Electrical Generation and Distribution

AIA Continuing Education Provider

1

Credit(s) earned on completion of this course will be reported to American Institute of Architects (AIA) Continuing Education Session (CES) for AIA members.

Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

AIA Continuing Education Provider

2

Course Description

Electrical production and distribution equipment and systems are characterized by highly sophisticated technologies that continue to develop rapidly. College and university electrical distribution systems generally consist of a switching station for receiving the electricity into the university system, switching substations (which include transformers), medium-voltage conductor circuits, electric power generation, and system protection. This class will explore electrical systems typical of university-owned facilities where electricity, whether generated on campus, purchased, or both is received and further distributed to points on campus.

AIA Continuing Education Provider

3

Learning Objectives

In the next 45 minutes you will learn
- how electricity relates to campus sustainability
- how electricity is made and used
- options for using electricity to meet campus goals

AIA Continuing Education Provider

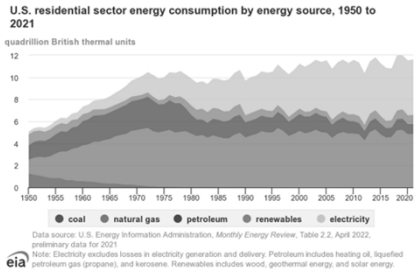
4

Households, Businesses, and Universities face similar sustainability challenges

- US home annual energy use:
  43% electricity, 50% gas/propane
  - https://www.eia.gov/energyexplained/use-of-energy/homes.php
- University of Iowa average annual energy use:
  25% electricity, 75% steam

5

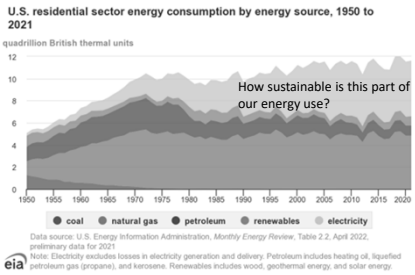
How is sustainability tied to electric generation and distribution?



https://www.eia.gov/energyexplained/use-of-energy/homes.php

6

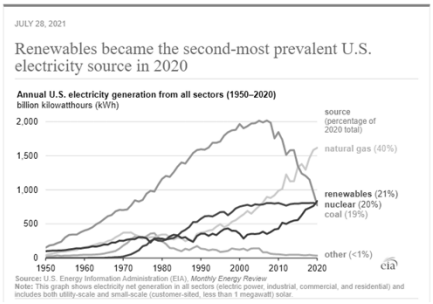
How is sustainability tied to electric generation and distribution?



https://www.eia.gov/energyexplained/use-of-energy/homes.php

7

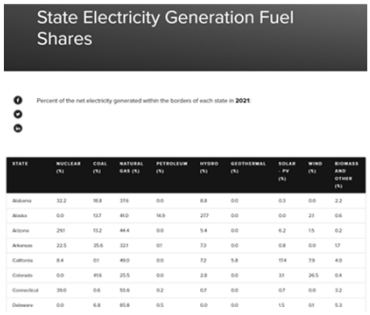
How is sustainability tied to electric generation and distribution?



https://www.eia.gov/todayinenergy/detail.php?id=48896

8

How green is my state's grid?

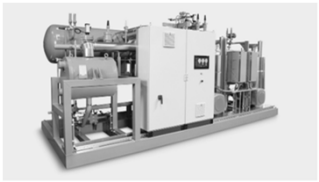


https://www.nei.org/resources/statistics/state-electricity-generation-fuel-shares

9

So I ask again, how does this tie to sustainability?

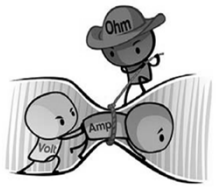
- The most common/popular way to decarbonize today is to electrify.
- Heat pumps/hot water (for now) are the most common way to decarbonize your:
  - Home
  - Business
  - University/College
- This means you campus will be buying, distributing, and possibly making more electricity in the future than you are today.



https://www.gea.com/en/products/refrigeration-heating/heat-pumps/open-type-heat-pump.jsp

10

Vocab



Electricity= flow of electrons

- Voltage (volts)= potential energy created by difference in charge between two points
- Current (amps) = rate at which the charge is flowing
- Resistance (ohms) = the material's tendency to resist the flow of charge.

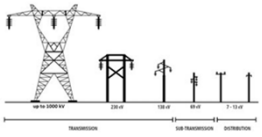
Plumbing analogy: Voltage = water pressure. Current = flow rate. Resistance = pipe size.

