JISEA Joint Institute for Strategic Energy Analysis

Low-Carbon Energy for Industry

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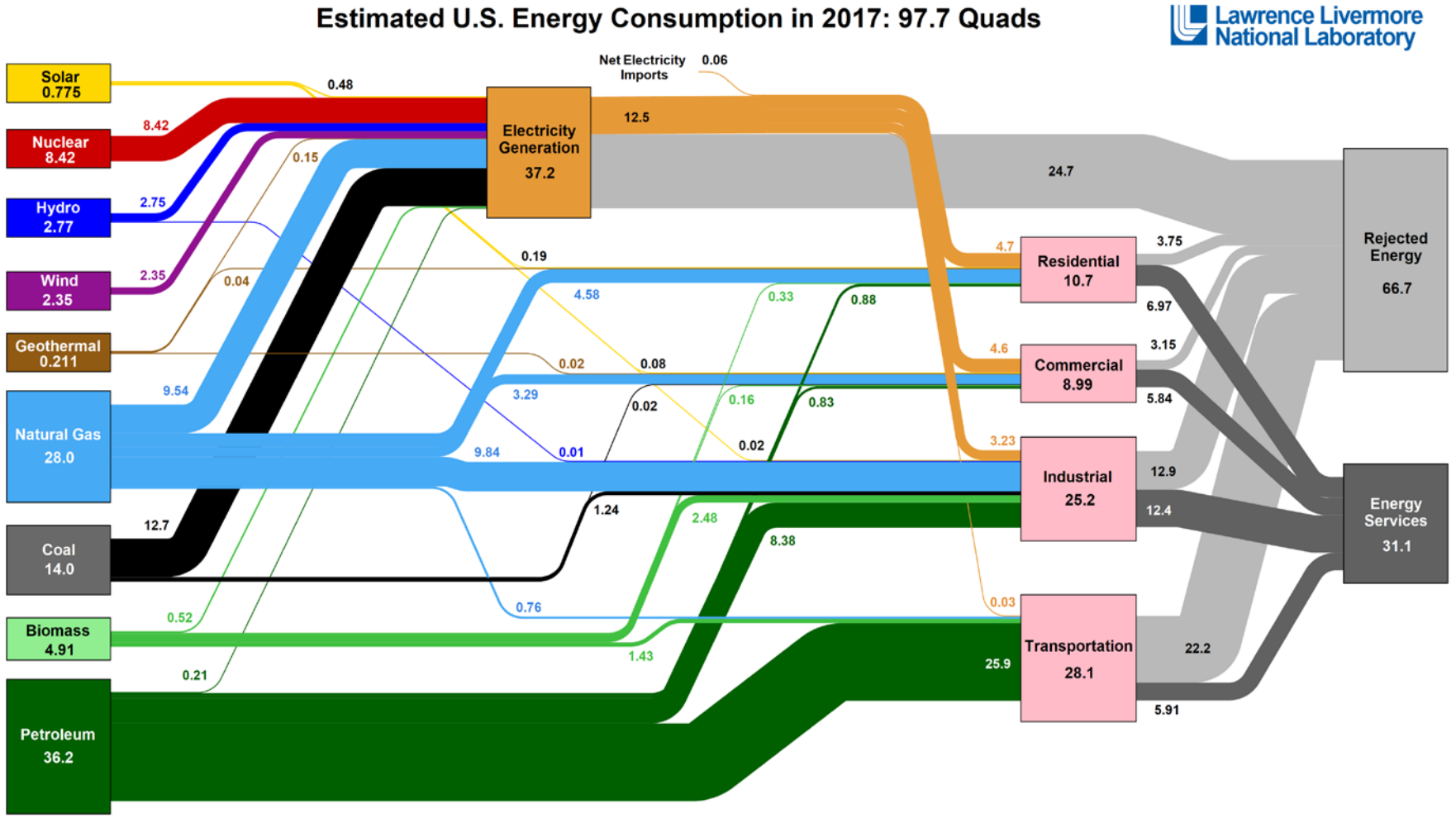
JISEA Annual Meeting

