Powerful Facility
Energy Conference

Decarbonization and Electrification: Beneficial Electrification for Existing Buildings

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March 16, 2023

Introduction

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Agenda

- **WHAT**: Definitions - Electrification and Decarbonization
- **WHY and HOW**: Goals of Electrification and The Role of Buildings
- **Benefits** of Electrification
- Overview of Electrification **Technology**
- Common **Barriers**
- **Strategies** to overcome barriers
- **Case Study**: Seattle Central College's EcoDistrict Project.

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The What

What is Decarbonization?

Reduction or elimination of CO_2 emissions

Images source: energy.gov

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What is Electrification?

Replacing technologies that use fossil fuels

- Natural gas
- Petroleum/diesel

With technologies and systems that use electricity

Images source: energy.gov

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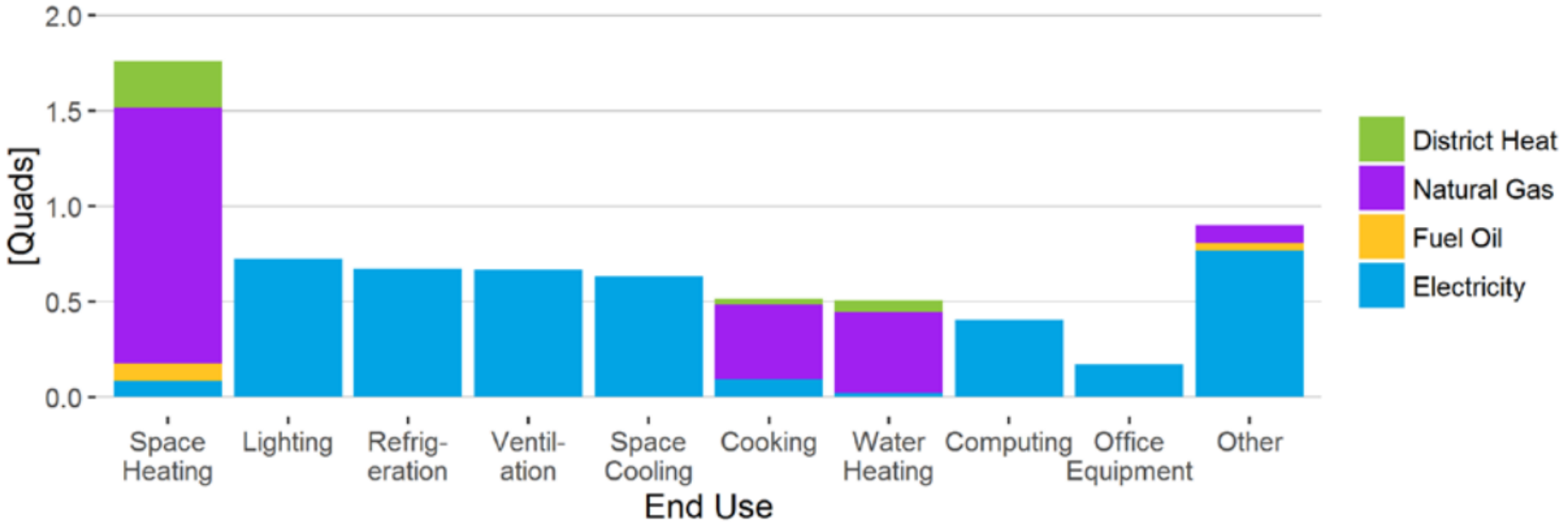
Carbon Emissions in Existing Buildings



Final energy end use in commercial buildings (based on 2012 CBECS)

