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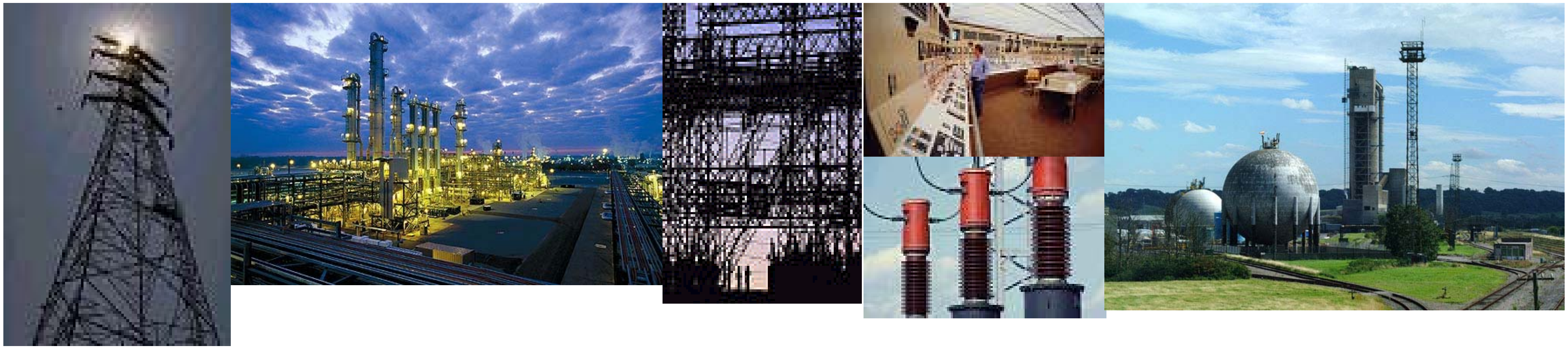

Louisiana industrial cogeneration trends.

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Study purpose.

- Purpose of this project includes (a) **updating** Louisiana industrial CHP status and (b) examining the degree to which already-developed Louisiana industrial **CHP is utilized**.
- CHP **utilization** can be an important indicator of **CHP profitability** both under traditional PURPA-based "puts" and, increasingly, in competitive wholesale markets.
- **Anecdotal evidence** from prior study suggested that **CHP was under-utilization due to a variety of market and regulatory barriers**. This **reduces CHP attractiveness** since it **increases CHP development/profitability risks**.
- Under-utilized CHP **also has clean air/carbon emissions implications** since under some proposals (like the Clean Power Plan) CHP and **higher utilized** natural gas fired generation, **can be used for compliance**.
- This study **examines historic trends in Louisiana CHP generation and utilization** to test the claim that current CHP capacity is/has been, underutilized.

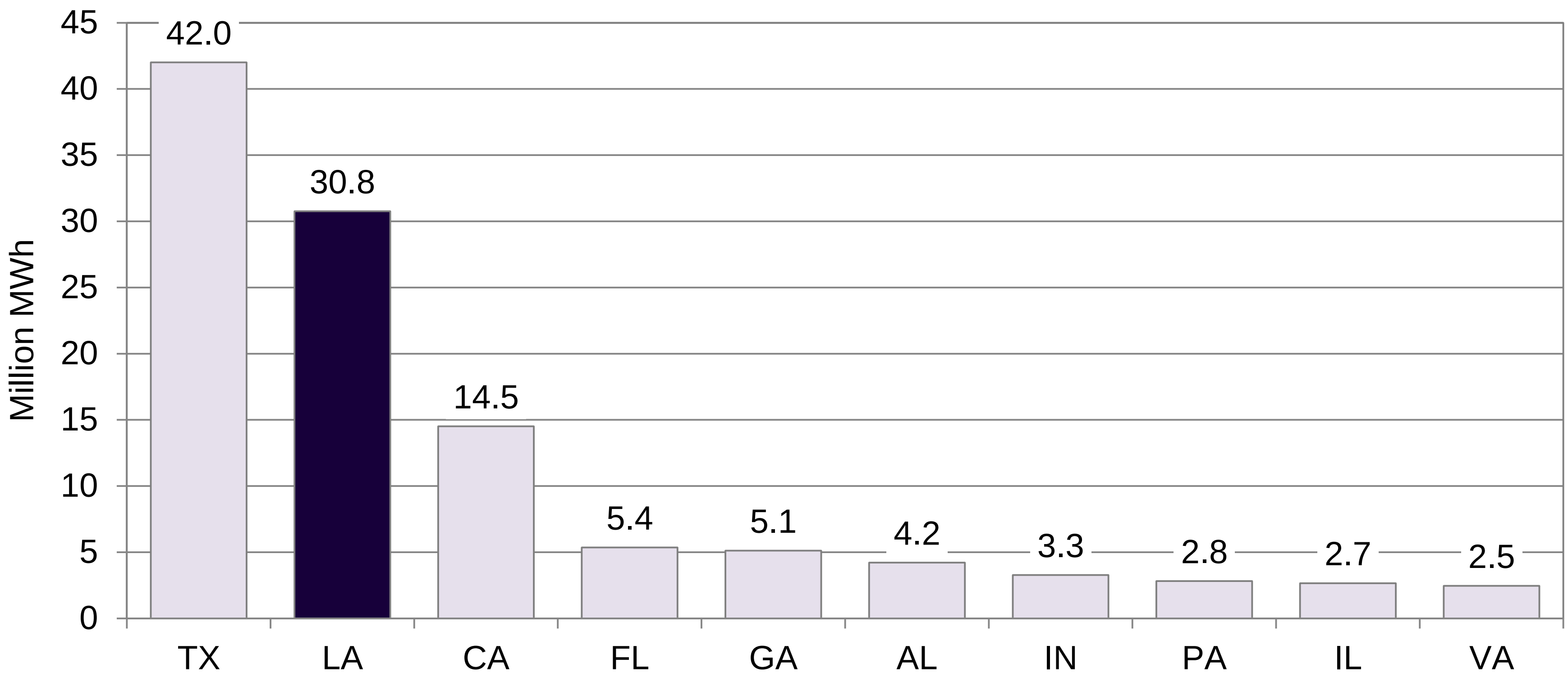
Acknowledgements.

The Center for Energy Studies recognizes and appreciates the financial support provided by the Louisiana Department of Natural Resources for conducting this research.

Overview

Industrial cogeneration by leading states (million MWh).

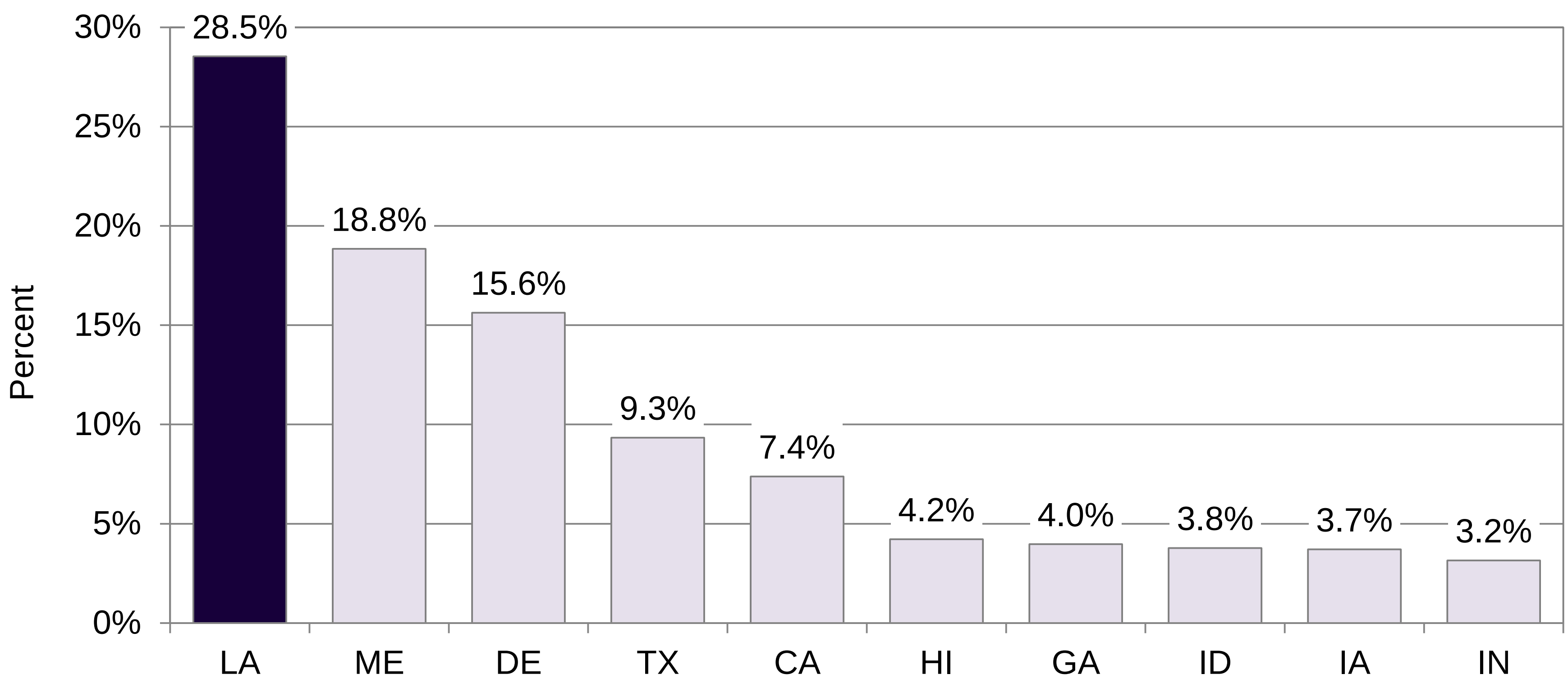
In 2015, Louisiana's industries generated almost 31 million MWh of electricity, making Louisiana the second largest industrial CHP generator (in absolute terms) in the U.S.



Note: Includes Industrial CHP only, as defined by Energy Information Administration.
Source: Energy Information Administration, U.S. Department of Energy.

Industrial cogeneration shares by leading states (2015).

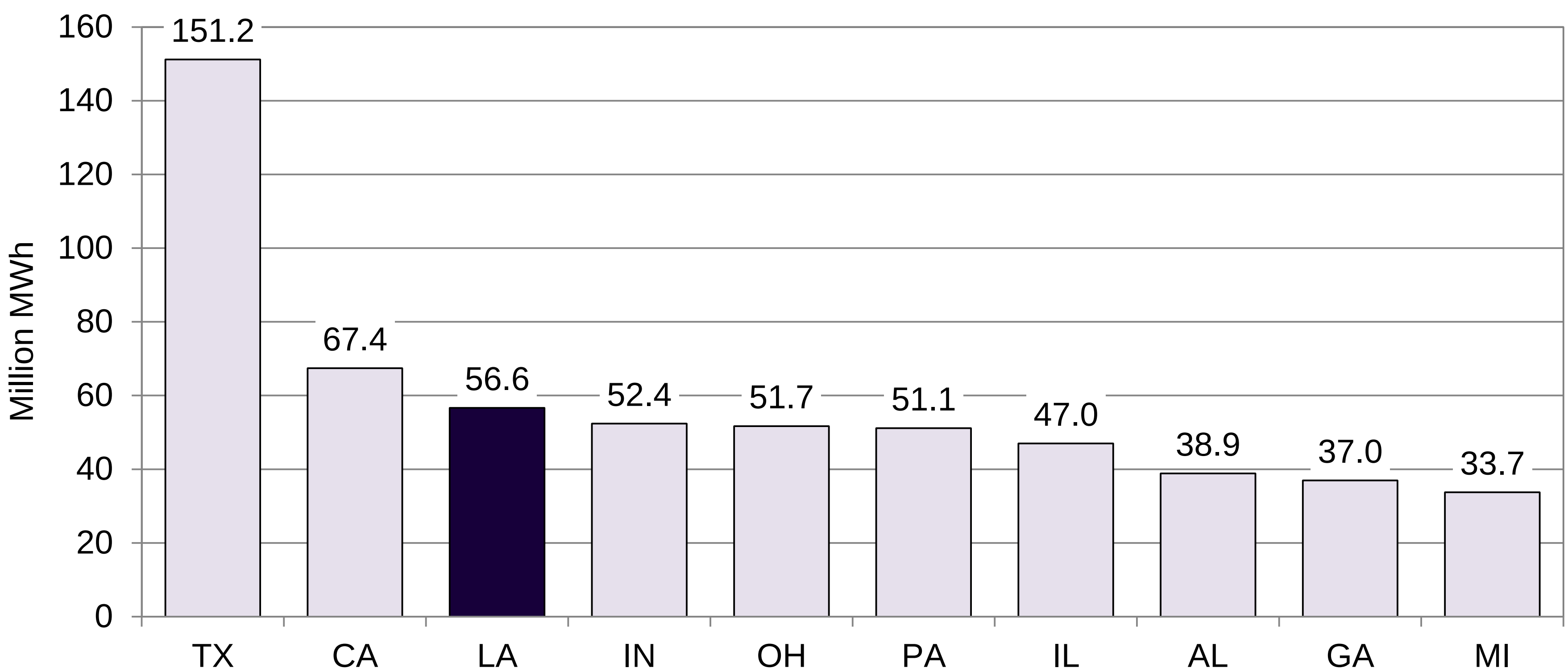
Close to 30 percent of Louisiana's electricity is generated at industrial CHP facilities: a level considerably more significant than just about any other state including Texas.



Note: Includes Industrial CHP only, as defined by Energy Information Administration.
Source: Energy Information Administration, U.S. Department of Energy.

Combined industrial usage and CHP generation comparison (2015).

