Energy Transition
Everything Everywhere All At Once

AIEE

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Everything, everywhere, all at once

Plot of movie

- Heroine must navigate multiple versions of herself to save the multiverse from an evil being
- Metaphor for **energy transition**
- => **everything, everywhere all at once**
- Evil multiverse**?**
- Fossil fuels
  - Profitable & politically powerful
  - **G20 subsidies in 2022: $1.1 trillion**

Main message

- Climate change is real & is here
- Solution “on paper” is simple
- Two intertwined steps
  - Electrify all that can be electrified
  - Supplied from low-carbon sources
- => Electric power sector key to transition

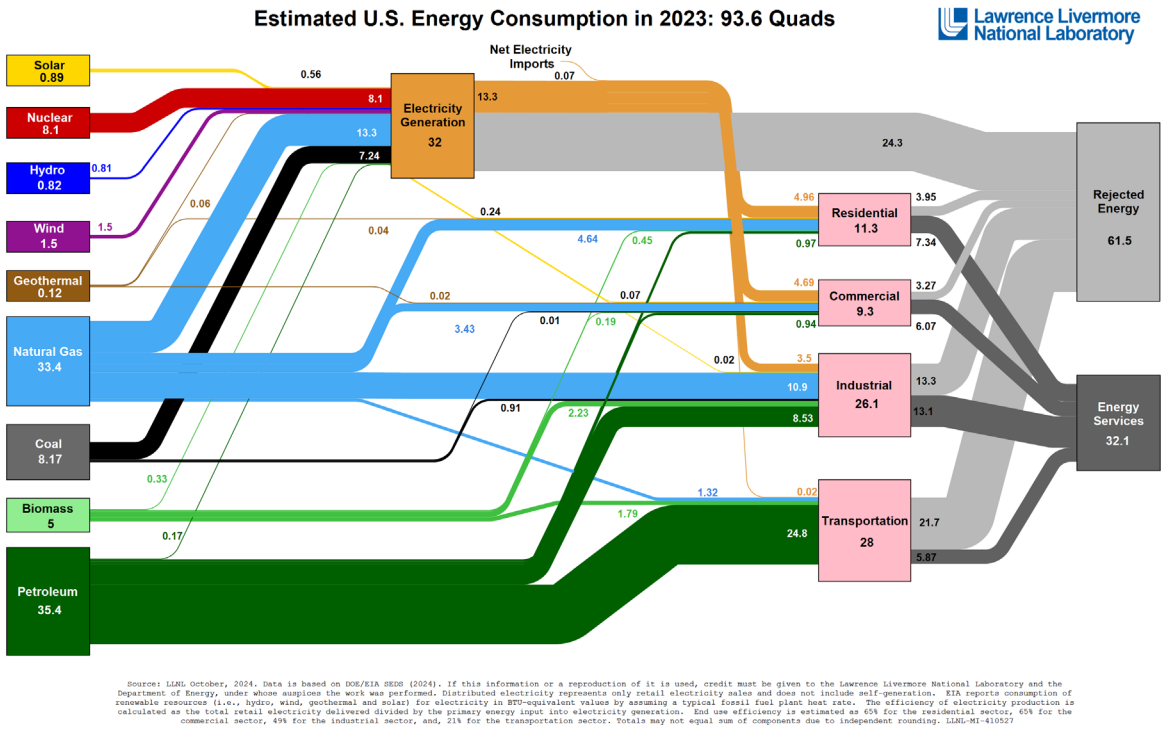
Global GHG emissions, 2023

Energy related		**68%**
▪ Electric Power Generation	26%	
▪ Transport	15%	
▪ Industry	11%	
▪ Fuel production	10%	
▪ Buildings	6%	
Industrial Processes		**9%**
Agriculture, forestry, land use, waste, other		**23%**

Electrification is key

- Power generation: Convert to renewables
- 11% road transport: Convert to EVs
- Industrial processes: Electrify
- Fuel production: Diminishes w fossil fuels
- Buildings: Heat pumps, efficiency
- Agriculture, forestry, land use: Hard to abate

US Energy Flow, 2023



Source: LLNL October, 2024. Data is based on DOE/EIA SEDS (2024). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 49% for the industrial sector, and, 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

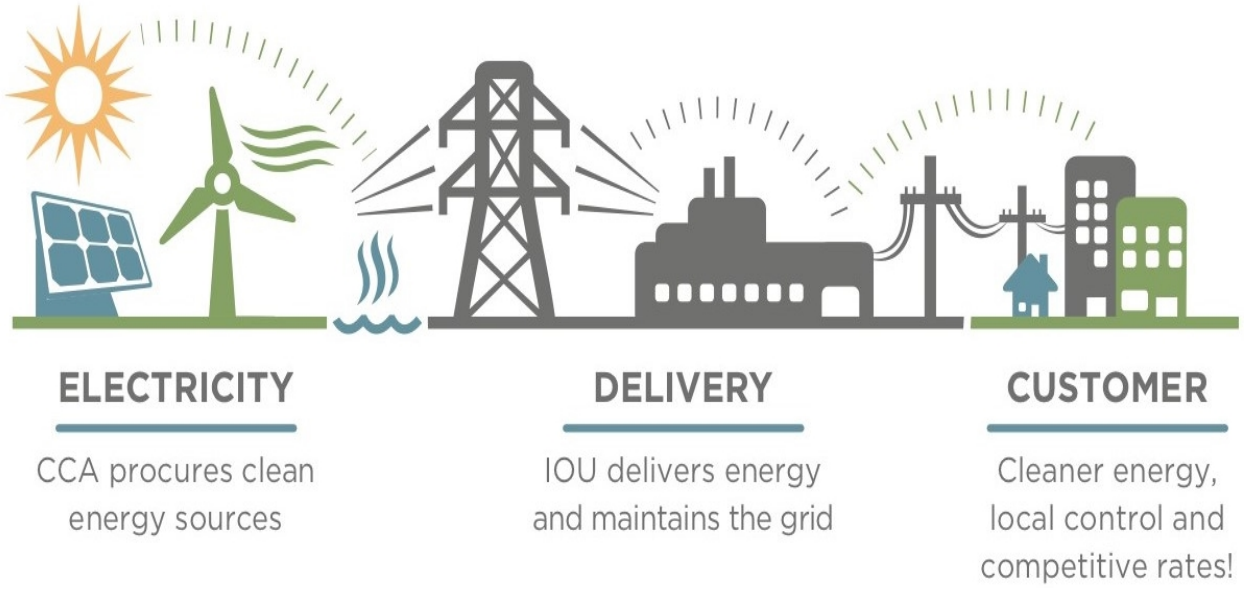
Fossil fuel combustion
Inherently inefficient

