Lean and the Environment

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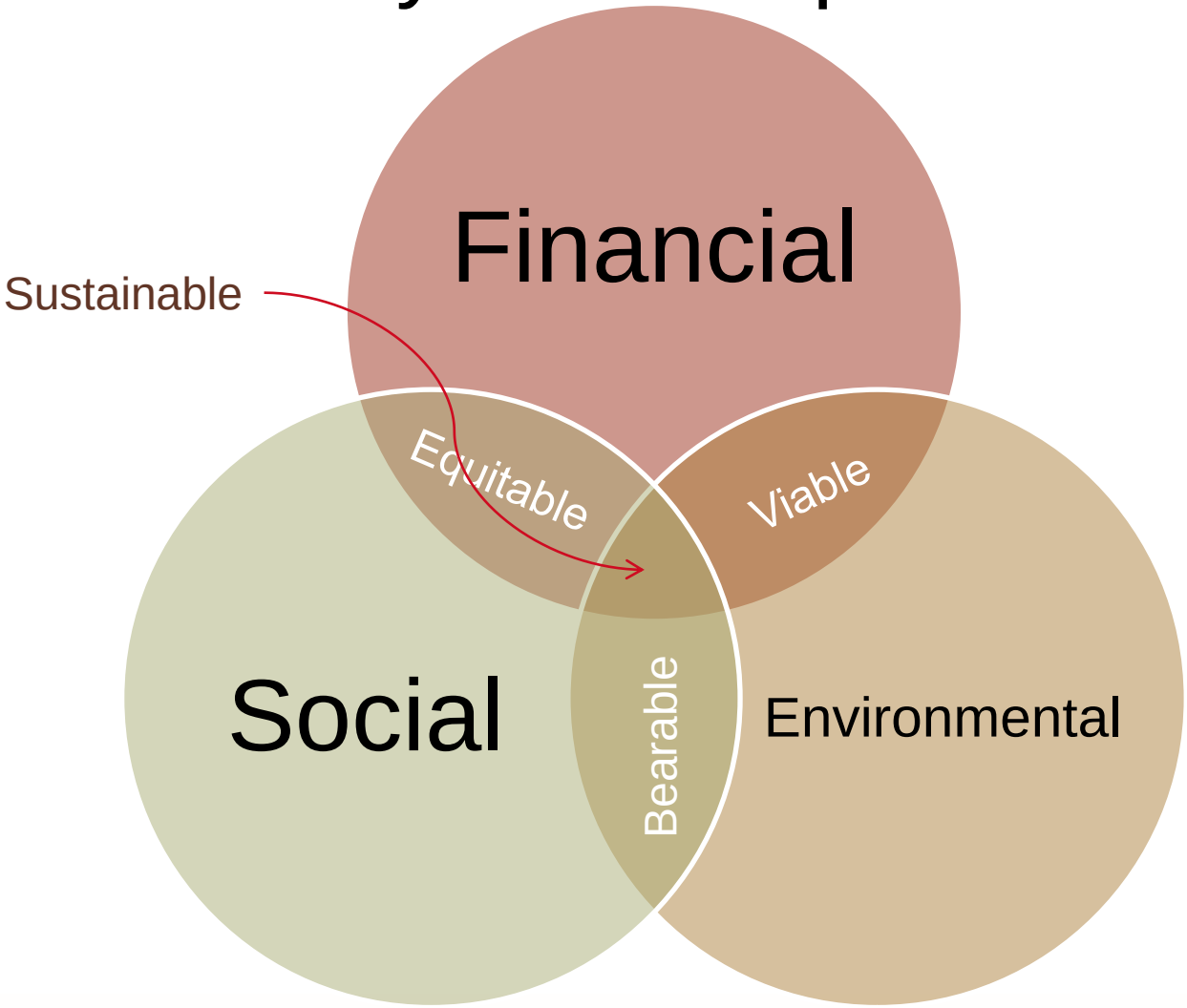
Agenda

- Introduction to Lean & Green
  - Green Manufacturing's Role in Lean
  - How Lean & Green Tools Work together
  - Implementing Green Manufacturing
- Green Manufacturing Simulations

Sustainability & the Triple Bottom Line



Wastes are environmental too…

Water

Air

Solids

Toxicity
(Chemicals)

Energy

Isn’t the environment part of Lean already?

