California Energy Commission

Estimating Fuel Displacement for California Electricity Reductions

Staff Workshop on Combined Heat and Power

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Outline

- Purpose
- Scope & Limits
- Characterizing Grid Resources
- Data Source & Assumptions
- Historic & Estimated Heat Rates
- Application & Examples
- Questions

Purpose

- Estimate fuel displacement from avoided use of grid electricity
- Be an apples-to-apples way to compare programs
  - Be policy-neutral
  - Use a common set of assumptions
  - Displace similar resources
- Starting point for discussion

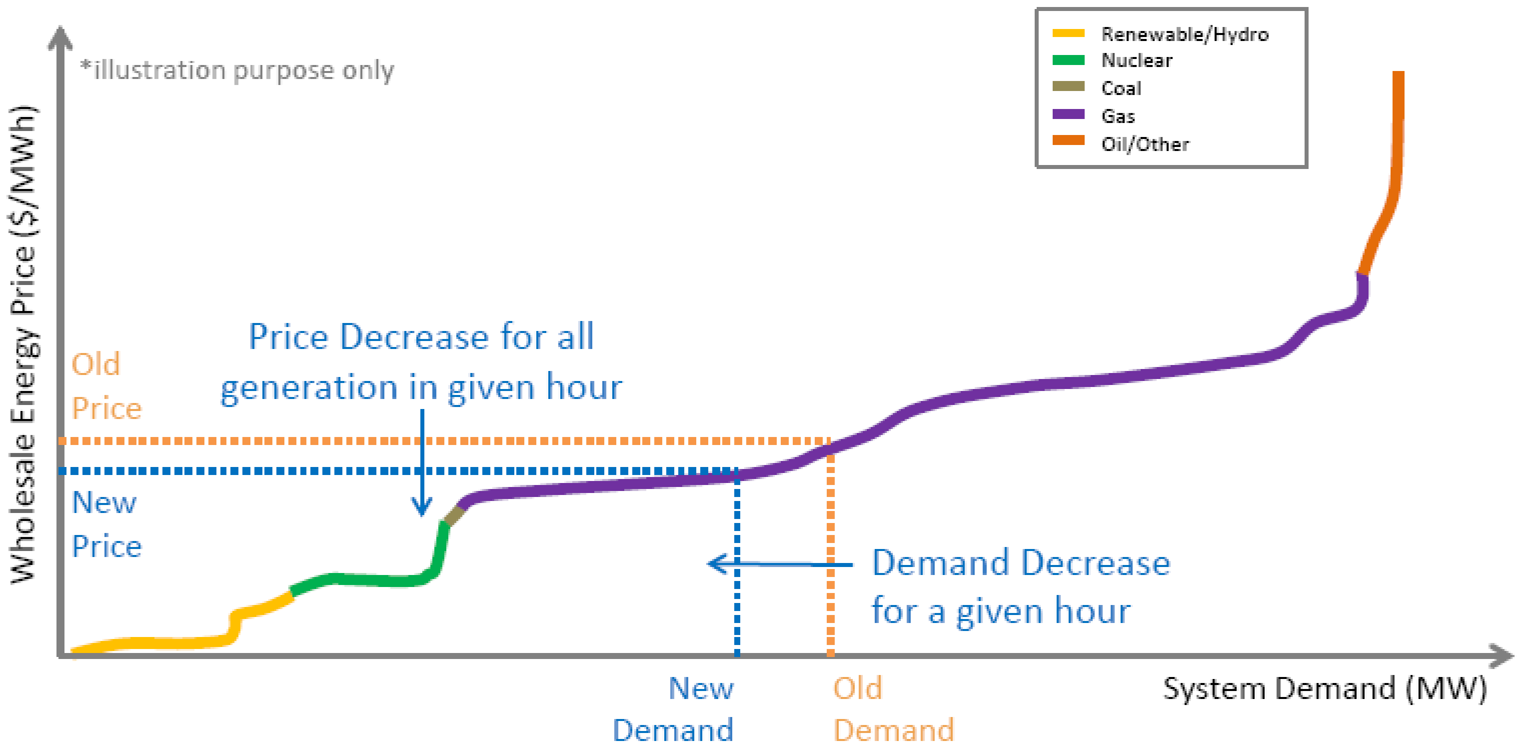
Scope of Method

- Uses grid heat rates to calculate fuel displacement
- Two resource categories
  - Peaking
  - Load Following (off-peak)
- Uses annual average (not seasonal)
- Single state-wide projection

