



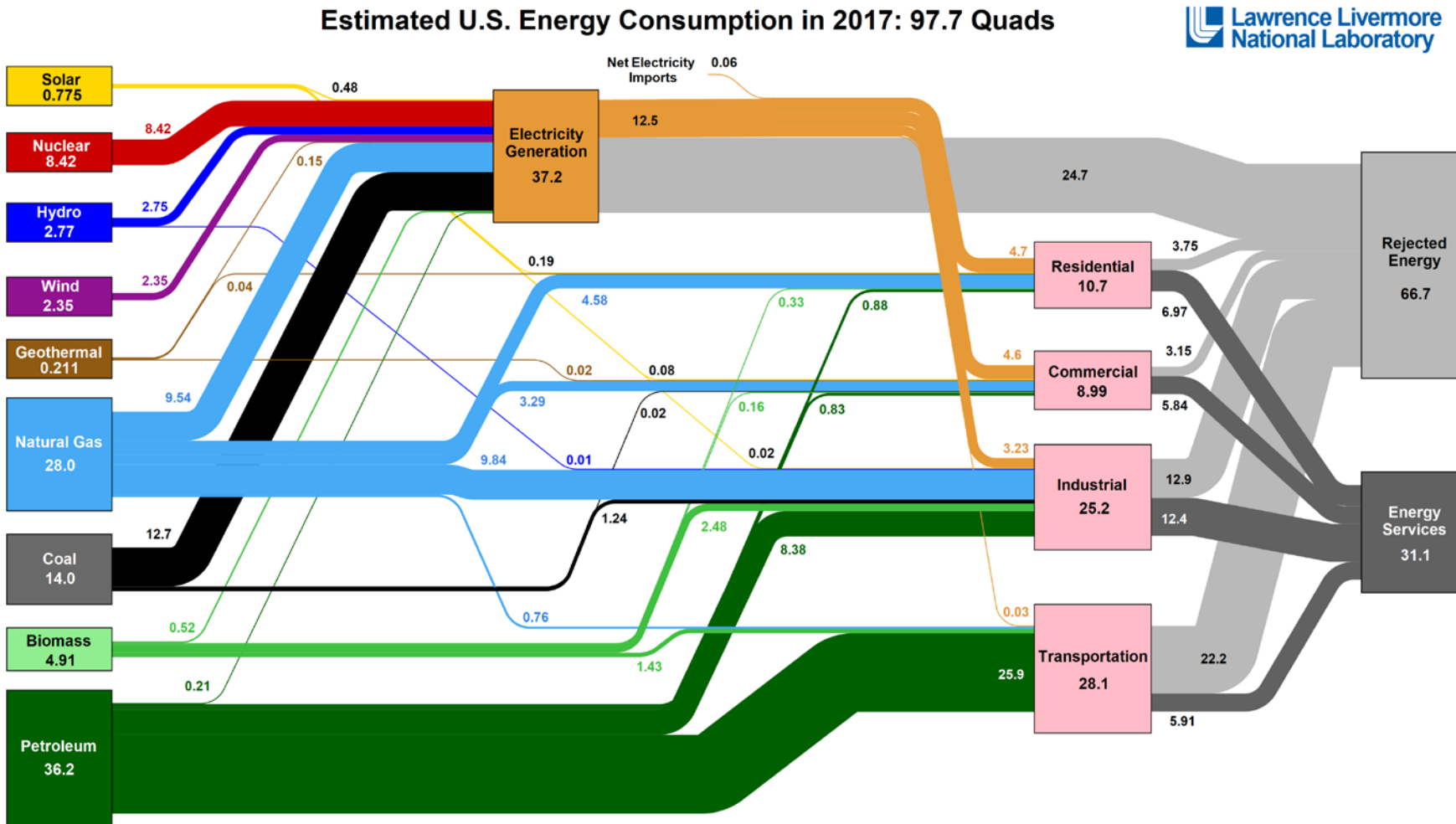
## Low-Carbon Energy for Industry

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JISEA Annual Meeting

# Industrial Energy Use



- 29% of global energy use
