Sustainability in Facilities

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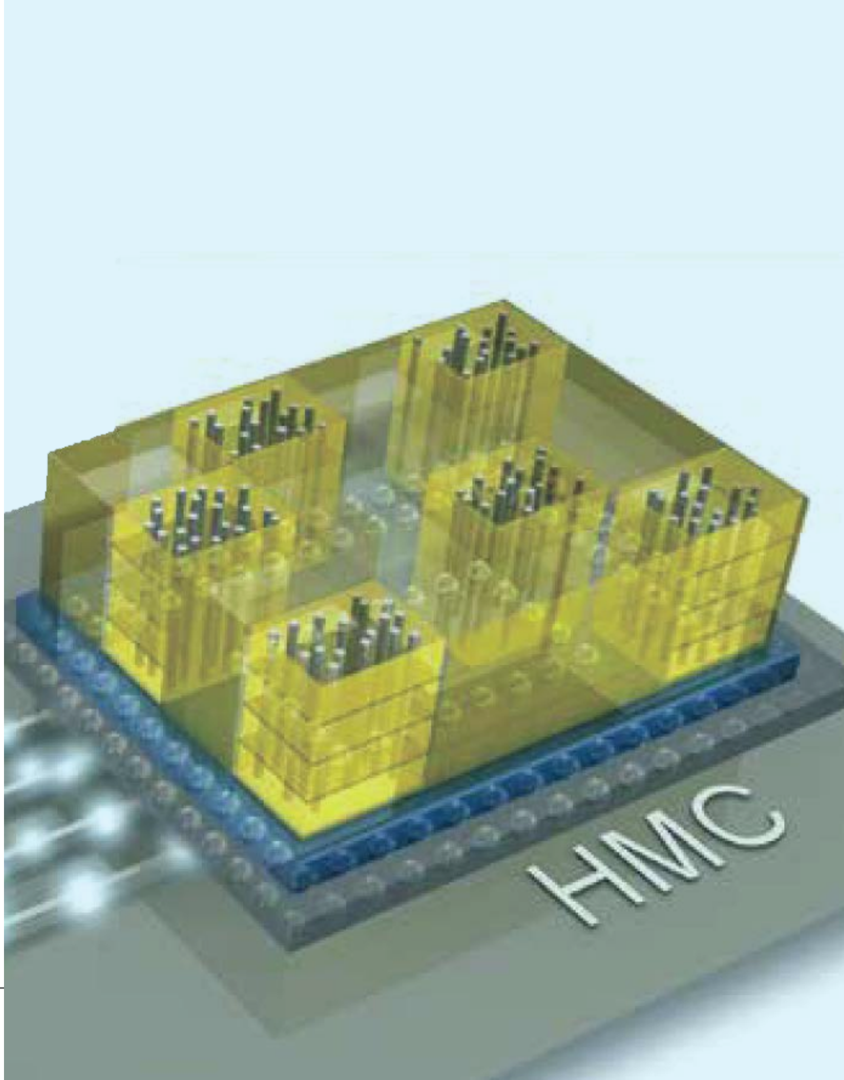
Agenda

- Micron Overview
- Corporate Sustainability Overview
- Next Node Challenges for Facilities
- Sustainability in Facilities – A Few Examples
- Conclusions

