Approaches for Quantifying Emission Impacts of Energy Efficiency and Renewable Energy Policies and Programs

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EPA United States Environmental Protection Agency

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Overview of Process & Presentation

- Quantifying the emission impacts of energy efficiency (EE) and renewable energy (RE) policies requires:
  1. Identifying a specific EE/RE policy and getting estimates of the projected energy impacts
  2. Understanding how EE/RE policies affect electricity generation
  3. Accessing data on electricity generation and emissions of electric generating units in a State or Region from available sources:
  4. Becoming familiar with the range of available quantification methods and when to use them:
     - eGRID subregion non-baseload emission rates approach
     - Electric Generating Units (EGU) capacity factor emission rates approach
     - Historic hourly emission rate approach
     - Energy modeling
  5. Choosing the best method for your analysis

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VA Case Study: Virginia's Legislature Enacted a Voluntary Energy Savings Goal in 2007

VA Policy:

- Voluntary Goal: By the year 2022, consumption of electric energy will be reduced through the implementation of cost-effective energy efficiency programs by an amount equal to 10%, of the amount consumed in 2006.

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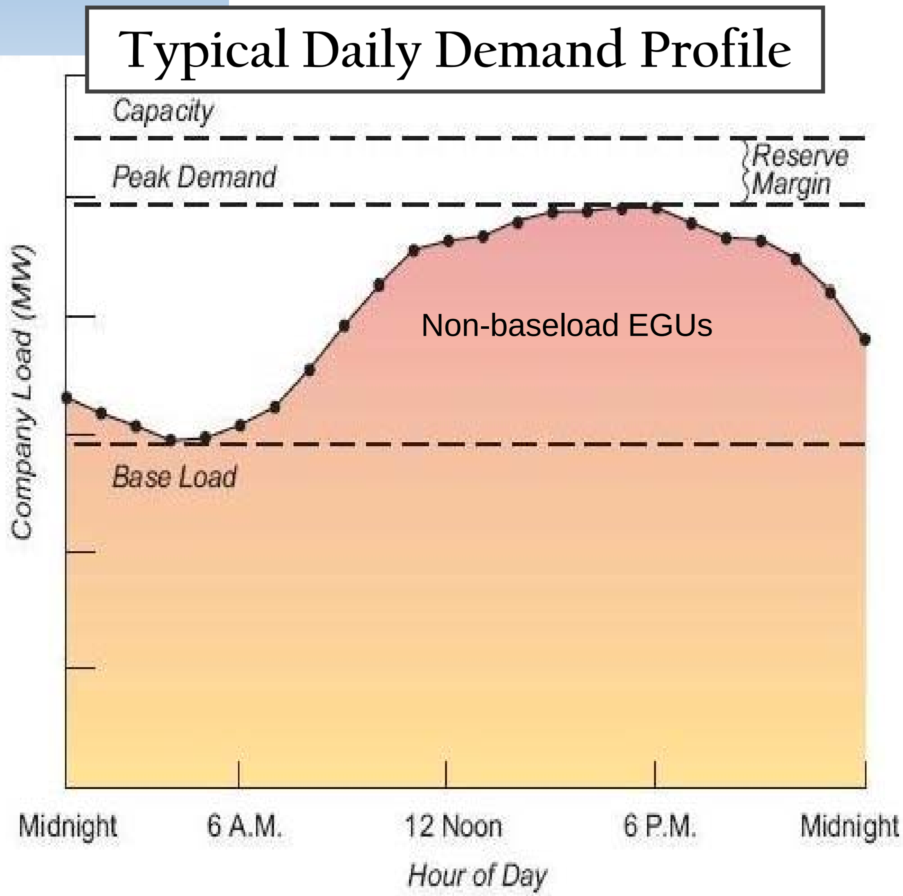
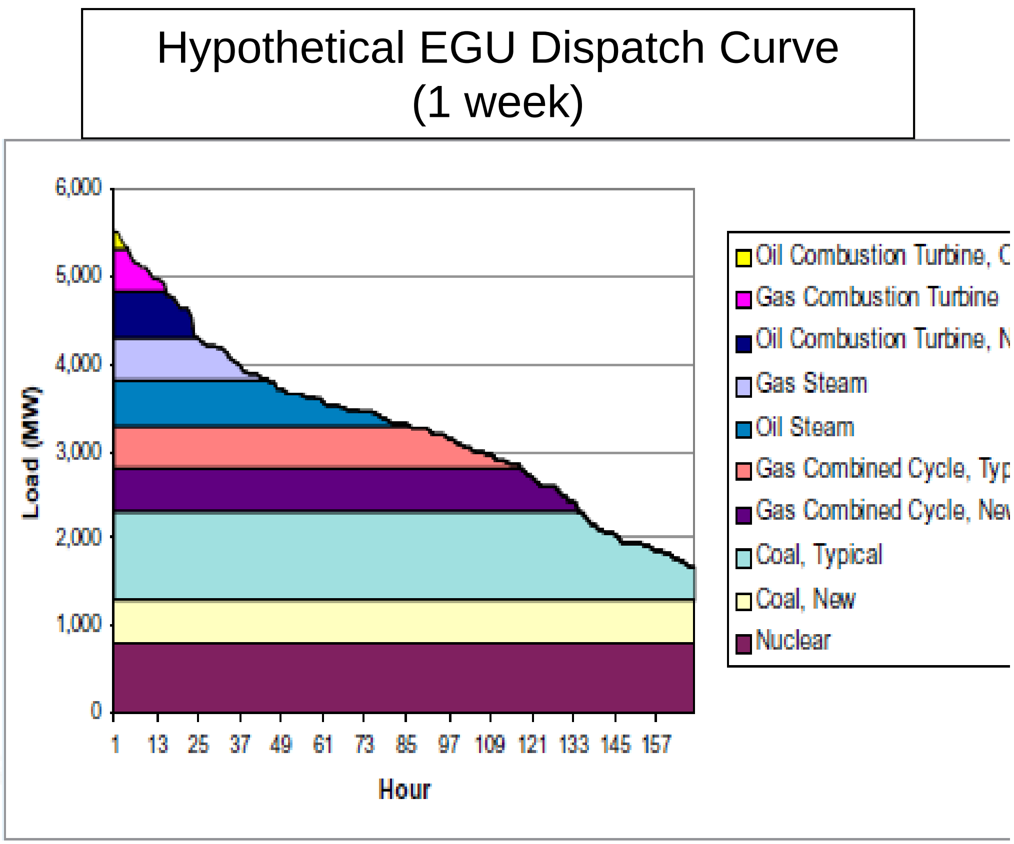
Understanding how EE/RE policies affect electricity generation