- “Cost of doing business,” not viewed as opportunity
- Costs and impacts can be blanketed across many areas, hard to isolate data to biggest users
- Improvement opportunities may be found outside of normal working operations
- Environmental and human health risks are often not explicitly considered in business decisions
- Side benefits of efforts not anticipated
  - take-back, talent acquisition, employee engagement

Does it really work?

Results from "Lean and Environment" Efforts (Box ES-2)

- ✓ **3M** reduced volatile air emissions by 61% and toxic inventory releases by 64% from 2000 to 2005 using Lean and Six Sigma techniques in coordination with pollution prevention.
- ✓ **Columbia Paint & Coatings** recovered 49,200 lbs per year of paint solids from wash water and reduced wastewater by 36,900 gallons per year based on a few Lean and environment events.
- ✓ **Woodfold Manufacturing** reduced volatile organic compound (VOC) emissions by nearly 1,000 lbs per year and diverted 6 tons per year of solid PVC waste from the landfill through opportunities identified in a value stream mapping event.

"…savings have offset the expenses by approximately 2 to 1" - IBM

http://www.epa.gov/lean/environment/toolkits/professional/resources/Enviro-Prof-Guide-Six-Sigma.pdf

It works both ways

Lean Tools → Green Benefits

Green Tools → Lean Benefits

Lean Tools (Modified)

- 7 Forms of Waste
- 5 Why's
- DMAGIC/DMAIC
- Go and See (Gemba)
- VSM
- QDIP
- OEE
- Defect Concentration chart
- Regression
- Event Checklists

7 Forms of Waste

Waste Type	Environmental Impacts
Overproduction	• More raw materials consumed in making the unneeded products • Extra products may spoil or become obsolete requiring disposal • Extra hazardous materials used result in extra emissions, waste disposal, worker exposure, etc.
Inventory	• More packaging to store work-in-process • Waste from deterioration or damage to stored WIP • More materials needed to replace damaged WIP • More energy used to heat, cool, and light inventory space
Transportation and Excessive Motion	• More energy use for transport • Emissions from transport • More space required for WIP movement, increasing lighting, heating, and cooling demand and energy consumption • More packaging required to protect components during movement • Damage and spills during transport • Transportation of hazardous materials requires special shipping and packaging to prevent risk during accidents
Defects	• Raw materials consumed in making defective products • Defective components require recycling or disposal • More space required for rework and repair, increasing energy use for heating, cooling, and lighting
Over Processing	• More parts and raw materials consumed per unit of production • Unnecessary processing increases wastes, energy use, and emissions
Waiting	• Potential material spoilage or component damage causing waste • Wasted energy from heating, cooling, and lighting during production downtime

Identify Wastes and Opportunities

Water

- ✓ How much water is used in the process and how is it used?
- ✓ How can you reuse water and/or reduce overall water use?
- ✓ Can you reduce contaminants in wastewater discharges?

Air

- ✓ What types and amounts of air emissions are generated by the process?
- ✓ How can you reduce the overall amount or toxicity of air emissions?
- ✓ Can you reduce the vehicle miles traveled and emissions from transportation?

Solids

- ✓ What types and quantities of solid waste are generated by the process?
- ✓ How can you reduce the overall amount of solid waste generated?
- ✓ How can you reuse or recycle solid wastes?

Identify Wastes and Opportunities

Toxicity

- ✓ What types and quantities of chemicals and hazardous waste are generated?
- ✓ How can you reduce the amount or toxicity of hazardous waste generated?
- ✓ Can you eliminate any non-value added use of chemicals or materials from the product or process (excess packaging, unneeded painting, etc.)?

Energy

- ✓ How much energy is used in the process and how is it used?
- ✓ How can you reduce overall energy use?
- ✓ Is equipment running or are lights on when not being used?
- ✓ Are you using efficient light bulbs?
- ✓ Can you save energy by consolidating operations and/or storage space?
- ✓ Can you shift to a cleaner source of energy?