Industrial Energy Use



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

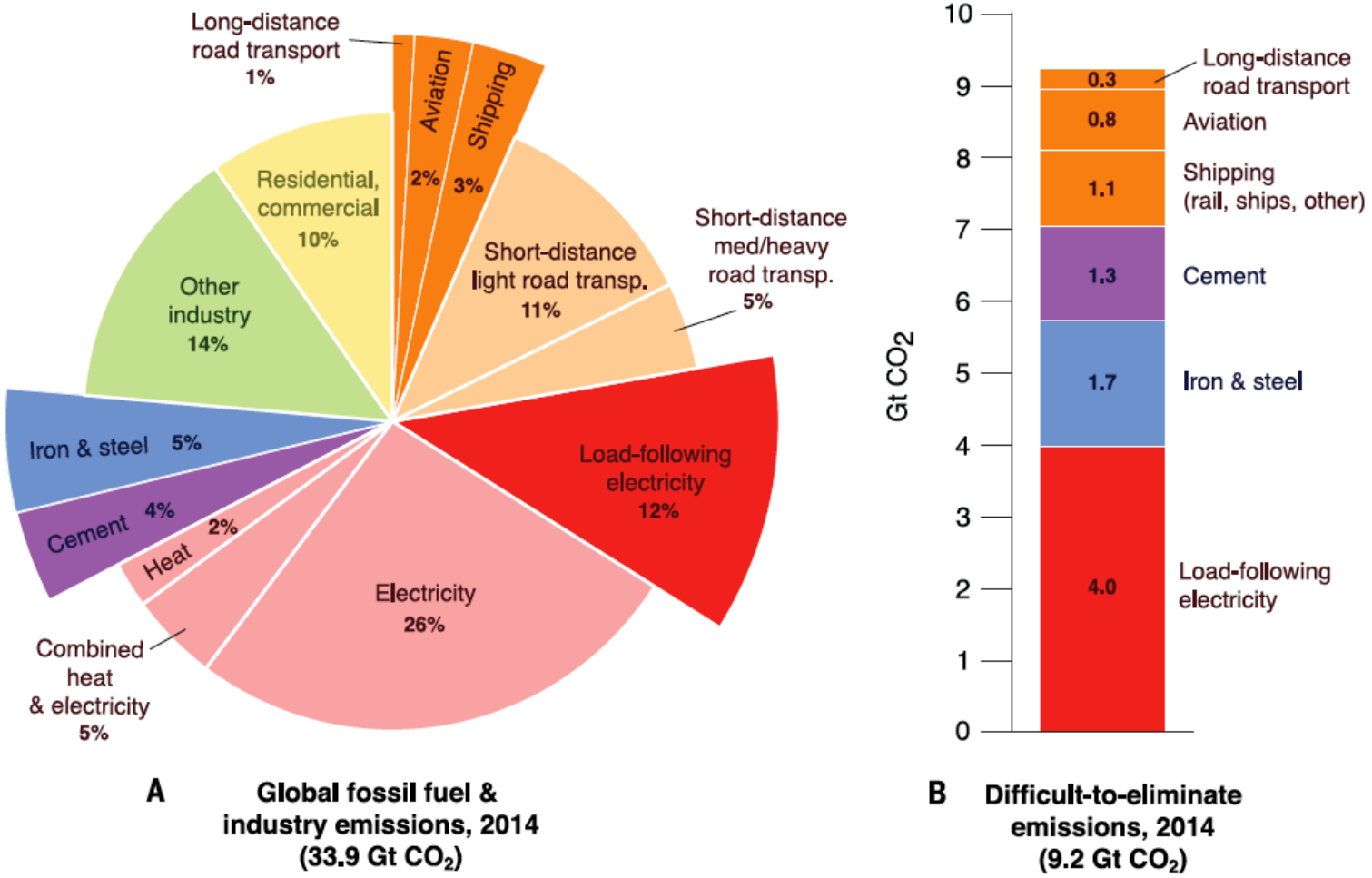
- 29% of global energy use
- 36% of global CO_2 emissions