Generally, EE/RE policies reduce emissions at non-baseload EGUs, and at the most expensive units, that are dispatched last





Available Data Sources for Power Plant Generation and Emissions

- State's emissions inventory
  - Emissions for EGUs permitted by State DEPs
  - Includes smaller units not captured in EPA data collection
  - Scale of emissions varies depending upon permitting requirements
- EPA's eGRID (Emissions Generation Resource Integrated Database)
  - Emissions for NOx, SO_2, Hg, CO_2, CH_4 and N_20
  - Different aggregation levels – boiler to subregions
  - Capacity factors – the ratio between generation and max capacity
- EPA's Clean Air Markets Division (CAMD) database
  - Reported emissions for EGUs subject to Cap and Trade Programs
  - Emission unit level
  - Temporal scales – 5min – hourly - annual emissions data

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Available emission quantification approaches

Each approach is best used in certain situations depending upon analytical objectives.

- eGRID subregion non-baseload emission rates approach
- EGU capacity factor emission rates approach
  - EPA's Capacity Factor Emissions Calculator
- Historical hourly emission rates approach
  - EPA's Hourly Marginal Emissions Tool
- Energy Modeling (E.g., dispatch, capacity expansion model)

* Note: This does not cover the full scope of all possible approaches

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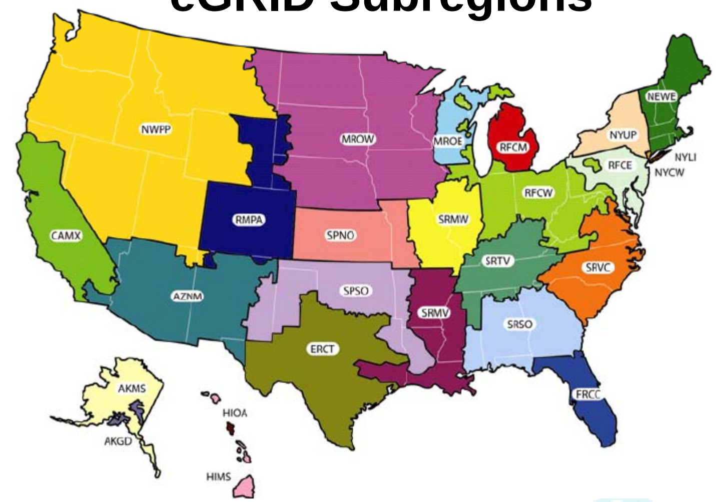
eGRID subregion non-baseload emission rates approach