Limits of Method

- Not a life-cycle analysis
- Not meant for short term evaluations
- Not a dispatch model
- Uses simplifying assumptions
- Only valid as long as assumptions hold

Characterizing Grid Resources

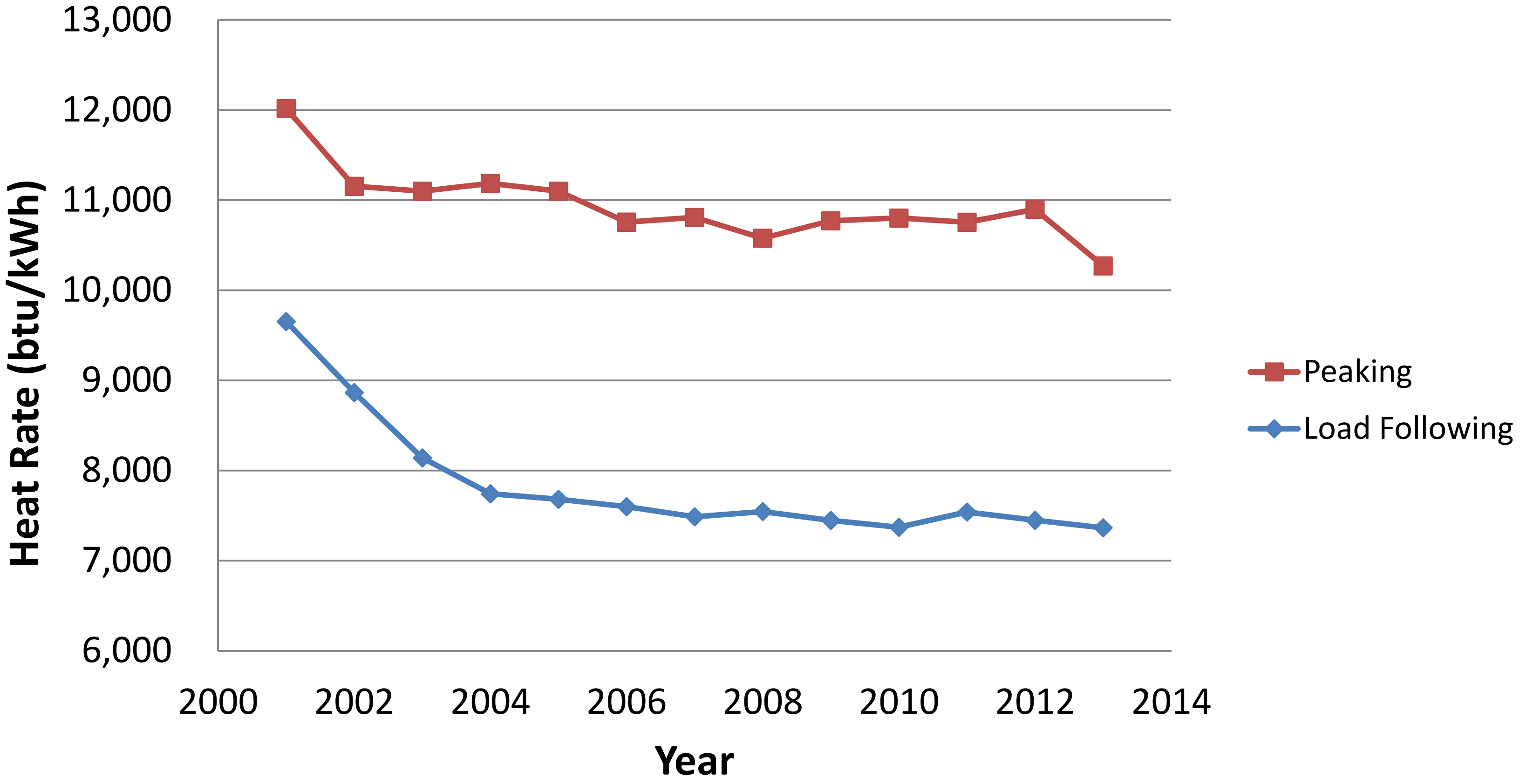


Source: EtaGen Inc., based on California ISO data as reported by Dynegy Inc.