U.S. Industrial Energy Use Composition

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

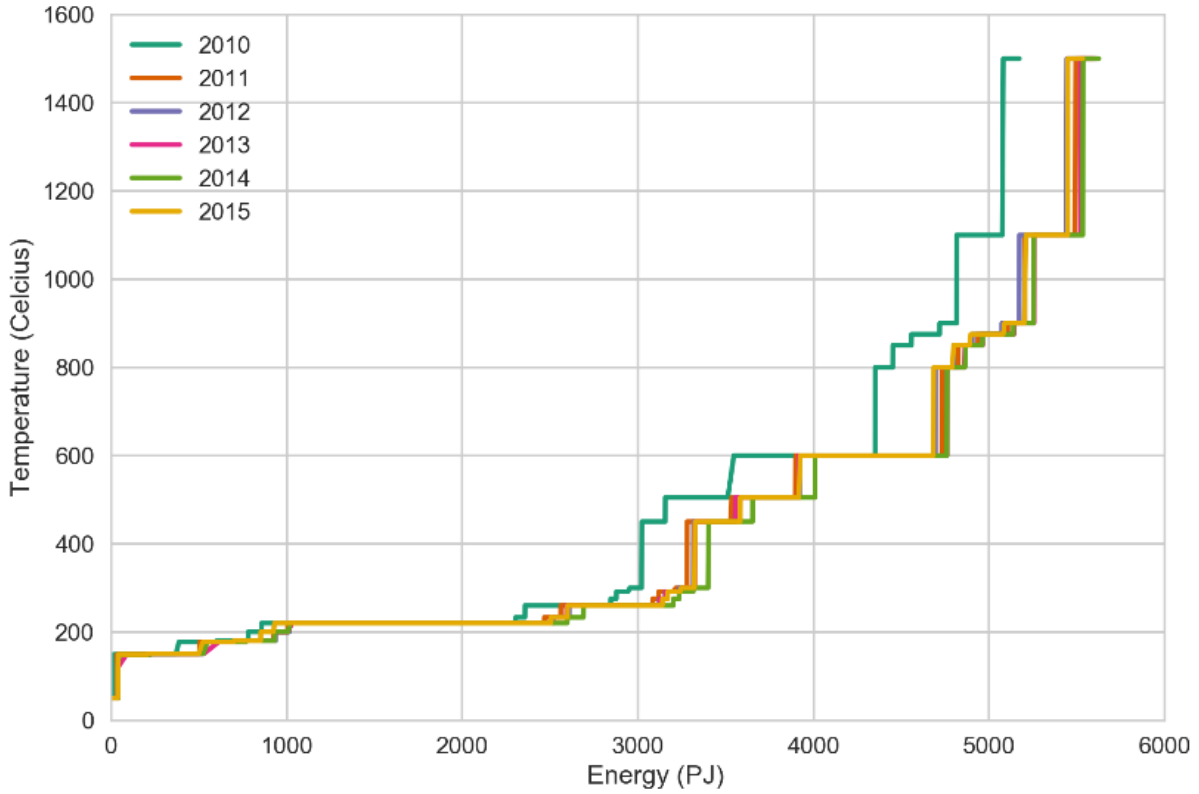
Challenges for Low-Carbon Uses in Industry