- The way it works:
  - Use emission rates that represent average emissions of non-baseload units in an eGRID subregion.
- Examples for when to use:
  - Estimate emission reduction potential during ozone season
- Advantages:
  - Requires few resources
  - Straight forward calculation
- Limitations:
  - Does not specify which power plant is reducing emissions
  - Future electric system changes are not represented
  - Data is available on a three year lag

eGRID Subregions



CALCULATION USING eGRID

Enegy saving of EE (MWh)

X

eGRID nonbaseload emission rate (lbs/MWh)

=

emissions avoided by EE (lbs)

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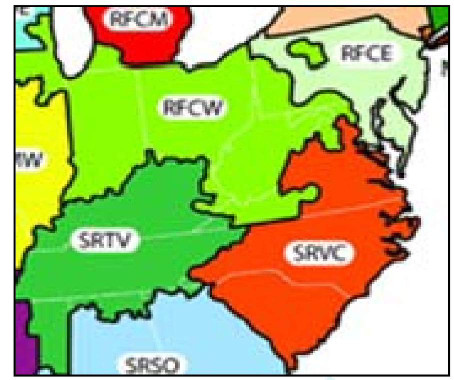
VA Example: Quantifying VA's 10% EE goal using eGRID emission rates approach

Step One: Estimate energy savings of EE policy = 10,672 GWhs

Step Two: Apportion EE savings to eGRID subregions based on VA Utility Sales Data (EIA-861)

Step Three: Multiply EE savings by each eGRID subregion's non-baseload emission rates

eGRID Subregions



eGRID subregion	Apportioned EE Savings (%)	EE Savings (GWhs)	eGRID non-baseload emission rates		Emission Reductions	
			NOx (lbs/MWh)	SO_2 (lbs/MWh)	NOx (Tons)	SO_2 (Tons)
RFCE	1%	95	1.4	8.3	67	395
RFCW	25%	2,668	2.03	9.3	2,708	12,407
SRVC	72.3%	7,729	1.3	5.04	5,024	19,478
SRVT	1.7%	180	1.6	5.7	143	511

EGU capacity factor emission rates approach

- **The way it works:**
  - An EGU's capacity factor is an indicator for how much emissions could be displaced
    - EGUs with ~ 0.8 capacity factors rarely get displaced
    - EGUs with ~ 0.2 capacity factors most likely will get displaced
  - Assign emissions reductions to each EGU based on 1) capacity factor 2) annual/seasonal emissions rates and 3) amount of generation displaced
- **Examples for when to use:**
  - Understand which EGUs are 'on the margin' and where emissions most likely could be displaced

AN EGU's CAPACITY FACTOR IS A RATIO:

The actual electricity produced

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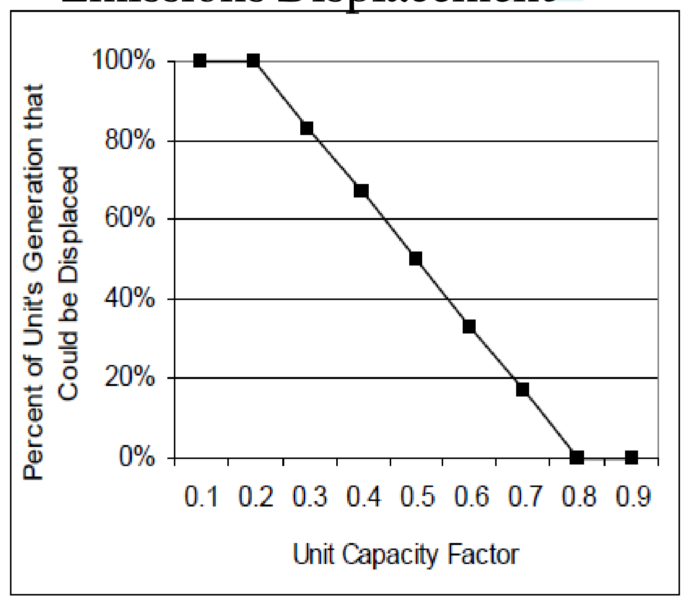
The available electricity production at maximum capacity