Data Assumptions

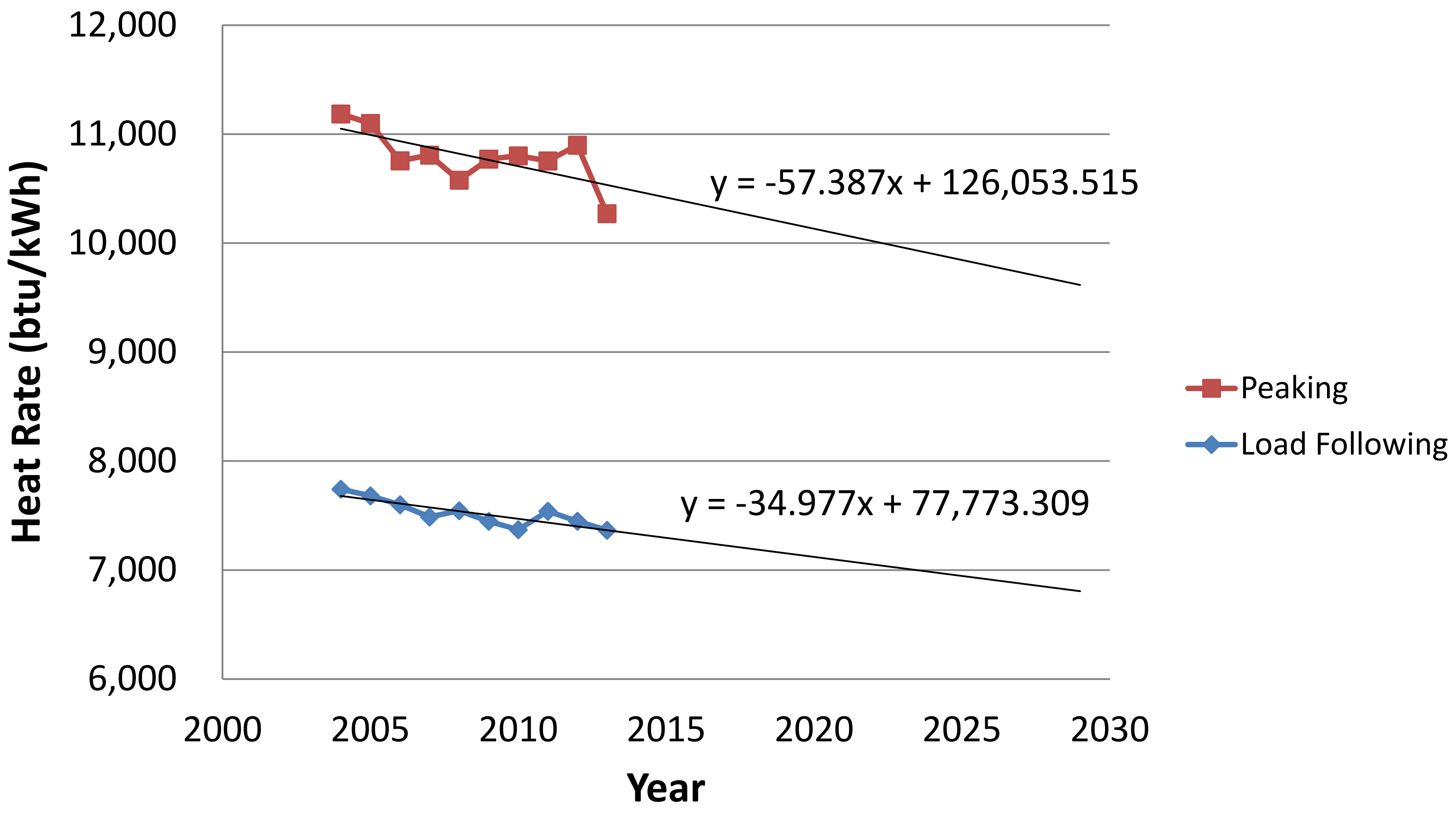
- QFER data
- Heat rates aggregated annually
- Single state-wide group
- System stability resources removed

Decreasing Heat Rate Trends



Source: Energy Commission, Electricity Analysis Office, Electricity Supply Analysis Division.

Heat Rate Projection Using Linear Regression



Source: Energy Commission, Electricity Analysis Office, Electricity Supply Analysis Division.

