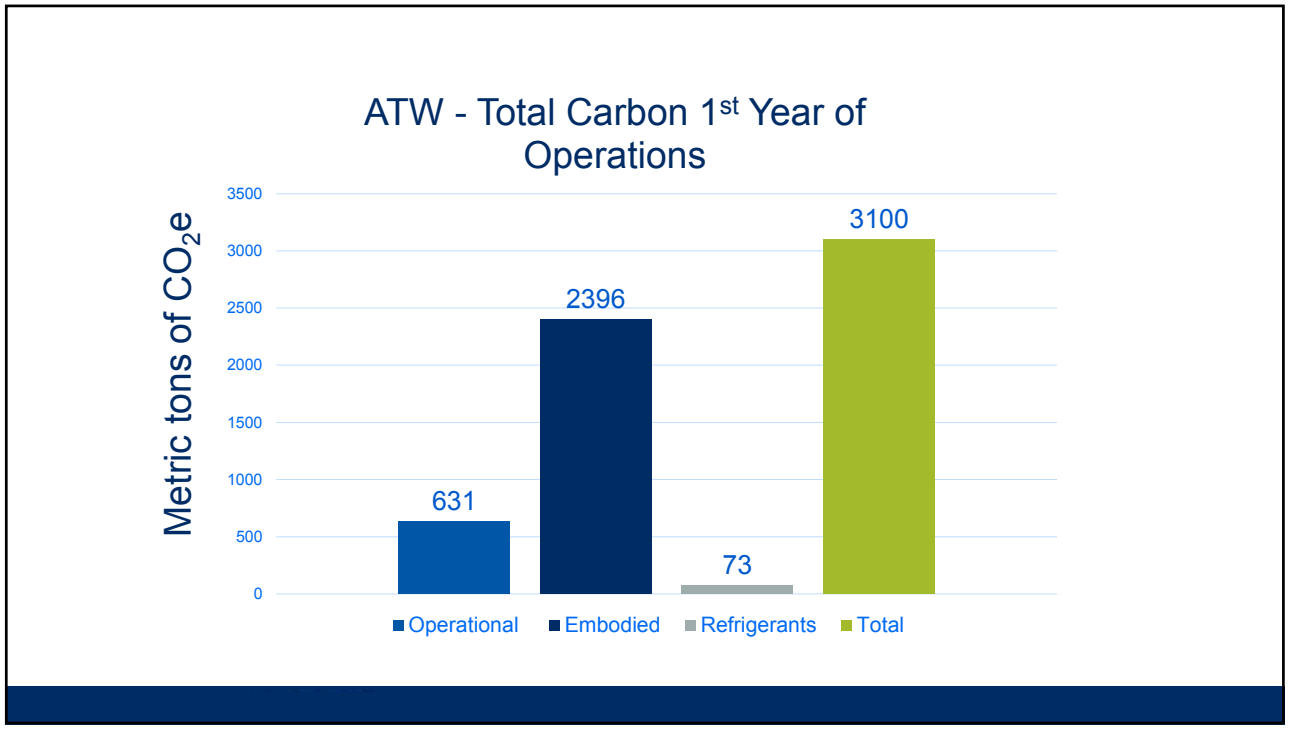
- Refrigerants in chillers
- R-410a
- Charge = 500 lbs