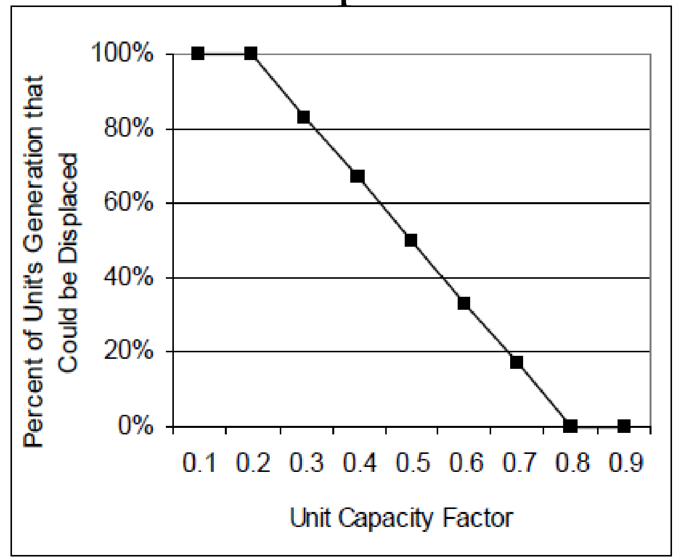
Capacity Factors Relationship to Emissions Displacement



EGU Capacity Factor Emission Rates Approach

- **Advantages:**
  - Emissions can be assigned to each EGU
  - Relatively easy analysis
- **Limitations:**
  - Assumes power plants are operating at the same rate throughout the year or ozone season
  - Capacity factors are approximate and don't account for maintenance, outages, etc.
- Capacity factors can be found in eGRID:
  - http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

Capacity Factors Relationship to Emissions Displacement



A draft Capacity Factor Emissions (CFEC) Calculator will be released Summer of 2012

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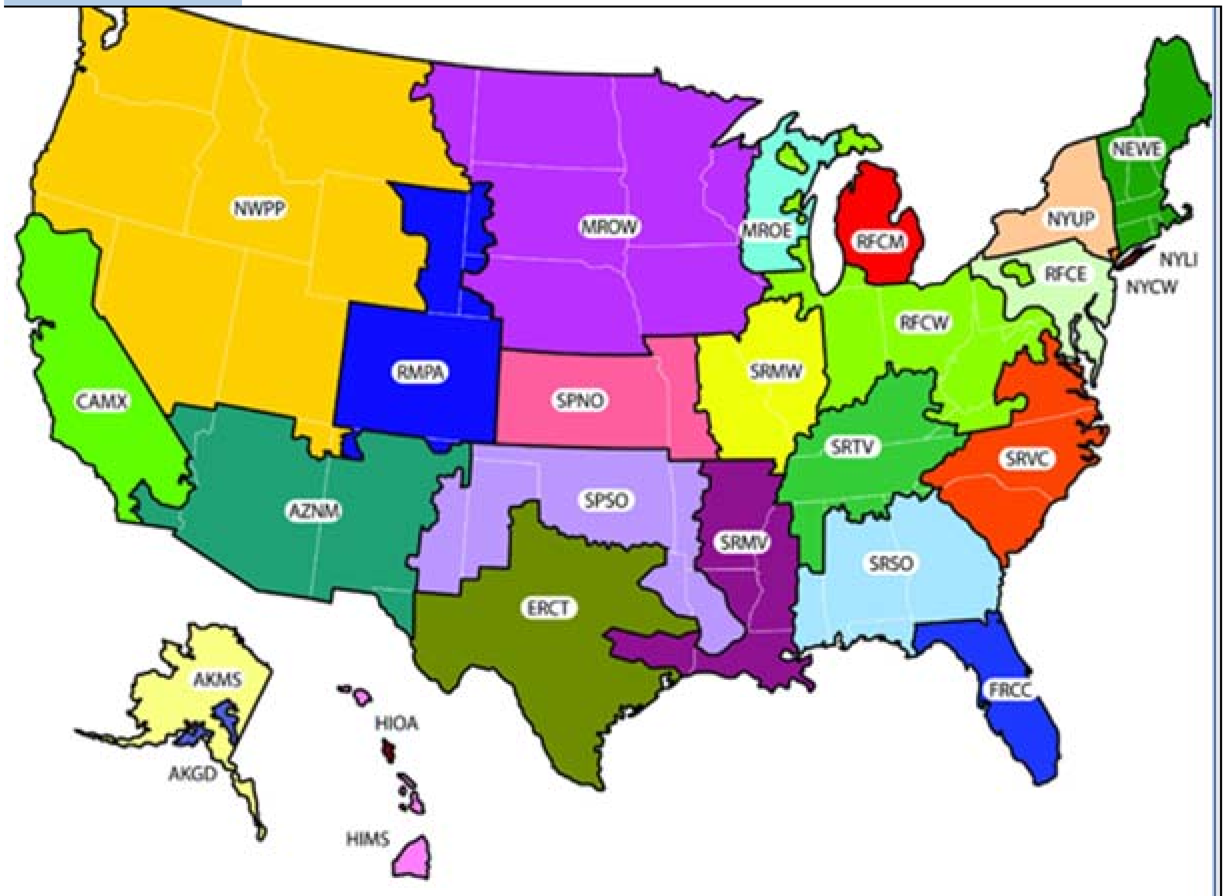
VA Example: Quantifying VA's 10% EE goal using Capacity Factor Emissions Calculator (CFEC)

