



# New York State Pollution Prevention Institute

Eugene Park, Trish Donohue

June 7, 2016

# Course Agenda:



- Welcome & Introduction to NYSP2I and Sustainability/P2
- Tools in P2 Assistance
  - Traditional Technologies
  - Innovative Technologies
- Detailed Case Studies
  - Direct Client Assistance Program
  - Sustainable Supply Chain Program
  - Green Technology Accelerator Program
- Q&A Session

**Eligible participants will receive 1.5 hours of PE continuing education credits.**

# NYS Pollution Prevention Institute



- Established in 2008 “**NYSP2I**”
- HQ at RIT
- **\$4M** in annual NYS funding
- Focus on reduction of natural resource consumption (water, raw material, energy) and elimination of waste and toxics
- P2 research, technical assistance, education and outreach
- **15+** full-time staff

R·I·T

Clarkson  
UNIVERSITY  
*defy convention™*



Department of  
Environmental  
Conservation

UB University at Buffalo  
The State University of New York



Rensselaer

10 NYS RTDCs

# Business Assistance



- Must be **NY-based** company
- Technical assistance provided from an interdisciplinary team of experts including engineers and environmental scientists
- Typical project cost ranges **\$15-\$50K**
- P2 funding offsets most of the project cost to the company
- **3** years of post-project reporting
- Expenses are non-capital expenses
- Typical project takes about **2-4** months



# Types of Business Assistance



## Areas of Technical Expertise:

- P2 problem identification, reducing environmental “footprint” of process or facility
- Technology assessments, validation and effectiveness studies
- Supply chain sustainability assessments, strategy, and implementation
- Green or eco-innovation products in the commercialization stages

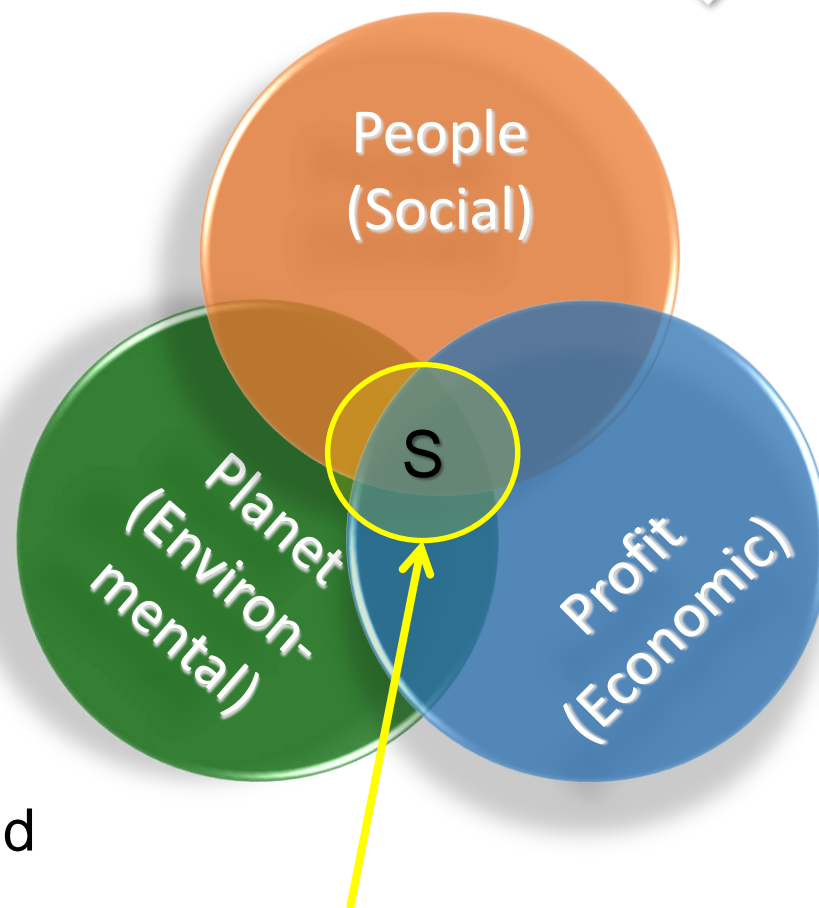
# Sustainability – Defined



Many terms for addressing social, environmental and economic initiatives:

- “3Ps” – People, Planet, Profit
- Social, Economic, Environmental
- “Corporate Social Responsibility”
- “Corporate Citizenship”
- “Sustainable Growth”

Each company or organization should define how they address “sustainability”



*Sustainability is actualized*



# Sustainability – Defined



**Sustainable Development**: “development that meets the **needs** of the present without compromising the ability of future generations to meet their own **needs**”



“We do not inherit the earth  
from our ancestors, we  
borrow it from our children.”

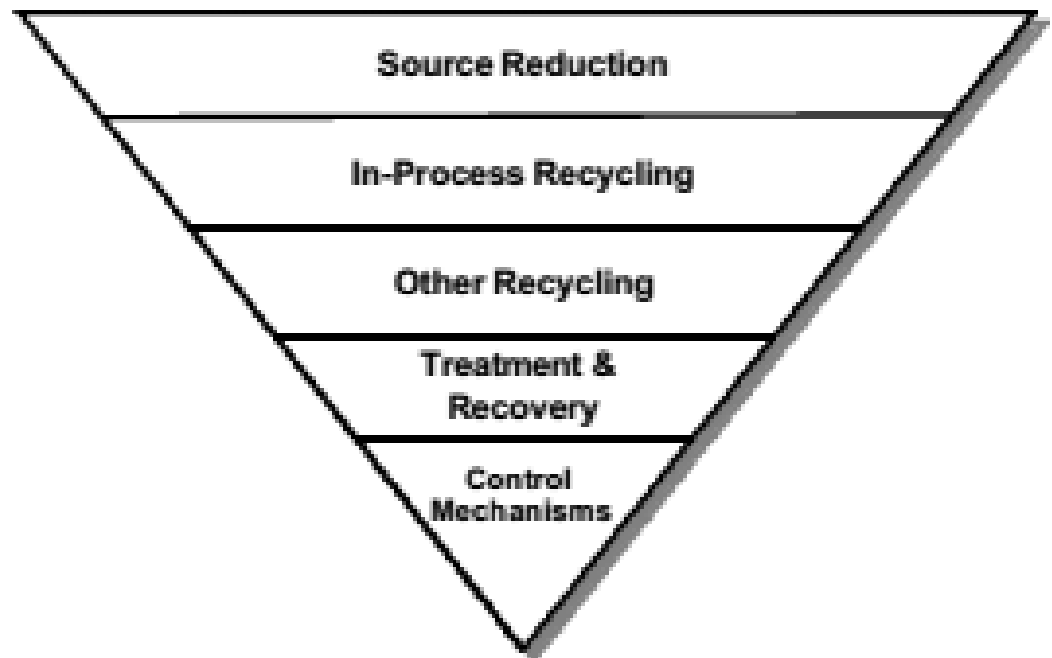
~Native American Proverb

# Pollution Prevention Hierarchy



In evaluating P2 opportunities, organizations should start at the top of the pyramid (i.e., source reduction) and work their way down as needed to define the most appropriate methods for preventing pollution.

**Prevention of Pollution Hierarchy**





# Pollution Prevention Hierarchy



## Source Reduction

- Product/process change
- Green chemistry/toxics reduction

## In-Process Recycling

- Direct reuse of materials or by-products in process

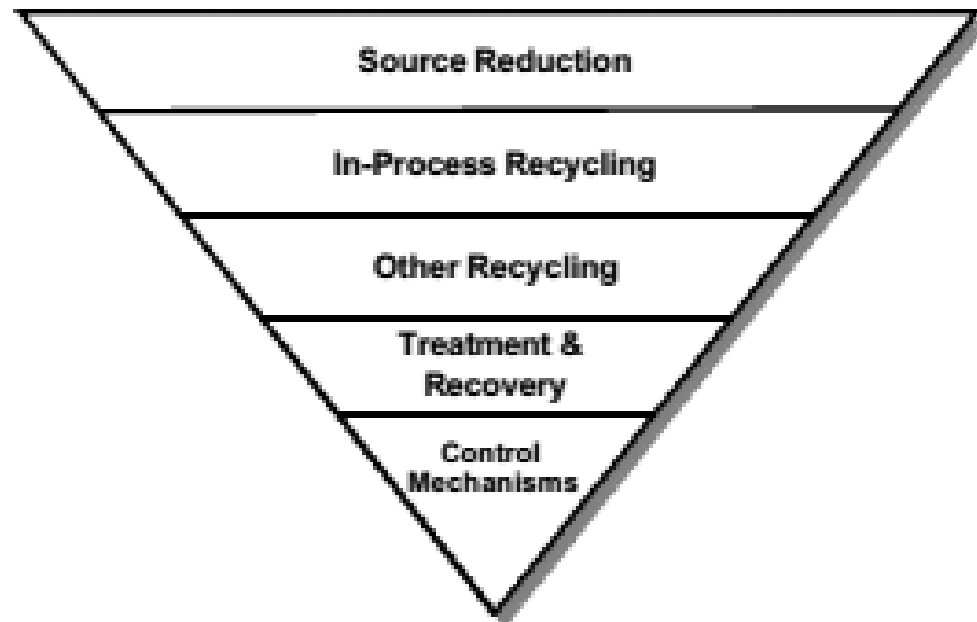
## Other Recycling

- Reuse/repurpose of waste in other applications
- Anaerobic digestion

## Treatment and Disposal

- Safe conversion of waste to environmentally-friendly form
- Proper disposal
- LAST RESORT

Prevention of Pollution Hierarchy



# Summary



- Over **170+** companies assisted to date
- Nearly **\$2M** in R&D projects funded to solve industry problems
- Over **\$1M** invested across nearly **80** communities in NYS
- Impact
  - Almost **10M** pounds of waste & emissions reduced
  - **70M+** gallons in avoided water use and **44M+** gallons of avoided discharges
  - Nearly **9M kWh** in reduced electricity use



# Pollution Prevention Technologies

**Eugene Park, PhD**  
**Asst. Director Technical Programs**  
**June 7, 2016**

# Pollution Prevention Technologies



Approaches to implement P2 vary from “Low-Tech” to “High-Tech” innovative technologies

## ➤ Low-Tech examples

- Process stream segregation (Source Reduction)
- Improved housekeeping (Source Reduction)
- Screen filters (Recycling, Treatment)

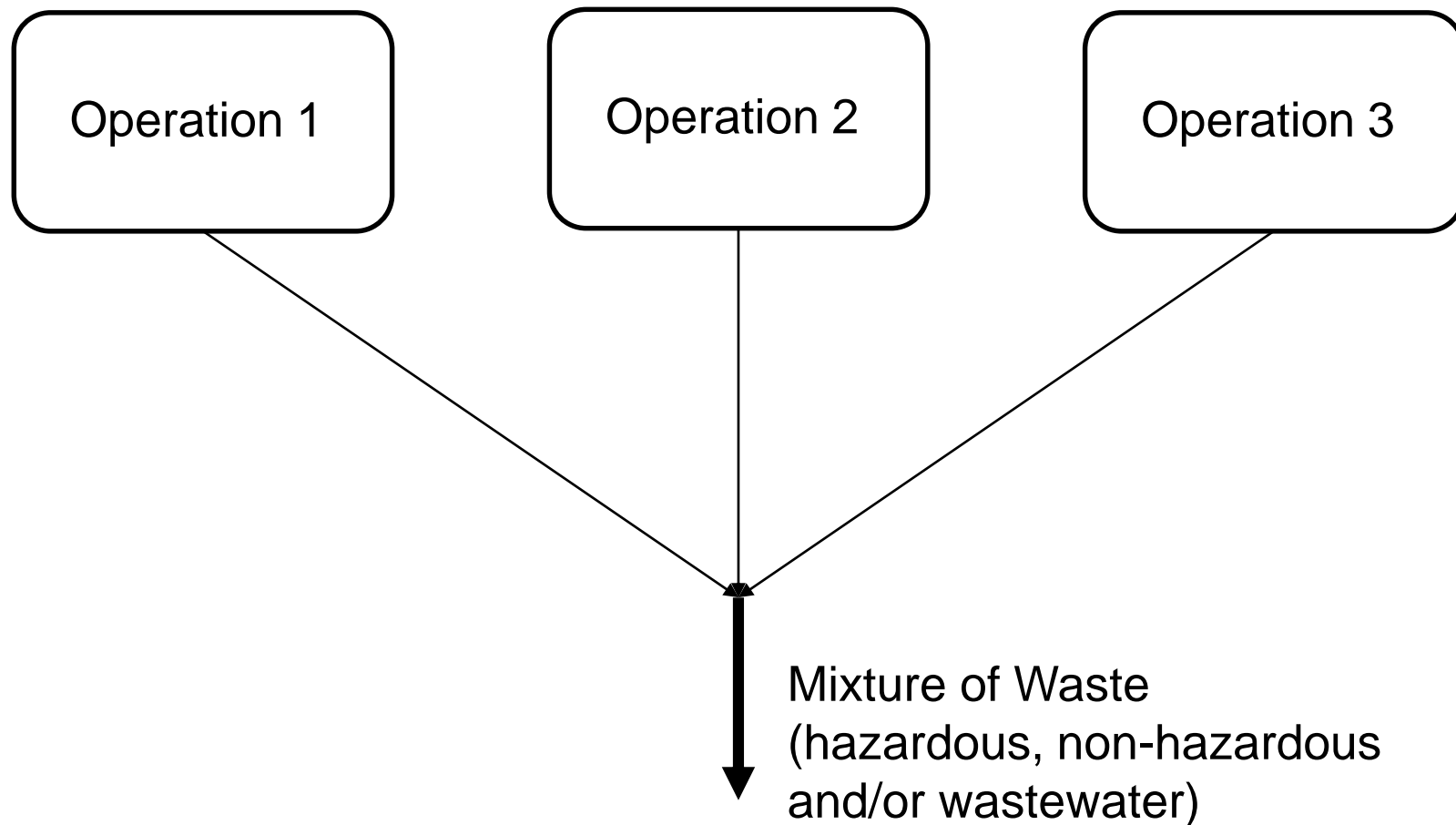
## ➤ High-Tech examples

- Membrane filtration (Recycling, Treatment)
- Vacuum cycle nucleation (Source Reduction)
- Ultimo non-contact densitometer (Source Reduction)