Source: National Renewable Energy Laboratory

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The Why

Environmental Drivers: GHG Emissions

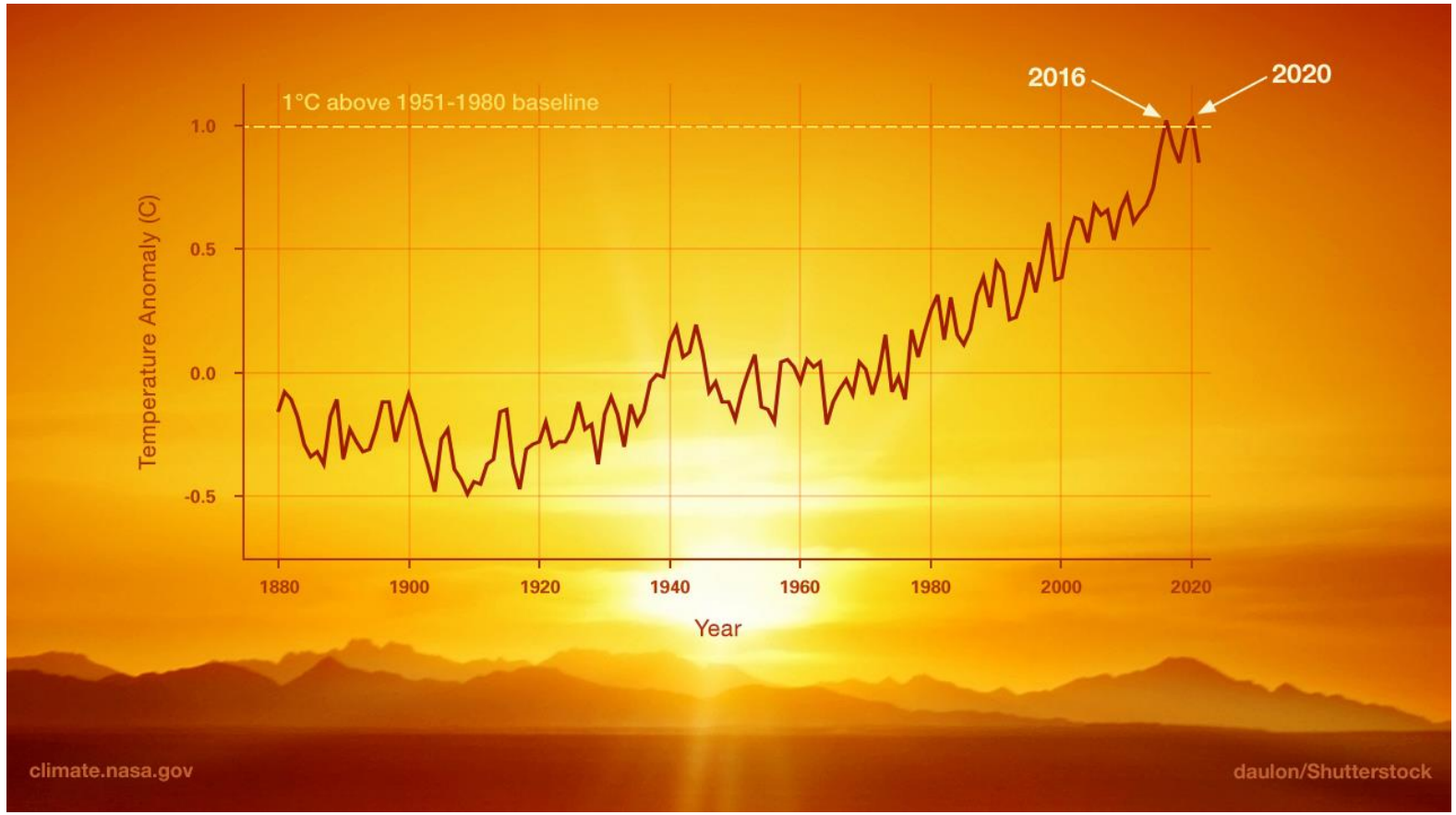

Image credit: NASA/JPL-Caltech

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Policy Trends

2025
NO COAL
STANDARD

2030
GHG NEUTRAL
STANDARD

2045
100% CLEAN
STANDARD

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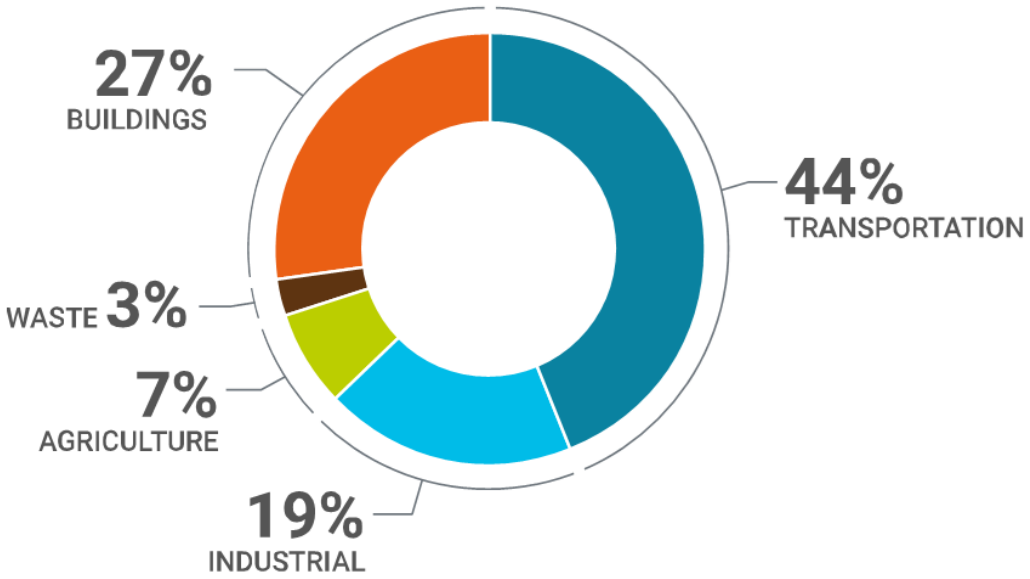
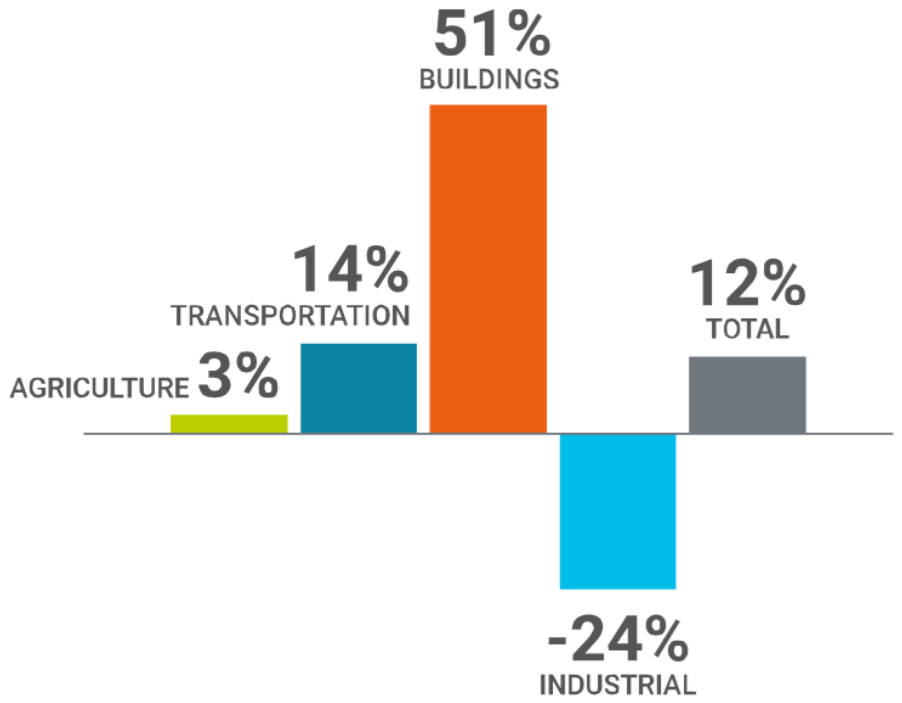
The Impact of Buildings

Buildings are the second largest source of greenhouse gas emissions in Washington (2015)



As Washington's population has grown, greenhouse gas emissions from buildings jumped significantly from 1990-2015



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The How

The HOW

Need 50% reduction in carbon emissions by 2030 and zero carbon by 2050

Role of the buildings sector:

- 39% of carbon emissions globally
- 80% of buildings that will exist in 2030 already exist today

To meet targets:

- 50% renewables in electricity generation by 2030
- Energy-using equipment must be electrified
- Annual energy-efficiency investments need to grow by a factor of four by 2040

Source: Rocky Mountain Institute

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The HOW

To meet the needs of changing energy infrastructure, buildings will need to be:

- More energy-efficient
- Grid-interactive
- Load flexible

Buildings will need to leverage:

- Onsite generation
- Energy storage (thermal/electric)
- Intelligent, predictive controls that shift, shed and modulate building loads

Buildings can provide grid services needed to support the energy transition

- Seth Coan, RMI Source: Orchestrating the energy transition: Tuning into buildings | Greenbiz

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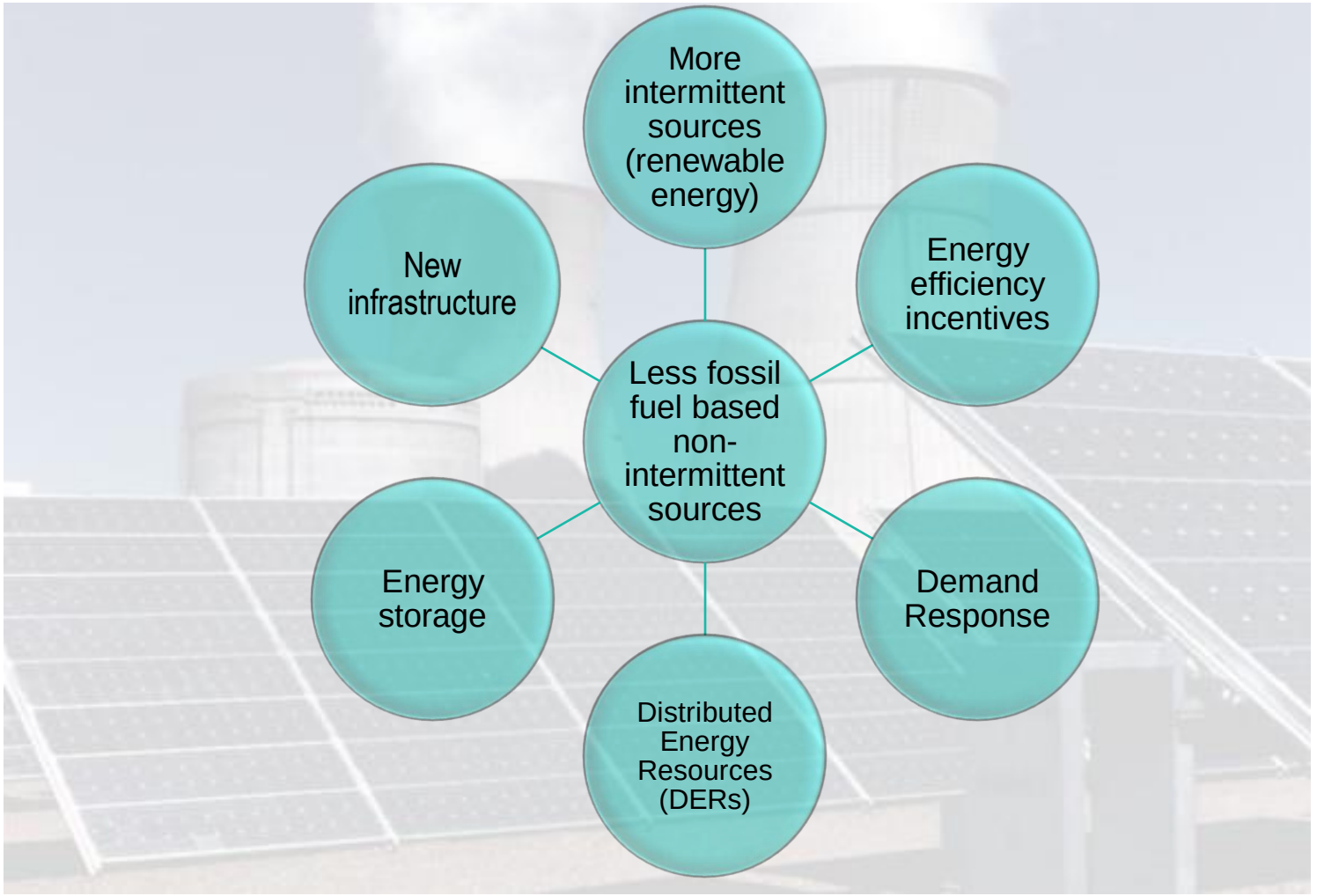
Utility Response



