Electrifying U.S. Industry

A Technology- and Process-Based Approach to Decarbonization

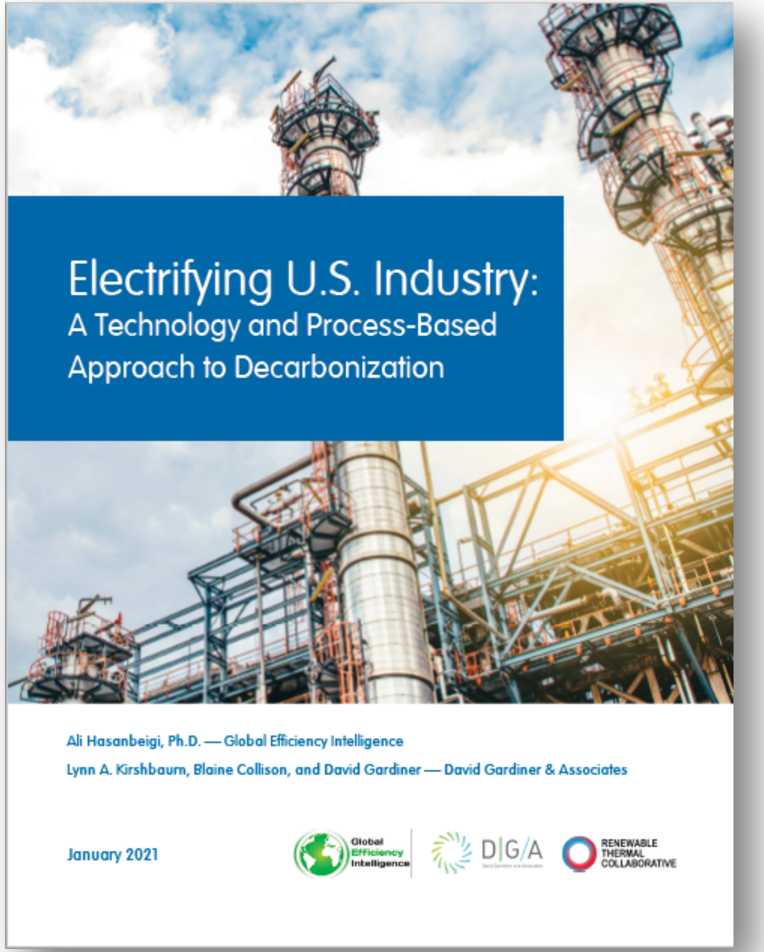
January 27, 2021

RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

D|G/A David Gardiner and Associates

Global Efficiency Intelligence (GEI) and David Gardiner and Associates (DGA) are pleased to announce the release today of their report to the Renewable Thermal Collaborative (RTC): *Electrifying U.S. Industry: A Technology- and Process-Based Approach to Decarbonization.*



Today's Speakers

Blaine Collison
Executive Director
Renewable Thermal Collaborative

Steve Skarda
Global Energy Sustainability Leader
Procter & Gamble

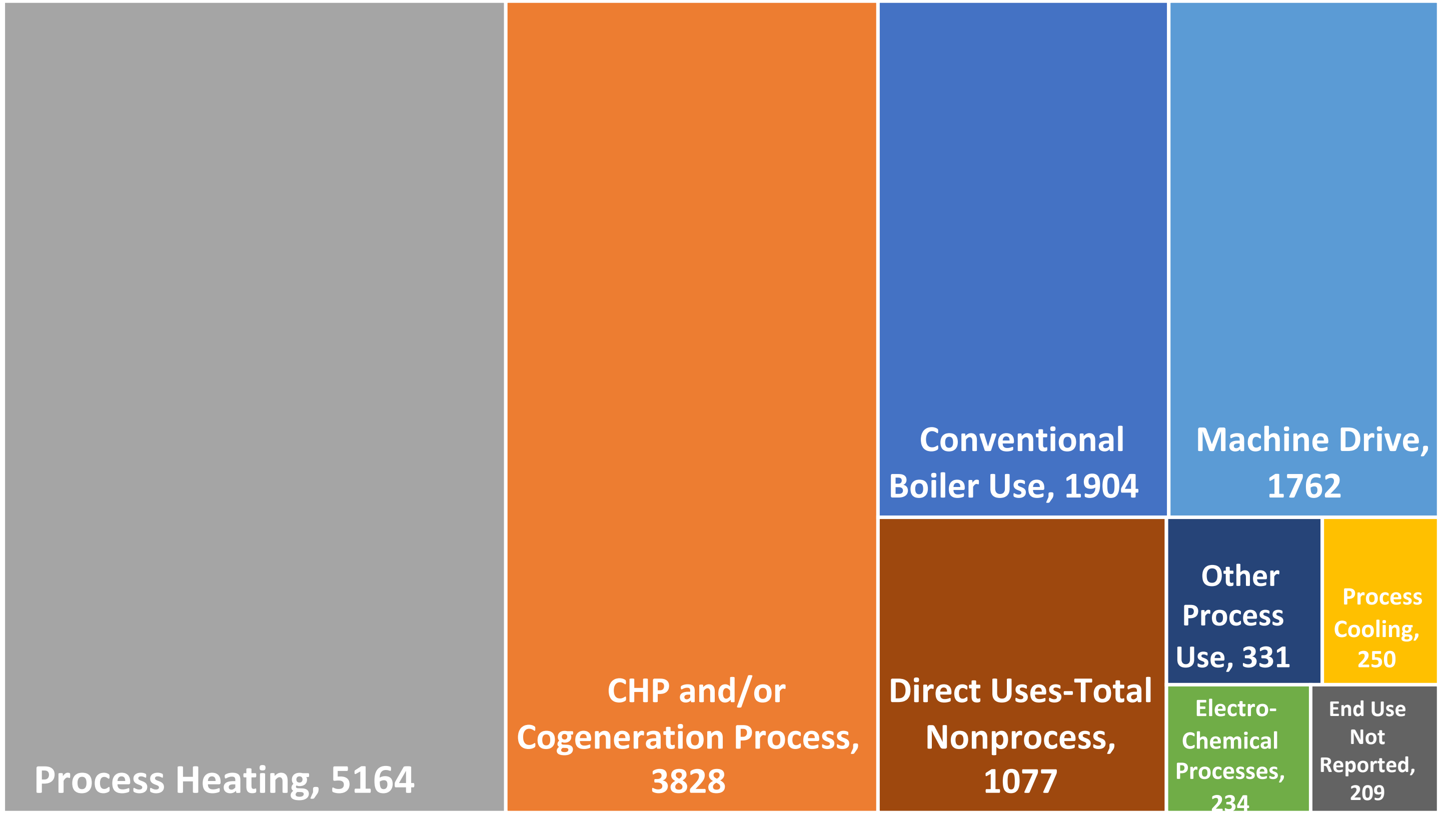
Ali Hasanbeigi, PhD
Founder & CEO
Global Efficiency Intelligence, LLC

Lynn A. Kirshbaum
Senior Associate
David Gardiner and Associates

RENEWABLE THERMAL COLLABORATIVE
Global Efficiency Intelligence
D|G/A David Gardiner and Associates

Technical Assessment

U.S. Manufacturing Energy Use by End Uses (Trillion Btu)



RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

DGA David Gardiner and Associates

Source: US DOE 2019- manufacturing energy footprints

Industrial Heat Demand Profile

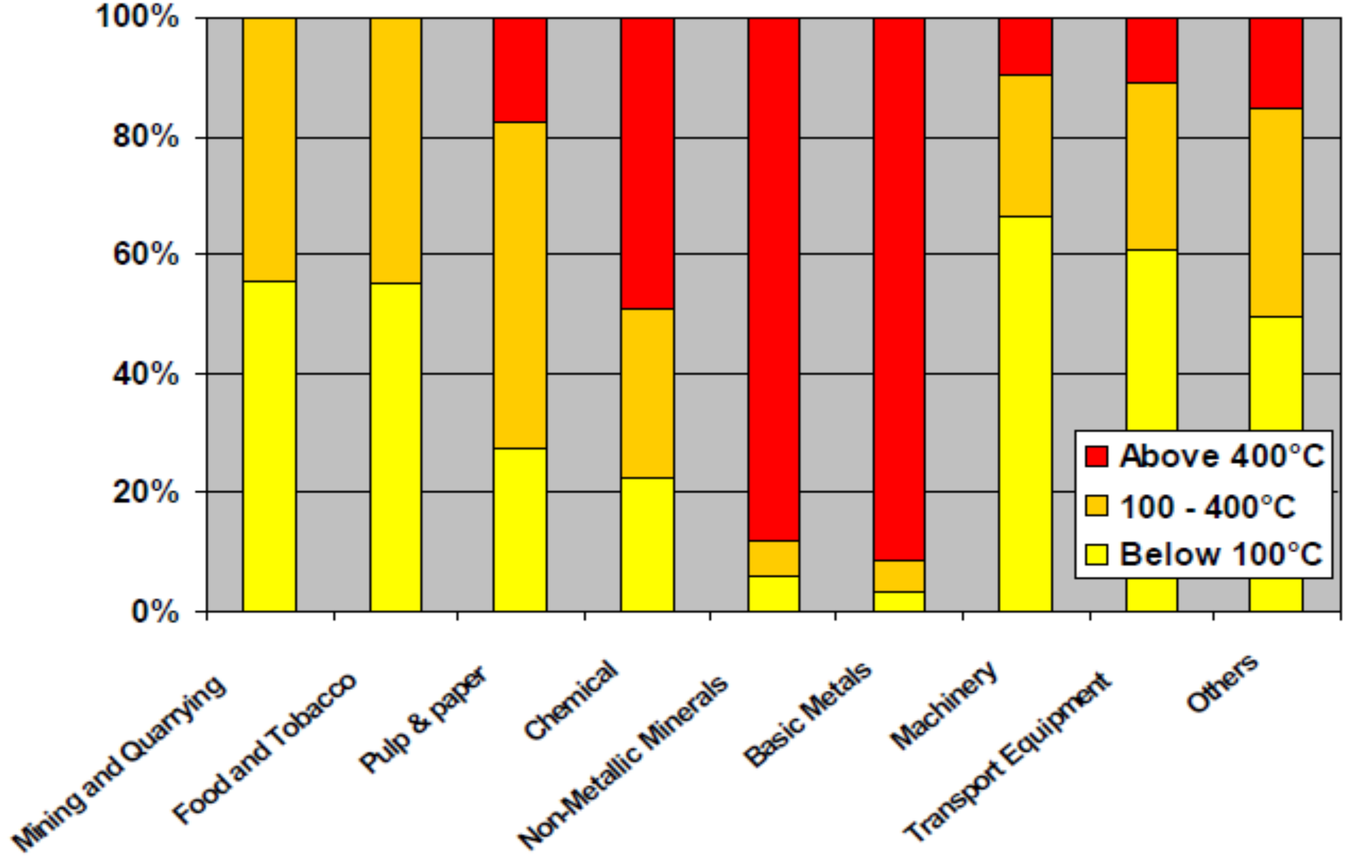


Figure a: Share of industrial heat demand by temperature in selected industries (Caludia et al., 2008)

