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Valuing Air Pollutant Externality Benefits from Distributed Energy Resources

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Outline

- Basic principles and methodology
- Methods and data needs
- Examples
- Summary

Distributed Energy Resources and Externalities

- Pollution imposes costs on society that are not borne by the polluters themselves

- Internalize environmental externalities
  - Polluter pays a tax based on those damages; or
  - Other resources are paid for the damage that they avoid

- The Commission can increase economic efficiency by directly incorporating the monetary value of avoided emissions into the value stack in the Value of Distributed Energy Resources Proceeding

Principles

- DERs should be compensated for uninternalized damages they avoid
- “E” value should depend on:
  - **Location**: DER worth more when avoiding air pollution in areas with high population density and more vulnerable population
  - **Time:** DER worth more when higher emitting generators are on the margin
  - **Pollutant:** Different pollutants cause different levels of public health and climate damage
- For emitting DERs, “E” value should be reduced based on their emissions and could potentially be negative
- Payment should balance accuracy and administrability

Methodology

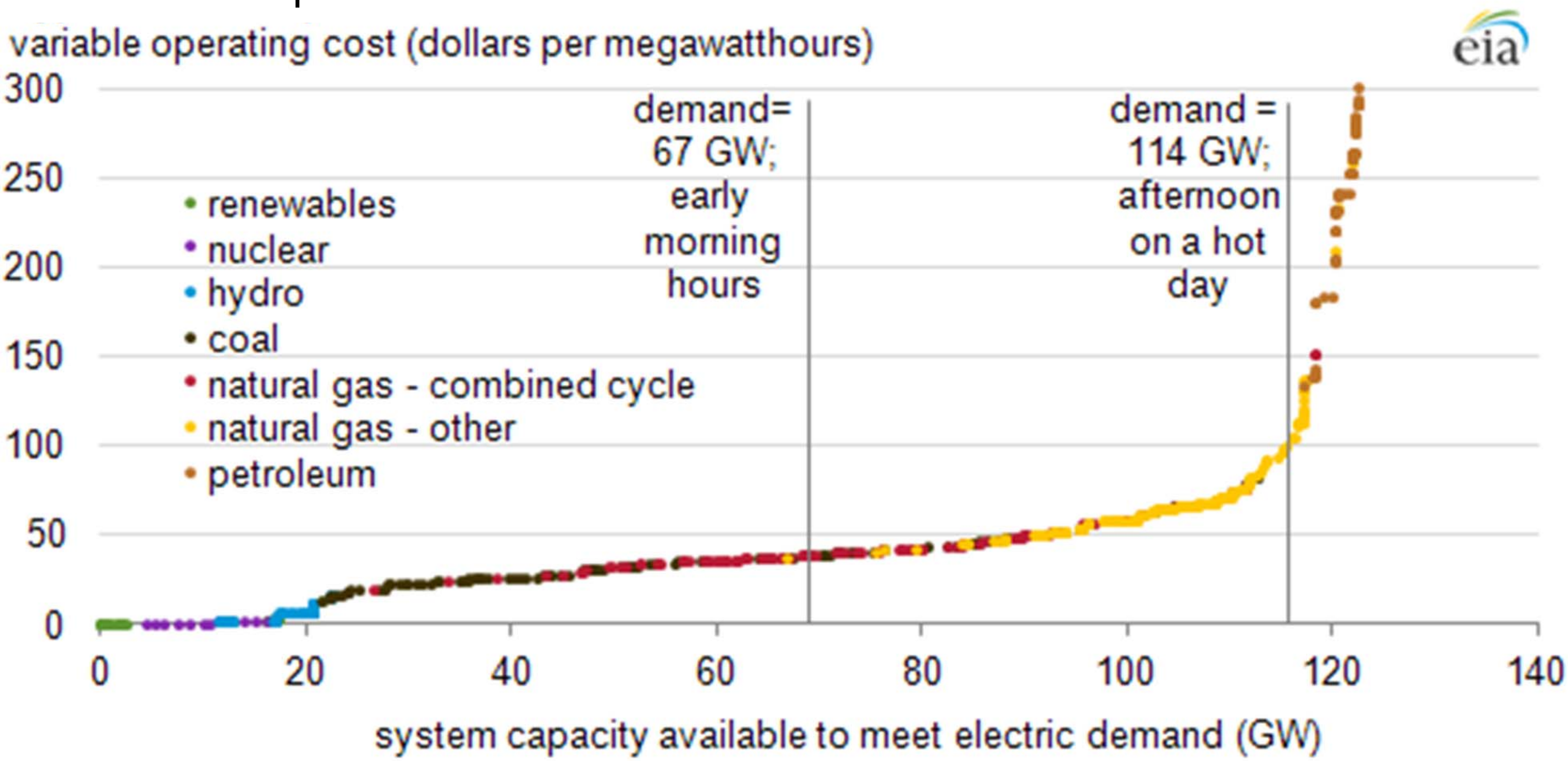
Goal: To calculate environmental value of each kWh of DER generation to be added to DER value stack