- 36% of global CO<sub>2</sub> emissions

## U.S. Industrial Energy Use Composition

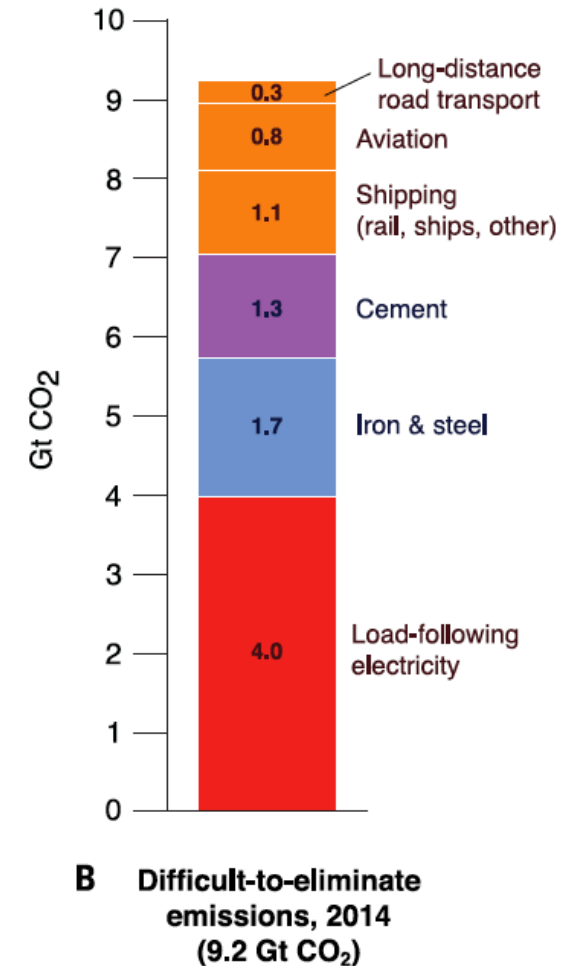
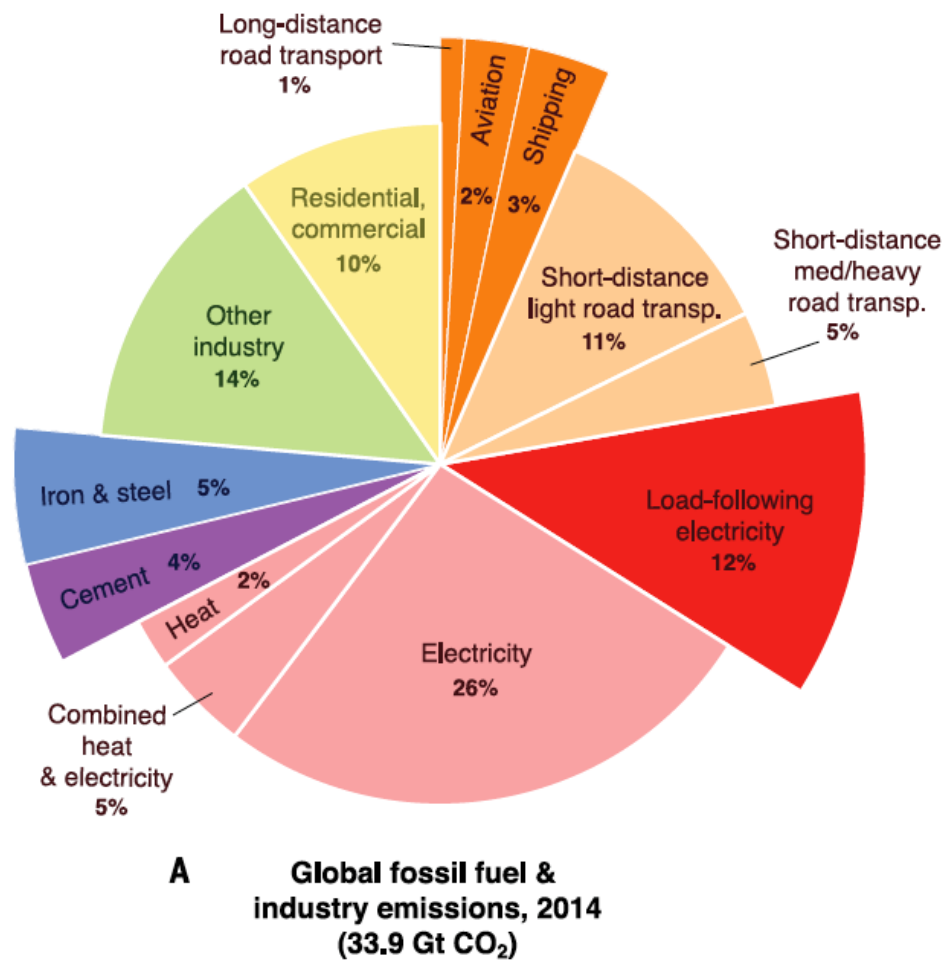
- 82% Manufacturing
- 9% Mining
- 5% Construction
- 4% Agriculture