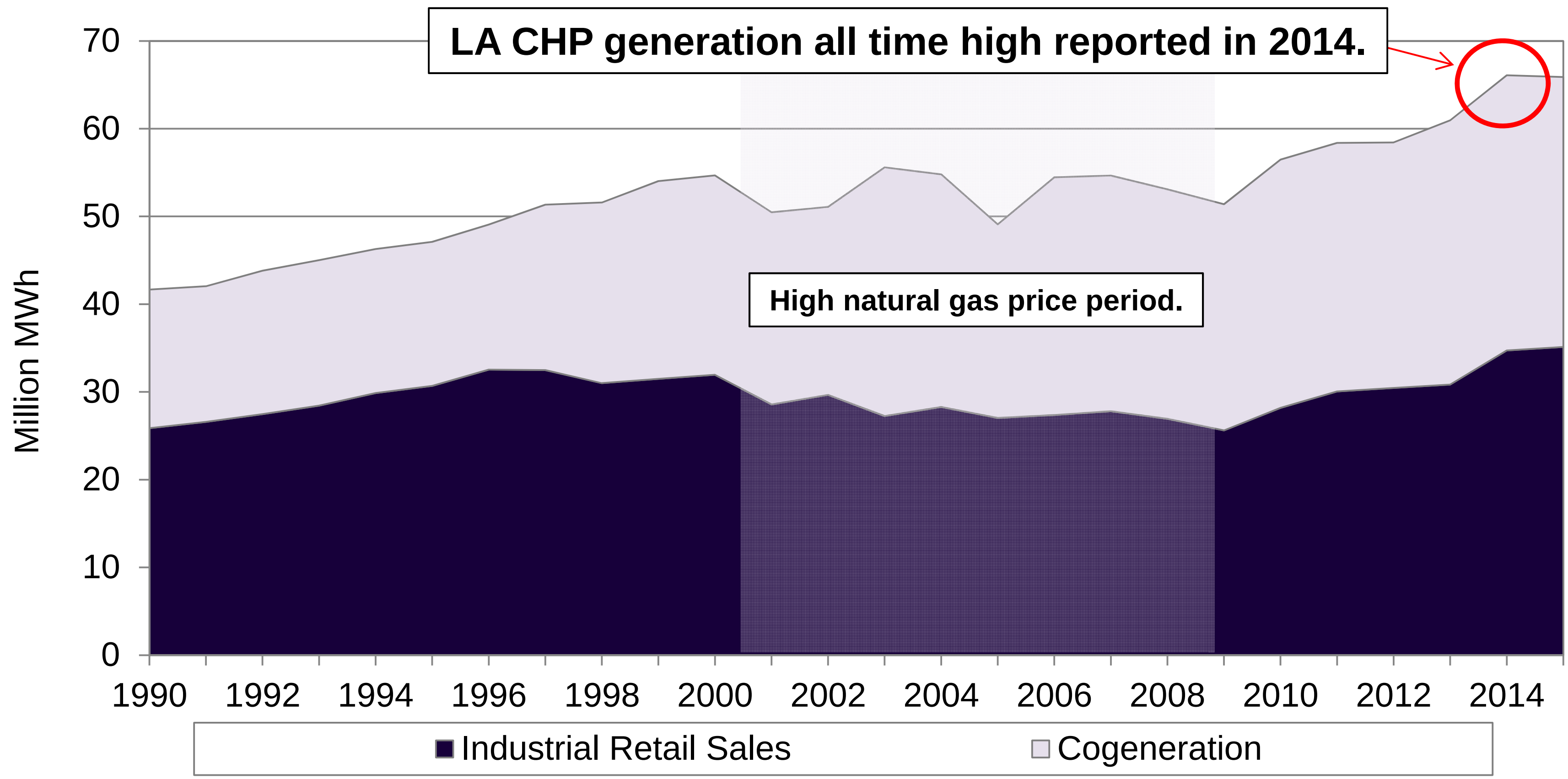
Louisiana ranks third in combined industrial usage and CHP.



Note: Includes Industrial CHP only, as defined by Energy Information Administration.
Source: Energy Information Administration, U.S. Department of Energy.

Historic Louisiana Industrial sales and cogeneration.

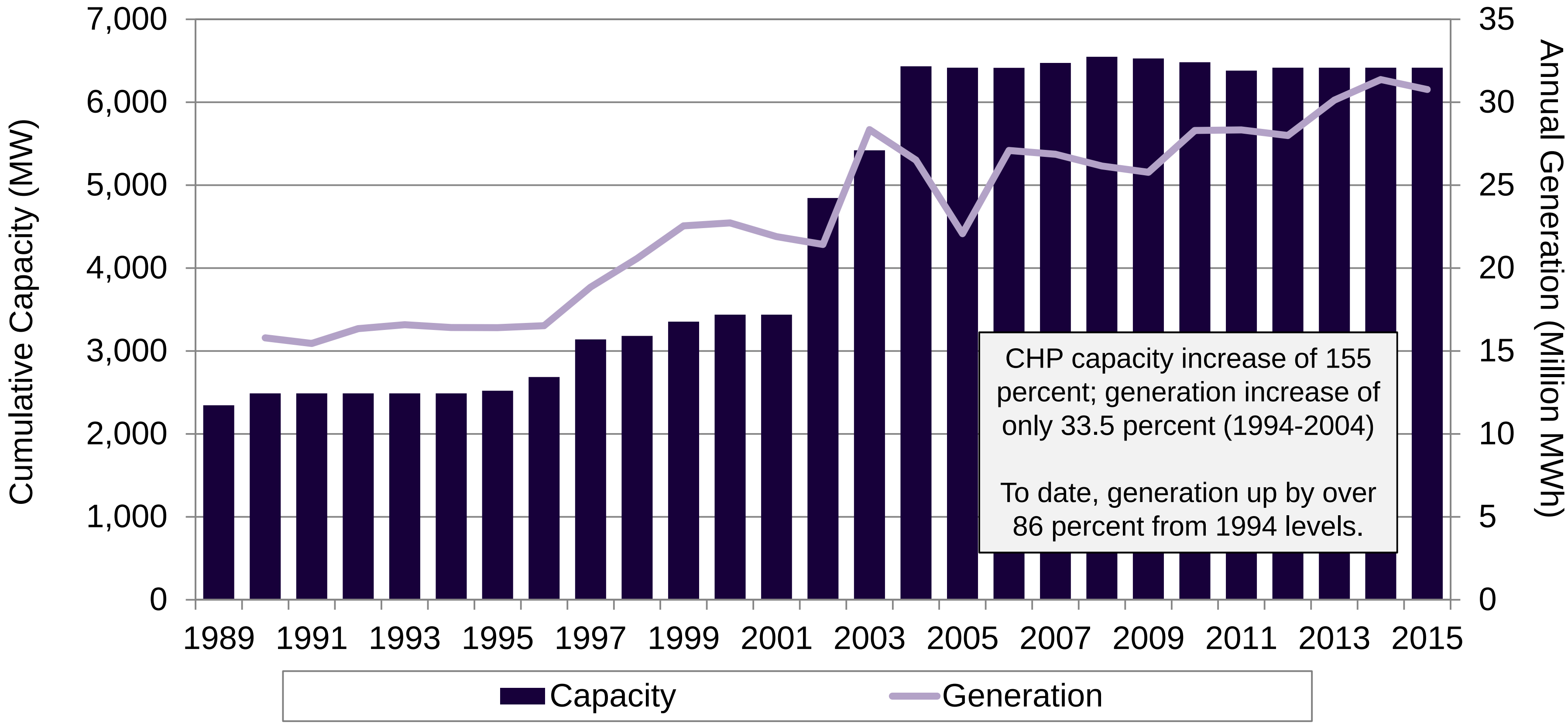
Since 2009, Louisiana's industrial retail sales have increased by 37 percent while industrial CHP generation has increased 19 percent, for a combined 28 percent overall increase in CHP generation and industrial use.



Note: Includes Industrial CHP only, as defined by Energy Information Administration.
Source: Energy Information Administration, U.S. Department of Energy.

Louisiana cogeneration capacity and production

In Louisiana, CHP generation continues to grow despite flat capacity growth (around 6,200 MW). This is comparable to the prior-discussed US trends. Louisiana CHP generation has been climbing to new highs, for each year, since around 2010.



Note: Cumulative capacity is net of retirements. Includes Commercial CHP, Industrial CHP and IPP CHP as defined by the Energy Information Administration.
Source: Energy Information Administration, U.S. Department of Energy.

CHP utilization:
motivation and methods

Motivations for understanding utilization trends – cost-effectiveness potentials

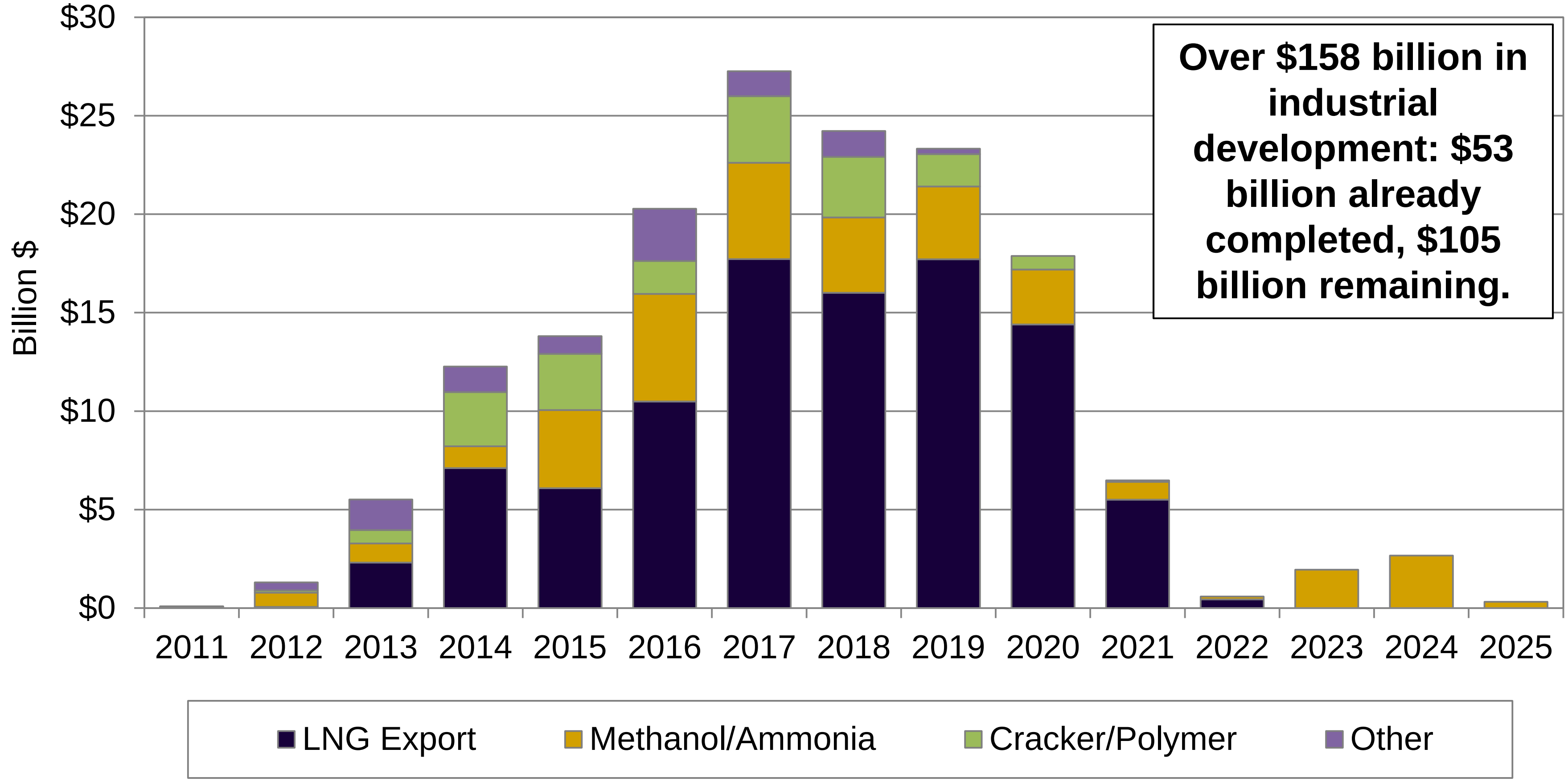
Prior Louisiana CHP studies have find that there is not a very large potential for new CHP applications at existing facilities.

Implication is that any additional CHP generation that may arise in the future will have to come from either efficiencies or expansions at existing facilities, not from the development of new CHP at the state's current portfolio of industrial host sites.

NAICS Category		CHP Capacity (MW)			
		Existing	Market Identification	Technical Potential	Cost Effective
311-312	Food, Beverage and Tobacco	23.7	100.5	98.7	1.6
313-314	Textile Mills	-	0.9	0.9	0.9
315	Apparel Manufacturing	-	0.2	0.2	-
321	Wood Products	-	31.4	31.4	6.4
337	Furniture and Related Products	-	0.2	0.2	-
322	Paper Manufacturing	555.6	404.1	3.0	-
323	Printer and Related Support	-	9.1	9.1	0.2
325	Chemical Manufacturing	4,972.5	2,222.7	934.6	298.7
324	Petroleum and Coal Products	643.7	1,319.5	304.6	209.9
326	Plastics and Rubber Products	-	48.0	7.9	-
316	Leather and Products	-	0.6	0.6	-
327	Nonmetallic Mineral Products	-	13.7	13.7	7.5
331	Primary Metal Manufacturing	84.1	49.5	49.5	35.0
332	Fabricated Metal Products	-	14.3	14.3	-
333-334	Machinery and Electronics	-	18.9	18.9	-
335	Electrical Equipment and Appliances	-	2.8	2.8	-
336	Transportation Equipment	-	7.7	7.7	-
	Misc	7.5	1.1	1.1	-
	Total	**6,287.1**	**4,245.3**	**1,499.3**	**560.3**

Motivations for understanding utilization trends – new industrial facilities.

There may be CHP potentials at new industrial facilities. Perceptions about Louisiana-based CHP risk and profitability important for development decisions.



Source: David E. Dismukes (2013). *Unconventional Resources and Louisiana's Manufacturing Development Renaissance*. Baton Rouge, LA: Louisiana State University, Center for Energy Studies and author's updates.

Implications that utilization has on development.

Focusing on CHP utilization is important for a number of reasons:

(1) Anecdotal evidence suggests that utilization is below potential. If this is true, then:

a) Increased utilization may represent an **additional efficiency opportunity.**

b) Could be **sending negative signals** to the market about the **risk and profitability of CHP development** in Louisiana.

(2) Potentially represents low hanging fruit for **carbon emissions reductions and compliance** with potential future carbon regulations (like the Clean Power Plan).

(3) Suggests potential **market barriers may exist** and that there may be an opportunity for a **market/policy solution rather than one based on (financial) incentives**.

Data utilized.

Analysis looks at operational trends on per unit basis for Louisiana CHP facilities. This analysis uses the Major Industrial Plant Database (“MIPD”) for Louisiana prepared by IHS.

- Plant name, location and address (including latitude and longitude);
- Plant products by SIC or NAICS code;
- Hours of production, capacity utilization and dollar value of shipments;
- Electric utility, use, demand and price;
- Plant cogeneration percentage;
- Fuel usage by type: boiler, furnace or feedstock;
- Steam demand, pressure and temperature; and
- Number and rating of boilers, including primary and secondary fuels.

This database was supplemented with monthly generation statistics on an individual unit basis reported to the Energy Information Administration in the Form EIA- 923.