CFEC Step 1: Locate which eGRID subregion the EE policy/program will be implemented

eGRID Subregion Map



VA Utility Sales span across four eGRID subregions:

The retail sales distribution is:

- RFCE – 1%
- RFCW – 25%
- SRVC – 72.3 %
- SRVT – 1.7%

VA Example: Quantifying VA's 10% EE goal using Capacity Factor Emissions Calculator (CFEC)

CFEC Step 2: Enter the Energy Impact (in MWhs) of the EE Policy or Program in the cell that corresponds to your eGRID subregion.

EE Savings for each eGRID Subregion – Entered into CFEC

RFC East = 95 GWh

RFC West = 2668 GWhs

SRVC = 7729 GWhs

SRVT = 179 GWhs

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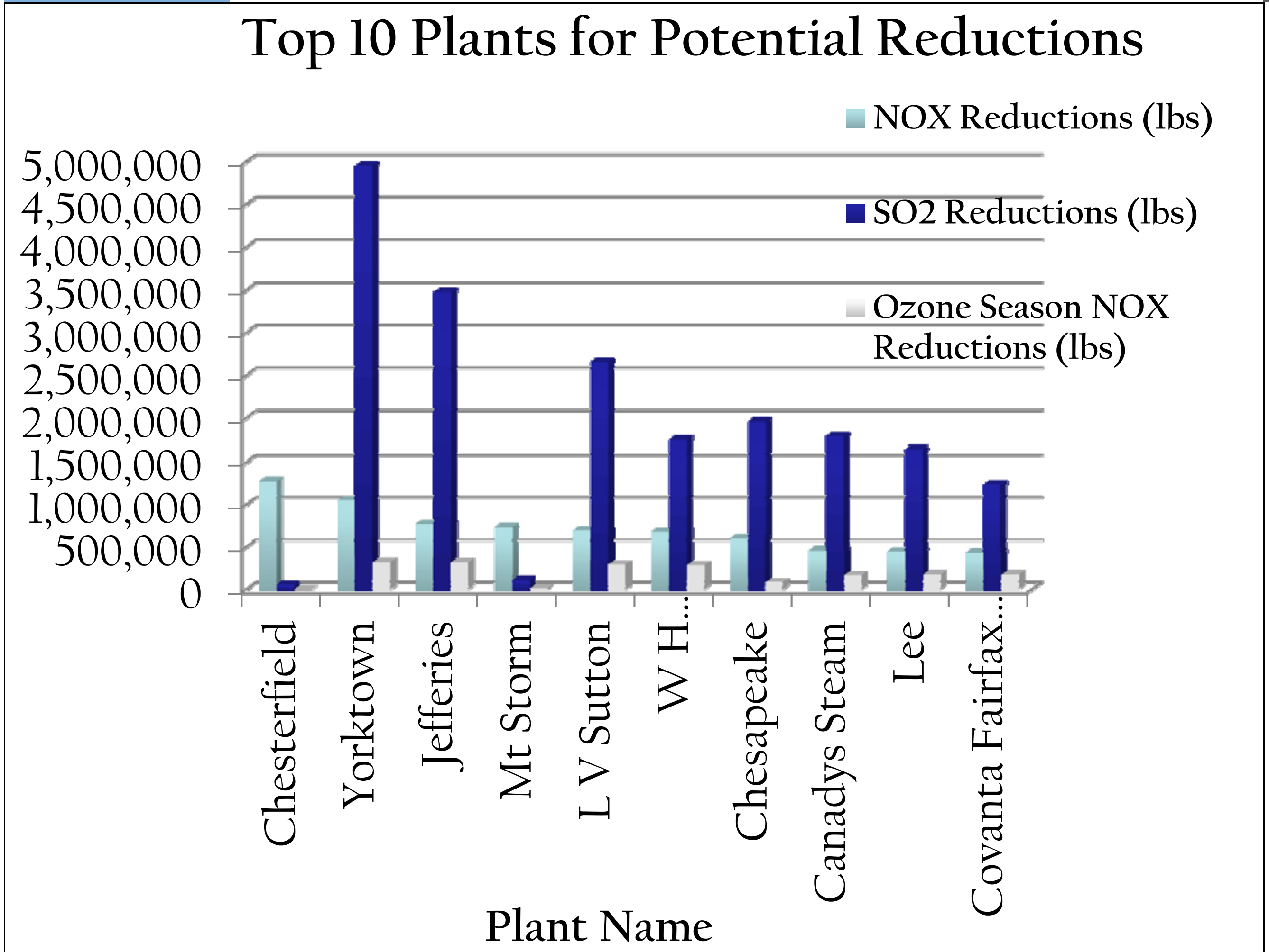
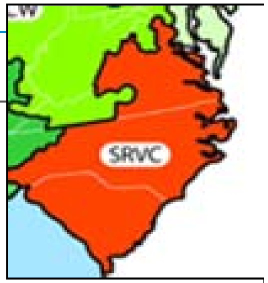
Quantifying VA's 10% EE goal using CFEC

