Marginal abatement cost curves for NOx incorporating both controls and alternative measures

Office of Research and Development

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Abstract

A marginal abatement cost curve (MACC) traces out the efficient marginal abatement cost level for any aggregate emissions target when a least cost approach is implemented. In order for it to represent the efficient MAC level, all abatement opportunities across all sectors and locations must be included in the curve. However, in the context of air quality management, MACCs typically are approximated by sorting well-characterized *end-of-pipe* controls by their respective cost effectiveness. Alternative measures, such as renewable electricity, energy efficiency, and fuel switching (RE/EE/FS), are not considered as it is difficult to quantify their abatement potential. As such, existing approximations of MACCs may be biased high.

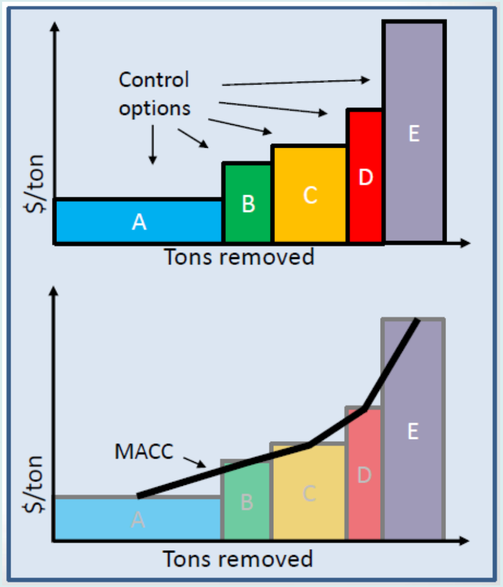
We demonstrate the use of an energy system model to develop national and sectoral MACCs for nitrogen oxides (NOx) that incorporate both end-of-pipe controls and these alternative measures. The resulting MACCs may be incorporated into other modeling tools, such as Integrated Assessment Models, and may be of use in developing emission control strategies.

Background

A MACC traces out the relationship between the amount of control and the cost of reducing the next ton of emissions.

EPA has developed MACCs representing end-of-pipe control measures.

EPA's Control Strategy Tool (CoST) includes a database of such measures.



Problem and research questions

For stringent control targets, end-of-pipe controls may not be sufficient to meet the required reductions.

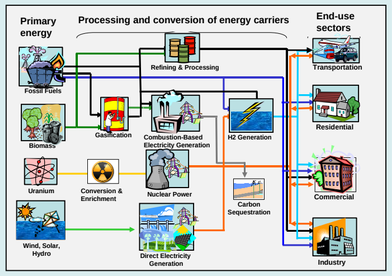
However, MACCs developed using CoST do not include non-end-of-pipe measures, such as renewable electricity, energy efficiency and fuel switching (RE/EE/FS).

- How many additional emission reductions are available via RE/EE/FS once end-of-pipe controls have been exhausted?
- What is the cost-effectiveness of RE/EE/FS relative to end-of-pipe controls?
- How do we keep from double-counting reductions from end-of-pipe and RE/EE/FS?
- Can we develop control strategies that optimally combine end-of-pipe controls and RE/EE/FS?

Approach: Model

Name: MARKet ALlocation model
Dataset: EPAUS9r_14 database
Resolution: U.S. Census Division
Temporal: 2005-2055, 5-yr steps
Sectoral resolution: electric, residential, commercial, industry transportation, resource extraction
Solution: linear programming with perfect foresight
Runtime: 30 min-1 hour on desktop PC

MARKAL energy system model
US EPA 9-region database



Approach: Method

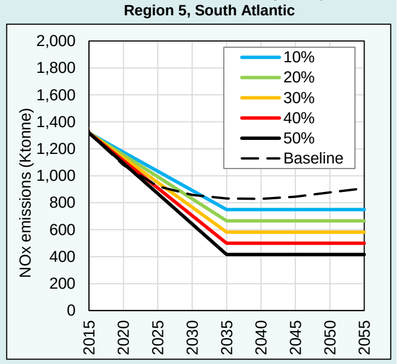
Step 1. Iteratively solve MARKAL for increasingly stringent regional NOx trajectories

