Deciding an Approach for Quantifying Emission Impacts of Clean Energy Policies and Programs

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U.S. EPA
State Climate and Energy Program
Today’s Presentation

- Overview of important terms
- Which electric generating units are generally displaced once a State, Local or third-party implements clean energy policies and programs
- Important factors when deciding which emissions quantification approach to use
- Overview of available emission quantification approaches and examples for when to use them
  - eGRID subregion nonbaseload emission rates
  - EGU capacity factor emission rates
  - Hourly emission rates
  - Energy modeling
Common Terms and Abbreviations

- **Clean Energy (CE)**: no-to-low emitting options to meet energy demand, such as energy efficiency, combined heat and power, and renewable energy.
- **Electric generating unit** (EGU): a power plant or generator that produces electricity and is connected to the grid.
- **Baseload EGUs**: operate near maximum capacity most hours of day. (E.g., nuclear, in most cases coal & hydro plants)
- **Nonbaseload EGUs**: fluctuate generation based on changes in demand (E.g., gas combined cycle, gas turbines, oil-fired plants)
- **Peaking EGUs**: only operate during the highest demand periods (older oil combustion turbines, gas combustion)
- **Marginal Unit**: the last (or next) EGU called upon to meet demand
How do Clean Energy policies reduce emissions?

Generally, CE policies reduce emissions at nonbaseload EGUs, and the most expensive units are dispatched last.
Types of Clean Energy Policies and Their Impacts

Examples of State Energy Efficiency Policies:

- Energy Efficiency Resource Standards
- Public Benefits Funded EE programs

Examples of State Renewable Energy Policies:

- Renewable Portfolio Standards (RPS)
- Renewable Energy Incentives (E.g., rebates)

Clean Energy policy impacts are estimated in Megawatt-hours (MWh).

> Capturing energy impacts of CE policies will provide the most emissions benefits.


http://www.epa.gov/statelocalclimate/resources/action-guide.html
Available Data Sources for EGU generation and emissions

- **EPA’s eGRID (Emissions Generation Resource Integrated Database)**
  - Annual emissions for NOx*, SO₂, Hg, CO₂, CH₄ and N₂O
  - Different aggregation levels – boiler to subregions
  - Most recent data from 2007

- **EPA’s Clean Air Markets Division (CAMD) database**
  - Monitored NOx, SO₂, CO₂ emissions for EGUs reporting to EPA
  - Emission unit level
  - Updated every quarter

- **State emissions inventories**
  - Emissions for EGUs permitted by State DEPs
  - Includes units not captured in EPA data collection
  - Scale of emissions varies depending upon permitting requirements and State regulations

*Ozone season emissions available for NOx
Choosing The Method

- There are several key questions that can help narrow your options as you select a method:
  - What is the purpose of the analysis?
  - What types of emissions are you interested in?
  - What scale do you care about?
  - How much time and resources do you have?

- Match your answers to the methods.

### Key Considerations When Selecting an Approach

<table>
<thead>
<tr>
<th>Purpose</th>
<th>eGRID subregion nonbaseload</th>
<th>EGU Capacity Factor Approach</th>
<th>Hourly Emission Rates</th>
<th>Energy Modeling</th>
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<tbody>
<tr>
<td>Preliminary Analysis</td>
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<td>Voluntary Programs</td>
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<td>General benefits Info</td>
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<td>Regulatory or statutory requirement</td>
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### Approaches

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Emissions of interest</th>
<th>Geographical</th>
<th>Source aggregation</th>
<th>Temporal</th>
<th>Time</th>
<th>Money</th>
<th>Staff expertise</th>
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</thead>
<tbody>
<tr>
<td>Preliminary Analysis</td>
<td>NOx, SO₂, CO₂, (biogenic CO₂), CH₄, N₂O, Hg</td>
<td>eGRID subregion partially addressed</td>
<td>boiler, generator, plant</td>
<td>annual &amp; ozone season (NOx) historical</td>
<td>low</td>
<td>low</td>
<td>low</td>
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<tr>
<td>Voluntary Programs</td>
<td>NOx, SO₂, CO₂</td>
<td>both partially addressed</td>
<td>plant</td>
<td>annual &amp; ozone season (NOx) historical</td>
<td>low</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>General benefits Info</td>
<td>NOx, SO₂, CO₂</td>
<td>both not addressed</td>
<td>emission unit (boiler)</td>
<td>Annual, monthly, hourly historical</td>
<td>medium</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>Regulatory or statutory requirement</td>
<td>NOx, SO₂, CO₂, Hg, varies</td>
<td>electric grid region - fully addressed</td>
<td>emission unit (boiler)</td>
<td>annual, ozone season (NOx), hourly forecasted</td>
<td>high</td>
<td>high</td>
<td>high</td>
</tr>
</tbody>
</table>

### Resources

- Time: low, low, medium, high
- Money: low, low, medium, high
- Staff expertise: low, low, medium, high
When to Use Emission Quantification Approaches

The chosen approach will be useful for different types of analysis:

- **Basic approaches** are useful when:
  - time or resources are limited
  - high-level or preliminary analyses are needed
  - a long list of options need to be shortened

- **Sophisticated approaches** are useful when:
  - policy options are well-defined
  - high degree of precision and analytic rigor is desired
  - sufficient time, data and financial resources are available.
eGRID subregion nonbaseload emission rates approach

- **How it works:**
  - Uses emission rates that represent average emissions of nonbaseload units in an eGRID subregion.