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



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

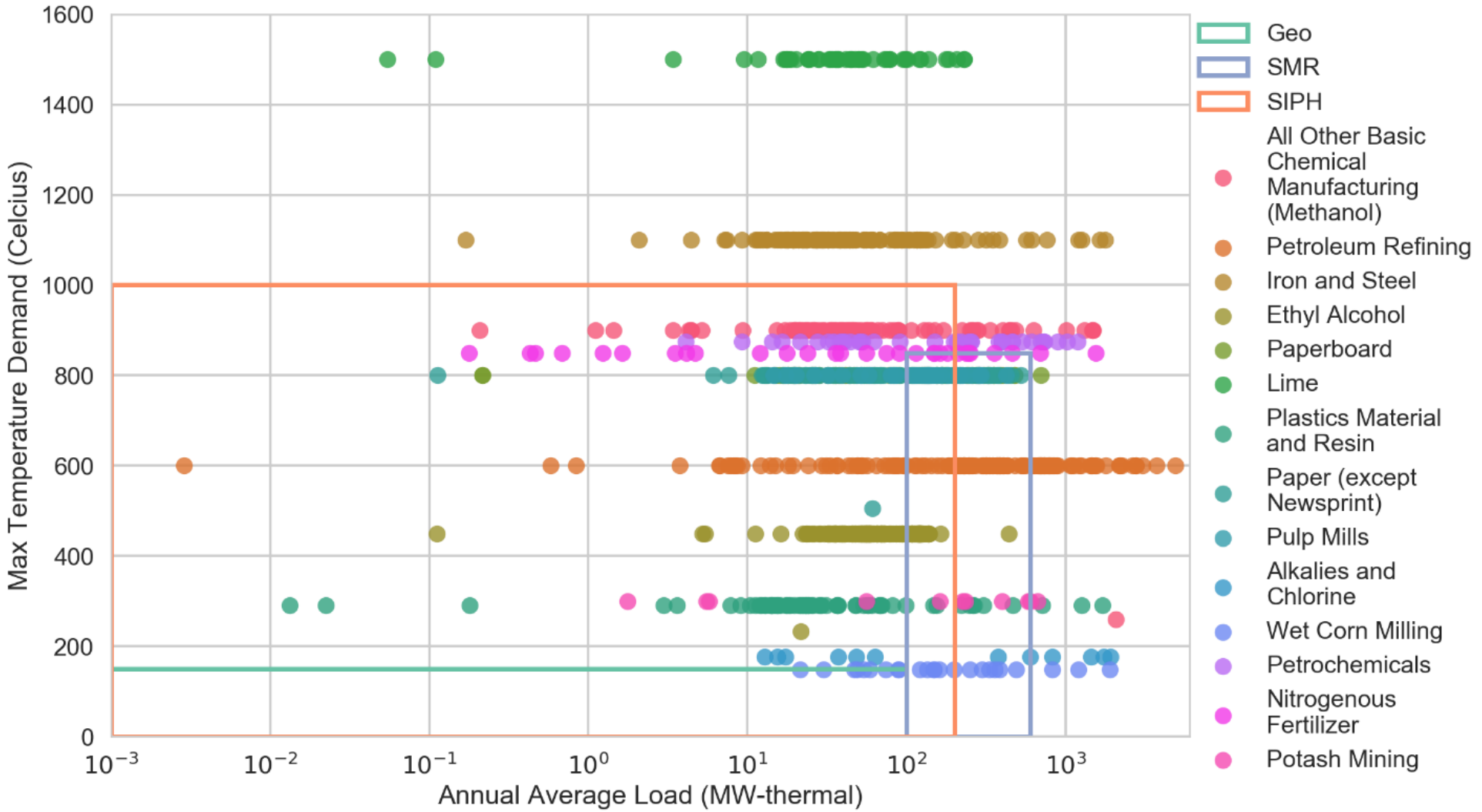
Thermal Energy is the Key Demand for Industry



- Process heat is about 51% of U.S. industrial energy demand
- Heat integration is very common within industrial 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

