



High-Performance Power and Hall-Effect Sensor ICs



TURA 20th Anniversary Symposium - 11/4/09
TUR and Competiveness – Allegro MicroSystems, Inc.
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Overview

- Background
- TUR program
- ISO-14001
- Summary
- Questions



Background

- Allegro MicroSystems, Inc. is a leader in developing, manufacturing and marketing high-performance power and Hall-effect sensor integrated circuits. Allegro's innovative solutions serve high-growth applications within the automotive, communications, computer/office automation, consumer and industrial markets.
- Allegro is headquartered in Worcester, Massachusetts (USA) with design and applications centers located in North and South America, Asia, and Europe.
- Allegro has wafer fabrication facilities in Worcester, MA and Bloomington, MN, and an assembly plant in Manila, Philippines.
- Further information about Allegro can be found at www.allegromicro.com.



Background

- By the nature of the business, operation of a wafer fab is very chemical and energy intensive.
 - Much of the process is performed in a class 100 designed clean room, which operates at class 10 or better.
 - Potential contamination includes
 - Unwanted material that adversely affects the physical or electrical characteristics of a semiconductor wafer.
 - Types: Particles, Metallic Ions, Chemical and Bacteria.
 - Sources: Air, People, Clean room, Equipment, and Processes.
 - The clean rooms must be closely monitored and controlled to maintain the desired cleanliness, temperature and humidity.
 - Certain process and support equipment uses a significant amount of electricity.
 - The peak electrical usage for the facility was 39 million KWH in 2005 at a cost of \$3.9 million.
 - The peak chemical usage was 855 tons in 1995.



TUR Program

- Implementation of TURA in 1989 required that Allegro develop a TUR Plan, report annually to the MassDEP, and make a good faith effort to reduce it's use of toxic chemicals.
 - The TUR team was formed, consisting of representatives from production, process engineering, finance, facilities, DI building, EHS, and a chemist, with the following responsibilities:
 - Develop/maintain project list.
 - Hold meetings every one to two months to review progress and to discuss new projects.
 - Send annual notice to employees requesting their input.
 - Utilize employee suggestion and recognition program to process suggestions.
 - Update plan every 2 years.



TUR Program

Option # (year/ sequence)	Description	Production Unit	Project Type	TURA Technique	Owner	Evaluation Date	Estimated Implementation Date	Actual Implementation Date	Status	Capital Cost or Expense	Annual Savings	Annual Toxics or Resource Reduction	Comments
08-10	Change Metal 2 Track Develop Process	1	TUR	Change Production Unit Design	Denham		TBD	Nov-08	Complete	\$0	\$44,400	17140#	This change went into effect 11/19/08, and reduced the usage of MF-320 developer.
09-03	Eliminate Use of Argon During Gate Oxidation and HCl During Poly Deposition	1	TUR	Process Modification	Amons	Jan-09	Nov-09		Open	\$0	\$ 60,000	Argon	Gate Oxidation change went into effect 6/18/09. Poly Deposition change should be complete by Nov.
09-04	Reduce Amount of 3513 Photo Resist Dispensed Without Causing Resist Spikes	1	TUR	Process Modification	Denham	Mar-09	Sept-09	Aug-09	Complete	\$0	\$ 96,000	Photo Resist	Trials have been run to reduce the amount of 3513 photo resist dispensed from 4.0 to 3.0 ml per wafer without causing resist spikes. Made adjustments on one photoresist pump per month and monitored results. Complete as of 8/18/09.
09-05	Eliminate TiW Bath and TiW Sputter Target	1	TUR	Process Modification	Denham	Mar-09	Jul-09	Aug-09	Complete	\$0	TBD	TiW, 180 gal H2O2	ECN issued 6/18/09 to replace TiW layer with oxide layer under the metal, and eliminate TiW bath which is only used for metal etch rate testing. Working on final details for implementation of bath elimination.
94-12	Reuse Sulfuric Acid in Waste Water Treatment System	2	TUR	Input Substitution	Feraco	Nov-96	Not Applicable	---	Closed	na	na	na	Not implemented
94-19	Install pH probe to Deionizer Regenerations	2	TUR	Process Modernization	Feraco	Sep-96	Not Applicable	Nov-96	Complete	\$ 1,000	\$ 135	816#	Insures proper pH of regenerant chemicals.
94-20	Reverse Osmosis	2	TUR	Process Modification	Feraco	Jan-95	Not Applicable	Jan-97	Complete	\$ 480,000	\$ 110,000	176700#	Install RO system that will reduce the frequency of the ion exchange regenerations