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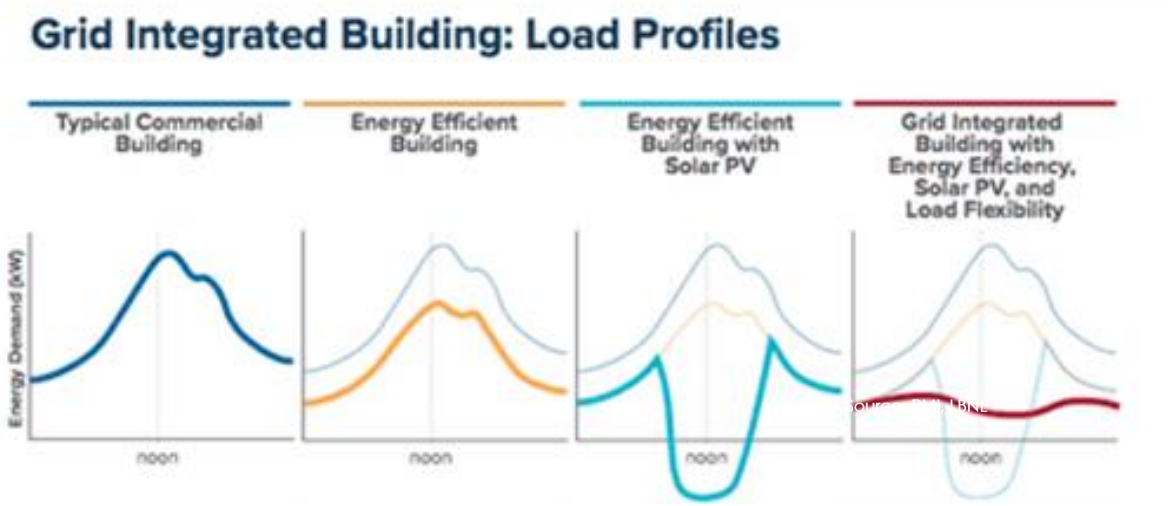
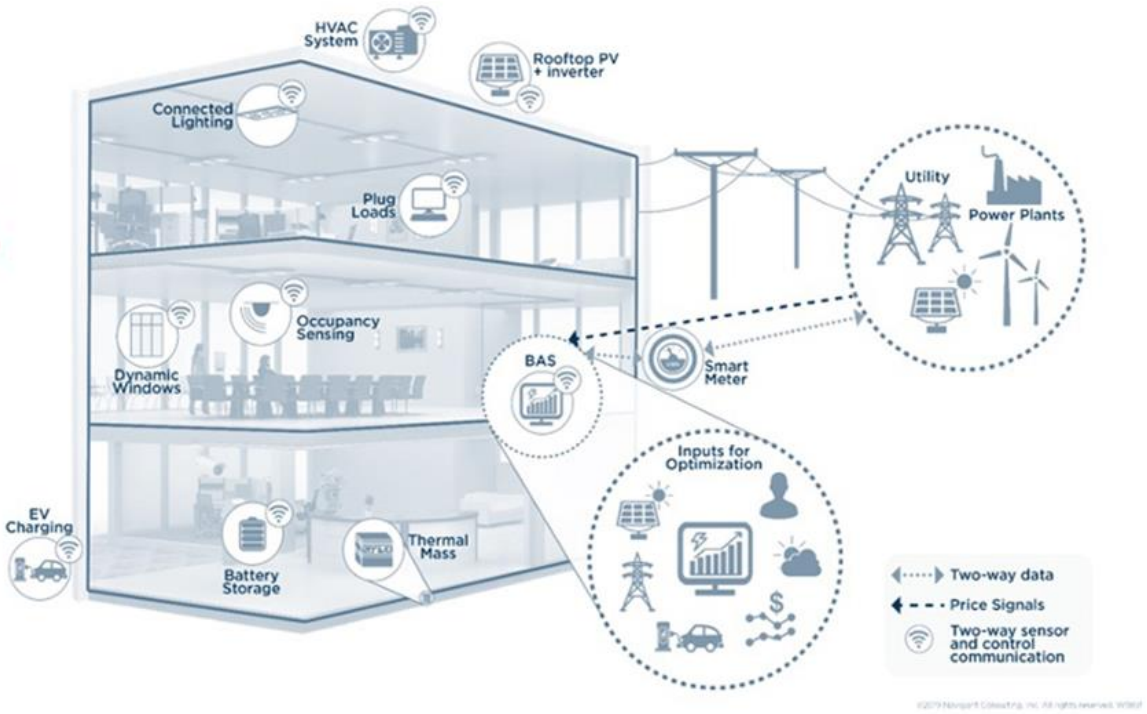
Grid Integration





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Benefits of Electrification

Benefits of Electrification

- Mitigation of the most severe effects of climate change
- Improved air quality and health
- Energy cost savings
- Job creation
- Improved comfort and productivity