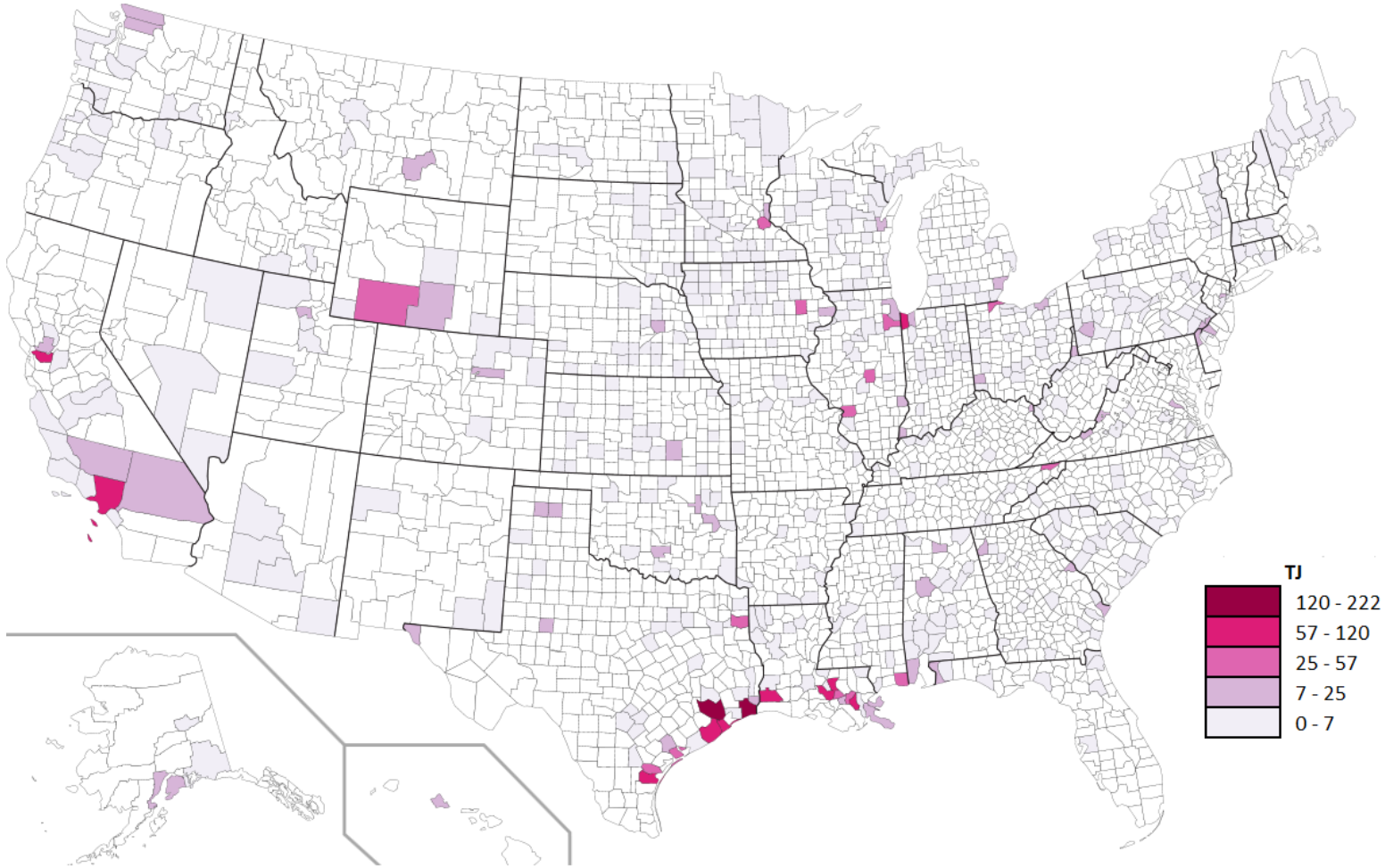


We are starting to identify geothermal (geo), small modular nuclear (SMR), and solar industrial process heat (SIPH) opportunities

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

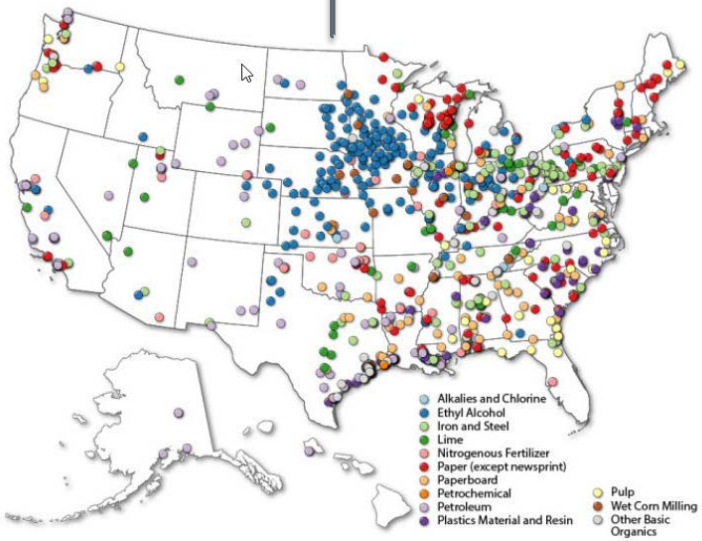


Demands are distributed across the U.S.

