CLIMATE ACTION RESERVE

Adipic Acid Production Project Protocol V1.0

Workgroup Meeting 1
October 8, 2019

Purpose

- To present and solicit feedback from workgroup members on key considerations for the Adipic Acid Production Project Protocol Version 1.0

Housekeeping

- Workgroup members have the opportunity to actively participate throughout the meeting
- We will ask and take questions throughout the session
- All other attendees/observers are in listen-only mode
- Observers are free to submit questions in the GoToWebinar question box
- We will follow up via email to answer any questions not addressed during the meeting
- The slides and a recording of the presentation will be posted online

Agenda

I. Introductions (5 min)

II. Process Overview (5 min)

III. Background and History (15 min)

IV. Protocol Considerations (45-50 min):

   a) Project Definition
   b) Baseline Setting
   c) Leakage
   d) Additionality
   e) Location

V. Open Discussion (10-15 min)

VI. Next Steps (5 min)

INTRODUCTIONS

Climate Action Reserve

Non-profit organization with the mission to develop, promote and support innovative, credible market-based climate change solutions that benefit economies, ecosystems and society

- Develop high-quality, stakeholder-driven, standardized carbon offset project protocols
- Accredited Offset Project Registry under the California cap-and-trade program
- Serve compliance and voluntary carbon markets

Reserve Staff:

- Trevor Anderson, *Policy Manager*
  - Protocol development lead
- Heather Raven, *Senior Project Coordinator*
  - Development process coordinator

Workgroup Members

Name (alphabetical)	Organization
Seth Baruch	Carbonomics, LLC
Phillip Cunningham	Ruby Canyon Engineering, Inc
William Flederbach	ClimeCo Corporation
John McDougal	Element Markets
Lambert Schneider	Öko-Institut

PROCESS OVERVIEW

Protocol Development Overview

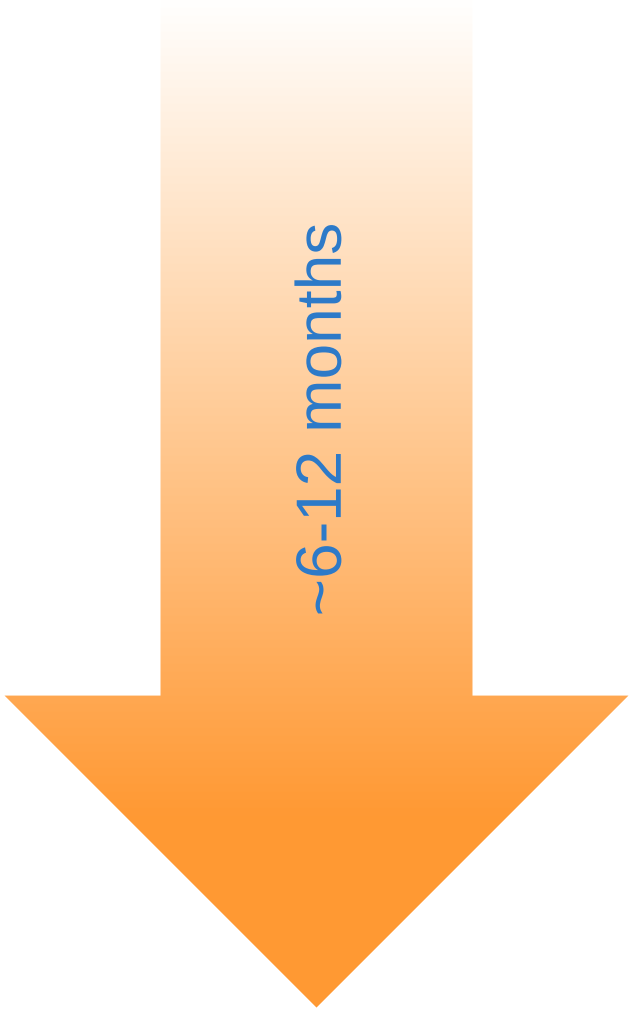
- **GOAL**: To create a robust Adipic Acid Production Project Protocol that builds on best practices for GHG accounting and reducing GHG emissions at adipic acid plants (AAPs) in order to generate Climate Reserve Tonnes (“CRTs”)
  - Adhere to high quality offset criteria and Reserve’s principles
  - Leverage lessons learned from historical international projects
  - Rely on existing Reserve Nitric Acid Production Project Protocol, where possible
  - Solicit and incorporate expert stakeholder feedback

