Estimating the Environmental Benefits of Renewable Energy

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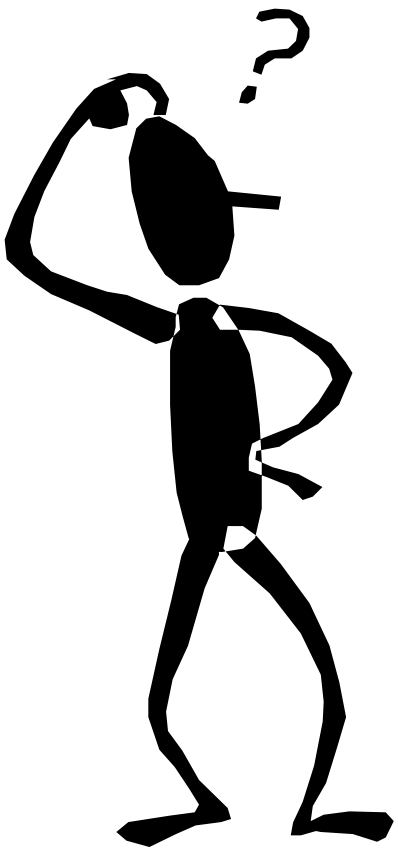
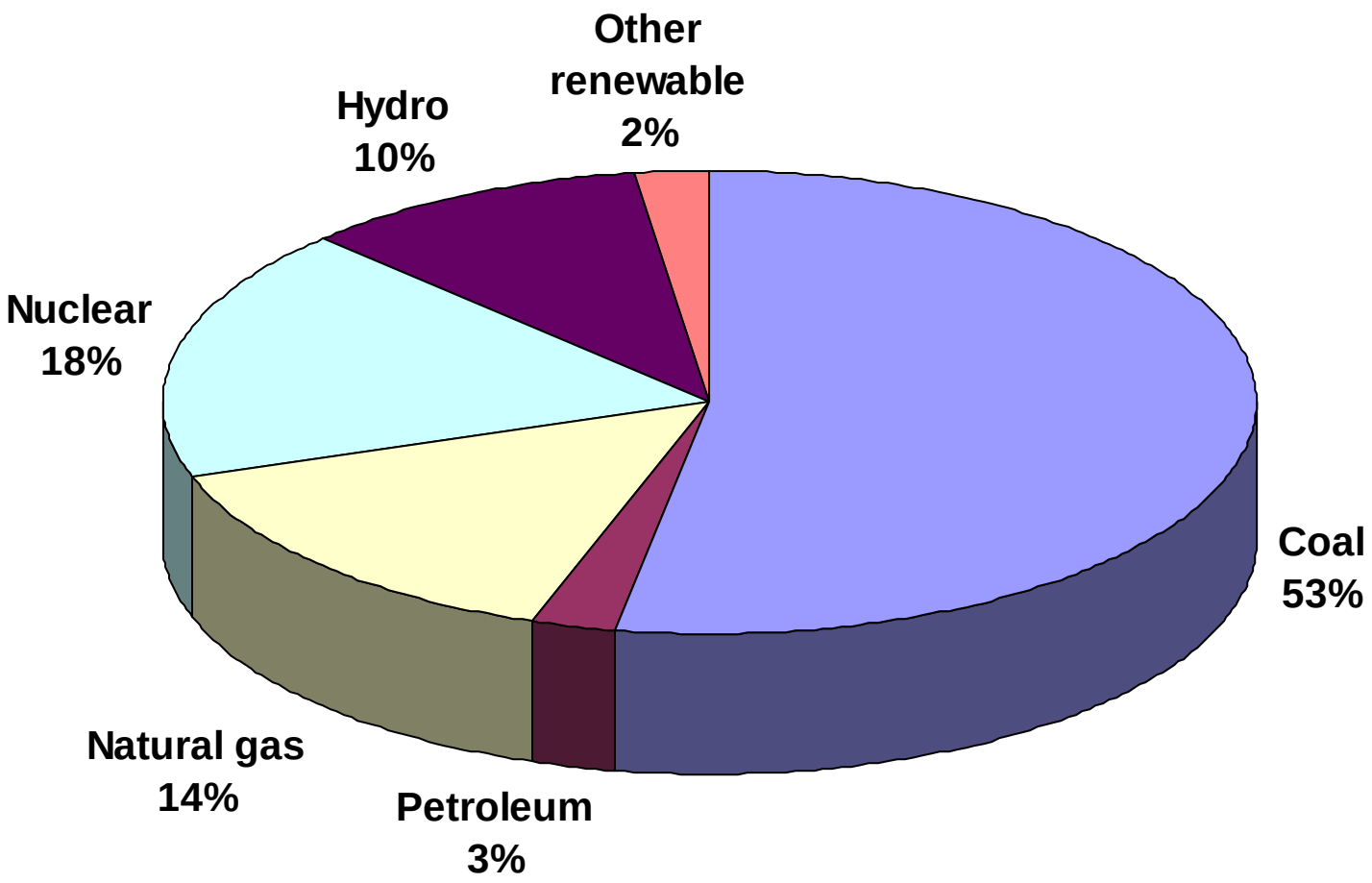
Estimating Emissions Displaced by Clean Energy