Finding Hidden Costs

If a product is broken in the shipping department:

True cost of waste =

Cost of wasted raw materials
+ cost of utilities used
+ lost time
+ waste treatment/handling
+ disposal costs

The total cost of waste is generally around *20 times* the first estimate that a company makes.

Tecmotiv Example

Improvement and savings / TABLE 1

Wastes	Improvements	Annual results
Overprocessing	Widened orifices in glass bead blast cabinets, reducing cleaning time per cylinder by 50%, overall energy use and material (glass bead) and nonhazardous waste.	Reduced labor hours
Defects	In-process inspection moved to the beginning of process, thereby identifying bad parts at the start of the process instead of passing defects to downstream processes, thus reducing rework. Implemented quality at the source (for example, transferred responsibility for quality from inspectors to assemblers). This required cross-training and visual standard work procedures.	Less detergent used: 41 gallons Less water used: 1,480 gallons
Overprocessing	Boring, honing and cross-hatching now performed on an automatic honing machine instead of doing one cylinder at a time manually.	Less nonhazardous wastewater: 259 gallons
Unnecessary motion	Parts repackaged in special crates to minimize handling.	Less glass bead: 3,631 pounds
Overprocessing	Eliminated one process-cleaning step, reducing electricity use (less use of high-pressure spray washer).	Less nonhazardous solid waste: 5,791 pounds
Waiting and scrap	Reused (clean and plate) formerly discarded hardware, resulting in less work stoppage due to unavailable parts.	$64,335 in total cost savings

http://asq.org/quality-progress/2010/03/lean/leaning-toward-green.html?WT.dcsvid=OTA2NDMxNDY0MgS2&WT.mc_id=EM118436

5 Why's

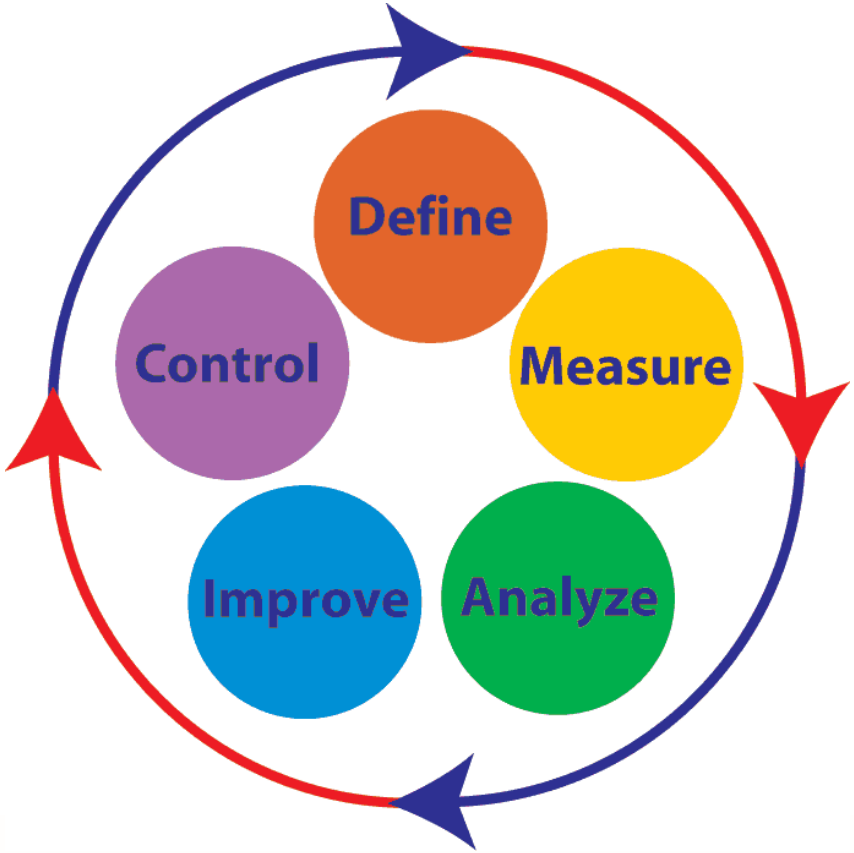
- ***Why are we using so much water?***
  The parts need to be cleaned before painting
- ***Why do the parts need to be cleaned?***
  The parts fail quality checks if they aren't cleaned before being painted
- ***Why do the parts fail quality checks?***
  The paint doesn't adhere when part surfaces are not prepared properly
- ***Why do the surfaces of the part need to be prepared?***
  The surfaces get contaminated with oils used in the previous process
- ***Why are oils used in the previous process?***
  The oils are used to prevent corrosion during storage