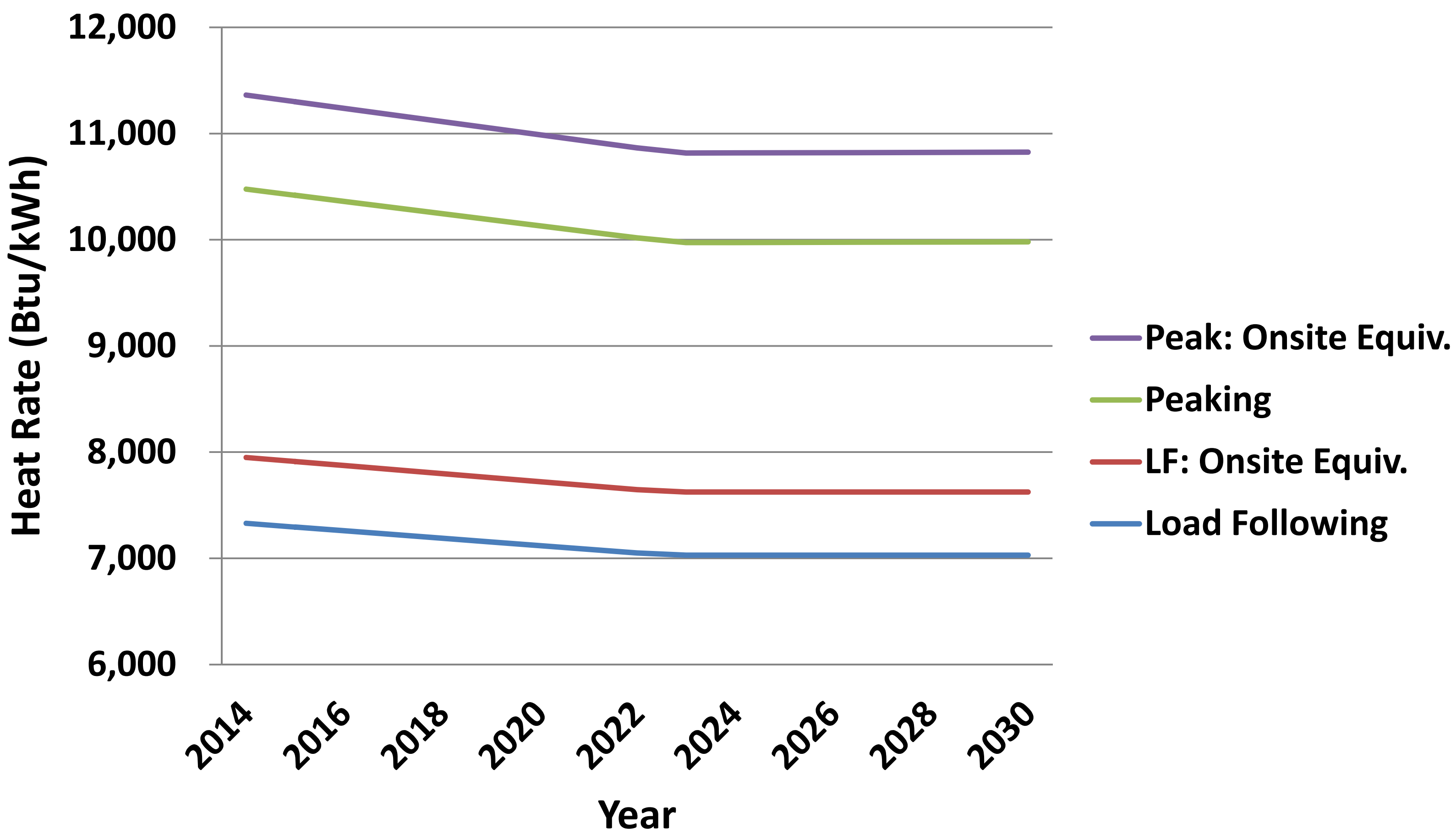
Heat Rate Floor & Loss Factor

Technology	Mid	High	Low
Conventional CT	10,585	11,890	9,980
Advanced CT	9,880	10,200	9,600
Conventional CC	7,250	7,480	7,030
Conventional CC With Duct Firing	7,250	7,480	7,030

Source: See Energy Commission, CEC-200-2014-003-SD.