Methodology: 5 steps, updated as often as feasible:

1. Identify the generator that is displaced by DER
2. Calculate emission rates (kg/kWh) of the displaced resource *and* DER
3. Calculate the damage per unit ($/kg) of avoided emissions and DER emissions (if any)
4. Monetize the value of avoided damage from displaced generation ($/kWh)
5. *Net* the damages avoided by DER and damages from DER itself (if any)

Step 1: Identify the Generation Resource that Is Displaced

Illustrative Dispatch Curve



Step 1: Identify the Generation that Is Displaced by DER

- A counterfactual ISO run
- Assume that each kWh of DER displaces a kWh of the marginal resource in a particular geographic region/time
  - Assumption: DERs do not change the marginal resource
  - Regional analysis is important when congestion is high
- Approach to Avoid: Grid Average
  - Misses temporal/regional variation
  - Does not guarantee that DERs truly avoid emissions

Step 2: Calculate Emission Rates (kg/kWh) for Displaced Generation Resource and DER

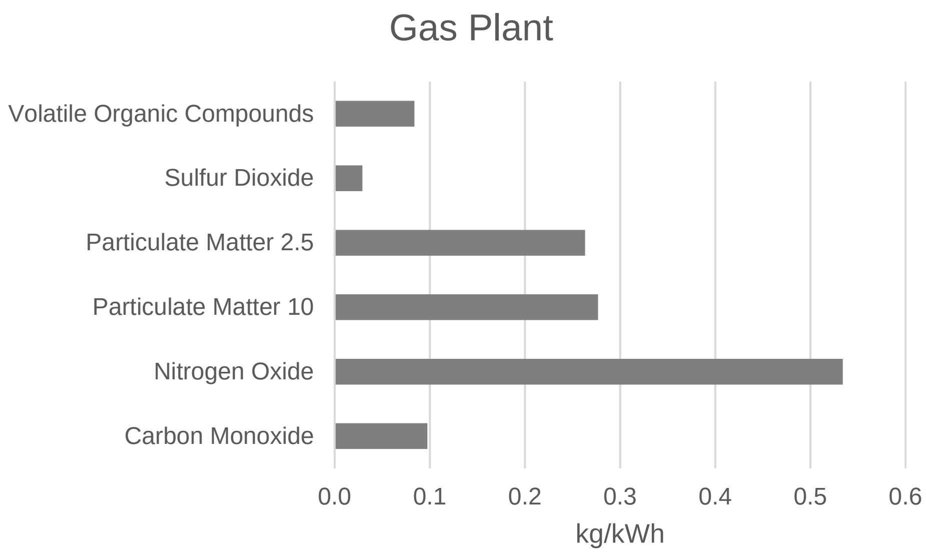
- Historical average emission rates readily available from EPA for large generators
  - Updated every 3 years.
  - Greater than 25 MW
- Smaller, newer generators may require assumed rates based on fuel input, design efficiency, existing/use of pollution control equipment
- Emission rates also vary over time, due to equipment aging, capacity factor changes, and weather
  - Engineering estimates
  - Regression estimates like Graff Zivin (2014)