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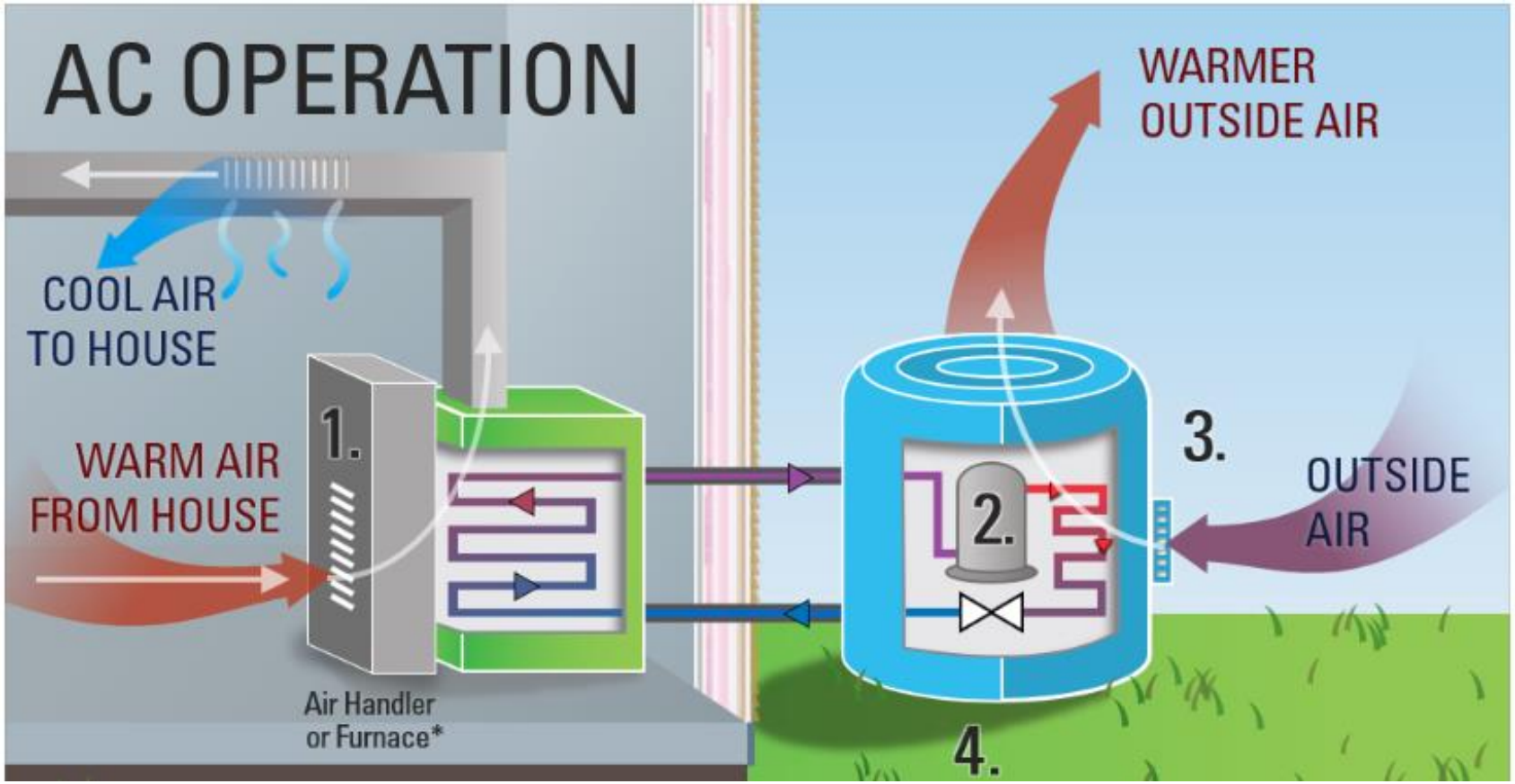
Overview of Electrification Technology

Heat Pumps



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Heat Pump Classification

Source	• air, water, or ground
Distribution	• ducted or ductless
Configuration	• packaged or split

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Variable Refrigerant Flow (VRF)

- Very efficient
- Multiple zones
- Heating and cooling
- All electric
- Can provide DHW

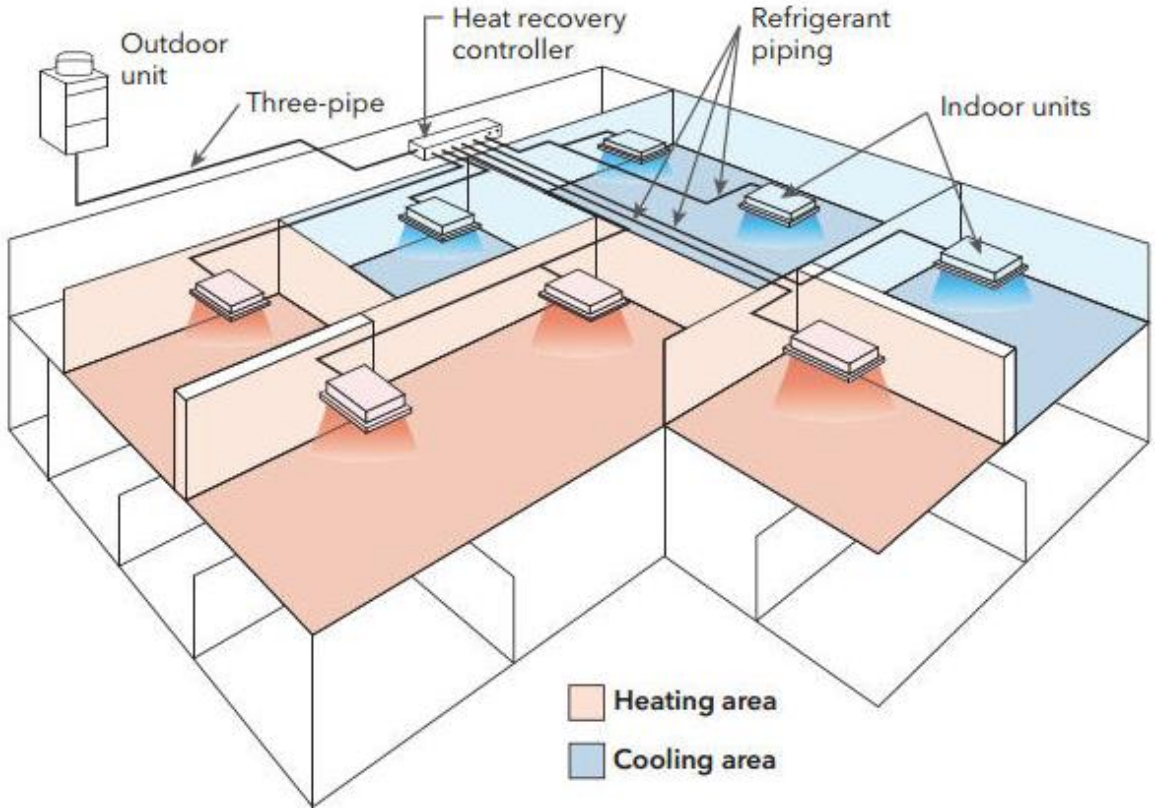

Image courtesy of Slipstream Inc.

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Domestic Hot Water Heating

- Heat Pump Water Heaters (HPWH)
- Unitary
- Split

- Components:
- Heat pumps
- Hot water storage
- Temp maintenance
- Controls

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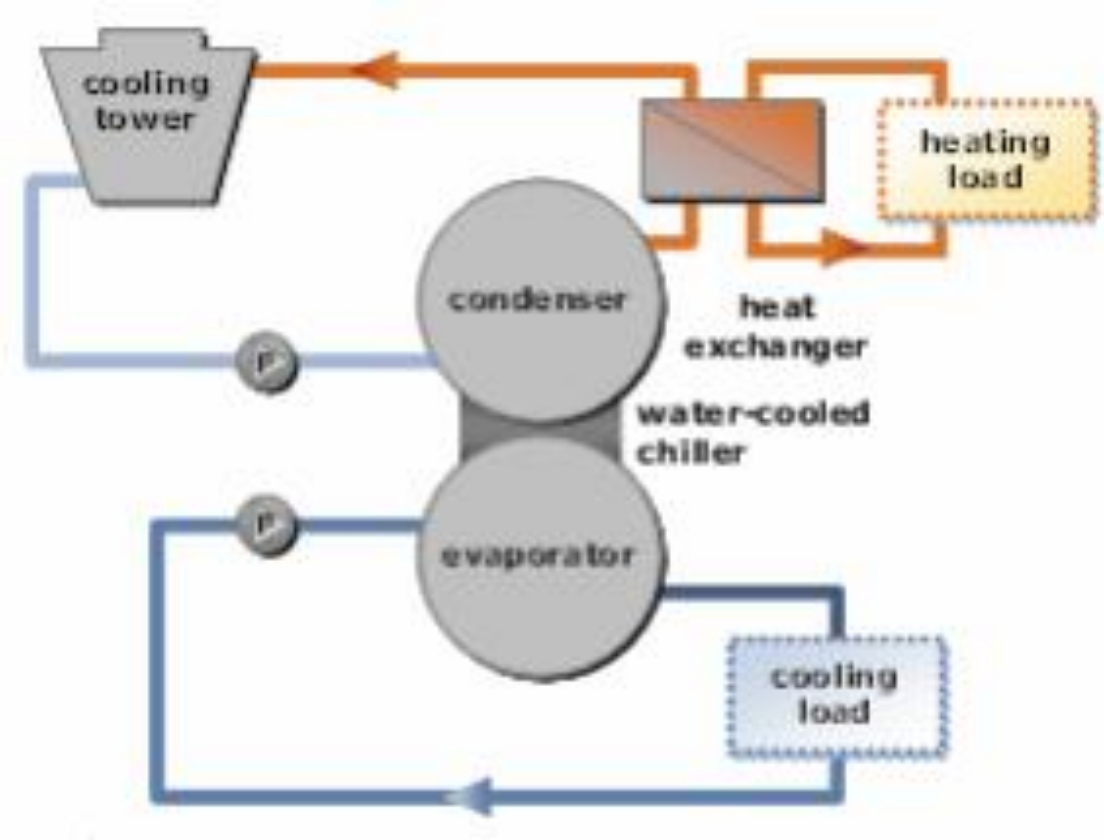
Energy/Heat Recovery