Louisiana CHP Units - On-Site Generation and Utilization

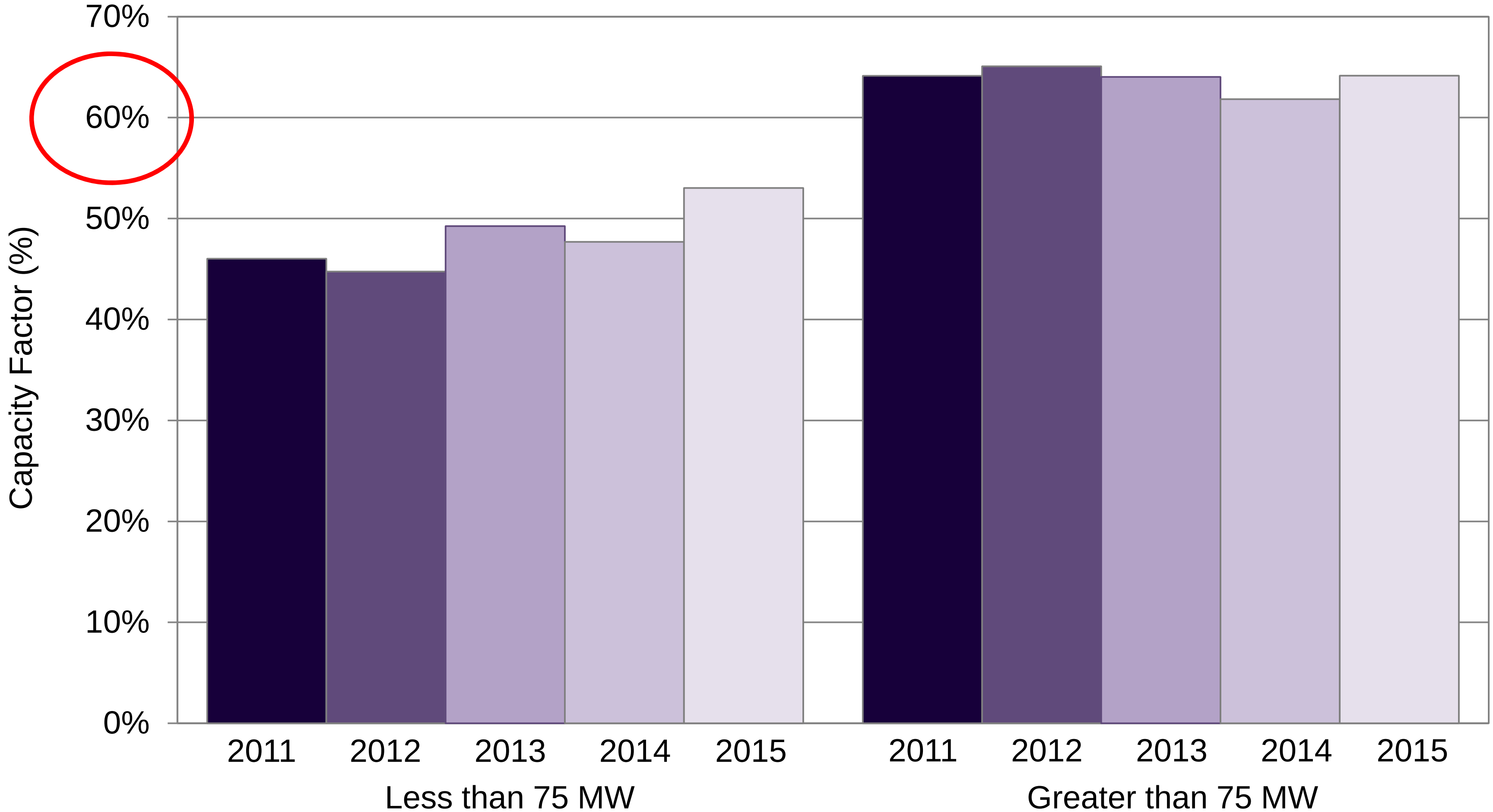
	Company - Facility	Parish	Nameplate Capacity (MW)	Primary Fuel	Year Online	NAICS Category	Gross Generation 2011	2012	2013	2014	2015	Implied Capacity Factor 2011	2012	2013	2014	2015
							(MWh)					(%)				
1.	Occidental Chemical Corp - Taft	St Charles	894.2	Natural Gas	2002	Chemical	5,753,409	5,356,850	5,316,063	5,584,416	4,987,212	73.4%	68.2%	67.9%	71.3%	63.7%
2.	Dow Chemical Co - Plaquemine	Iberville	987.0	Natural Gas	2004	Chemical	4,558,093	5,314,735	5,561,221	4,706,882	4,426,597	52.7%	61.3%	64.3%	54.4%	51.2%
3.	PPG Industries Inc - RS Cogen	Calcasieu	493.0	Natural Gas	2002	Chemical	2,992,184	3,045,799	1,800,549	2,909,685	3,175,042	69.3%	70.3%	41.7%	67.4%	73.5%
4.	Entergy Gulf States - Louisiana 1	E. Baton Rouge	406.3	Natural Gas	1951	Petroleum/Coal	2,822,624	2,950,064	-	3,029,064	2,868,297	79.3%	82.7%	-	85.1%	80.6%
5.	Carville Energy LLC	Iberville	570.0	Natural Gas	2003	Chemical	2,198,145	2,945,246	2,316,136	2,106,253	2,768,080	44.0%	58.8%	46.4%	42.2%	55.4%
6.	Dow Chemical Co - LaO Energy Sys.	Iberville	589.5	Natural Gas	1958	Chemical	2,877,650	2,167,690	2,303,991	2,082,950	2,306,519	55.7%	41.9%	44.6%	40.3%	44.7%
7.	Dow Chemical Co - St Charles	St Charles	343.2	Natural Gas	1996	Chemical	1,809,789	1,948,773	1,957,288	1,963,037	1,964,772	60.2%	64.6%	69.0%	65.3%	65.4%
8.	PPG Industries - PPG Powerhouse C	Calcasieu	357.7	Natural Gas	1977	Chemical	1,822,467	1,914,872	2,268,376	2,069,034	1,878,055	58.2%	60.9%	72.4%	66.0%	59.9%
9.	Georgia Gulf Plaquemine	Iberville	306.0	Natural Gas	1997	Chemical	1,697,616	1,802,578	1,734,020	1,670,670	1,671,869	63.3%	67.1%	64.7%	62.3%	62.4%
10.	IPC-Mansfield Mill	De Soto	135.0	Black Liquor	1981	Paper	817,989	827,370	796,966	804,913	833,448	69.2%	69.8%	67.4%	68.1%	70.5%
11.	Georgia Pacific Corp - Port Hudson	E. Baton Rouge	127.7	Black Liquor	1986	Paper	888,185	901,032	852,345	775,616	760,692	79.4%	80.3%	76.2%	69.3%	68.0%
12.	BASF Corporation - Geismar	Ascension	84.1	Natural Gas	1985	Primary Metals	580,064	553,190	654,192	662,046	642,202	78.7%	74.9%	88.8%	89.9%	87.2%
13.	Air Liquide - Geismar	Ascension	83.9	Natural Gas	2000	Chemical	571,500	629,718	638,815	294,860	623,529	77.8%	85.4%	86.9%	40.1%	84.8%
14.	Exxon Mobil Baton Rouge Refinery	E. Baton Rouge	85.3	Natural Gas	1990	Petroleum/Coal	644,869	636,697	659,353	650,297	607,084	86.3%	85.0%	88.2%	87.0%	81.2%
15.	Air Liquide - Shell	Ascension	80.0	Natural Gas	2002	Chemical	608,679	568,191	618,483	590,916	588,490	86.9%	80.9%	88.3%	84.3%	84.0%
16.	Temple-Inland - Gaylord Container	Washington	99.5	Wood/Wood Waste	1999	Paper	473,863	452,931	448,235	472,155	501,259	54.4%	51.8%	51.4%	54.2%	57.5%
17.	Stone Container Hodge	Jackson	74.4	Natural Gas	1938	Paper	507,873	450,588	465,068	435,076	471,465	77.9%	68.9%	74.4%	66.8%	72.3%
18.	Boise Packaging - DeRidder Mill	Beauregard	61.5	Black Liquor	1969	Paper	339,587	352,465	375,446	376,579	404,799	63.0%	65.2%	69.7%	69.9%	75.1%
19.	Formosa Plastics	E. Baton Rouge	105.5	Natural Gas	1990	Chemical	362,480	389,978	394,388	389,120	383,950	39.2%	42.1%	44.7%	42.1%	41.5%
20.	Noranda Alumina LLC	St James	117.3	Natural Gas	1969	Chemical	273,244	263,426	263,790	242,165	237,874	26.6%	25.6%	25.7%	23.6%	23.1%
21.	CITGO Refinery Powerhouse	Calcasieu	75.0	Other Gas	1942	Petroleum/Coal	204,347	209,675	214,610	230,662	234,925	31.1%	31.8%	32.7%	35.1%	35.8%
22.	Renew Paper - St Francisville	West Feliciana	12.5	Black Liquor	1966	Paper	-	-	114,747	98,630	91,629	-	-	104.8%	90.1%	83.7%
23.	Chevron Oronite - Oak Point	Plaquemines	23.5	Natural Gas	1999	Petroleum/Coal	90,552	86,645	92,395	90,796	88,568	44.0%	42.0%	44.9%	44.1%	43.0%
24.	IMC Phosphates Co. Uncle Sam	St James	11.0	Other	1968	Chemical	109,060	-	77,243	88,262	88,402	56.6%	-	80.2%	91.6%	91.7%
25.	ADA Carbon Solutions Red River	Red River	20.8	Waste Heat	2011	Chemical	14,452	30,415	26,321	43,747	60,025	7.9%	16.6%	14.4%	24.0%	32.9%
26.	CII Carbon LLC	St Bernard	46.0	Petroleum Coke	1951	Petroleum/Coal	64,474	55,201	33,938	38,233	52,067	16.0%	13.7%	8.4%	9.5%	12.9%
27.	Placid Refining Co LLC - Port Allen	W. Baton Rouge	7.6	Natural Gas	1990	Petroleum/Coal	50,855	50,897	48,353	43,487	51,582	76.4%	76.2%	72.6%	65.3%	77.5%
28.	Louisiana Tech University	Lincoln	7.5	Natural Gas	2004	Misc	47,030	45,934	47,207	41,383	44,848	71.6%	69.7%	71.9%	63.0%	68.3%
29.	American Sugar - Domino	St Bernard	14.0	Natural Gas	1949	Food/Bev/Tobacco	41,174	44,611	39,871	43,433	44,075	33.6%	36.3%	32.5%	35.4%	35.9%
30.	Louisiana Sugar Refining	St James	6.7	Natural Gas	1977	Food/Bev/Tobacco	22,076	13,780	15,655	16,729	17,660	34.1%	21.2%	24.2%	28.5%	30.1%
31.	PPG Industries Inc - PPG Plant C	Calcasieu	3.4	Natural Gas	1986	Chemical	16,170	18,366	7,908	11,970	8,965	54.3%	61.5%	26.6%	40.2%	30.1%
32.	Graphic Packaging - Plant 31	Ouachita	45.0	Natural Gas	1964	Paper	291,480	291,600	300,532	-	-	73.9%	73.8%	76.2%	-	-
33.	M A Patout & Sons Ltd	Iberia	3.0	Agric. Byproducts	1981	Food/Bev/Tobacco	1,020	1,250	1,400	1,100	-	3.9%	4.7%	5.3%	4.2%	-
34.	PCS Nitrogen Fertilizer LP	Iberville	10.0	Waste Heat	2006	Chemical	-	-	-	-	-	-	-	-	-	-
						Average/Total	**33,553,000**	**34,320,567**	**30,444,905**	**32,564,166**	**32,883,981**	**56.2%**	**56.6%**	**57.1%**	**55.6%**	**59.5%**

Note: The PCS Nitrogen plant’s reported status is “standby/backup,” which means it is available for service but not normally used (has little or no generation during the year) for this reporting period. The Graphic Packaging and M A Patout units are listed as operating, but did not report generation for 2014 and/or 2015. Source: Energy Information Administration, U.S. Department of Energy.

CHP utilization versus Size, age and industrial classification

Average utilization by generator capacity.

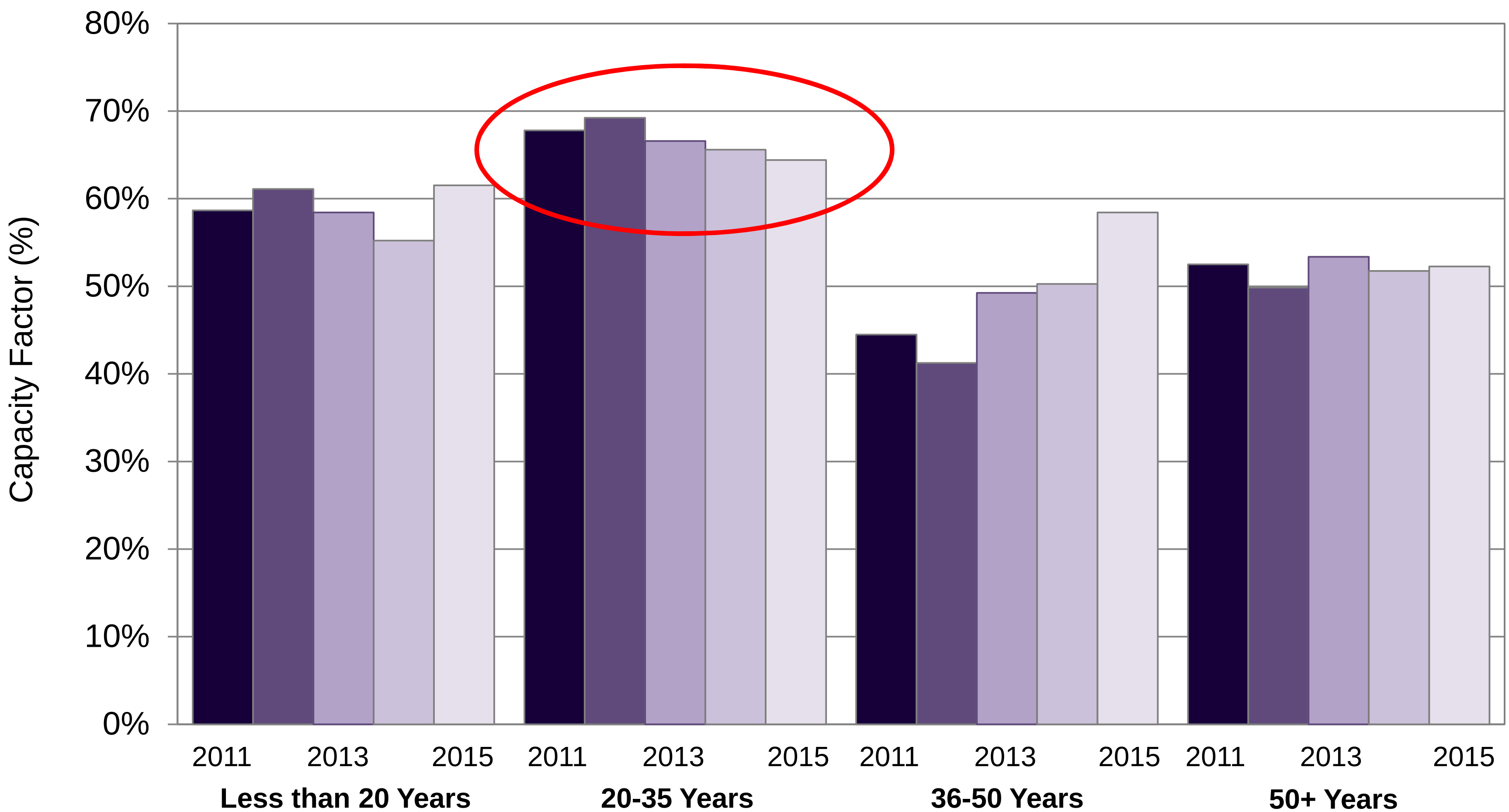
Larger facilities have higher utilization rates. But most of those larger facilities have utilization rates barely above **60 percent** of their total power generation capabilities.