Solution: Protect parts during storage to prevent corrosion

[1]Based on an example from Robert B. Pojasek, "Asking 'Why' Five Times," *Environmental Quality Management* (Autumn 2000): 83.
http://www.epa.gov/lean/environment/toolkits/water/resources/lean-water-toolkit.pdf

DMAIC

- Simple approach to solve problems or improve processes – derived from scientific method



JEA's DMAGIC roadmap

- JEA added a "Green It Up" step to the DMAIC process, creating "DMAGIC"
  - designed to ensure that every improvement project addresses environmental concern
- The team performs the "Green it Up" phase after identifying root causes and before developing any countermeasures, to explore areas such as air quality, water quality, and ecosystem-related issues.
- This assures that environmental and societal concerns are "baked into" every countermeasure explored before it is evaluated.

http://www.epa.gov/sustents/environment/studies/jea.pdf

Rockwell Collins Energy Go and See

1) Off hours observations
2) Case for change
3) Define the team
4) Prepare for event
5) Kickoff training
6) Run the events
7) Organize and prioritize opportunities
8) Reviews action items
9) Establish roles and responsibilities
10) Communicate successes

Energy Treasure Hunts

Energy Treasure Hunts at General Electric (Box 8)

With mentoring assistance from Toyota, General Electric (GE) launched an integrated Lean and energy initiative that has identified upwards of $110 million in energy savings through energy treasure hunts. GE's corporate commitment to energy use and greenhouse gas reductions has helped drive this effort. As of March 2009, GE:

- ✓ Conducted over 200 energy treasure hunts at GE facilities worldwide, and trained over 3,500 employees on how to conduct treasure hunts
- ✓ Used energy treasure hunts to identify 5,000 related kaizen projects, most of which are funded and in various stages of implementation
- ✓ Through those project have identified opportunities to eliminate 700,000 metric tons of greenhouse gas emissions and $111 million operational cost.

Source: Gretchen Hancock. (2009, May 13). How GE's 'Treasure Hunts' Discovered More Than $110M in Energy Savings. Retrieved from http://www.greenbiz.com/blog/2009/05/13/how-ges-treasure-hunts-discovered-more-110m-energy-savings .

Water Gemba Walk

1. Identify all water-consuming equipment, high-use areas, and meter locations.
2. Note all water losses, evaporative losses, and water incorporated in product; excessive water pressure; and leaks.
3. Observe shift clean-ups and process changeovers.
4. Quantify water flow rates and usage.
5. Note the water quality used in each process step.
6. Determine water quality needs for each process, and quality of wastewater discharged

Table 4: Key Areas to Check During a Water Gemba Walk

Process and Equipment Use
- Cleaning, Washing, Rinsing
- Metal Finishing
- Painting
- Dyeing and Finishing
- Photo Processing
- Process Water Reuse
- Product Fluming (Water Transport)
- Pretreatment/filtration systems
- Pump and Conveyor Lubrication
- Water Use in Products

Cooling and Heating
- Single-Pass Cooling
- Cooling Towers
- Boilers, Hot Water, Steam Systems
- Air Washers
- Boiler Scrubbers

