CLIMATE ACTION RESERVE

Adipic Acid Production Project Protocol V1.0

Public Scoping Webinar
September 17, 2019

Housekeeping

- All attendees are in listen-only mode
- We will take questions at the end of the session
- Please submit your 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

Purpose

- Provide an overview of the Climate Action Reserve and our protocol development process
- Share our research findings and protocol development plans for adipic acid production with the stakeholder community
- Discuss key issues and get initial feedback
- Recruit stakeholders to partake in our adipic acid workgroup

Agenda

I. Climate Action Reserve
II. Protocol Development Process
III. Adipic Acid Production & GHG Emissions
IV. International Adipic Acid Offsets Project
V. Reserve's Proposed Protocol Approach
VI. Timeline & Next Steps
VII. Questions

Reserve Staff

- Trevor Anderson, *Policy Manager*
- Heather Raven, *Senior Project Coordinator*

CLIMATE ACTION RESERVE

Climate Action Reserve

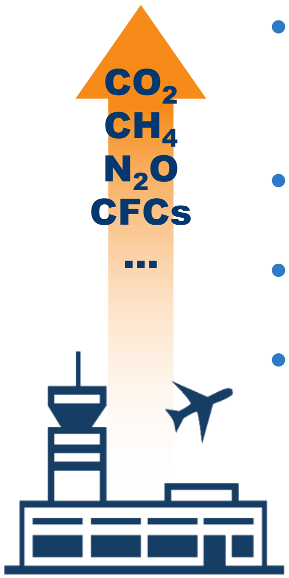
- Mission: to develop, promote and support innovative, credible market-based climate change solutions that benefit economies, ecosystems and society
- Develop high-quality, stakeholder-driven, standardized carbon offset project protocols across North America
- Accredited Offset Project Registry under the California cap-and-trade program
- Serve compliance and voluntary carbon markets
- Reputation for integrity and experience in providing best-in-class registry services for offset markets
- Based in Los Angeles, CA

Separation of Roles

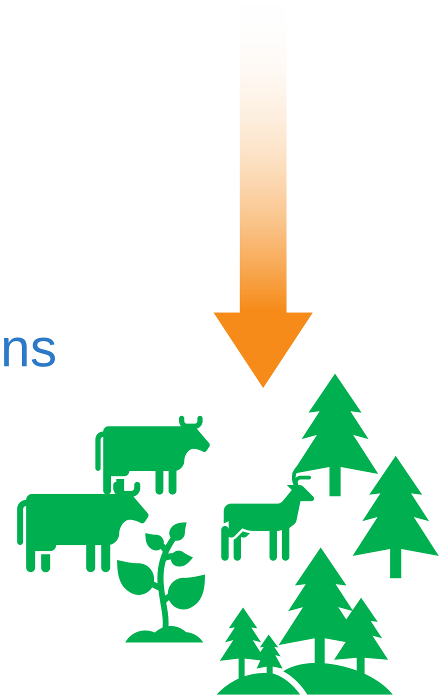
The Reserve is a 501(c)3 not-for-profit organization

- Independent from the State of California
- Does not fund or develop projects
- Does not take ownership of offsets
- Is not an exchange
- Independent from 3rd-party verification
  - Consistent with international standards
  - ANSI accreditation, training by Reserve or ARB

Carbon Offsets



- Verified emissions reductions in unregulated sectors with barriers to adoption
- Sellers need incentives to reduce GHGs
- Buyers want/need to offset their own emissions
- 1 offset credit = 1 tCO_2e
  - 1 CRT = 1 Climate Reserve Tonne (CRT)



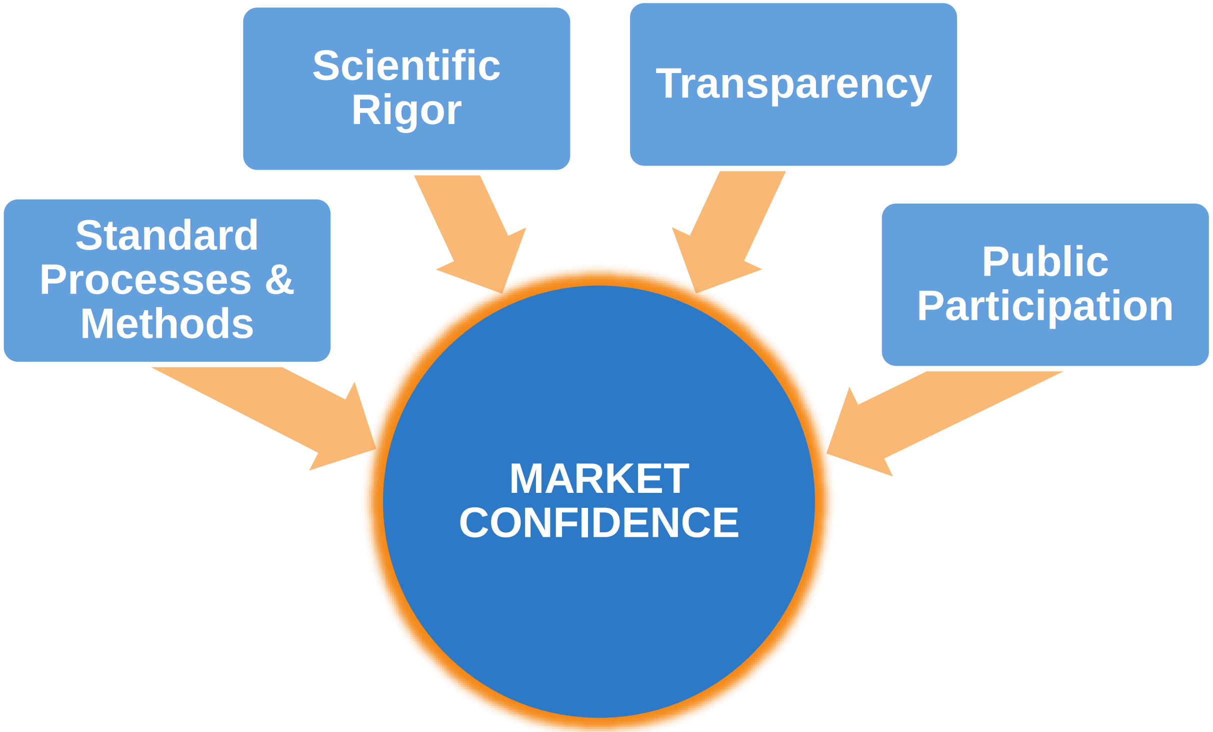
Protocol development → Project development → Public listing → 3rd-party verification → Registry review → Credit issuance & trading