# Pollution Prevention Technologies



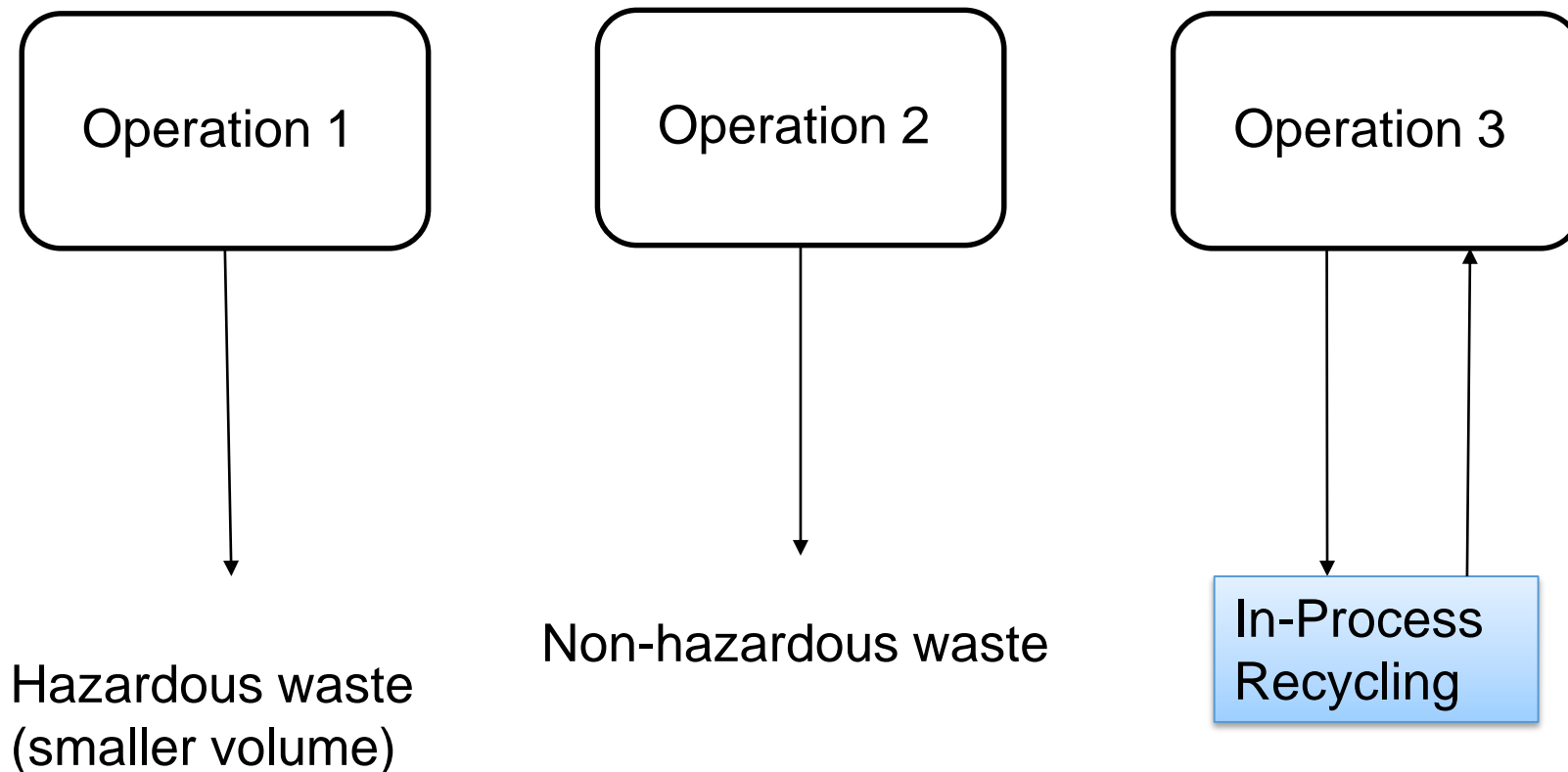
## Process stream segregation



# Pollution Prevention Technologies



## Process stream segregation, cont.

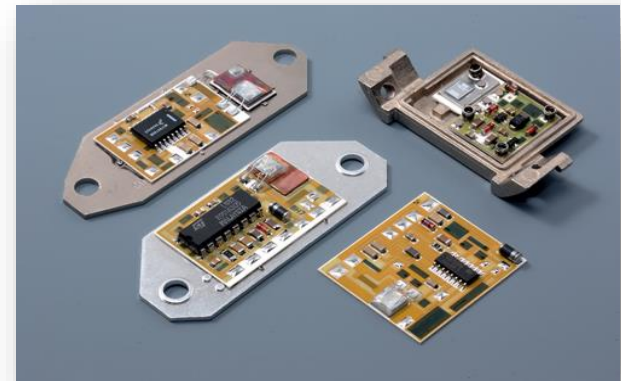


# Innovative P2 Technologies



## Vacuum Cycle Nucleation

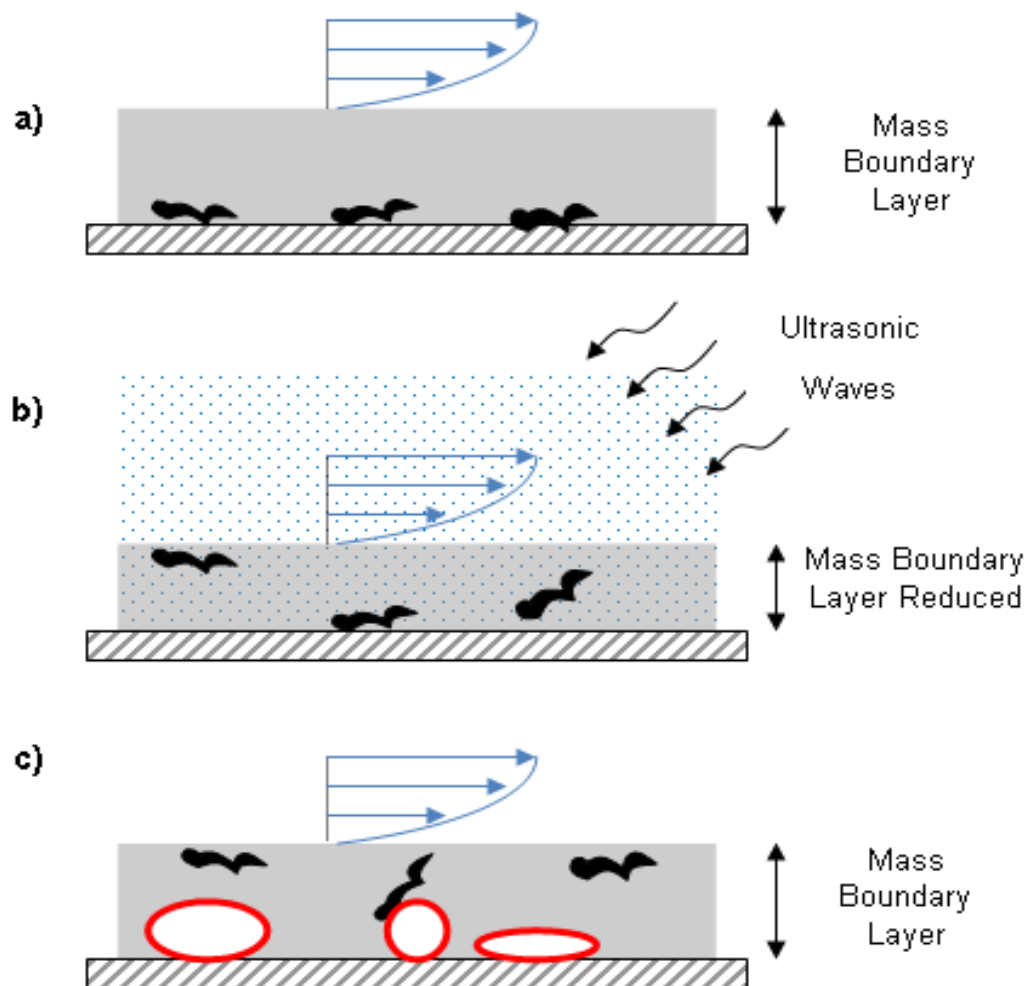
- Newer technology designed to replace or minimize use of chemicals in precision cleaning applications
- Applications where simple aqueous cleaning and ultrasonics ineffective
- Medical device, micro-electronics, any precision parts
- Lower boiling point of aqueous cleaning solution to nucleate bubbles under safe conditions



Photos courtesy of [www.hason-precision.com](http://www.hason-precision.com)



# Vacuum Cycle Nucleation



- a.) Normal fluid flow characteristics
- b.) Ultrasonics - reduced boundary layer but with tiny bubbles formed in bulk solution using high levels of energy
- c.) VCN - larger bubbles formed at the substrate surface where particles exist and serve as nucleation sites

# Vacuum Cycle Nucleation



BUBBLES  
FORM IN  
TIGHT  
AREAS



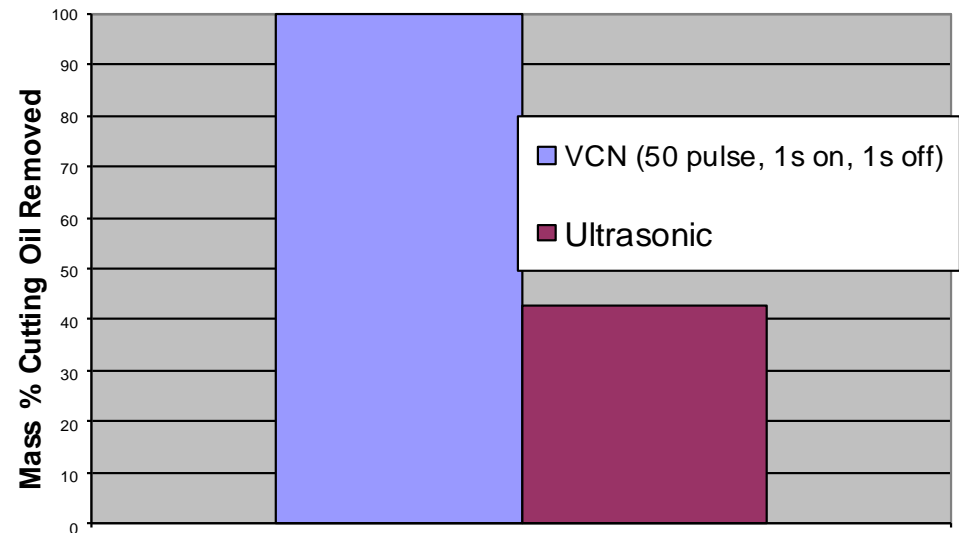
# Vacuum Cycle Nucleation: Close-up View



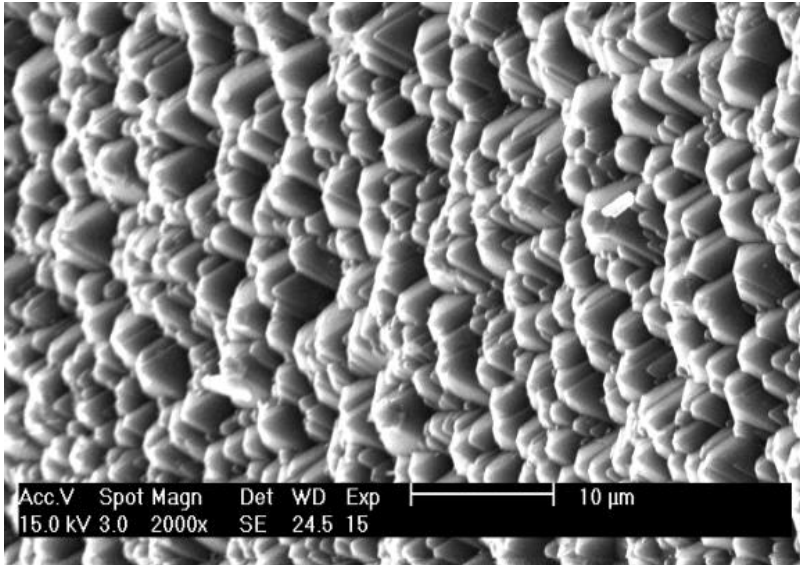
# Example VCN Application - Cleaning



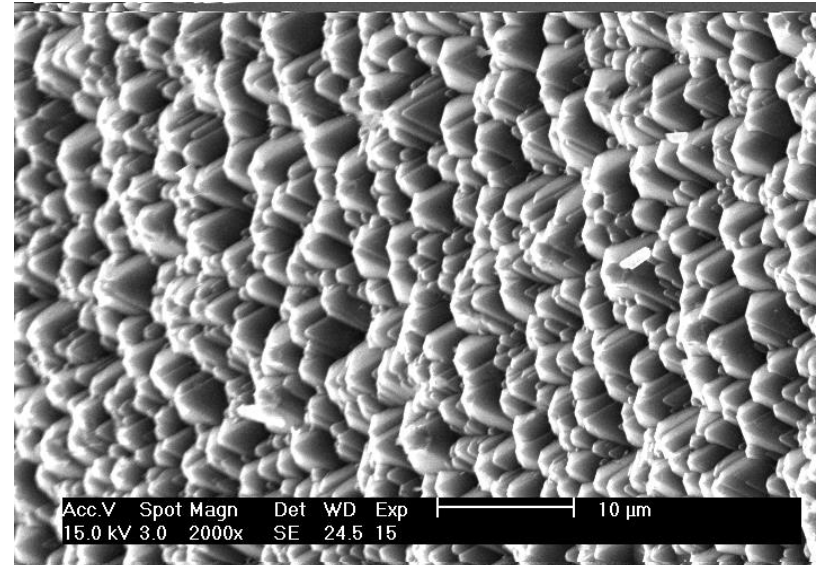
- VCN removed all oil in porous part
- Ultrasonics cannot penetrate pores



# VCN Application – Solar Wafer Texturizing



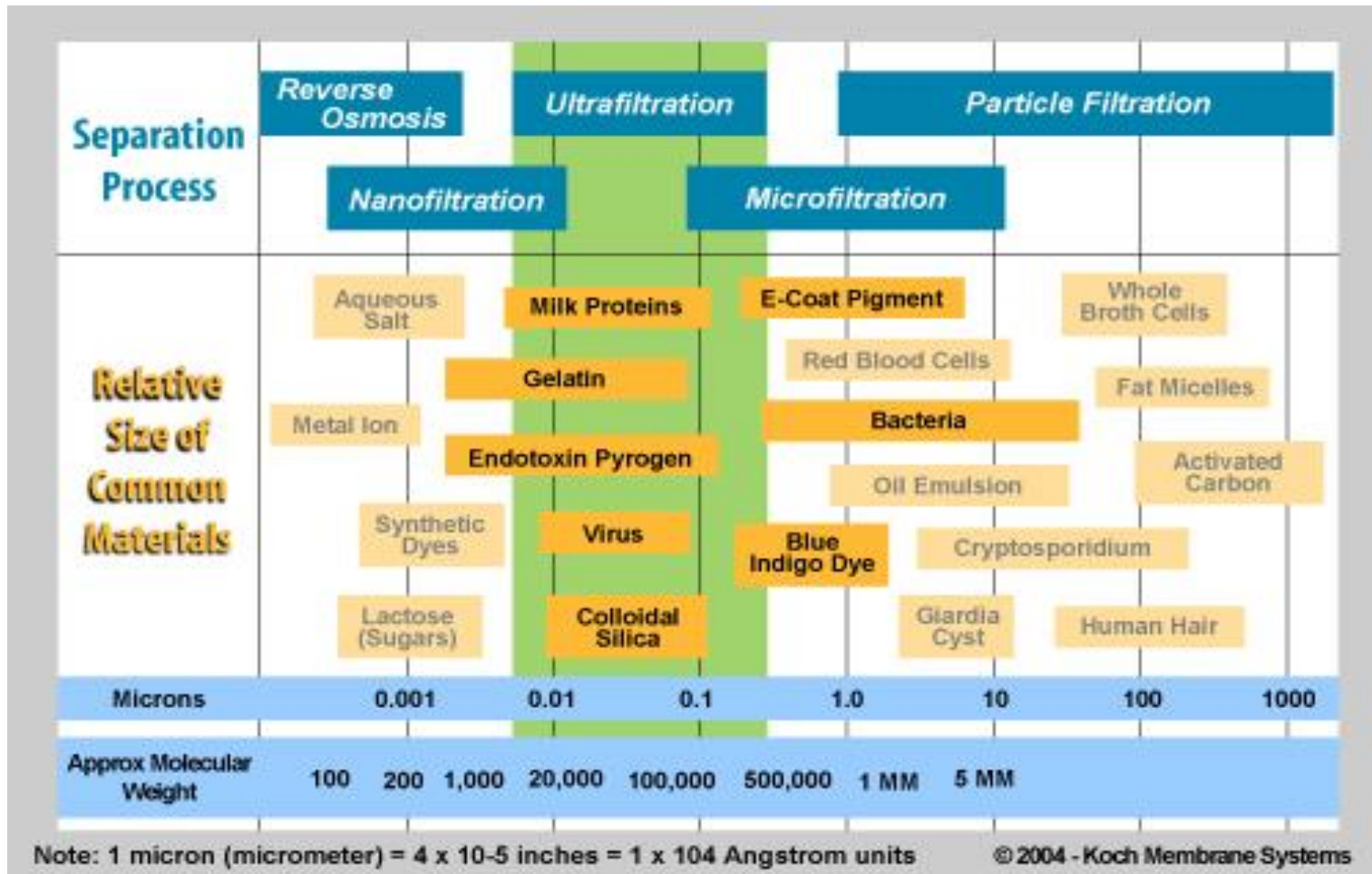
Commercial Solar Wafer



Solar Wafer Processed  
Using VCN with Lower  
Amounts of Chemicals and  
Shorter Time



# Membrane Filtration



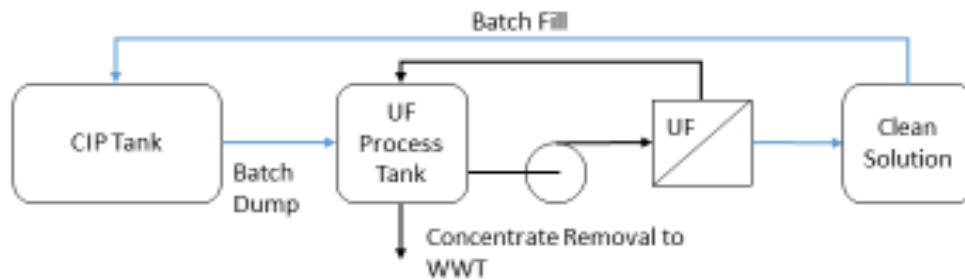
Courtesy of Koch  
Membrane

# Cross-Flow Filtration

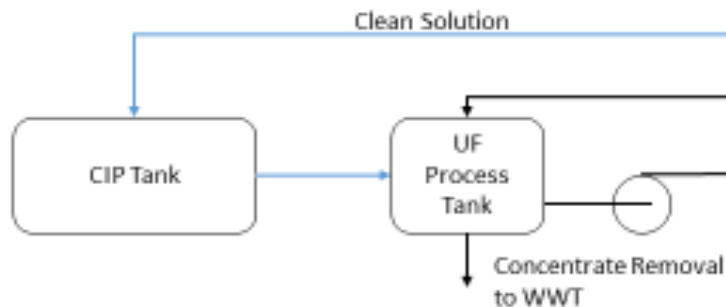




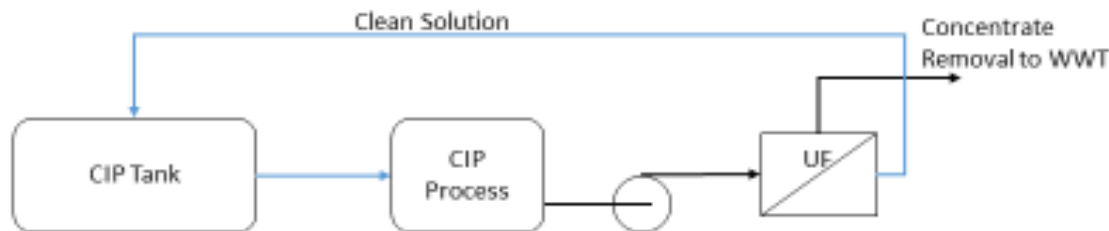
# Membrane Filtration



**Batch Mode**



**Semi-Batch Mode**



**Continuous Mode**



# Case Studies

# Evaluation of Vacuum Cycle Nucleation (VCN) as an Environmentally Preferable Cleaning Process



## Precision Parts Manufacturer

- Main product line: Small parts with tiny openings
- Current precision cleaning process relies on multi-stage ultrasonics that utilizes over 1500 gal/year of caustic cleaning chemicals at a cost of over \$60,000/year
- Other issues include higher than acceptable reject rates

## Work Performed

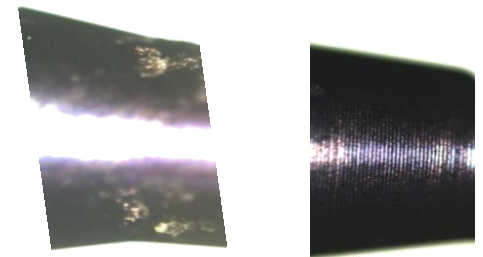
- NYSP2I performed a series of VCN tests under different operating conditions (chemical type, chemical concentration [ $<1\%$ ], temperature, pulse pattern, total cleaning time)
- Preliminary economic analysis

## Results

- Optimum VCN process was determined which increased cleaning effectiveness significantly (lower rejection rates)
- Chemical costs savings calculated to be over \$60,000/year
- Implementation is economically justified, 1-2 year payback