TUR Program

- **Toxics use reduction projects**

- Total annualized savings of \$1.1 million per year (not adjusted for inflation).
- **Wafer fab** (production unit #1). Did a major upgrade starting in 1995 and purchased equipment to allow processing of 6" versus 4" diameter wafers. Key TUR projects included:
 - Changed the chemistry of the photo resist from negative to positive resist.
 - Switched to a water-based developer that could be neutralized and disposed of as a waste water rather than as a hazardous waste, and eliminated the use of IPA to rinse the developer from the wafers (IPA).
 - Changed many of the wet etch processes to dry etch, where a small amount of a gas is used (acids).
 - Eliminated the use of IPA for wafer cleaning (IPA).
 - Changed from bath wash to spray wash systems (HNO₃).
 - Purchased high efficiency tube cleaners (HF).
 - Reduced annual usage by 166 tons/46% between 1996 and 2008.
 - 2009 projected usage to be 25% less than in 2008



TUR Program

- **DI building** (production unit #2). This is where the high purity water for the fab is made and the waste water is neutralized before discharge to UBWPAD plant. Key projects as follows:
 - Purchase a reverse osmosis system (saved NaOH and H₂SO₄ used to regenerate the ion exchange system).
 - Reuse regenerant NaOH and H₂SO₄ for wastewater neutralization (NaOH, H₂SO₄).
 - Raise caustic temperature (NaOH, H₂SO₄).
 - Optimize mixed bed deionizers (NaOH, H₂SO₄).
 - Reduced annual usage by 310 tons/57% between 1995 and 2008.
 - 2009 projected usage to be 17% less than in 2008.