- Paired with heat pump systems to increase efficiency
- Energy recovery ventilators (ERVs) or heat recovery ventilators (HRVs)
- Heat recovery chillers



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Barriers

Barriers

Technical/Logistical

- Infrastructure limitations
- Hardware and software integration
- Electrical service capacity
- Maintenance support

Financial

- Upfront costs
  - Installation
  - Downtime
- Training/hiring for additional trade skills

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Strategies & Solutions

Strategies & Solutions

Technical/Logistical

- Efficiency measures to reduce need for capacity upgrades
- Thorough planning for retrofits
- Onsite renewables
- Energy storage
  - Thermal
  - Electrical (batteries, EVs)
- Maintenance – in-house staff training/ clearly defined outsourced maintenance contract

Financial

- End-of-life equipment retrofit opportunities
- Consider total cost of ownership (TCO) including health/safety benefits
- Leverage benefits of smart building technology to reduce operating costs
- Demand response revenue opportunities
- Funding:
  - Creative financing structures
  - Incentives, rebates, grants

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Funding Mechanisms

- Federal/State (e.g. IRA, CBPS) grants
- Utility Incentives
- Pay for Performance
- C-PACER
- Energy Service Performance Contracting (ESPC)
- Energy Efficiency as a Service (EEaS)

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Strategy – Retrofit Planning

Opportunity to:

- Accomplish energy efficiency
- Incorporate electric replacement options
- Update electrical infrastructure and meet power requirements
- Introduce and integrate technologies for control and load reduction

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Retrofit and Replacement Considerations

Logistical considerations

- Type of equipment to be replaced
- Size/layout of building and equipment
- Climate zones
- Load profiles
- Energy distribution temperatures required
- Electrical service capacity/distribution
- Maintenance skills required

Cost Considerations

- First cost vs. total cost of ownership (TCO)
- Utility rate structures, incentives and value of resilience

Technical Considerations: i.e. Refrigerant types and GWP

- Preventative and reactive maintenance programming, training and technical skills
- Refrigerant management program

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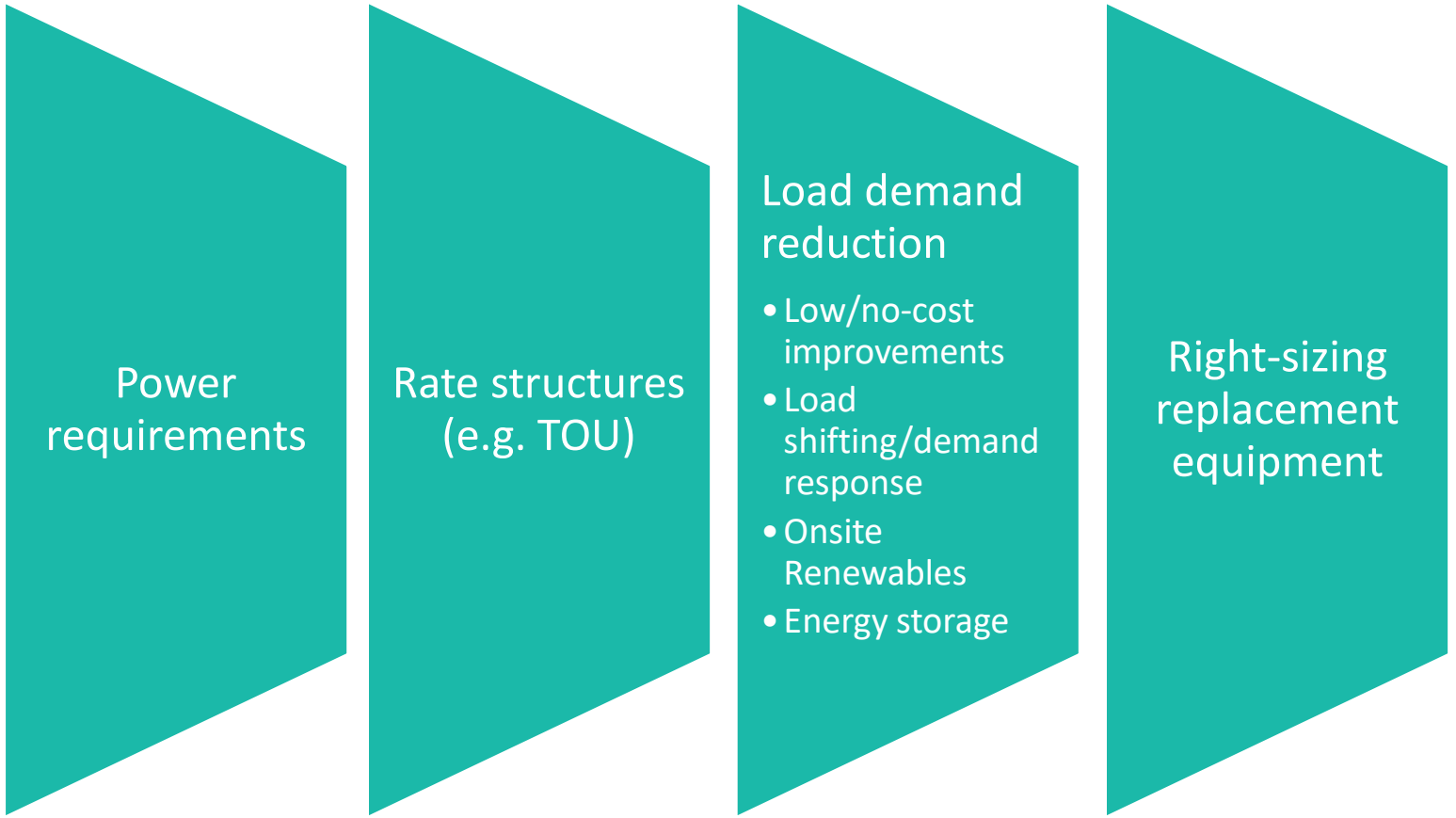
Retrofit and Replacement Considerations (cont.)



