FUELS & ENERGY RESOURCES

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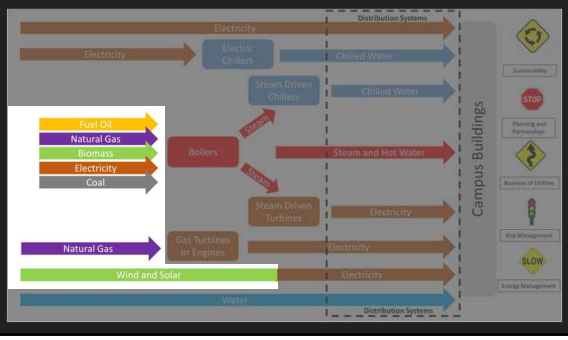
FUELS & ENERGY RESOURCES



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COURSE DESCRIPTION

Overview of fuel and energy resource terms and concepts

- **Primary fuels:**
  - Natural Gas
  - Coal
  - Oil
- **Fuel market volatility and risk management**
- **Carbon emissions and Levelized cost of energy**
- **Common variable renewable energy resources:**
  - Solar
  - Wind
- **Nuclear**
- **Geothermal & Geo-exchange**

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LEARNING OBJECTIVES

Basic understanding of:

- Primary fuels used to generate energy
- Fuel market volatility and risk management
- Energy resource options

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CHANGING ENERGY LANDSCAPE

Resource	Government	Institution Goals
• Availability • Cost • Risk	• Policies • Incentives	• Carbon emissions • Renewable energy

What energy resources make the most sense for your campus?

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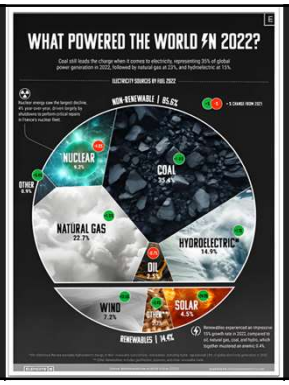
GLOBAL SNAPSHOT



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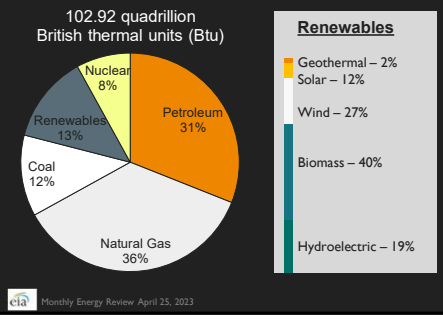
2022 U.S. ENERGY PRODUCTION



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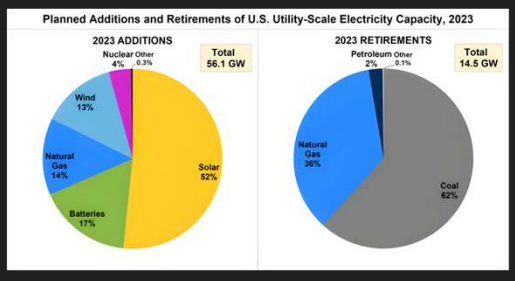
2023 U.S. ENERGY CAPACITY CHANGES



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COAL
Energy-Dense
Technological demands are small
Economic costs are low
Contains impurities
Release impurities into the air
Trace metals like mercury and lead
Ash is left behind
10