DI Building

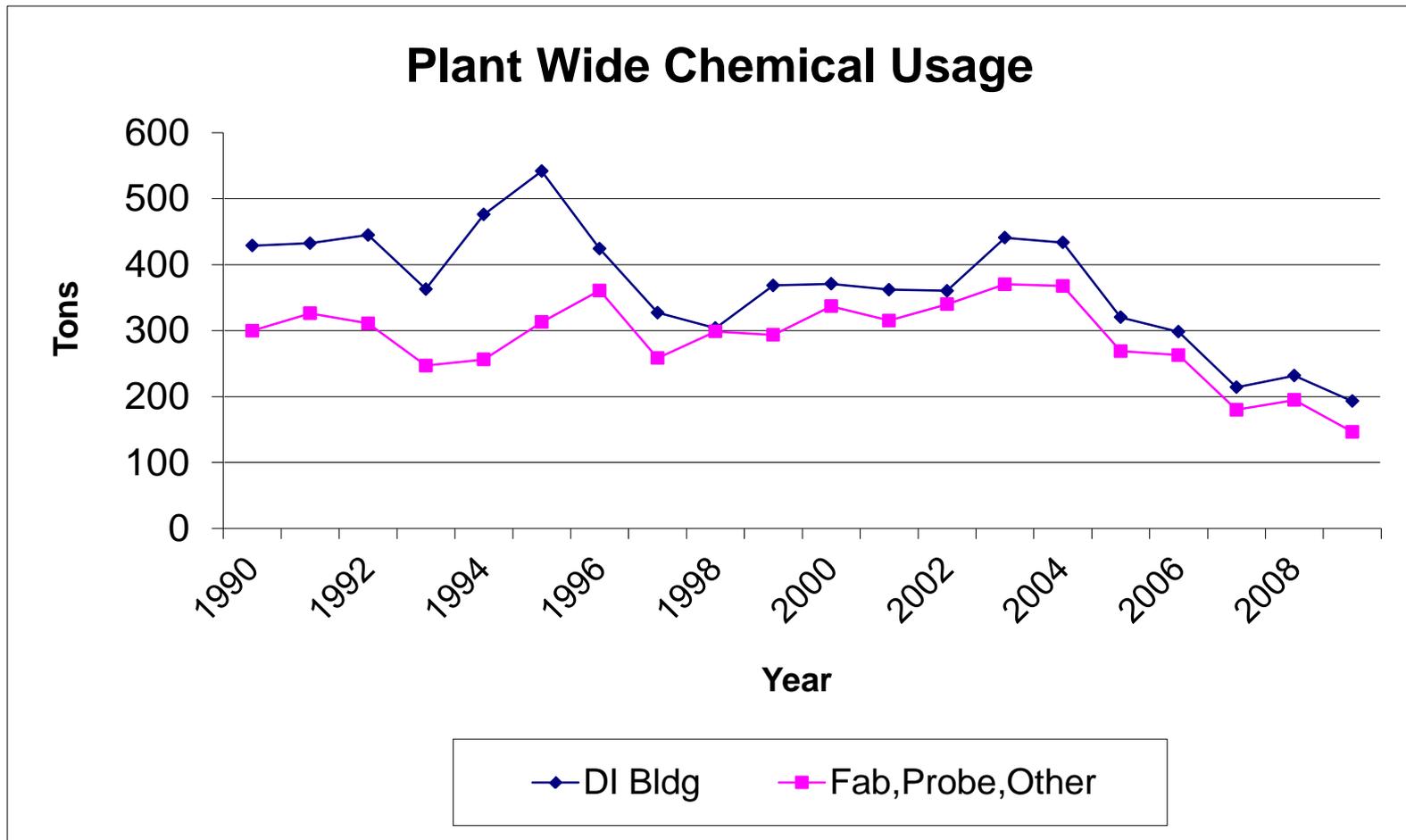


Wastewater Treatment Operators neutralize process wastewater from the facility before discharging to the city sewer, as well as make the high purity water used in the wafer fab





TUR Projects





Resource Conservation Projects

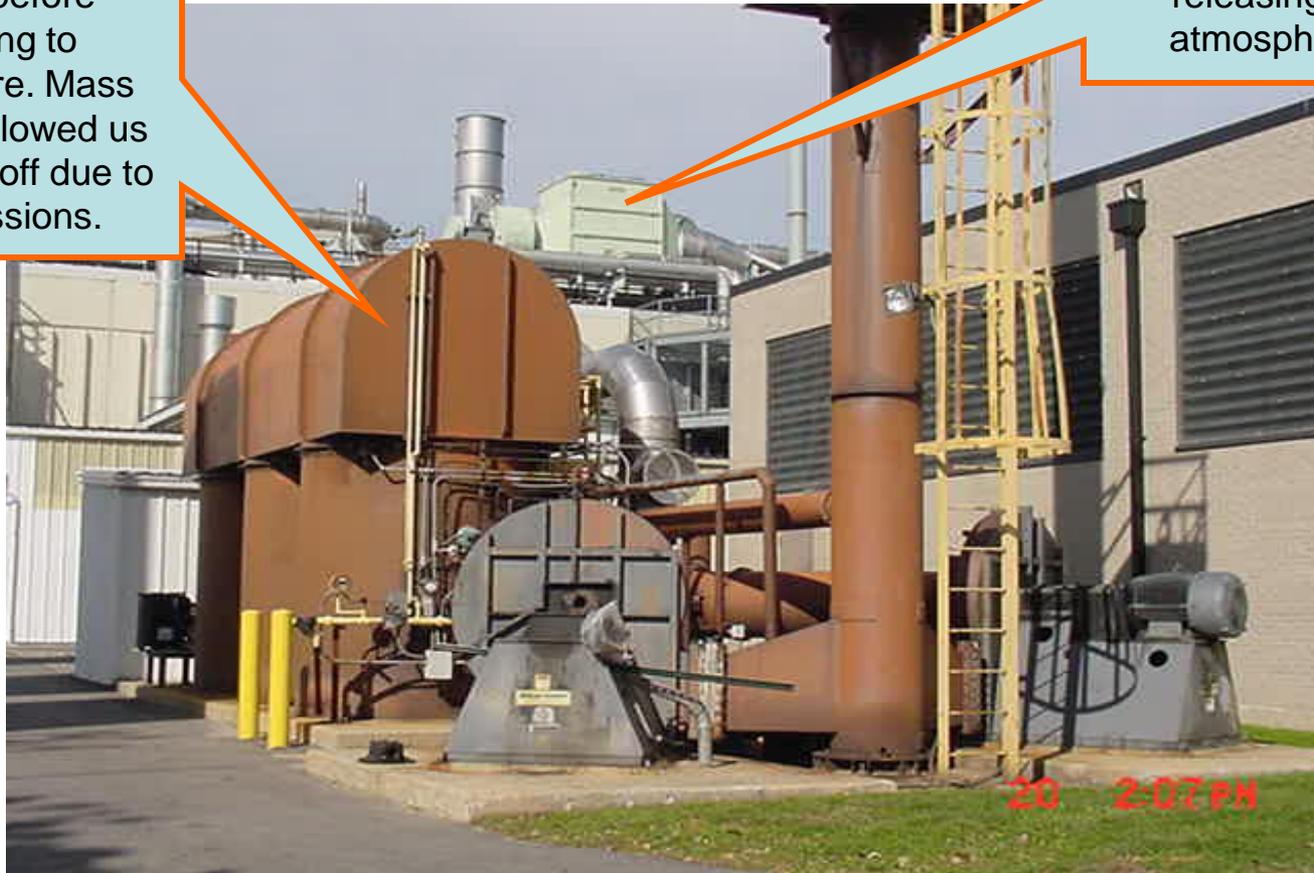
- Resource conservation projects were being performed all along, but became more of a focus as resource costs began to rise significantly.
- Began to include them on our TUR project list after this became a planning option.
- Total annual savings of \$1.5 million per year (projects since 2003, excluding inflation), with key projects as follows:
 - Shut down thermal oxidizer for VOC abatement after receiving approval from MassDEP. After shutting down 4" wafer process in 2006, cost of abatement rose from \$9000 to \$52000 per ton (natural gas and electricity).
 - Worked with process engineers to greatly reduce water consumption in the fab (water).
 - Installed a heat exchanger so that wastewater from the fab could be used to preheat the city water used to make the high purity water (natural gas).
 - Discontinued use of ultra filtration system (electricity).
 - Installed T-12 bulbs and ballasts in facility (electricity).
 - Installed occupancy sensors throughout facility (electricity).
 - Installed variable frequency drives on various motors throughout the facility (electricity).
 - Turn off production and DI bldg equipment whenever possible (electricity).
 - Send monitor wafers to supplier for reclaim/salvage.