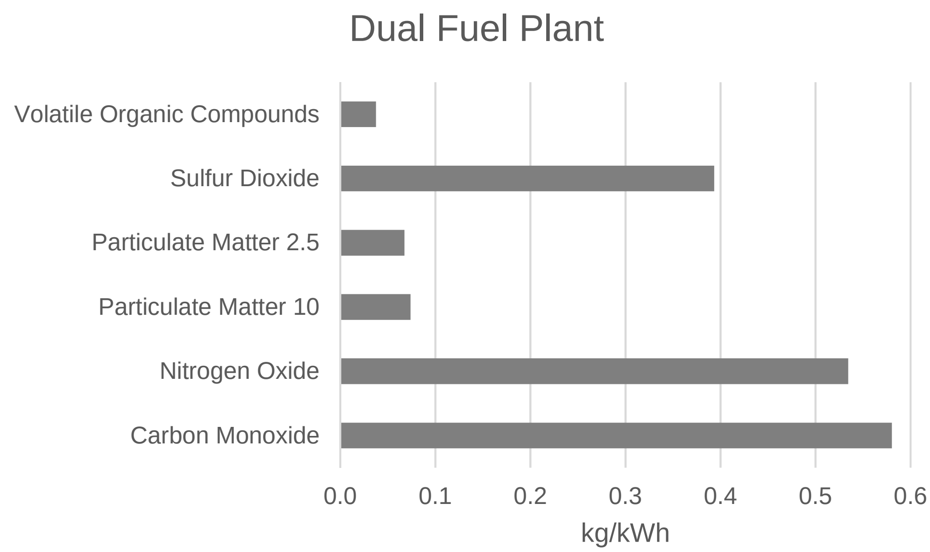
Step 2: Data Needed to Calculate Emission Rates