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Identifying Replacement Options

Scenario	Replacement Option
Small buildings • Conventional RTU	• Heat pump RTU, ERV/HRV, VRF
Medium buildings • VAV Reheat	• Heat pump AHUs, ASHPs, multi-pipe with heat recovery
Large buildings • Steam boilers • Hot water boilers • Chillers	• Reduce load, weatherization, radiator redesign, VRF • ASHPs, WSHPs, VRF • Heat recovery chillers, chilled water return as source for heat pumps

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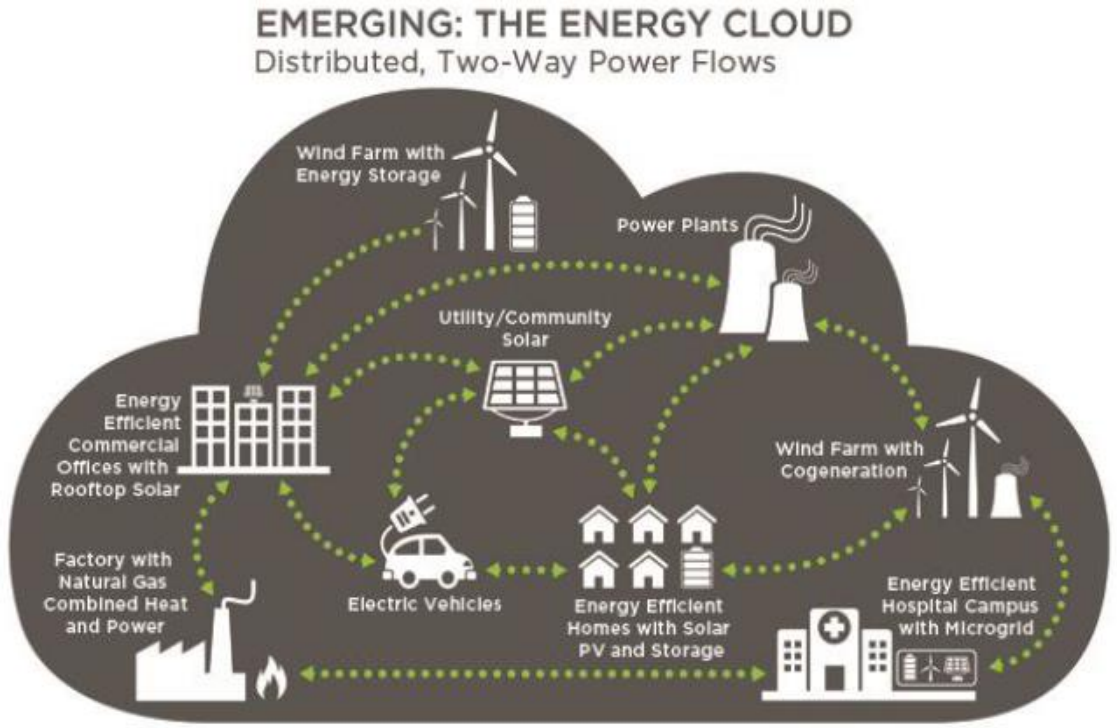
Comparison of Refrigerants

Refrigerant	Refrigerant Family	GWP
R22	HCFC	1,810
R32	HFC	675
R134A	HFC	1,430
R290 (propane)	HC	3.3
R404a	HFC	3,922
R407c	HFC	1,774
R410a	HFC	2,088
R717 (ammonia)	Inorganic compound	0
R744 (CO_2)	Inorganic compound	1
R1234ze (E)	HFO	~1

Distributed Energy Resources (DER)



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O&M Considerations

- Preventive maintenance
- Staffing/training
- Outsourced support
- Safety protocols
- IT Security
- Automation and Programming

Resources

Electrification & Decarbonization: Exploring U.S. Energy Use and Greenhouse Gas Emissions in Scenarios with Widespread Electrification and Power Sector Decarbonization
https://www.nrel.gov/docs/fy17osti/68214.pdf

Orchestrating the energy transition: Tuning into buildings
https://www.greenbiz.com/article/orchestrating-energy-transition-tuning-buildings

Variable Refrigerant Flow Technology for Commercial Buildings

https://facilityexecutive.com/2019/04/variable-refrigerant-flow-technology-commercial-facilities/

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Case Study

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Existing Building Decarbonization

Steve Abercrombie, South Seattle College
March 16, 2023

Broadway Edison – Seattle Central College (SCC)

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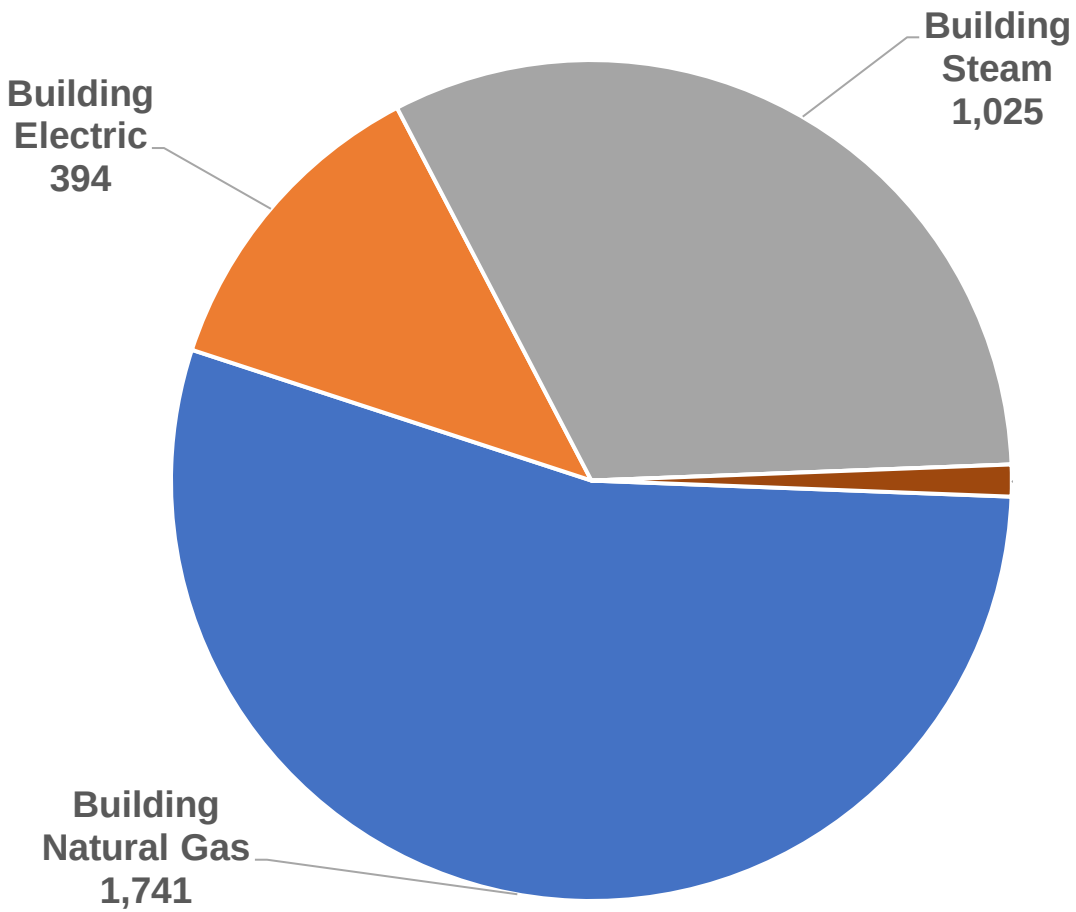
- 486,000 Square feet
- Oldest building in the Seattle district
- Heating system harks back to the days of steam power
- Doesn’t fit WA state’s standard capital funding model
- 60% of SCC’s campus, 85% of instructional space
- Steam heating system served by Centrio is reaching a point of system failure