Industrial Heat Demand Profile

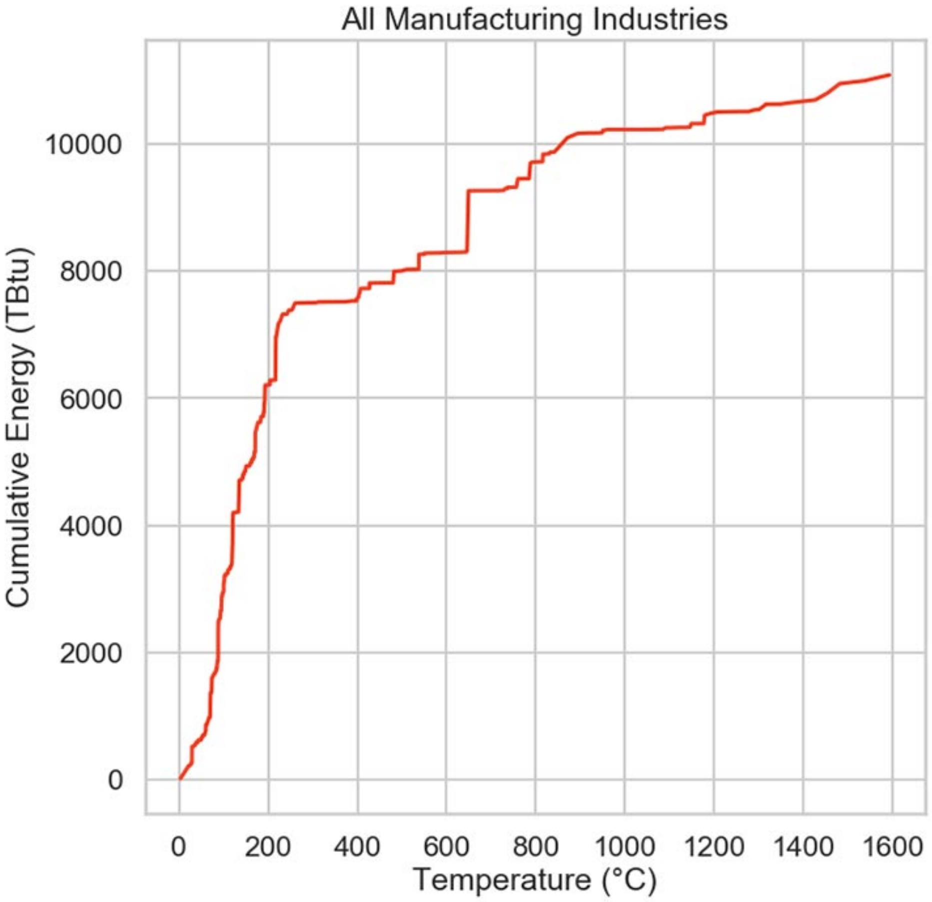


Figure b. Cumulative process heat demand by temperature in 2014

(McMillan, 2019)

Two-thirds of process heat is used in the U.S. industry is for applications below 300°C (572°F)

RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

D|G/A David Gardiner and Associates

Bottom-up Analysis Method

Step1
- Detailed analysis of existing heating system

Step2
- Selection of suitable electrification technology

Step3
- Process integration assessment with new electrified heating technology

Step 4
- Calculation of changes in energy use and GHG emissions and cost implications

	Industry
1	Aluminum casting
2	Ammonia
3	Methanol
4	Recycled plastic
5	Paper (from virgin pulp)
6	Recycled paper
7	Container Glass
8	Steel
9	Beer
10	Beet Sugar
11	Milk powder
12	Wet corn milling
13	Soybean oil
	Electrification of all industrial boilers

Electrification of the **Container Glass Industry** in the U.S.

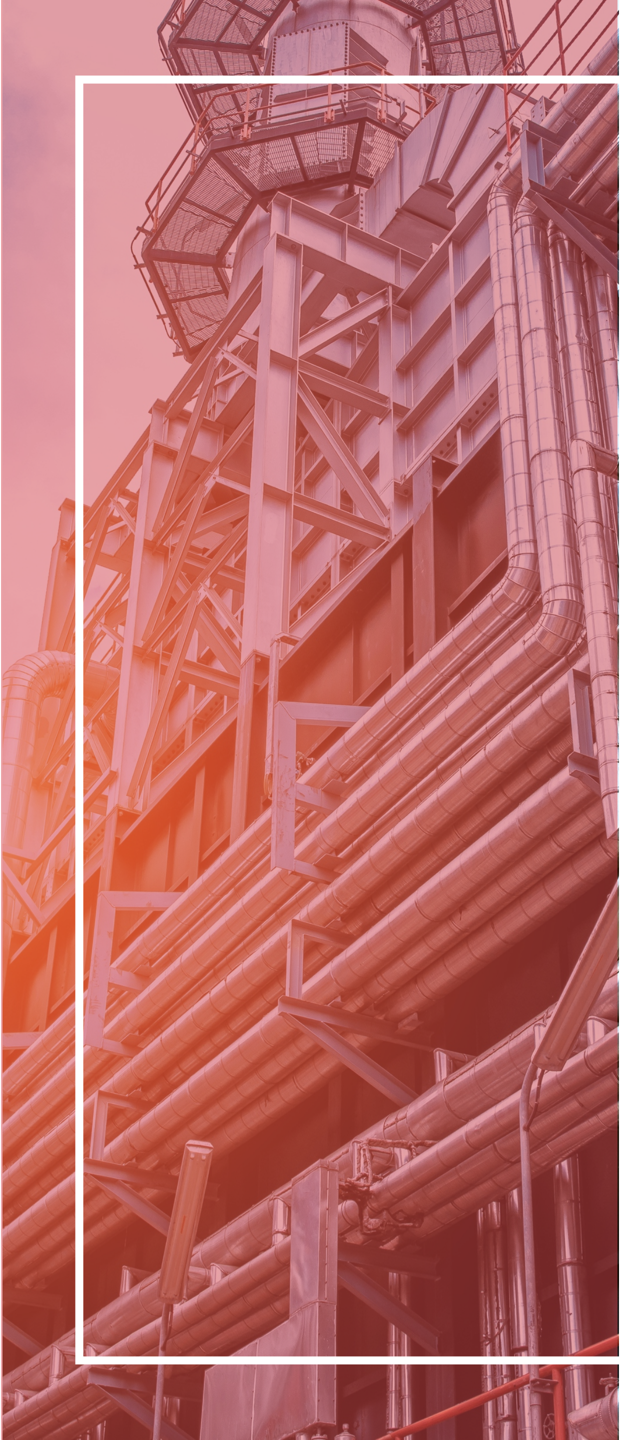
Conventional System Process				All Electric Process	
Heating Equipment	Electrical Demand (kWh/tonne)	Thermal Demand (kWh/tonne)	Process steps	Electrical Demand (kWh/tonne)	Heating Equipment
Electrically-powered mixer/crusher	161.0	0.0	Mixing	161.0	Electrically-powered mixer/crusher
Gas-fired furnace	204.0	1150.0	Melting	860.0	Electric glass melter
Forehearth and forming equipment	26.0	105.0	Conditioning & Forming	104.0	Electric forehearths
Gas-fired Anealing lehr	25.0	210.0	Poat Forming(Annealing)	183.0	Electric Anealing lehr
	416.0	**1465.0**	**Sum**	**1308.0**	
	1881		**Total Energy**	**1308**	

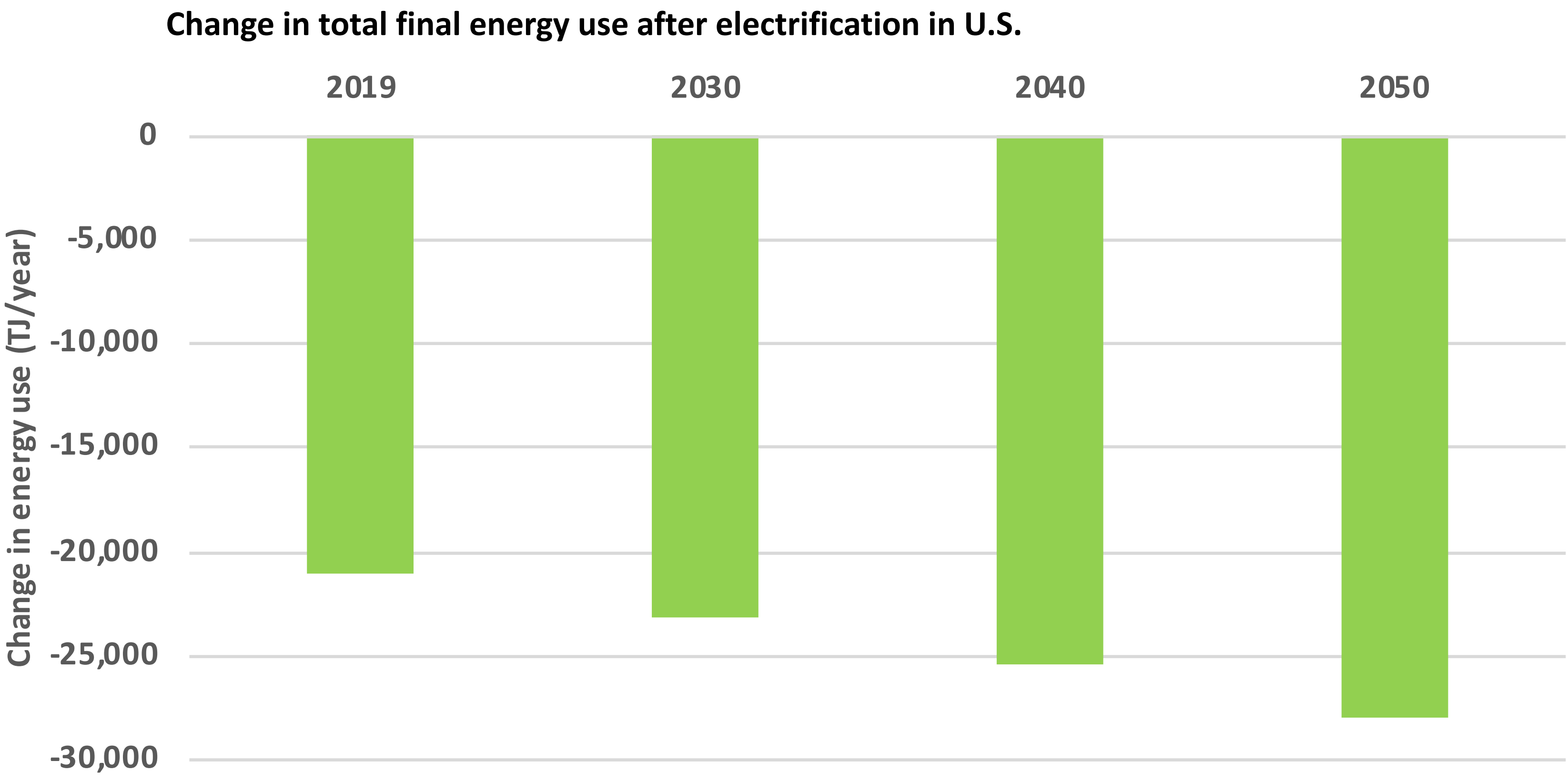
RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

D|G/A David Gardiner and Associates

Electrification of the **Container Glass Industry** in the U.S.