Potential Emissions Data Sources

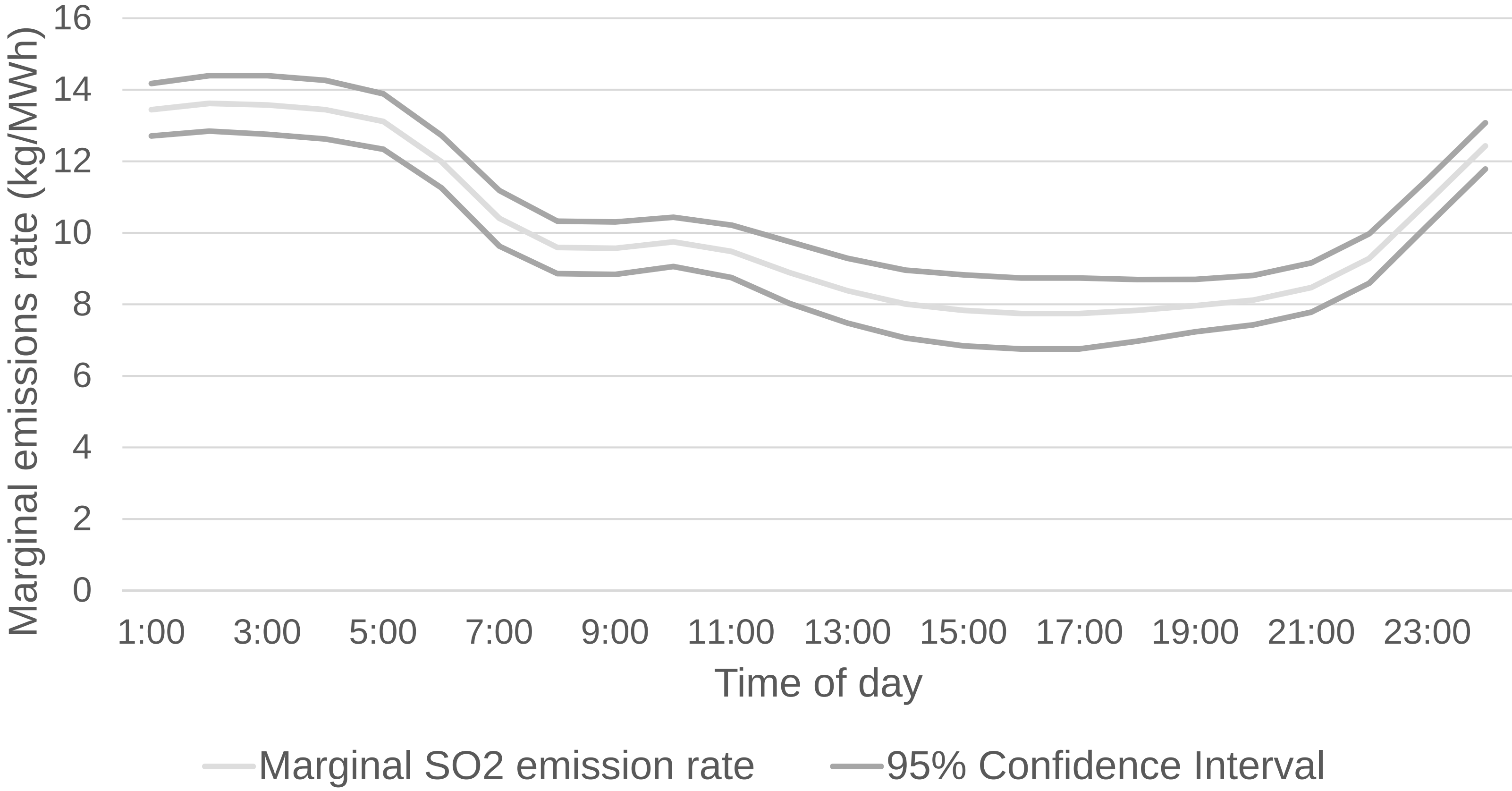
Category	Pollutant	Data Source (latest data year)
Criteria Air Pollutants	SO_2, NOx	EPA eGrid (2014): plant-level emission rates for steam units > 25MW; CT, CC, & ICE online after 1990
	PM2.5 (direct)	• National Emissions Inventory (2014): plant-level annual emissions • National Energy Technology Laboratory (2010): Technology-based emission factors for NGCC • AP-42 (2011): estimate of natural gas and petrol steam turbines and combustion turbines. • NY DEC
GHGs	CO_2, N_2O	eGrid (2014)

Example: Average Emission Rates Based on Fuel Type





Example: Grid-wide Estimated Hourly Emissions Rate for SO_2 in Eastern Interconnection Region



Source: Graff Zivin et. al (2014)

Step 3: Calculate Damage per Unit of Emissions ($/kg)

- CO_2 is a global pollutant so damage calculation is straightforward by using the Interagency Working Group's Social Cost of Carbon

- For other pollutants, damage per unit of emissions is a function of:
  - **Location**
    - Air transport
    - Population density
    - Ambient concentration
    - Local population health status
  - **Time**
    - Ozone is a daytime, seasonal pollutant
  - **Pollutant**
    - Each pollutant has a different damage function
    - Secondary pollutants ($PM_{2.5}$, ozone) are formed by combinations of other pollutants