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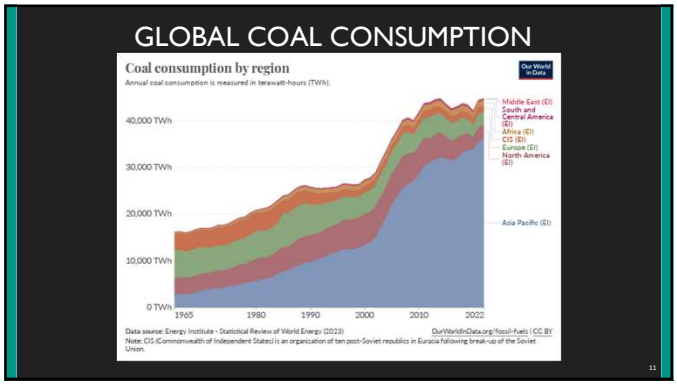
GLOBAL COAL CONSUMPTION
Coal consumption by region
Annual coal consumption is measured in terawatt-hours (TWh).
Our World in Data
40,000 TWh
30,000 TWh
20,000 TWh
10,000 TWh
0 TWh
1965
1980
1990
2000
2010
2022
Middle East (EI)
South and Central America (EI)
Africa (EI)
CIS (EI)
Europe (EI)
North America (EI)
Asia Pacific (EI)
Data source: Energy Institute - Statistical Review of World Energy (2023)
OurWorldInData.org/fossil-fuels | CC BY
Note: CIS (Commonwealth of Independent States) is an organization of ten post-Soviet republics in Eurasia following break-up of the Soviet Union.
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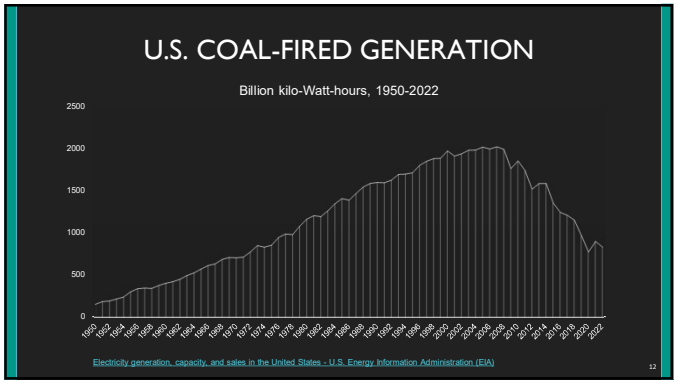
U.S. COAL-FIRED GENERATION
Billion kilo-Watt-hours, 1950-2022
2500
2000
1500
1000
500
0
Electricity generation, capacity, and sales in the United States - U.S. Energy Information Administration (EIA)
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WHERE ARE THE U.S. COAL BASINS?

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NATURAL GAS

Cleaner to burn – half as much CO_2 as coal	More efficient – 10% energy lost	60 – year supply at current rates	Difficult to transport	Can be polluting, dangerous when extracted	Methane bed drilling pollutes

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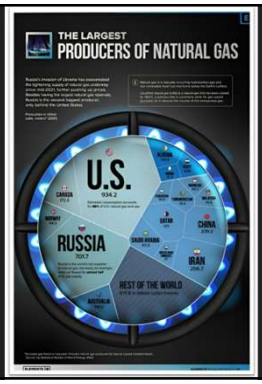
GLOBAL



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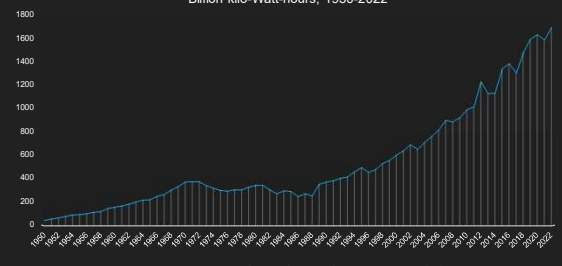
U.S. NATURAL GAS-FIRED GENERATION

Billion kilo-Watt-hours, 1950-2022



Electricity generation, capacity, and sales in the United States - U.S. Energy Information Administration (EIA)

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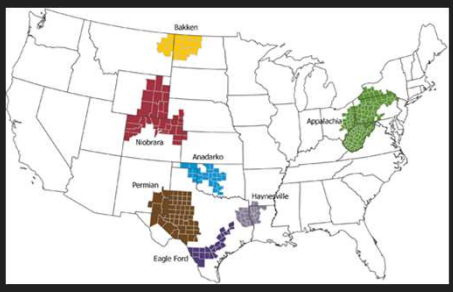
WHERE IS THE U.S. NATURAL GAS?