Micron at a Glance

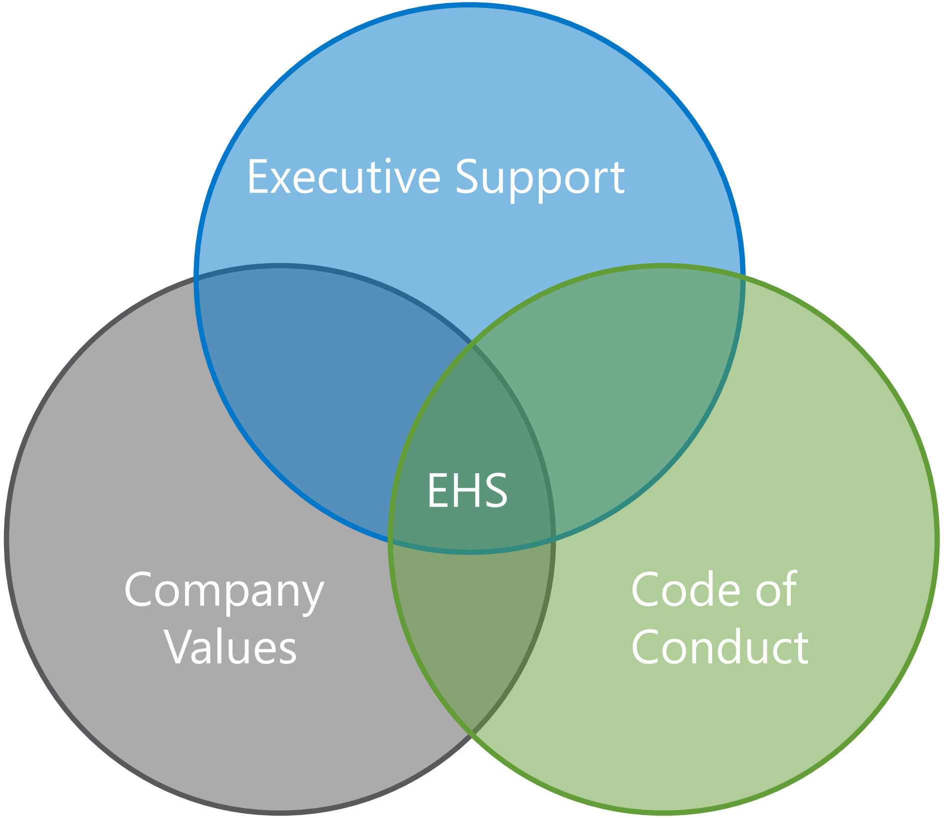
- Number of Employees: 35,000
- Founded: 1978
- Systems-level solutions: DRAM, NAND flash, NOR flash memory
- High volume 300mm Fabs in US, Singapore, Taiwan, and Japan
- Backend assembly Fabs in Singapore, Malaysia, China, and Taiwan

Memory Makes It Possible
Micron Makes It Happen



We Must Protect Our Natural Resources

Micron’s Approach



Micron is committed to maintaining environmental quality and protecting employee health, safety, and security.
We work vigorously to continuously improve in support of these commitments.

Micron Sustainability Vision

"Drive stakeholder value through enterprise-wide Sustainability goals and increased transparency"

  | May 12, 2016

Sustainability Materiality Assessment

Environment in Operations

- Hazardous substances in operations
- Energy in operations
- Water use and recycling in operations
- GHG emissions and climate change risks to operation

Labor

- Working hours
- Workforce attraction and retention
- Worker safety equipment and training
- Workforce diversity and non-discrimination
- Employee training and development
- Health & safety management systems

Governance and Management

- Ethical business practices and compliance
- Transparency, accountability and reporting

Supply Chain

- Conflict minerals in products
- Supply chain labor standards and supplier/contractor selection

Customers and Products

- User privacy and data protection
- Product energy efficiency
- Hazardous substances in products

Communities

- Communications and stakeholder engagement
- Community development
- Employee volunteerism and giving
- Philanthropic programs

Micron

Committed to Continuous Improvement Globally

Impacts of DRAM Process Complexity – "Problem Statement"

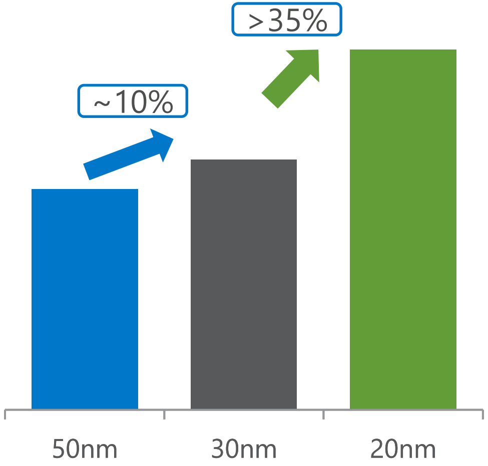
- Large increase in number of process steps to enable shrink
- Conversion Capital Expenditure scales with the number of steps
- Significant reduction in wafer output per existing cleanroom area