Serving Multiple Markets

	Voluntary Market	Compliance Market
End Buyer	Any individual, business, nonprofit, municipality, or utility voluntarily reducing emissions	Large emitters and utilities required to reduce emissions by law (California, Quebec, EU)
Standard	Climate Action Reserve protocols, other carbon registries	CA Air Resources Board approved protocols
Project Types	18 project types	6 project types, only Forest, MMC, ODS, Livestock used to date
Credit Prices	50¢ - $50*, depending on project type, location, buyer needs, co-benefits, etc.	$10-$14, tracking close to allowance prices
Costs	Generally lower than compliance Variable; includes: project feasibility study, installation, on-going monitoring & reporting, verification, business development for credit sales	Variable by project type; includes: project feasibility study, installation, on-going monitoring & reporting, verification, business development for credit sales
Risks	• Finding buyers • Price uncertainty overtime	• Policy uncertainty re: Cap and Trade Program implementation • ROC to ARBOCs conversion process • Invalidation
End Users	DELTA, Microsoft, lyft, Google	TESORO, City of Glendale California, Union Pacific Railroad, bp

Role as Offset Project Registry

- Clear rules for eligibility, quantification, monitoring, QA/QC, reporting, & verification
- Engage with public & expert stakeholders
- Administrative services for project & credit registration and tracking
- Oversight of 3rd-party verification program
- Tools & trainings



Offset Quality

GHG accounting is conservative, comprehensive, and scientifically credible

REAL

GHG reductions would not have occurred in the absence of the carbon market

ADDITIONAL

GHG reductions or removals persist for at least 100 years

PERMANENT

Ex-post 3rd-party verification prior to credit issuance

VERIFIABLE

No other parties may reasonably claim ownership of GHG reductions

NO DOUBLE COUNTING

GHG Accounting Principles (1 of 2)

Relevance

- Protocols are designed around standardized, practical approaches to GHG accounting while still adhering to other core accounting principles

Completeness

- All relevant information is considered when developing criteria and procedures, and all relevant GHG emissions and removals are accounted for

Consistency

- Protocols are standardized to apply consistent GHG accounting and monitoring methods to all projects of the same type
- Protocols are designed to reflect similarly rigorous and conservative accounting methods and assumptions for all project types

GHG Accounting Principles (2 of 2)

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Transparency

- Sufficient information is disclosed to allow reviewers and stakeholders to make decisions about the credibility and reliability of GHG reduction claims with reasonable confidence

Accuracy

- Uncertainties and bias should be reduced as far as is practical

Conservativeness

- Conservative assumptions, values, and procedures are used to ensure that GHG reductions are not over-estimated