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OIL

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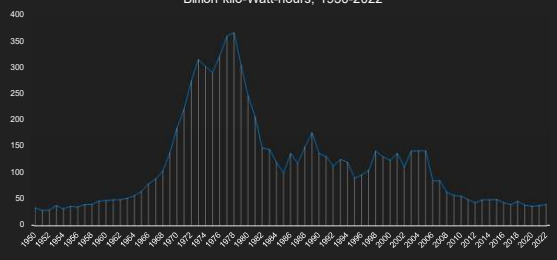
U.S. PETROLIUM-FIRED GENERATION

Billion kilo-Watt-hours, 1950-2022



Electricity generation, capacity, and sales in the United States - U.S. Energy Information Administration (EIA)

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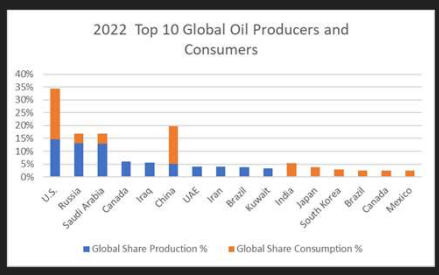
OIL PRODUCTION & CONSUMPTION

GLOBAL



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FUEL MARKET VOLATILITY & RISK

- Commodity Markets
  - Coal
  - Natural Gas
  - Petroleum
- Transportation and Storage
  - Increases volatility and risk
- Procurement/Contracting Process
  - Take or pay requirements
  - Balancing issues

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FUEL RISK MANAGEMENT STRATEGIES

- Hedging or Futures Options
- Ability to Switch Fuels
- Demand Response/Peak Shaving
- Thermal Energy Storage
- Combined Heat & Power
- Customer Incentives
- Renewables

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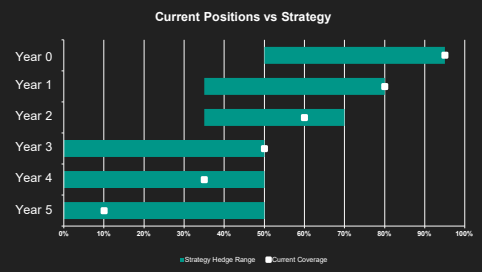
FUEL HEDGING STRATEGY EXAMPLE



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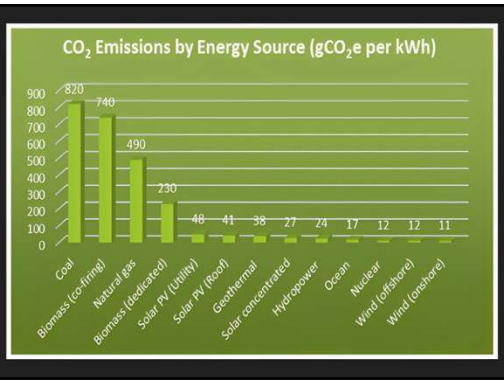

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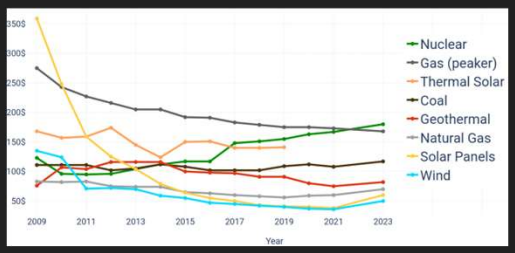
LEVELIZED COST OF ENERGY $/MWh



Average unsubsidized levelized cost of energy.
Data source is Lazard.

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SOLAR

Photovoltaic (PV)

Concentrated Solar

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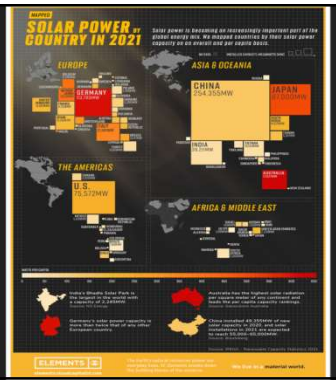
GLOBAL



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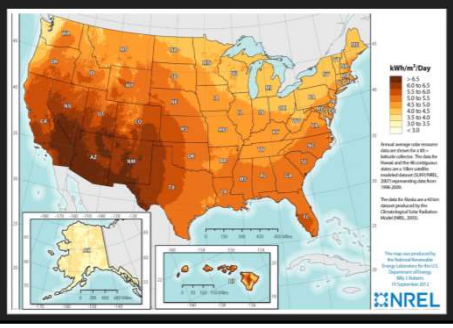
POTENTIAL SOLAR ENERGY