Bubble Formation on Part



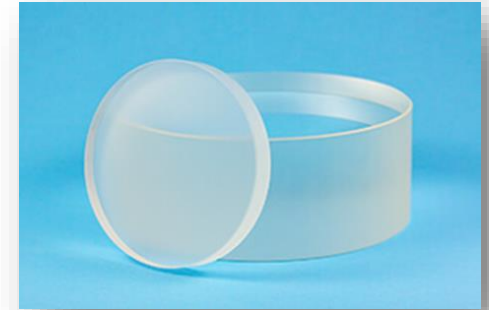
Before and After VCN

# Recovery of Cerium Oxide and Solvent Substitution



## Sydor Optics

- Main product line: Optical lenses for industrial application
- Almost 50% of expensive polishing compound (cerium oxide,  $\text{CeO}_2$ ) lost to sewer as TSS (9-10 kg/day, \$15,000-20,000/year); 3-400 gallons xylene used to remove wax from lenses
- Looking to recover more  $\text{CeO}_2$  and reduce or eliminate use of xylene in lens cleaning



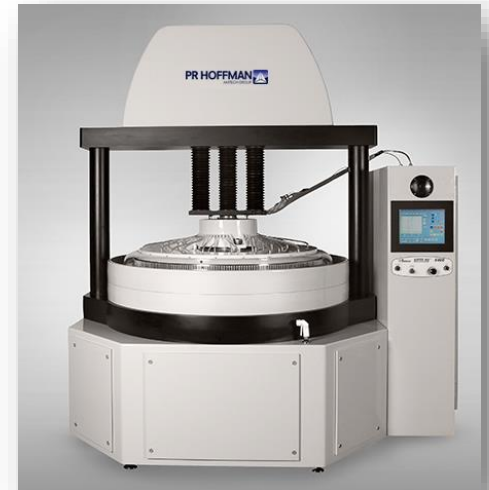
Optical Lenses

## Work Performed

- NYSP2I evaluated 1) solids separation and recovery technologies (centrifugation and membrane filtration) to capture more  $\text{CeO}_2$  and 2) different alternative chemistries and processes to clean prepared samples

## Results

- Bigger centrifuge and microfiltration can increase  $\text{CeO}_2$  recovery to 100%; TSS loadings to sewer would also be eliminated
- Hot water, ultrasonics, and small amounts of acetone possible replacement for xylene
- Implementation is economically justified, 1-2 year payback
- Follow-up implementation project has commenced



Lens Polishing Equipment

# Halogenated Solvent Use Reduction in Corian® Production



## DuPont

- Main product line: **Corian®** solid surface material
- 8,400 lbs/year methylene chloride (MeCl<sub>2</sub>) and 1,750 lbs/year of trichloroethylene-perchloroethylene spray (TCE-PCE) used as cleaning chemicals
- Looking to reduce or eliminate use of halogenated solvents

## Work Performed

- NYSP2I evaluated different alternative chemistries and processes to clean prepared samples



*Part currently cleaned using MeCl<sub>2</sub>*

## Preliminary Results

- Potential to eliminate 100% MeCl<sub>2</sub> and TCE-PCE use at the facility using more benign chemistries and processes
- For MeCl<sub>2</sub> replacement, positive results were observed with Acrastrip 950, VCN, and ultrasonics
- For TCE-PCE replacement: CRC Chlor-Free Non-Chlorinated Degreaser, Sakrete Concrete Mortar Dissolver, Bio-Solv & Acrastrip 950 were also positive
- Further feasibility studies & economic analysis needed



*Spray cleaners tested to replace TCE-PCE*

# Winery Water, Energy, & Chemical Assessment



## Channing Daughters

- A winery on the South Fork Wine Trail of Long Island
- Produces 12,000 cases/year of red, rose, and white wines
- Having already implemented various sustainable viticulture practices, Channing wanted to look into similar sustainability improvements in their winery operation

## Work Performed

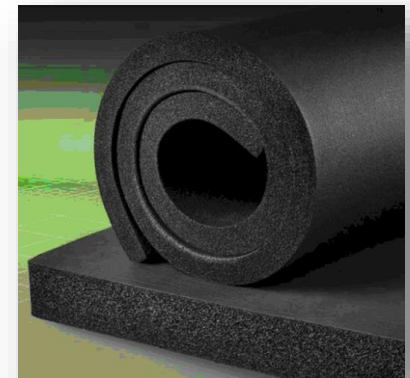
- On site assessment to analyze water, chemical, and energy use; evaluate improvement opportunities



High Pressure Washer

## Results

- NYSP2I identified improvement/cost saving opportunities:
  - Reduce water consumption by 22% through utilization of high pressure washers for cleaning equipment (pressure washer already on location)
  - Save energy and money in different locations:
    - 2.4 year payback to replace fluorescent lighting with LED lighting in hospitality room (already implemented, \$414/year savings)
    - **Insulation of chiller tanks can lead to \$3,500 savings annually (\$200-350 per 30-day cold stabilization run)**
    - Reduce electricity demand charges with control system
    - Switchover from propane to natural gas heating would save \$10,000/year and reduce GHG emissions by 18%



Tank Insulation Material



# Channing Daughters Winery – Tank Insulation





# Optimization of Dewatering/Drying Process in Manufacturing of Dog Treats



## Full Circle Feed

- Start-up company located in Syracuse that produces dog treats from leftover buffet food destined for landfill
- Requested assistance to optimize energy use and evaluate management of wastewater to enable company expansion

## Work Performed

- NYSP2I performed a baseline energy analysis, wastewater analysis, and a drying analysis which examined how drying time is affected by an alternative drying technology (convection)



Doggy Bag Treats being prepared

## Results

- Forced-air convection oven would reduce drying time by 64%, resulting in a corresponding reduction in energy usage and an estimated \$1344 savings in annual energy costs based on current production rates
- Wastewater contains high levels of organics and solids. Simple settling would reduce organic content by over 50% and reduce potential surcharges



Convection oven used during testing



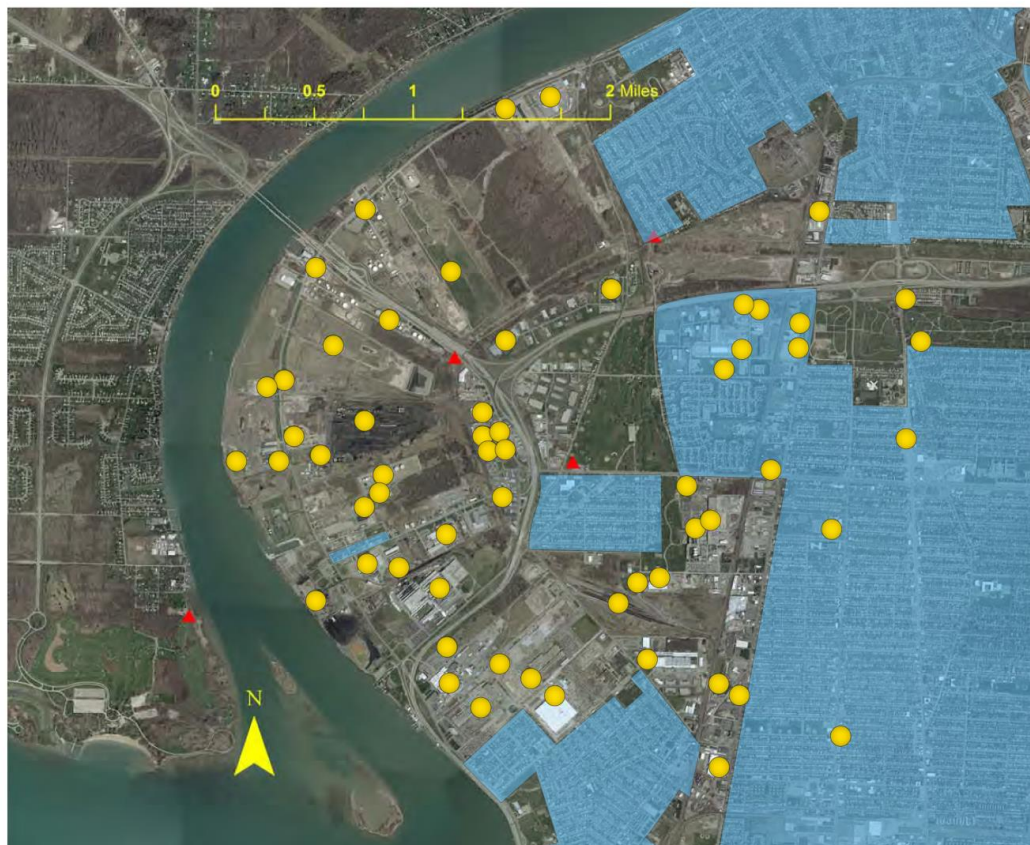
# *Using E3 to Incorporate Sustainability and Green Technologies in Tonawanda, NY*

# The Challenge



- One of the highest densities of industrial development in New York State (59 facilities).
- 2008 TRI reported approximately 1 million pounds of toxics released from the 10 biggest facilities.

- Manufacturing Facility
- Residential Neighborhood



Map of Tonawanda

# NYSDEC Air Monitoring Study



## Six HAPs Exceeded Guideline Concentrations

- **Benzene:** fossil fuel combustion (FF), manufacturing
- **Formaldehyde:** FF, manufacturing, atmospheric
- **1,3 Butadiene:** FF, manufacturing
- **Acetaldehyde:** FF, manufacturing, atmospheric
- **Acrolein:** FF, manufacturing, atmospheric
- **Carbon Tetrachloride:** *atmospheric, historical artifact*

Sources vary according to chemical, but approximately:

- 15%-95% from large stationary sources, including both fossil fuel combustion and manufacturing
- 5%-60% from mobile sources, fossil fuel combustion
- 10% from atmospheric oxidation (transport from other areas)



# The Concept:



**E3: ECONOMY • ENERGY • ENVIRONMENT**  
SUPPORTING MANUFACTURING LEADERSHIP THROUGH SUSTAINABILITY



**Lead Technical Resource  
in Tonawanda  
E3 Initiative**



**SBA**  
U.S. Small Business Administration

# Energy Reduction from Improved Pipeline Insulation



## NOCO Energy's Tonawanda Intermodal Terminal

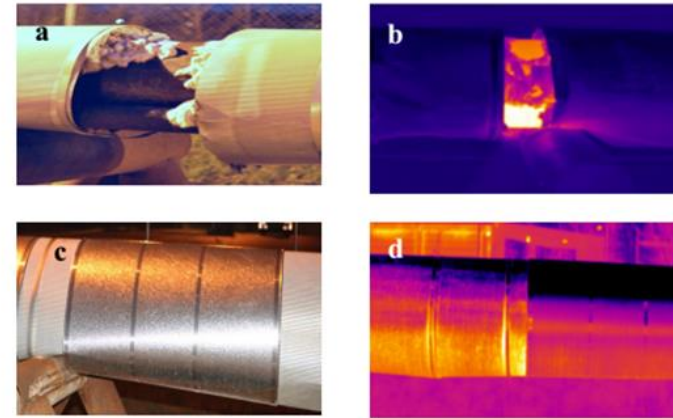
- Provides services such as vessel loading/unloading, pipeline receipt, rail tank car loading/unloading and tank truck weighing
- 80 tanks located on 80 acres with a storage capacity of over 45 million gallons
- Products include asphalt, heavy oils, distillate, gasoline and bio-fuels.

### Work Performed - Energy assessment:

- Evaluated thermal energy lost due to compromised or missing insulation during transportation of asphalt through the heated transport pipeline
- Calculated potential natural gas savings for boiler heating of the pipeline if the insulation was replaced

### Results

- 124 feet of asphalt pipe were bare or poorly insulated
- Potential avoided thermal energy loss, including boiler efficiency, of approximately 1,785 MMBTU/year
- Potential reduction of 210,325 pounds/year of various air emissions including 95 Metric Tons of greenhouse gas emissions (CO<sub>2</sub>Eq.)



- a.) Image of bare pipe;
- b.) Thermal image of bare pipe
- c.) Image of new insulation with aluminum jacket;
- d) Thermal image of intersection of old and new insulation

# NOCO Energy – potential 1,785 MMBTU/yr reduction of natural gas



Air Emission	Quantity Avoided (with insulation replaced on 124 ft) (lbs / year)	Criteria Pollutant (Yes / No)	Hazardous Air Pollutant (Yes / No)	Greenhouse Gas Contributor (Yes / No)
Nitrogen Oxides (NO <sub>x</sub> )	175	Yes	No	Yes
Nitrous Oxide (N <sub>2</sub> O)	4	Yes	No	Yes
Carbon Monoxide (CO)	147	Yes	No	No
Lead	0.001	Yes	Yes	No
Total Particulate Matter (PM)	13	Yes	No	No
Sulfur Dioxide (SO <sub>2</sub> )	1	Yes	No	No
Carbon Dioxide (CO <sub>2</sub> )	209,969	No	No	Yes
Total Organic Compounds (TOC)	19	No	No	No
Volatile Organic Compounds (VOC)	10	Yes	No	No
Methane	4	No	No	Yes
**Benzene	0.004	No	Yes	No
**Formaldehyde	0.131	No	Yes	No

Source: U.S. EPA “AP-42, *Compilation of Air Pollutant Emission Factors*”, <http://www.epa.gov/ttnchie1/ap42/>,



# Assessment of Alternative Coatings for Improved Cathode Longevity and Toxic Metal Elimination



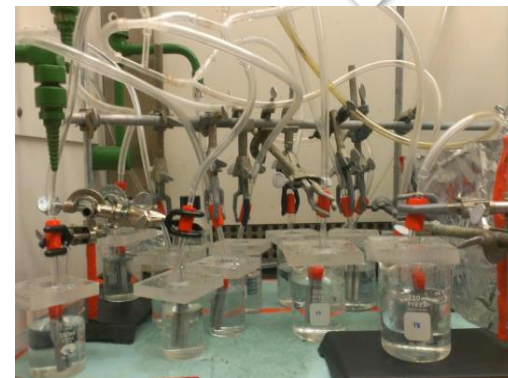
**PeroxyChem LLC** manufactures hydrogen peroxide, peracetic acid, persulfates and adjacent technologies in Tonawanda, NY.

## Work Performed

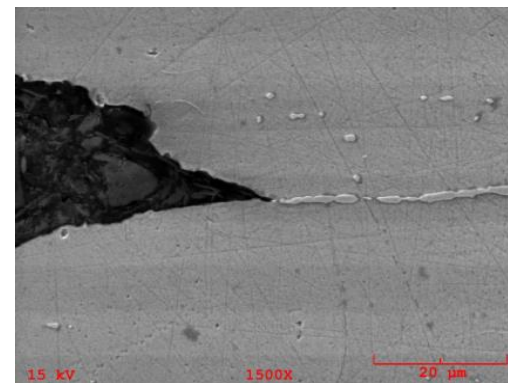
- Evaluated new metal cathodes to find the root cause of corrosion and shorter life-span using Scanning Electron Microscope (SEM) analysis and SEM Energy Dispersive X-ray (EDX).
- Identified potential coatings and conducted accelerated corrosion and delamination tests.

## Results

- Determined original coating had poor performance and the new metal had a manufacturing defect.
- Identified an alternative coating material that can potentially withstand the process environment, prevent corrosion, and provide improved longevity for the new cathode metal.
- Should the new coating material be implemented, it would enable the replacement of the previous cathode metal thereby eliminating toxic materials and the generation of over 1,000 pounds of toxic hazardous waste.



Laboratory setup for accelerated corrosion/delamination testing of coatings on cathode substrates



1500 magnification using SEM showing a defect as the point of initiation for the corrosion

# Solvent Use and Associated Air Emissions Reduction



## Title: Tread-End Cement Reduction

### Project Mission:

Reduce the amount of Volatile Organic Compounds (VOC) exhausted at the Goodyear Dunlop Tire North America (GDTNA) Plant located in Tonawanda, New York. Reduce the amount Cement applied to the end of treads on the 224 and 227 Extruding lines and reduce the amount of dollars spent on Tread-End Cement.

