Understanding the policy implications of uncertainty in modelled biofuel life-cycle greenhouse gas emissions to improve policy design
Kimberley Mullins, W. Michael Griffin, H. Scott Matthews

Motivation
Biofuels have received legislative support recently in California’s Low-Carbon Fuel Standard and the Federal Energy Independence and Security Act. These include required life-cycle greenhouse gas emission reductions of biofuels over fossil fuels set to be displaced. Although legislation acknowledges uncertainty and variation in input parameters in the LCI calculations, particularly related to land use change emissions, no quantitative methodology to deal with the uncertainty is prescribed. This is troublesome for two reasons: first, using only single values disregards the ranges and uncertainty in data used to generate a point estimate (such as a mean value), and second, new fuel life cycles can only be predicted, not measured.

Approach
This work utilizes Monte Carlo simulation to estimate life-cycle emissions distributions from ethanol and butanol from corn or switchgrass. Data for input distributions are drawn primarily from previous literature studies and government databases.

Results and Conclusions
Life-cycle emissions for each feedstock and fuel pairing modeled distributions span an order of magnitude or more. Corn ethanol emissions range from 50 to 250 g CO2e/MJ, for example, and each feedstock-fuel pathway show some probability of greater emissions than a distribution for gasoline (Venkatesh et al., 2010). Potential GHG emissions reductions from biofuel use are difficult to forecast given this high degree of uncertainty in life-cycle emissions. This uncertainty is driven by the importance and uncertainty of indirect land use change emissions.

Incorporating uncertainty in the decision making process can illuminate the risks of policy failure (i.e., increased emissions), and a calculated risk of failure due to uncertainty can be used to inform more appropriate reduction targets in future biofuel policies.

Future work will examine how best to incentivize agents within the biofuel supply chain to act to reduce GHG emissions in their respective life-cycle stages, and how GHG reduction targets written into policy may be designed to intelligently accommodate certain irreducible uncertainties in the biofuel life cycle.

References

For more information, contact
Mike Griffin
mwg@andrew.cmu.edu
(412) 268-2299