Source: LLNL April, 2018. Data is based on DOE/EIA MER (2017). 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. This chart was revised in 2017 to reflect changes made in mid-2016 to the Energy Information Administration's analysis methodology and reporting. 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, 21% for the transportation sector, and 4% for the industrial sector which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Credit: <https://flowcharts.llnl.gov/>

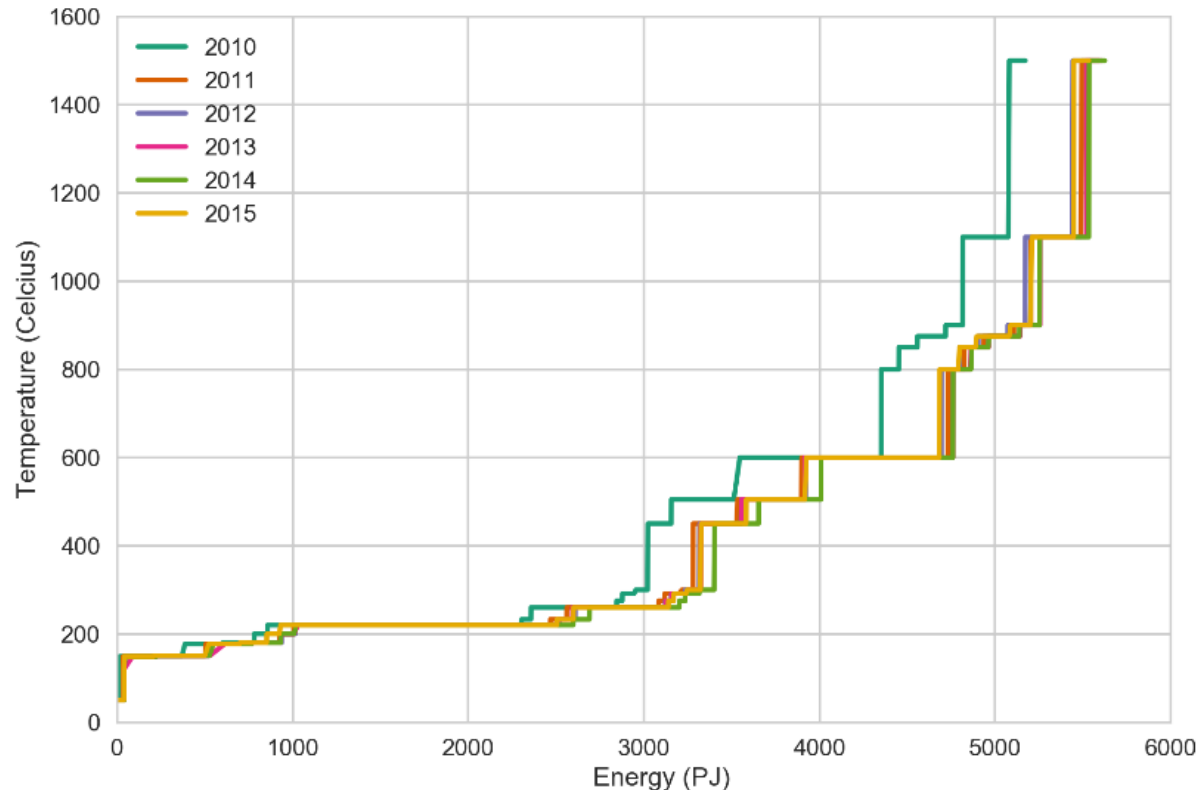
# Challenges for Low-Carbon Uses in Industry