### Improvement Category:

X	Safety		Delivery
X	Quality	X	Engagement
X	Cost	X	Communications

### Improvement Goals

### Current State

### Future Goal

1. Reduce VOC at Buffalo Plant

**Not Optimal**

**Better**

2. Reduce Tread-End Cement

**6.8 grams/Tread**

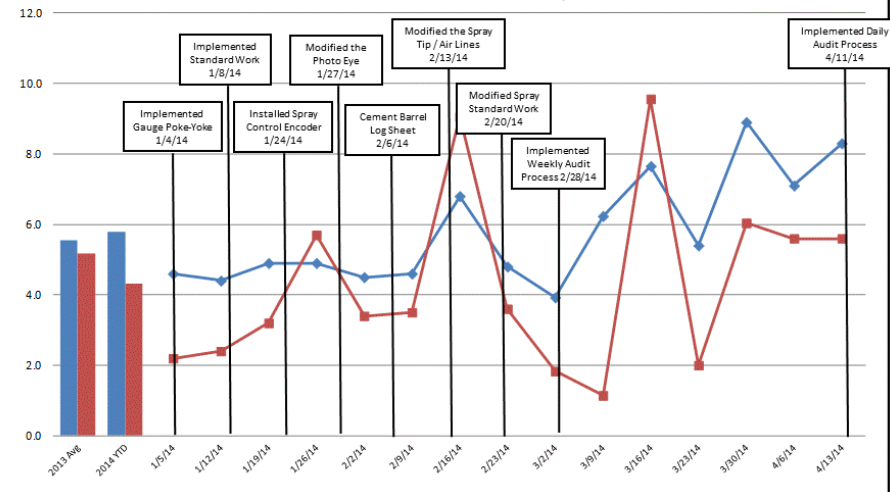
**3.5 grams/Tread**

3. Reduce Tread-End Cement Cost

**\$54,000 / Year**

**\$24,000 / Year**

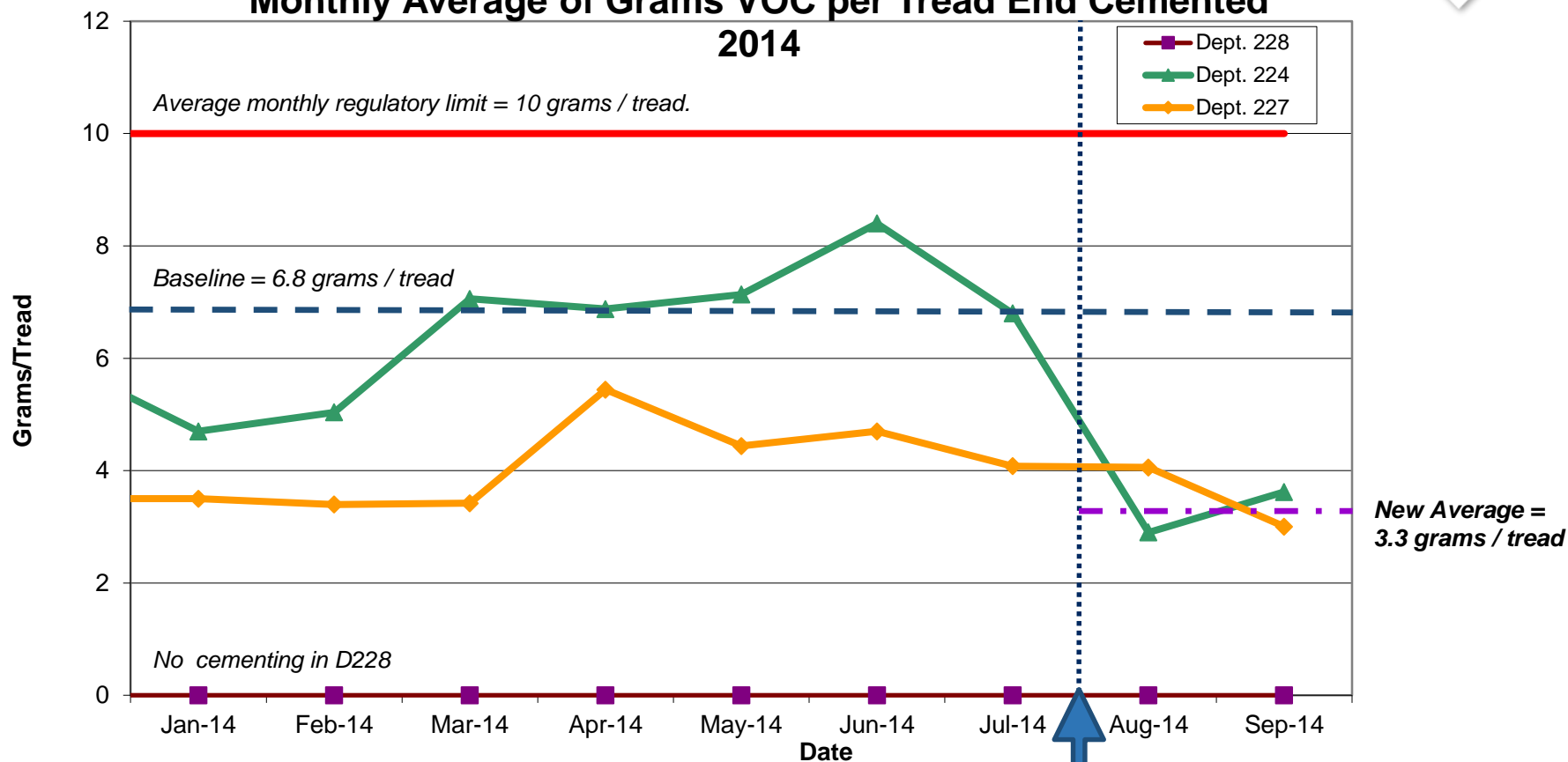
### Grams of Cement Per Treads By Week





## Goodyear Dunlop Tires North America, LTD. Tonawanda, New York

### Monthly Average of Grams VOC per Tread End Cemented



- Improved gun height above the tread
- Changed photo eyes from AC to DC
- Shortened air lines between solenoid valves and spray guns

# NYSP2I Results



**E3: ECONOMY - ENERGY - ENVIRONMENT**

SUPPORTING MANUFACTURING LEADERSHIP THROUGH SUSTAINABILITY



## Funding:

U.S. EPA Source Reduction Assistance grant

- **2 years, \$130,000**
- **Assess opportunities** for local manufacturers to reduce
  - energy
  - environmental impacts
  - associated costs

## Requirements:

- **Screen 8** manufacturing companies for potential projects
- **Assess 4** of the screened companies for LE2 projects - Baseline metrics collected
- **Implement 2** recommendations from the assessment at the assessed companies
- **Outreach and dissemination** of successes after implementation of solutions is completed

## Status:

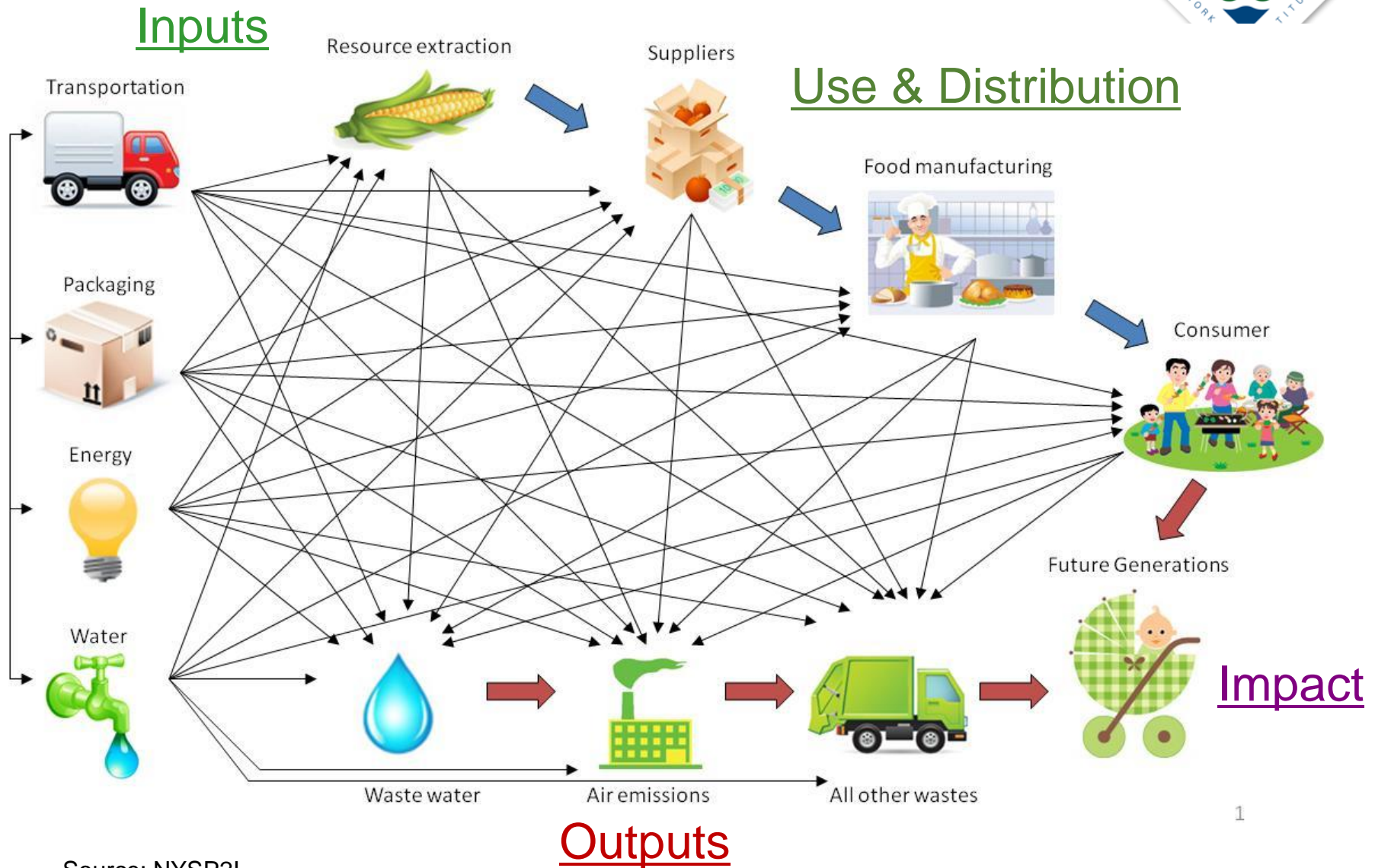
- **Screened 13** manufacturing companies for potential projects
- **4 company assessment projects** completed with EPA grant
- **1 feasibility study** completed with EPA grant
- **2 implementations** completed with EPA Grant
- Resulting in potential reductions:
  - 102,151 lbs of hazardous materials
  - 1,040 lbs of toxic hazardous waste
  - 21,320 lbs of VOC emissions
  - over 3 million kwh of electricity
  - 3,000 MMBTU of natural gas
- **5 additional projects in Tonawanda** also assisted through NYSP2I funding



# Sustainable Supply Chain Program

New York State Pollution Prevention Institute

# Supply Chains & Relationships



Source: NYSP2I



# “Supply Chain Sustainability” – A Definition



The United Nations Global Compact defines **supply chain sustainability** as “the *management of environmental, social and economic impacts*, and the *encouragement of good governance practices*, throughout the *lifecycles of goods and services*”

*“The objective of supply chain sustainability is to create, protect and grow long-term environmental, social and economic **value** for all stakeholders involved in bringing products and services to market.”*

[http://unglobalcompact.org/docs/issues\\_doc/supply\\_chain/SupplyChainRep\\_spread.pdf](http://unglobalcompact.org/docs/issues_doc/supply_chain/SupplyChainRep_spread.pdf)

# Supply Chain Sustainability Assessments



## Opportunity Areas

Companies are under greater pressure today to measure and communicate their environmental and societal impacts. Businesses that strategize, set targets, measure, monitor, and report their sustainability efforts will likely generate more revenue, retain and potentially create jobs, and reduce the risk of jeopardizing potential business.

## Work Performed

NYSP2I created an assessment tool to use with companies to inquire about various common components of internationally accepted sustainability guidelines, standards, and protocols.

## Results

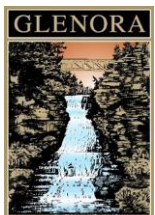
- 5 companies have requested an SSC assessment
- Companies anticipate an average of **10% increase in sales** and an average of **10% increase in job growth** (17 new jobs from these 5 companies)

Opportunities identified include:

- Informing procurement personnel of sustainable purchasing alternatives;
- Measuring impacts to set objectives and targets and to track performance;
- Adding policy, objectives and targets, performance and action plans to marketing and communications material.

“...With credibility as a green supplier, BRF has a recognized competitive advantage in the market place which makes the company a preferred business partner within the food and beverage industry.”

—John Cairns,  
**Baldwin Richardson Foods**





# ISO 14001 EMS Readiness Assessment with a Metal Finishing Manufacturer



## Acro Industries, Inc.

A Rochester-based, privately owned, contract metal finishing manufacturer that strives for continuous improvement throughout its business. Pressure from customers regarding conformance to an Environmental Management System (EMS), such as ISO 14001, heightened in 2014.

## Opportunity Areas

Acro recognized the need to address the pressure from customers and the opportunity to differentiate themselves with larger companies that seek sustainable suppliers with ISO certifications. An EMS would foster Acro's commitment towards continuous improvement through more effective measurement and monitoring techniques, resulting in opportunities to reduce environmental impacts and operating costs.



"To achieve the customer requested ISO 14001 certification, we needed a gap analysis completed along with some recommended best practices to accompany our current Quality Management System. NYSP2I worked with the Acro team, not only utilizing decision making tools that were unfamiliar to Acro, but actually spending days on our shop floor truly understanding how we operate and what gaps need to be closed to achieve certification. Due to the detailed project planning process provided by NYSP2I, our customers were confident enough in our success that we were awarded a \$1.5 million dollar contract. We are on track to be ISO 14001 certified by June of 2016."

-- Bob Coyne, General Manager,  
Acro Industries Inc.

## NYSP2I Work Performed

- Reviewed Acro's waste manifests, energy and water data, existing policies, procedures and objectives & targets from their quality management system to determine synergies with the ISO 14001 standard.
- Conducted an on-site assessment to identify activities (aspects) that create environmental impacts.
- Developed input-output diagrams for processes; an Environmental Aspects Guidance and Rating Chart; a Risk Criteria Matrix; Readiness Gap Assessment with recommendations to prepare for certification to the ISO 14001 standard.

## Results

Acro anticipates a 10% increase in sales within 3 years, and a 20% increase in customers, ultimately anticipating the creation of approximately 10 new positions.



# **Green Technology Accelerator Center**

NEW YORK STATE POLLUTION PREVENTION INSTITUTE

# EDG-trac Knife Advance System Performance Evaluation



## Tristar, Ltd. (Tonawanda, NY)

- Manufacturer of fabricated components and equipment, including remanufactured filtration systems
- EDG-trac Knife Advance System for rotary vacuum drum filters features key design improvements over conventional systems, such as the use of a single motor gear drive and control based on motor frequency versus drum rotation

## Opportunity

- It was anticipated that the enhanced control enabled by the EDG-trac Knife Advance System would decrease energy and water use and increase process throughput

## GTAC Project Objective

- Evaluate Tristar's Edg-trac Knife Advance System at a manufacturing facility as compared to a traditional rotary vacuum drum filter system

## Results

Tristar's EDG-trac Knife Advance System exhibited the following performance results:

- **700% ave increase in water filtration throughput**
- **87.4% reduction in energy use**, on a per gallon filtered basis
- Comparable sludge moisture content and suspended solids removal efficiencies
- Tristar is targeting the **creation of 5 NY State jobs** to expand manufacturing of EDG-trac

# Ecovative Design Life Cycle Assessment



## Ecovative Design, LLC

- Ecovative uses fungal mycelium (mushroom "roots") to bond together locally sourced agricultural byproducts into Mushroom® Packaging base material.
- A patented process cleans and prepares a blend of agricultural byproducts, and inoculates it with mycelium (mushroom tissue).
- Packaging material is then "grown" into the required custom shape.

## Opportunity

- By using fungal mycelium and agricultural byproducts, Ecovative uses materials that are environmentally low-impact, biodegradable and renewable.
- This product replaces synthetic materials such as Styrofoam™.



## GTAC Project Objectives

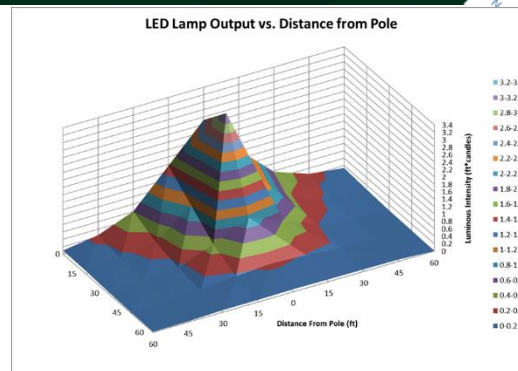
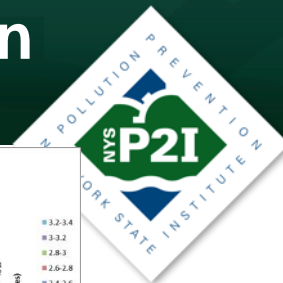
- Apply Life Cycle Assessment (LCA) methodology to compare the environmental impact of 3 different Mushroom® Packaging base material configurations to understand and help optimize Ecovative's unique biomaterials manufacturing process.

## Results:

- The LCA results supported process improvements and energy efficiency gains including:
  - Utilization of higher performance feedstocks that could be grown locally to also reduce transportation impacts on the environment.
  - **Evaluation of a new drying process to reduce energy consumption by 1/3.**
- Ecovative is forecasted market expansion and creation of **14 jobs** to support design and manufacturing in NY state



# LED vs. Metal Halide Lighting Energy Comparison



## LED Display Technology, Inc. (@ Stonybrook)

- LED Display Technology, Inc. manufactures lighting fixtures that use proprietary optical components, innovative heat management technology and LED's.
- Products are a direct replacement for exterior metal halide lighting systems

## Opportunity

- Reduction in exterior lighting energy with equivalent light output vs. metal halide systems
- Improvement in lighting system lifespan and reduced maintenance due to improved thermal management

## GTAC Project Objectives

- Perform a comparative analysis of light output and electrical energy use of LED Display's new LED lighting system
- Compare energy use to a specific metal halide parking lot lamp (i.e. KD 400M R5S)
- Evaluate the energy savings attributable to the LED lighting system

## Results

- The energy consumed by the LED lamp tested ranged from **79% to 88% less than the R5S metal halide lamp.**
- For equivalent illumination levels, the potential energy savings was 79%.
- LED Display is targeting the creation of: **25 NY state jobs**

# Questions?



## Contact us at:

New York State Pollution Prevention Institute

111 Lomb Memorial Drive, Rochester, NY 14623

[nysp2i@rit.edu](mailto:nysp2i@rit.edu)

telephone: 585-475-2512

Follow us/FB, Twitter, LinkedIn





# New York State Pollution Prevention Institute

Eugene Park, Trish Donohue

June 7, 2016

# Course Agenda:



- Welcome & Introduction to NYSP2I and Sustainability/P2
- Tools in P2 Assistance
  - Traditional Technologies
  - Innovative Technologies
- Detailed Case Studies
  - Direct Client Assistance Program
  - Sustainable Supply Chain Program
  - Green Technology Accelerator Program
- Q&A Session

**Eligible participants will receive 1.5 hours of PE continuing education credits.**

# NYS Pollution Prevention Institute



- Established in 2008 “**NYSP2I**”
- HQ at RIT
- **\$4M** in annual NYS funding
- Focus on reduction of natural resource consumption (water, raw material, energy) and elimination of waste and toxics
- P2 research, technical assistance, education and outreach
- **15+** full-time staff

R·I·T

Clarkson  
UNIVERSITY  
*defy convention*



Department of  
Environmental  
Conservation

UB University at Buffalo  
The State University of New York



Rensselaer

10 NYS RTDCs

# Business Assistance



- Must be **NY-based** company
- Technical assistance provided from an interdisciplinary team of experts including engineers and environmental scientists
- Typical project cost ranges **\$15-\$50K**
- P2 funding offsets most of the project cost to the company
- **3** years of post-project reporting
- Expenses are non-capital expenses
- Typical project takes about **2-4** months



# Types of Business Assistance



## Areas of Technical Expertise:

- P2 problem identification, reducing environmental “footprint” of process or facility
- Technology assessments, validation and effectiveness studies
- Supply chain sustainability assessments, strategy, and implementation
- Green or eco-innovation products in the commercialization stages

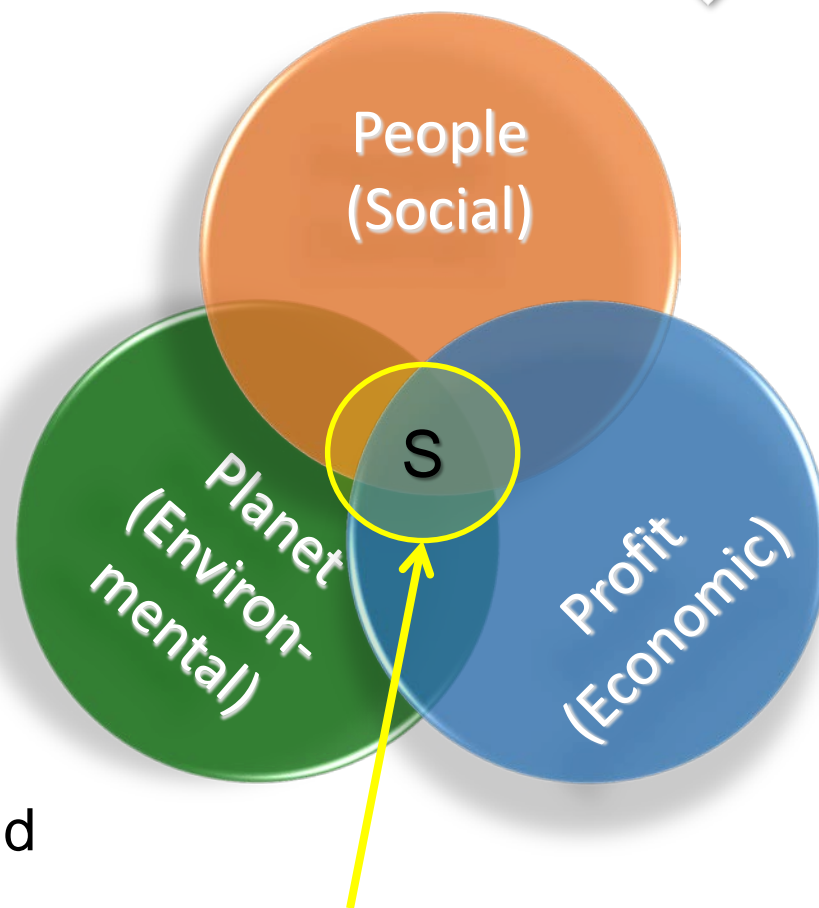
# Sustainability – Defined



Many terms for addressing social, environmental and economic initiatives:

- “3Ps” – People, Planet, Profit
- Social, Economic, Environmental
- “Corporate Social Responsibility”
- “Corporate Citizenship”
- “Sustainable Growth”

Each company or organization should define how they address “sustainability”



*Sustainability is actualized*



# Sustainability – Defined



**Sustainable Development**: “development that meets the **needs** of the present without compromising the ability of future generations to meet their own **needs**”



“We do not inherit the earth  
from our ancestors, we  
borrow it from our children.”