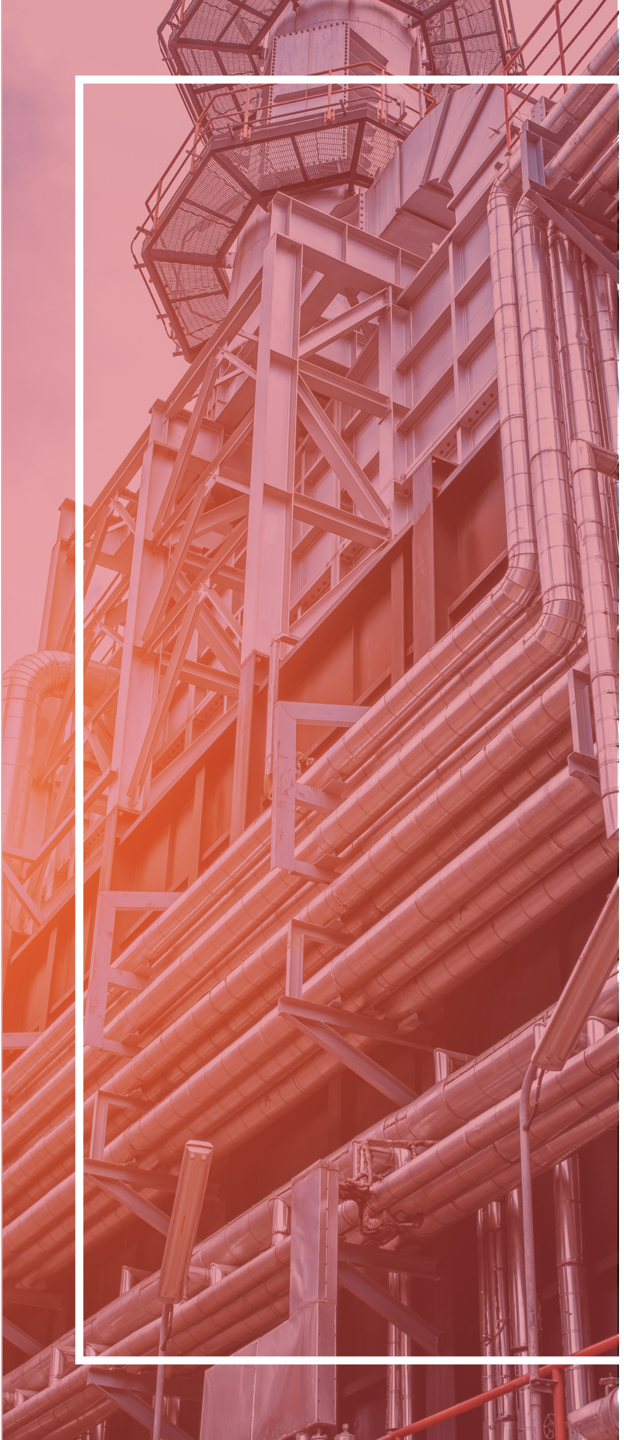


Note: This is the technical potential assuming 100% adoption rate.

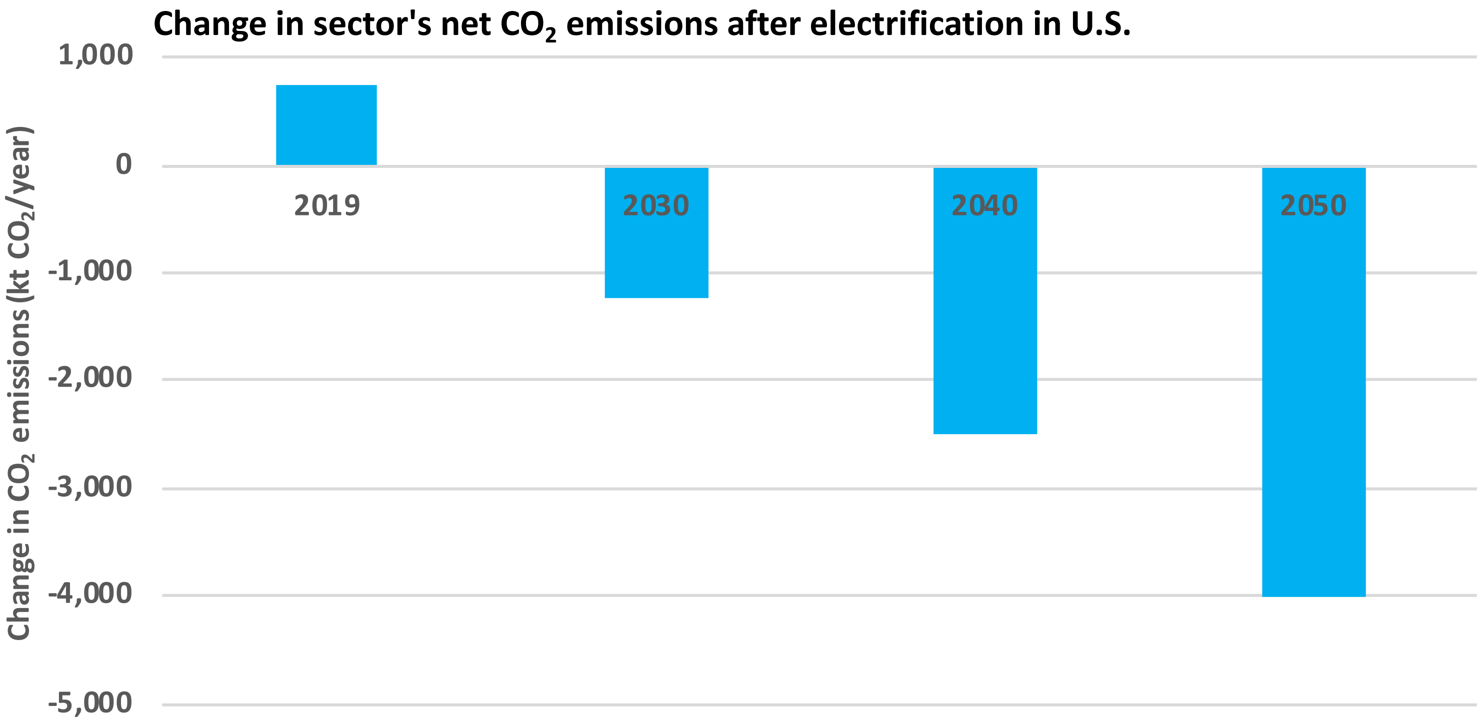
RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

DGA David Gardiner and Associates



Electrification of the **Container Glass Industry** in the U.S.



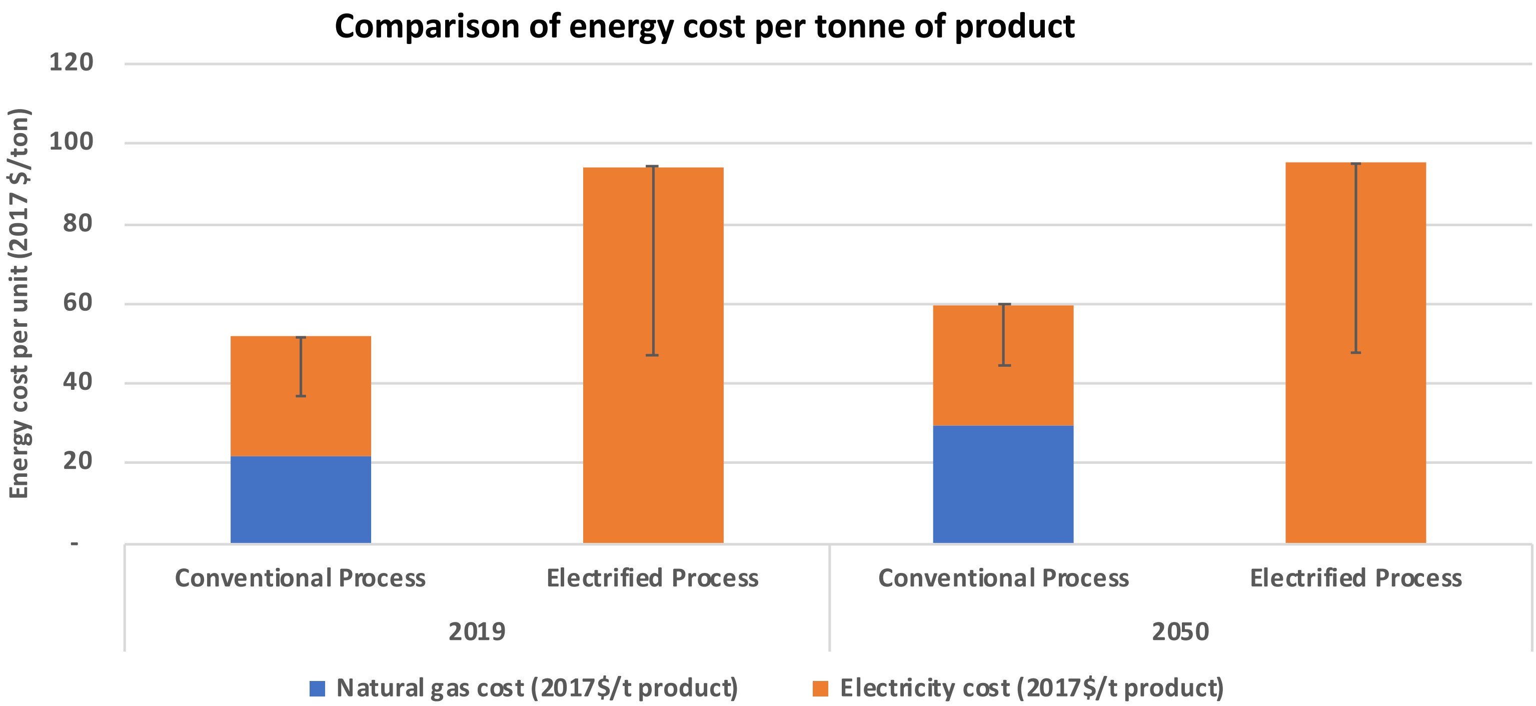
	2019	2030	2040	2050
Emission factor for grid electricity in US (kgCO_2/MWh)	414	207	103	0

RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

DGA David Gardiner and Associates

Electrification of the **Container Glass Industry** in the U.S.



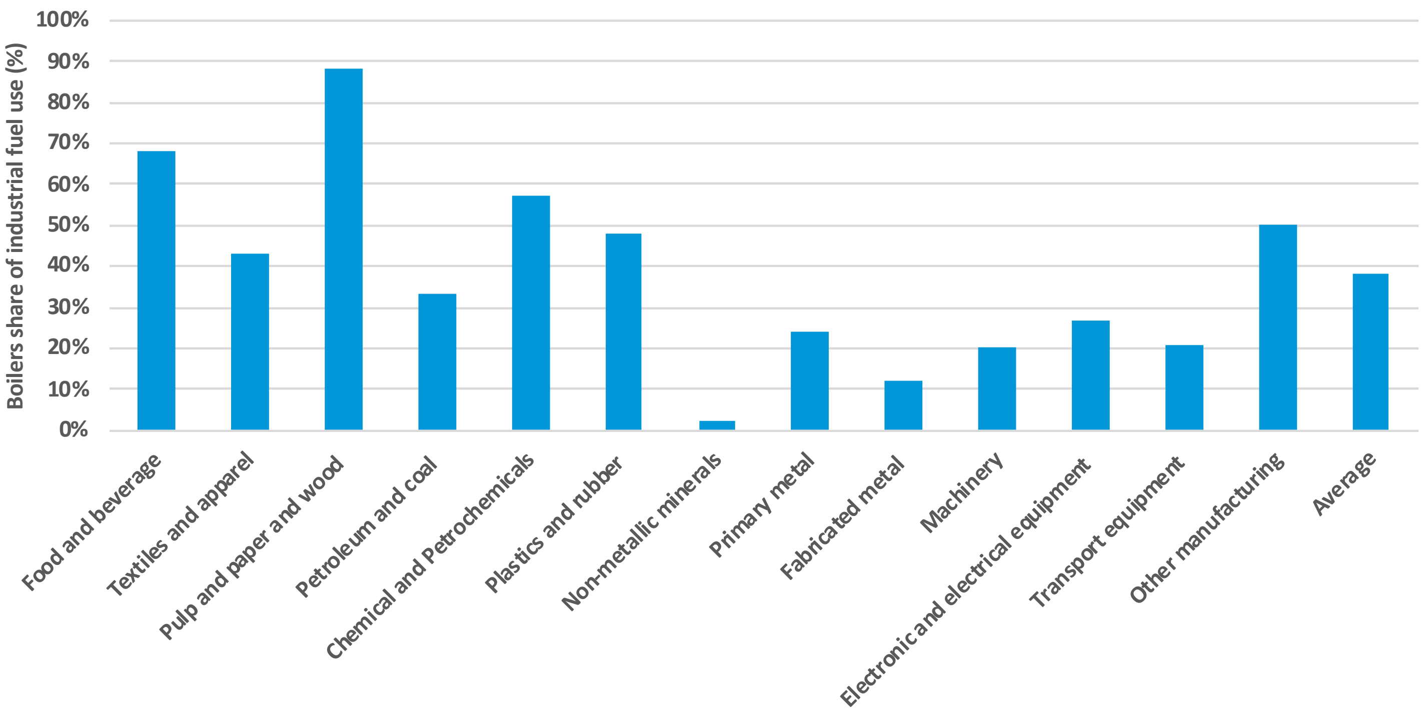
	2019	2050
Average unit price of **electricity** for industry in U.S. (2017 US$/kWh)	0.072	0.073
Average unit price of **NG** for industry in U.S. (2017 US$/kWh)	0.015	0.020

RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

D|G/A David Gardiner and Associates

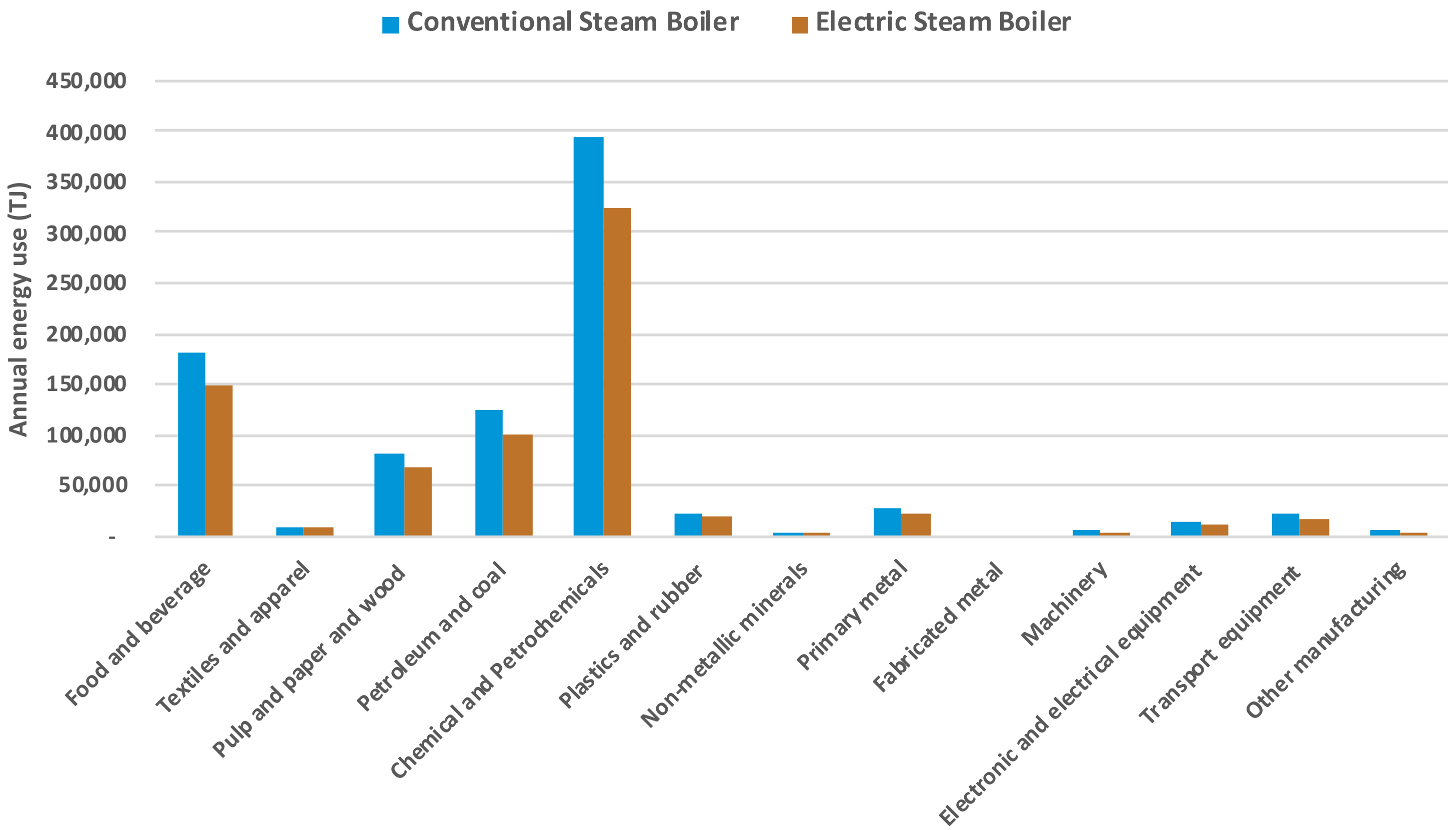
Industrial Conventional Boilers in the U.S.



Share of boilers energy use as a percent of total fuel consumption in the U.S. industry

Source: US DOE, 2017

Electrification of **All Industrial Conventional Boilers** in the U.S.

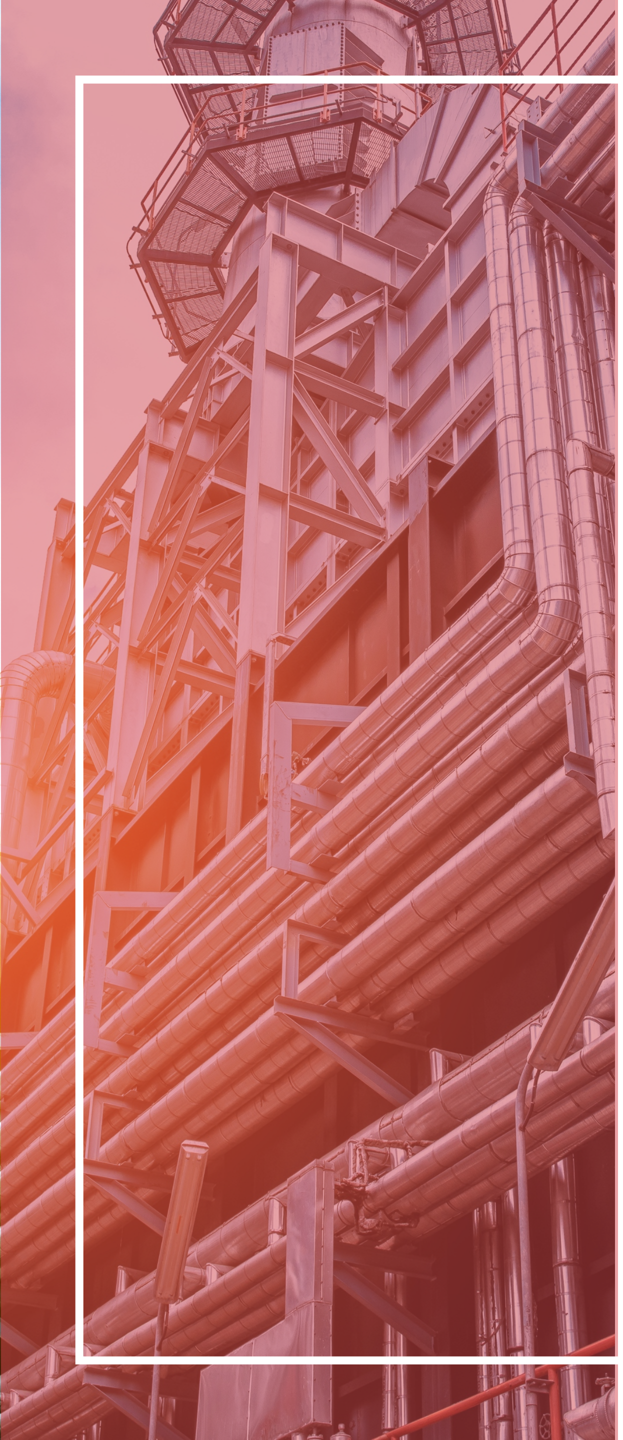


Estimated final energy use in conventional and electric steam boilers in the U.S. industrial sectors