- Industry is heterogenous
- Majority of the energy required is for heat
  - Temperature
  - Quantity
  - Transmission limitations
- Heat is less fungible than electricity



Source: Adapted from S. J. Davis et al., *Science* **360**, eaas9793 (2018). DOI: 10.1126/science.aas9793

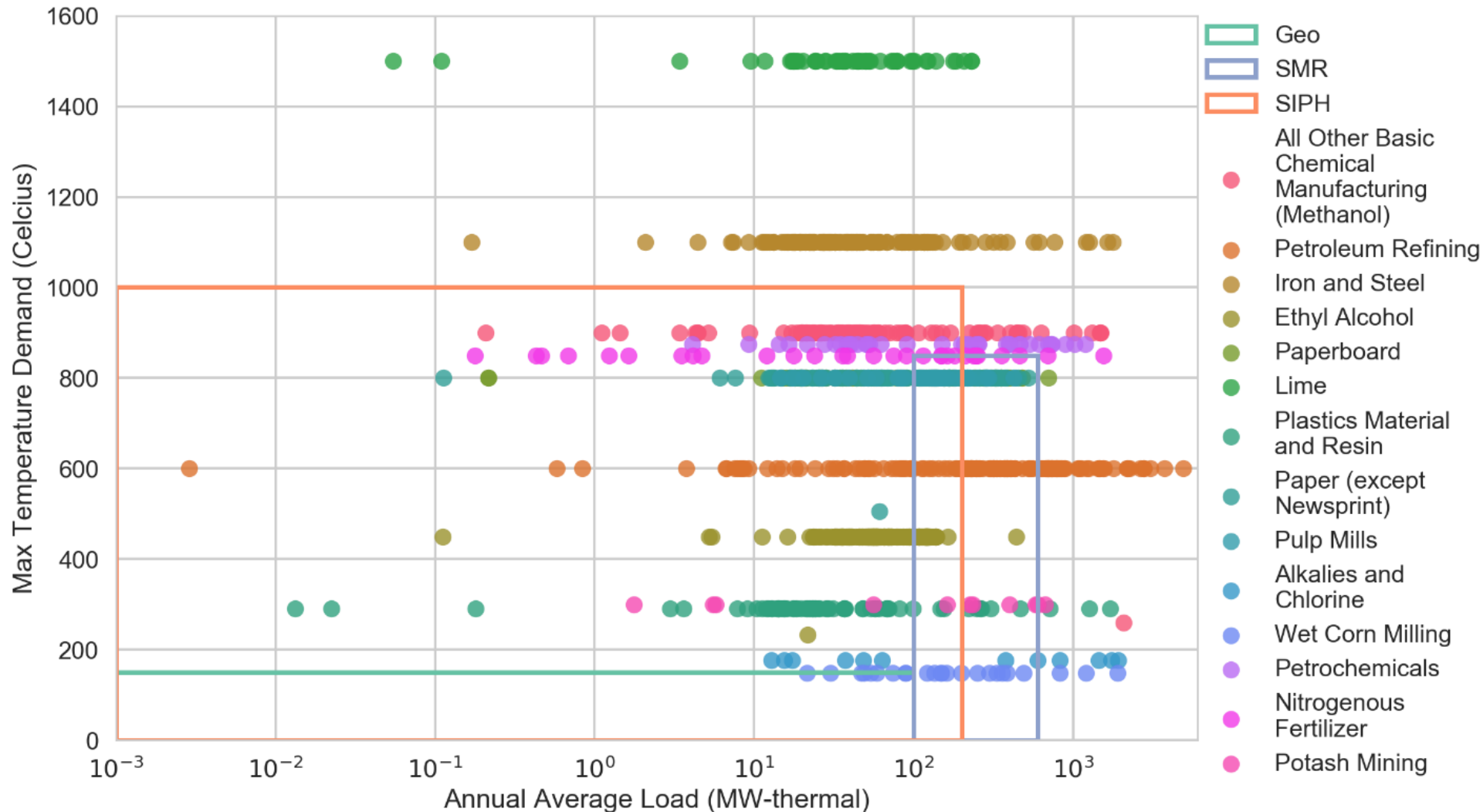
# Thermal Energy is a Need



- Process heat consumes about 51% of U.S. industrial energy demand
- Heat integration is very common within facilities but cross-facility heat integration and valorization could provide new opportunities
- Low-carbon sources that meet quality requirements and are economic is a key challenge

**Source:** Colin A. McMillan, Mark Ruth. "Using facility-level emissions data to estimate the technical potential of alternative thermal sources to meet industrial heat demand" *Applied Energy*, V. 239, (2019) p.1077-1090,