Complexity comparison for enablement of ~100% bits/wafer increase

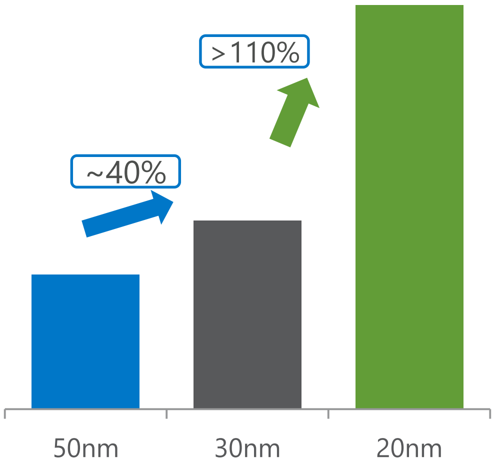
50nm ⇒ 30nm

30nm ⇒ 20nm

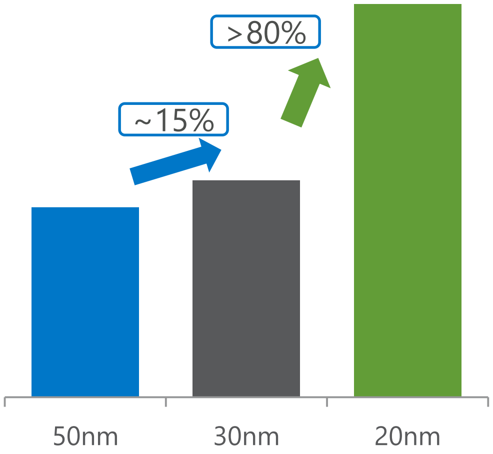
Number of Mask Levels



Number of non-Litho Steps per Critical Mask Level



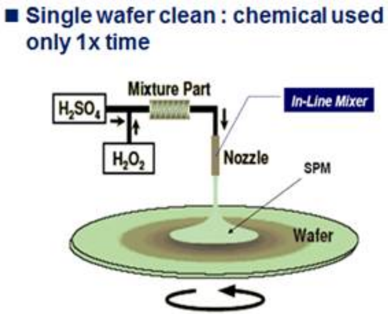
Cleanroom Space per Wafer Out

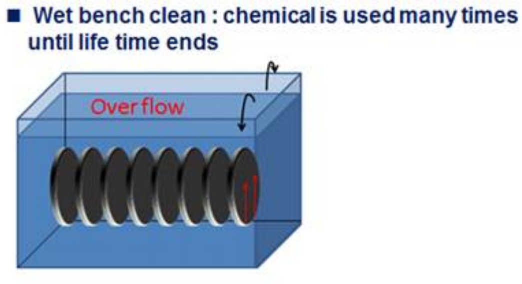


Process Complexity Drives Material Criticality

- Single wafer clean developments change water and chemical use profiles
- Chemical and gas demand increases over time creating market pressures
- Chemical reduction and reuse initiatives and technologies become even more important
- Intersection of global water demand and manufacturing node complexity drive reclaim and reduction activities

Single Wafer Clean (SWC)



