

Supporting Information for  
Estimating End-Use Emissions Factors For Policy Analysis:  
The Case of Space Cooling and Heating

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***Details on data management.*** Any observation from the disaggregated data in which the amount of CO<sub>2</sub> or NO<sub>x</sub> reported is zero is dropped, as well as observations for which the amount of SO<sub>2</sub> reported is zero and the plant's primary fuel types is not natural gas. These observations are primarily from observations in which the generation amount is very small. In observation where the generation amount is not very small, these observations are likely data errors.

In calculating mean CDDs and HDDs for each NERC region, each state observation is weighted by the number of people in the state that are served by the corresponding NERC region. These population numbers are estimated by combining utility data from the Energy Information Administration's Form 861, which includes information on both the NERC region and county in which a utility operates, with annual county-level population estimates from the US Census.

In aggregating the disaggregated data to NERC-level, 17 out of 1368 plants could not be found in either the eGrid or CEMS databases that link plants to NERC regions. These plants were assigned to the NERC region primarily served by generators within their state. Additionally, because some generators in the CEMS data are not observed in the eGrid data, some generators cannot be linked to their primary fuel category. However, generation from the plants that cannot be linked comprise less than 1% of total generation recorded in the CEMS data. Moreover, plants that do not merge are still used in the analysis, they are just not reflected in the descriptive statistics presented on seasonal fuel source patterns.