Thermal Oxidizer and Ceilcote Scrubber

Thermal oxidizer used to burn solvent vapors (EBR, photo resist), before releasing to atmosphere. Mass DEP has allowed us to shut this off due to low emissions.

Ceilcote scrubber neutralizes acid vapors before releasing to atmosphere





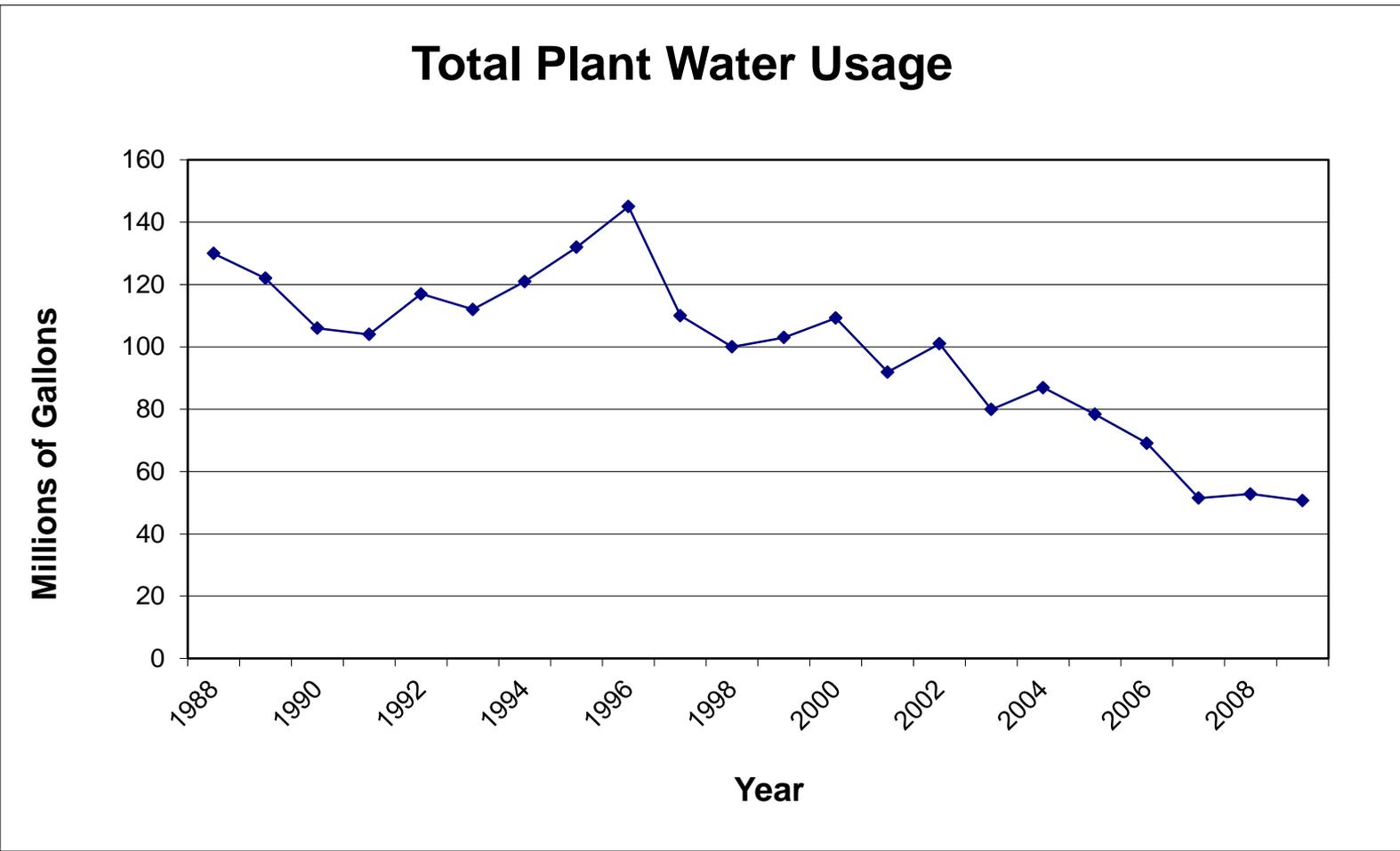
Resource Conservation Projects

- **Water Usage Reduction**
 - Reduced annual usage by 92 million gallons/37% between 1996 and 2008
 - First 4 months 2009 usage down by 4% versus same period 2008