# Matching Demand to Thermal Generation Options

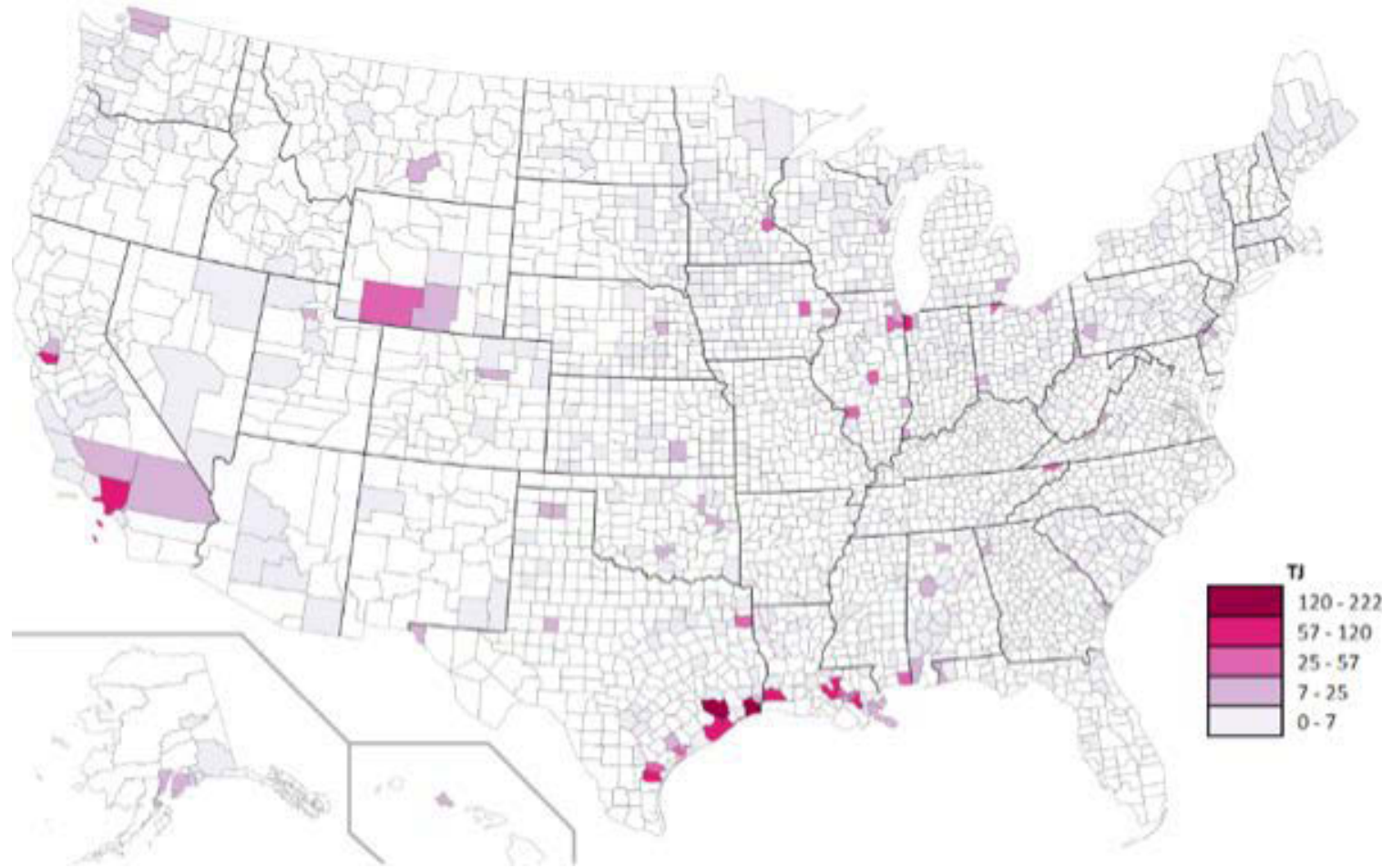


We are starting to identify geothermal (geo), small modular nuclear (SMR), and solar integrated process heat (SIPH) opportunities

Source: Colin A. McMillan, Mark Ruth. "Using facility-level emissions data to estimate