How do you measure something that isn't there?

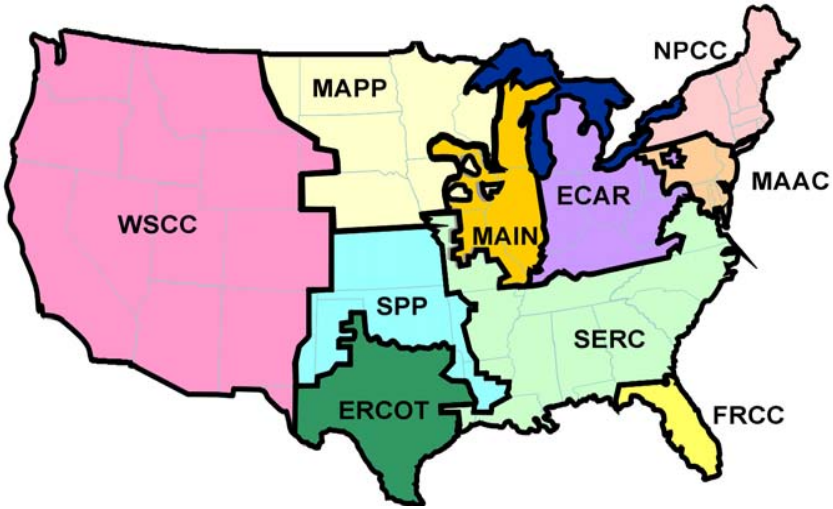


Average System Mix as a Proxy



System Average Output Emission Rates, 2000 (lbs/MWh)

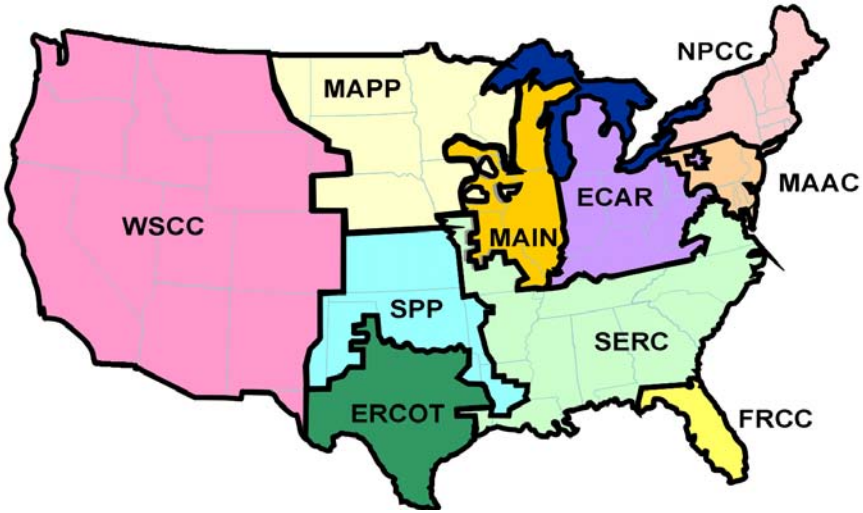
NERC region	NOX	SO2	CO2
ECAR	4.70	12.51	1913
ERCOT	2.24	2.96	1408
FRCC	3.28	5.54	1390
MAAC	2.47	7.65	1098
MAIN	2.95	5.53	1342
MAPP	3.98	5.54	1839
NPCC	1.48	3.97	942
SERC	3.04	7.06	1345
SPP	3.79	4.77	1960
WECC	1.79	1.54	1014
U.S. avg.	**2.96**	**6.04**	**1392**