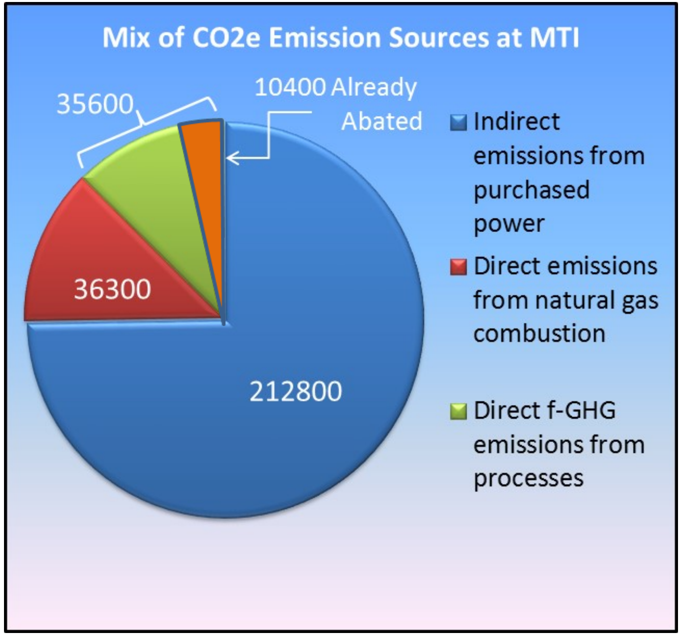


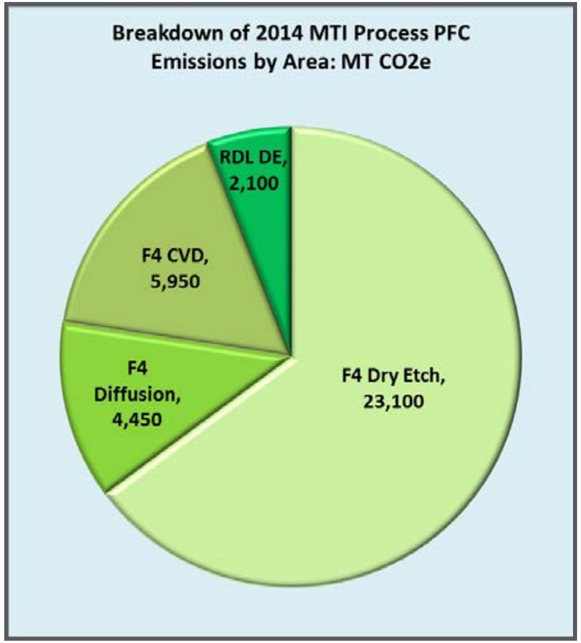
- As technology shrinks, there is a need to move towards better particle free and excellent uniformity technology.
- Single wafer cleans offer this benefit, due to the nature of cleaning process that occurs wafer by wafer, as compared to batch clean (50 wafers at the same time).
- Chemical usage and waste generation has an estimated increase of ~ 3x-5x.
- DIW usage, in contrast is reduced to ~ 0.5x, due to lesser rinse time needed to remove residue / particle after chemical dispense.

Sustainability in Facilities Focus Areas
“Benchmarking Across the Fab Network”

- Wafer Fab Carbon Footprint Example
- GHG Emissions Reduction
- Sustainable Construction
- Energy in Operations Reduction – “Electrical Intensity”
- Water Conservation and Recycling
- Conservation of Chemicals and Gases