 - 82% of current usage is for Fab and DI Bldg

- **Natural Gas and Oil Usage Reduction**
 - Reduced annual usage by 15% between the peak in 1998 and 2008
 - First quarter 2009 usage 2% higher than same period in 2008
 - 92% of consumption is in main boilers

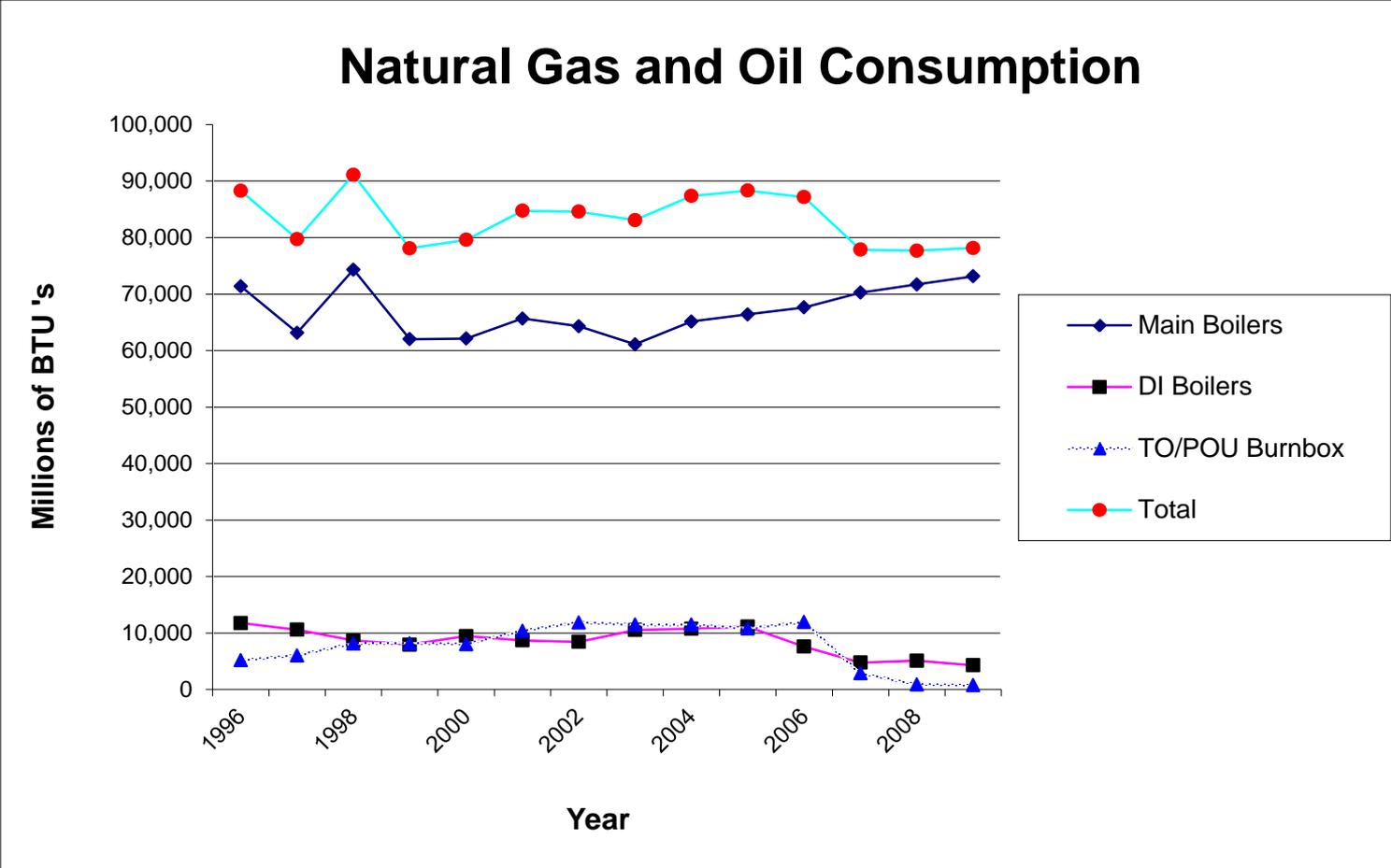
- **Electricity Usage Reduction**
 - Reduced annual usage by 15% between the peak in 2005 and 2008
 - Usage for 2009 projected to be 10% less than 2008