Source: eGRID2002, Version 2.01:
www.epa.gov/cleanenergy/egrid

Natural Gas Output Emission Rates (lbs/MWh), 2000

NERC region	NOX	SO2	CO2
ECAR	1.44	0.24	1093
ERCOT	1.97	0.06	1112
FRCC	1.62	1.94	1102
MAAC	0.83	0.12	945
MAIN	1.57	0.45	1436
MAPP	3.11	0.23	1370
NPCC	0.97	0.29	1166
SERC	2.44	0.46	1317
SPP	3.05	0.23	1589
WECC	1.17	0.03	1144
U.S. avg.	**1.72**	**0.25**	**1187**



Source: eGRID2002, Version 2.01:
www.epa.gov/cleanenergy/egrid

Estimating Marginal Emission Rates

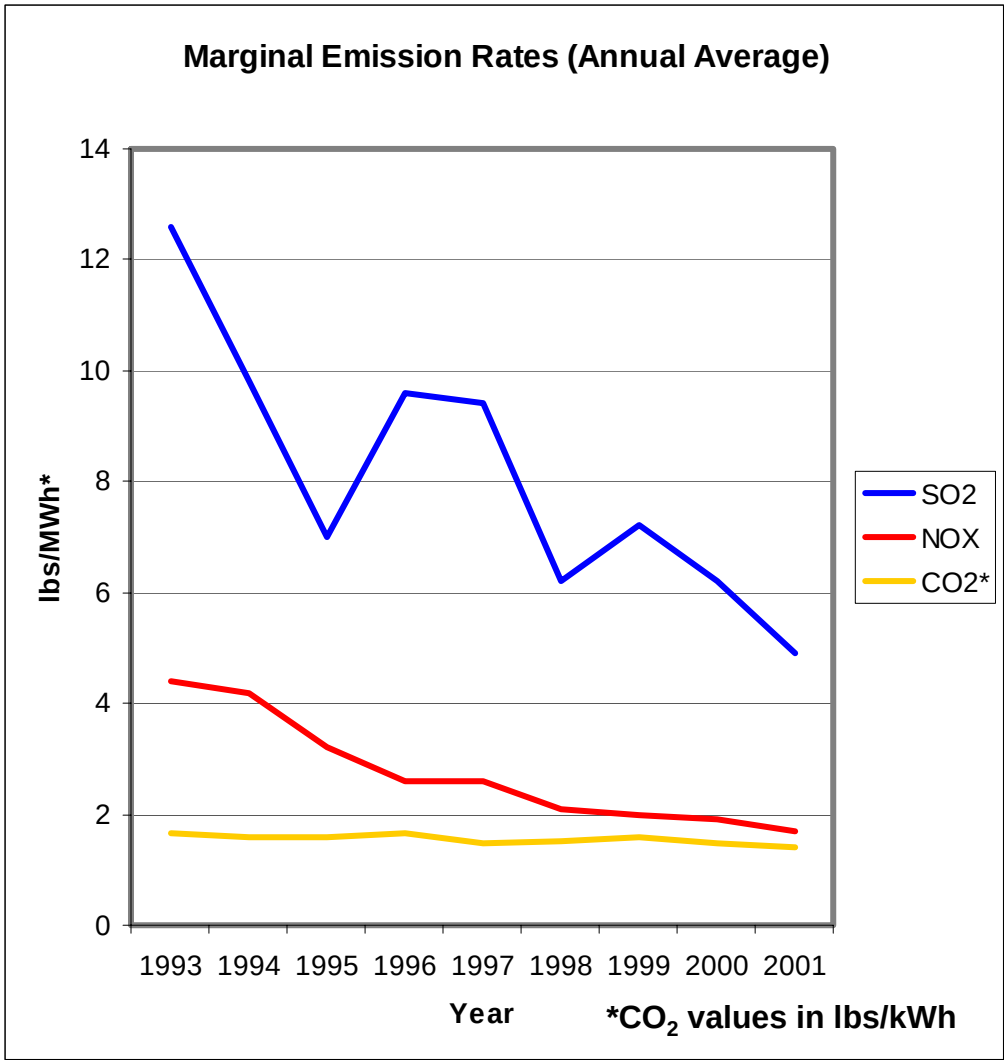
Approaches:

- Dispatch models
- Planning models
- Spreadsheet models

Considerations/Trade-offs:

- Defining marginal generation
- Short-run vs. long-run perspective
- Robustness/sensitivity to assumptions
- How much resolution?
- How to model capped emissions

NEPOOL's Short-term Marginal Emissions Analysis



- **Calculations based on dispatch model (PROSYM™)**
- **Assumes capacity is fixed**
- **Source: *www.iso-ne.com***

EPA's ADER* Project

- **Goal: a robust methodology for evaluating displaced emissions from clean energy technologies or energy efficiency**
  - **evaluation tool for EPA programs**
- **Utilizes ICF's Integrated Planning Model (IPM®)**
  - **adjusts generation and capacity in response to CET or EE measures**
- **Based on ADER parameter:**

$$\frac{\text{displaced emissions (lbs)}}{\text{displaced generation (MWh)}}$$

Average Displaced Emission Rate

ADER Output

- Analyzes five regions of U.S. power grid
- Results cover four time frames:
  - 2005, 2010, 2015, 2020
- Focus on CO_2

- Technology-specific results vary by loadshape
- Forthcoming Excel-based calculator

Technology Loadshapes Analyzed by ADER

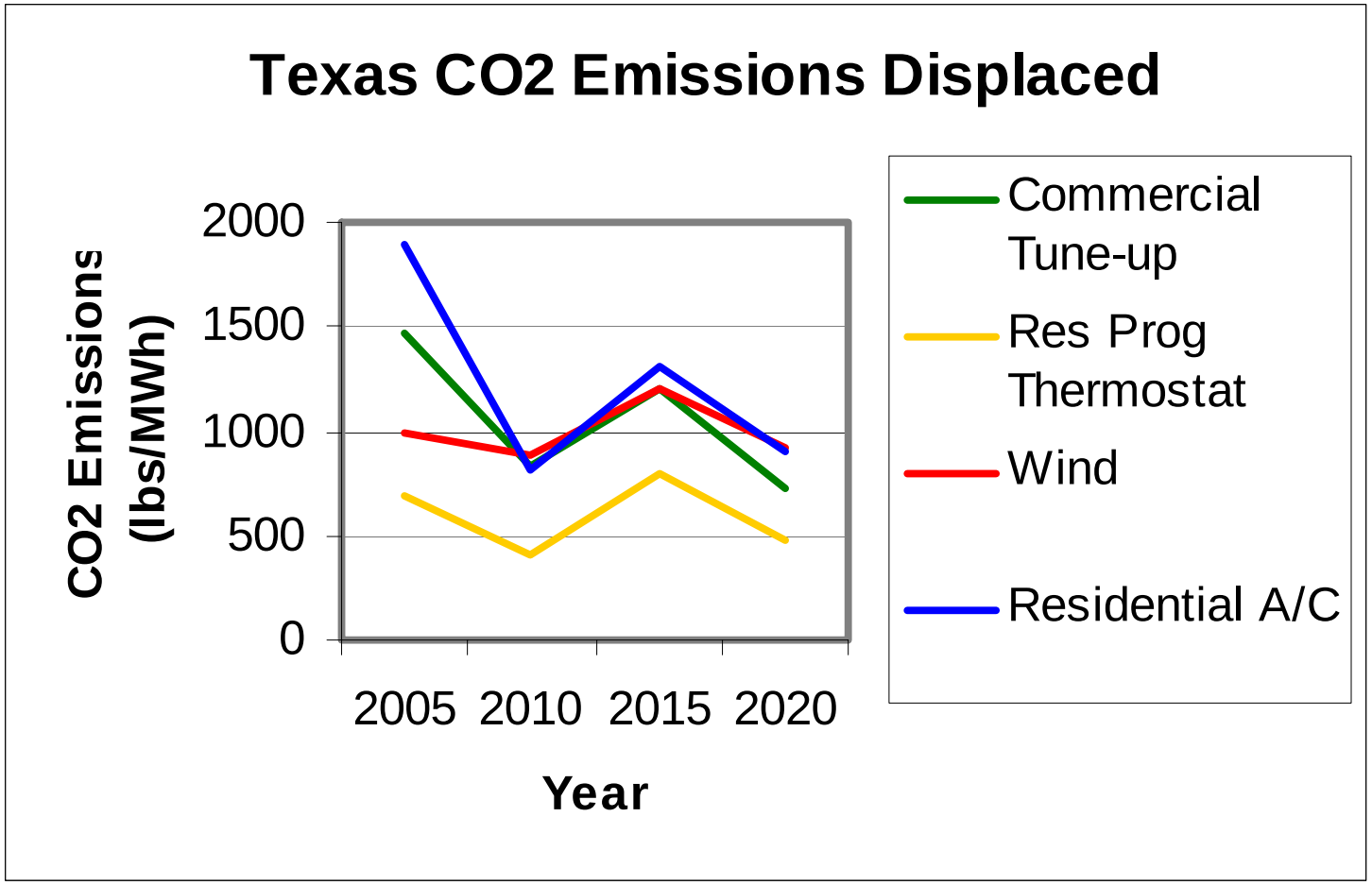
- Residential weatherization
- Residential programmable thermostat
- Residential heating
- Residential air conditioning
- Residential new overall
- Commercial equipment
- Commercial fans & motors
- Commercial lighting
- Commercial tune-up
- Commercial plant
- Commercial overall
- Solar PV
- Solar Thermal
- Wind
- Baseload generation