CO2e Emissions - Site and Process

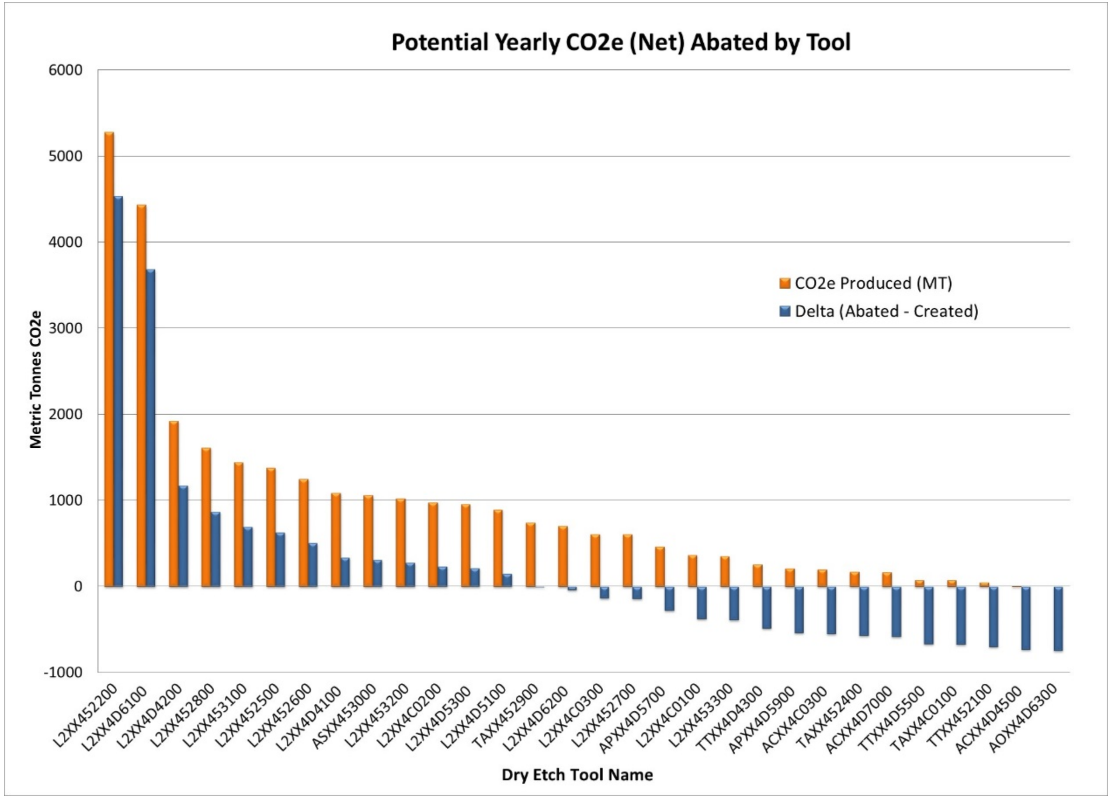




Greenhouse Gases

- In 1999 the industry voluntarily agreed to reduce PFC emissions by at least 10% below baseline levels by 2010; WSC reported 32% reduction in 2011
- WSC new target is a 30% reduction but normalized to cm2 wafer processed
- Micron will continue to be a responsible contributor to SIA and WSC greenhouse gas and climate change programs
- Major effort spooled up to reduce GHG's through new abatement technologies. Pilot projects in progress in Boise and Lehi. Traditional "burn wet" approaches are "Carbon additive" in many RIE applications.

CO2e Produced and Net Abated by Dry Etch Tool (Pre-Optimization)

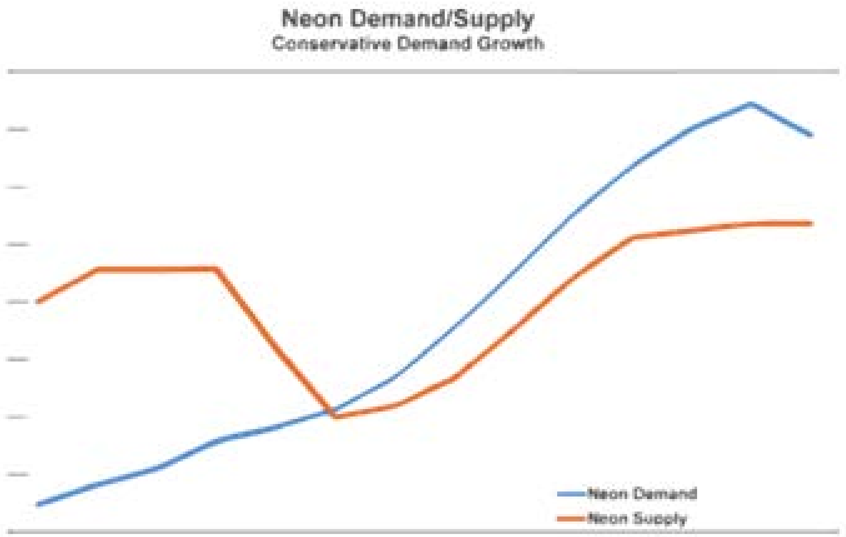


Chemicals and Gases

- Stringent review and approval
- Reduce, reuse or recycle
- Successes:
  - 50% reduction in photolithography Spinfil chemical use
    - $800K annual material spend savings
    - Reduced hazardous waste
  - Patented drum tilt device to maximize chemical use and minimize hazardous waste
  - Noble gas reclaim

Neon Supply vs. Demand

- Demand
  - Neon demand projected to significantly increase for semiconductor lithography
    - Development of new semiconductor fabs globally will lead to continued growth in semiconductor production
    - Delay of EUVL implementation necessitates the need for multi-patterning process flow
    - V-NAND process flows
  - High Growth Neon Consumption Area’s
    - Lasik
    - OLED/FPD (displays)