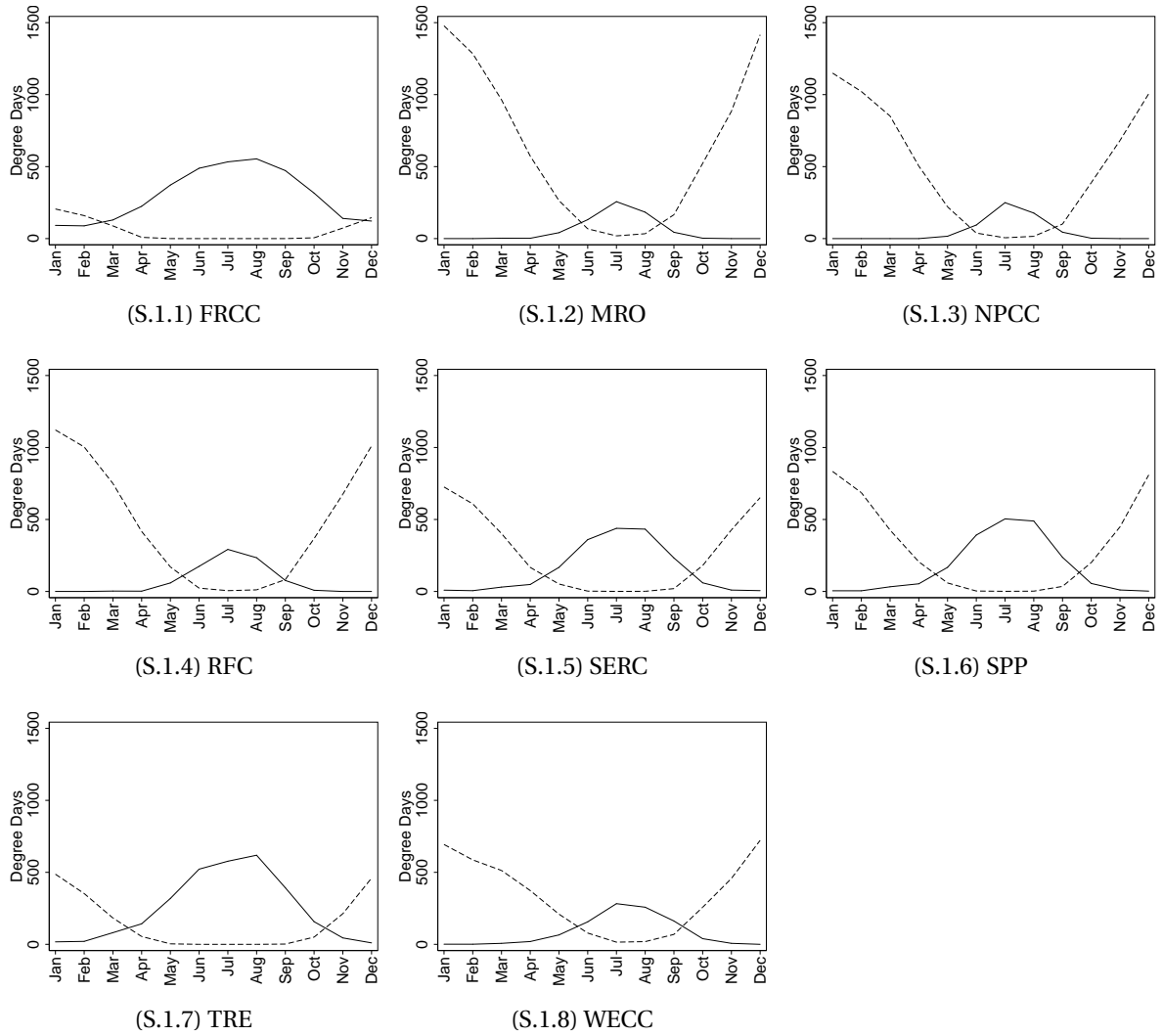


Figure S.1: Average CDDs and HDDs by Month for each NERC Region. The solid lines represents CDDs and the dashed line represents HDDs.

Table S.1: Robustness Check: Estimates of CO<sub>2</sub> Emissions Factors (lbs. per kWh) Based on Weekly Aggregation

	FRCC	MRO	NPCC	RFC	SERC	SPP	TRE	WECC
<i>Instrumental Variable Results</i>								
Space Cooling Emissions Factor	1.64 (0.05)	1.84 (0.04)	1.50 (0.02)	1.88 (0.04)	1.75 (0.04)	1.54 (0.05)	1.46 (0.06)	1.27 (0.05)
R-Squared	0.971	0.973	0.973	0.988	0.983	0.965	0.949	0.968
Space Heating Emissions Factor	1.80 (0.09)	2.10 (0.08)	1.77 (0.09)	1.92 (0.04)	1.75 (0.04)	1.62 (0.08)	1.35 (0.05)	1.37 (0.06)
R-Squared	0.957	0.979	0.956	0.988	0.983	0.966	0.953	0.971
$p$ -value ( $\beta_{COOL} = \beta_{HEAT}$ )	0.022	0.001	0.001	0.372	0.912	0.330	0.102	0.178
First Stage								
CDD / 10	0.07 (0.01)	0.06 (0.01)	0.10 (0.02)	0.30 (0.04)	0.37 (0.05)	0.06 (0.01)	0.10 (0.01)	0.16 (0.04)
HDD / 10	0.05 (0.02)	0.01 (0.00)	0.02 (0.00)	0.07 (0.01)	0.17 (0.02)	0.02 (0.00)	0.06 (0.01)	0.06 (0.01)
F-Stat	4.49	5.90	5.93	5.81	6.94	6.31	9.14	5.03
<i>Ordinary Least Squares</i>								
Overall Emissions Factor	1.58 (0.02)	2.03 (0.03)	1.51 (0.02)	1.90 (0.02)	1.69 (0.02)	1.62 (0.03)	1.34 (0.02)	1.37 (0.02)
R-Squared	0.971	0.978	0.971	0.988	0.984	0.966	0.952	0.971

*Notes:* The space cooling emissions factor is estimated by two-stage least squares (2SLS) using CDD as an instrument for generation. The space heating emissions factor is estimated by two-stage least squares (2SLS) using HDD as an instrument for generation. The overall emissions factor is estimated using ordinary least squares. Models are estimated separately for each NERC region. The unit of observation is a NERC region and a week. Each regression is based on 415 observations. Newey-West standard errors based on a two-month lag are reported in parentheses.

Table S.2: Robustness Check: Estimates of CO<sub>2</sub> Emissions Factors (lbs. per kWh) Based on Bi-Weekly Aggregation