	Winter			Summer		
	Weekday	Peak Day	Weekend	Weekday	Peak Day	Weekend
12 AM - 1 AM	1	1	1	6	6	6
1 AM - 2 AM	1	1	1	6	6	6
2 AM - 3 AM	1	1	1	6	6	6
3 AM - 4 AM	1	1	1	6	6	6
4 AM - 5 AM	1	1	1	6	6	6
5 AM - 6 AM	4	4	1	9	9	6
6 AM - 7 AM	4	4	1	9	9	6
7 AM - 8 AM	2	2	5	7	7	10
8 AM - 9 AM	2	2	5	7	7	10
9 AM - 10 AM	2	2	5	7	7	10
10 AM - 11 AM	2	2	5	7	7	10
11 AM - 12 PM	2	2	5	7	7	10
12 PM - 1 PM	3	3	5	8	8	10
1PM - 2 PM	3	3	5	8	8	10
2 PM - 3 PM	3	3	5	8	8	10
3 PM - 4 PM	3	3	5	8	8	10
4 PM - 5 PM	3	3	5	8	8	10
5 PM - 6 PM	3	3	5	8	8	10
6 PM - 7 PM	3	3	5	8	8	10
7 PM - 8 PM	4	4	5	9	9	10
8 PM - 9 PM	4	4	5	9	9	10
9 PM - 10 PM	4	4	5	9	9	10
10 PM - 11 PM	1	1	1	6	6	6
11 PM - 12 AM	1	1	1	6	6	6

[1]Hour Block 11 (not shown here) consists of hour blocks 2,3,7 and 8.