GHG Emissions

SUSTAINABLE BUILDING SCIENCE TECHNOLOGY SBST

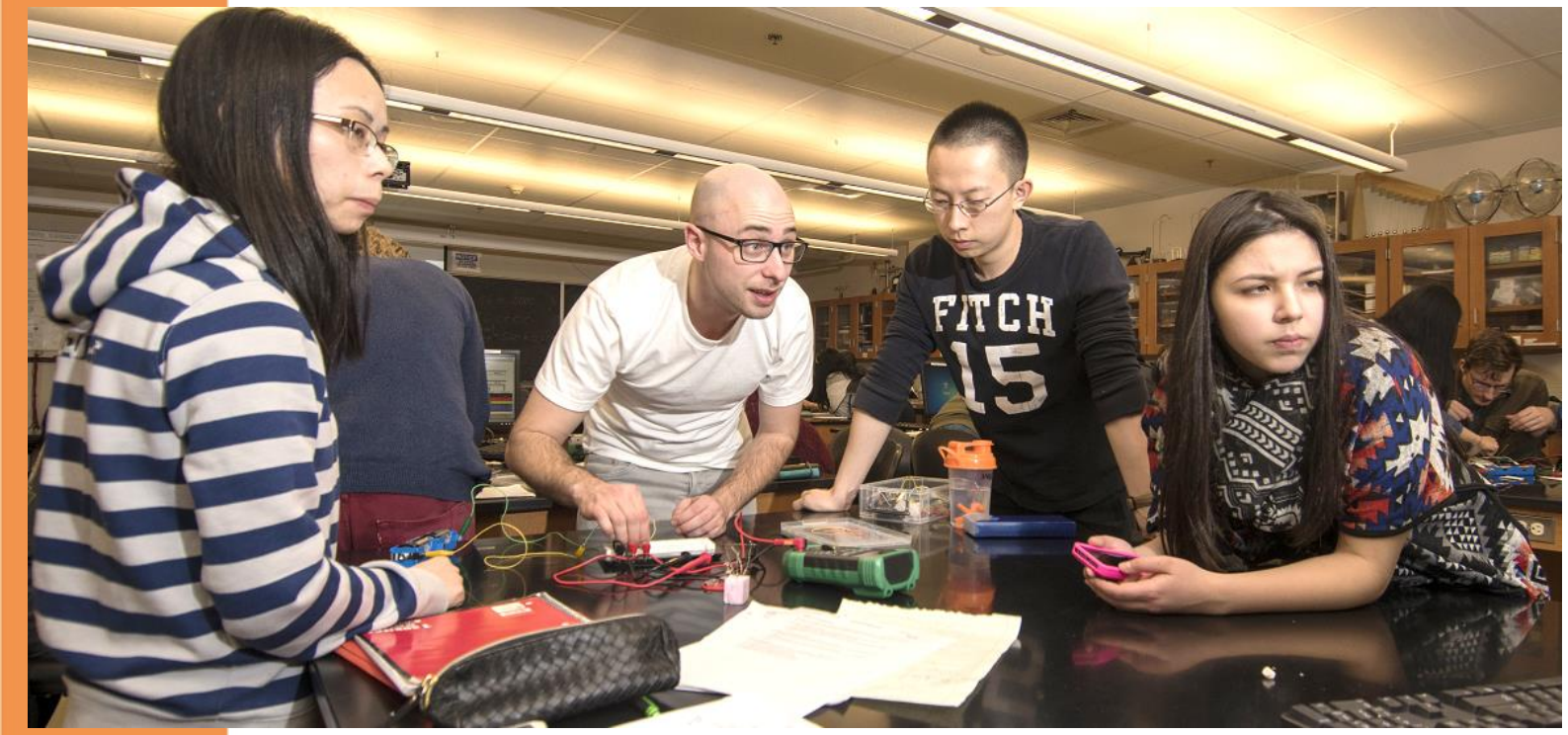


Seattle Colleges 2021 CO2E Emissions in MT

Replacing Central steam with low carbon heat generation

- Steam replacement an imperative
- Reduces CO2 and other emissions
- $23+ million investment
- ~$1 million increase in annual expense
- Energy consumer -> provider transition
- Living laboratory for students

Our Vision - A New Approach to Resilient and Clean Infrastructure



- Reduce risk of long-term campus outages (Moving from steam heating to heat pump technology)
- Reduce climate change impact
- Reduce utility increases through efficiencies
- Mitigate increase of deferred maintenance

