The air quality co-benefits of US clean energy and climate policies

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1. Clean energy and clean air

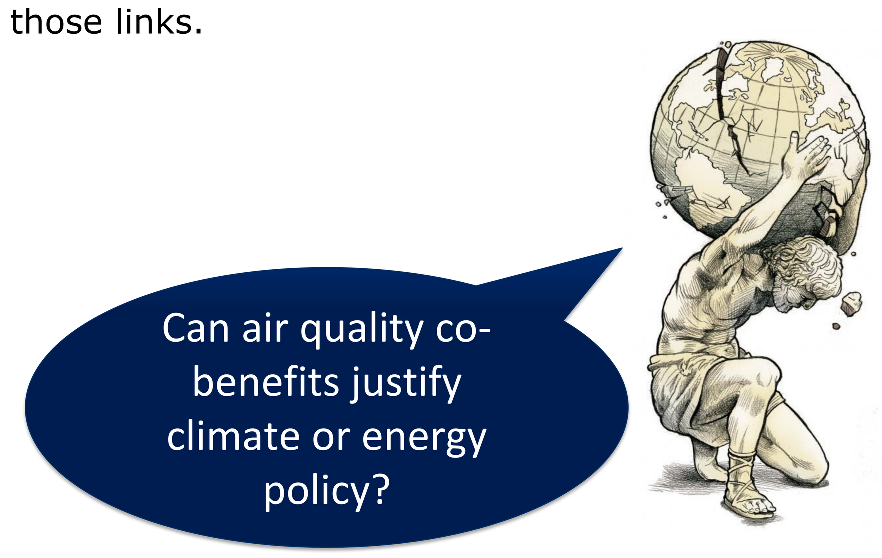
FORWARD ON CLIMATE.

Sustainable policy for clean energy and clean air in a changing climate

In his State of the Union address, President Obama called for policies to mitigate climate change, reduce pollution, transition to clean energy, and drive strong economic growth. Climate change, air pollution, and clean energy are grand sustainability challenges and are intimately linked. This work is part of a growing literature to understand those links.

Will clean energy and climate mitigation change the air?

Here we examine the impacts of energy and climate policy on air pollution. We wonder whether air quality benefits alone can overcome the costs of these policies. Many claim they can, but we need to better understand the drivers and uncertainties of these co-benefits to forge a sustainable path.[1,2,3]



2. What factors drive air quality co-benefits?

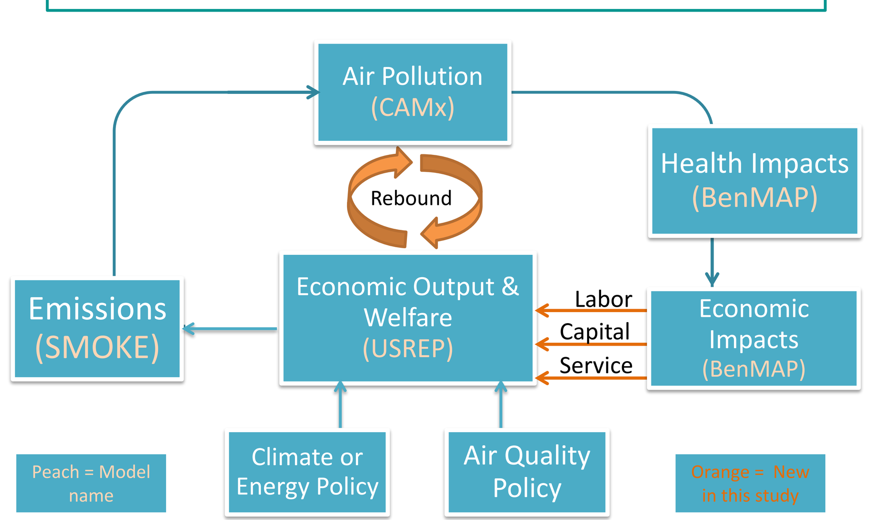
- **Scientists agree that the air quality co-benefits of clean energy and climate policy will be important.** They estimate \$2-196 in co-benefits per ton of CO_2 avoided.[2]
- **But, we do not have a good understanding of what factors drive the differences in these estimates.** Is it the type of policy? Economic assumptions? Our estimation techniques?
- **This poster compares the air quality co-benefits to the costs of two policies**, and presents the effect of policy type, economic assumptions and valuation techniques on estimates of air quality co-benefits of a clean energy standard and cap-and-trade program.