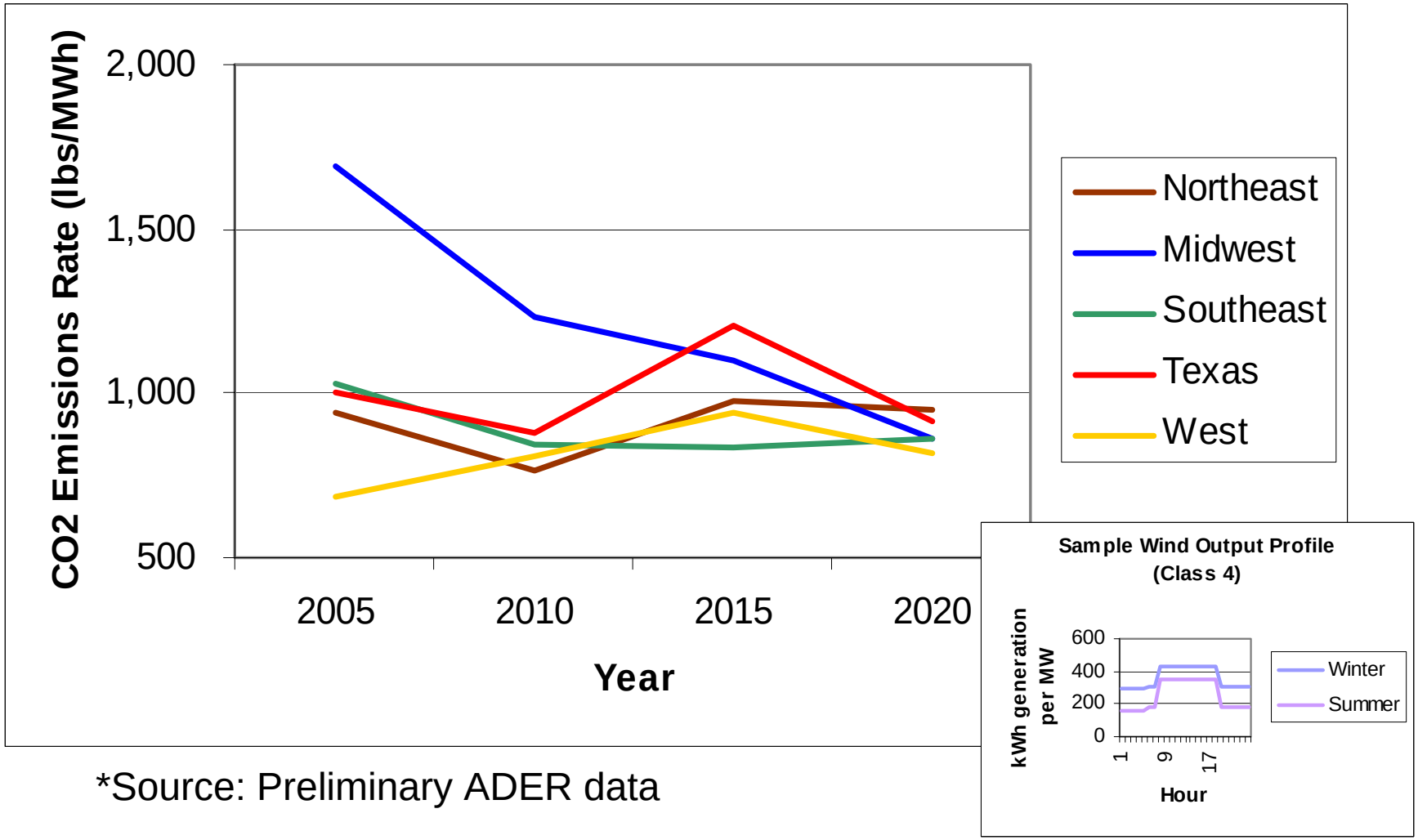
- Custom-made loadshape option available

Emissions Displacement Is Technology-Specific*



*Source: Preliminary ADER Data

Displaced CO_2 Emission Rates for Wind*



*Source: Preliminary ADER data

Tradeoffs for a Robust Methodology

- **Geographic scope**
  - resolution vs. robustness
  - results sometimes counterintuitive
- **Temporal considerations**
  - sensitivity to assumptions about the future, e.g.:
    - demand & economic growth
    - relative fuel prices
    - cost & performance of new units
  - actual values will change over time
- **Consider variations in loadshape**

Modeling Capped Emissions

- **Emission caps**
  - **SO_2:**
    - **Acid Rain Program's cap & trade applies to 48 states**
  - **NO_X:**
    - **9 northeastern states + DC currently under cap & trade**
    - **soon expanding to ~19 eastern states + DC**
- **Dilemma for modelers**
  - **emission caps may preclude emission reduction benefits**
  - **"potential" benefits can be estimated by relaxing cap constraint**

Uses for Displaced Emission Values

- Program evaluation
- Marketing, e.g., green power, CHP
- Corporate emissions inventories
- GHG registries
- Assign carbon credit

Other Displaced Emissions Methodologies

- **OTC Emission Reduction Workbook**
  - dispatch model approach for Northeast
  - download from: www.sso.org/otc (pubs)
- **LBNL's MAGPWR**
  - methodology for granting carbon credits
  - http://ies.lbl.gov/iespubs/46063.pdf
- **Under development:**
  - MIT PV assessment (connorsr@mit.edu)
  - EPA Texas methodology (diem.art@epa.gov)
  - ERT's dispatch ranking protocol (ahathaway@ert.net)

Conclusion