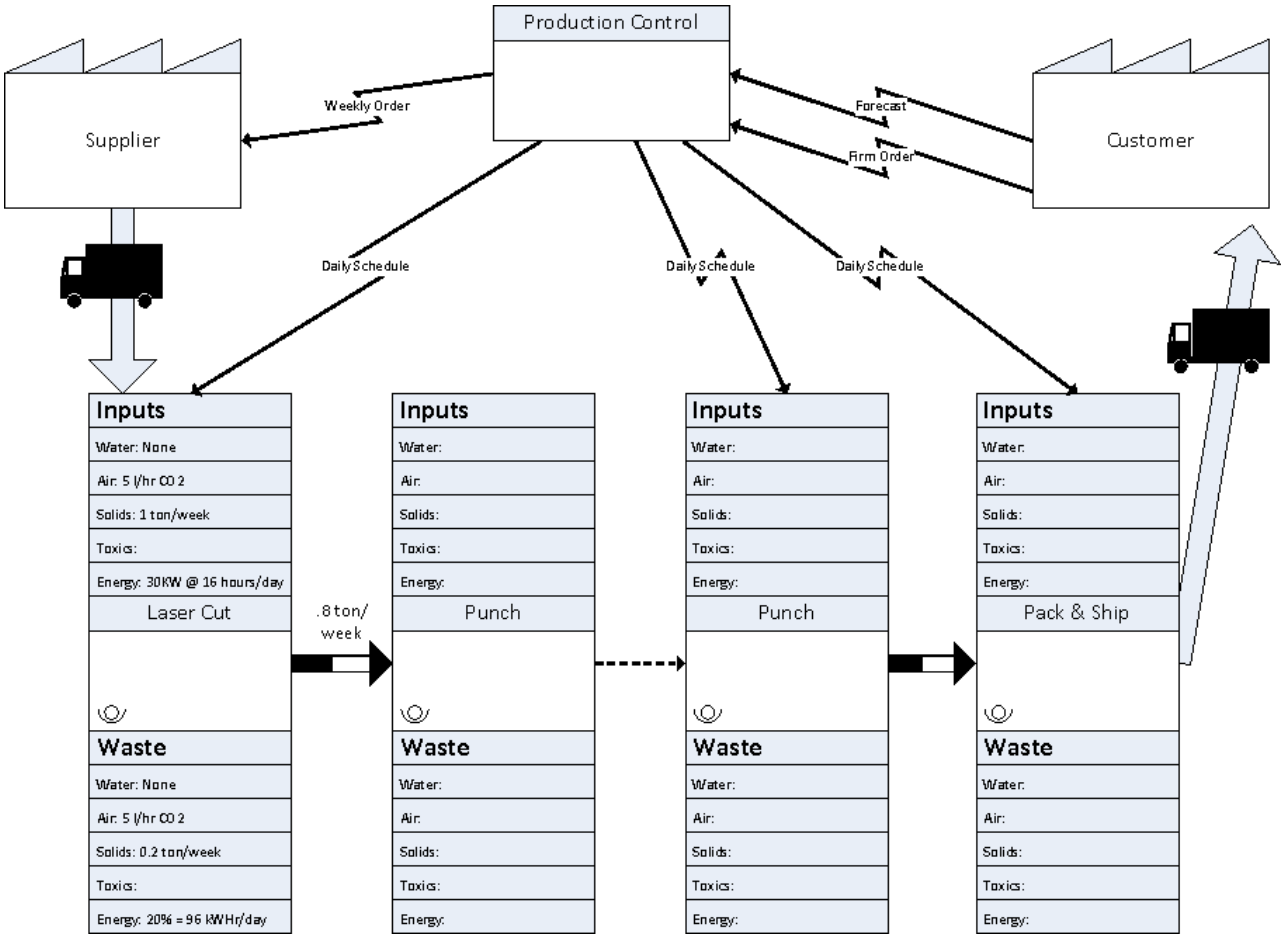
Sanitary and Domestic
- Toilets
- Faucets
- Urinals
- Showers
- Wash-up Basins