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U.S. SOLAR PRODUCTION TOP 10

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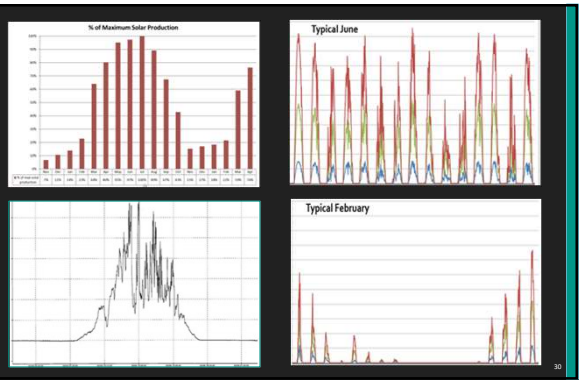
MICHIGAN CARPORT PV



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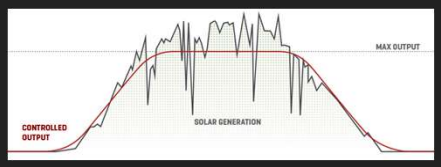
FIRMING SOLAR PV

USING BATTERY ENERGY STORAGE



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WIND

Off Campus

On Campus

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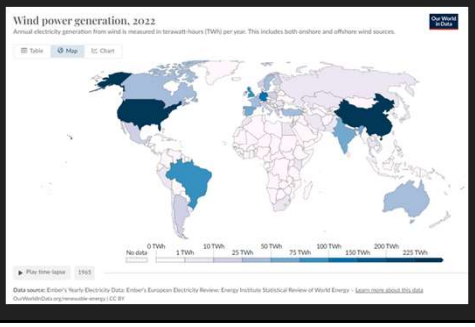
GLOBAL WIND POWER GENERATION



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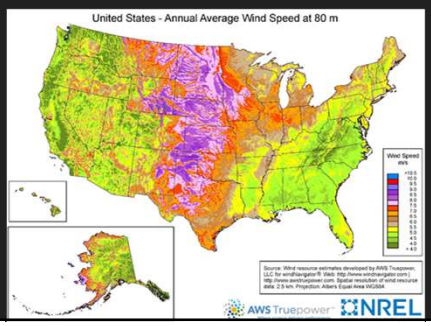
U.S. WIND ENERGY POTENTIAL



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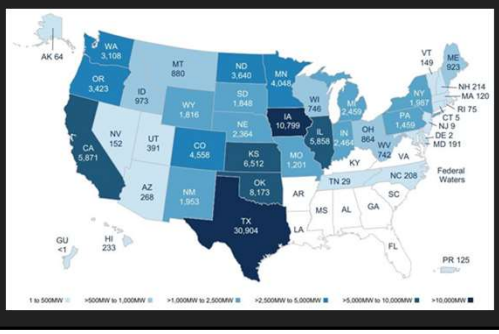
U.S. INSTALLED WIND ENERGY



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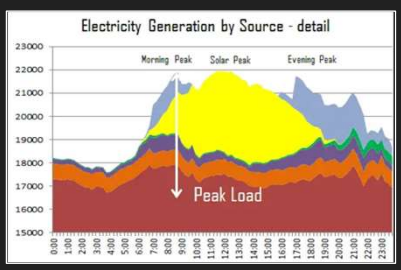
WIND GENERATION PROFILE



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NUCLEAR

Why ISN'T nuclear energy considered renewable?

- Nuclear fuels, such as uranium, are not considered renewable as they are a finite material mined from the ground and can only be found in certain locations.

Why IS nuclear energy considered clean?

- It produces zero carbon emissions and doesn't produce other noxious greenhouse gases through its operation.

Uranium is the main fuel for nuclear reactors.

Uranium is mined and goes through refining and enrichment to make the fuel for a nuclear reactor.