Source: Energy Information Administration, U.S. Department of Energy.

Average utilization by facility age.

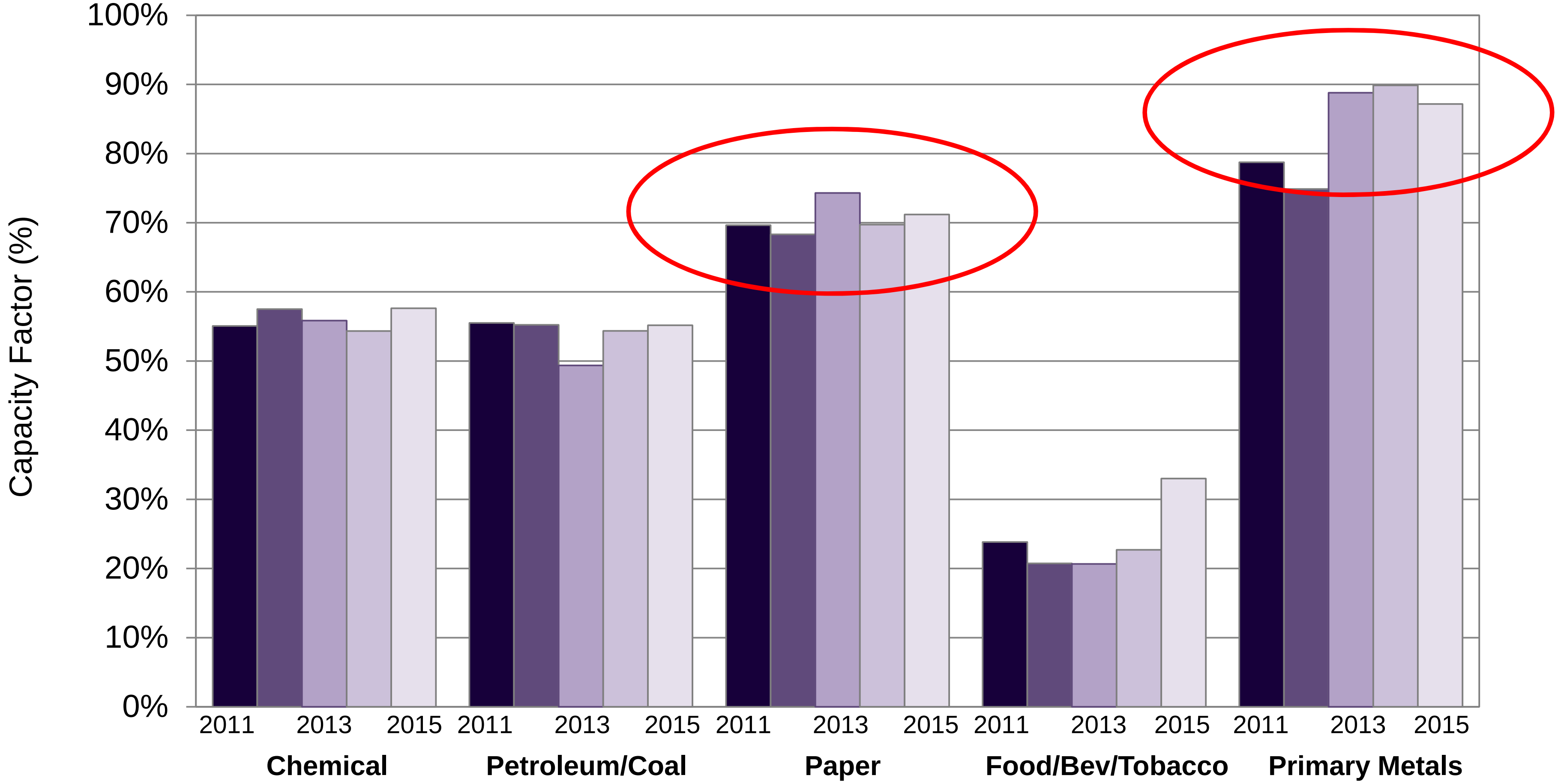
Moderately-aged CHP facilities are utilized more than relatively new CHP facilities – although those differences are **converging and are hovering around 60 percent**.



Source: Energy Information Administration, U.S. Department of Energy.

Average utilization by industrial sector

Paper and steel mills have higher utilization **raises the possibility that operating constraints may be thermal in nature**. Also possibility this is cyclical trend. Also like the source of the **higher utilizations of "moderately aged" facilities**.

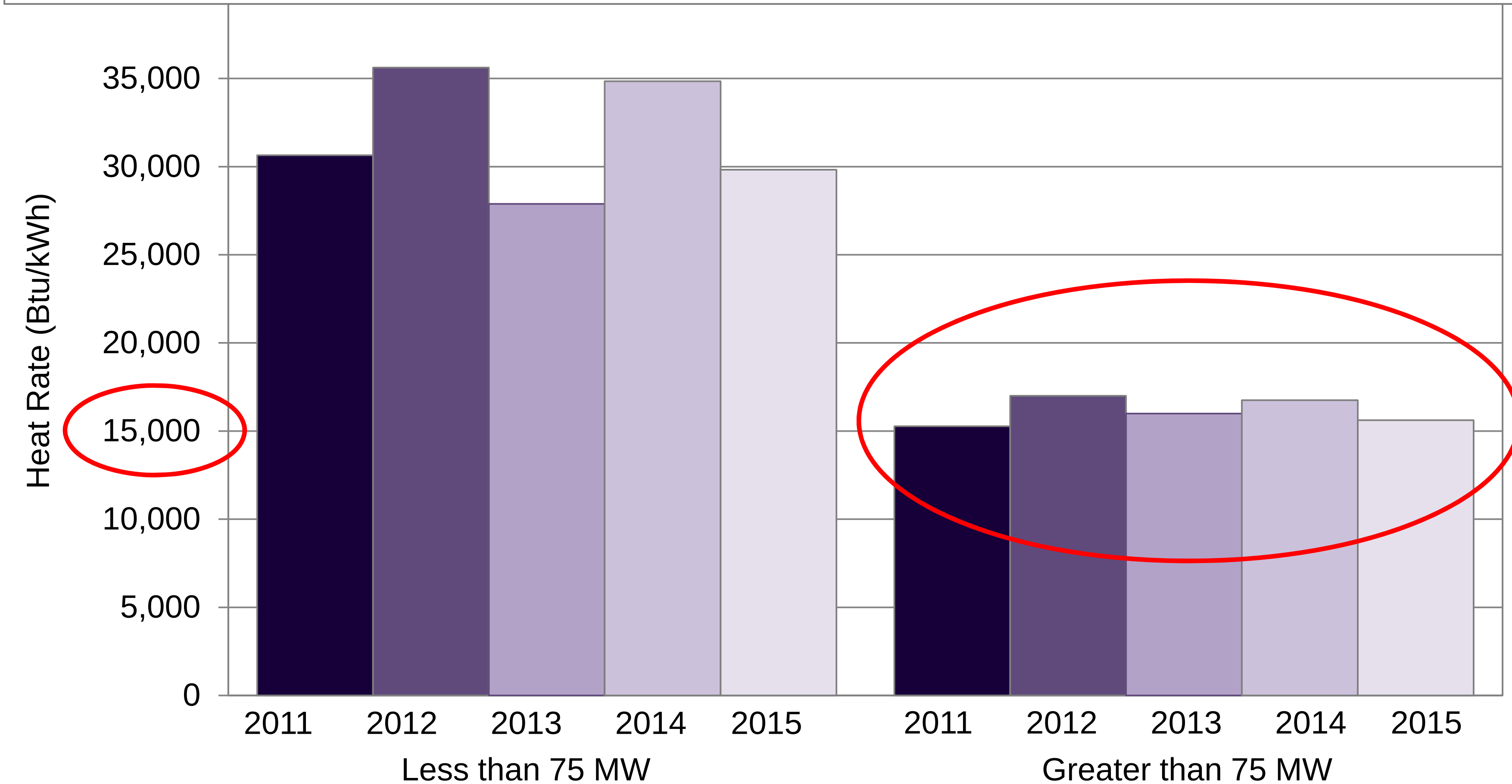


Source: Energy Information Administration, U.S. Department of Energy.

Thermal efficiency versus Size, age and industrial classification

Thermal efficiencies by generator capacity size.

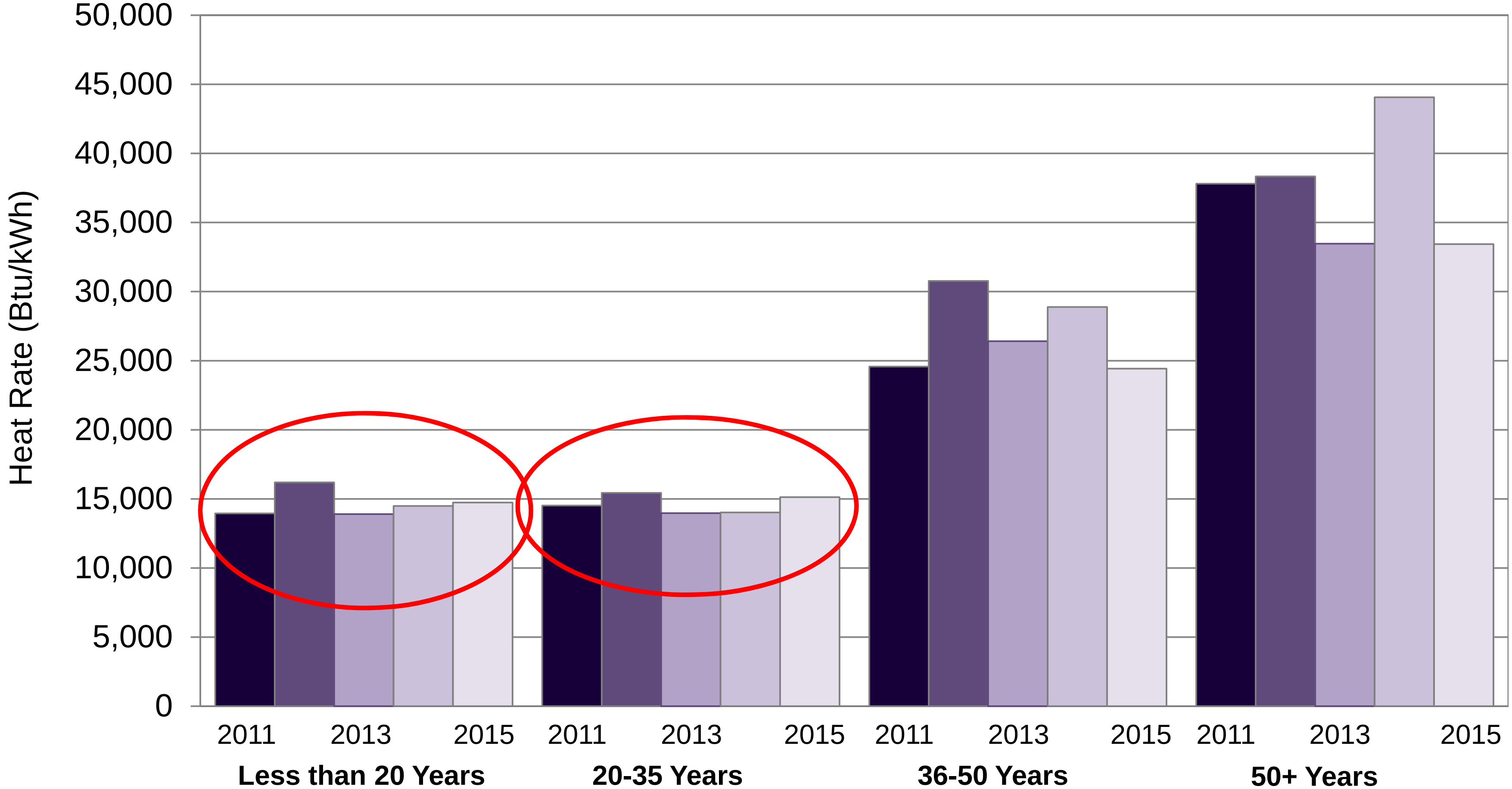
Larger facilities have considerably higher thermal efficiencies than smaller industrial CHP units, although those efficiencies are still around the 15,000 level (on average). Efficiencies are also **highly variable** for smaller facilities.



Source: Energy Information Administration, U.S. Department of Energy.

Thermal efficiencies by facility age.

