Executive Summary

Background Information on the MSU-EPRI Methodology for Quantifying Nitrous Oxide Emissions Reductions from Reduced Use of Nitrogen Fertilizer on Agricultural Crops

The MSU-EPRI Methodology for Quantifying Nitrous Oxide (N\textsubscript{2}O) Emissions Reductions from Reduced Use of Nitrogen Fertilizer on Agricultural Crops (i.e., the “MSU-EPRI N\textsubscript{2}O Offsets Protocol”) provides a way for farmers to obtain carbon offset credits by reducing the amount of nitrogen used to fertilize crops. This methodology was developed by Michigan State University (MSU) as part of a collaborative research project with the Electric Power Research Institute (EPRI).

How Does This Protocol Work?

This new greenhouse gas (GHG) emissions offsets protocol makes it possible for farmers in the 12-state North Central Region (NCR) of the United States to generate GHG emissions offsets by reducing N\textsubscript{2}O emissions from fertilized corn by reducing the amount of nitrogen fertilizer applied. Fertilizer reductions would be achieved with more precise estimates of crop needs or other emerging technologies. The NCR region encompasses the twelve Midwestern states of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. The region is the major producer of the nation’s corn - in 2010, of the 88 million acres of corn for grain planted in all the United States; 73 million acres (~83%) were planted in the NCR. The estimated technical potential for reducing emissions of N\textsubscript{2}O by reducing nitrogen fertilizer rate in NCR corn crops eligible for use in offset projects utilizing the MSU-EPRI protocol is approximately 6 million metric tons CO\textsubscript{2}e per year.

To achieve desired production levels, most U.S. farmers apply synthetic and organic nitrogen fertilizer to their corn fields every year. Once nitrogen fertilizer hits the ground however, it is hard to contain in the field and is easily lost to groundwater, rivers, oceans and the atmosphere. Nitrogen lost to the environment from agricultural fields is nitrogen not used by the crops. This costs farmers money, degrades water and air quality, and contributes to GHG emissions.

Farmers already manage fertilizer to avoid large nitrogen losses, but they are often reluctant to further reduce their use of fertilizer because they fear doing so will decrease valuable crop production and will end up costing more than the fertilizer savings. The MSU-EPRI N\textsubscript{2}O Offsets Protocol is an innovative approach to pay farmers to apply nitrogen fertilizer in a way that more precisely matches crop needs, and therefore in a way that does not jeopardize crop yields. It provides farmers an opportunity to participate in existing and
emerging carbon markets by creating GHG emissions offsets. When farmers reduce their nitrogen fertilizer use, they can generate carbon offset credits. These credits then can be sold to other participants in the carbon markets who may be required to reduce their GHG emissions, and to corporations and organizations that want to buy offsets to meet voluntary internal sustainability goals.

The Issue
GHG offsets can be an effective option for electric power companies and other organizations to reduce GHG emissions more cost-effectively than otherwise would be possible as state and potentially federal climate change policies are adopted. Offsets are an attractive compliance option because they allow companies to substitute lower-cost GHG offsets for more expensive internal emissions reductions or buying CO₂ emissions allowances in the open market. As offsets policies and programs continue to evolve, increased attention is being focused on the development of offsets in the U.S. agriculture and forestry sectors. These are the only large economic sectors likely to remain “uncovered” in the future and so be eligible to produce GHG offsets.

Nitrous Oxide Emissions in the United States
N₂O is a powerful GHG with a global warming potential about 300 times greater than carbon dioxide (CO₂). It can remain in the atmosphere for more than 100 years. This means that small changes in N₂O emissions are very important, and that lowering emissions through offset projects will be beneficial in mitigating climate change in the long-term.

Agriculture is an important source of N₂O. In soils, the production of N₂O through microbial activity is a natural process. By applying large amounts of nitrogen fertilizer, however, humans have greatly increased N₂O emissions from soils to the atmosphere. This is especially true when farmers apply more nitrogen fertilizer than the crop needs to achieve optimum yields, and when it is applied at times or in ways that make it difficult for the crop to get full benefit of the fertilizer.

Reducing N₂O emissions in row-crop agriculture like corn and wheat is one of the most promising approaches to reducing agricultural GHG emissions in the United States and around the world. Globally, more than 50% of N₂O emissions are from agricultural soil. N₂O emissions from agricultural land management in the United States account for about 226 million tons CO₂e of emissions annually, comprising 68 percent of total U.S. N₂O emissions, and more than three percent of total U.S. GHG emissions. Since 1990, U.S. agricultural N₂O emissions have increased by 5.3%. Corn is among the most intensive user of fertilizer (both per acre and in total use), and fertilizer applied to corn is least likely to be applied in accordance with best management practices that can help to reduce N₂O emissions. A large proportion of agricultural-related N₂O emissions in the United States are emitted from corn crops grown in the 12 states of the NCR.