Seattle Central College Energy District Approach

SUSTAINABLE BUILDING SCIENCE TECHNOLOGY SBST


Shared Energy


Zero Carbon


Digital Backbones

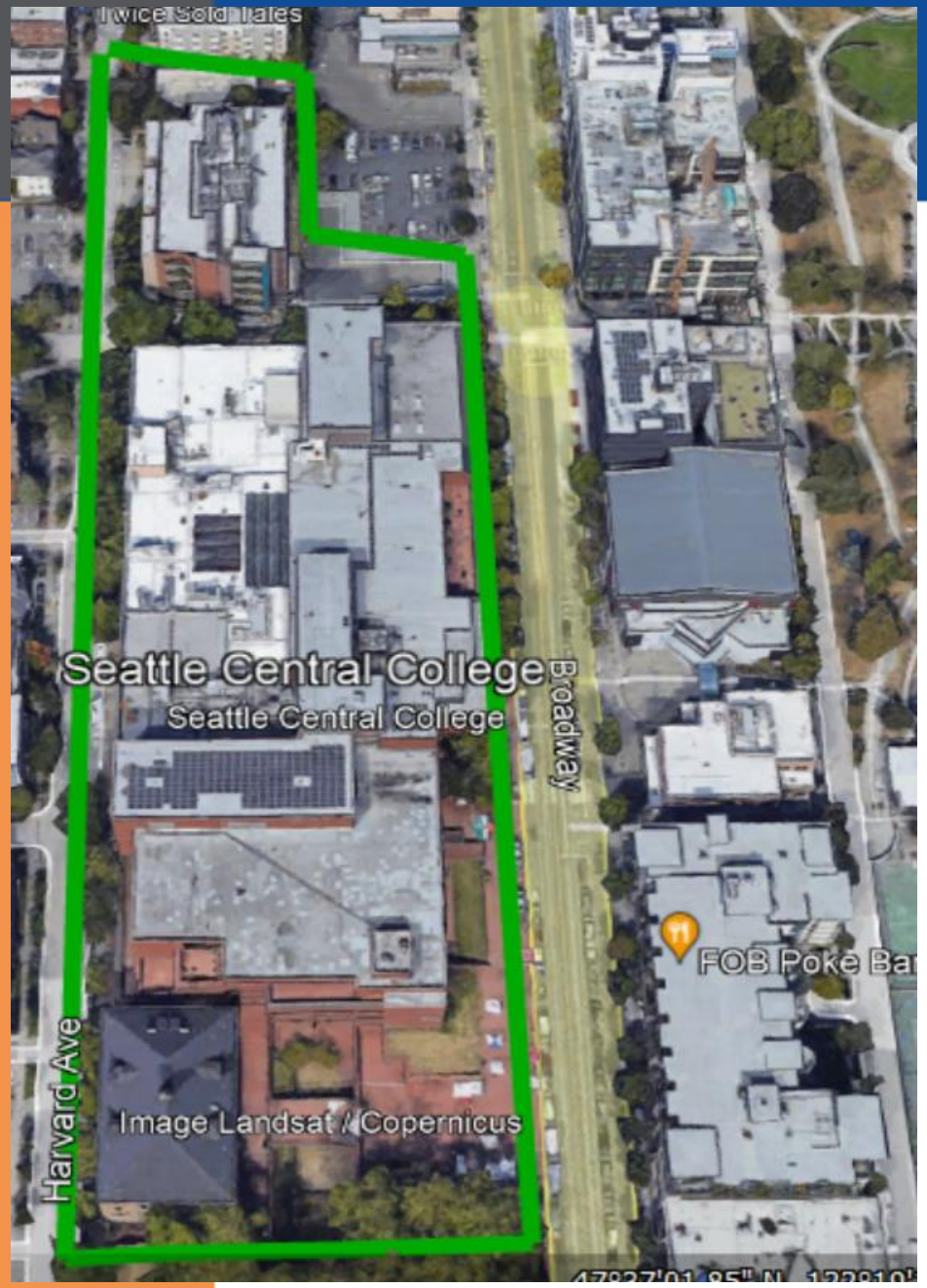

Building & Utility Partnerships

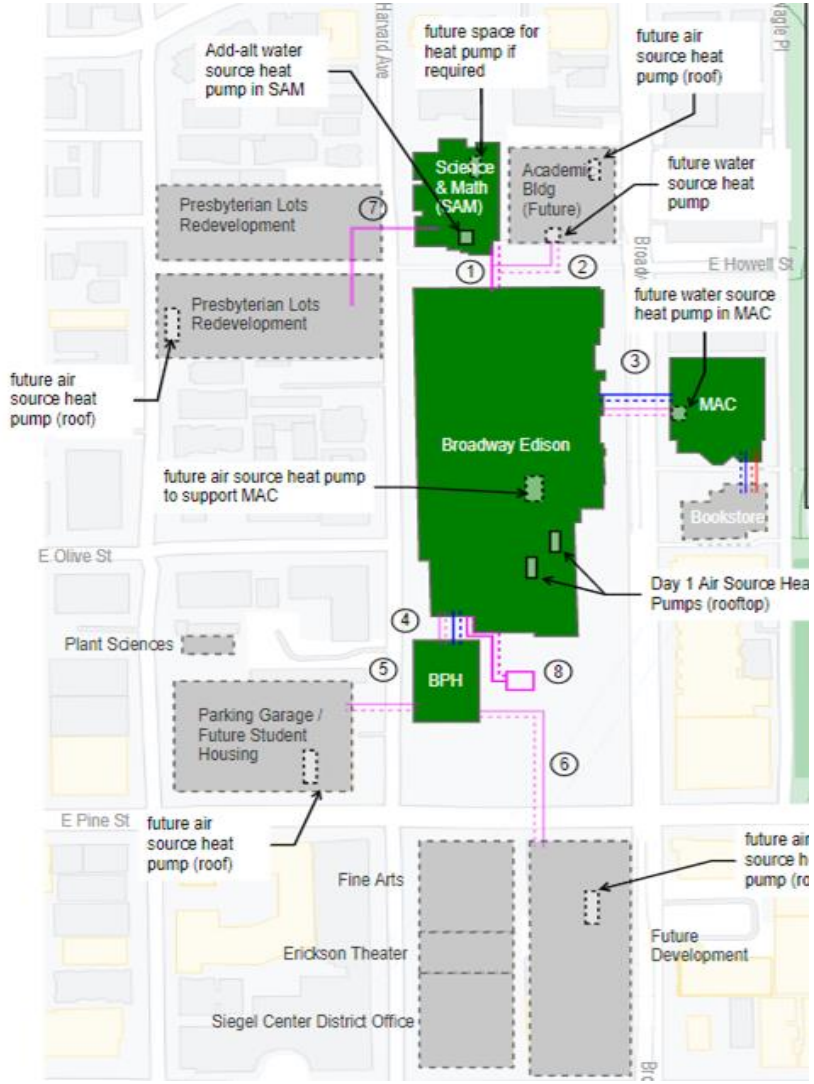

Engaged Occupants

- Develop a district energy sharing strategy to address energy efficiency, decarbonization and resiliency concerns
- Engage Seattle City Light as a partner to support its electrification and decarbonization goals for Capital Hill
- Onboard key community partners / neighbors to develop and align on the goals and objectives of a Capital Hill Energy District approach & solution
- Capitalize on industry partnerships and experience to develop a strategy and plan to address immediate needs and future goals.

Eco District Site Plan

SUSTAINABLE BUILDING SCIENCE TECHNOLOGY SBST





Addressing deferred infrastructure resiliency risk while decarbonizing.

Strategy

- Efficiency first:
  - Lighting retrofits
  - Air Source Heat pumps
  - Envelope improvements
- R & D grant from Commerce
  - Installation of Air -> Water heat pump. Demonstrate replacement at central plan
- Major Capital project
  - Working through public funding!?!

SUSTAINABLE BUILDING SCIENCE TECHNOLOGY SBST

Join an Information Session!

http://bit.ly/SBST_Info

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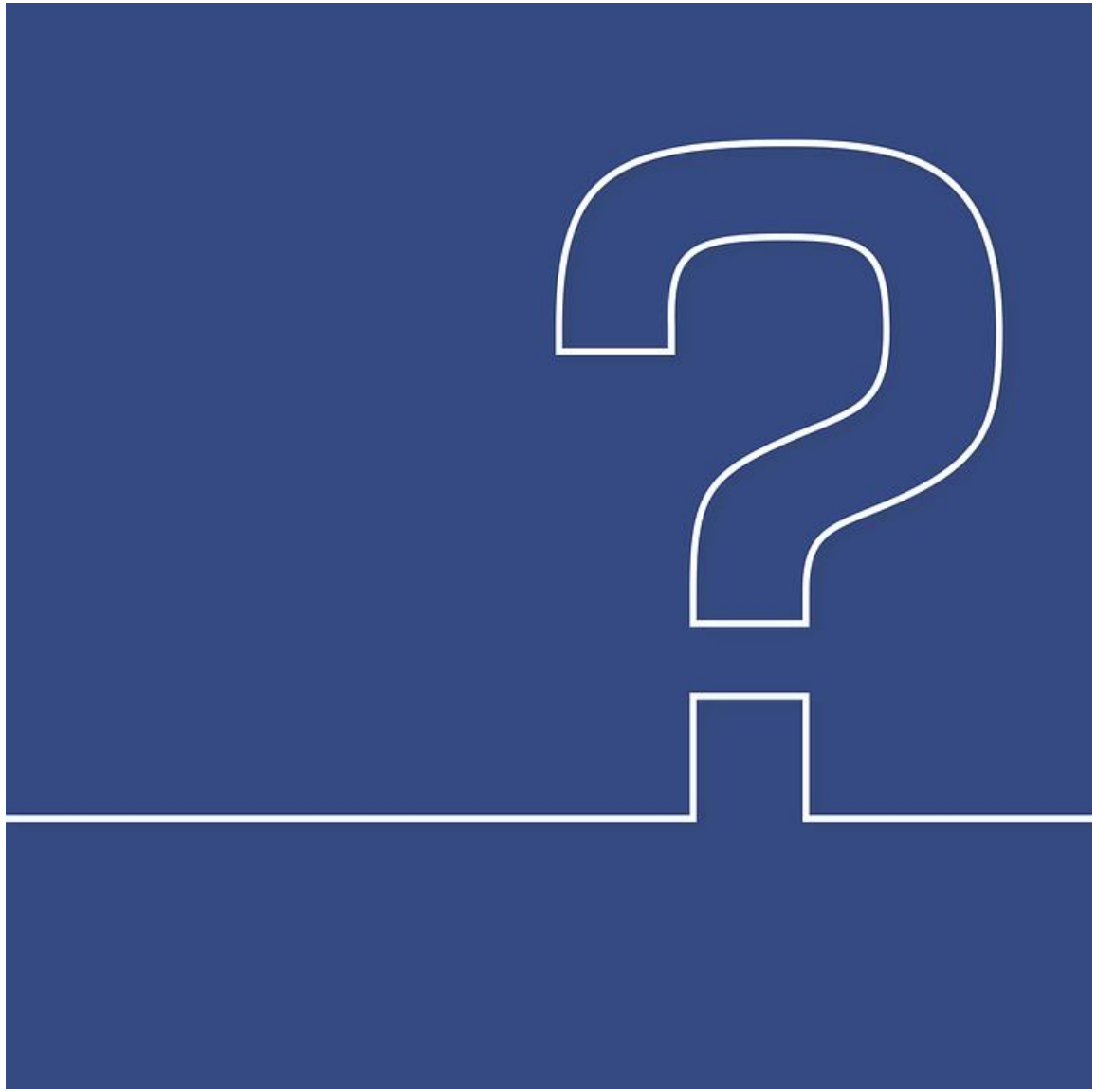
- https://southseattle.edu/programs/sustainable-building-science-technology

Q & A



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