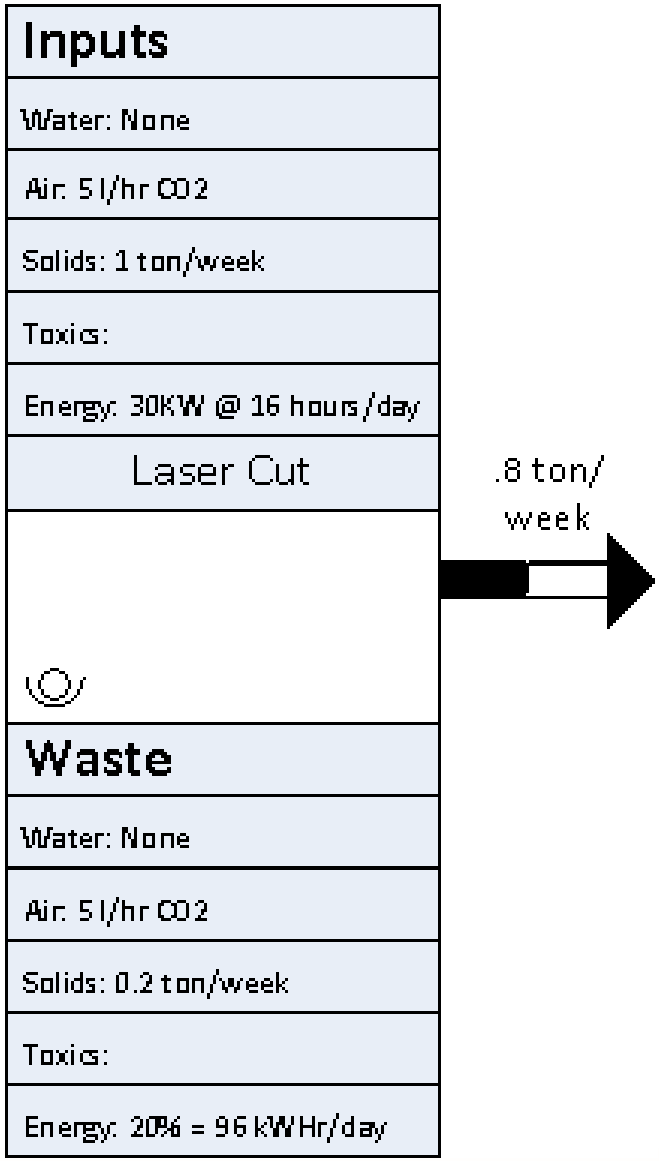
Other Facility Support
- Floor Washing
- Air Emission Wet Scrubbers
- Building Washing
- QA/QC Testing
- Laboratories
- Landscaping and Irrigation
- Dust and Particulate Emission Control
- Decorative Fountains and Ponds
- Vehicle Washing
- Cooling Water for Air Compressors and Vacuum Pumps
- Hazardous Waste Storage and Effluent

Kitchens
- Food Preparation and Cleaning
- Dishwashers
- Ice Machines
- Faucets
- Food Disposals

http://www.epa.gov/lean/environment/toolkits/water/resources/lean-water-toolkit.pdf

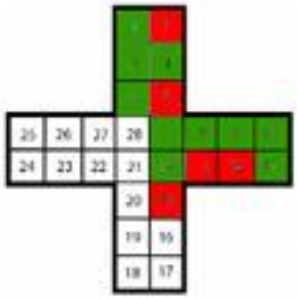
Waste Stream Maps



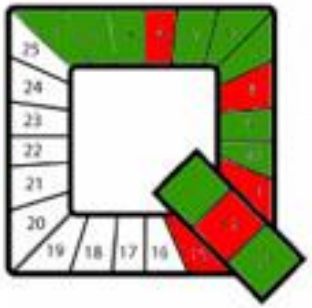


- Integrated with VSM or standalone.
- Provides new ways to identify waste
  - Lean and Green
- Familiar approach makes transition to green easy