- **Examples for when to use:**
  - Estimate emission reduction potential
  - Explain emission benefits to the general public

- **Advantages:**
  - Requires low resources – easy calculation
  - Great for annual emissions reductions, regional and national estimates

- **Limitations:**
  - Does not specify which power plant is reducing emissions
  - Most recent year of data: 2007

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**CALCULATION USING eGRID**

- Energy saving of EE (MWh)
- eGRID nonbaseload emission rate (lbs/MWh) (Account for Grid loss factor)
- Emissions avoided by EE (lbs)
eGRID subregion nonbaseload emission rates approach

Informational resources:

- **eGRID website:**
  - [http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html](http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html)

- **eGRID summary tables:**
  - [http://www.epa.gov/cleanenergy/documents/egridzips/egrid2010V1_1_year07_SummaryTables.pdf](http://www.epa.gov/cleanenergy/documents/egridzips/egrid2010V1_1_year07_SummaryTables.pdf)

- **eGRID overview presentation:**

- **New Mexico example using eGRID:**

**eGRID Subregions**

**USERS of eGRID**

- EPA’s Power profiler
- EPA’s CHP calculator
- Energy Star Portfolio Manager
- EPA’s Personal GHG calculator
- EPA’s GHG equivalency calc.
- EPA’s Wastewise GHG calc.

(The emission rates may vary within each tool depending upon the purpose)
EGU Capacity Factor Emission Rates

Approach

How it works:

- An EGU’s capacity factor is indicative of how much emissions could be displaced
  - EGUs with high capacity factors are generally baseload EGUs
  - EGUs with low capacity factors are generally nonbaseload EGUs
- Distribute emissions reductions to each EGU based on 1) displaceability 2) CE impacts 3) EGU emission rates

Examples for when to use:

- Understand which EGUs are nonbaseload and where emissions could most likely be displaced
- Identify specific areas where reductions could take place

AN EGU’s CAPACITY FACTOR IS A RATIO:

The actual electricity produced

The available electricity production at maximum capacity

Capacity Factors Relationship to Emissions Displacement
EGU Capacity Factor Emission Rates Approach

- **Advantages:**
  - Emissions can be distributed to each EGU
  - Relatively easy calculation
  - Great for preliminary analysis

- **Limitations:**
  - Capacity factors are approximate and don’t account for maintenance, outages, etc.
  - Dynamics of electric grid not captured (E.g., exports, imports)
  - Most recent year available: 2007

- **Examples using this approach:**
  - Energy efficiency policy analysis in Texas (S.B. 5)
    - Estimated how much and where emission reductions occur within TX

Capacity Factors can be found in eGRID’s excel workbooks
Hourly Emission Rates Approach

How it works:

- Use reported hourly generation and emissions information to derive hourly emission rates.
- Historical hourly emissions rates can be aggregated to any temporal scale to answer policy questions.

Examples for when to use:

- Regulatory analysis
- Analyze high electric demand days
- How RE technologies reduce emissions

Reported Hourly Emissions information can be found at EPA’s Clean Air Market’s Division website:
http://camddataandmaps.epa.gov/gdm/index.cfm?fuseaction=iss.progressresults

ISO New England Report
March 2011
Hourly Emission Rates Approach

Advantages:

- Emission impacts at different times of day and year
- Continuous quarterly reporting to EPA at emission unit level

Limitations:

- Data intensive w/out infrastructure set up
- Hourly load impacts of energy programs are required

Examples of this approach:

Energy Modeling Approach

- **How it works:**
  - Dynamic simulation models are used to forecast emissions
  - Models account for complex interaction of the electric grid
    - Dispatch Models
    - Capacity Expansion Models

- **Examples of when to use:**
  - Regulatory analysis
  - When policy assumptions are well defined and detailed input data is available

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*NEMS - National Energy Modeling System
**IPM - Integrated Planning Model includes dispatch capabilities
*** MARKAL - Market Allocation Model

EPA uses the Integrated Planning Model (IPM) for all electric sector regulatory analysis
Energy Modeling Approach

- Examples of this approach:
  - Energy Information Administration's (EIA) Annual Energy Outlook (AEO) Projections (NEMS)
    [http://www.eia.gov/forecasts/aeo/](http://www.eia.gov/forecasts/aeo/)
  - U.S. EPA’s Regulatory Analysis (IPM)
  - Emission reductions of clean energy policies in California’s Air Management Districts (PROSYM)
## Advantages and Disadvantages of Energy Models

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<tr>
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<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td><strong>Dispatch Models</strong></td>
<td>■ Provides very detailed estimations about specific plant and plant-type effects within the electric sector.</td>
<td>■ Often lacks transparency. ■ Requires technical experience ■ Labor- and time- intensive. ■ Often high labor and software licensing costs. ■ Requires establishment of specific operational profile of the clean energy resource.</td>
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<tr>
<td>■ Prosym,</td>
<td>■ Provides highly detailed, geographically specific, hourly data.</td>
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<td>■ Promod,</td>
<td>■ Model impacts of cap and trade programs</td>
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<td>■ Ventyx</td>
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<td><strong>Capacity Expansion Models</strong></td>
<td>■ Model selects optimal changes in generation mix based on assumptions and energy system (10–30 years).</td>
<td>■ Often lacks transparency ■ Requires significant technical experience ■ Labor- and time- intensive. ■ Often high labor and software licensing costs. ■ Requires assumptions that have large impact on outputs (e.g., future fuel costs).</td>
</tr>
<tr>
<td>■ NEMS,</td>
<td>■ Captures emission changes from new power plants and retirements</td>
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<tr>
<td>■ IPM,</td>
<td>■ May provide plant specific detail and perform dispatch simultaneously (IPM).</td>
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<td>■ Energy 2020,</td>
<td>■ Model impacts of cap and trade programs</td>
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