- Primary energy 93.6 quads
- Useful energy 32.1 quads
- Conversion efficiency? 34%
- Wasted? 61.5 quads
- Why?
  - Thermal power plants
    - 32 quads in; 13.3 quads out
    - Rest is wasted heat
  - Internal combustion engines
    - Most of energy is wasted as heat

82.5%

- Fossil fuels in US energy mix
- To lower GHG emissions
  - Electrify everything
  - Substitute renewables in generation
- Not going to happen fast
- Or without a fight
- Especially now!

Once upon a time



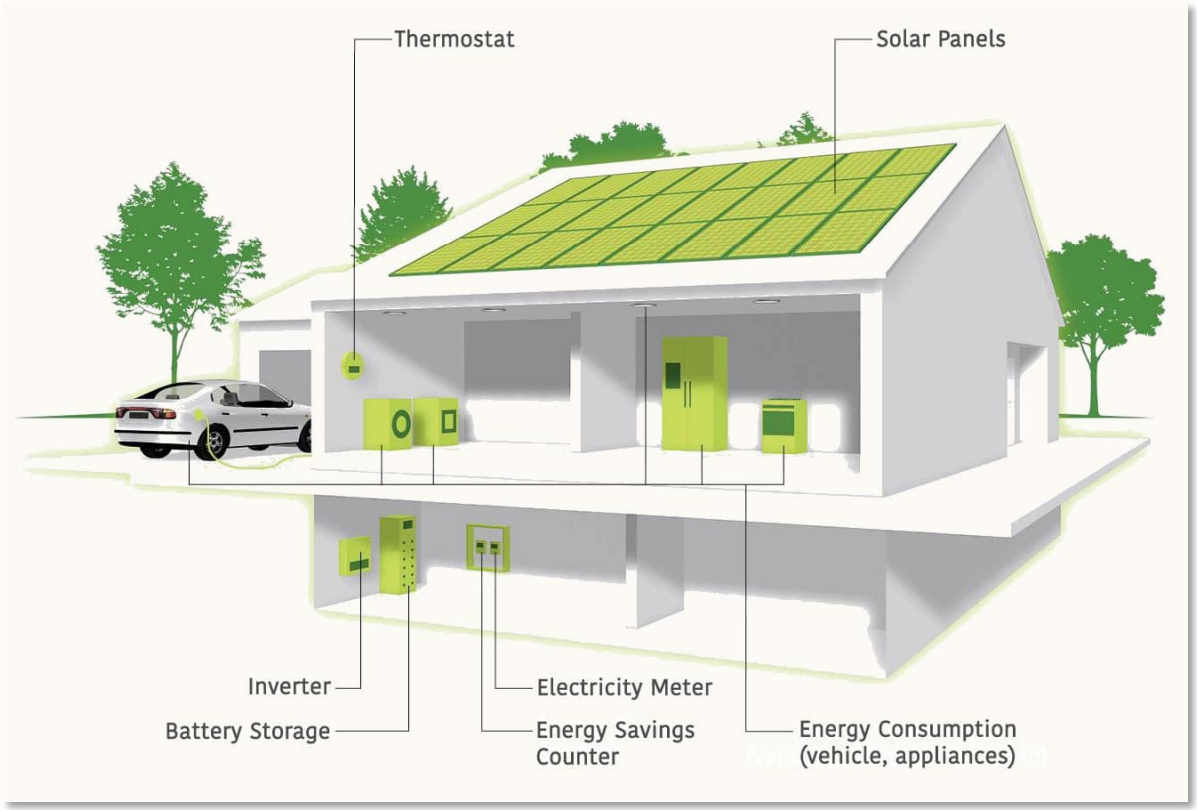
Source: Source: Cal CCA Association
https://cal-cca.org/cca-impact/

Transmission & distribution

“Prosumager”

Source: Tesla’s solar tiles, Powerwall and EV

Mini micro-grid



Example

Actual data averaged over 2020-23, in kWhs	
Rooftop solar generation	**10,210**
Total household consumption	**11,125**
Net imports from the grid	**840**

25 solar panels, 8 kW capacity

9.8 kWh battery

EV with a 75 kWh battery consuming 2,500 kWh/yr

Customers as net generators

Big customers can do it

Small customers can do it too

Just as this is history ….