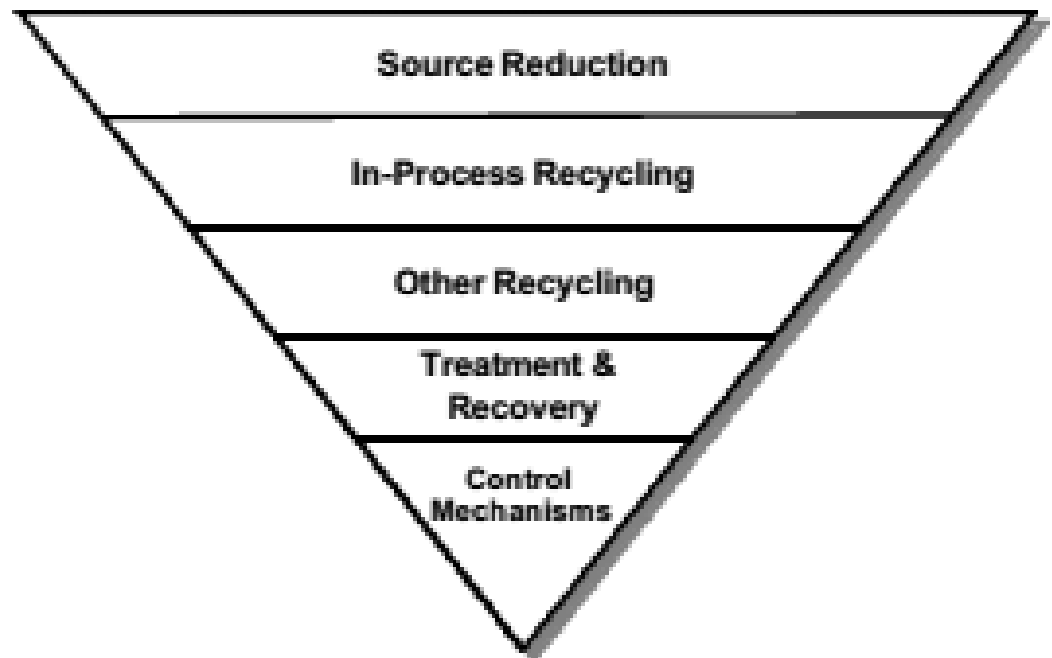
~Native American Proverb

# Pollution Prevention Hierarchy



In evaluating P2 opportunities, organizations should start at the top of the pyramid (i.e., source reduction) and work their way down as needed to define the most appropriate methods for preventing pollution.

**Prevention of Pollution Hierarchy**



# Pollution Prevention Hierarchy



## Source Reduction

- Product/process change
- Green chemistry/toxics reduction

## In-Process Recycling

- Direct reuse of materials or by-products in process

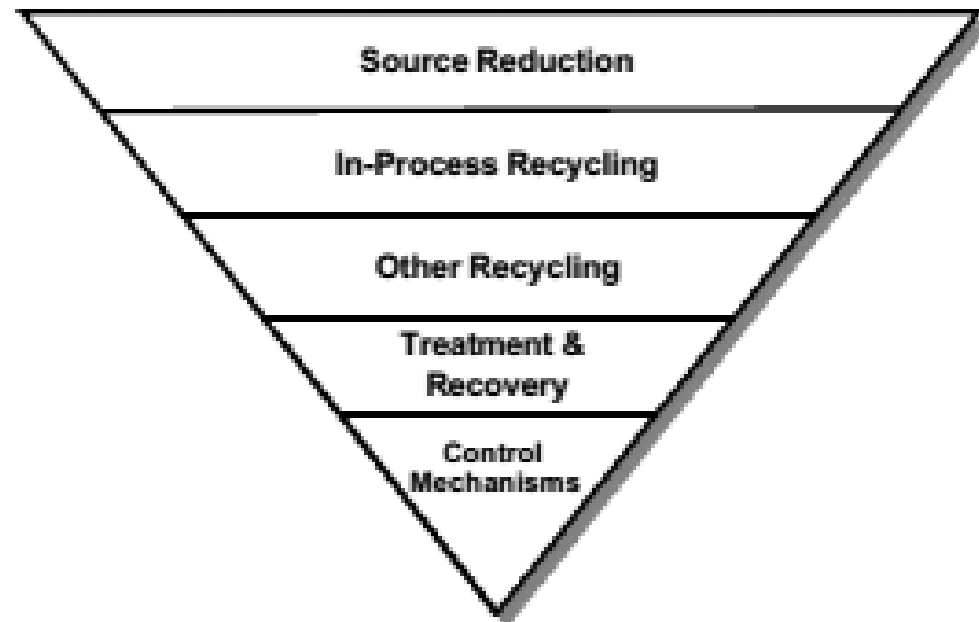
## Other Recycling

- Reuse/repurpose of waste in other applications
- Anaerobic digestion

## Treatment and Disposal

- Safe conversion of waste to environmentally-friendly form
- Proper disposal
- LAST RESORT

Prevention of Pollution Hierarchy



# Summary



- Over **170+** companies assisted to date
- Nearly **\$2M** in R&D projects funded to solve industry problems
- Over **\$1M** invested across nearly **80** communities in NYS
- Impact
  - Almost **10M** pounds of waste & emissions reduced
  - **70M+** gallons in avoided water use and **44M+** gallons of avoided discharges
  - Nearly **9M kWh** in reduced electricity use



# Pollution Prevention Technologies

**Eugene Park, PhD**  
**Asst. Director Technical Programs**  
**June 7, 2016**

# Pollution Prevention Technologies



Approaches to implement P2 vary from “Low-Tech” to “High-Tech” innovative technologies

## ➤ Low-Tech examples

- Process stream segregation (Source Reduction)
- Improved housekeeping (Source Reduction)
- Screen filters (Recycling, Treatment)

## ➤ High-Tech examples

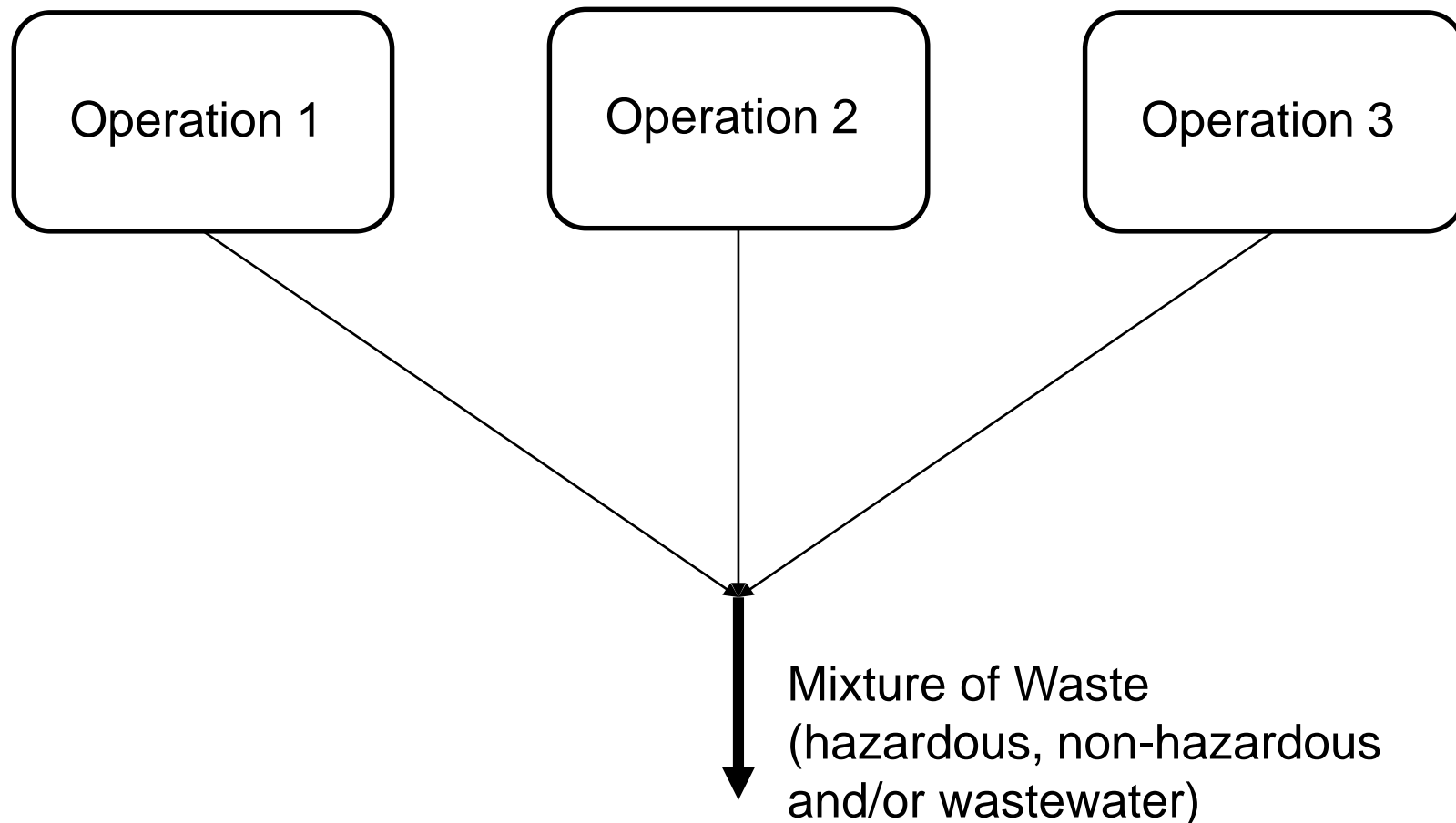
- Membrane filtration (Recycling, Treatment)
- Vacuum cycle nucleation (Source Reduction)
- Ultimo non-contact densitometer (Source Reduction)



# Pollution Prevention Technologies



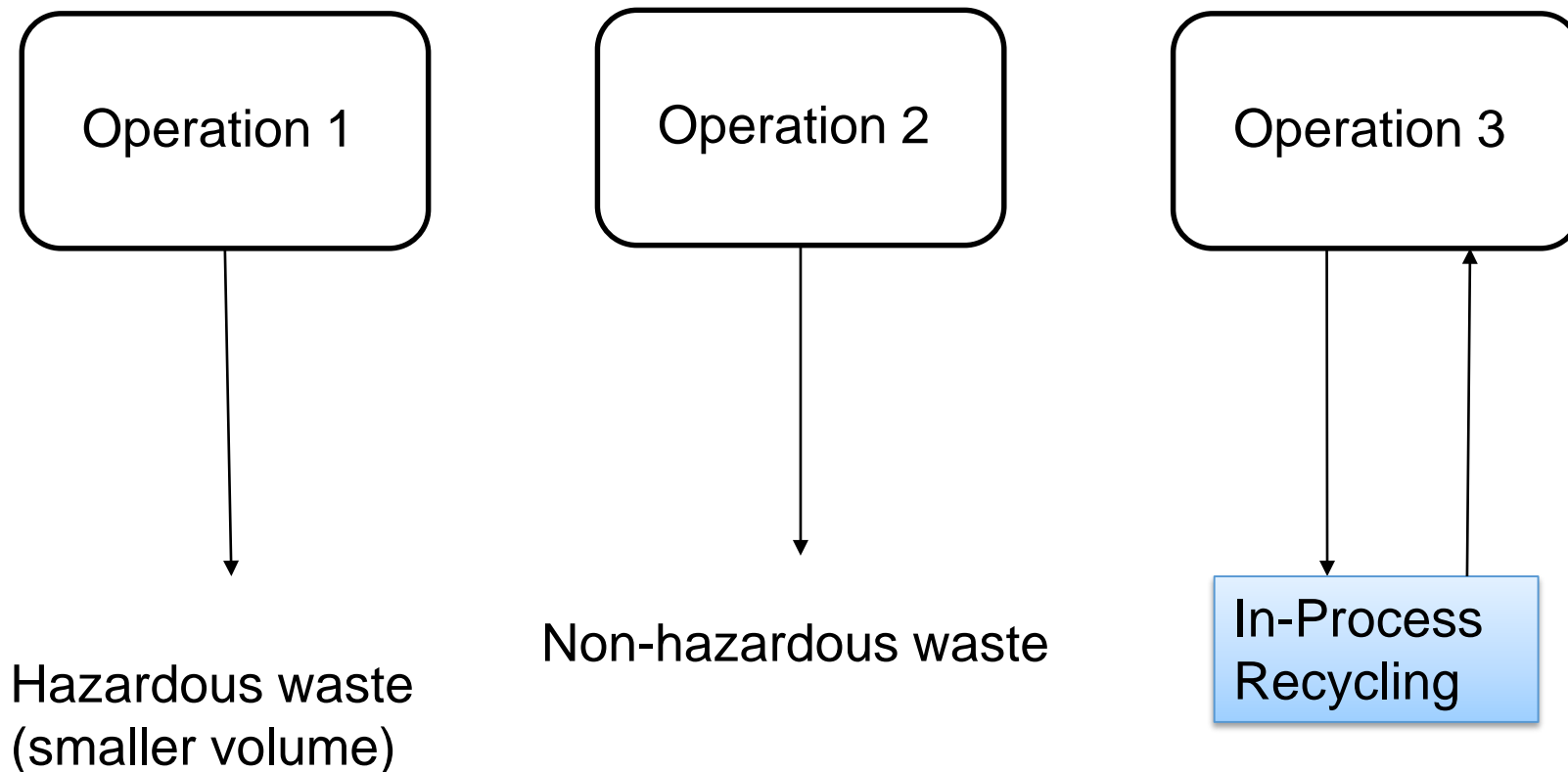
## Process stream segregation



# Pollution Prevention Technologies



## Process stream segregation, cont.

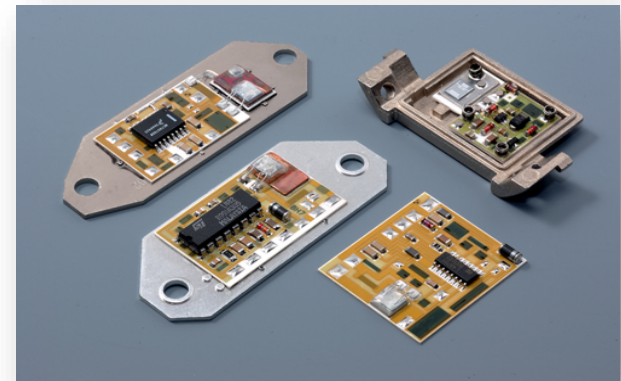


# Innovative P2 Technologies



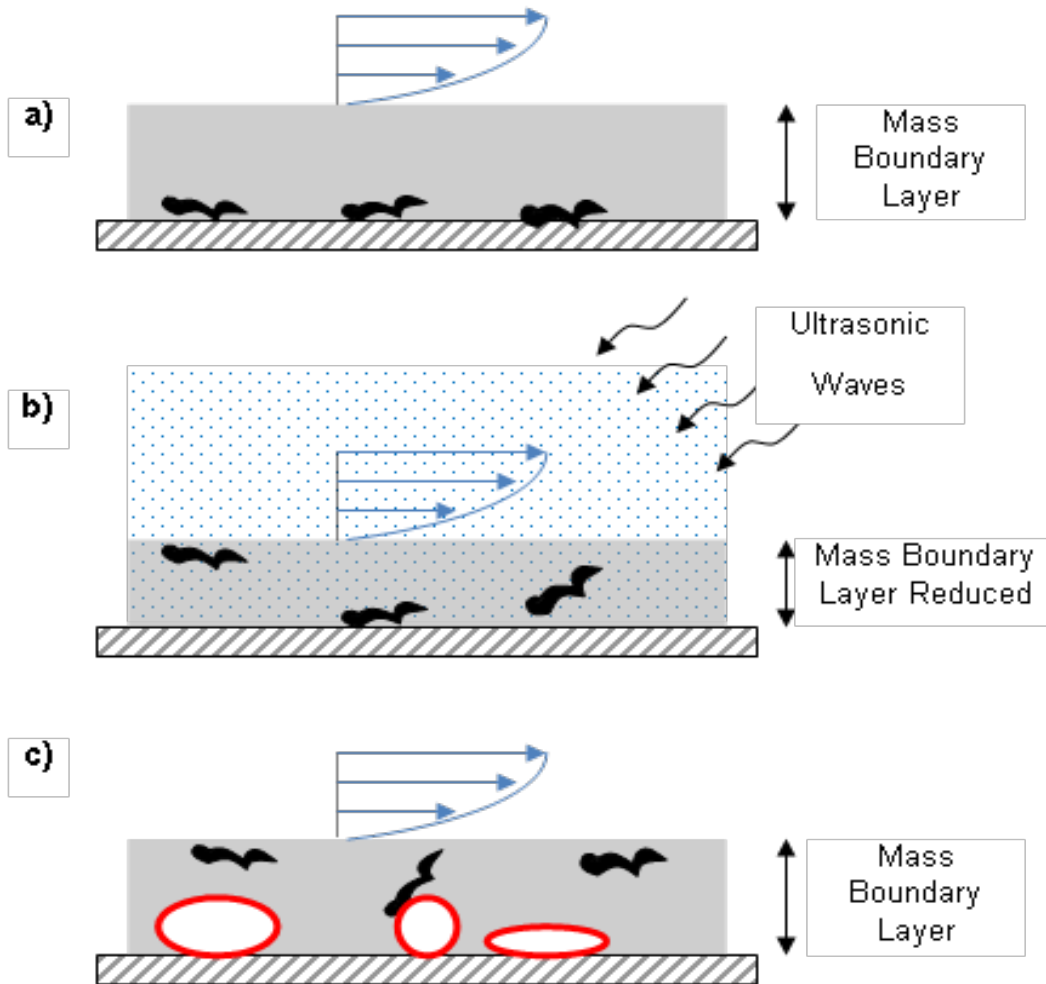
## Vacuum Cycle Nucleation

- Newer technology designed to replace or minimize use of chemicals in precision cleaning applications
- Applications where simple aqueous cleaning and ultrasonics ineffective
- Medical device, micro-electronics, any precision parts
- Lower boiling point of aqueous cleaning solution to nucleate bubbles under safe conditions