Protocol Components

- Define the GHG project
- Define eligibility (including additionality)
- Establish GHG Assessment Boundary
  – Sources, Sinks, & Reservoirs (SSRs) included in quantification
- Quantify GHG reductions or removal enhancements
  – Baseline emissions
  – Project emissions
- Monitor eligibility and quantification parameters
- Report and Verify project performance

Protocol Development Timeline

1. Internal research and scoping (*completed*)
2. Reserve protocol drafting (*Sep – Dec 2019*)
   – Revisions based on workgroup feedback (*Oct – Nov 2019*)
   – Revisions based on public comments (*Dec 2019*)
3. Scoping meeting (*September 17, 2019*)
4. Issue paper (*October 4, 2019*)
5. Workgroup process (*Sep – Nov 2019*)
   – Formation (*Sep – Oct 2019*)
   – Meeting 1 (*today – Oct 8, 2019*)
   – Meeting 2 (*October 31, 2019*)
6. 30-day public comment period (*Nov - Dec 2019*)
7. Board adoption *(Jan 2020)*



Workgroup Process and Expectations

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Process:

- Reserve staff identify and solicit feedback on specific protocol criteria
- Reserve staff schedule and hold 2 meetings
- Reserve staff produce draft protocol for review
- Reserve staff revise protocol based on feedback

Expectations:

- Review, comment on and provide recommendations on specific protocol criteria
- Participate in meetings via webinar
- Provide written comments on draft protocol
- Be constructive, collaborative, and productive

BACKGROUND AND HISTORY

What is Adipic Acid?

White crystalline solid used in the manufacture of synthetic fibers, plastics, coatings, urethane foams, elastomers & synthetic lubricants

Among the top 50 synthetic chemicals annually produced in the US

Largest use is in the manufacture of nylon 6,6

Nylon is used in carpets, tire cord, safety air bags, apparel, upholstery, auto parts and countless other applications, for example:

Manufacturing Process

Adipic acid is produced through a two-stage process:

1. The oxidation of cyclohexane to form a cyclohexanone (K)/cyclohexanol (A) mixture
2. The oxidation of the mixture (KA) with nitric acid (HNO_3) to produce adipic acid
   - Nitrous oxide (N_2O) is generated and emitted as an unavoidable & unwanted by-product
   - N_2O is ~300x as potent as 1 metric ton of carbon dioxide (CO_2)

$$(CH_2)_5CO(cyclohexanone) + (CH_2)_5CHOH(cyclohexanol) + wHNO_3 \rightarrow HOOC(CH_2)_4COOH(adipic\ acid) + \boxed{xN_2O} + yH_2O$$

Adipic acid N_2O abatement or control technology can be installed downstream of where the reaction occurs to treat the facility's off gas

Abatement Technology

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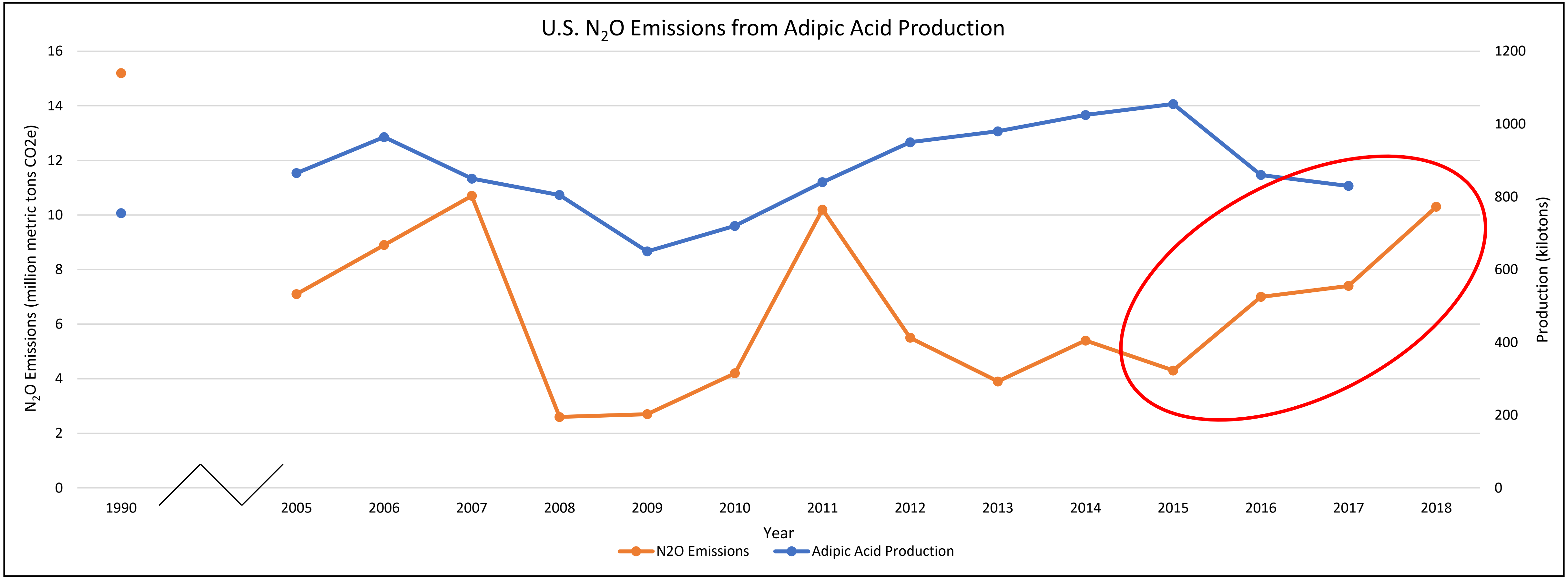
Control technology fall into 4 types of systems, outlined the table below:

Abatement Type	Description	Example
Catalytic Destruction	Destroy N_2O using a catalyst – selective catalytic reduction (SCR) or non-selective catalytic reduction (NSCR)	Noble or precious metal catalysts
Thermal Destruction	Destroy N_2O in using reducing flame burners with pre-mixed CH_4 or natural gas	Thermal Reduction Units (TRUs)
Recycling / Utilization Technologies	Utilize N_2O as a reactant or input to produce other products	Using N_2O off gas as an oxidant to produce phenol from benzene.
Recycle to Nitric Acid	Recycle N_2O to create nitric acid by burning the gas at high temperatures with steam	Nitrogen recycling adiabatic reactor

Currently, both U.S. AAPs are fitted with some N_2O abatement technology

There are often barriers (e.g., capital/operating expenses, trade-offs) that make it impracticable to fully utilize existing technology to abate N_2O

U.S. Production and N_2O Emissions Trends



2015 – Present:

- 2 U.S. AAPs in operation

2017 Production: 830 kt

- Increased by ~10% over the period of 1990 – 2017

2017 Emissions: 7.4 M tCO_2e

- Reduced by ~51% over the period of 1990 – 2017

2018 Emissions**:

10.3 M tCO_2e

*1990 – 2017 data from *US EPA GHG Inventories* ** 2018 data from *US EPA GHGRP (Oct 2019)*

Takeaways and Opportunities

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Adipic acid production is so emissions intensive, even after abating the majority of their emissions, the only 2 U.S. facilities still released 10.3 M tCO_2e in 2018

- Equivalent to GHG emissions from ~2.2 M passenger vehicles driven for 1 year or the amount avoided by ~2,200 wind turbines running for 1 year

Adipic acid production trends are closely correlated with nylon consumption trends, which is anticipated to stay in high demand

Currently no economic incentives to abate N_2O emissions further

- The industry has an enormous potential to reduce emissions given the appropriate incentives to install control technologies

Carbon offsets can provide that incentive!

International Offset Projects History (1 of 3)

Clean Development Mechanism (CDM): *Baseline Methodology for decomposition of N_2O from existing adipic acid production plants* (**CDM AM0021)**

- Projects install a catalytic or thermal N_2O destruction facility at an existing AAP
- ISSUES: Caused production-shifting (i.e., “leakage”), leading to over-crediting and the generation of non-additional credits
  - Set the baseline N_2O abatement emissions level at 0% (i.e., assumed no historical or current abatement), leading to high volume of credits (“CERs”) as all abatement was credited
  - The value of the CERs exceeded the value of the adipic acid itself, creating perverse incentives to overproduce the product
  - Caused a substantial shift in worldwide adipic acid production, from non-CDM AAPs to CDM projects, resulting in an estimated 20% non-additional CERs
- Led the EU to ban the use of these offsets from its carbon market

International Offset Projects History (2 of 3)

Joint Implementation (JI) mechanism (project-specific approaches)

- JI AAPs already voluntarily installed abatement technology in the 1990s
  - Used a baseline that represents an abatement level of 90%
  - Only received credits (“ERUs”) for abatement beyond this level
- Further increased abatement rates to > 97%
  - Retrofitted existing abatement technology – *or* –
  - Installed a second, redundant N_2O abatement facility that minimizes the overall downtimes of the N_2O abatement system

International Offset Projects History (3 of 3)

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Lessons Learned*,**:

- Most straightforward and efficient way to effectively reduce the risk for leakage is to set a baseline emission benchmark (i.e., emissions per adipic acid production)
  - Only emission reductions beyond the benchmark would be credited; i.e., multiply the amount of adipic acid production eligible for crediting with a baseline emission factor
  - Still provide considerable incentives for the industry to abate N2O emissions (e.g., JI projects)
- JI projects show that very high levels of N_2O abatement can be, and have been, achieved by implementing additional abatement measures
  - Possibly even enable the elimination of nearly all N2O emissions
- The carbon market provided incentives to innovate and implement highly effective N_2O abatement solutions

*Stockholm Environment Institute (2010). *Industrial N2O Projects Under the CDM: Adipic Acid – A Case of Carbon Leakage?*
**Öko-Institut (2016). *How additional is the Clean Development Mechanism?*

PROTOCOL CONSIDERATIONS

Project Definition

The installation and operation of a new N_2O control technology, or the enhancement of an existing control technology, at a single AAP that results in the reduction of N_2O emissions that would otherwise have been vented to the atmosphere

- *Objective:* only generate credits for the incremental emission reductions above a baseline based on an individual AAP’s historical production, emissions rates, and abatement levels

Baseline Setting

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Establish an AAP-specific Baseline Emission Factor based on historical data*

- *How to establish? Goal: reasonably accurate & conservative but not overly restrictive*
  - *Maximum / average / minimum adipic acid production and associated N_2O emissions?*
  - *Combination approach – e.g., minimum N_2O emissions per maximum adipic production?*
  - *Maximum / average / minimum abatement rate or destruction efficiency (%)?*
  - *Provide multiple options and select most conservative one?*
  - *Other options?*
- *Baseline look-back period – how far back to look (e.g., 3 years, 5 years, etc.)?*
  - *Any reasons to exclude a given year (e.g., plant idling)?*
- *Include N_2O emissions from HNO_3 production (precursor) for recycling projects?*
  - *How to determine decrease in virgin HNO_3?*

*in line with IPCC Guidelines' best practices for adapting IPCC Adipic Acid Production methods to national circumstances

Leakage

Should an adjustment or risk factor be included in the emissions quantification to mitigate the potential for production shifting (within the U.S. and/or from international AAPs)?

- *Necessary?*
- *What if adipic acid production in project > maximum adipic production in baseline look-back period?*
- *How to establish such a factor? Suggestions?*
  - *Adjust Baseline Emission Factor?*
  - *Default value?*
  - *Set cap on maximum adipic acid production?*
  - *Threshold on allowable upper production limit (e.g., acceptable % increase, statistically significant % increase)?*

Additionality: Performance Standard Test

Existing AAPs can reduce their emissions beyond a business-as-usual level and pass this test in 2 ways:

1. Utilize existing emissions control technology at a higher rate
   - *How to verify?*
2. Install new emissions abatement control technology:
   - Catalytic destruction; Thermal destruction; Recycling / utilization technologies; Recycle to nitric acid (see Table on slide 16)
   - *Others?*

Automatically additional?

Additionality: Legal Requirement Test

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There are no existing federal, states, or local regulations that require AAPs to abate N_2O emissions under typical conditions

If a facility triggers certain provisions under the Clean Air Act, they may be required to install some GHG abatement equipment

- **Prevention of Significant Deterioration [PSD] and Title V Greenhouse Gas Tailoring Rule ("Tailoring Rule")**
  - When necessary, PSD permits for GHG emissions require an assessment of "best available control technology" (BACT), with the permitting authority ultimately mandating installation of a selected BACT
  - If future PSD permits require installation of the same abatement technologies that would be voluntarily deployed as part of carbon offset projects, projects would become ineligible for offsets

Other regulations (effective or adopted) to take into consideration?

Location

Projects may only be implemented at existing, relocated, or upgraded U.S. AAPs

What would be required to extend applicability at the onset to new U.S. AAPs?

- *How to establish baseline?*
- *How to determine additionality of abatement technology?*

OPEN DISCUSSION – FEEDBACK AND SUGGESTIONS

NEXT STEPS

Next Steps

- Submit comments/feedback by ***COB Tuesday, 10/15***
- Protocol drafting by Reserve staff – *ongoing*
- Share protocol draft with workgroup – *Thursday, 10/24* (goal)
- Workgroup Meeting 2 – *Thursday, 10/31*
  - Review DRAFT protocol, section x section
  - ~2-4 hour session via webinar

Contact Information

[Adipic Acid Production Project Protocol]

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