3. Modeling energy & climate policy

- We compare the air quality impacts of **two national climate policies**:

- **Clean Energy Standard (CES)** modeled from the Clean Energy Standard Act of 2012, reducing total greenhouse gas (GHG) emissions by 10% in 2030 relative to 2006, beginning in 2012.
- **Cap-and-Trade (CAT)** program requiring the same GHG reductions.
- We track the effect of each policy on pollutant emissions, concentrations and impacts through a novel integrated assessment framework.[4]

Integrated Assessment Model of Air Quality Co-Benefits



Economic Model:
We use a Computable General Equilibrium (CGE) economic model to estimate the effect of policy on emissions, and of air quality impacts on the economy. With simplified production and human behavior, the model is able to track the many decisions made under these policy instruments. It has rich detail in the energy sector, and is grounded in economic data.[5]

Air Quality Model:
We use a 3D high-resolution chemical transport model to estimate outdoor pollution levels due to emissions. This model has been validated and used extensively.[6]

Health Impacts Model:
We use a regulatory health impact model which relates air pollution to health impacts and costs through peer-reviewed epidemiologic and economic studies.[7]

- Here, we improve this framework to estimate policy costs and co-benefits using consistent economic assumptions and economic impacts by estimating costs and co-benefits using the CGE model. We track shocks to labor and capital, and demand for health services.[8,9,10,11]

4. The key drivers of air quality co-benefits

Effect of Policies on Pollutant Emissions

Each policy affects the output of polluting sectors. Though the total changes are similar, the location and timing of these emissions are important in determining the final atmospheric concentrations. For the CES, these changes are more focused on areas near electric generating units, whereas for the CAT the reductions are spread more uniformly.[4]

Sensitivity Analysis

Colleagues assessed the impact of high economic growth, readiness of renewables, transportation efficiency, and baseline emissions. The effect on the total emissions were small. For example, reductions in NOx across scenarios for the CES were 104 to 107%.[4]

Policy	Percent Emissions Change by Pollutant in 2030 NO_x	CO	SO_2	VOC	NH_3
Clean Energy Standard	-106%	-101%	-124%	-101%	-101%
Cap and Trade	-103%	-101%	-110%	-101%	-100%

Both policies reduce pollutants. CES removes more SO_2.

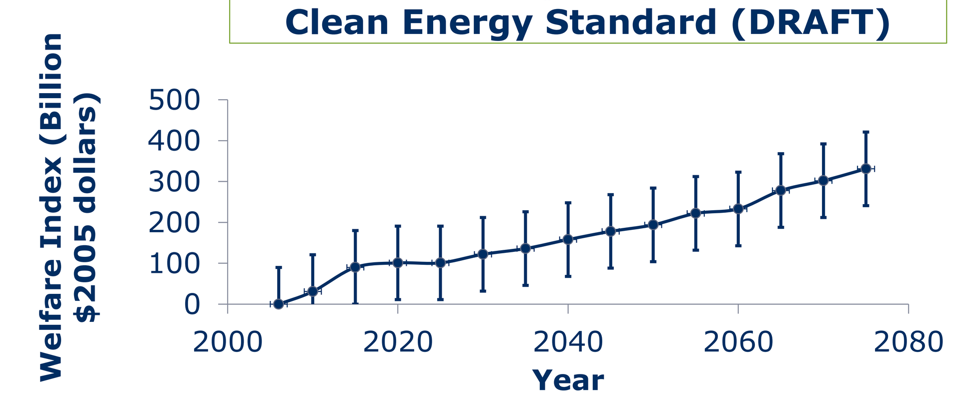
Effect of Compounding and Indirect Economic Effects

Typical environmental benefits assessments will assess benefits in a single year.

Our work assesses impacts every year, so that a change, e.g., in productivity or investment, in one year will have indirect effects that compound into future years.

An illustration of this effect is shown to the right for the CES. (Error bars represent 95% CI of health impacts).

Cumulative Air Quality Co-Benefits of Clean Energy Standard (DRAFT)



Co-benefits affect welfare in future years.