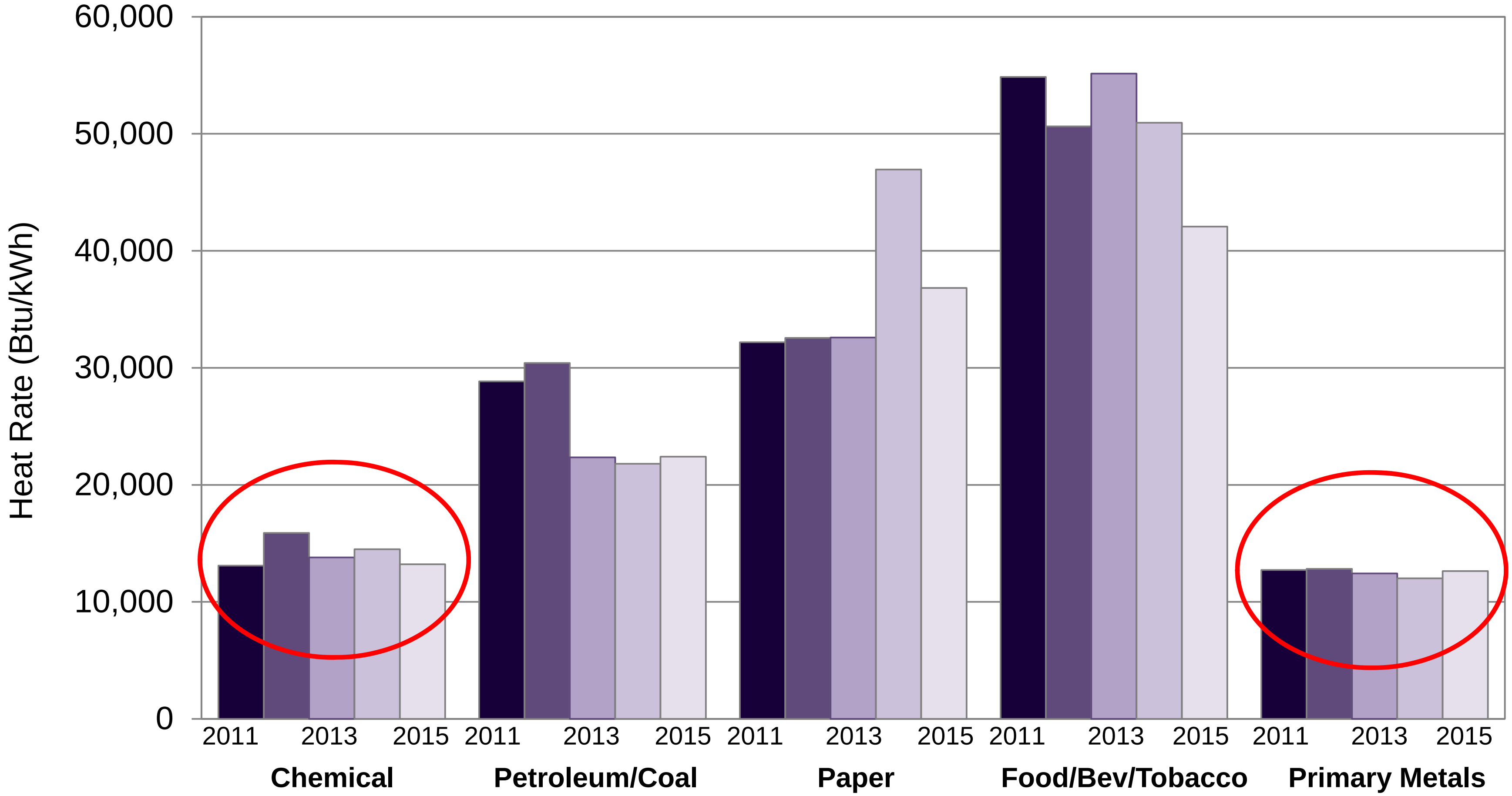
Newer facilities have better thermal efficiencies. Note that moderately new facilities report very comparable thermal efficiencies, reconciling, in part, their slightly higher utilizations.



Source: Energy Information Administration, U.S. Department of Energy.

Thermal efficiencies by industrial sector.

Thermal efficiencies are highest in chemicals and metals, followed by refining

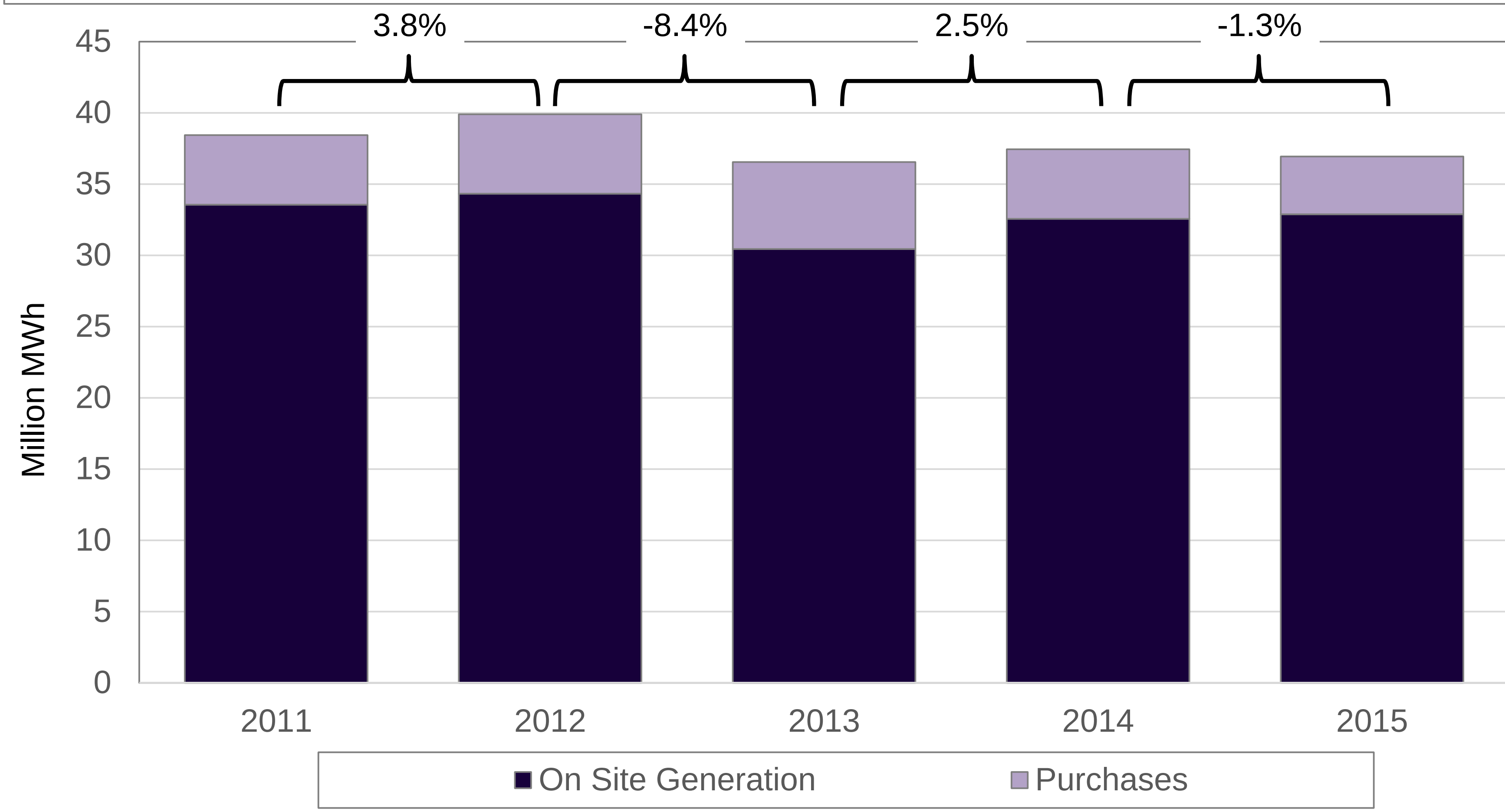


Source: Energy Information Administration, U.S. Department of Energy.

CHP generation versus on-site usage and utility “puts”

CHP facilities, generation vs. utility purchases.

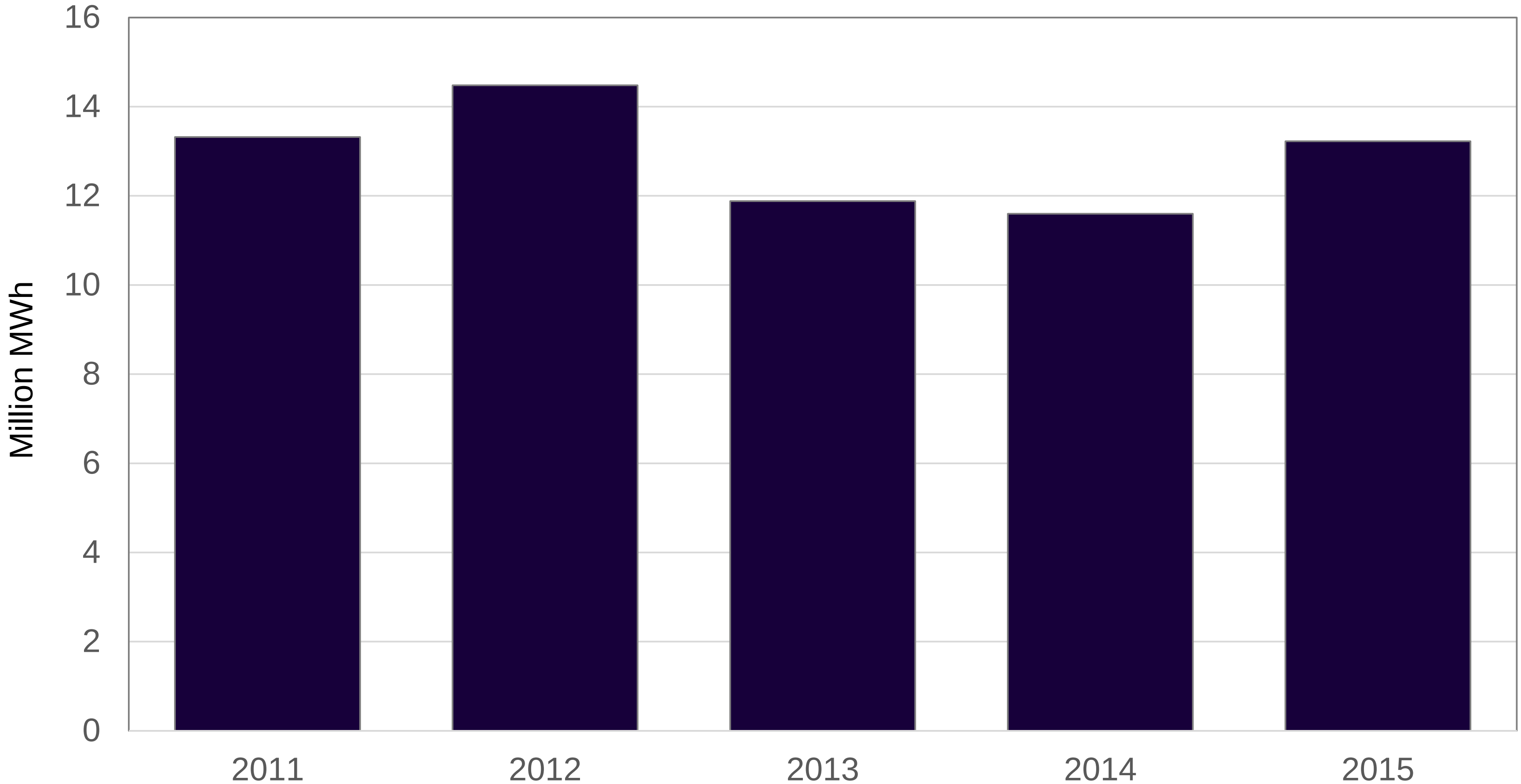
On-site generation has remained stable, while purchases increased in 2012 and 2014, but declined in 2014 and 2015.



Source: Energy Information Administration, U.S. Department of Energy.

CHP sales to utilities.

CHP reported sales to utilities have been relatively stable – slightly down in 2014-2014.

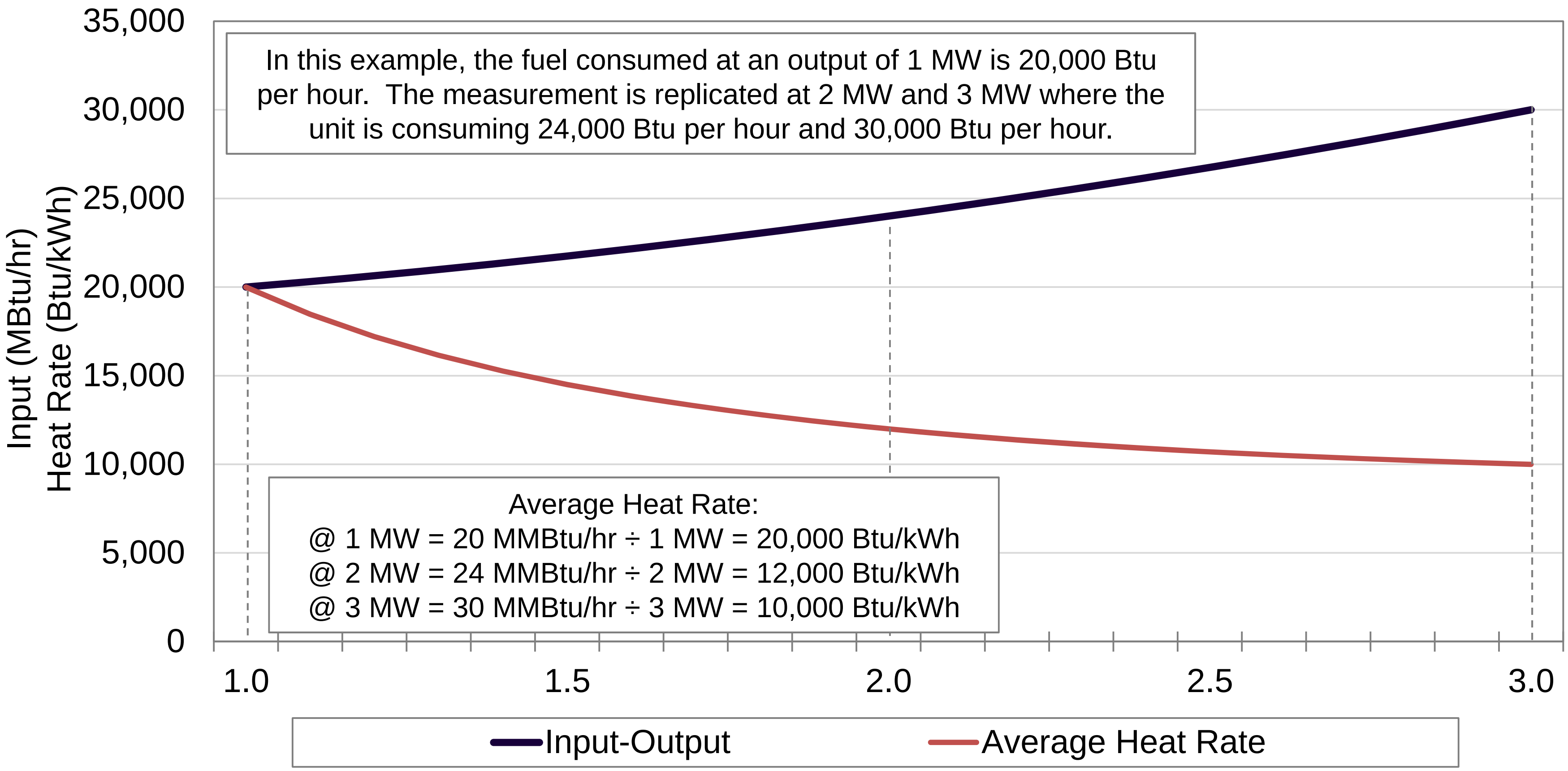


Source: Energy Information Administration, U.S. Department of Energy.