Step 3: Tools to Calculate Damage per Unit of Emissions

Tool	Geographic Granularity	Add'l Data Needed	Pollutants Covered	Notes	Source
Custom model	Variable	High	ozone (NOx,VOC), $PM_{2.5}$ (directly emitted $PM_{2.5}$, NOx, VOC, SO_2), air toxics	Geographic-specific damage estimates based on: • Air transport • Ambient concentrations • Population, • Comorbidity	Bay Area Air Quality Management District (2017)
EASIUR	36 km	Low	SO_2, NOx, NH_3, $PM_{2.5}$	• Detailed air transport model • Easy calculation of location and time specific emission damage • Seasonal variation	Heo, Adams, and Gao (2016)
BenMAP	High (default); Variable (custom)	Medium (default); Varies (custom)	ozone, $PM_{2.5}$	• Translates all pollutants into secondary PM & ozone; • Driven primarily by mortality; • Can input own data	U.S. EPA
AP2	County	Low	SO_2, NOx, VOC, NH_3, $PM_{2.5}$, PM_{10}	• Accounts for air transport • Broader monetized damage categories	Muller, Mendelsohn, Nordhaus (2011)
COBRA	State or county	Low	$PM_{2.5}$ (directly emitted $PM_{2.5}$, NOx, VOC, SO_2)	• Recently updated (2017) • Previously used by NY PSC • Accounts for air transport • Driven primarily by mortality	U.S. EPA (2017)

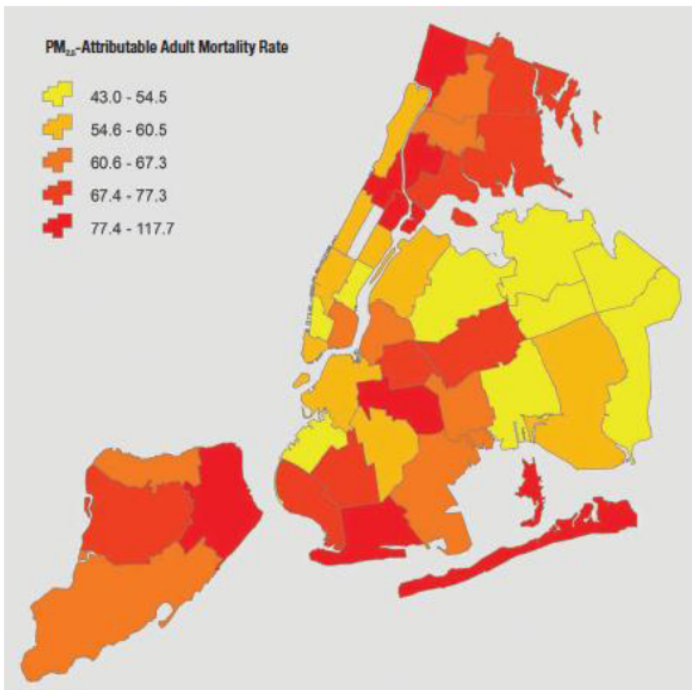
Examples of Damage Per Unit of Emissions

Dollar value of average damage per kg

Pollutant	2016 EPA RIA	DPS	Bay Area
SO2	$40 to $91 per kg	$27 per kg	$39 per kg
NOx	$10 to $40 per kg	$13 per kg	$8 per kg
PM2.5 (direct)	$175 to $400 per kg		$500 per kg