	FRCC	MRO	NPCC	RFC	SERC	SPP	TRE	WECC
<i>Instrumental Variable Results</i>								
Space Cooling Emissions Factor	1.80 (0.05)	2.09 (0.06)	1.75 (0.03)	2.18 (0.04)	2.01 (0.05)	1.79 (0.06)	1.53 (0.05)	1.47 (0.04)
R-Squared	0.968	0.982	0.977	0.990	0.986	0.974	0.960	0.976
Space Heating Emissions Factor	1.91 (0.06)	2.46 (0.07)	1.95 (0.11)	2.28 (0.05)	2.00 (0.05)	1.73 (0.09)	1.58 (0.05)	1.53 (0.06)
R-Squared	0.966	0.988	0.973	0.990	0.986	0.973	0.961	0.977
$p$ -value ( $\beta_{COOL} = \beta_{HEAT}$ )	0.043	0.000	0.048	0.104	0.809	0.562	0.465	0.474
First Stage								
CDD / 10	0.10 (0.01)	0.09 (0.01)	0.16 (0.01)	0.40 (0.03)	0.45 (0.04)	0.08 (0.01)	0.13 (0.01)	0.28 (0.02)
HDD / 10	0.11 (0.02)	0.02 (0.00)	0.02 (0.00)	0.09 (0.01)	0.23 (0.03)	0.03 (0.00)	0.09 (0.01)	0.08 (0.01)
F-Stat	10.25	18.39	30.03	36.91	31.67	25.45	19.01	25.95
<i>Ordinary Least Squares</i>								
Overall Emissions Factor	1.82 (0.03)	2.34 (0.04)	1.75 (0.03)	2.22 (0.03)	1.96 (0.03)	1.88 (0.04)	1.57 (0.04)	1.54 (0.02)
R-Squared	0.967	0.985	0.977	0.990	0.986	0.975	0.961	0.977

*Notes:* The space cooling emissions factor is estimated by two-stage least squares (2SLS) using CDD as an instrument for generation. The space heating emissions factor is estimated by two-stage least squares (2SLS) using HDD as an instrument for generation. The overall emissions factor is estimated using ordinary least squares. Models are estimated separately for each NERC region. The unit of observation is a NERC region and a bi-week. Each regression is based on 207 observations. Newey-West standard errors based on a two-month lag are reported in parentheses.

Table S.3: Robustness Check: Estimates of CO<sub>2</sub> Emissions Factors (lbs. per kWh) for Years from 2010-2013

	FRCC	MRO	NPCC	RFC	SERC	SPP	TRE	WECC
<i>Instrumental Variable Results</i>								
Space Cooling Emissions Factor	1.64 (0.12)	1.73 (0.10)	1.64 (0.07)	2.11 (0.08)	1.86 (0.05)	1.60 (0.09)	1.45 (0.15)	1.25 (0.14)
<i>R</i> -Squared	0.983	0.996	0.993	0.996	0.997	0.990	0.982	0.982
Space Heating Emissions Factor	1.84 (0.11)	2.23 (0.11)	2.13 (0.23)	1.90 (0.07)	1.91 (0.08)	1.82 (0.19)	1.45 (0.20)	1.09 (0.36)
<i>R</i> -Squared	0.980	0.998	0.983	0.996	0.997	0.990	0.982	0.977
<i>p</i> -value ( $\beta_{COOL} = \beta_{HEAT}$ )	0.041	0.001	0.116	0.081	0.564	0.389	0.991	0.704
First Stage								
CDD / 10	0.14 (0.02)	0.10 (0.02)	0.22 (0.04)	0.55 (0.08)	0.60 (0.06)	0.12 (0.02)	0.20 (0.02)	0.43 (0.08)
HDD / 10	0.14 (0.01)	0.03 (0.01)	0.04 (0.01)	0.15 (0.01)	0.32 (0.03)	0.05 (0.01)	0.17 (0.02)	0.08 (0.06)
F-Stat	106.68	79.42	700.48	82.93	166.96	295.99	192.05	25.40
<i>Ordinary Least Squares</i>								
Overall Emissions Factor	1.67 (0.10)	2.09 (0.08)	1.59 (0.05)	2.08 (0.06)	1.88 (0.04)	1.69 (0.07)	1.49 (0.13)	1.38 (0.08)
<i>R</i> -Squared	0.980	0.997	0.992	0.996	0.997	0.990	0.982	0.983

*Notes:* The space cooling emissions factor is estimated by two-stage least squares (2SLS) using CDD as an instrument for generation. The space heating emissions factor is estimated by two-stage least squares (2SLS) using HDD as an instrument for generation. The overall emissions factor is estimated using ordinary least squares. Models are estimated separately for each NERC region. The unit of observation is a NERC region and a month. Each regression is based on 47 observations. Newey-West standard errors based on a two-month lag are reported in parentheses.