Simulating Utilization Improvements

CHP input-output and average heat rate.

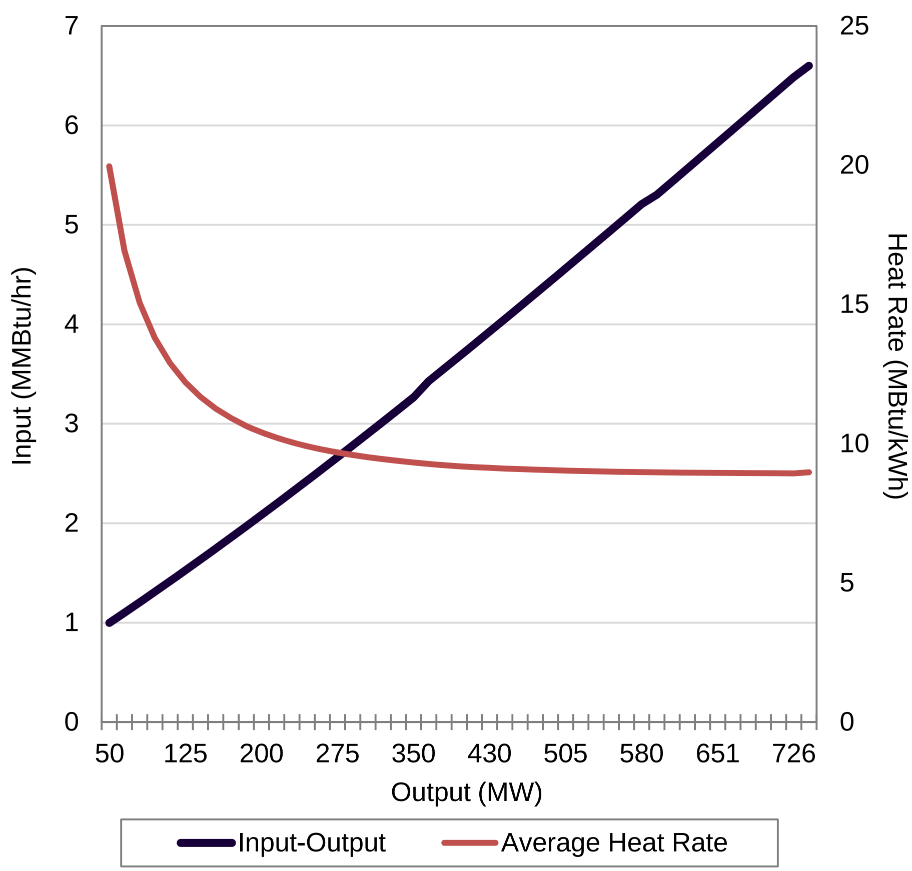
An input-output curve is constructed by measuring the fuel (input) required to maintain different levels of generation (output). An average heat rate is simply the input fuel at a certain level of generation divided by the amount of power generated.

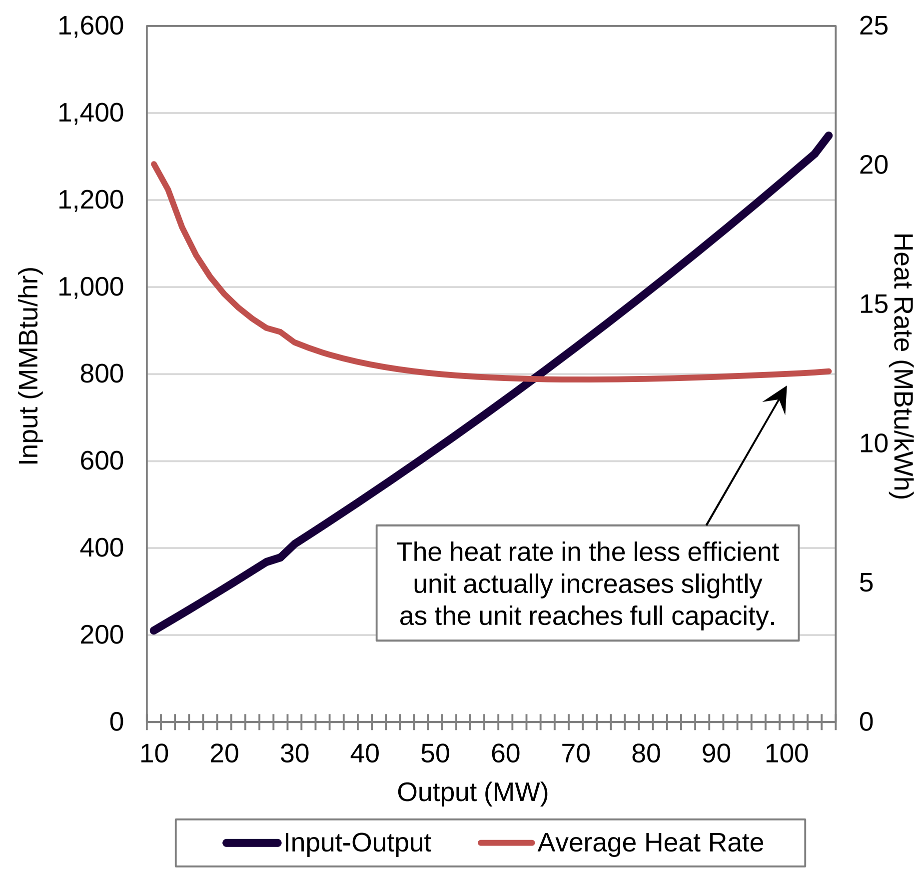


Source: Developed from analysis included in Joel B. Klein (1998). *The Use of Heat Rates in Production Cost Modeling and Market Modeling*. Sacramento, CA: California Energy Commission. Pp.124.

Application of average heat rate to CHP units.

Two actual observed input-output and average heat rate curves were applied to the CHP units in this analysis. One for a large efficient unit with a **full-capacity heat rate of 8,971 Btu/kWh** and another for a smaller less efficient unit with a **full-capacity heat rate of 12,598 Btu/kWh**.

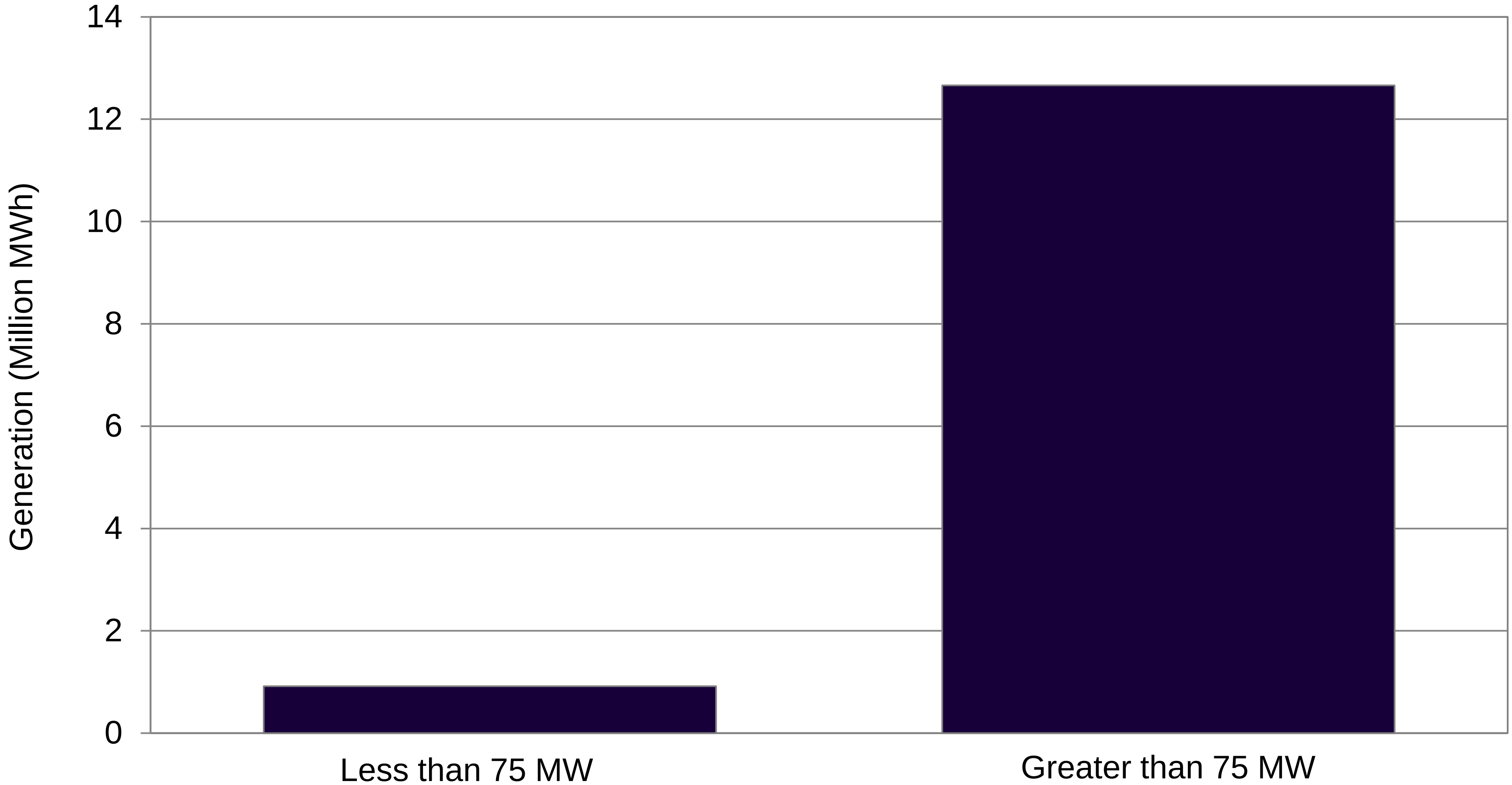




Source: Developed from analysis included in Joel B. Klein (1998). *The Use of Heat Rates in Production Cost Modeling and Market Modeling*. Sacramento, CA: California Energy Commission. Pp.124.

Increase in generation by plant capacity.

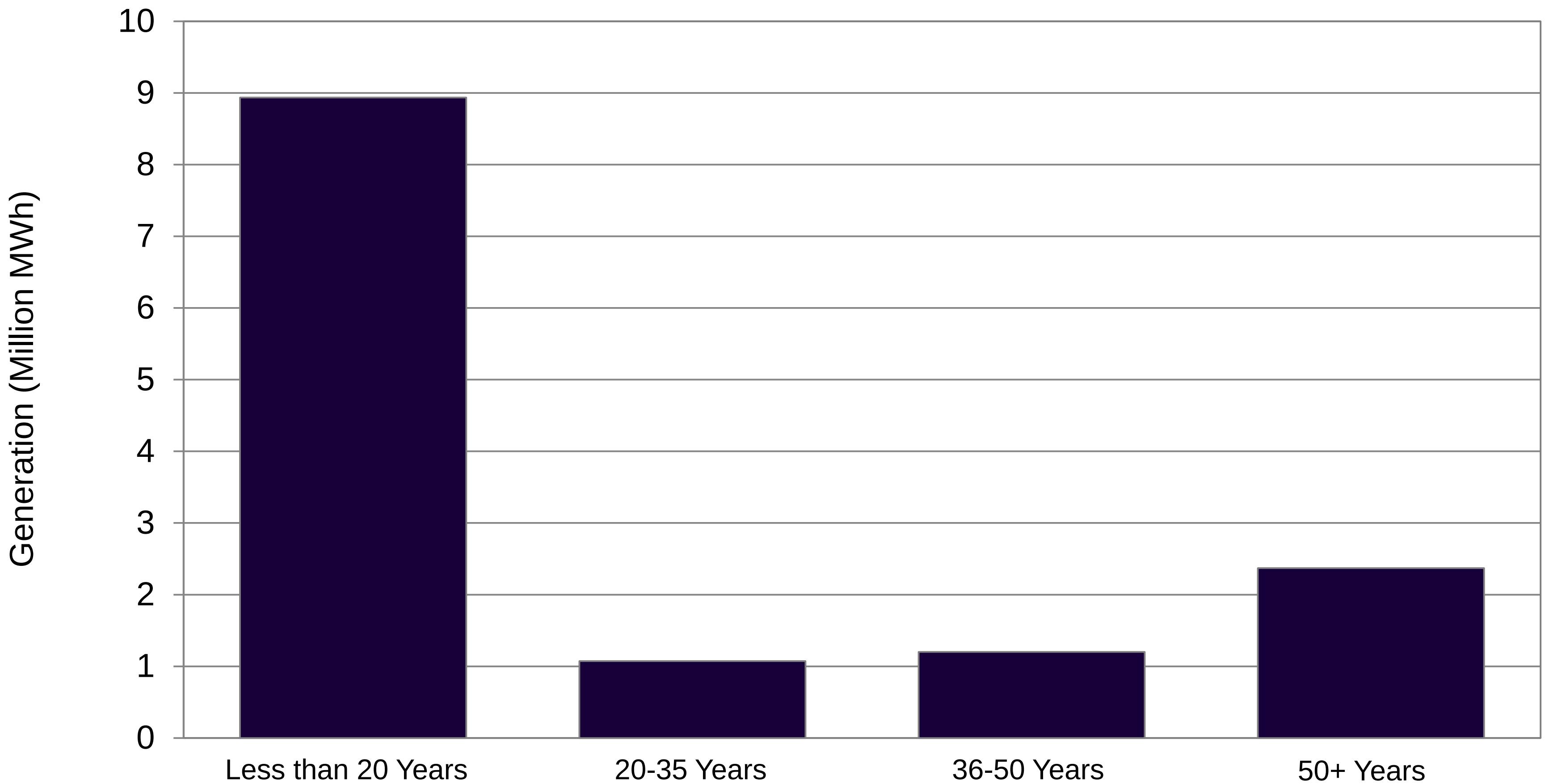
Larger facilities account for most of the increased generation.