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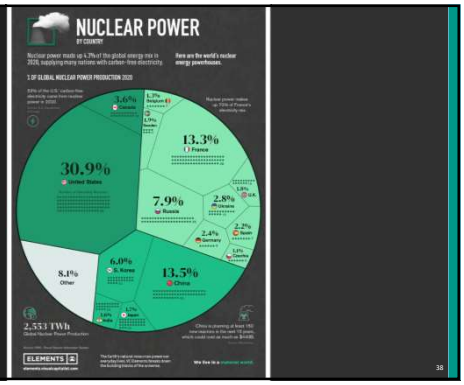
GLOBAL



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FUEL ENERGY DENSITY

About the size of a gummy bear

1 uranium fuel pellet =

- 1 ton of coal
- 17,000 cubic feet of natural gas
- 5,000 pounds of wood
- 149 gallons of oil

Source: Nuclear Energy Institute

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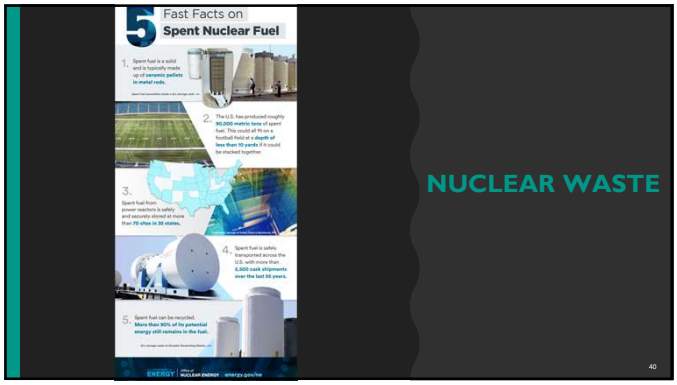
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Fast Facts on
Spent Nuclear Fuel
NUCLEAR WASTE
40