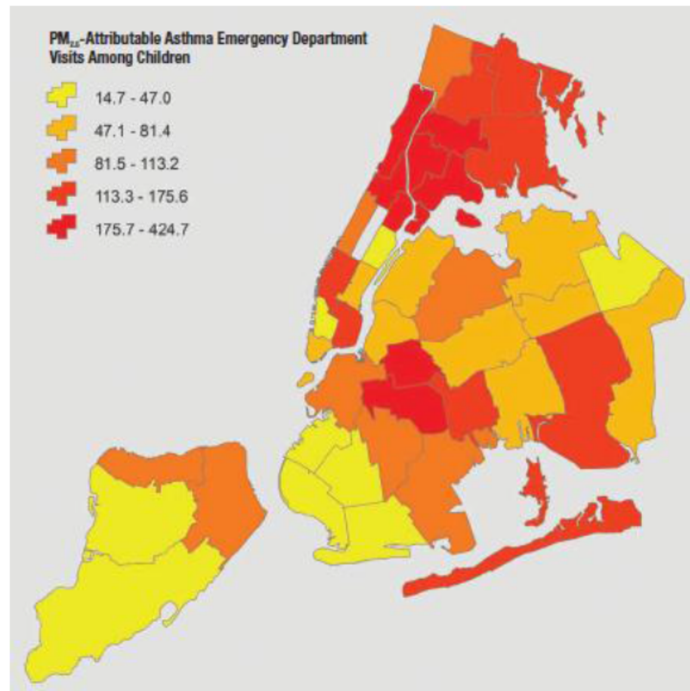
Example: Locational Variation in Damages

Mortality (Krewski *et al* 2009)



2.7-fold variation by neighborhood
73% of deaths occur in ages 65 and above

ED Visits, Asthma (Ito *et al* 2007)



30-fold variation by neighborhood

Source: NYC Department and Health of Mental Hygiene Bureau of Environmental Surveillance and Policy (2013)

Step 4: Monetize the Avoided Externality from Displaced Generation ($/kWh)

- Take into account any existing policies that partially internalize the damages
  - Carbon charge, RGGI, Cross-state air pollution rule (CSAPR)

- Calculate the monetized value of avoided damages per unit of displaced generation for each pollutant
  - Multiply the results of Step 2 and Step 3

Example: Avoided CO_2 damages per unit of generation from a displaced gas generator

Emissions rate = $0.9\,\frac{kg\;CO_2e}{kWh}$

Uninternalized damage rate = $0.035\,\frac{\$}{kg\;CO_2e}$

CO2e monetized value = $0.9\,\frac{kg\;CO_2e}{kWh} \times 0.035\,\frac{\$}{kg\;CO_2e} = 0.032\,\frac{\$}{kWh}$