- Risks
  - Continued instability in Ukraine
  - Low quality sources require additional purification
  - Steel production in the Ukraine remains tenuous
  - China's rationalization in the steel industry imminent
  - High cost and long lead time to add rare gas collection capability to ASUs

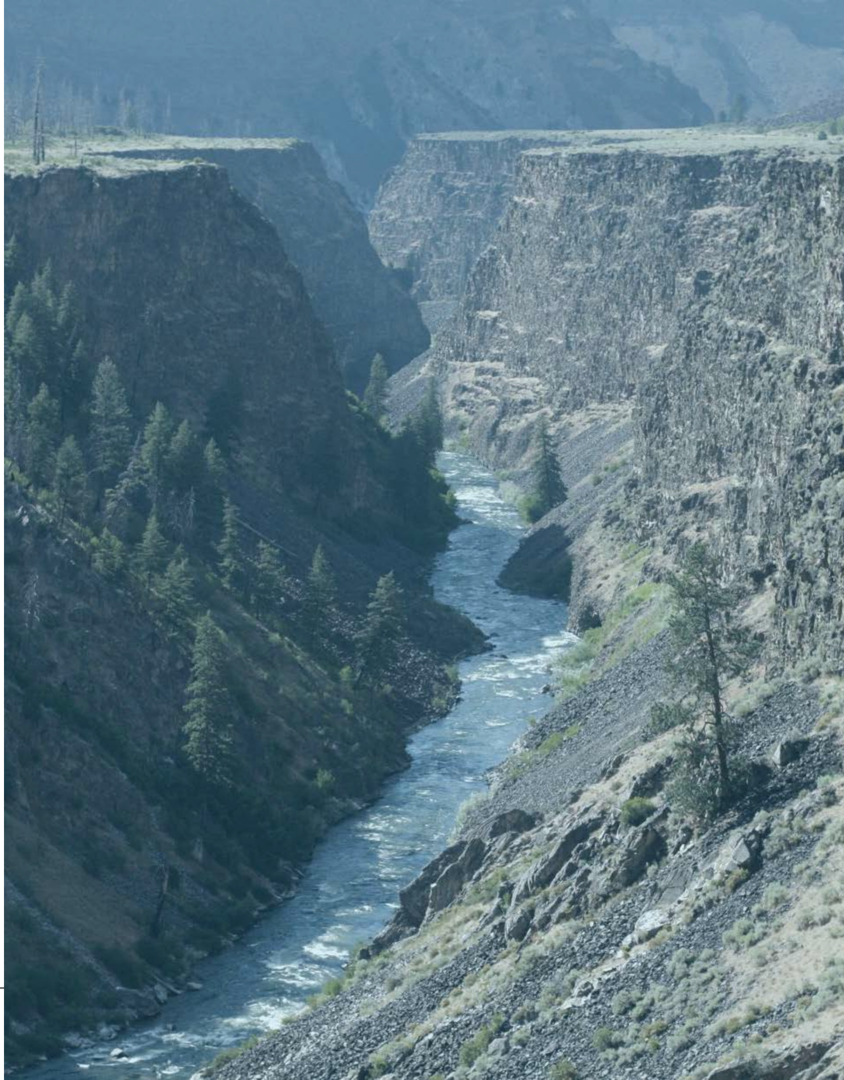
Boise Green 2014

- **730 million gallons of water** conserved
- **104,761pounds** of integrated circuit trays recycled
- **1.4 million pounds** of paper, plastic, cardboard, wood recycled
- **10 million kWh of energy** saved due to chilled water economizer
- Plus, another **7.5 million kWh** savings in energy efficiency