Photos courtesy of [www.hason-precision.com](http://www.hason-precision.com)

# Vacuum Cycle Nucleation

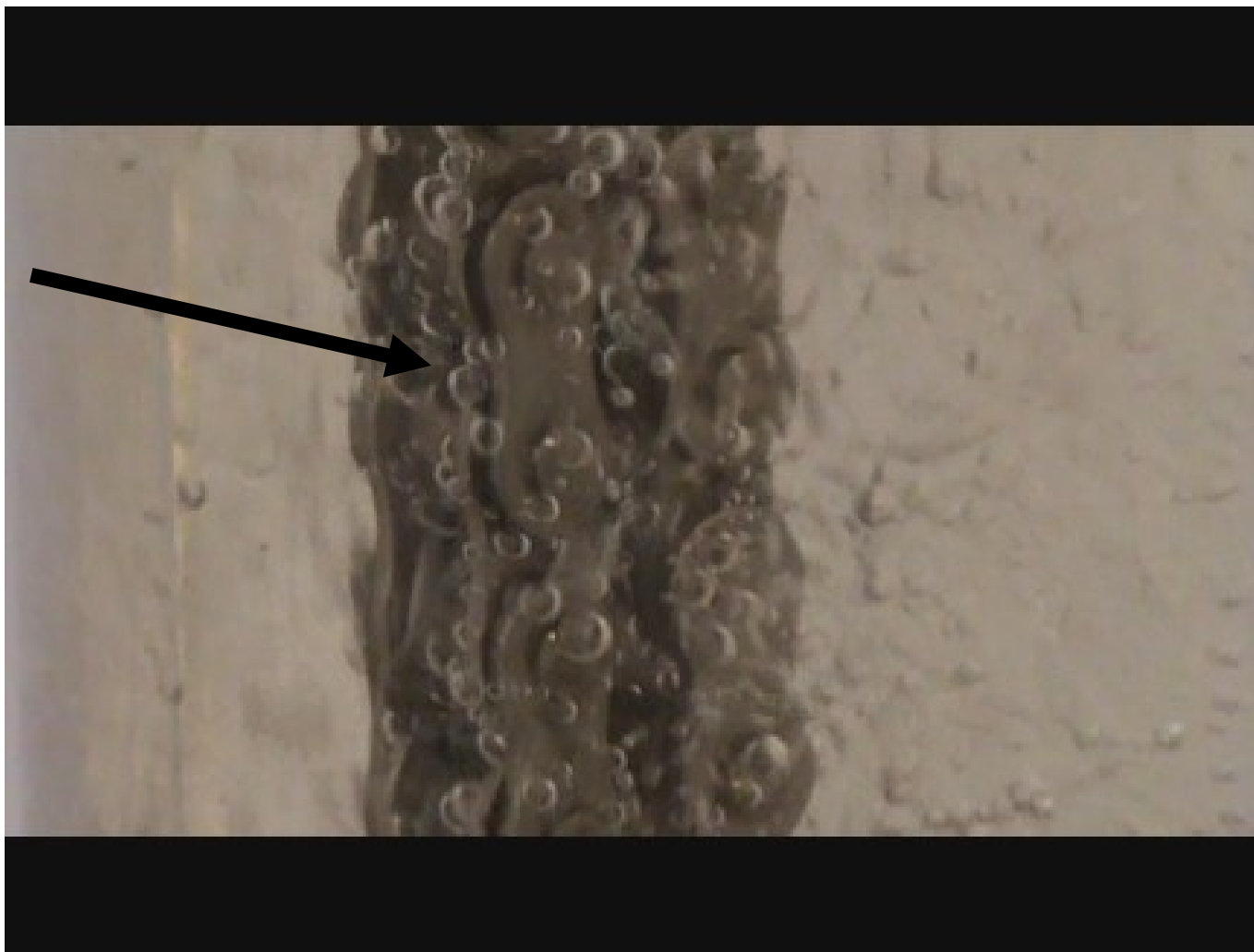


- a.) Normal fluid flow characteristics
- b.) Ultrasonics - reduced boundary layer but with tiny bubbles formed in bulk solution using high levels of energy
- c.) VCN - larger bubbles formed at the substrate surface where particles exist and serve as nucleation sites

# Vacuum Cycle Nucleation



BUBBLES  
FORM IN  
TIGHT  
AREAS



# Vacuum Cycle Nucleation: Close-up View

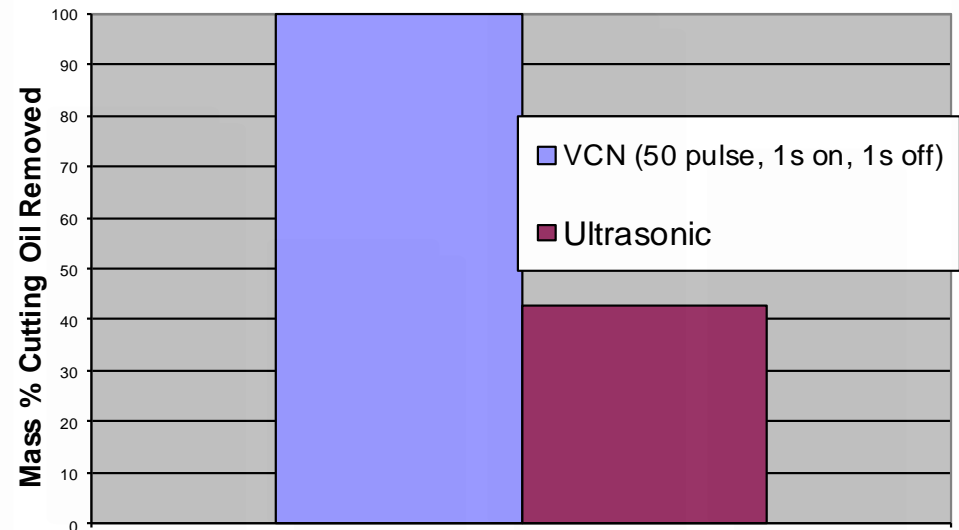




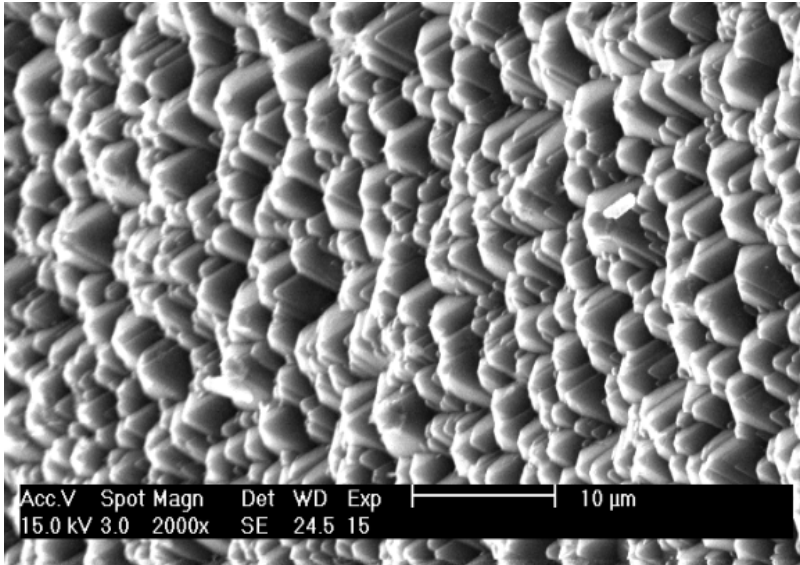
# Example VCN Application - Cleaning



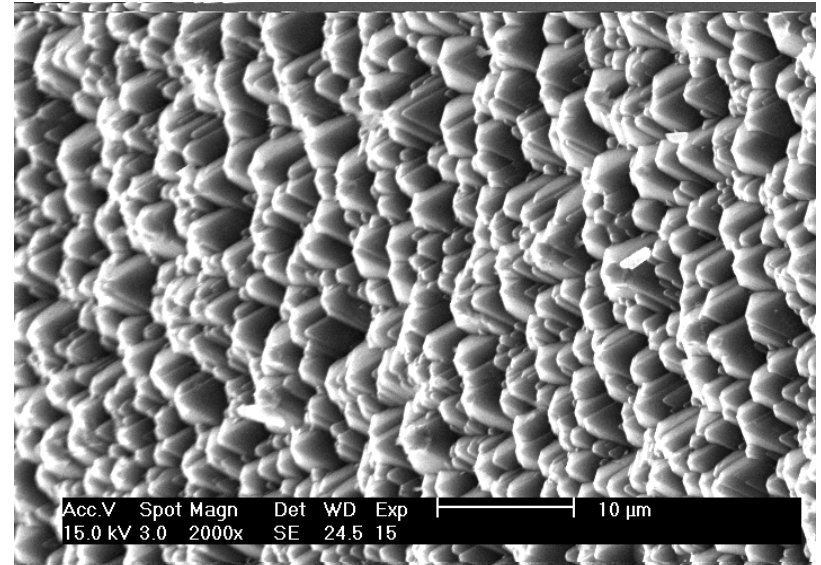
- VCN removed all oil in porous part
- Ultrasonics cannot penetrate pores



# VCN Application – Solar Wafer Texturizing

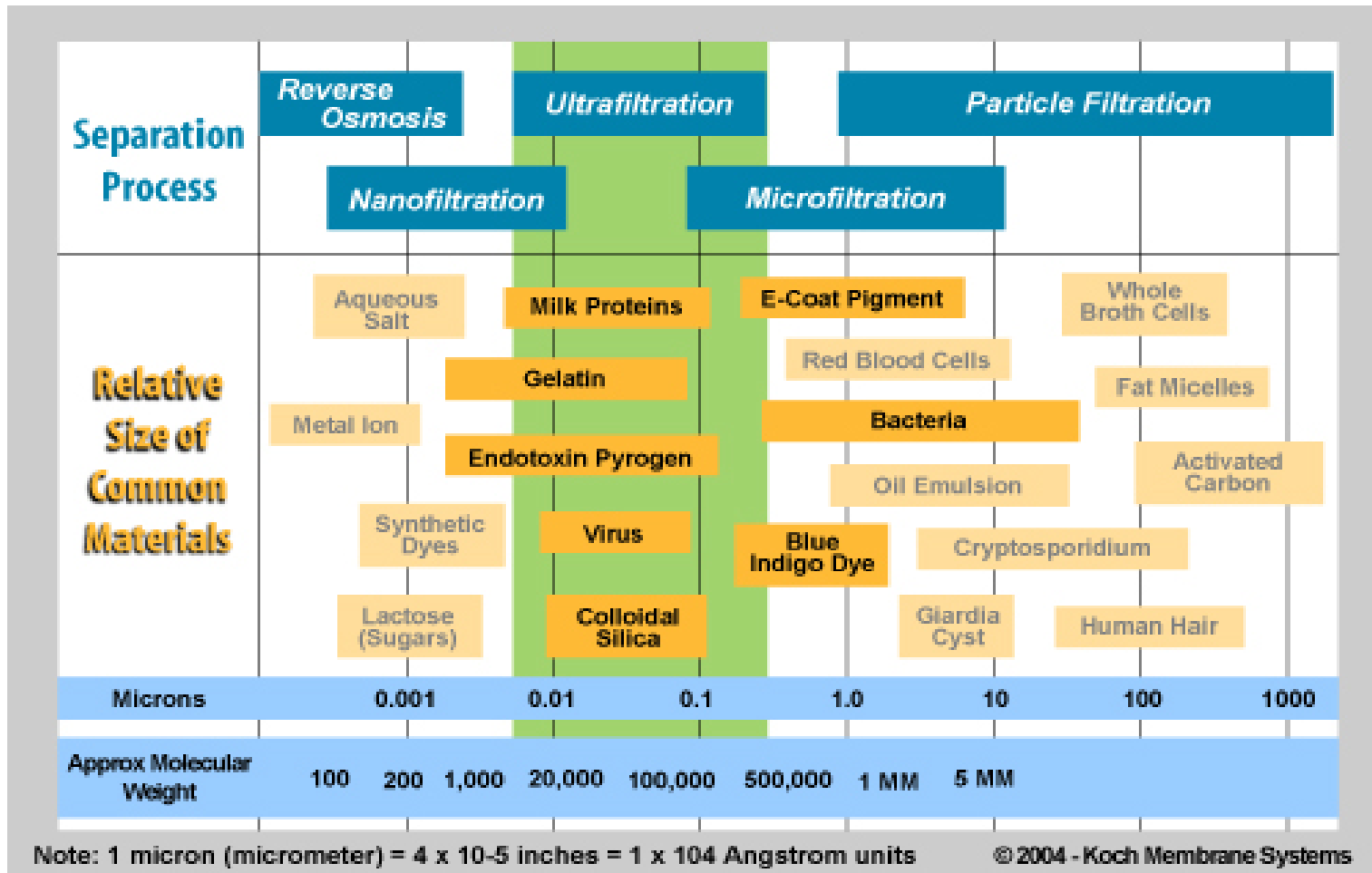


Commercial Solar Wafer



Solar Wafer Processed  
Using VCN with Lower  
Amounts of Chemicals and  
Shorter Time

# Membrane Filtration

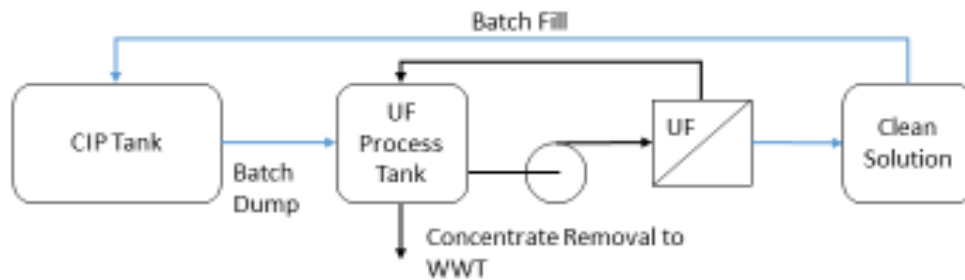


Courtesy of Koch  
Membrane

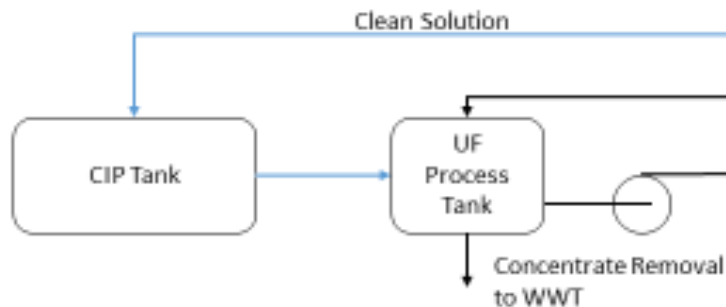
# Cross-Flow Filtration



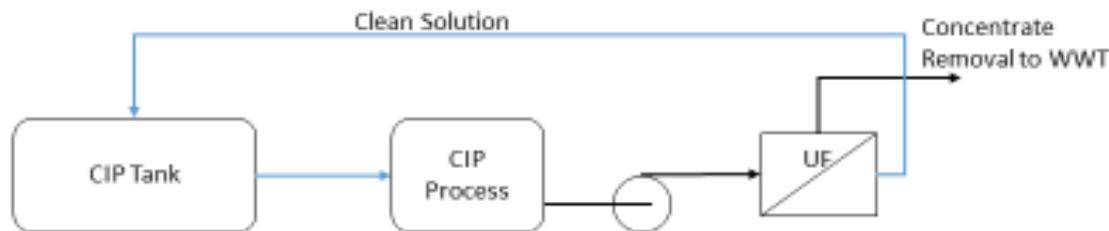
# Membrane Filtration



**Batch Mode**



**Semi-Batch Mode**



**Continuous Mode**



# Case Studies



# Evaluation of Vacuum Cycle Nucleation (VCN) as an Environmentally Preferable Cleaning Process



## Precision Parts Manufacturer

- Main product line: Small parts with tiny openings
- Current precision cleaning process relies on multi-stage ultrasonics that utilizes over 1500 gal/year of caustic cleaning chemicals at a cost of over \$60,000/year
- Other issues include higher than acceptable reject rates