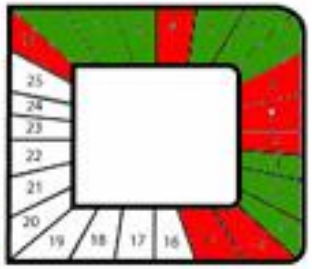
QDIP Visual Controls



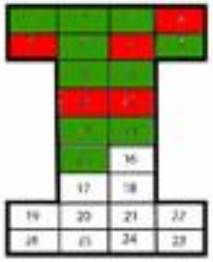
SAFETY



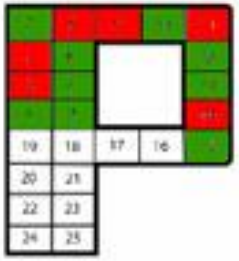
QUALITY



DELIVERY



INVENTORY



PRODUCTIVITY

ENVIRONMENT

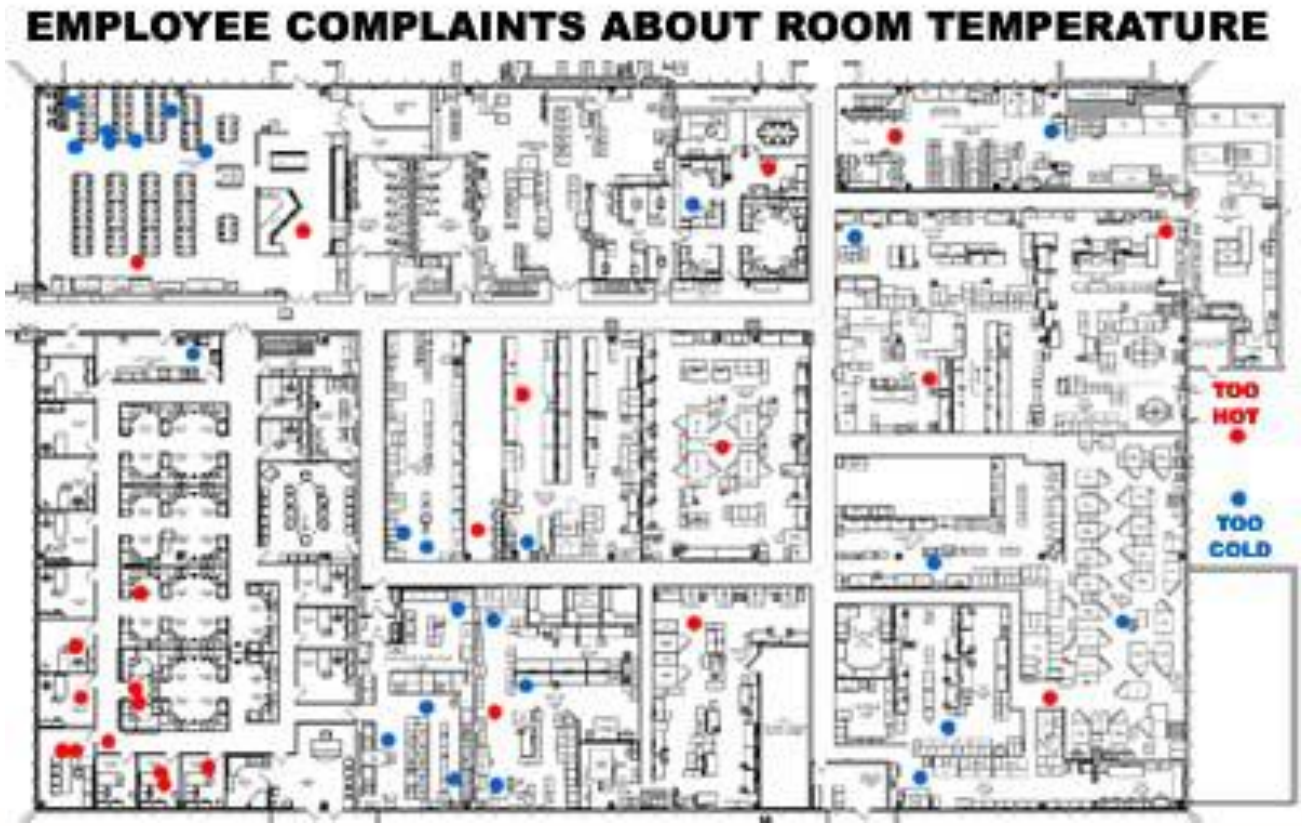
Safety	Quality	Delivery	Inventory	Productivity	Environment
•No missed days •No injuries	•Less than 5 defects per day •DPMO less than 50 •Test Yield greater than 95%	•100% on-time to customers, schedule, next process, etc •Complete 10 units per day	•WIP less than 10 units •No more than 3 pieces at each station •WIP less than $10,000	•$/hr greater than $150 •Less than 10 minutes of downtime •Team met daily takt time goals	•All equipment shut off at end of shift •No recyclables in trash •100% Hazardous waste adherence