37

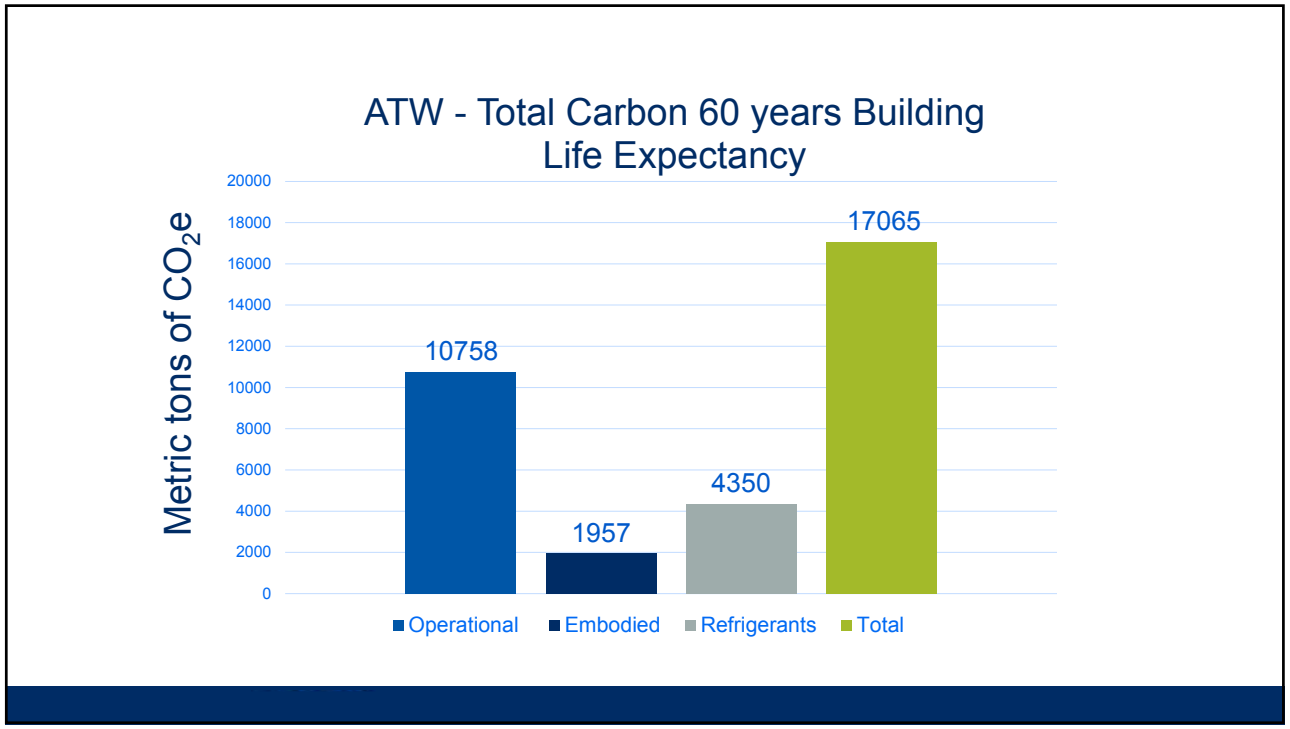
New Building Decarbonization Design
Appleton International Airport (ATW) – Embodied Carbon

- Concrete and Steel Structural system
- CLT deck replacing steel deck on roof
- Exterior Walls with brick and metal panel cladding
- PIR insulation

38


ATW - Total Carbon 1st Year of Operations
Metric tons of CO_2e
3500
3000
2500
2000
1500
1000
500
0
631
2396
73
3100
Operational
Embodied
Refrigerants
Total

39


ATW - Total Carbon 60 years Building Life Expectancy
Metric tons of CO_2e
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
10758
1957
4350
17065
Operational
Embodied
Refrigerants
Total

40

Pathway to Electrification

41

Where to Start on the Electrification Pathway

1. • Define the goals and the scope (audits/retro-commissioning, renewables, electrification)
   • Define the boundary (operational, vehicular, process equipment)
2. • Asset management survey
   •existing fossil fuel generative equipment
   •existing electrical capacity
   •age and lifetime of existing equipment
3. • Determine alternatives to each equipment piece
   • Perform a payback period or life-cycle cost analysis
4. • Train operations and maintenance staff on electric equipment
   • Develop policy for retrofits, replacements, new construction

42

Considerations

- Discuss electrification in master planning or sustainability planning for military installations
- Understand the code requirements around electrification
- When electrifying, consider the bigger picture of decarbonization and look at all types of carbon in a building
- Approach for new construction vs existing facilities in electrification and decarbonization planning

43

Thank you.

44