Reserve Voluntary Project Protocols

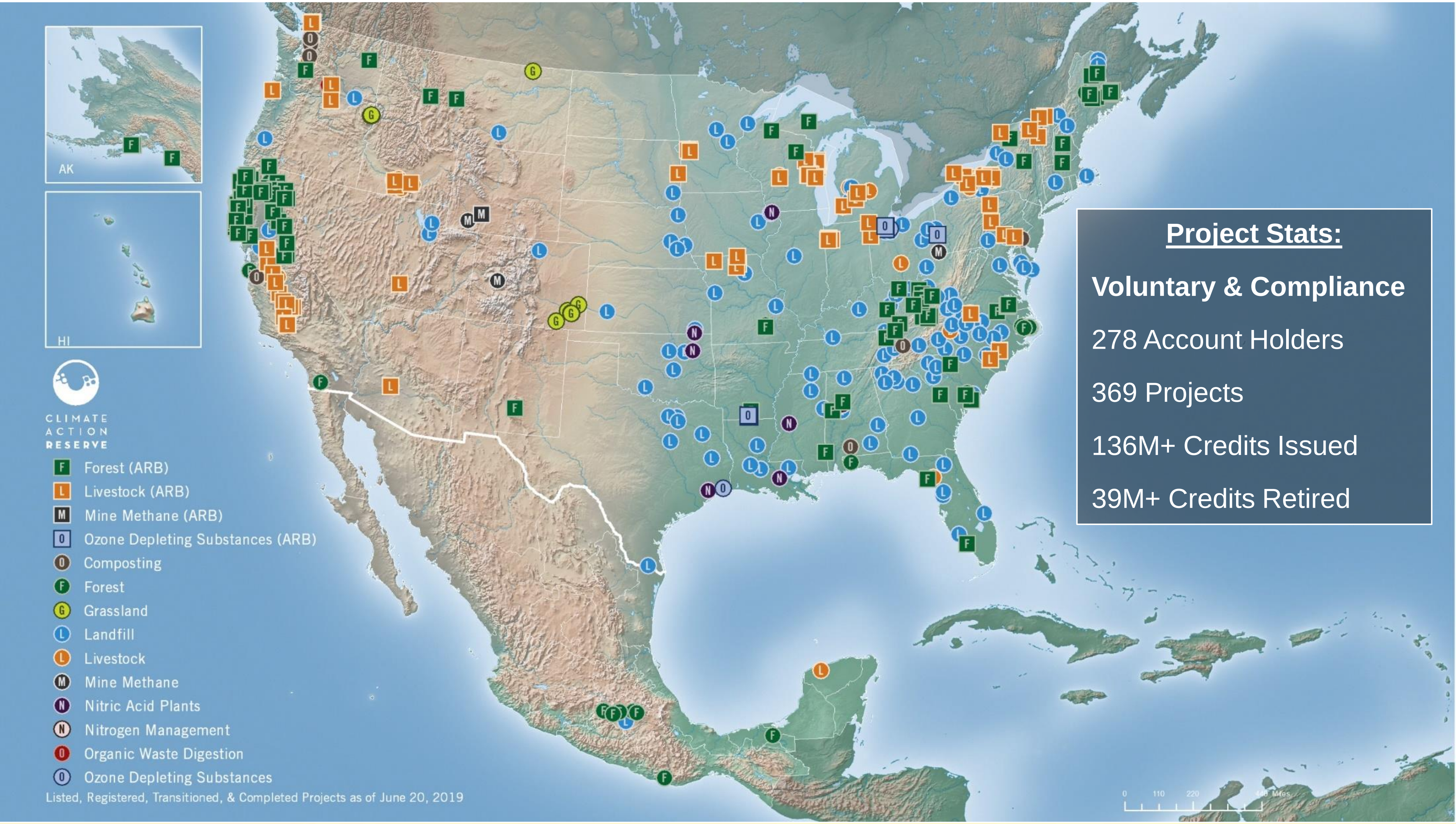
18 protocols applicable for emissions reduction activities in North America

2 protocols in development

LAND USE	AGRICULTURE	INDUSTRIAL GASES	ORGANIC WASTE
• **Forest** *(US & MX)* • **Urban forest management** • Urban tree planting • Grassland *(US & CAN – under development)*	• **Livestock** *(US & MX)* • Nitrogen management • **Rice cultivation**	• **Coal mine methane** • Boiler efficiency *(MX)* • **Ozone depleting substances** *(US & MX)* • Nitric acid production • Adipic acid production *(under development)*	• Landfill gas *(US & MX)* • Organic waste composting • Organic waste digestion

Bold indicates also California compliance protocol

Project Map



Project Stats:

Voluntary & Compliance

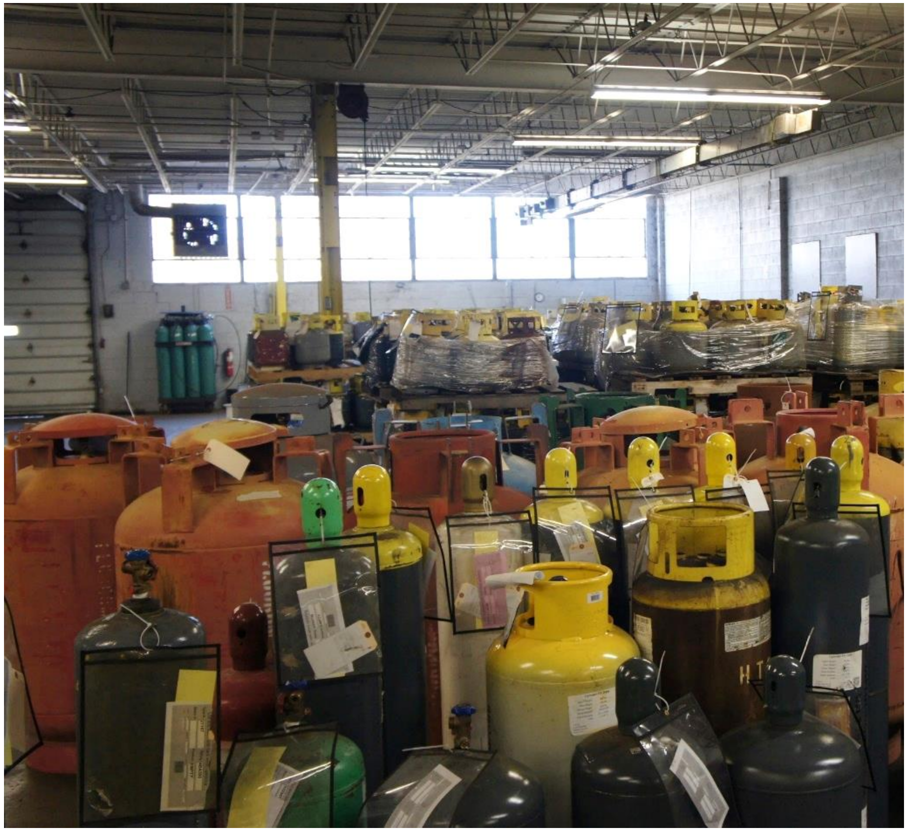
278 Account Holders

369 Projects

136M+ Credits Issued

39M+ Credits Retired

Example: Ozone Depleting Substances



- Collection and destruction of used refrigerants and foam blowing agents
- CFCs and HCFCs
- Chemicals have been phased out by the Montreal Protocol, but are still being recycled, and have very high GWPs
- Gases are transported to approved facilities and then permanently destroyed
- Credit based on average leak rates, minus expected leaks of substitute gases
- **113 projects listed and registered**
- **17,788,520 credits issued**

PROTOCOL DEVELOPMENT

Protocol Development

- Broad public input, sector-specific work groups
- Goal is to create a uniform standard that is widely recognized and builds on best practice
  - We incorporate the best elements of other protocols
  - We do not adopt methodologies from other sources (e.g. CDM, Gold Standard, VCS, project developers, etc.)
- Designed as step-by-step instructions on project implementation

Protocol Development Goals

- Develop a standardized approach for quantifying, monitoring, and verifying GHG reductions
  - Research industry trends in adoption of GHG reducing practices
  - Set criteria and reference points based on industry trends
  - Provide specific tools for quantifying emissions
  - Detailed and specific monitoring requirements
  - Train verifiers with a consistent set of protocol-specific standards
- Maintain consistency with or improve upon existing methodologies
- Balance accuracy, conservativeness, and practicality

The Standardized Approach

Standardized offset crediting has 2 main elements:

1. Determining the eligibility and additionality of projects using standard criteria, rather than project-specific assessments
2. Quantifying GHG emission reductions using standard baseline assumptions, emission factors, and monitoring method

Benefits:

- Low up-front costs to project developers
- Efficient review and approval of projects
- Transparency and consistency
- Same approach applies across projects
- Prescriptive guidance to eliminate judgment calls

*But…*high initial resource investment to program

Protocol Development Timeline

1. Internal research & scoping
2. Issue paper
3. Scoping meeting
4. Workgroup formation
5. Draft development
6. Workgroup process
7. Public comment (*30-day*)
8. Board adoption

- *Consideration by ARB*

~6-18 months

Workgroup Formation

Stakeholder participation & feedback is critical to protocol development

The Reserve assembles and uses an intensive multi-stakeholder workgroup to advise protocol development and produce rigorous, well-vetted, and credible protocols

- Strive for balanced representation from government, environmental NGOs, industry, project developers, verifiers, academia, and scientific and technical consultants
- Interested stakeholders complete and submit Statement of Interest (SOI) forms

Full engagement requires a significant time commitment, a solid understanding of project-based GHG accounting, and familiarity with the practices, technologies, and/or activities for which the protocol is being developed

Workgroup Process & Expectations

Process:

- Reserve staff identify and solicit feedback on specific protocol criteria
- Reserve staff schedule and hold meetings (~2 – 3)
- 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

Project 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

ADIPIC ACID PRODUCTION & GHG EMISSIONS

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 a byproduct
   - 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

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, most AAPs are fitted with some N_2O abatement technology

There are often barriers (financial or otherwise) that make it impracticable to fully utilize existing technology to abate N_2O

- For example, there can be a trade-off between N_2O abatement and abating other potentially harmful pollutants such as nitrogen oxide (NO_x), which are regulated under the Clean Air Act 40 CFR Part 50

U.S. Production History

The US accounts for the largest share of global adipic acid production (~30%); followed by Europe (~29%) and China (~22%)

Companies:

1. Invista Performance Technologies
2. Ascend Performance Materials
3. Inolex

1990

- 4 AAPs operating in the U.S.

1996-1998

- 3 AAPs voluntarily installed N_2O abatement technologies

2006

- Inolex AAP ceased production
- Accounted for ~2% of domestic production
- Had not abated N_2O

2008 – 2010

- AAP idling

2015

- Invista AAP in Orange, TX ceased production

Present day:

- 2 U.S. AAPs in operation
  - Invista
  - Ascend

*Data from *US EPA GHG Inventories*

U.S. Adipic Acid Plants

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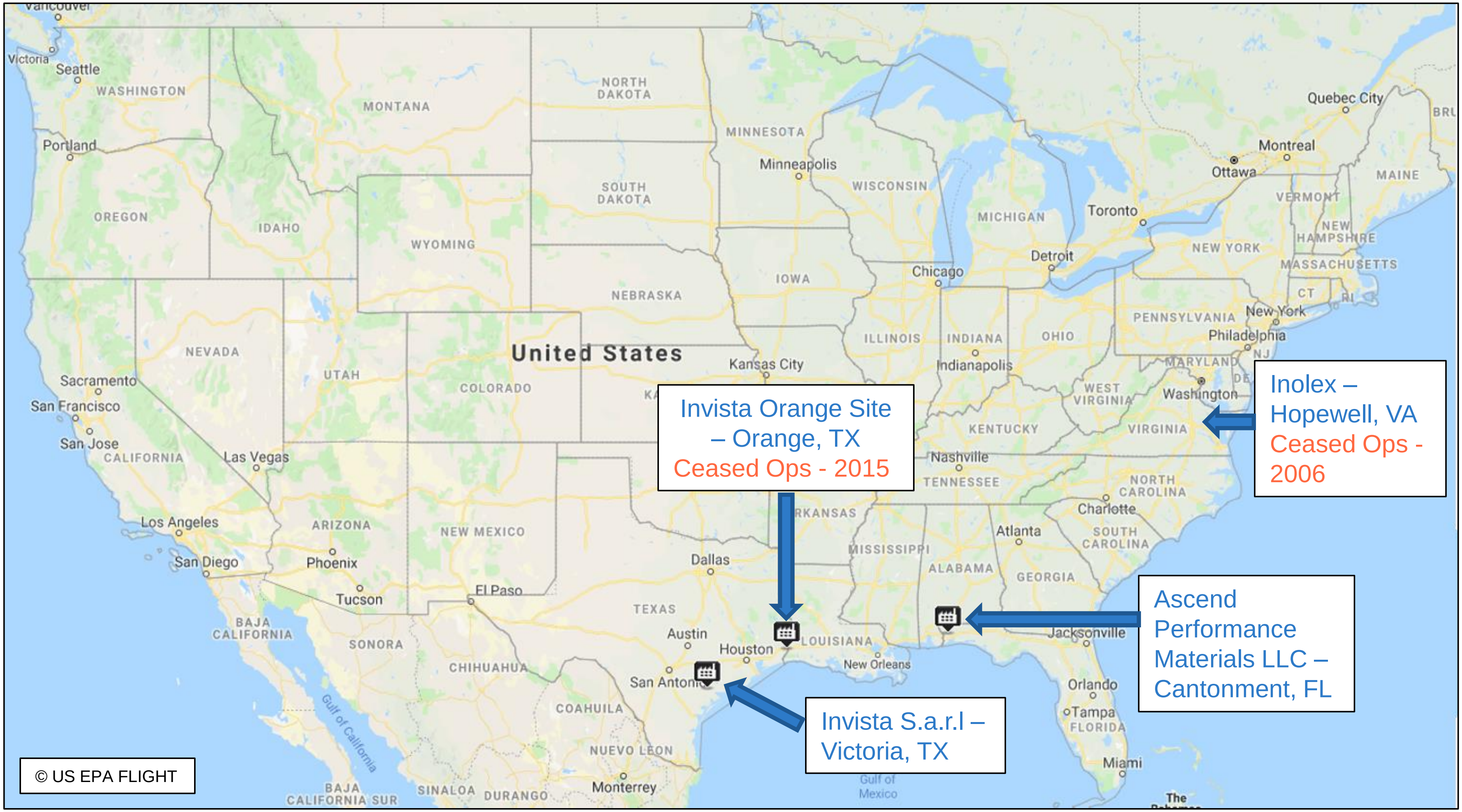


Invista S.a.r.l – Victoria, TX

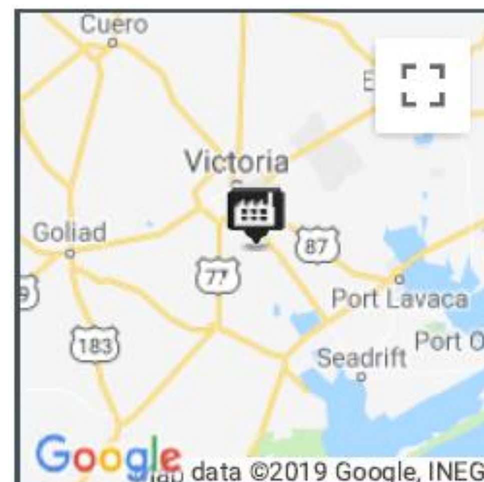
2017 Facility Information*:

*Data from *US EPA GHGRP FLIGHT*

- Number of abatement technologies: 2
- Type of abatement technology: Boilers; and

  Selective Catalytic Reduction (SCR)
- Abated 97% of its gross N_2O emissions
- Net emissions from adipic acid production: 626,694 tCO_2e

INVISTA™



Ascend Performance Materials LLC – Cantonment, FL

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2017 Facility Information*:

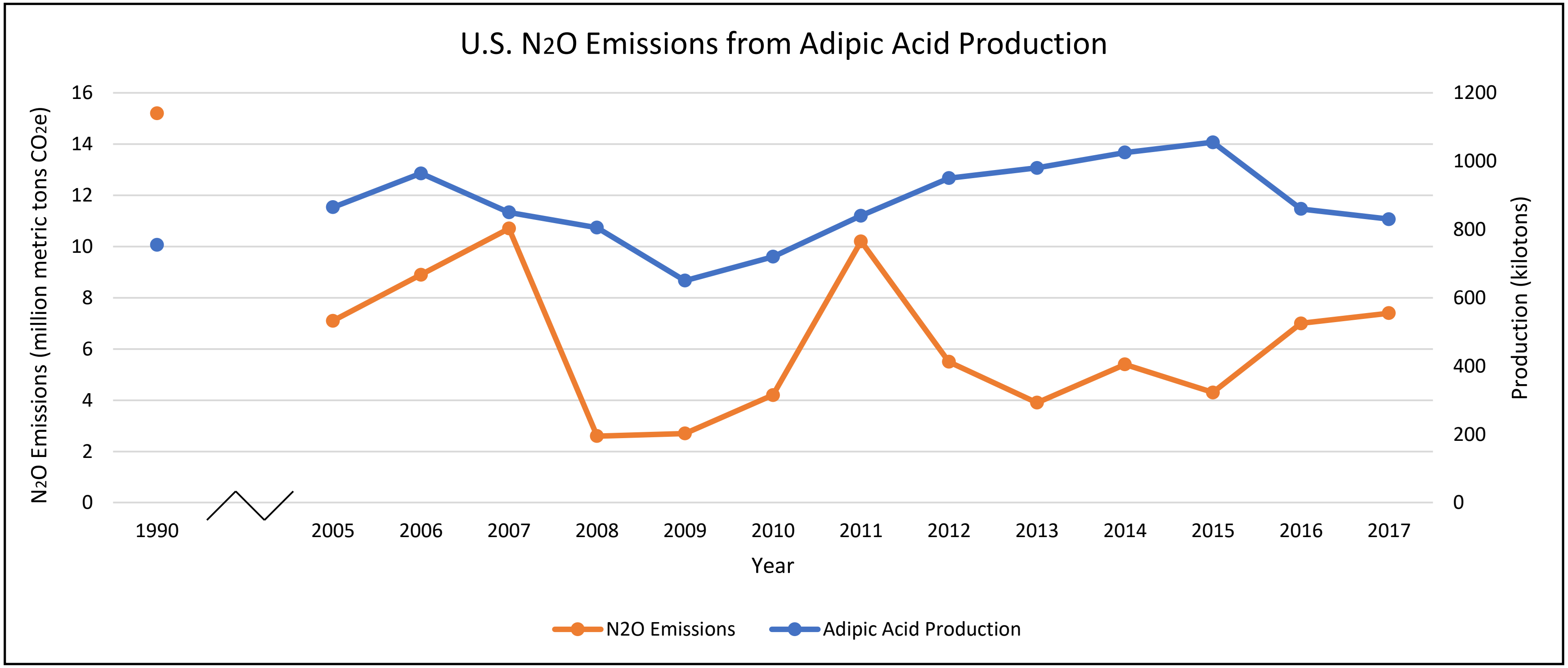
- Number of abatement technologies: 1
- Type of abatement technology: Thermal Reduction Unit (TRU)
- Abated 83.3% of its gross N_2O emissions
- Net emissions from adipic acid production: 6,745,159 tCO_2e

ASCEND
PERFORMANCE MATERIALS

*Data from *US EPA GHGRP FLIGHT*

U.S. Production & N_2O Emissions Trends

Process emissions from adipic acid production vary with the types of technologies and level of emission controls employed by a facility



<u>2017 Production</u>: 830,000 metric tons
- Increased by ~10% over the period of 1990 – 2017

<u>2017 Emissions</u>: 7.4 M tCO_2e
- Reduced by ~51% over the period of 1990 – 2017