eGRID subregion SRVC Emission Reduction Summary





SRVC eGRID subregion emission reductions:

Annual

- 5,024tons of NOx
- 19,478 tons of SO_2
- 5MM tons of CO_2

Ozone Season (May-Sept)

- 2,100 tons of NOx

Note: This is a hypothetical example

VA Example: Quantifying VA's 10% EE goal using Capacity Factor Emissions Calculator (CFEC)

The CFEC allows you to identify which plants could reduce the most emissions within a county or nonattainment area

Top Three Virginia Power Plants with Most NOx Emission Reduction Potential

Power plant	Plant Owner	County	Annual NOx	Ozone season NOx	Annual SO2	Annual CO2
Chesterfield	Dominion VA Power Co	Chesterfield	637 tons	0.3 tons	27 tons	39,000 tons
Yorktown	Dominion VA Power Co	York	525 tons	163 tons	2,470 tons	290,000 tons
Covanta Fairfax Energy	Covanta	Fairfax	217 tons	89 tons	136,800 tons	46,000 tons

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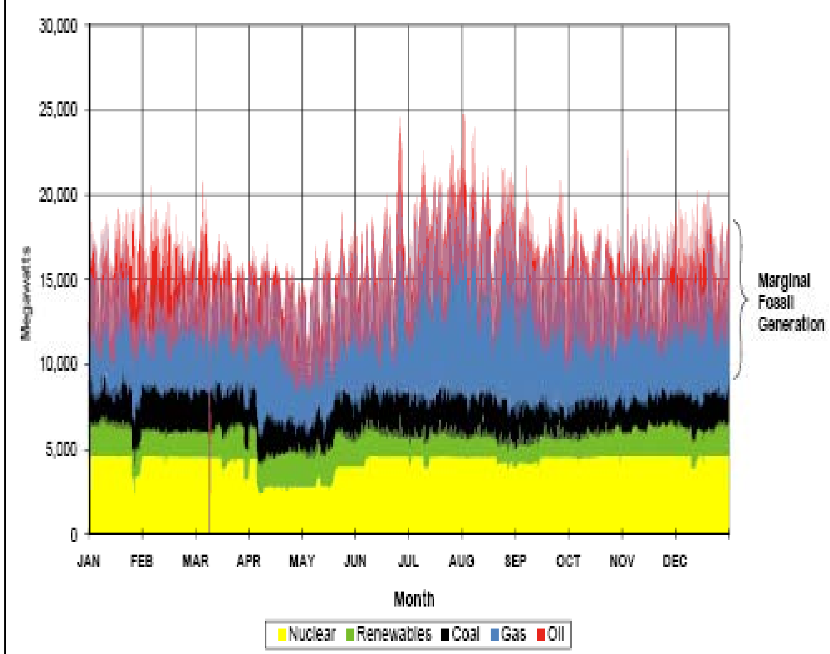
Note: This is a hypothetical example