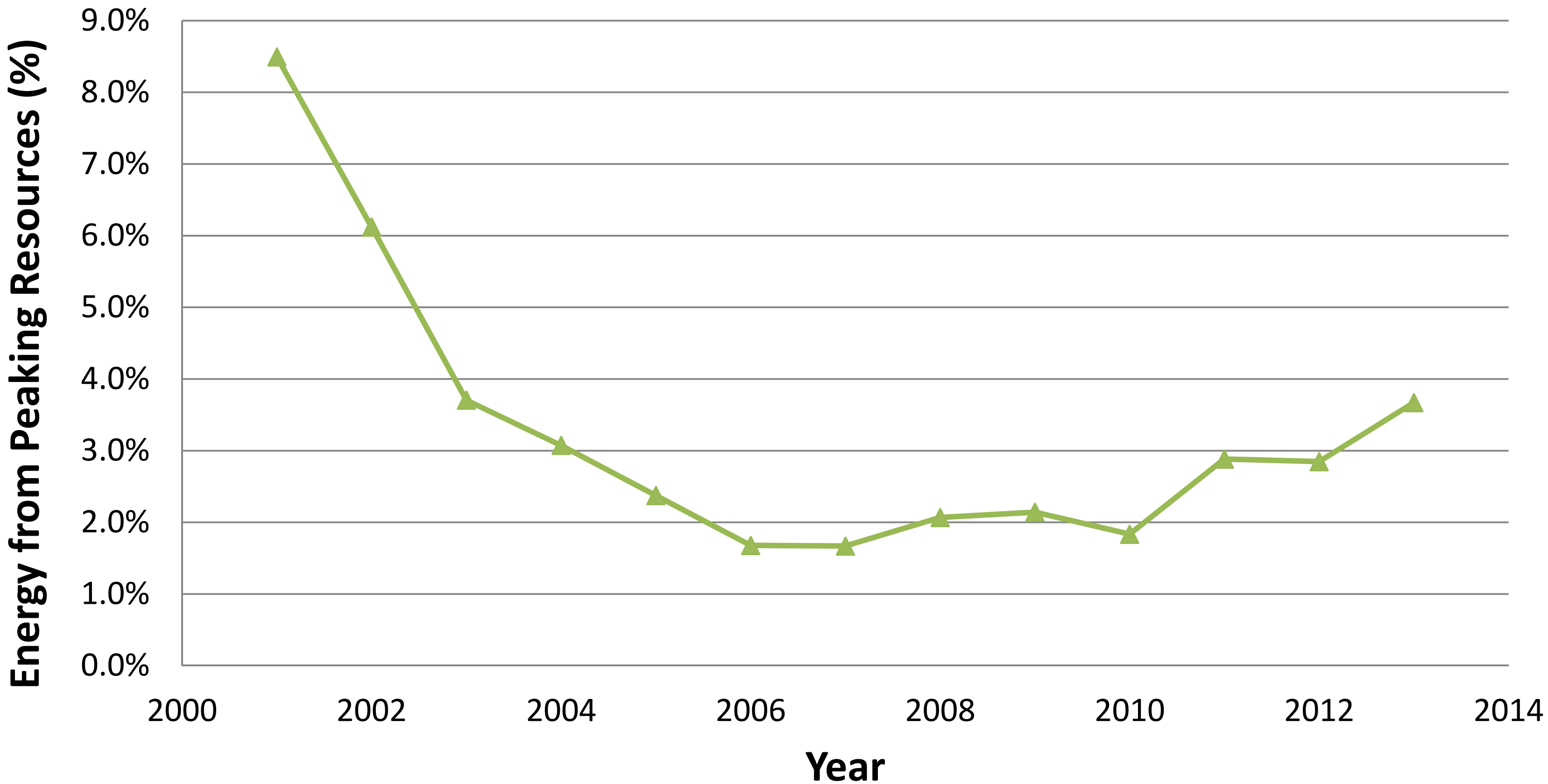
Avoided Line Loss = X / (1 – 0.078), where X is the reduced grid demand

Applicable Heat Rate Estimates



Source: Energy Commission, Electricity Analysis Office, Electricity Supply Analysis Division.

Limited Peak Energy Displacement



Source: Energy Commission, Electricity Analysis Office, Electricity Supply Analysis Division.