RENEWABLE THERMAL COLLABORATIVE

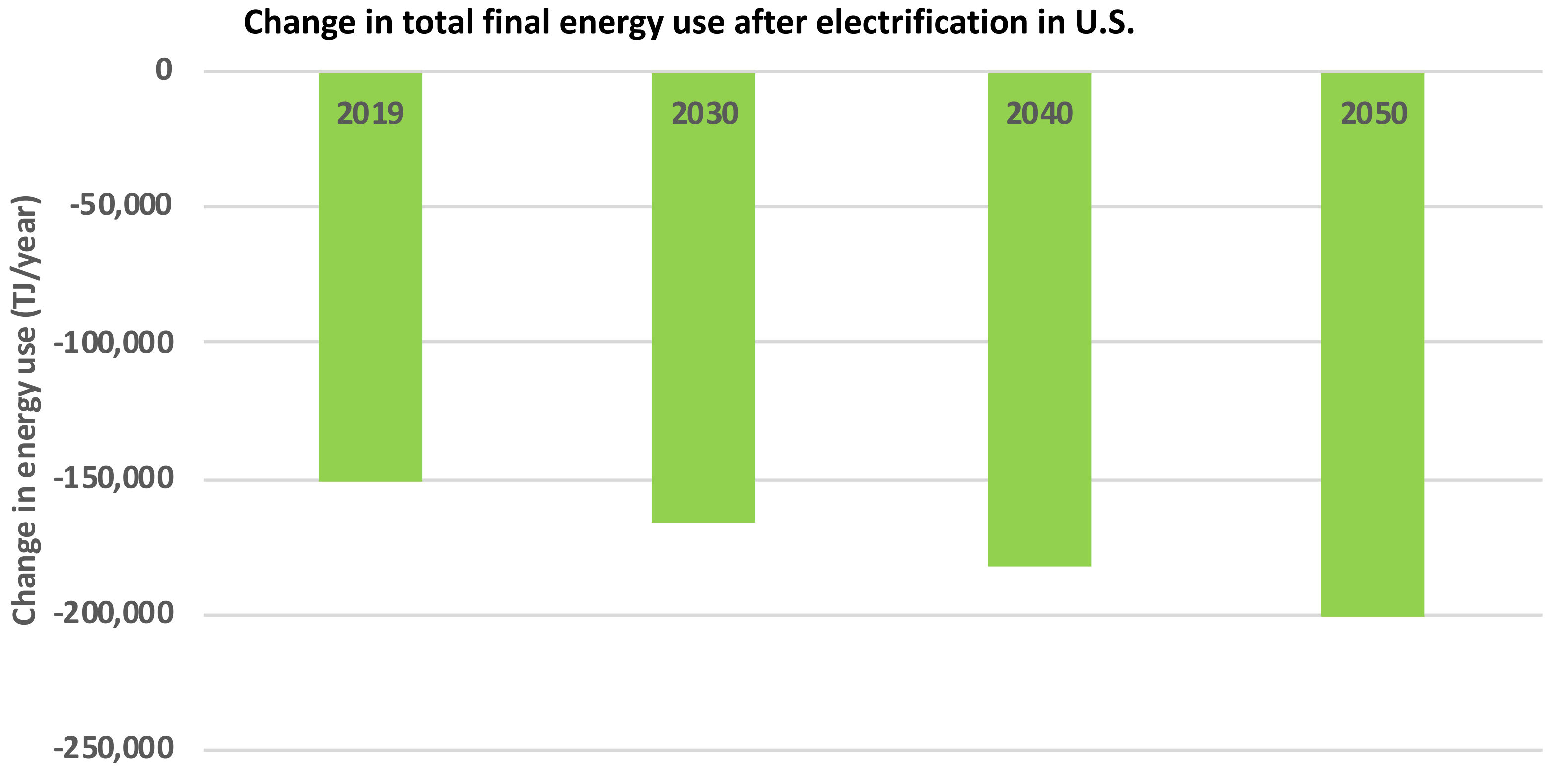
Global Efficiency Intelligence

DGA David Gardiner and Associates



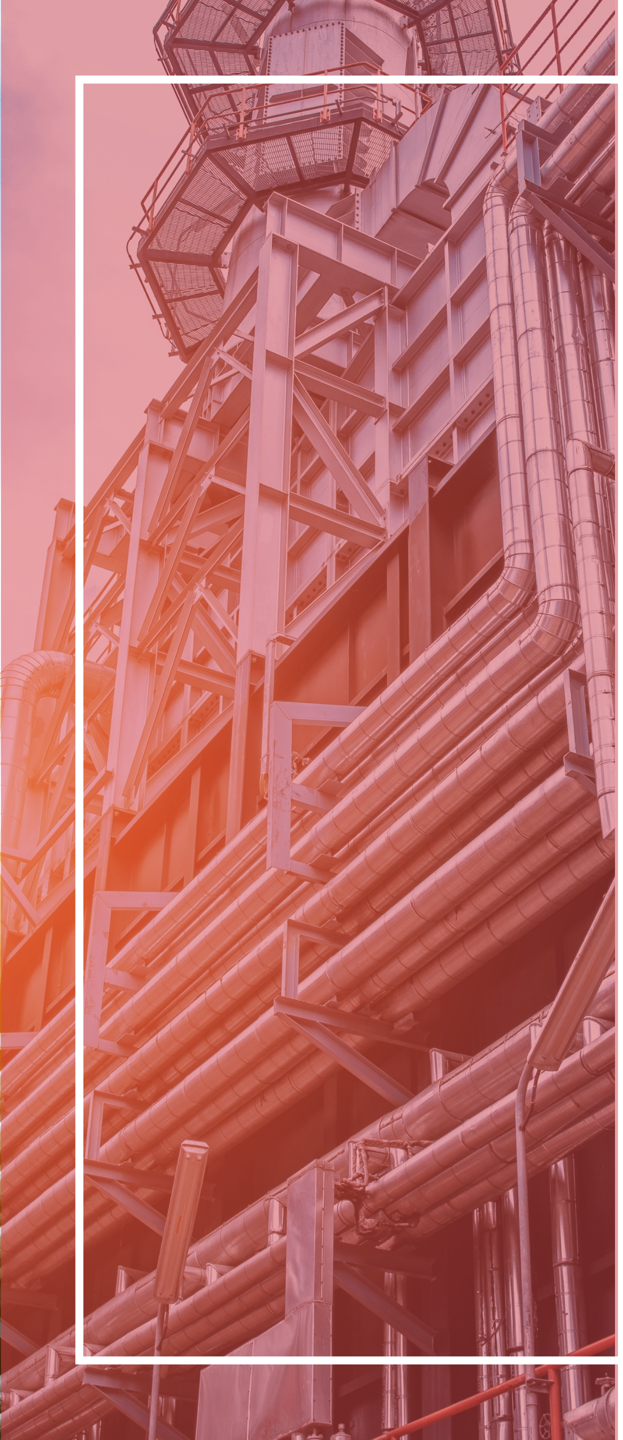
Technical Assessment

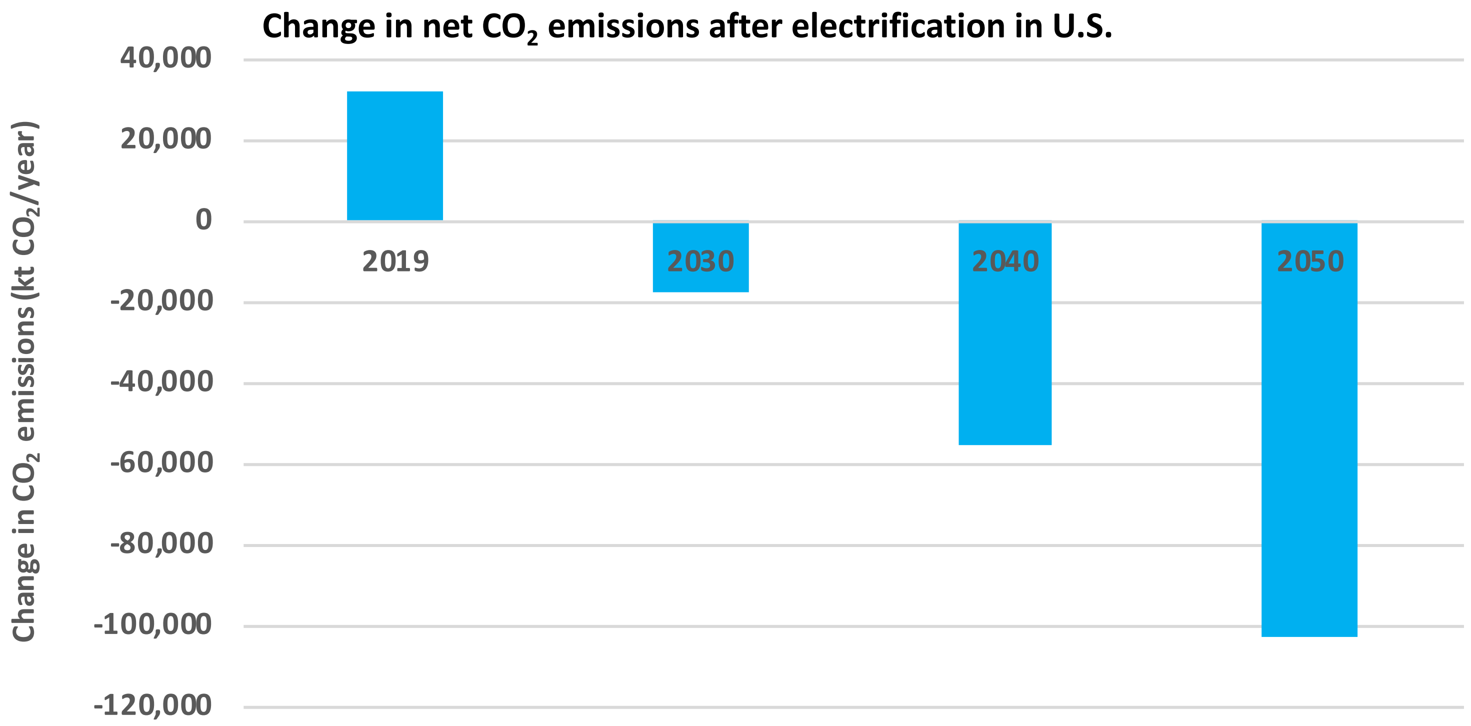
Electrification of **All Industrial Conventional Boilers** in the U.S.



RENEWABLE THERMAL COLLABORATIVE
Global Efficiency Intelligence
D|G/A
David Gardiner and Associates

Electrification of **All Industrial Conventional Boilers** in the U.S.



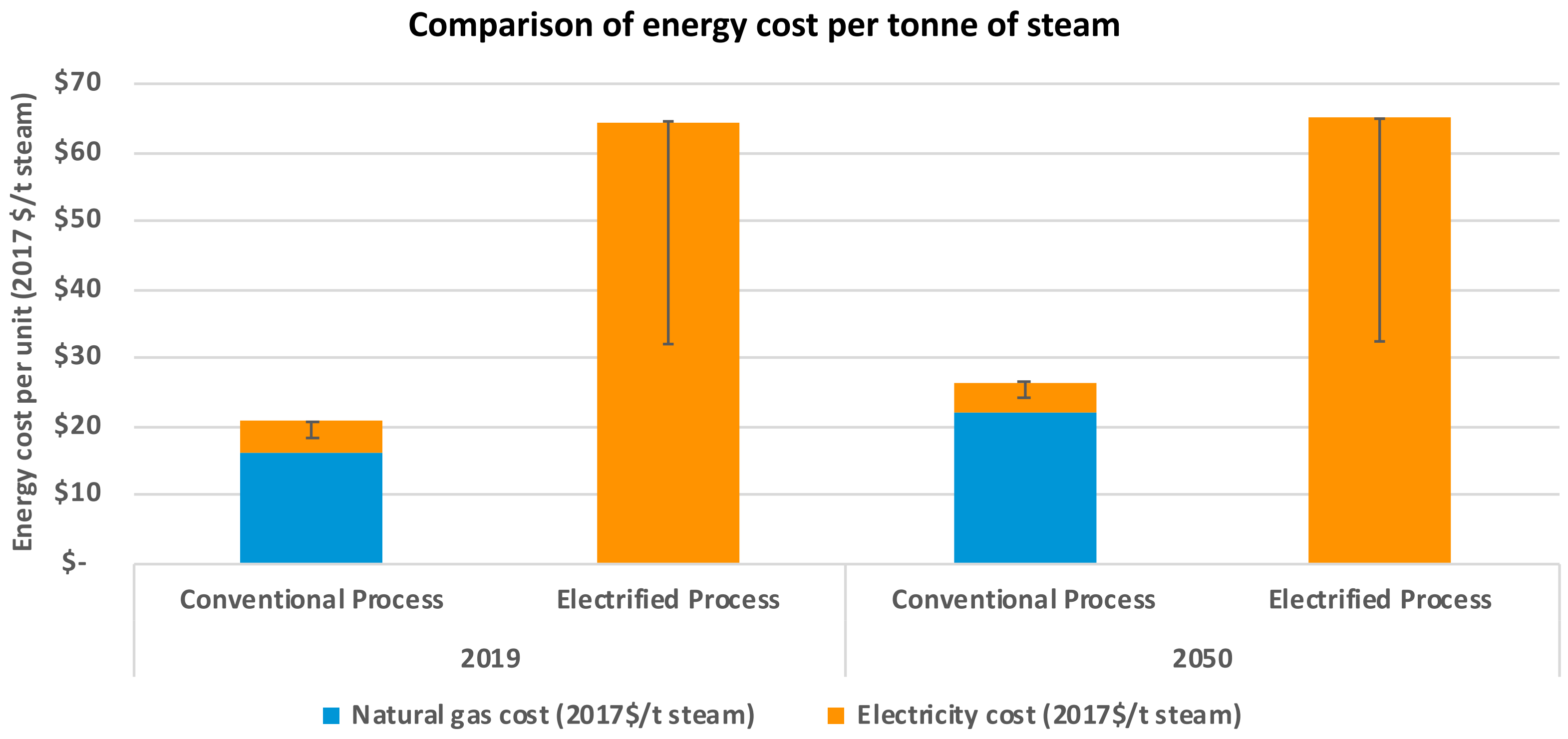


RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

D|G/A David Gardiner and Associates

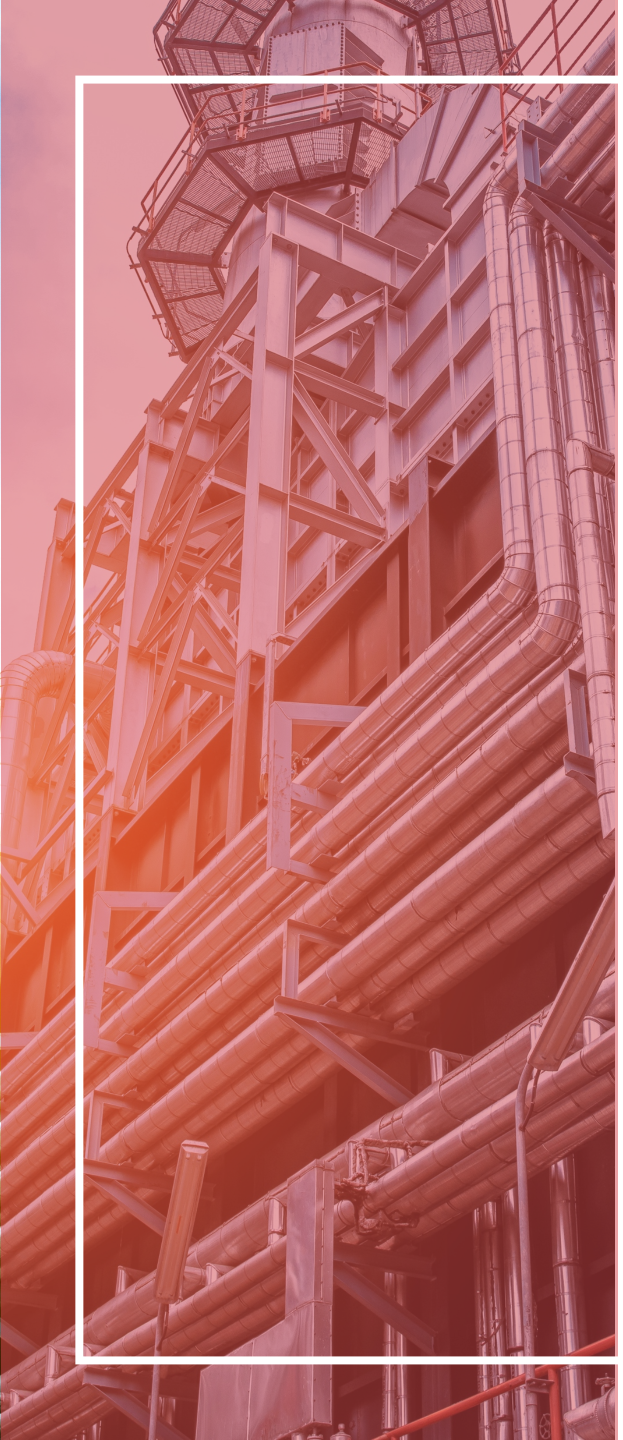
Electrification of **All Industrial Conventional Boilers** in the U.S.