## Work Performed

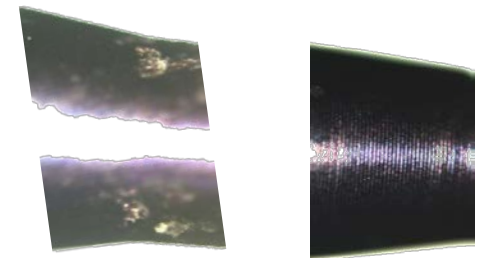
- NYSP2I performed a series of VCN tests under different operating conditions (chemical type, chemical concentration [ $<1\%$ ], temperature, pulse pattern, total cleaning time)
- Preliminary economic analysis

## Results

- Optimum VCN process was determined which increased cleaning effectiveness significantly (lower rejection rates)
- Chemical costs savings calculated to be over \$60,000/year
- Implementation is economically justified, 1-2 year payback



Bubble Formation on Part



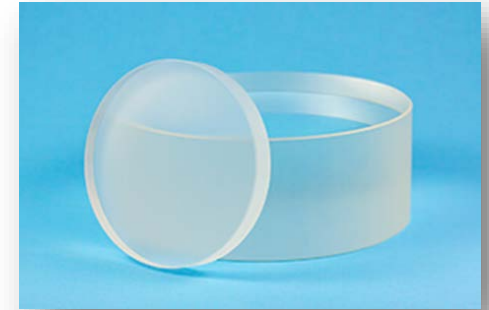
Before and After VCN

# Recovery of Cerium Oxide and Solvent Substitution



## Sydor Optics

- Main product line: Optical lenses for industrial application
- Almost 50% of expensive polishing compound (cerium oxide,  $\text{CeO}_2$ ) lost to sewer as TSS (9-10 kg/day, \$15,000-20,000/year); 3-400 gallons xylene used to remove wax from lenses
- Looking to recover more  $\text{CeO}_2$  and reduce or eliminate use of xylene in lens cleaning



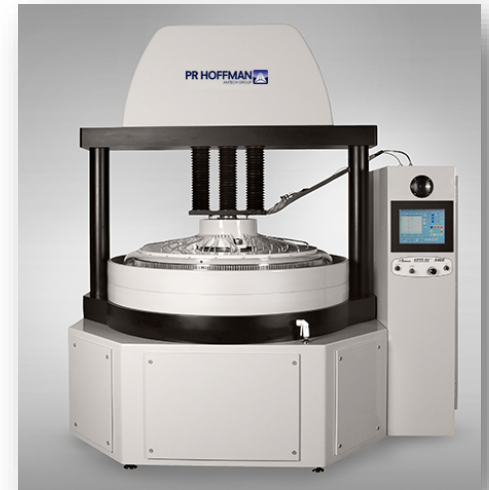
Optical Lenses

## Work Performed

- NYSP2I evaluated 1) solids separation and recovery technologies (centrifugation and membrane filtration) to capture more  $\text{CeO}_2$  and 2) different alternative chemistries and processes to clean prepared samples

## Results

- Bigger centrifuge and microfiltration can increase  $\text{CeO}_2$  recovery to 100%; TSS loadings to sewer would also be eliminated
- Hot water, ultrasonics, and small amounts of acetone possible replacement for xylene
- Implementation is economically justified, 1-2 year payback
- Follow-up implementation project has commenced



Lens Polishing Equipment

# Halogenated Solvent Use Reduction in Corian® Production



## DuPont

- Main product line: **Corian®** solid surface material
- 8,400 lbs/year methylene chloride (MeCl<sub>2</sub>) and 1,750 lbs/year of trichloroethylene-perchloroethylene spray (TCE-PCE) used as cleaning chemicals
- Looking to reduce or eliminate use of halogenated solvents

## Work Performed

- NYSP2I evaluated different alternative chemistries and processes to clean prepared samples



*Part currently cleaned using MeCl<sub>2</sub>*

## Preliminary Results

- Potential to eliminate 100% MeCl<sub>2</sub> and TCE-PCE use at the facility using more benign chemistries and processes
- For MeCl<sub>2</sub> replacement, positive results were observed with Acrastrip 950, VCN, and ultrasonics
- For TCE-PCE replacement: CRC Chlor-Free Non-Chlorinated Degreaser, Sakrete Concrete Mortar Dissolver, Bio-Solv & Acrastrip 950 were also positive
- Further feasibility studies & economic analysis needed



*Spray cleaners tested to replace TCE-PCE*

# Winery Water, Energy, & Chemical Assessment



## Channing Daughters

- A winery on the South Fork Wine Trail of Long Island
- Produces 12,000 cases/year of red, rose, and white wines
- Having already implemented various sustainable viticulture practices, Channing wanted to look into similar sustainability improvements in their winery operation

## Work Performed

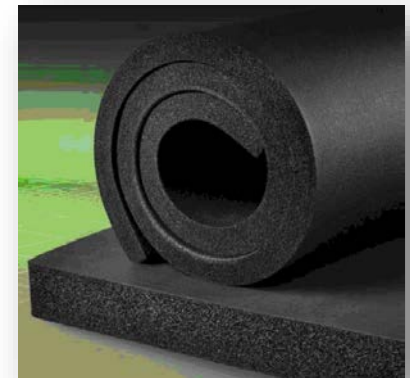
- On site assessment to analyze water, chemical, and energy use; evaluate improvement opportunities



High Pressure Washer

## Results

- NYSP2I identified improvement/cost saving opportunities:
  - Reduce water consumption by 22% through utilization of high pressure washers for cleaning equipment (pressure washer already on location)
  - Save energy and money in different locations:
    - 2.4 year payback to replace fluorescent lighting with LED lighting in hospitality room (already implemented, \$414/year savings)
    - **Insulation of chiller tanks can lead to \$3,500 savings annually (\$200-350 per 30-day cold stabilization run)**
    - Reduce electricity demand charges with control system
    - Switchover from propane to natural gas heating would save \$10,000/year and reduce GHG emissions by 18%



Tank Insulation Material



# Channing Daughters Winery – Tank Insulation



# Optimization of Dewatering/Drying Process in Manufacturing of Dog Treats



## Full Circle Feed

- Start-up company located in Syracuse that produces dog treats from leftover buffet food destined for landfill
- Requested assistance to optimize energy use and evaluate management of wastewater to enable company expansion

## Work Performed

- NYSP2I performed a baseline energy analysis, wastewater analysis, and a drying analysis which examined how drying time is affected by an alternative drying technology (convection)



Doggy Bag Treats being prepared

## Results

- Forced-air convection oven would reduce drying time by 64%, resulting in a corresponding reduction in energy usage and an estimated \$1344 savings in annual energy costs based on current production rates
- Wastewater contains high levels of organics and solids. Simple settling would reduce organic content by over 50% and reduce potential surcharges



Convection oven used during testing





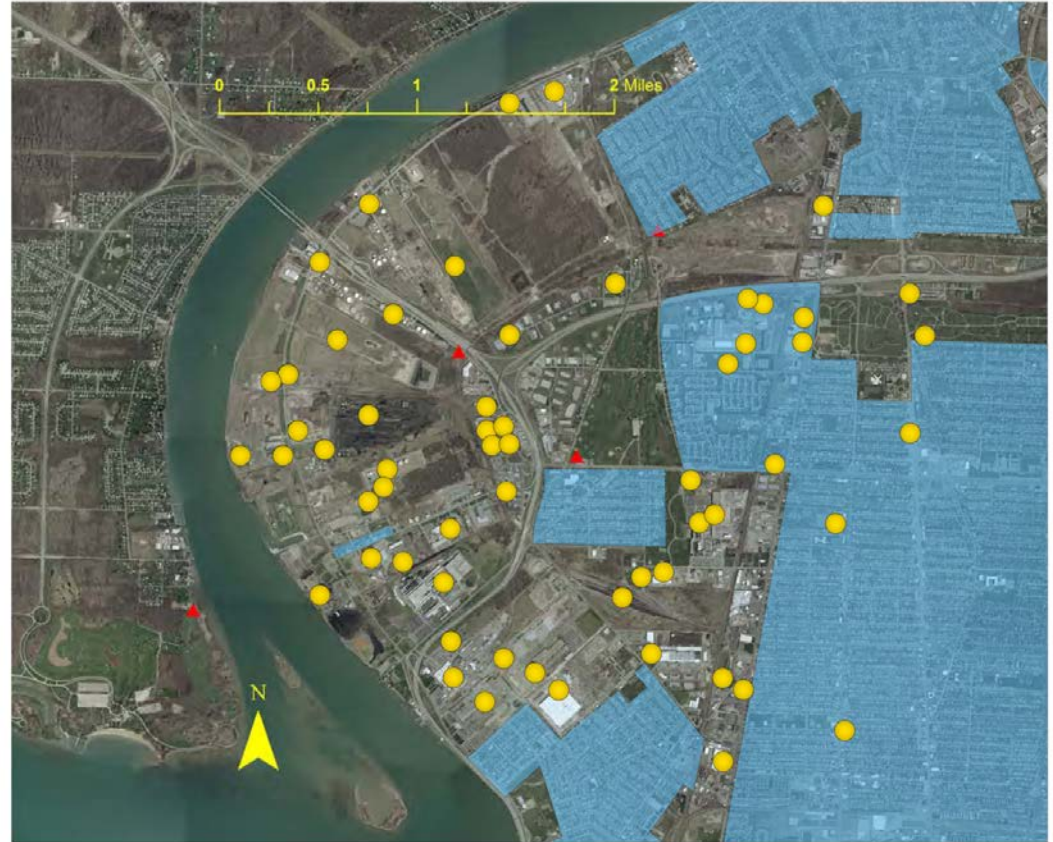
# *Using E3 to Incorporate Sustainability and Green Technologies in Tonawanda, NY*

# The Challenge



- One of the highest densities of industrial development in New York State (59 facilities).
- 2008 TRI reported approximately 1 million pounds of toxics released from the 10 biggest facilities.

- Manufacturing Facility
- Residential Neighborhood



Map of Tonawanda

# NYSDEC Air Monitoring Study



## Six HAPs Exceeded Guideline Concentrations

- **Benzene:** fossil fuel combustion (FF), manufacturing
- **Formaldehyde:** FF, manufacturing, atmospheric
- **1,3 Butadiene:** FF, manufacturing
- **Acetaldehyde:** FF, manufacturing, atmospheric
- **Acrolein:** FF, manufacturing, atmospheric
- **Carbon Tetrachloride:** *atmospheric, historical artifact*

Sources vary according to chemical, but approximately:

- 15%-95% from large stationary sources, including both fossil fuel combustion and manufacturing
- 5%-60% from mobile sources, fossil fuel combustion
- 10% from atmospheric oxidation (transport from other areas)

# The Concept:



**E3: ECONOMY • ENERGY • ENVIRONMENT**  
SUPPORTING MANUFACTURING LEADERSHIP THROUGH SUSTAINABILITY



**Lead Technical Resource  
in Tonawanda  
E3 Initiative**





# Energy Reduction from Improved Pipeline Insulation



## NOCO Energy's Tonawanda Intermodal Terminal

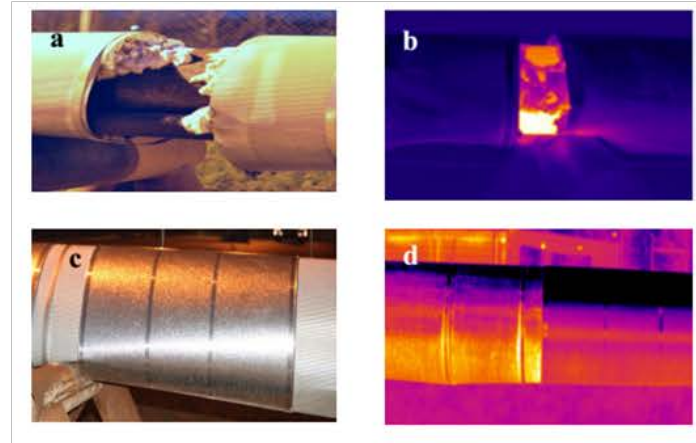
- Provides services such as vessel loading/unloading, pipeline receipt, rail tank car loading/unloading and tank truck weighing
- 80 tanks located on 80 acres with a storage capacity of over 45 million gallons
- Products include asphalt, heavy oils, distillate, gasoline and bio-fuels.

### Work Performed - Energy assessment:

- Evaluated thermal energy lost due to compromised or missing insulation during transportation of asphalt through the heated transport pipeline
- Calculated potential natural gas savings for boiler heating of the pipeline if the insulation was replaced

### Results

- 124 feet of asphalt pipe were bare or poorly insulated
- Potential avoided thermal energy loss, including boiler efficiency, of approximately 1,785 MMBTU/year
- Potential reduction of 210,325 pounds/year of various air emissions including 95 Metric Tons of greenhouse gas emissions (CO<sub>2</sub>Eq.)



- a.) Image of bare pipe;
- b.) Thermal image of bare pipe
- c.) Image of new insulation with aluminum jacket;
- d) Thermal image of intersection of old and new insulation

# NOCO Energy – potential 1,785 MMBTU/yr reduction of natural gas



Air Emission	Quantity Avoided (with insulation replaced on 124 ft) (lbs / year)	Criteria Pollutant (Yes / No)	Hazardous Air Pollutant (Yes / No)	Greenhouse Gas Contributor (Yes / No)
Nitrogen Oxides (NO <sub>x</sub> )	175	Yes	No	Yes
Nitrous Oxide (N <sub>2</sub> O)	4	Yes	No	Yes
Carbon Monoxide (CO)	147	Yes	No	No
Lead	0.001	Yes	Yes	No
Total Particulate Matter (PM)	13	Yes	No	No
Sulfur Dioxide (SO <sub>2</sub> )	1	Yes	No	No
Carbon Dioxide (CO <sub>2</sub> )	209,969	No	No	Yes
Total Organic Compounds (TOC)	19	No	No	No
Volatile Organic Compounds (VOC)	10	Yes	No	No
Methane	4	No	No	Yes
**Benzene	0.004	No	Yes	No
**Formaldehyde	0.131	No	Yes	No

Source: U.S. EPA "AP-42, *Compilation of Air Pollutant Emission Factors*", <http://www.epa.gov/ttnchie1/ap42/>,



# Assessment of Alternative Coatings for Improved Cathode Longevity and Toxic Metal Elimination



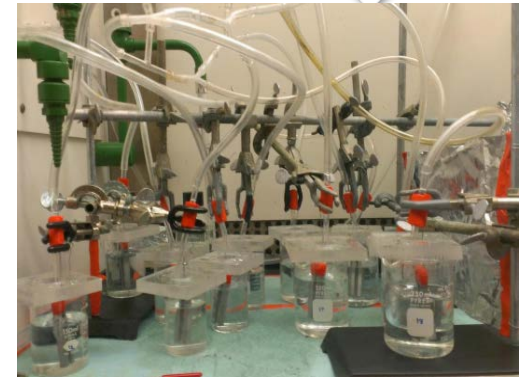
**PeroxyChem LLC** manufactures hydrogen peroxide, peracetic acid, persulfates and adjacent technologies in Tonawanda, NY.

## Work Performed

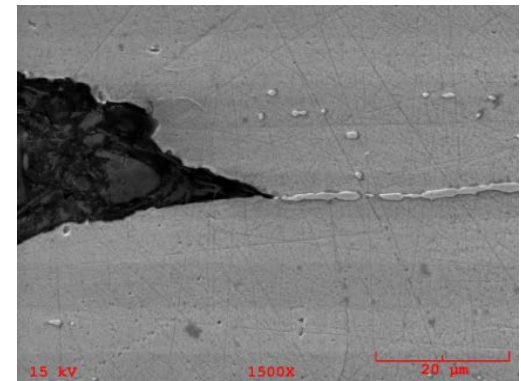
- Evaluated new metal cathodes to find the root cause of corrosion and shorter life-span using Scanning Electron Microscope (SEM) analysis and SEM Energy Dispersive X-ray (EDX).
- Identified potential coatings and conducted accelerated corrosion and delamination tests.

## Results

- Determined original coating had poor performance and the new metal had a manufacturing defect.
- Identified an alternative coating material that can potentially withstand the process environment, prevent corrosion, and provide improved longevity for the new cathode metal.
- Should the new coating material be implemented, it would enable the replacement of the previous cathode metal thereby eliminating toxic materials and the generation of over 1,000 pounds of toxic hazardous waste.



Laboratory setup for accelerated corrosion/delamination testing of coatings on cathode substrates



1500 magnification using SEM showing a defect as the point of initiation for the corrosion

# Solvent Use and Associated Air Emissions Reduction



## Title: Tread-End Cement Reduction

### Project Mission:

Reduce the amount of Volatile Organic Compounds (VOC) exhausted at the Goodyear Dunlop Tire North America (GDTNA) Plant located in Tonawanda, New York. Reduce the amount Cement applied to the end of treads on the 224 and 227 Extruding lines and reduce the amount of dollars spent on Tread-End Cement.