*Data from *US EPA GHG Inventories*

U.S. Industrial Processes & Product Use GHG Emissions

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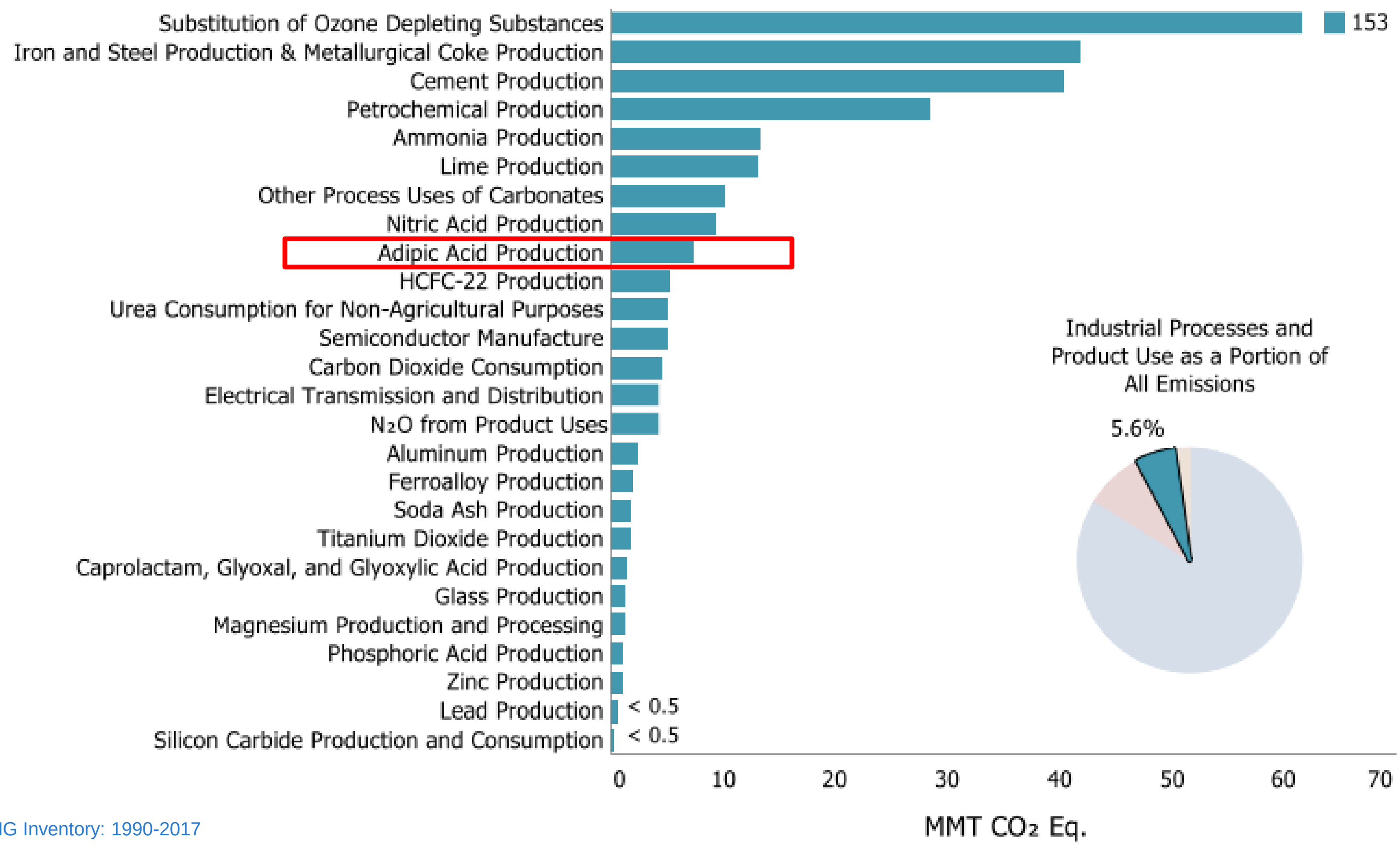
Figure 4-1: 2017 Industrial Processes and Product Use Chapter Greenhouse Gas Sources ($MMT\ CO_2$ Eq.)



© US EPA GHG Inventory: 1990-2017

Takeaways & Opportunities

Because adipic acid production is so emissions intensive, even after abating the majority of their emissions, the only 2 U.S. facilities still released 7.4 M tCO_2e in 2017

- Equivalent to GHG emissions from ~1.6 M passenger vehicles driven for 1 year or the amount avoided by 1,500+ wind turbines running for 1 year

Since the main use for adipic acid is as a component of nylon, adipic acid production trends are closely correlated with nylon consumption trends, which remains in high demand

As such, the industry has an enormous potential to reduce emissions given the appropriate incentives to install control technologies

Carbon offsets can provide AAPs with an incentive to make a capital investment to utilize their existing emissions control technology at a higher rate or to install new emissions abatement control technology

INTERNATIONAL ADIPIC ACID OFFSET PROJECTS

Kyoto Protocol Mechanisms

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1) The Clean Development Mechanism (CDM) allows a country with an emission reduction/limitation commitment under the Kyoto Protocol to implement an emission reduction project in developing countries

- Projects can earn saleable certified emission reduction (CER) credits, each equal to 1 tCO_2e, which can be counted towards meeting Kyoto targets

2) Joint Implementation (JI) is a mechanism that allows a developed country with an emission reduction/limitation commitment under the Kyoto Protocol to earn emission reduction units (ERUs) from an emission reduction or emission removal project in another developed country

- JI offers countries a flexible and cost-efficient means of fulfilling a part of their Kyoto commitments, while the host country benefits from foreign investment and technology transfer

CDM Adipic Acid Production Methodology

CDM AM0021: *Baseline Methodology for decomposition of N_2O from existing adipic acid production plants*

- Projects install a catalytic or thermal N_2O destruction facility at an existing AAP

ISSUES:

International CDM adipic acid abatement projects implemented under the first version of the methodology faced historical criticism for:

1. Creating secondary effects (i.e., “leakage”); and
2. Generating non-additional credits

Led the EU to ban the use of these offsets from its carbon market

Over-Crediting

CDM adipic acid projects caused a substantial shift in worldwide adipic acid production, from non-CDM AAPs to CDM projects, resulting in an estimated 20% non-additional CERs

According to an assessment of the CDM protocol completed by the Stockholm Environmental Institute (SEI), there were 2 primary drivers:

1. The protocol set the baseline N_2O abatement emissions level at 0% (i.e., assumed no historical or current abatement); *and*
2. The value of the CERs created through abatement technology exceeded the value of the adipic acid itself, creating perverse incentives; i.e., the value of the carbon offset created a perverse incentive to overproduce the product

Key Recommendation

SEI suggests that setting baselines based on emissions rates would be the most straightforward and efficient way to prevent secondary effects

- This strategy was utilized in later JI projects that had more stringent leakage protections and did not appear to have had any secondary effects or carbon leakage
- JI projects had baseline historical abatement levels around 90%
- By only crediting the incremental emissions beyond individual facility's abatement levels, the economic incentives for JI projects remained attractive but did not appear to create the same highly skewed incentive structure

Outlook for the U.S.