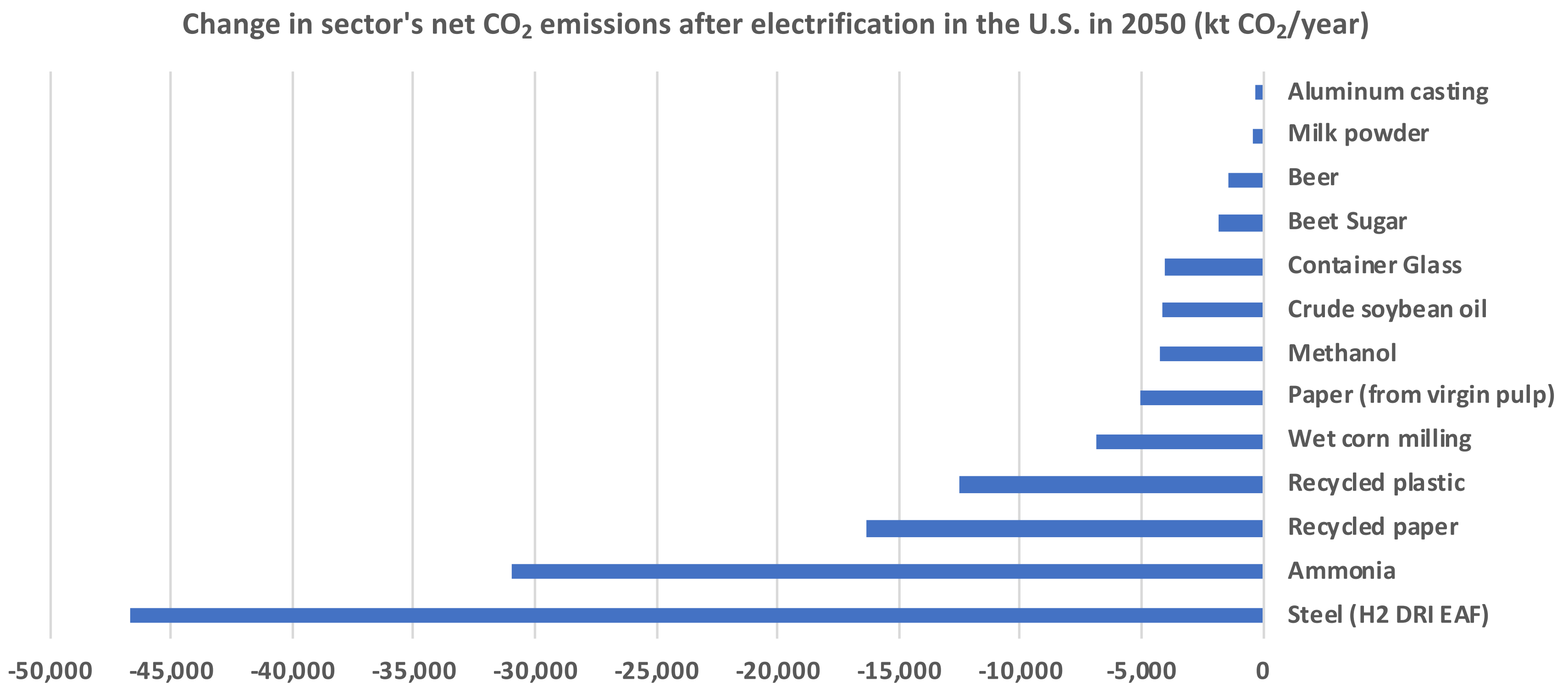
RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

D|G/A David Gardiner and Associates



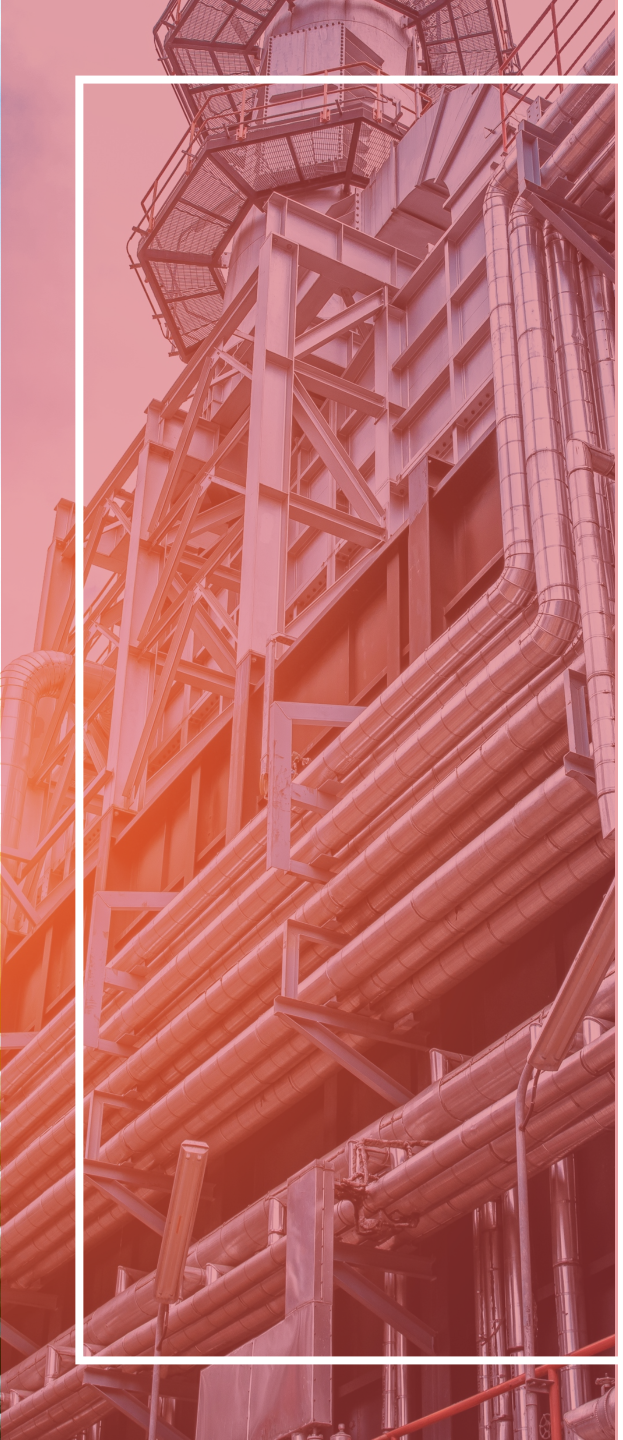
All Sectors' Results for 2050



RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

D|G/A David Gardiner and Associates



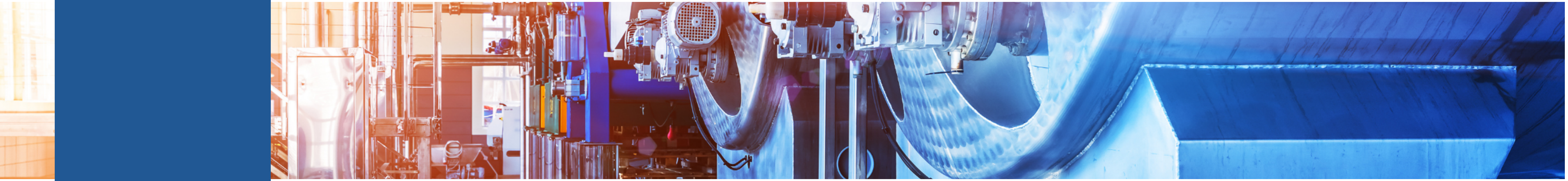
All Sectors' Results for 2050

No.	Sectors	Change in total final energy use after electrification (TJ/Year)				Change in sector's net CO_2 emissions after electrification in U.S. (kt CO_2/year)			
		2019	2030	2040	2050	2019	2030	2040	2050
1	Aluminum casting	-2,314	-2,546	-2,800	-3,080	17	-112	-195	-294
2	Paper (from virgin pulp)	-33,995	-32,295	-30,681	-29,147	26,970	9,997	2,075	-5,080
3	Recycled paper	-75,121	-82,634	-90,897	-99,987	4,239	-4,402	-9,827	-16,295
4	Container glass	-5,745	-6,320	-6,952	-7,647	747	-1,240	-2,498	-3,996
5	Ammonia	-22,695	-24,965	-27,461	-30,207	21,868	-779	-14,516	-30,991
6	Methanol	75,688	86,310	96,933	106,228	11,896	5,046	883	-4,275
7	Recycled plastic	-257,955	-283,751	-312,126	-343,338	-19,743	-16,032	-14,508	-12,519
8	Steel (H_2 DRI EAF)	-123,599	-136,527	-150,024	-154,712	-6,211	-24,022	-35,825	-46,668
9	Beer	-20,591	-22,132	-23,427	-24,660	-92	-669	-1,010	-1,381
10	Beet sugar	-7,801	-8,385	-8,875	-9,342	662	-441	-1,076	-1,775
11	Milk powder	-3,657	-4,023	-4,425	-4,868	-104	-223	-304	-400
12	Wet corn milling	-20,305	-21,825	-23,102	-24,318	3,717	-1,095	-3,853	-6,892
13	Crude soybean oil	-31,732	-34,107	-36,102	-38,002	-46	-1,865	-2,934	-4,100
Total		-529,824	-573,199	-619,938	-663,079	43,919	-35,837	-83,590	-134,665

RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

DGA David Gardiner and Associates

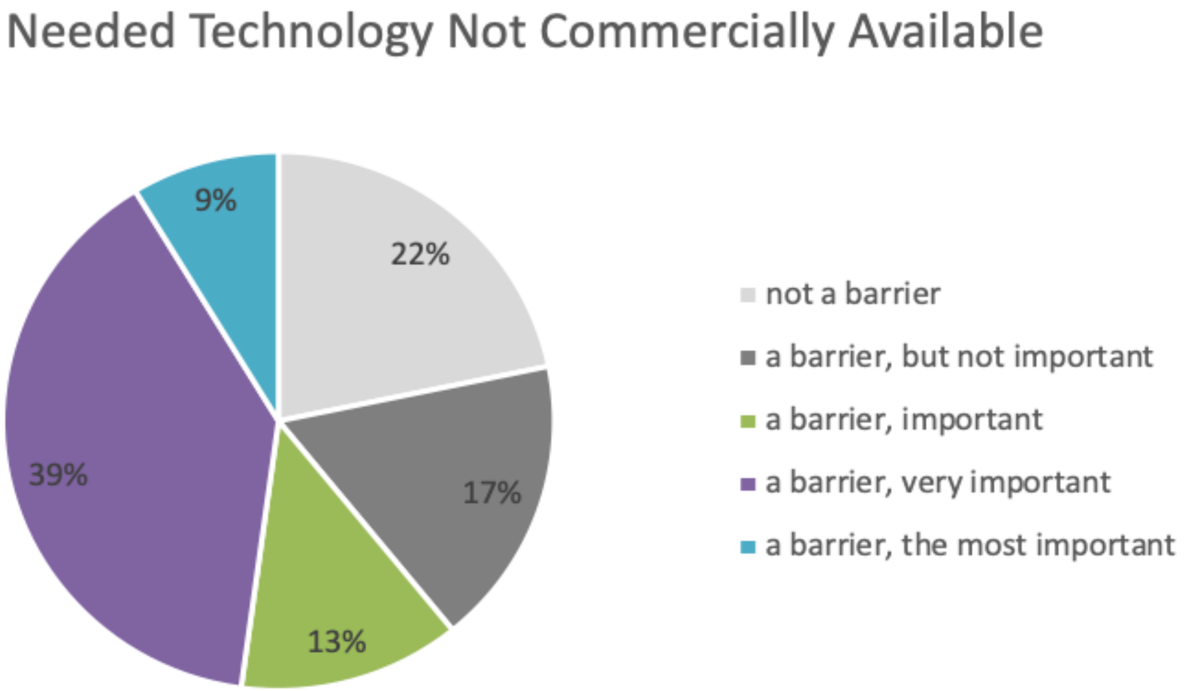


Barriers & Opportunities

Types of Barriers and Proposals to Overcome

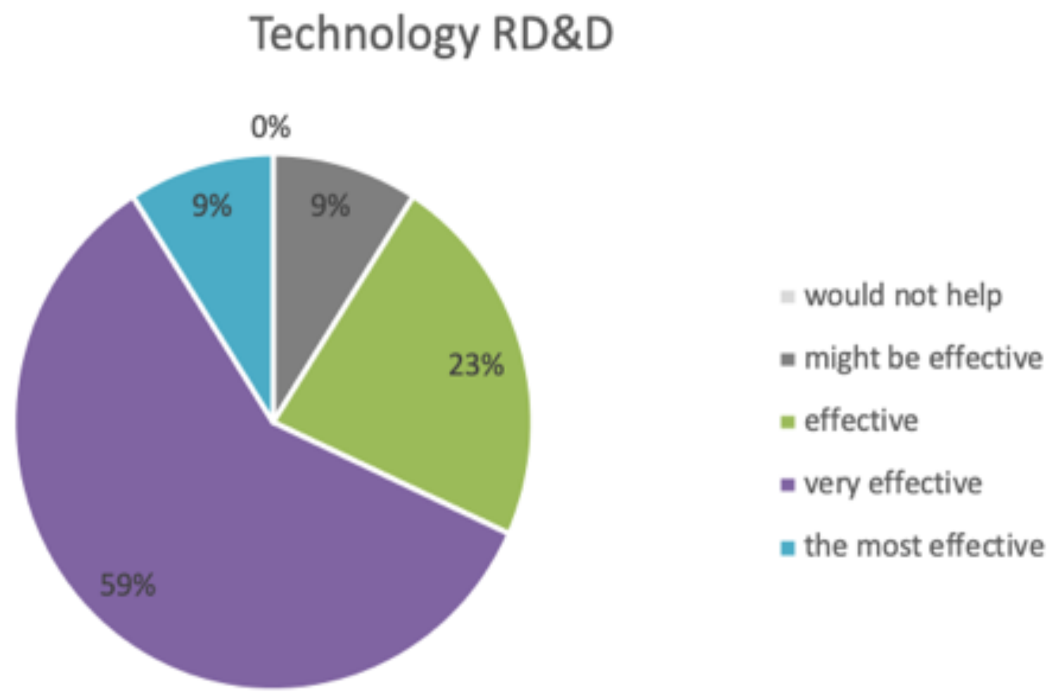
- **Technology**
- **Knowledge and Education**
- **Cost**
- Financing
- **Policy**
- Electric Utility Connection and Reliability

Technology: Barriers



RENEWABLE THERMAL COLLABORATIVE
Global Efficiency Intelligence
D|G/A David Gardiner and Associates

Technology: Proposals

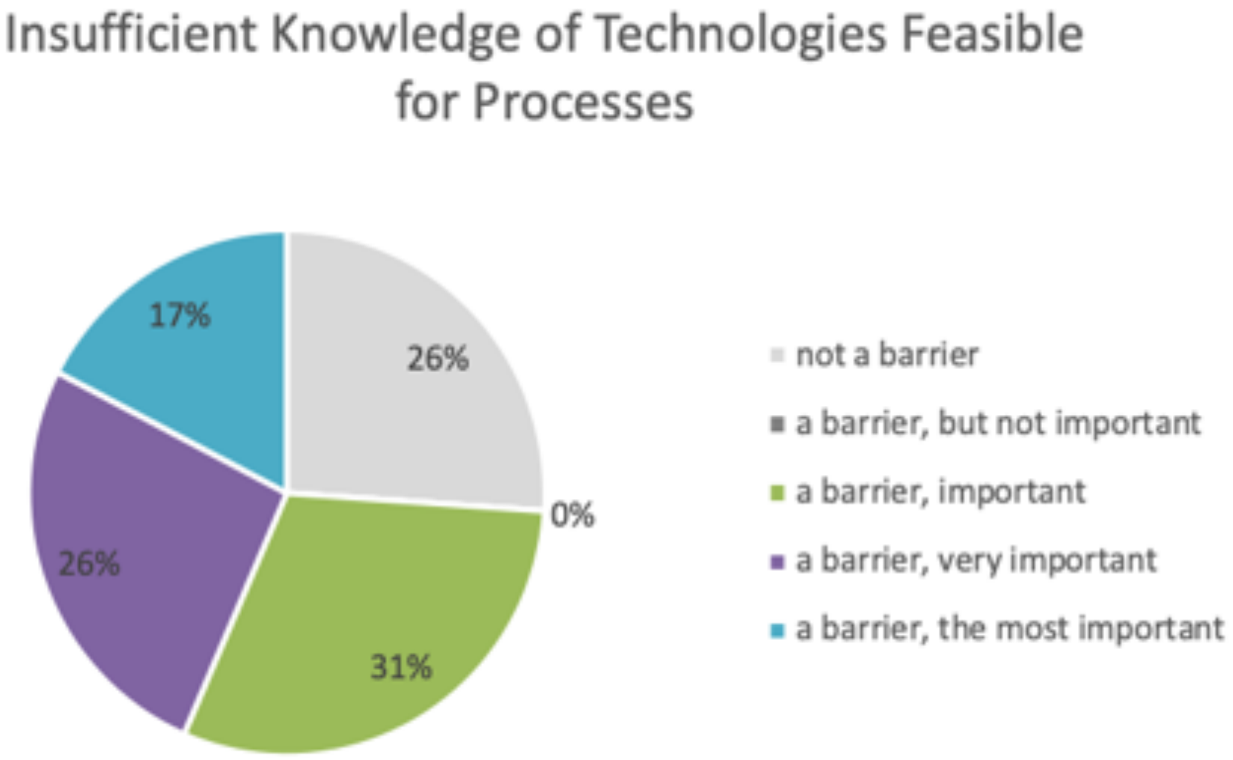


RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

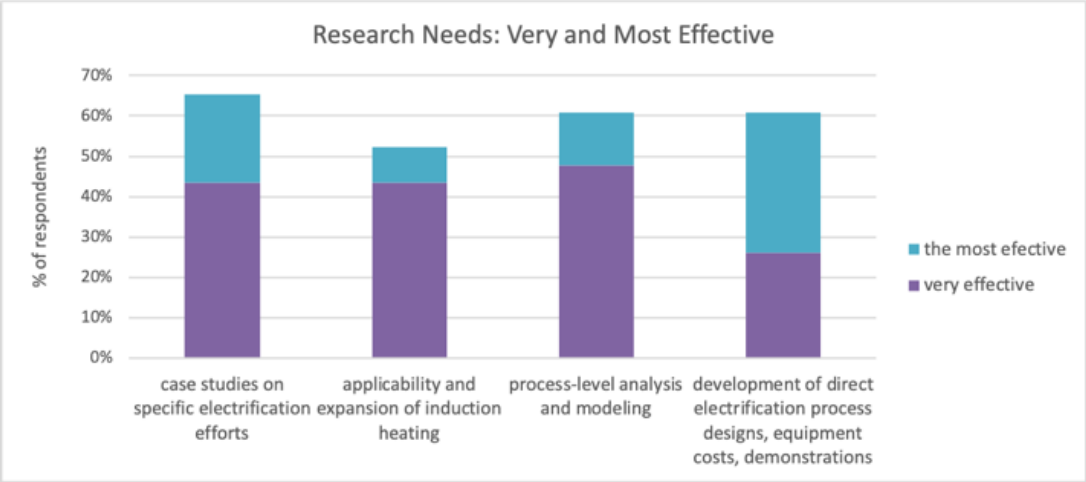
D|G/A David Gardiner and Associates

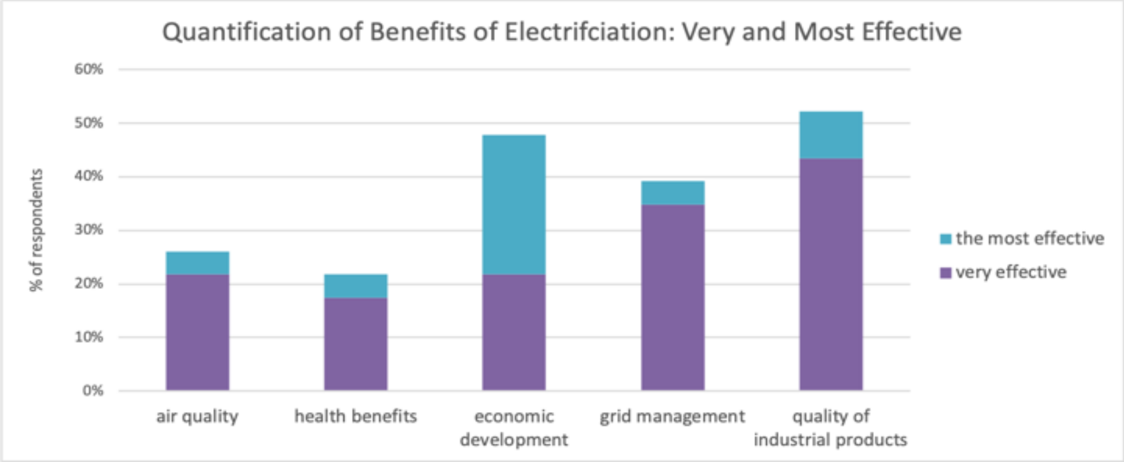
Knowledge and Education: Barriers



RENEWABLE THERMAL COLLABORATIVE
Global Efficiency Intelligence
DGA David Gardiner and Associates