the technical potential of alternative thermal sources to meet industrial heat demand" *Applied Energy*, V. 239, (2019) p.1077-1090,

# Identifying Opportunity Locations

County-level industrial heat demand 100°C – 400°C



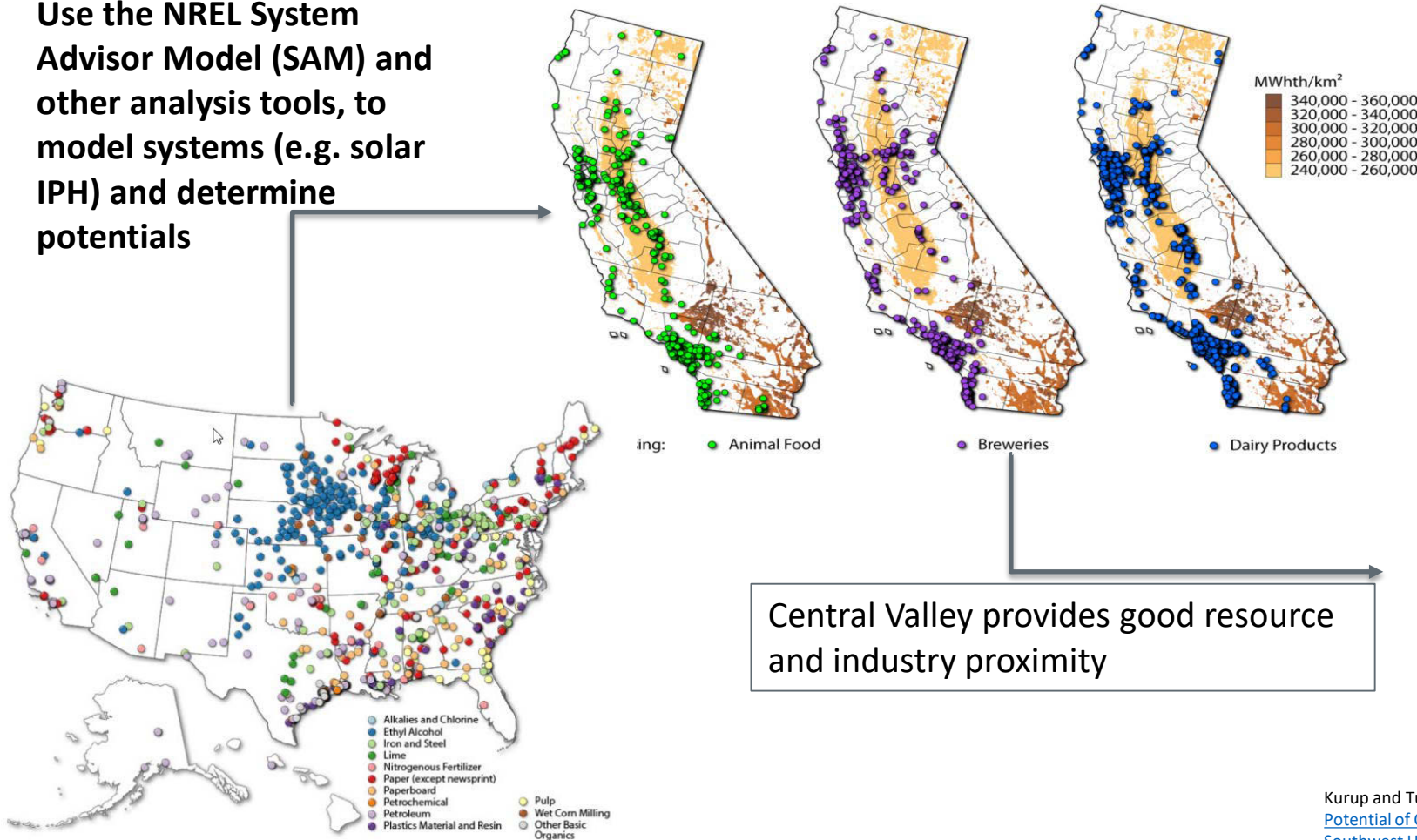
Demands are distributed across the U.S.