Historical Hourly Emission Rates Approach

- The way it works:
  - Use reported hourly generation and emissions information to derive hourly emission rates.
  - Historical hourly emissions rates can correlated to a specific EE/RE policy or program
- Examples for when to use:
  - Regulatory analysis
  - Understand dispatch during peak energy demand
  - Analyze emission impacts of different EE programs

Figure 3.1: New England 2007 Hourly Generation



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

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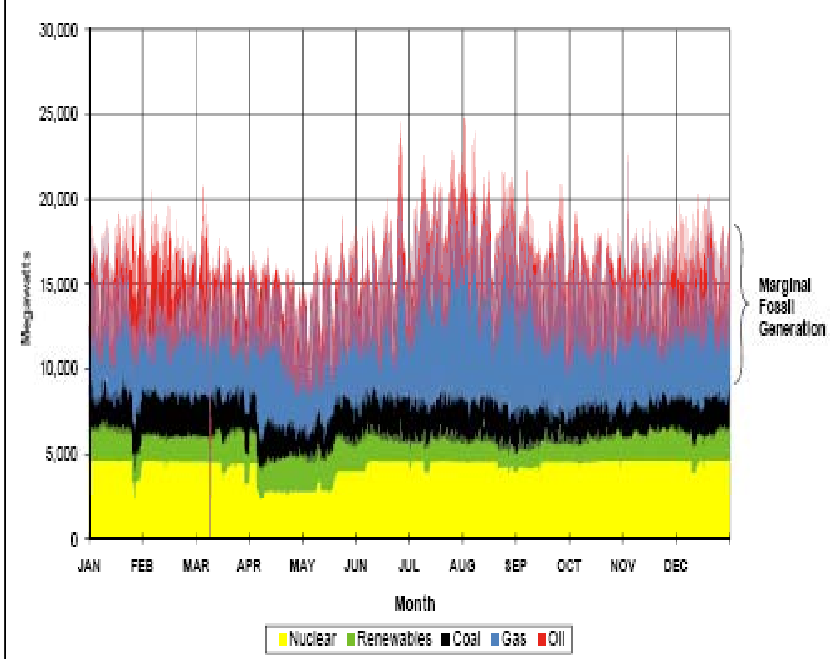
Historical Hourly Emission Rates Approach

- **Advantages:**
  - Provides detailed results – hourly, unit level emission reductions
  - Can derive emission rates for any group of hours
- **Limitations:**
  - Resource intensive
  - Future generation is not represented

Figure 3.1: New England 2007 Hourly Generation



EPA will be releasing a draft Hourly Marginal Emissions Tool summer of 2012

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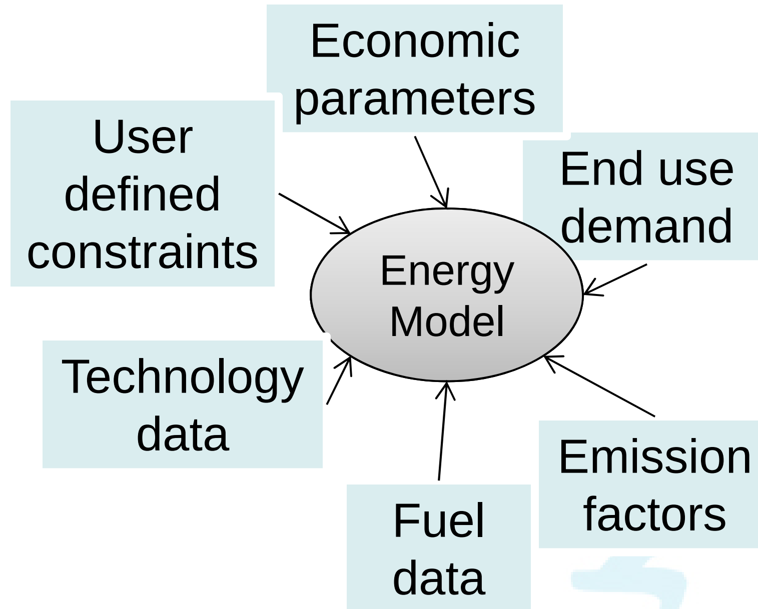
Energy Modeling Approach