Low risk for over-crediting in the U.S. for the following reasons:

- In the US, over-production is especially costly because the facility would need to increasingly abate its NOx emissions
- The value of voluntary carbon offsets in the US is lower than historical CDM CER level when product gaming occurred
  - Average of $2.40/voluntary credit in Q1 2018* compared to over $18 USD/CER
- Baseline setting: Like JI projects, the Reserve's protocol would only generate credits for the incremental emission reductions above a baseline based on individual AAPs' historical emissions rates and abatement levels
  - Discussed further in slide 50

As a result, it's not anticipated U.S.-based projects would achieve nearly the same volume of CERs as created under the CDM

*Data from *Ecosystem Marketplace*

RESERVE-PROPOSED PROTOCOL APPROACH

GOAL

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To create a robust Adipic Acid Production Project Protocol that builds on best practices for GHG accounting and reducing GHG emissions at 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
  - Adipic acid production and GHG abatement technology closely mirror the production and abatement of GHGs from nitric acid production
- Solicit and incorporate expert stakeholder feedback

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

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

Eligibility

- Location: existing AAPs in the US
- Start Date: date on which production first commences after the installation or modification of a specific N_2O control technology
- Crediting Period: 10 years; may renew for a 2^{nd} one
- Additionality:
  - Performance Standard Test
  - Legal Requirement Test
- Regulatory Compliance: compliance with all applicable laws

Performance Standard Test

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

1. Utilize their existing emissions control technology at a higher rate
2. Install new emissions abatement control technology

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)
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Recycle to Nitric Acid	Recycle N_2O to create nitric acid by burning the gas at high temperatures with steam	Nitrogen recycling adiabatic reactor

Legal Requirement Test

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

GHG Assessment Boundary

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SSRs in the project boundary:

1. N_2O from adipic acid production (baseline and project);
2. CO_2 and/or CH_4 hydrocarbons used as reducing agents and/or reheating the off gas (project); and
3. CO_2, CH_4 and N_2O for reheating the off gas before entering the abatement technology (project)

Quantification

Baseline emissions:

- Based on the AAP-specific historical quantity of N_2O in the off gas before it entered the existing abatement technology
- Must establish an AAP-specific *Baseline Emission Factor* of the ratio of N_2O emissions to maximum adipic acid production that accounts for the abatement level in the last 5 years prior to project start date

Project emissions:

- N_2O abatement is not 100% efficient
- N_2O emissions that are not destroyed by abatement technology are measured and included as project emissions.

Leakage:

- Further consideration will be given to assess and reduce potential risk for production shifting

Monitoring

AAPs are already required to have a continuous emissions monitoring systems ("CEMS") for NOx emissions testing under the Clean Air Act (40 CFR, Part 60)

- CEMS provide the most accurate approach; can account for the variability in the overall process and directly capture the effects of control measures
- CEMS will be implemented upstream and downstream of N_2O abatement units to achieve real-time destruction efficiency data

Follow relevant sections of 40 CFR Part 60 and 75

- Provide guidance on the standards of performance for stationary emission sources and CEMS for NO_x emission testing
- Also applicable to N_2O emission testing at AAPs

Reporting & Verification

GHG emission reductions must be quantified, reported, and verified on at least an annual basis

Reporting periods shall cover the same time period as a full campaign (i.e., adipic acid production cycle); may be less than 12 months

Multiple reporting periods may be verified during one verification period

Verification requires an annual site visit

Summary

Despite historical and current voluntary abatement, U.S. adipic acid production still represents a substantial source of GHG emissions from very few facilities

The industry has an enormous potential to reduce emissions given the appropriate incentives to install and/or further utilize control technologies

The carbon market can play an effective role in incentivizing further abatement, provided careful offset protocol design to reduce the risk of secondary effects

The Reserve will apply its principles for high-quality offsets and solicit feedback from expert stakeholders to produce a robust Adipic Acid Production Project Protocol

TIMELINE & NEXT STEPS

Protocol Development Timeline

1. Internal research and scoping (*completed*)
2. Issue paper (*pending release*)
3. Scoping meeting (*today*)
4. Workgroup formation (*in progress*)
5. Draft development (*in progress*)
6. Workgroup process (*Sep - Nov 2019*)
7. Public comment (*Nov - Dec 2019*)
8. Board adoption *(Jan 2020)*

Next Steps

- SOI Forms due Friday, 9/20
- Reserve to form workgroup the week of 9/23
- Schedule workgroup meeting 1 (Sep – Oct)
  - Review key protocol elements (e.g., additionality, baseline)
  - ~1.5 hour meeting via webinar
- Schedule workgroup meeting 2 (Oct – Nov)
  - Review DRAFT protocol, section x section
  - ~2-6 hour session via webinar
- Protocol drafting (Sep ‘19 – Jan ‘20)
- Solicit workgroup feedback throughout

QUESTIONS

Contact Information

Adipic Acid Production Project Protocol

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Statement of Interest (SOI) Forms

Policy Account

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