New Tools to Rapidly Quantify the Impacts of Mitigation Policies Affecting Climate Change and Air Pollution

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(& IIASA, Norwegian Govt)
Greenhouse gas emissions pathways

• To limit warming to 1.5°C, CO₂ emissions fall by about 45% by 2030 (from 2010 levels)

• To limit warming to 1.5°C, CO₂ emissions would need to reach ‘net zero’ around 2050

• Reducing non-CO₂ emissions would have direct and immediate health benefits
Greenhouse gas emissions pathways

- Limiting warming to 1.5°C would require changes on an unprecedented scale
  - Deep emissions cuts in all sectors
  - A range of technologies
  - Behavioural changes
  - Increased investment in low carbon options
Achieving 1.5°C means more, and redirected, investment

Carbon prices (Interquartile over whole century):
~$100-180 ton$^{-1}$ low, $60-140$ high OS
Public Perceptions

People greatly discount uncertain future events when considering costs and benefits over multiple timescales.

People discount risks that occur remotely and tend to believe climate change will largely influence people in far away places.

Highlighting risks for specific localities more effectively communicates the damaging effects of climate change.

Berns et al., Trends in Cog. Sci., 2007
Leiserowitz et al., Risk Analysis, 2005
Van der Linden et al., Persp. Psych. Sci., 2015
Scannell & Gifford, Env. & Bhvr., 2013
Going from 2°C to 1.5°C or not relying on ‘negative emissions’

1.5°C pathways lead to ~1.3 million fewer premature deaths yr\(^{-1}\) in 2030 vs 2°C, ~150 million over century (due to both ozone and PM\(_{2.5}\))
With an Integrated Approach
Integrated Metrics

METRICS
Measures to quantify impact of emissions

Increasing Policy Relevance

Emissions

Atmospheric Concentrations

Radiative Forcing

Climate Change

Impacts

Development of mitigation strategies, including mitigation costs, damage costs, discount rates

Increasing Uncertainty

IPCC AR5, 2013
Economics of Benefits from Climate Change Mitigation

Only 5% of benefits national for US natural gas

Shindell et al, Nature Climate Change, 2018
Synergies between Clean Air and Climate Change Mitigation

All linked to SDGs

All 25 measures: CO₂ by ~20%; CH₄ by ~40%; BC by ~70%; HFC by ~80%

Reduce warming by ~0.3 °C

Development measures reduce pollution control costs $75B

Several hundred thousand premature deaths prevented annually (~1/3 reduction)
Ozone
Several hundred thousand premature deaths prevented annually (~40% drop), ~45% drop in crop yield losses

FIGURE 2.7: ESTIMATED NUMBER OF PREMATURE DEATHS ASSOCIATED WITH EXPOSURE TO OZONE IN 2015, AND IN 2030 FOR THE BASELINE AND THE TOP 25 CLEAN AIR MEASURES FOR THE MODELLED SUB-REGIONS OF ASIA

FIGURE 2.8: ESTIMATED OZONE-INDUCED CROP LOSSES FOR MAIZE, RICE, SOY AND WHEAT IN 2015, 2015 AND 2030 FOR THE BASELINE AND THE TOP 25 CLEAN AIR MEASURES

UN Environment, CCAC, APCAP, Asian Solutions Report, 2018
Norway: Planned (top) vs low-CO$_2$+Maximum Feasible Reduction (bottom)

Planned reductions in CO$_2$

Additional potential via end-of-pipe reductions: Dominated by CH$_4$
Arctic Council nations potential climate impact

Impacts of combined low-\(\text{CO}_2\) and Air Quality+Methane policies
<table>
<thead>
<tr>
<th>CUMULATIVE METHANE BENEFITS</th>
<th>UNCERTAINTY RANGE</th>
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<tbody>
<tr>
<td>Premature deaths due to ozone</td>
<td>-383,000 (-248,000 to -552,000)</td>
</tr>
<tr>
<td>Mt yield loss in wheat+rice+maize+soy due to ozone only</td>
<td>-214 (-135 to -372)</td>
</tr>
<tr>
<td>Economic losses (billions $US)*</td>
<td>-149 (-101 to -199)</td>
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</tbody>
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*due to forestry, agriculture, & non-mortality health impacts
1.5°C relative to 2°C via greater emissions cuts: ~0.6% of world GDP due to reduced air pollution worldwide in 2060 (based on OECD)

Air pollution valuation: market costs due to labor, capital, healthcare and agriculture only

Mitigation costs 1-2% of world GDP

With non-market costs benefits greatly outweigh mitigation costs considering climate & air pollution (World Bank, OECD, Shindell et al., NCC, 2016, etc.)
Synergies between Clean Air and Climate Change Mitigation

**Ozone**: New epidemiology (Turner et al., AJR, 2016) indicates greater respiratory impacts and existence of cardiovascular effects. Net effect: *much larger impacts* despite model biases (Seltzer et al., ERL, 2018)

**PM$_{2.5}$**: New epidemiology (Burnett et al., PNAS, 2018) indicates *much larger impacts* (>100%)

Health benefits presented here are very likely to be biased quite low (& hence valuation likely offsets the *majority or all* of mitigation costs)
Synergies between Clean Air and Climate Change Mitigation
Synergies between Clean Air and Climate Change Mitigation

~$1B in power lost each year

Figure 4. Modeled influence of both ambient PM and deposited PM on the reduction of available energy for solar power production in three key regions.

based on Bergin et al, ES&T, 2017
Economic benefits of climate change mitigation

2016-2006 vs. 1980-1990 Labor loss (millions $) due to temperature
All Emissions to Date: Absolute Production Changes

Impacts due to climate change and ozone
Economic benefits of climate change mitigation

**Quantification practical for:**

- labor lost due to climate & AQ
- crops lost due to climate & AQ
- health care expenses due to climate & AQ
- solar power generation lost to AQ
- forestry due to ozone
- VSL for mortality
Conclusions

Achieving 1.5°C and air quality guidelines is challenging, but means improved public health, increased labor productivity, improved crop yields, increased solar power capacity, and many other benefits...

...these can be quantified to optimize policies & reveal cost-effective solutions