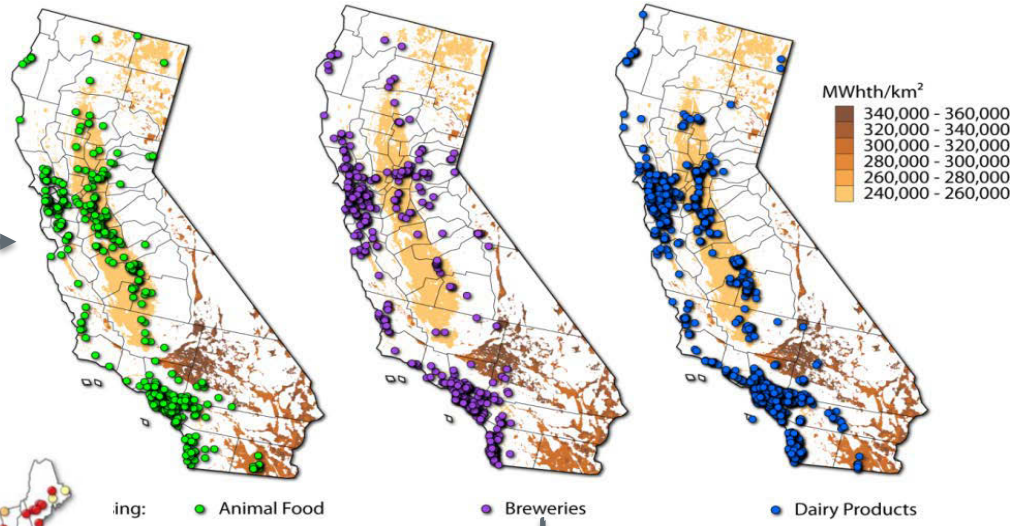
Source: Colin A. McMillan, Mark Ruth. "Using facility-level emissions data to estimate the technical potential of alternative thermal sources to meet industrial heat demand" *Applied Energy*, V. 239, (2019) p.1077-1090,

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



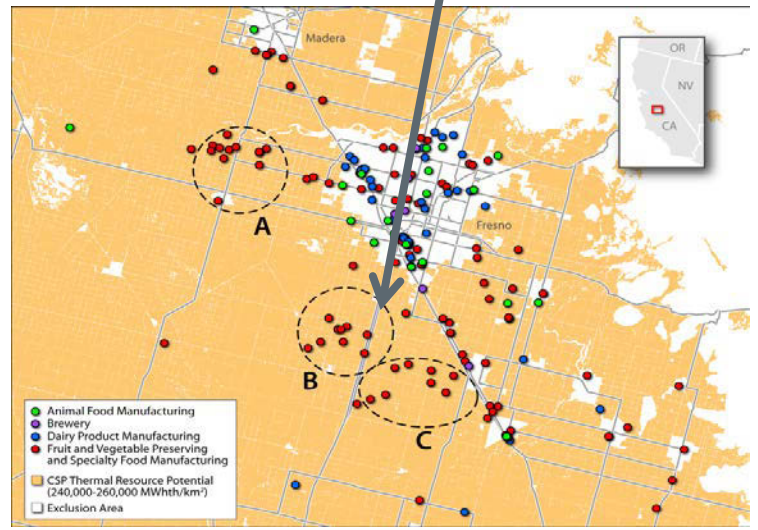
McMillan et al., "Generation and Use of Thermal Energy in the U.S. Industrial Sector and Opportunities to Reduce its Carbon Emissions", NREL, 2016