**Source:** Colin A. McMillan, Mark Ruth. "Using facility-level emissions data to estimate the technical potential of alternative thermal sources to meet industrial heat demand" *Applied Energy*, V. 239, (2019) p.1077-1090,



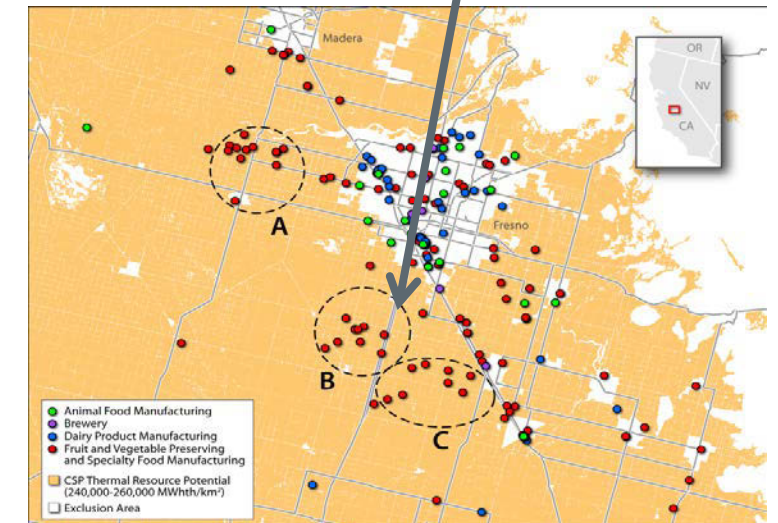
# Matching Resource with Demand (SIPH Example)

Use the NREL System Advisor Model (SAM) and other analysis tools, to model systems (e.g. solar IPH) and determine potentials



## Fresno, CA example

Industries such as Fruit and Veg clustered together in good thermal potential areas and with nearby available land



Kurup and Turchi, "[Initial Investigation into the Potential of CSP Industrial Process Heat for the Southwest United States](#)", NREL, 2015

McMillan et al., "[Generation and Use of Thermal Energy in the U.S. Industrial Sector and Opportunities to Reduce its Carbon Emissions](#)", NREL, 2016



# Thank you!

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[www.nrel.gov](http://www.nrel.gov)

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