Example: Monetized Values for a Non-emitting DER

Dollar value of average damage per MWh

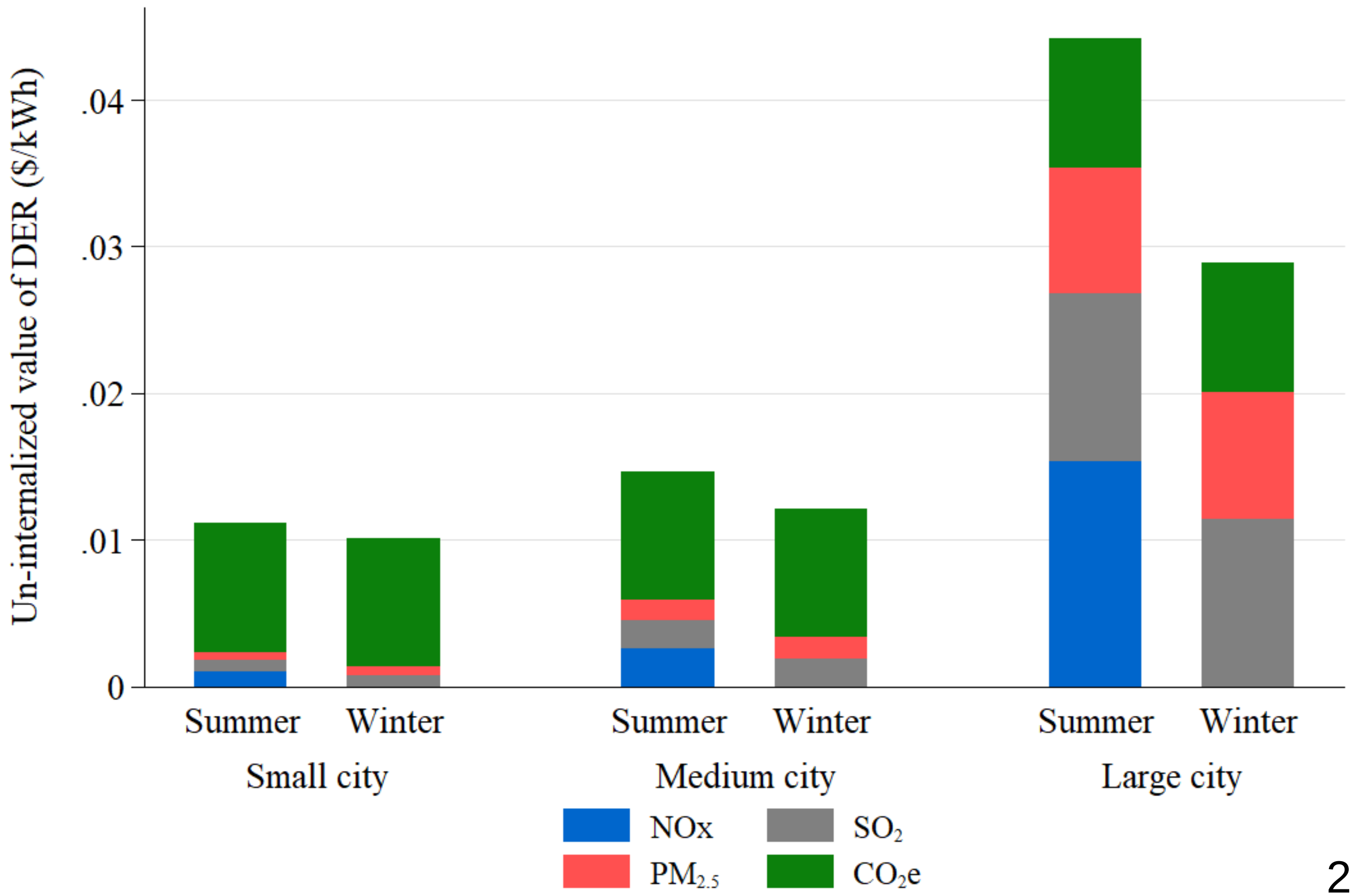
Pollutant	2016 EPA RIA	DPS	Bay Area
SO2	$76 to $171 per MWh	$52 to $55 per MWh	$77 per MWh
NOx	$4 to $12 per MWh	$5 per MWh	$3 per MWh
PM2.5	$7 to $16 per MWh		$22 per MWh

Step 5: Monetize Net Damages

- If the DER does not emit, then the monetized value is given by the previous step
- For emitting DER, monetized value of DER emissions must be subtracted from the amount calculated in Step 4
  - If the DER creates more damage than it avoids, then the “E” value should be negative