### Improvement Category:

X	Safety		Delivery
X	Quality	X	Engagement
X	Cost	X	Communications

### Improvement Goals

### Current State

### Future Goal

1. Reduce VOC at Buffalo Plant

**Not Optimal**

**Better**

2. Reduce Tread-End Cement

**6.8 grams/Tread**

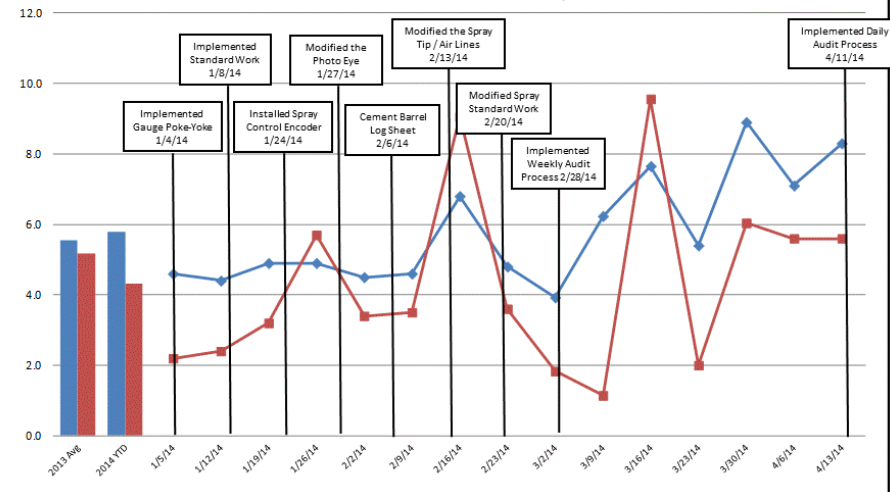
**3.5 grams/Tread**

3. Reduce Tread-End Cement Cost

**\$54,000 / Year**

**\$24,000 / Year**

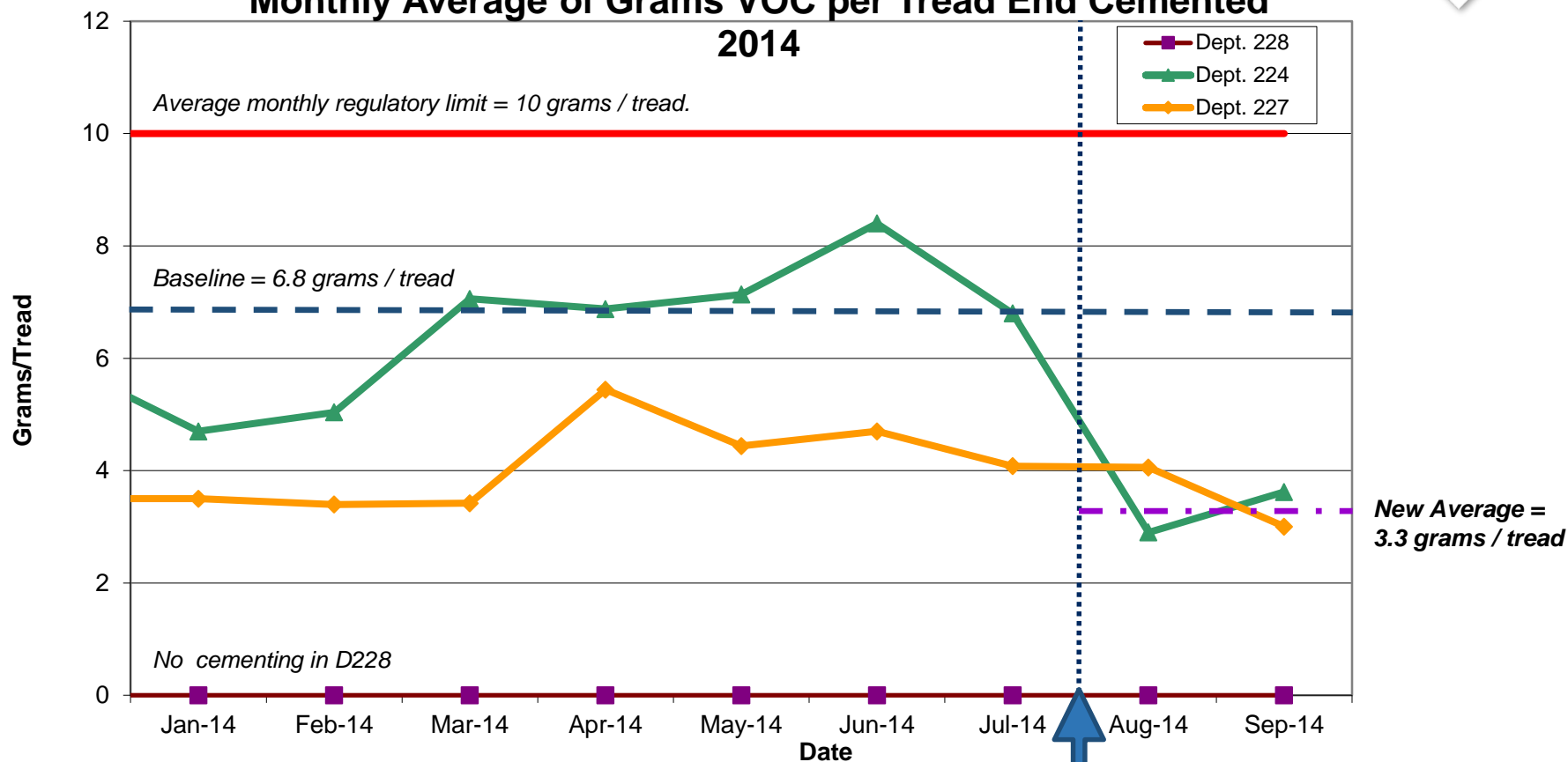
### Grams of Cement Per Treads By Week





## Goodyear Dunlop Tires North America, LTD. Tonawanda, New York

### Monthly Average of Grams VOC per Tread End Cemented



- Improved gun height above the tread
- Changed photo eyes from AC to DC
- Shortened air lines between solenoid valves and spray guns

# NYSP2I Results



**E3: ECONOMY - ENERGY - ENVIRONMENT**

SUPPORTING MANUFACTURING LEADERSHIP THROUGH SUSTAINABILITY



## Funding:

U.S. EPA Source Reduction Assistance grant

- **2 years, \$130,000**
- **Assess opportunities** for local manufacturers to reduce
  - energy
  - environmental impacts
  - associated costs

## Requirements:

- **Screen 8** manufacturing companies for potential projects
- **Assess 4** of the screened companies for LE2 projects - Baseline metrics collected
- **Implement 2** recommendations from the assessment at the assessed companies
- **Outreach and dissemination** of successes after implementation of solutions is completed

## Status:

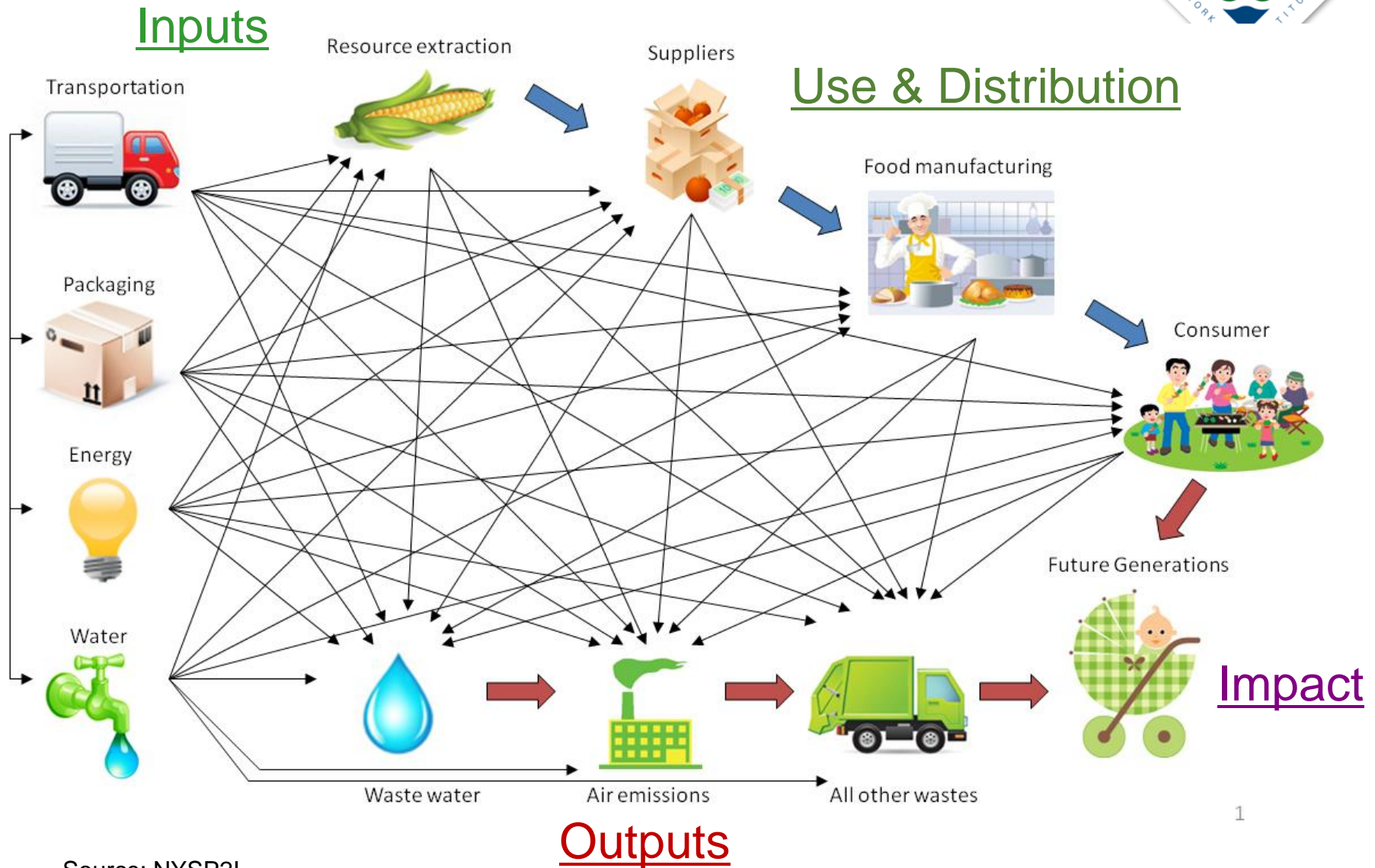
- **Screened 13** manufacturing companies for potential projects
- **4 company assessment projects** completed with EPA grant
- **1 feasibility study** completed with EPA grant
- **2 implementations** completed with EPA Grant
- Resulting in potential reductions:
  - 102,151 lbs of hazardous materials
  - 1,040 lbs of toxic hazardous waste
  - 21,320 lbs of VOC emissions
  - over 3 million kwh of electricity
  - 3,000 MMBTU of natural gas
- **5 additional projects in Tonawanda** also assisted through NYSP2I funding



# Sustainable Supply Chain Program

New York State Pollution Prevention Institute

# Supply Chains & Relationships



Source: NYSP2I



# “Supply Chain Sustainability” – A Definition



The United Nations Global Compact defines **supply chain sustainability** as “the *management of environmental, social and economic impacts*, and the *encouragement of good governance practices*, throughout the *lifecycles of goods and services*”

*“The objective of supply chain sustainability is to create, protect and grow long-term environmental, social and economic **value** for all stakeholders involved in bringing products and services to market.”*

[http://unglobalcompact.org/docs/issues\\_doc/supply\\_chain/SupplyChainRep\\_spread.pdf](http://unglobalcompact.org/docs/issues_doc/supply_chain/SupplyChainRep_spread.pdf)

# Supply Chain Sustainability Assessments



## Opportunity Areas

Companies are under greater pressure today to measure and communicate their environmental and societal impacts. Businesses that strategize, set targets, measure, monitor, and report their sustainability efforts will likely generate more revenue, retain and potentially create jobs, and reduce the risk of jeopardizing potential business.

## Work Performed

NYSP2I created an assessment tool to use with companies to inquire about various common components of internationally accepted sustainability guidelines, standards, and protocols.

## Results

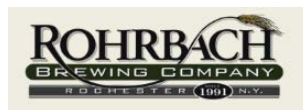
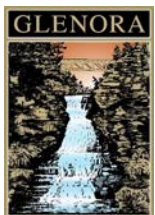
- 5 companies have requested an SSC assessment
- Companies anticipate an average of **10% increase in sales** and an average of **10% increase in job growth** (17 new jobs from these 5 companies)

Opportunities identified include:

- Informing procurement personnel of sustainable purchasing alternatives;
- Measuring impacts to set objectives and targets and to track performance;
- Adding policy, objectives and targets, performance and action plans to marketing and communications material.

“...With credibility as a green supplier, BRF has a recognized competitive advantage in the market place which makes the company a preferred business partner within the food and beverage industry.”

—John Cairns,  
**Baldwin Richardson Foods**



# ISO 14001 EMS Readiness Assessment with a Metal Finishing Manufacturer



## **Acro Industries, Inc.**

A Rochester-based, privately owned, contract metal finishing manufacturer that strives for continuous improvement throughout its business. Pressure from customers regarding conformance to an Environmental Management System (EMS), such as ISO 14001, heightened in 2014.

## **Opportunity Areas**

Acro recognized the need to address the pressure from customers and the opportunity to differentiate themselves with larger companies that seek sustainable suppliers with ISO certifications. An EMS would foster Acro's commitment towards continuous improvement through more effective measurement and monitoring techniques, resulting in opportunities to reduce environmental impacts and operating costs.



"To achieve the customer requested ISO 14001 certification, we needed a gap analysis completed along with some recommended best practices to accompany our current Quality Management System. NYSP2I worked with the Acro team, not only utilizing decision making tools that were unfamiliar to Acro, but actually spending days on our shop floor truly understanding how we operate and what gaps need to be closed to achieve certification. Due to the detailed project planning process provided by NYSP2I, our customers were confident enough in our success that we were awarded a \$1.5 million dollar contract. We are on track to be ISO 14001 certified by June of 2016."

-- Bob Coyne, General Manager,  
Acro Industries Inc.

## **NYSP2I Work Performed**

- Reviewed Acro's waste manifests, energy and water data, existing policies, procedures and objectives & targets from their quality management system to determine synergies with the ISO 14001 standard.
- Conducted an on-site assessment to identify activities (aspects) that create environmental impacts.
- Developed input-output diagrams for processes; an Environmental Aspects Guidance and Rating Chart; a Risk Criteria Matrix; Readiness Gap Assessment with recommendations to prepare for certification to the ISO 14001 standard.

## **Results**

Acro anticipates a 10% increase in sales within 3 years, and a 20% increase in customers, ultimately anticipating the creation of approximately 10 new positions.



# **Green Technology Accelerator Center**

NEW YORK STATE POLLUTION PREVENTION INSTITUTE

# EDG-trac Knife Advance System Performance Evaluation



## Tristar, Ltd. (Tonawanda, NY)

- Manufacturer of fabricated components and equipment, including remanufactured filtration systems
- EDG-trac Knife Advance System for rotary vacuum drum filters features key design improvements over conventional systems, such as the use of a single motor gear drive and control based on motor frequency versus drum rotation

## Opportunity

- It was anticipated that the enhanced control enabled by the EDG-trac Knife Advance System would decrease energy and water use and increase process throughput

## GTAC Project Objective

- Evaluate Tristar's Edg-trac Knife Advance System at a manufacturing facility as compared to a traditional rotary vacuum drum filter system

## Results

Tristar's EDG-trac Knife Advance System exhibited the following performance results:

- **700% ave increase in water filtration throughput**
- **87.4% reduction in energy use**, on a per gallon filtered basis
- Comparable sludge moisture content and suspended solids removal efficiencies
- Tristar is targeting the **creation of 5 NY State jobs** to expand manufacturing of EDG-trac

# Ecovative Design Life Cycle Assessment



## Ecovative Design, LLC

- Ecovative uses fungal mycelium (mushroom "roots") to bond together locally sourced agricultural byproducts into Mushroom® Packaging base material.
- A patented process cleans and prepares a blend of agricultural byproducts, and inoculates it with mycelium (mushroom tissue).
- Packaging material is then "grown" into the required custom shape.

## Opportunity

- By using fungal mycelium and agricultural byproducts, Ecovative uses materials that are environmentally low-impact, biodegradable and renewable.
- This product replaces synthetic materials such as Styrofoam™.

## GTAC Project Objectives

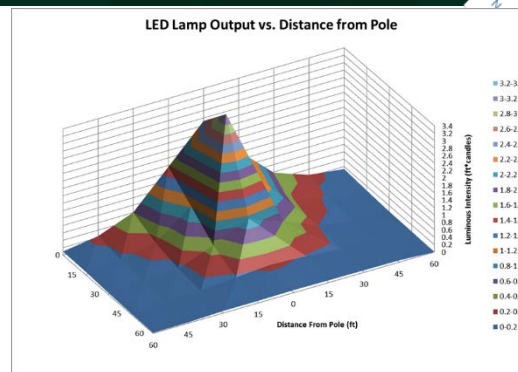
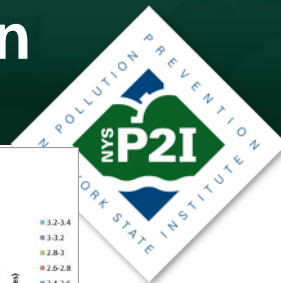
- Apply Life Cycle Assessment (LCA) methodology to compare the environmental impact of 3 different Mushroom® Packaging base material configurations to understand and help optimize Ecovative's unique biomaterials manufacturing process.

## Results:

- The LCA results supported process improvements and energy efficiency gains including:
  - Utilization of higher performance feedstocks that could be grown locally to also reduce transportation impacts on the environment.
  - **Evaluation of a new drying process to reduce energy consumption by 1/3.**
- Ecovative is forecasted market expansion and creation of **14 jobs** to support design and manufacturing in NY state



# LED vs. Metal Halide Lighting Energy Comparison



## LED Display Technology, Inc. (@ Stonybrook)

- LED Display Technology, Inc. manufactures lighting fixtures that use proprietary optical components, innovative heat management technology and LED's.
- Products are a direct replacement for exterior metal halide lighting systems

## Opportunity

- Reduction in exterior lighting energy with equivalent light output vs. metal halide systems
- Improvement in lighting system lifespan and reduced maintenance due to improved thermal management

## GTAC Project Objectives

- Perform a comparative analysis of light output and electrical energy use of LED Display's new LED lighting system
- Compare energy use to a specific metal halide parking lot lamp (i.e. KD 400M R5S)
- Evaluate the energy savings attributable to the LED lighting system

## Results

- The energy consumed by the LED lamp tested ranged from **79% to 88% less than the R5S metal halide lamp.**
- For equivalent illumination levels, the potential energy savings was 79%.
- LED Display is targeting the creation of: **25 NY state jobs**

# Questions?



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