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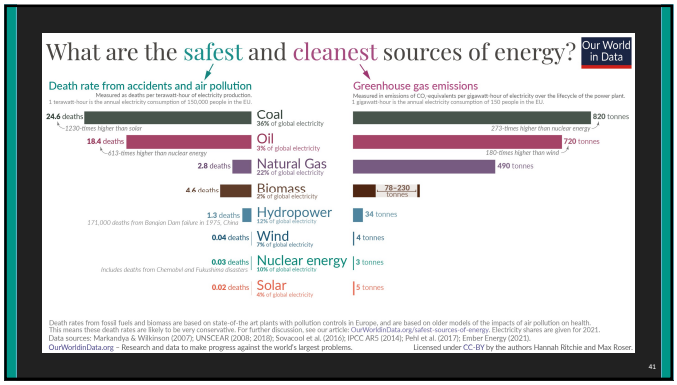
What are the safest and cleanest sources of energy?
Our World in Data
Death rate from accidents and air pollution
Greenhouse gas emissions
24.6 deaths
Coal
36% of global electricity
820 tonnes
18.4 deaths
Oil
3% of global electricity
720 tonnes
2.8 deaths
Natural Gas
22% of global electricity
490 tonnes
4.4 deaths
Biomass
2% of global electricity
78–230 tonnes
1.3 deaths
Hydropower
12% of global electricity
34 tonnes
0.04 deaths
Wind
7% of global electricity
4 tonnes
0.03 deaths
Nuclear energy
10% of global electricity
3 tonnes
0.02 deaths
Solar
4% of global electricity
5 tonnes
OurWorldinData.org – Research and data to make progress against the world's largest problems.
Licensed under CC-BY by the authors Hannah Ritchie and Max Roser.
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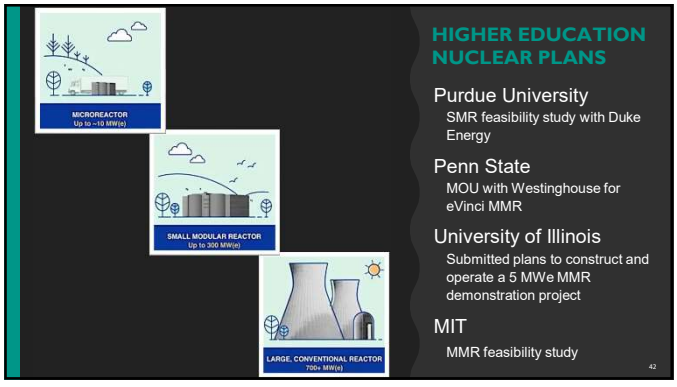
MICROREACTOR
Up to ~10 MW(e)
SMALL MODULAR REACTOR
Up to 300 MW(e)
LARGE, CONVENTIONAL REACTOR
700+ MW(e)
HIGHER EDUCATION NUCLEAR PLANS
Purdue University
SMR feasibility study with Duke Energy
Penn State
MOU with Westinghouse for eVinci MMR
University of Illinois
Submitted plans to construct and operate a 5 MWe MMR demonstration project
MIT
MMR feasibility study
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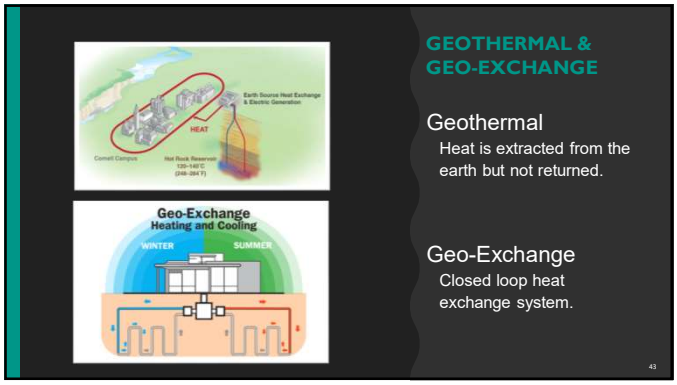
HEAT
Geo-Exchange
Heating and Cooling
WINTER
SUMMER
GEOTHERMAL &
GEO-EXCHANGE
Geothermal
Heat is extracted from the earth but not returned.
Geo-Exchange
Closed loop heat exchange system.
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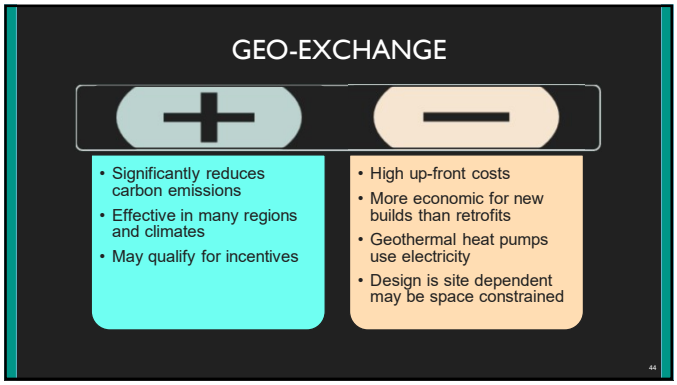
GEO-EXCHANGE
+
—
• Significantly reduces carbon emissions
• Effective in many regions and climates
• May qualify for incentives
• High up-front costs
• More economic for new builds than retrofits
• Geothermal heat pumps use electricity
• Design is site dependent may be space constrained
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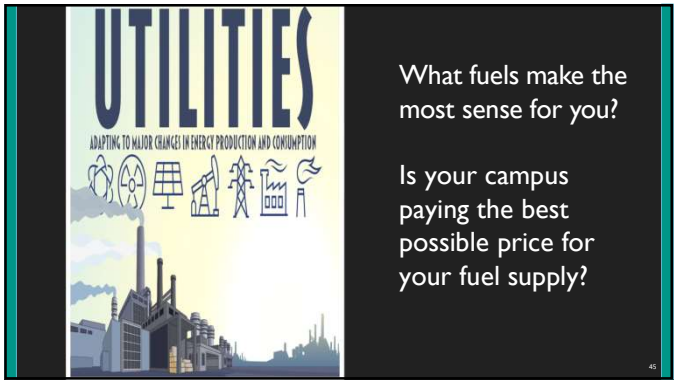
UTILITIES
ADAPTING TO MAJOR CHANGES IN ENERGY PRODUCTION AND CONSUMPTION
What fuels make the most sense for you?
Is your campus paying the best possible price for your fuel supply?
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This concludes The American Institute of Architects Continuing Education Systems Course

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QUESTIONS / COMMENTS

- Sign-in Sheet
- Evaluation Form

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