Central Valley provides good resource and industry proximity

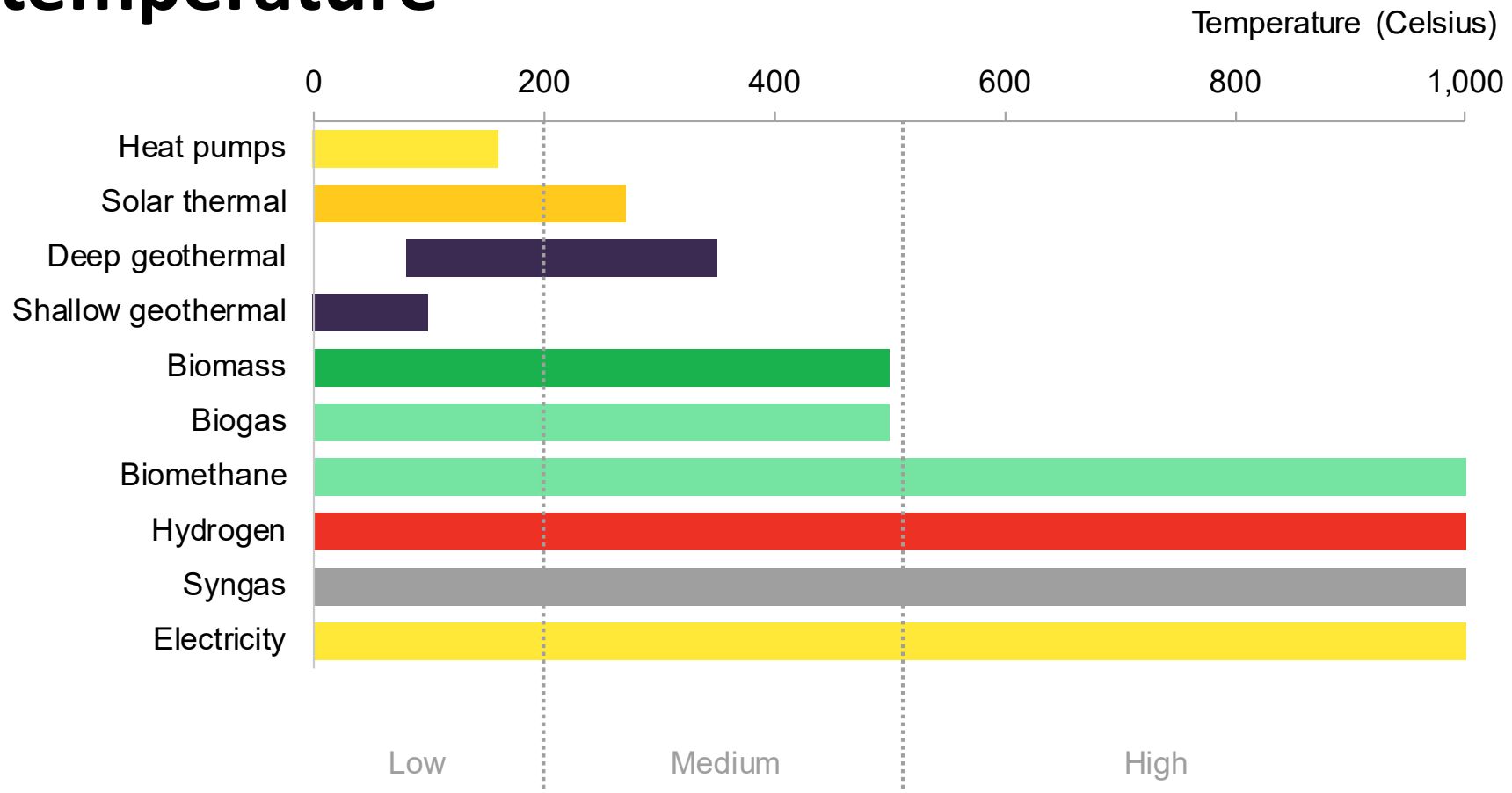
Fresno, CA example

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



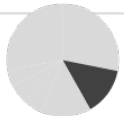
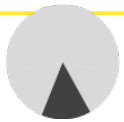
Kurup and Turchi, "Initial Investigation into the Potential of CSP Industrial Process Heat for the Southwest United States", NREL, 2015

Example technologies for low-carbon heating by output temperature



Source: Oxford Energy Institute, BloombergNEF, EHPA

Overview of process heating and ease of decarbonization in each sector

		Current status (2016)			Ease of heat decarbonization		
	Sector (ISIC, Rev.4 Code)	% of process heat demand	Major temperature	Major fuel	Efficiency gains	Fuel switching	New tech. or process
Big prizes (but hard to achieve)	**Iron and steel** Includes coke ovens and blast furnaces (241/31, 191)	 28%	High	Coal	Hard	Hard	Medium difficulty
	Non-metallic minerals (cement). Also includes glass, ceramics, brick (23)	 13%	High	Coal	Hard	Medium difficulty	Hard
Medium prizes (middle size or difficulty)	**Chemicals** Bulk chemicals, chemical products, pharma (20-1)	 15%	High	Coal	Medium difficulty	Medium difficulty	Hard
	Non-ferrous metals (aluminum). Also includes non-ferrous metals (242/32)	 6%	High	Electricity	Medium difficulty	Easier	Hard
Smallest prizes (but easiest to achieve)	**Food and tobacco** Includes beverage, excludes agriculture (10-12)	 5%	Low	Gas	Medium difficulty	Easier	Medium difficulty
	Pulp and paper Includes printing, excludes forestry (17, 18)	 5%	Low	Renewables (biomass/ waste)	Medium difficulty	Easier	Easier

Source: BNEF

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Thank you!

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