Resource Conservation Projects



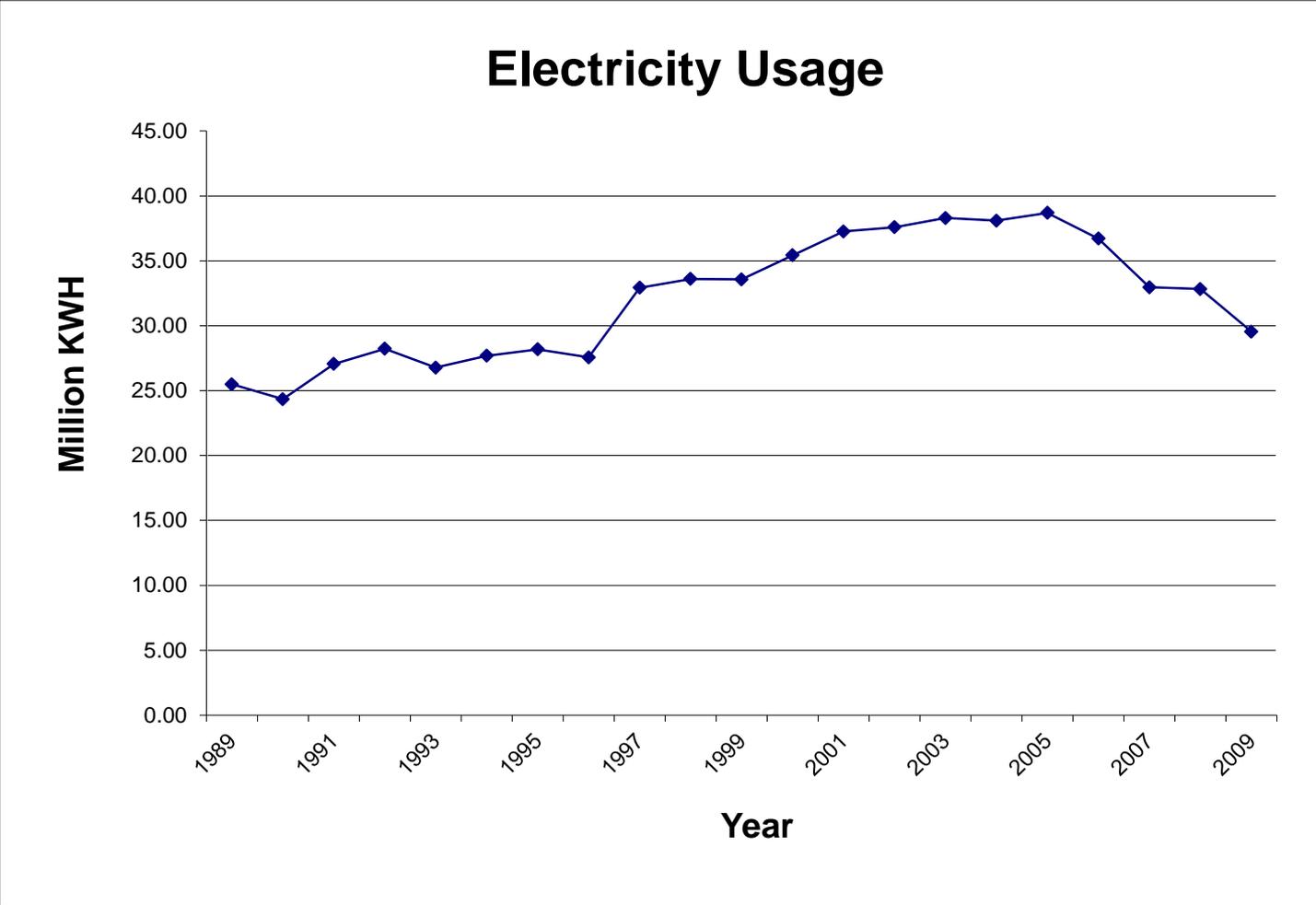


Resource Conservation Projects





Resource Conservation Projects





ISO-14001

- Allegro was encouraged by many of its customers to obtain registration to the ISO-14001 standard.
- Allegro's Worcester facility received its registration to ISO-14001 2/06.
- We have since passed the 2007, 2008, and 2009 recertification audits with no nonconformities.
- To meet one of the several requirements of our ISO-14001 certification, we have determined the significant aspects of our operations
 - They include the use of certain chemicals, city water, natural gas, oil, and electricity, as well as waste generation

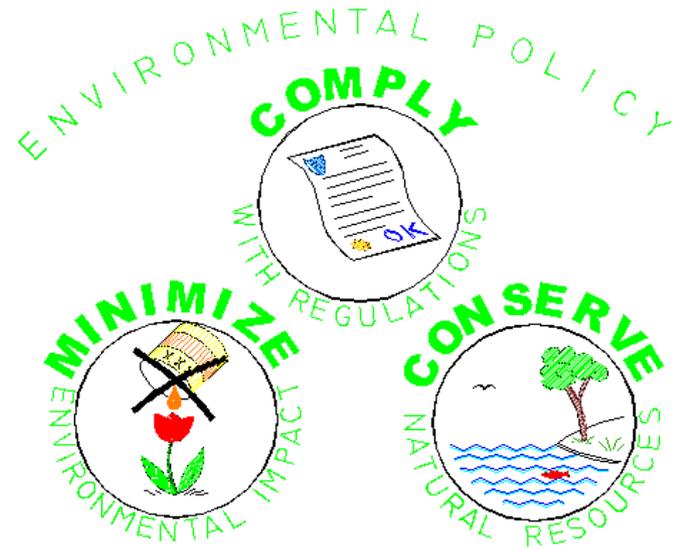


ISO-14001

- Goals have been set to reduce the impact of these aspects, and implementation of these goals ties nicely with the TUR program that was already in effect.
- Our environmental policy is $E=MC^2$, or environmental = minimize environmental impacts, comply with regulations, and conserve natural resources.
- If we did not have an active TUR and resource conservation program, it would have been much more difficult to develop and achieve goals that are related to our significant aspects and environmental policy.



ISO-14001



ENVIRONMENTAL = MINIMIZE * COMPLY * CONSERVE

$$E = M C^2$$





Summary

- By the nature of the business, operation of a wafer fab is very chemical and energy intensive.
- The TUR team was formed at Allegro consisting of representatives from production, process engineering, finance, facilities, DI building, EHS, and a chemist.
- Total current annual savings of \$1.1 million per year have been achieved from implementation of toxics use reduction projects (not adjusted for inflation).
- Total annual savings of \$1.5 million per year have been achieved from implementation of resource conservation projects (since 2003, not adjusted for inflation).
- Allegro's Worcester facility received its registration to ISO-14001 in 2/06.
- If we did not have an active TUR and resource conservation program at Allegro, it would have been much more difficult to develop and achieve goals that are related to our significant aspects and environmental policy.
- If you do your homework, you can effectively identify projects that help the environment, have a reasonable payback, and help your company to be more competitive.



Questions?