Step 2. Record corresponding marginal NOx reduction costs

Step 3. Evaluate the relative roles of controls and RE/EE/FS

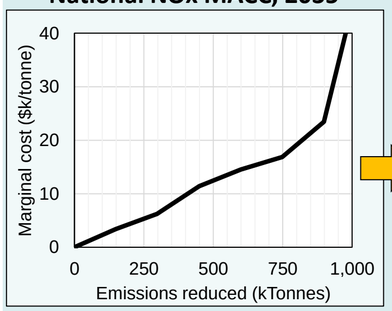
Note: Focus of the analysis (for now) is on 2035

NOx – Baseline and reduction target trajectories
Region 5, South Atlantic

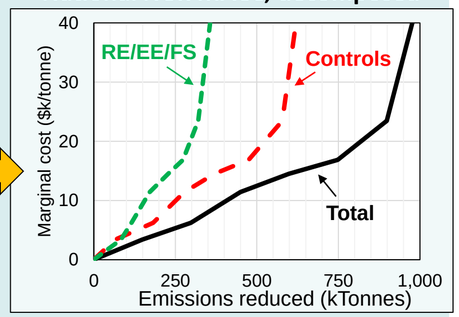


Illustrative results, 2035

National NOx MACC, 2035

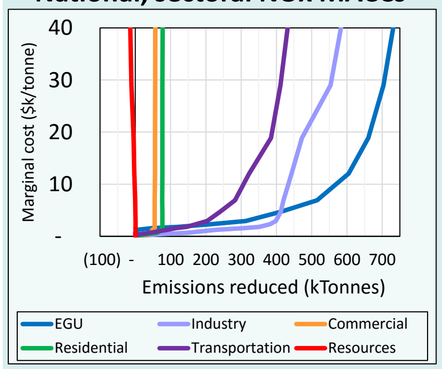


National NOx MACC, decomposed

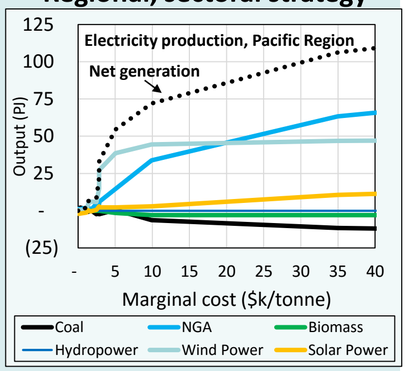


- Up to $5k/t, RE/EE/FS provide the same reduction as end-of-pipe controls
- Between $5k/t and $40k/t, RE/EE/FS increase the system-wide reduction potential by 50% relative to end-of-pipe controls

National, sectoral NOx MACCs



Regional, sectoral strategy



- Decomposing the MACC by sector helps identify control opportunities.
- Sectoral and regional MACCs can provide useful insights. The figure to the left shows that transportation and industrial opportunities may be plentiful. The figure to the right suggests that Pacific Region electricity output may increase substantially as a result of its relatively abundant renewable resources.

Conclusions

The MARKAL energy system model provides a good analytical platform for exploring emission reductions available from RE/EE/FS.

RE/EE/FS are shown to have the potential to increase NOx reductions by 50-100% beyond what is available via end-of-pipe controls.

Some RE/EE/FS are cost-competitive with end-of-pipe controls.

MACCs can be decomposed to explore regional and sectoral strategies.

For more information

Contact Dan Loughlin (loughlin.dan@epa.gov) , or see:

Loughlin, D.H., Kaufman, K., Macpherson, A. (2015). Characterization of regional abatement cost curves for NOx that incorporate control measures, renewable energy, and energy efficiency and fuel switching. In *Proceedings of Air & Waste Management Assoc. Annual Mtg.*, Raleigh, NC, June 22-25.

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