Source: Energy Information Administration, U.S. Department of Energy.

Increase in generation by plant age.

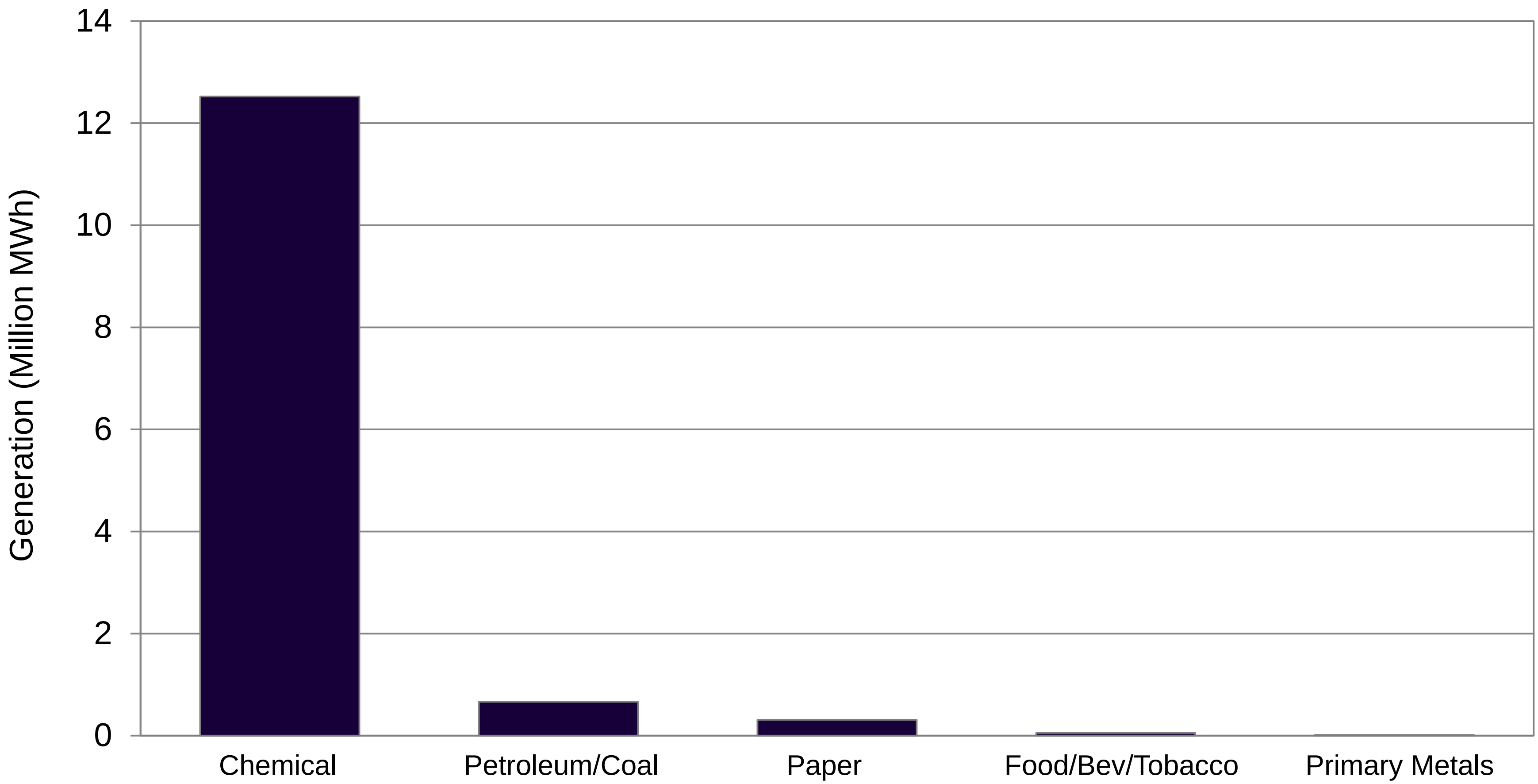
Newer facilities account for the greatest share of increased generation.



Source: Energy Information Administration, U.S. Department of Energy.

Increase in generation by NAICS.

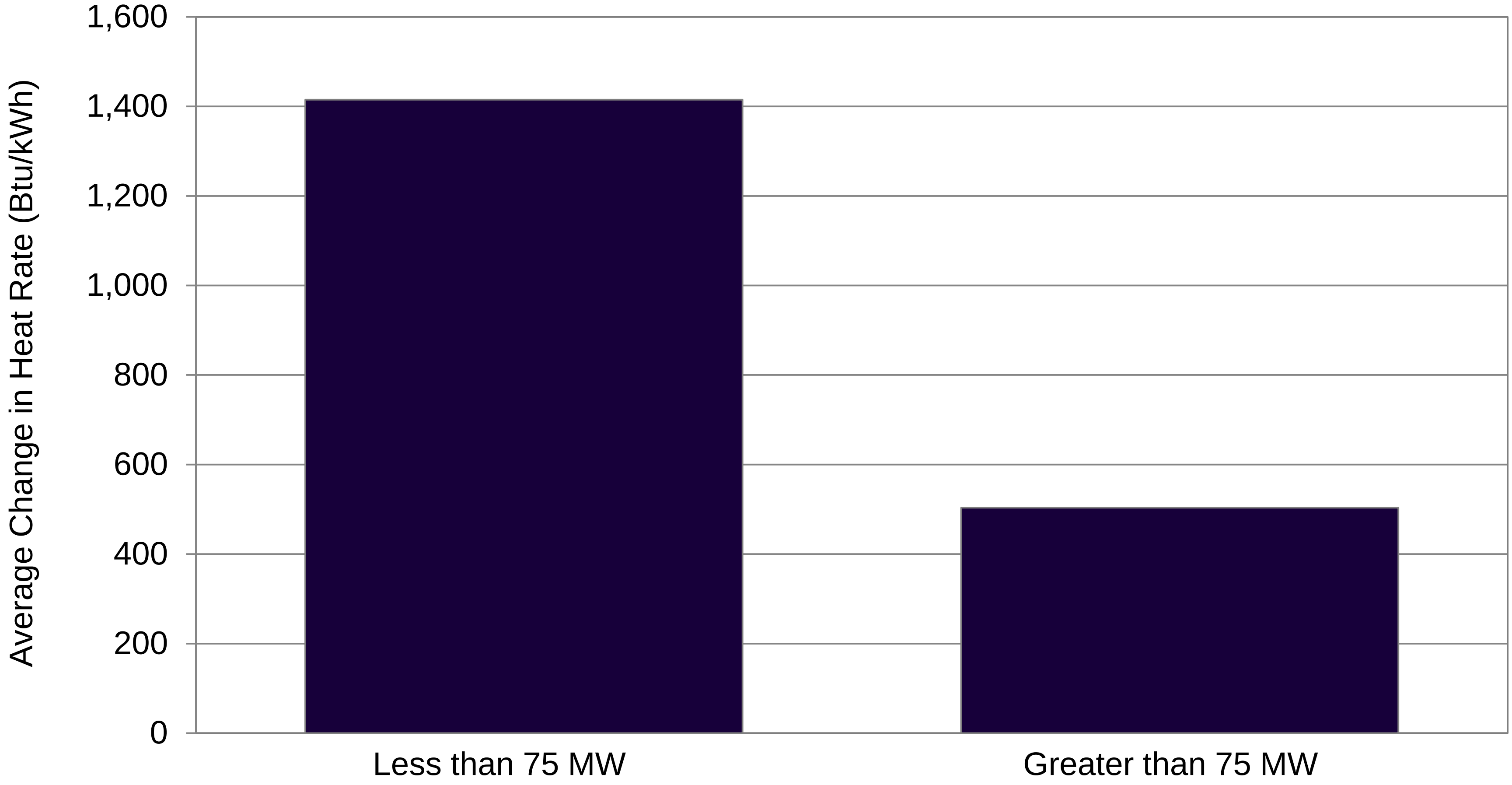
Increases in generation from increased capacity factors is seen most in the chemical industry, accounting for over 90 percent of the increase.



Source: Energy Information Administration, U.S. Department of Energy.

Change in heat rate by plant capacity.

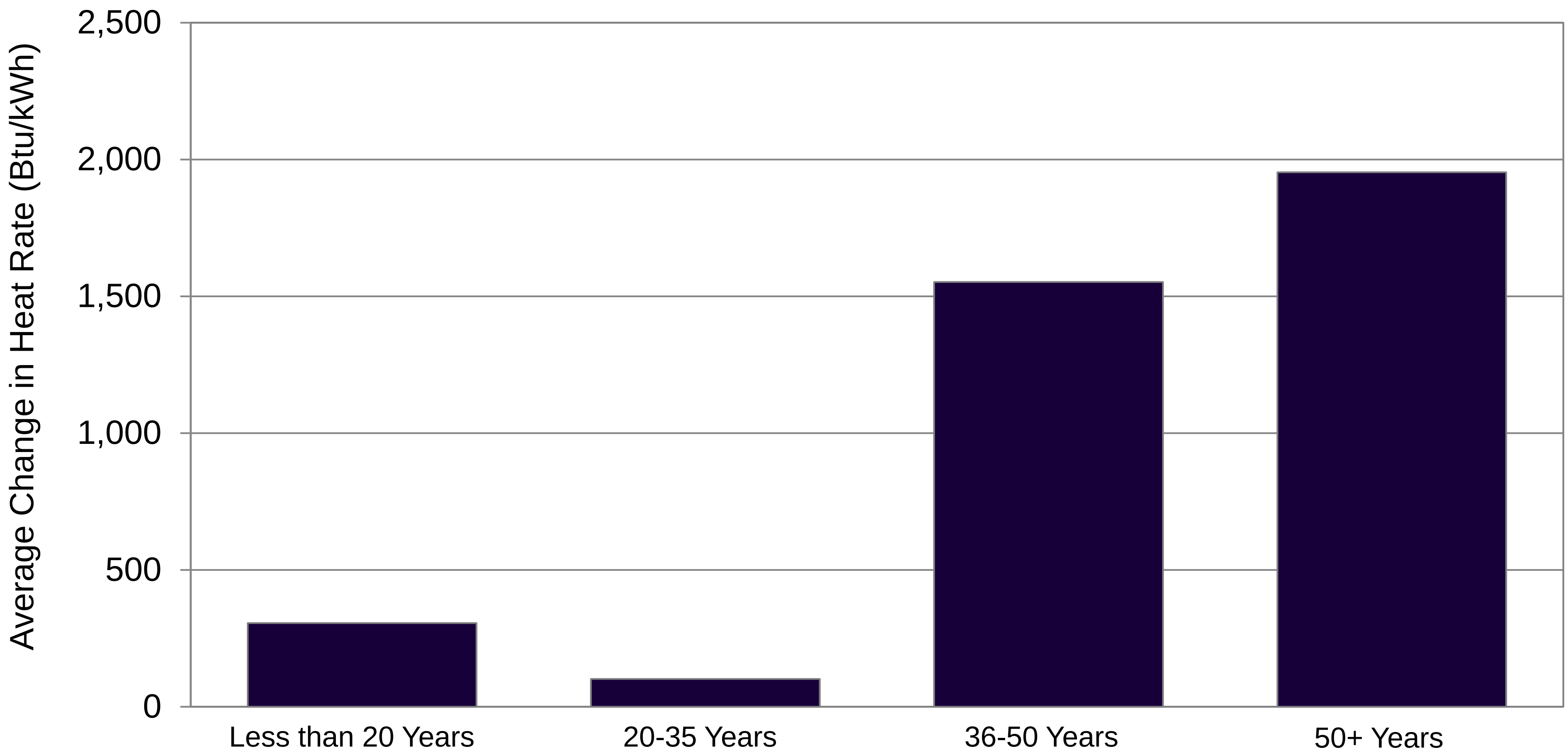
Smaller facilities would have the greater change in heat rate at over 1,400 Btu/kWh.



Source: Energy Information Administration, U.S. Department of Energy.

Change in heat rate by plant age.

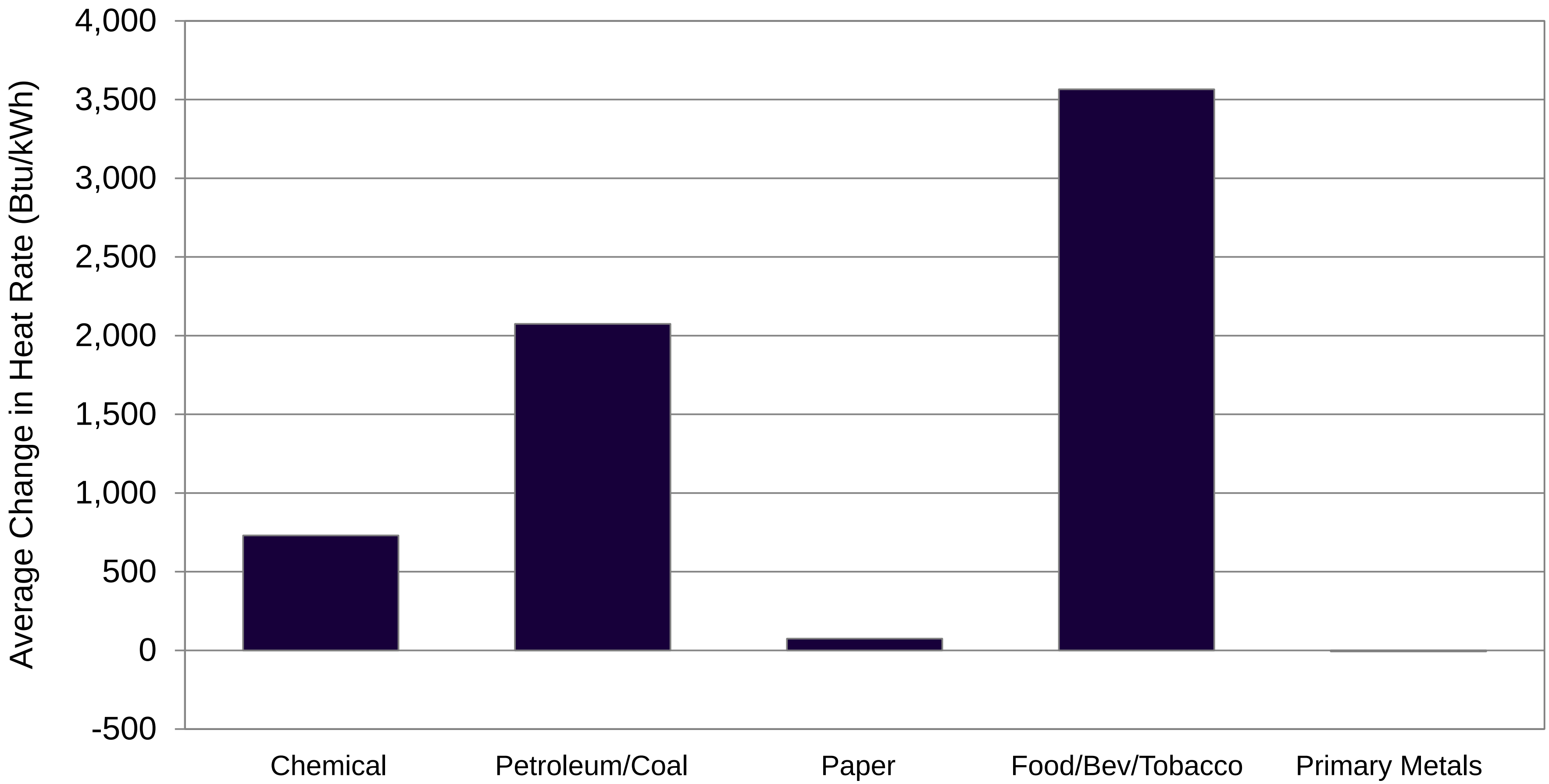
Older facilities would be most affected by the change in heat rate averaging a decrease of almost 2,000 Btu/kWh. Newer units would experience decreases of about 300 Btu/kWh.