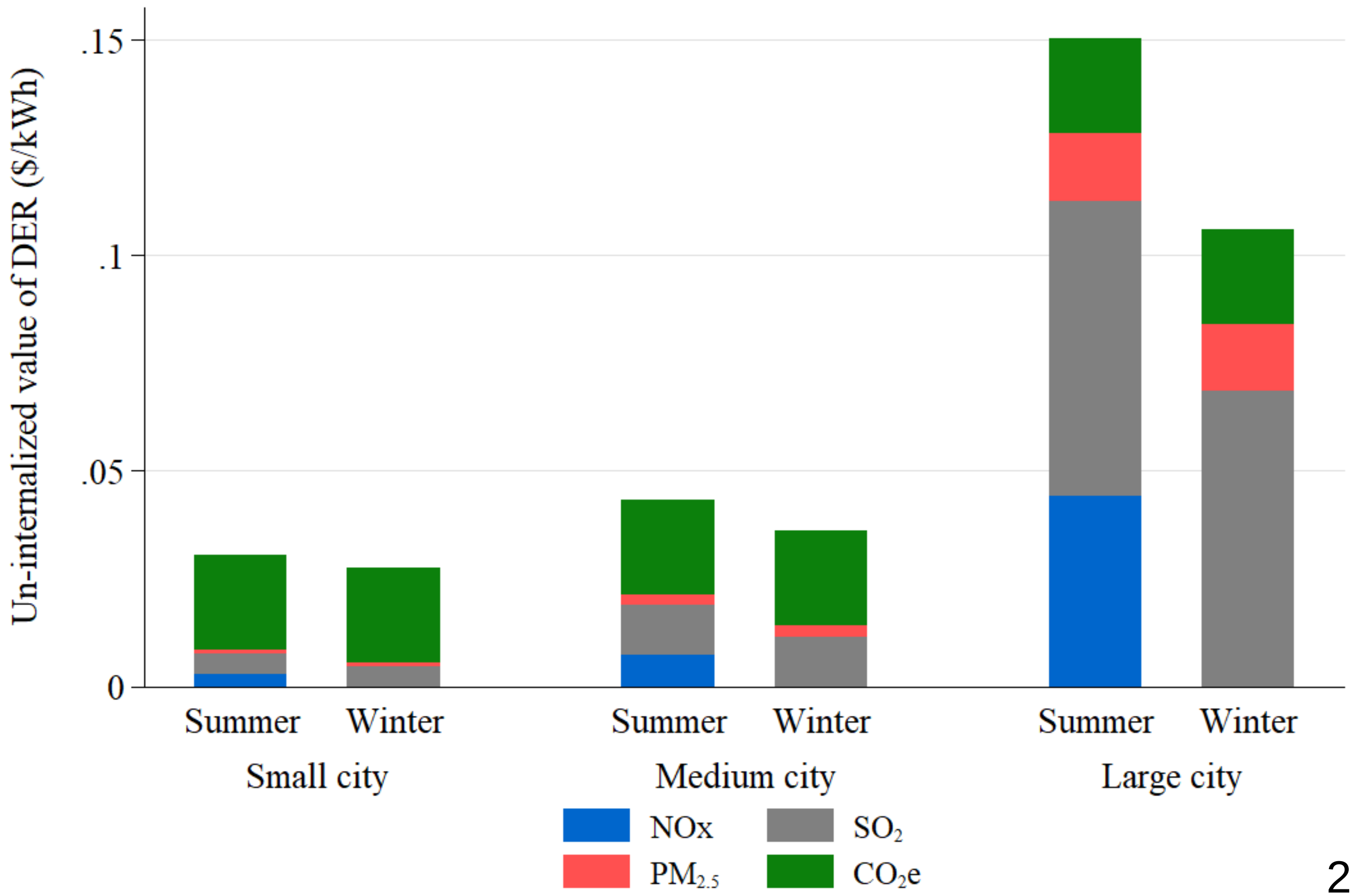
Example: Monetized Net Avoided Damage for Non-emitting DER

Example Values for Three Cities: Gas on the Margin



Example: Monetized Net Avoided Damage for Non-emitting DER

Example Values for Three Cities: Dual Fuel on the Margin



Summary of Methods and Necessary Data

1. Identify the resource displaced by distributed generation
   - Most granular: Counterfactual generation with and without DERs
   - Alternative: Marginal generator (can vary with zone based on congestion)
2. Calculate emission rates
   - Most granular: Real-time emission rates for all pollutants
   - Alternatives: Historical data, engineering or econometric estimates
3. Calculate damages per unit of emission
   - Most granular: Pollution transport, affected population, ambient concentration, comorbidity
4. Monetize the avoided damage from displaced emissions
   - Existing policies should be taken into account
5. Monetize net avoided damage from DERs

Bottom Line

- Externalities should be internalized
- The value of net avoided emissions is not zero
- This value changes with respect to time and location
- We have good, existing research and tools to be able to do this calculation
- The method can get more granular as more tools and data become available