- **The way it works:**
  - Dynamic simulation models are used to forecast emissions
  - Models account for complex interaction of the electric grid
    - Dispatch Models
    - Capacity Expansion Models
    - Energy Models
- **Examples of when to use:**
  - Regulatory analysis
  - Understand how many assumptions (including EE/RE) affect future EGU generation



Examples of Energy Models:
<u>Dispatch Models:</u> Prosym, Promod, Ventyx
<u>Capacity Expansion Models:</u> NEMS*, IPM**, Energy 2020
<u>Energy model</u>: MARKAL***

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

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Energy Modeling Approach

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

- Advantages
  - Emission changes from future power plant generation and retirements can be captured (10-30 year projections) (Capacity Expansion Model)
  - Uses many assumptions to determine how EGUs will be dispatched
  - Model selects optimal changes in generation mix based on assumptions and energy system (Capacity Expansion Model)
- Limitations
  - Generally useful for 1-7 year projections (Dispatch Model)
  - Average emission rates may only be available (Capacity Expansion)
  - Very resource intensive
  - All models are proprietary
  - Energy modeling expertise is recommended

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Choosing An Emissions Quantification 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	Typical Approaches			
		eGRID subregion nonbaseload	EGU Capacity Factor	Hourly Emissions	Energy Modeling
PURPOSE	**Prelimary** Analysis	*	*		
PURPOSE	**Voluntary** Programs	*	*		
PURPOSE	**General** benefits Info	*	*		
PURPOSE	**Regulation** or statutory requirement			*	*
EMISSIONS	**Emissions of interest**	CO_2, NOx, SO_2, CH_4, N_2O	NOx, SO_2, CO_2	NOx, SO_2, CO_2	NOx, SO_2, CO_2, varies
SCALE	**Geographical:** State vs. Regional import/export	eGRID subregion partially addressed			
SCALE	**Source Aggregation**	boiler, generator, plant	plant	emission unit (boiler)	emission unit (boiler)
SCALE	**Temporal** - length of time; historical vs. forecasted	annual & ozone season (NOx) historical	annual & ozone season (NOx) historical	hourly historical	annual, ozone season NOx, hourly forecasted
RESOURCES	**Time**	low	low	medium	high
RESOURCES	**Money**	low	low	medium	high
RESOURCES	**Staff expertise**	low	low	medium	high

Thank you!

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Appendix: Additional Resources for Emission Quantification Approaches

EGU Capacity Factor Emission Rates Approach

- eGRID website:
  - http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

Historical hourly emission rates approach

- Examples of this approach:
  - Washington Council of Governments calculator
  - http://www.mwcog.org/environment/air/EERE/default.asp
- Mid-Atlantic Regional Air Management Association Report
  - http://www.marama.org/RegionalEmissionsInventory/2007hourlypoint/FinalDoc_mar2011_Analysis_of_Hrly_CAMD_Emissions_Data.pdf.

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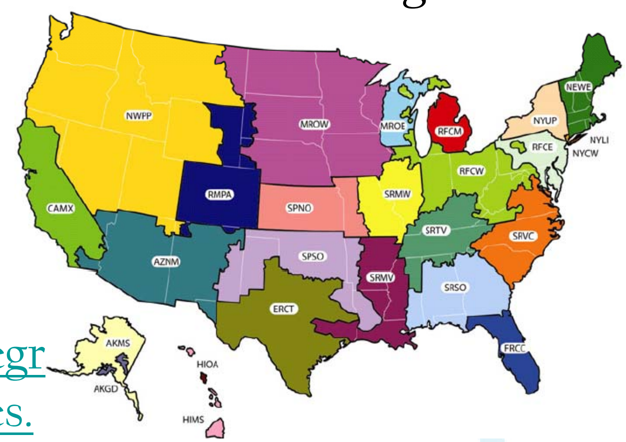
Resources for eGRID subregion non-baseload emission rates approach

Informational resources:

- eGRID website:
  - 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
- eGRID overview presentation:
  - http://www.epatechforum.org/documents/2010-2011/March%2031/Diem-eGRID-2011-03-11.pdf
- New Mexico example using eGRID:
  - http://www.epatechforum.org/documents/2010-2011/March%2031/DeYoung_eGRID_3.31.11.pdf

eGRID Subregions



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