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SAVE ENERGY, **BREATHE BETTER: QUANTIFYING THE SOCIETAL** HEALTH BENEFITS OF **IMPROVING AIR QUALITY** THROUGH ENERGY EFFICIENCY

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Energy Generation and Air Pollution

- Fine particulate matter (PM_{2.5}) is associated with cardiovascular and respiratory disease
 - (e.g., pre-mature mortality, asthma aggravation)
- Fossil-fuel combustion produces emissions of primary PM_{2.5} and precursors to secondary PM_{2.5} formation:
 - Nitrous oxides (NO_X)
 - Sulfur dioxide (SO₂)
 - Ammonia (NH₃)
 - Volatile organic compounds (VOCs)



Public Health and PM_{2.5}



- Socioeconomic and racial disparities in PM_{2.5} exposure well documented
 - Black Americans disproportionately exposed to PM_{2.5} from electricity generation (EPA 2019).

 1µg/m³ increase in county-level long-term PM_{2.5} concentrations in the U.S. associated with an 11–34% increase in mortality due to COVID-19 (Berg, Present, and Richardson 2021; Wu et al. 2020).





Our Work

- Evaluated electric and gas savings from Ameren Illinois Company's (AIC) 2018 EE portfolio
- Leveraged two U.S. EPA-developed tools to quantify emissions reductions and subsequent air quality improvements and monetize health benefits over measure lifetimes
- Estimated both national benefits and those specific to Illinois residents
- Is reproducible and transparent and can be extended to other program types (e.g., transportation, renewable energy)





Methods

ESTIMATE Lifetime energy Savings

2018 portfolio lifetime kWh and therms annual savings used in costeffectiveness testing



ESTIMATE Emissions Reductions

Electric: Use AVERT to estimate changes in electric generation and emissions from 2018– 2022, and to forecast changes from 2023– 2042

Gas: Multiply annual therm savings by emissions factors

ESTIMATE CHANGES IN AIR QUALITY & MONETIZE HEALTH IMPACTS

Use COBRA to estimate air quality changes (i.e., county level PM2.5 concentrations) and to estimate and monetize public health benefits resulting from improved air quality

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CREATE BENEFIT FACTORS

Divide \$ value of health benefits by annual energy savings, apply AIC discount rate, and adjust for inflation APPLY BENEFIT FACTORS & SUM LIFETIME STREAM OF BENEFITS

Multiply benefit factors by annual portfolio energy savings and sum lifetime stream of benefits



AVoided Emissions and geneRation Tool (AVERT)

- Estimates impact of changes in demand for electricity on emissions from individual fossil fuel power plants
 - Outputs: County-level changes in CO_2 , SO_2 , NO_X , and $PM_{2.5}$
- Uses historical hourly emissions and generation data
- Conducts modeling for one of 10 relatively autonomous electricity regions in the continental U.S.





CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)

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- Quantifies and monetizes public health impacts resulting from emissions changes
- Uses a reduced form climate dispersion model to convert emissions changes to air quality impacts

- Uses concentration-response and health valuation functions to calculate impacts on health and \$ value
- Baseline data estimates for 2016, 2023, 2028
- AVERT output file formatted for COBRA use







Results



Lifetime Health Benefits (Million 2018 USD)

	National		Statewide	
Estimates	Low Estimate	High Estimate	Low Estimate	High Estimate
Electric	\$89.53	\$201.86	\$11.83	\$ 26.65
Residential Gas	\$0.56	\$1.26	\$ 0.19	\$0.42
Nonresidential Gas	\$1.64	\$3.71	\$ 0.55	\$ 1.23
Gas Subtotal	\$2.20	\$4.97	\$0.73	\$1.65
Portfolio Total	\$91.73	\$206.82	\$12.56	\$28.30

- Energy savings of ~3,500 GWh and 49,000 thousand therms
- \$92-207M in national health benefits
 - 15% (\$13-27M) accrue to Illinois residents
- 98% of benefits attributable to avoided pre-mature mortality



Illinois vs National (High Estimate)

Electric Lifetime Benefits (Millions)



pinion **Dynamics**

Gas Lifetime Benefits (Millions)



Per-kWh Results



- Range of benefits reflects uncertainty in impact of PM_{2.5} exposure on pre-mature mortality and non-fatal heart attacks
- Annual changes reflect:
 - Decreasing emissions intensity
 - Changes in future baseline emissions, population, and health estimates
 - AIC discount rate of 2.22%



Per-therm Results









Conclusions

Limitations

- Analysis limited to health benefits associated with PM_{2.5}
 - Other emissions benefits (e.g., ground-level ozone, climate impacts) not captured
 - Additional benefits of PM_{2.5} reductions (e.g., visibility, agricultural yields) not captured
- Electric emissions modeling does not capture multiple grid dynamics
- Future electric emissions reductions are uncertain
- Air quality modeling is not sophisticated compared to other models



Future Work

- Use for EV, renewable energy, or building decarbonization programs
- Assess EE impact on specific communities or populations
- Update analysis with new EPA data
 - Use updated AVERT electricity regions
 - Add reductions of NH₃ and VOCs from electric programs





In Closing

- Can use publicly available tools to quantify and monetize health benefits resulting from reduced exposure to PM_{2.5}
 - AIC 2018 portfolio national benefits: \$0.03-\$0.06 per kWh and \$0.04-\$0.10 per therm
- Benefits are agnostic to specific measures
- Flexibility of tools allows for estimation of benefits that align with jurisdictional regulatory goals and/or policies
 - Can limit benefits to just those affecting population of interest
- Method can be used across jurisdictions and program types





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