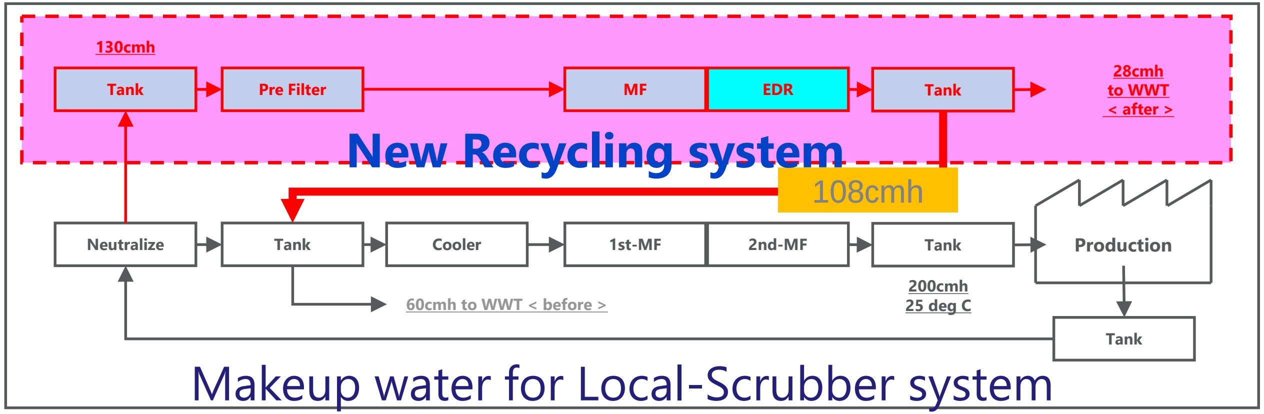
Water

Boise Aquifer Replenishment

- Local aquifer water supply levels declining in 1990’s
- Micron acquired river water rights and spent $7 million to pump water, treat via ultra-filtration membrane and inject into aquifer
- Aquifer levels are now increasing



Local Scrubber Reclaim – Success Story in Fab 15



  | Micron Confidential | May 12, 2016

LEED Buildings

- **2010 and 2016 LEED certifications for a New Construction**
  Micron's 300mm NAND fabrication facility achieved Leadership in Energy and Environmental Design (LEED) certification from the U.S. Green Building Council in August 2010 under the New Construction rating system. The certification identified the fab as a pioneering example of sustainable design and demonstrated it s leadership in transforming the building industry.

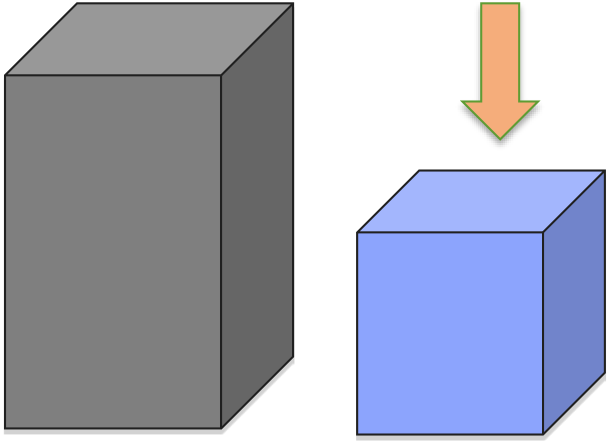
F10X –March 2016

LEED 10X Energy Saving Requirements

Baseline Building:
-ASHRAE 90.1

Minimum Efficiency for:
-ACMV equipment
-Air distribution equipment
-Lighting power
-Motor Efficiency
-Service water Heating
-Envelope design
- Fresh air provision
-Sensor control

Min Required Energy saving 10%



Base building
energy consumption
= x kWh/yr

Actual building
Reduced energy consumption
= y kWh/yr

Actual Building:
- Energy efficiency design:
-Reduced Thermal load
-Shading devices for windows

More efficient Eqpt:
-ACMV
-Air Distribution
-Lighting/ Lamps
-Motor
-CO2 control
-CO control
-Presence/ photo sensor
-ACVVF vertical sys
-Admin bldg.: Solar panels

Conclusions

- New technology node complexity presents a major challenge in Carbon footprint/cm2 (not per transistor).
- Must be offset with new technologies for GHG abatement, materials conservation, water reclaim, energy savings. Fortunately most investments also reduce COGS!
- Micron is aggressively driving reduction in Facilities Carbon Footprint, Material conservation, and overall CSR.
- Forums like the CMC are absolutely critical for driving collaboration!!!
- Thanks for your attention!

Memory Changing the World

Micron®