Knowledge and Education: Proposals



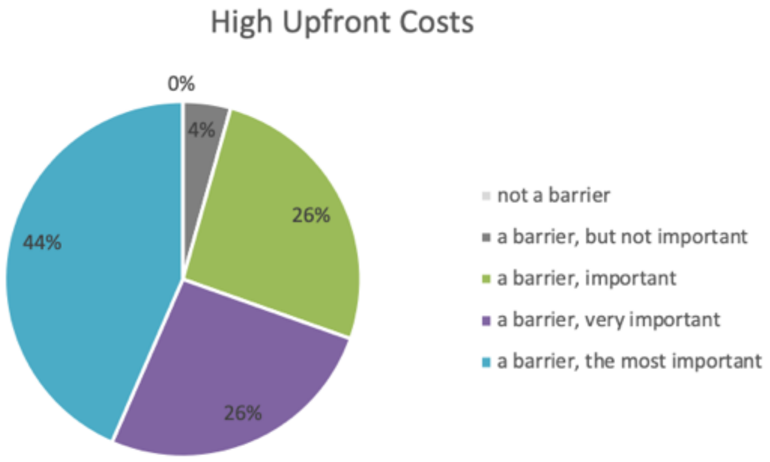


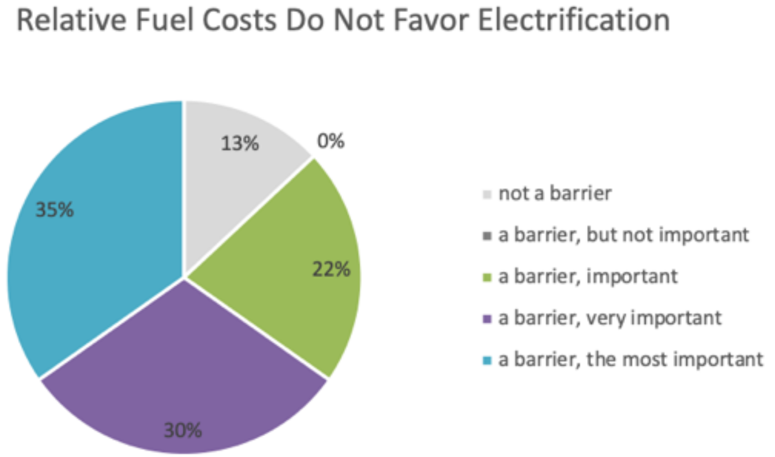
RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

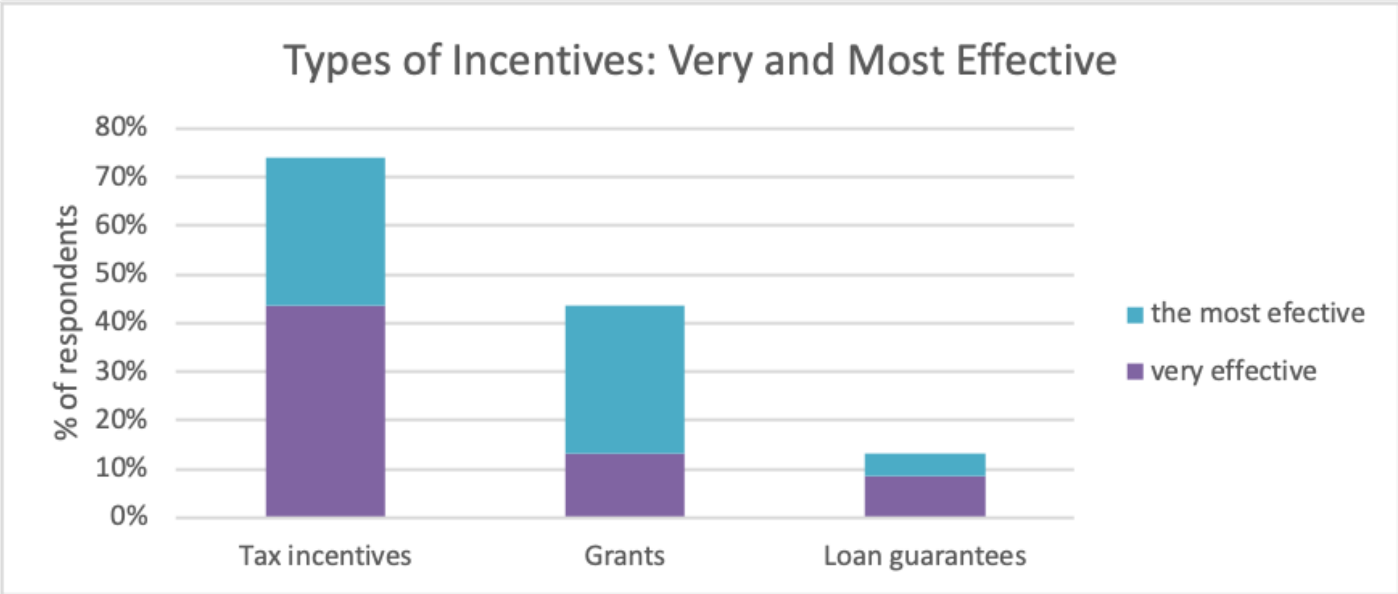
DGA David Gardiner and Associates

Cost: Barriers

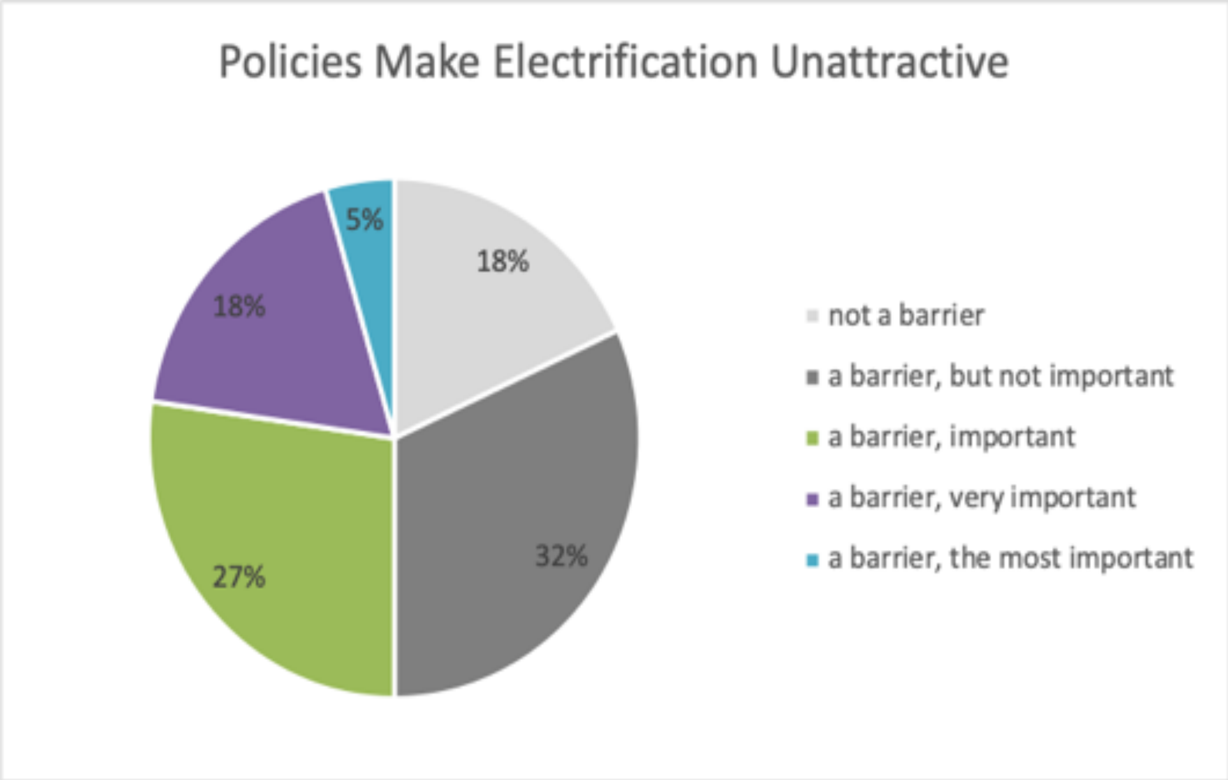




Cost: Proposals

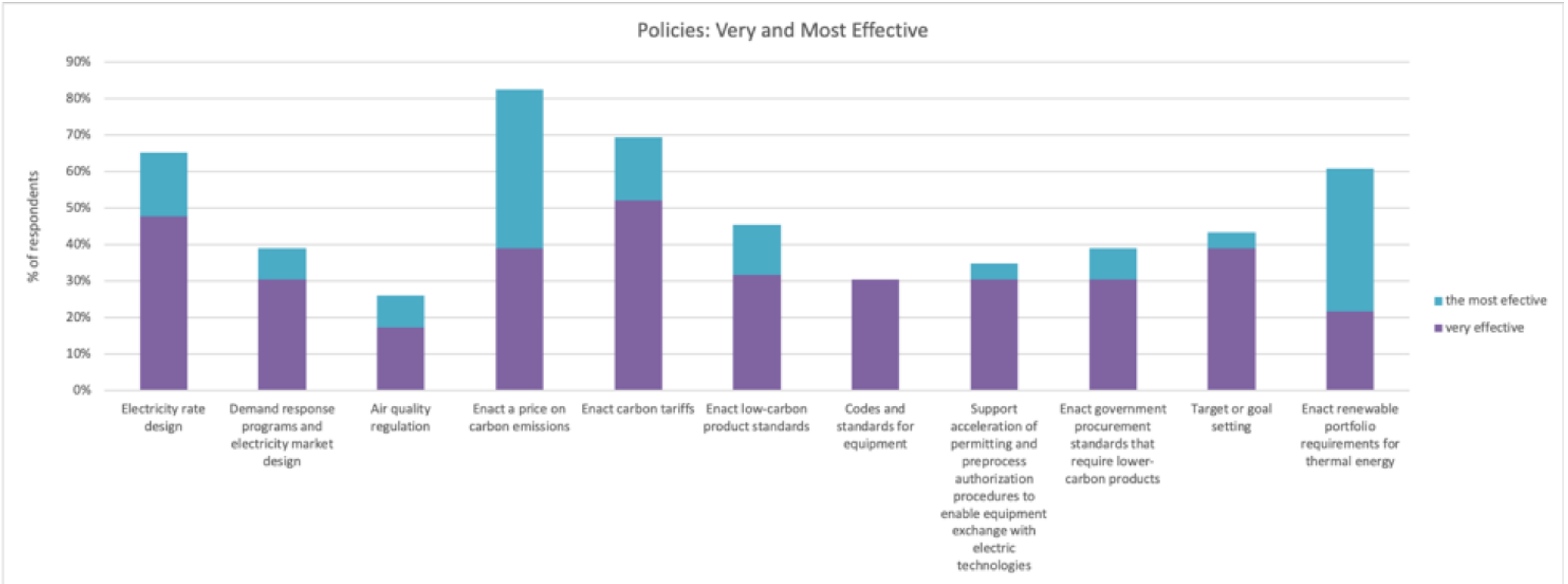


Policy: Barriers



RENEWABLE THERMAL COLLABORATIVE
Global Efficiency Intelligence
D|G/A David Gardiner and Associates

Policy: Proposals



RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

D|G/A David Gardiner and Associates

Action Plan

Key Actions

- **Industrial sector**
- **Governments**
- **Utilities**
- Suppliers of electrification technologies or equipment

Key Actions: Industrial Sector

- The industrial sector should **initiate partnerships** with academia, national labs, think tanks, and other stakeholders to develop or scale electrification technologies.
- Work with stakeholders to **educate policymakers, utilities, and financial institutions about the benefits** of electrification and what policy, regulatory, and financial support is required to electrify industrial processes.
- **Provide training for employees and contractors** about electrified technologies. Government and utilities should support such training programs.

RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

D|G/A David Gardiner and Associates

Key Actions: Governments

- **Provide incentives for electrification technology development and demonstration** and use the capacity at the U.S. Department of Energy (DOE) national labs to advance electrification technologies for industry.
- Work with utilities to **provide financial incentives** in the form of tax credits or grants for pilot projects and demonstration of emerging electrification technologies in industry.
- Adopt a variety of **policies and programs** to support industrial electrification.
- Conduct **techno-economic analysis** for all electrification technologies applicable to each industrial subsector using capital cost, operation and maintenance cost, and energy cost.

Key Actions: Utilities

- **Evaluate the demand response (DR) potential** that increased electrification in the industrial sector can provide to utilities and its financial implications.
- **Provide information** about their electric rates, market structures, and grid upgrade implications of industrial electrification.
- **Adopt electricity rate designs** that encourage electrification.

Thank You.

RENEWABLE THERMAL COLLABORATIVE

Global Efficiency Intelligence

D|G/A David Gardiner and Associates