Source: Energy Information Administration, U.S. Department of Energy.

Change in heat rate by NAICS.

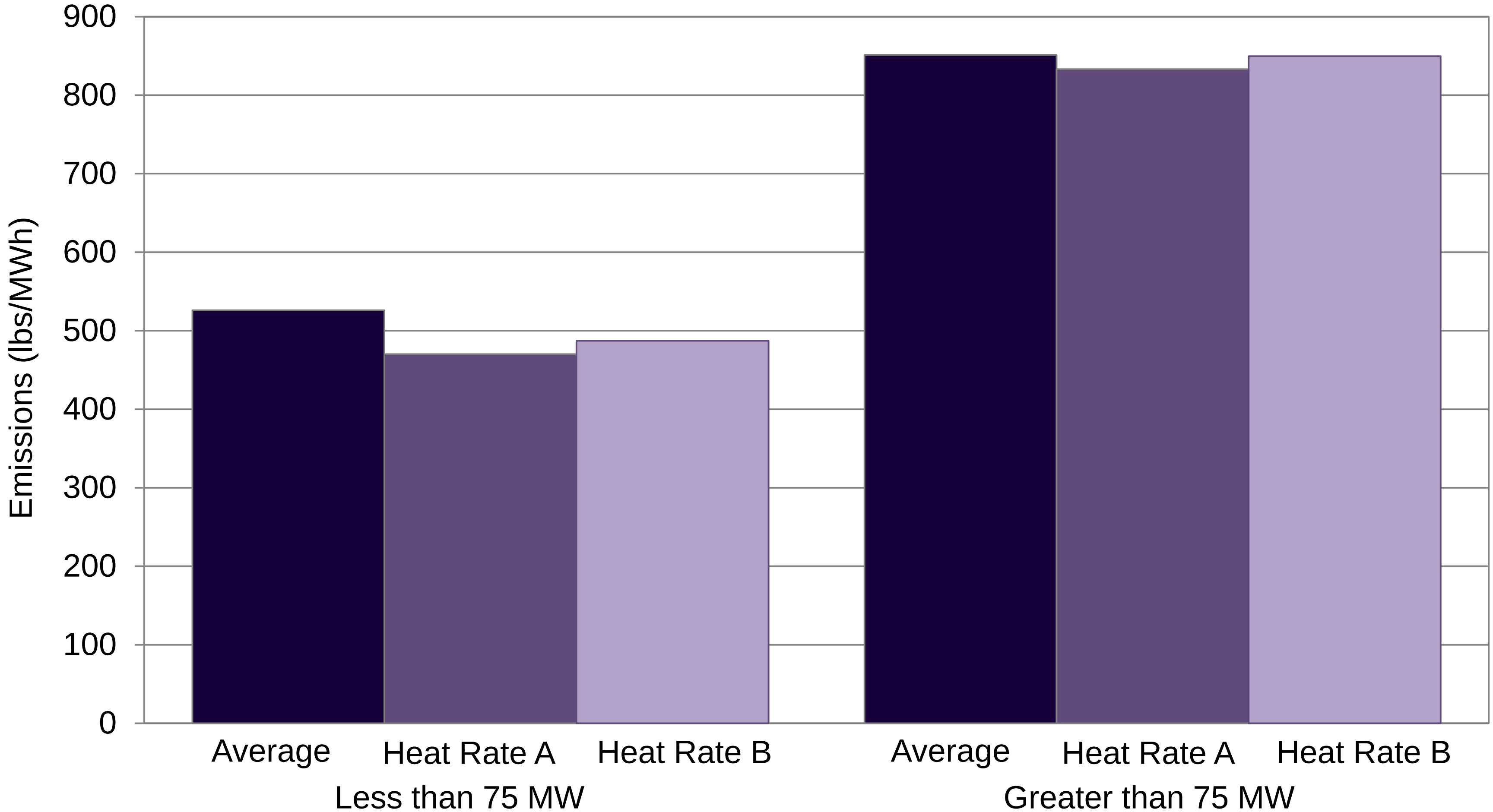
On average, facilities in the food, beverage and tobacco industry would see the largest change in heat rate, followed by the petroleum sector.



Source: Energy Information Administration, U.S. Department of Energy.

Estimated CO_2 emissions by plant capacity.

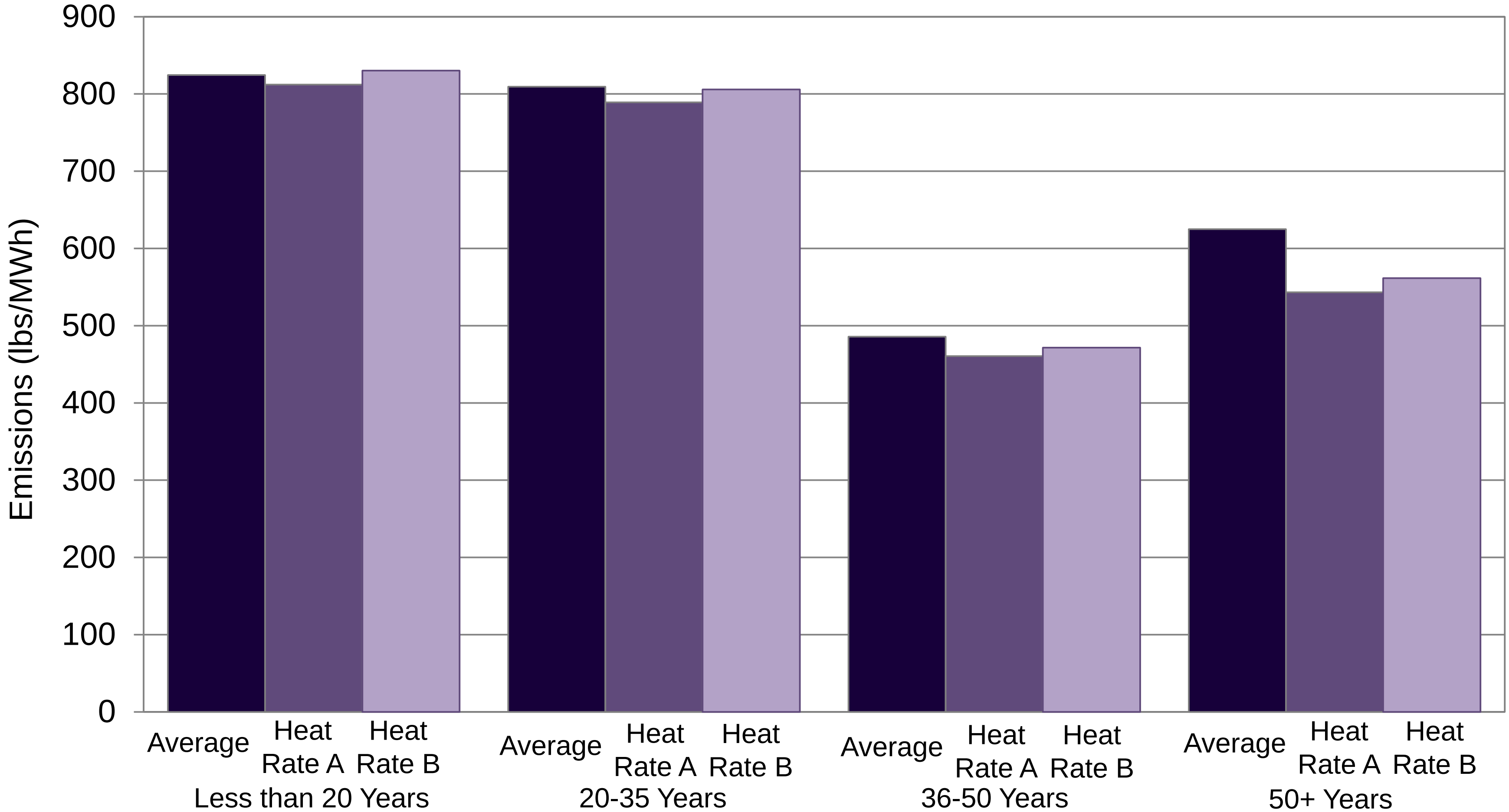
Smaller facilities would experience a greater reduction in emissions rates than larger facilities.



Note: Emissions estimates are based on reported 2012 emission rates.
Source: Energy Information Administration, U.S. Department of Energy.

Estimated CO_2 emissions by age of facility.

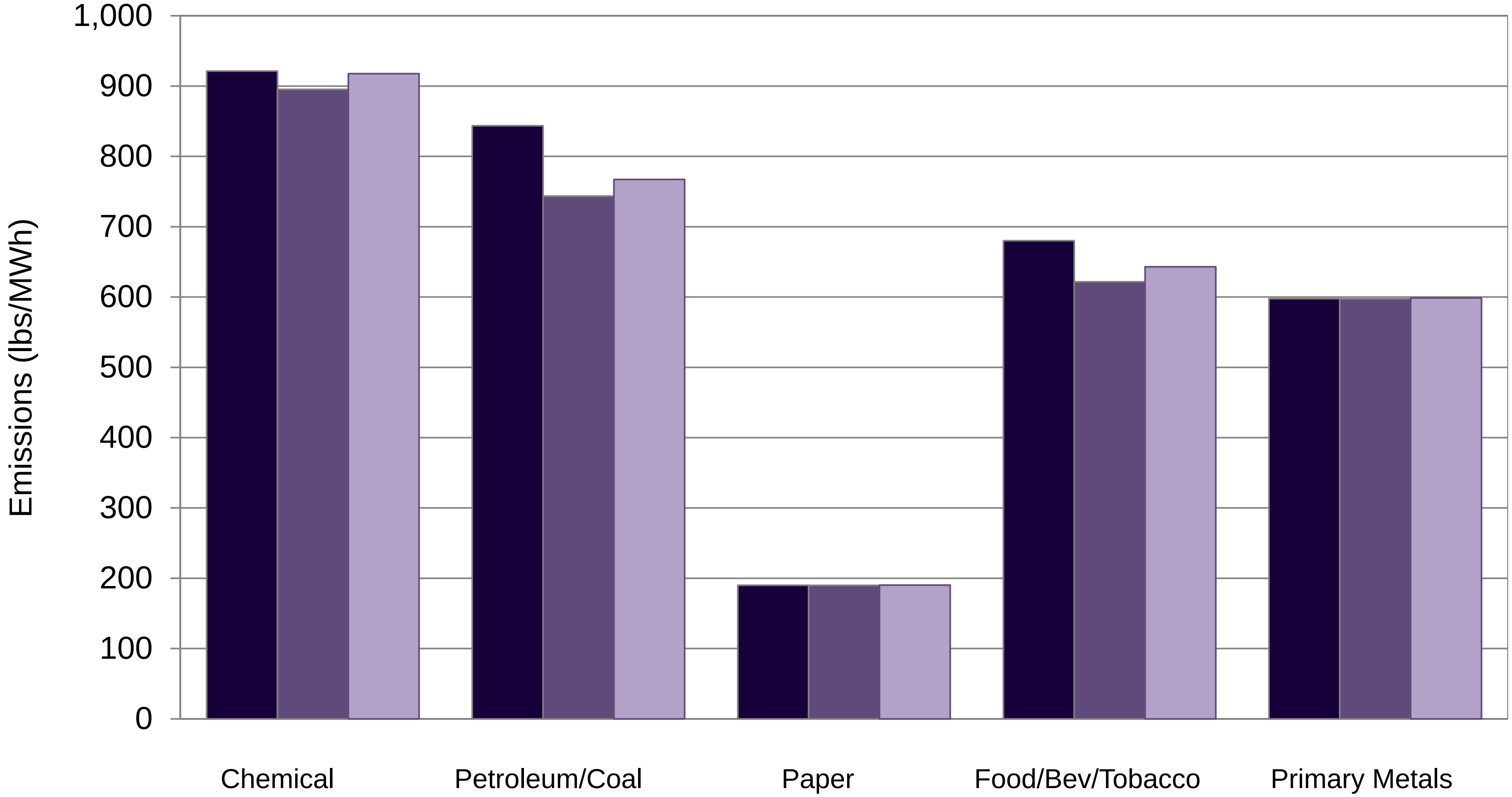
Older facilities would see the largest reduction in CO_2 emission rates.



Note: Emissions estimates are based on reported 2012 emission rates.
Source: Energy Information Administration, U.S. Department of Energy.

Estimated CO2 emissions by NAICS.

Refineries would have the most significant reduction in CO2 emission rates.



Note: Emissions estimates are based on reported 2012 emission rates.
Source: Energy Information Administration, U.S. Department of Energy.

Conclusions

Conclusions.

- CHP utilization and operating experience is important in conditioning **(de-risking) the opportunity for future industrial CHP applications**, particularly in GOM growth environment.
- Preliminary analysis of operating statistics suggests **there may be some room for improvement in CHP generation utilization** – that in turn, will have efficiency and emissions implications.
- Not entirely certain that market barriers are the culprit for the current lower operating utilization rates – **it could be the result of other operating/thermal constraints** particularly in chemicals and refining. Note, **the last year of available data is 2015, prior to full movement to MISO market and transmission governance**.
- However, **continued opening of markets**, and the development of more CHP wholesale market designs at the RTO level **should help to fill a void that is being created by regional utilities**.
- Increased CHP utilization **could contribute to clean air goals**. Challenge will be to **define what constitutes "marginal" improvements for compliance purposes**.

Questions, Comments and Discussion.

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