11

Transmission vs. Distribution

High Voltage Transmission lines:

- 69,000 volts and up
- Installed overhead for cost and efficiency.
- Not insulated.
- Insulation = weight = cost
- Higher voltage decreases losses



Distribution lines (Medium Voltage):

- Common voltages: 7,200-13,800 volts
- May be overhead or underground. U/G is much more reliable but up to 10X the cost of O/H. (Campus aesthetics another consideration!)
- If U/G, conduit may be direct buried, or encased in concrete "duct bank".
- Different utilities often share the same pole. Highest voltage electrical lines are always on top. Fiber optic, cable TV, telephone lines are installed below

12

Distribution: Radial vs. Loop Topology

Radial: One feeder line from generation to each load.
- Simple, lower cost, but inflexible in the event of a line fault
- No way to divert power through other feeders to keep power on

Loop: Multiple feeder lines, allowing power to flow to load from either direction
- Managed via switchgear (breakers, switches, etc) to allow or block the flow

13

UNDERGROUND DUCT

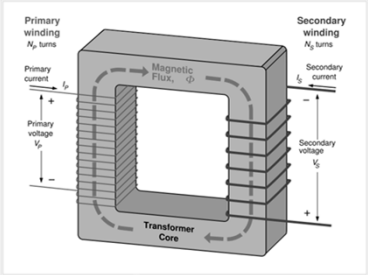
www.neca-neis.org/docs/
national electrical installation standards

14

DIRECT BURY CABLE

15

TRANSFORMER



https://energyeducation.ca/encyclopedia/Transformer

16

Transformer

Figure 1. Pad mounted transformer for electrical distribution.[1]

https://energyeducation.ca/encyclopedia/Transformer

https://www.amoselectric.com/5-things-not-to-do-during-a-power-outage/industrial-power-transformer-on-the-side-of-an-commercial-building/

17

Campus substation

18

Campus substation

19

Substation outage protection

20

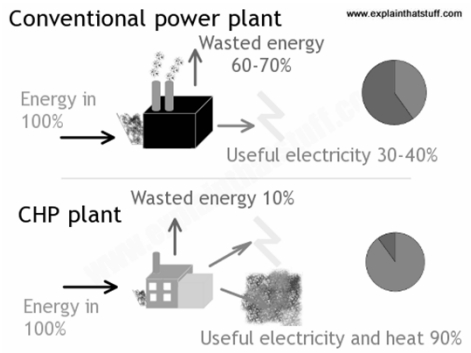
ABOVE GROUND CONDUIT

21

Combined Heat and Power

- District Energy: Central power plant distributes heating and cooling to all buildings via underground hot and chilled water pipes.
- Conserves energy & avoids need for each building to have furnace & A/C
- Standard Electric Power Plant: Energy contained in the primary fuel is used to make electricity only. On average, 66% of that energy is wasted.
- Combined Heat & Power: Primary fuel converted to multiple forms of useful energy. Only 20-25% energy wasted.

22



23

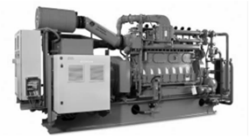
Solar PV

- Direct conversion of solar irradiance into electricity. No generator needed.
- PV panels contain silicon layers which carry a negative and positive charge
- Silicon molecules, like copper, are prone to losing electrons
- Photons from the sun dislodge electrons in the atoms from the negative layer
- Conductors embedded in panel collect the flowing electrons
- Output from all panels is combined and sent to grid

24

Gas Engines

- Provide automated backup power in an emergency
- Limit the use of natural gas
- Will become more critical if campus moving to electrical heating
- Can be used for curtailment, offsetting some cost
- Expensive equipment that is not used often (you hope)



https://www.power-technology.com/contractors/powerplant/ge-energy-gas-engines/

25

Virtual PPA

www.epa.gov/sites/default/files/2016-09/documents/webinar_kent_20160928.pdf

26

Virtual PPA

- PPA example
  - developer installs solar on campus
  - sells the electricity from the solar to campus per the PPA contract
- Virtual PPA
  - renewable electricity produced off site
  - you pay a fixed rate for the renewable electricity and get the renewable energy credits
  - continue to buy electricity from local provider
    - actual renewable electricity is sold to the local utility at market price
      - If market price is higher than VPPA contract price, you get the difference
      - If market price is lower than VPPA contract price, you pay the difference

27

Purchase or Generate? And Which Technologies?

Consider institutional priorities

- Sustainability goals
- Budget Stability
  - Fixed Costs – Construction & Regulatory
  - Marginal Costs – Fuel and O&M
- Energy Security
- Continuity of Services/Emergency Power
- Environmental Impacts

28

Purchase or Generate? And Which Technologies?

Consider limitations

- Available Capital
- Regional Energy Resources
- Physical Space / Existing Infrastructure
- Permitting Regime
- Community Support
- Timeline, Scalability
- Staffing & In-house Expertise
- Bring in third party operators – P3

29

THIS CONCLUDES THE AMERICAN INSTITUTE OF ARCHITECTS CONTINUING EDUCATION SYSTEMS COURSE

AIA Continuing Education Provider

30