Using the Estimates

- General formula:

(Peak Energy) x (Applicable Peak Heat Rate)
+ (LF Energy) x (Applicable LF Heat Rate)
= Displaced Electric Grid Fuel Equivalent

- Peaking resources limited to 2.5% energy annually
- CO_2 conversion factor of 117 lbs/MMBtu
  - Same as 0.05305 MT

CHP Example

Assumptions:

- 5 MW facility
- 80% capacity factor
- Down time during off-peak hours
- 43,800 MWh potential energy
  - 1,095 MWh on-peak (2.5% x annual potential)
  - 33,945 MWh off-peak (77.5% x annual potential)

Combined Heat and Power (50/50)

Displaced fuel estimate for 2014:

(547.5 MWh x 11,362 Btu/kWh)

+ (16,972.5 MWh x 7,950 Btu/kWh) +

(547.5 MWh x 10,476 Btu/kWh)

+ (16,972.5 MWh x 7,330 Btu/kWh)

= 271.3 billion Btus

Applying the CO_2 conversion factor yields:

BTUs x 117 lbsCO_2 / million Btus = 31.7 million lbsCO_2

CHP Displaced Carbon Intensities

Reduction Type	Total Avoided Grid Energy (MWh)	CO_2 Conversion (million $lbsCO_2$)	Displaced Carbon Intensity ($lbsCO_2$/MWh)
All Onsite	35,040	33.0	942
All Export	35,040	30.4	868
50/50 mix	35,040	31.7	905
50/50 mix, sans peaking energy	35,040	31.3	893

Conclusion

- Provides a common approach
- Program life-time estimates
- Standard for comparing relative value
  - Not a substitute for physical measurements
- Variation in displaced carbon intensities
  - Peak power and line losses
- Heat rates can be updated

Appendix

Historic Average Heat Rates

Year	Load Following Plants	Peaker Plants	Percentage of Load Balancing Energy from Peaking Resources
2001	9,653	12,017	8.5%
2002	8,865	11,154	6.1%
2003	8,140	11,100	3.7%
2004	7,742	11,186	3.1%
2005	7,681	11,099	2.4%
2006	7,599	10,756	1.7%
2007	7,487	10,808	1.7%
2008	7,545	10,578	2.1%
2009	7,447	10,771	2.1%
2010	7,371	10,802	1.8%
2011	7,540	10,755	2.9%
2012	7,448	10,899	2.8%
2013	7,365	10,271	3.7%

Source: Energy Commission, Electricity Analysis Office, Electricity Supply Analysis Division.

Applicable Heat Rate Estimates

Year	Load Following	LF: Onsite Equivalent	Peaking	Peaking: Onsite Equivalent
2014	7,330	7,950	10,476	11,362
2015	7,295	7,912	10,419	11,300
2016	7,260	7,874	10,361	11,238
2017	7,225	7,836	10,304	11,176
2018	7,190	7,798	10,247	11,113
2019	7,155	7,760	10,189	11,051
2020	7,120	7,722	10,132	10,989
2021	7,085	7,684	10,074	10,927
2022	7,050	7,646	10,017	10,864
2023 to 2030	7,030	7,625	9,980	10,824

Source: Energy Commission, Electricity Analysis Office, Electricity Supply Analysis Division.

Combined Heat and Power (onsite)

Displaced fuel estimate for 2014:

(1,095 MWh x 11,362 Btu/kWh)

+ (33,945 MWh x 7,950 BTU/kWh)

= 282.3 billion Btus

Applying the CO_2 conversion factor yields:

Btus x 117 lbsCO_2 / million Btus = 33.0 million lbsCO_2

Combined Heat and Power (export)

Displaced fuel estimate for 2014:

(1,095 MWh x 10,476 Btu/kWh)

+ (33,945 MWh x 7,330 Btu/kWh)

= 260.3 billion Btus

Applying the CO_2 conversion factor yields:

Btus x 117 lbsCO_2 / million Btus = 30.4 million lbsCO_2

Combined Heat and Power (50/50, sans peaking energy)

Displaced fuel estimate for 2014:

(17,520 MWh x 7,950 Btu/kWh)

+ (17,520 MWh x 7,330 Btu/kWh)

= 267.7 billion Btus

Applying the CO_2 conversion factor yields:

BTUs x 117 lbsCO_2 / million Btus = 31.3 million lbsCO_2