EPRI and MSU Research Findings
The science that underlies this new offsets methodology is a result of two decades of research conducted by MSU at the Kellogg Biological Station Long-Term Ecological Research (KBS LTER) site, and on scientific data developed by MSU through on-farm field testing conducted over a three-year period (2008 – 2010) in collaboration with EPRI. At the KBS site - and on commercial farm fields across Michigan - KBS LTER scientists conducted experiments on N₂O emissions from fields that received varying amounts of nitrogen fertilizer.

By closely tracking N₂O emissions, crop yields and other ecosystem responses to fertilizers, MSU researchers discovered that N₂O emissions increase exponentially with increasing nitrogen fertilizer use. In collaboration with EPRI, MSU researchers also successfully demonstrated that N₂O emissions in row-crop production can be substantially reduced by using less nitrogen fertilizer with no related reduction in crop yield. In other words, adding a small amount of fertilizer above the amount needed for optimal crop growth creates much more N₂O than otherwise would have been produced. The more excess nitrogen there is available, the greater the additional rate of N₂O production. Quantifying this exponential relationship provides a novel and powerful way for farmers to quantify and generate carbon credits by reducing fertilizer use while maintaining crop productivity.
American Carbon Registry Approves MSU-EPRI N₂O Offsets Protocol

The American Carbon Registry (ACR) of Winrock International recently approved the MSU-EPRI N₂O Offsets Protocol for use by farmers who participate in ACR’s GHG offsets program. The final version of the MSU-EPRI N₂O Offsets Protocol is available online at http://americancarbonregistry.org/carbon-accounting/carbon-accounting/methodology-for-n2o-emission-reductions-through-fertilizer-rate-reduction.

The MSU-EPRI N₂O offsets protocol differs from ACR’s 2010 methodology for N₂O Emissions Reductions from Changes in Fertilizer Management in some important ways. While the ACR 2010 methodology incorporates site specific data into a peer-reviewed, tested, and highly data-intensive computer simulation model to calculate N₂O emissions reductions that result from changes in how fertilizer is applied and used, the MSU-EPRI methodology is based on empirical equations and data gathered in the 12-state region to set conservative estimates for emission reductions. The MSU-EPRI N₂O Offsets Protocol requires little site-specific data to be compiled to calculate and verify N₂O emissions reductions and so is comparatively easy for farmer and offset project developers to implement.

In addition, on June 27, 2012, the Climate Action Reserve (CAR) program in California adopted Version 1.0 of its “Nitrogen Management Project Protocol: Reducing Nitrous Oxide Emissions through Improved Nitrogen Management in Crop Production (NMPP v1.0).” Many of the key provisions incorporated in this new CAR offsets protocol also are derived directly from EPRI and MSU’s original N₂O offsets protocol. For example, the only approach to quantifying N₂O emissions and emissions reductions quantification explicitly approved in NMPP v1.0 is the approach developed by MSU and EPRI. In addition, the only approved nitrogen management practice allowed to be used by farmers to generate N₂O offsets is the reduction in the rate of nitrogen fertilizer used to grown corn and was based on the scientific literature developed by MSU as part of this EPRI-MSU collaborative research project. Finally, v1.0 only applies to N₂O emissions reduction achieved in the 12 state NCR, based on the scientific R&D and field work completed by MSU and EPRI.

To spur on this development, MSU and EPRI developed an N₂O offset accounting “protocol” or “methodology.” It is the only offsets methodology in the world today published in a peer-reviewed scientific journal.¹ The MSU-EPRI N₂O Offsets Protocol is based on the empirical relationship observed in regionally-based studies of the relationship between fertilizer nitrogen rate and N₂O emissions. This relationship provided the basis for the development of a transparent, scientifically robust offsets protocol that can be used by developers of agricultural offset projects to create exchangeable GHG emission reduction credits for U.S. carbon cap-and-trade markets. By combining the N₂O emissions predicted using the MSU-EPRI N₂O Offsets Protocol with a recently developed approach for applying economically optimized nitrogen input rates to corn, called the maximum return to nitrogen (MRTN), the protocol provides the basis for incentivizing N₂O reductions without adversely affecting crop yields.

For the 12 states in the U.S. NCR, the protocol uses an Intergovernmental Panel on Climate Change “Tier 2” approach based on a regional N₂O emissions factor that was derived from eight site years worth of N₂O emissions data measured from field studies conducted at KBS and on commercial farms in Michigan. Tier 2 emissions factors can also be used to credit practices other than fertilizer rate reduction that reduce N₂O emissions. While nitrogen fertilizer rate is the best predictor of N₂O flux, a reduction in rate can also reflect the effects of for example, adopting improved fertilizer timing and placement, and the use of nitrification inhibitors.

Technical Contacts

The principal authors of this methodology are Dr. Neville Millar and Dr. G. Philip Robertson of MSU, and Adam Diamant of EPRI. Key contributors to the development of this methodology include: Dr. Peter Grace, Queensland University of Technology; Dr. Ronald Gehl, North Carolina State University; John Hoben, University of Kentucky; and Suzanne Sippel and Iurii Shcherbak, Michigan State University.

Additional support from the U.S. National Science Foundation’s Long-term Ecological Research (LTER) Program and MSU AgBioResearch provided key research for the scientific basis for this methodology.

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