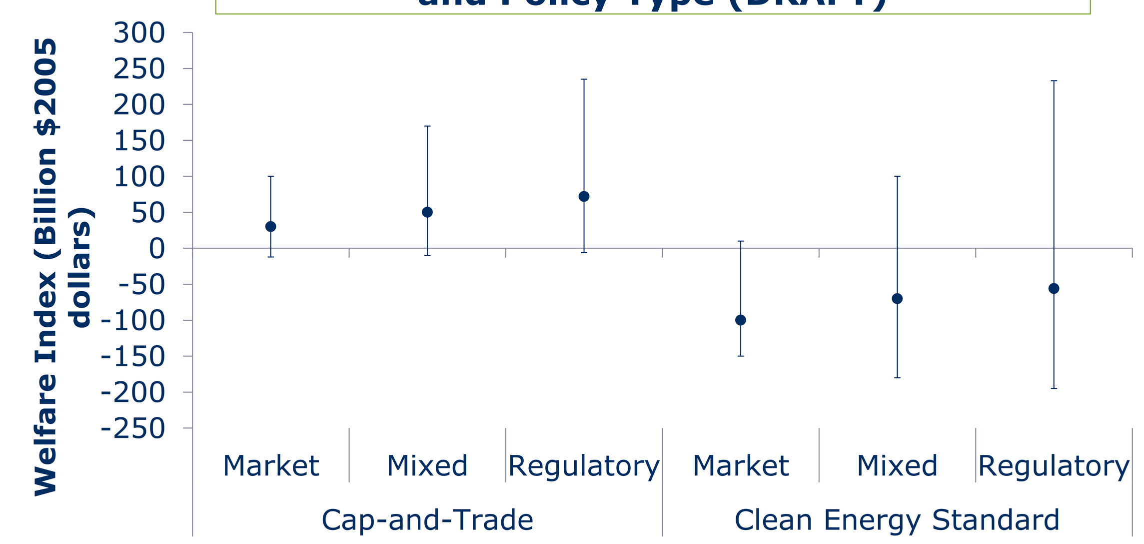
Effect of Economic Valuation Technique

We compare different techniques to assign economic value to health impacts:

1. "Market-based" approach looking at medical costs and lost wages [12]
2. "Mixed approach" using Willingness-to-Pay (WTP) to account for suffering as a loss of leisure [8,9,10]
3. "Regulatory approach" using WTP values wherever available, including for mortality risk. [12]

"Net Co-Benefits (NCB)" are co-benefits minus policy costs. If NCB > 1, then co-benefits alone offset the costs of this policy. (Errors based on health impacts).

Net Co-Benefits in 2030 by Valuation Method and Policy Type (DRAFT)

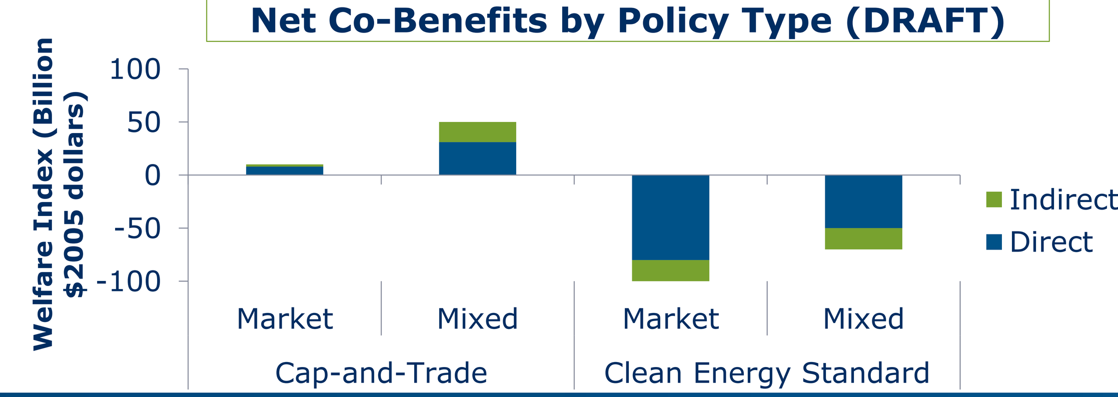


- Net Co-benefits of CAT are higher than CES.
- Both policies have some positive net benefits.
- Regulatory valuation method gives highest benefits.

Indirect Effects

The market and mixed methods are compatible with the CGE framework, and can thus account for cumulative and GE effects, unlike the regulatory approach. The sum of indirect effects compared to direct effects is shown to the right for the CES.

Contribution of Indirect Economic Effects to Net Co-Benefits by Policy Type (DRAFT)



5. Conclusions

Air quality co-benefits are high for both policies, and seem to justify a CAT

Air quality co-benefits alone are able to offset the costs of a CAT under most scenarios considered. Though a CES has higher total air quality benefits, it also has higher costs because it restricts abatement to one sector. Co-benefits can offset a significant fraction of costs of both policies.

Compounding and indirect effects can be important components of co-benefits

These effects can be important, and regulatory evaluations do not include them. Our estimates are conservative as we do not account for environmental preferences, which previous work shows can cause a 12-49% underestimation of benefits.[13] Challenges remain in valuing air quality as a public good and in representing preferences for environmental quality.

Choice of economic valuation method can determine whether co-benefits exceed costs

Market-based valuations leads to the smallest co-benefits estimates, as well as the smallest indirect effects. Adding some WTP estimates yields greater benefits with greater indirect effects. The full WTP valuation approach yields the highest co-benefits, but is not resource constrained.

Our co-benefits estimates are conservative

We do not value air quality as a public good, nor do we allow preferences for air quality to interact with preferences for market goods. We focus on health-related impacts, and exclude effects from pollutants other than ozone and fine particulate matter, damages to ecosystems, materials, and crops.

More work is needed to explore key drivers of co-benefits

We're concurrently analyzing assumptions of economic growth, availability of low-carbon substitutes for electricity, transportation efficiency, policy stringency, baseline pollutant emissions, and concentration response functions.[4] We previously examined model resolution.[14]

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Images from http://forumonenergy.com/2012/05/18/experts-project-significant-role-for-nuclear-under-the-clean-energy-standard-act/ and http://www.epa.gov/captrade/

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