OEE

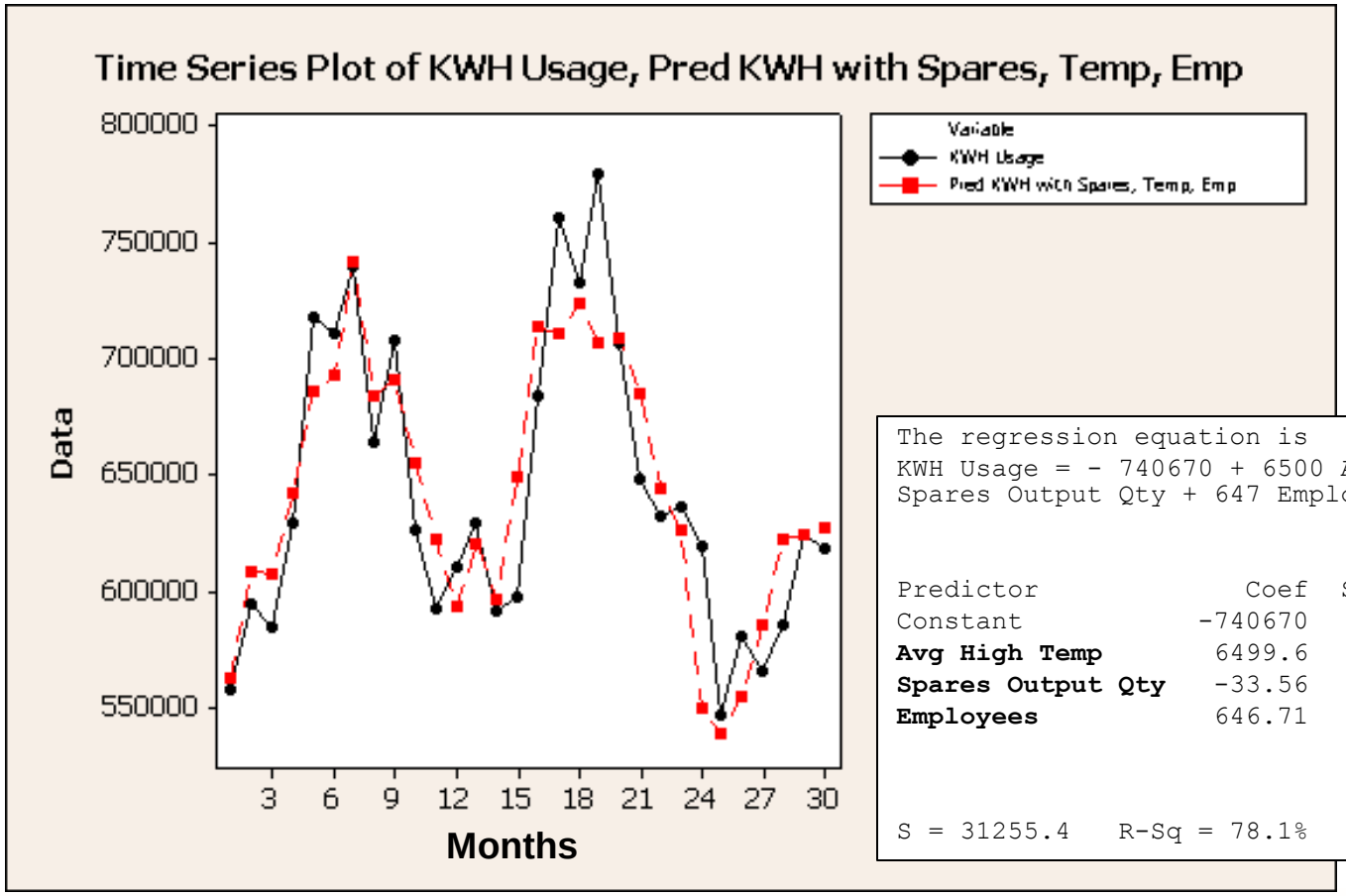
- Metric for overall utilization of facilities, time and material for manufacturing operations
  - **OEE = Availability x Performance x Quality**
- Infor™ suggests adding **Energy Consumption** to OEE metric
  - measured against the best energy performance for that equipment
  - As the equipment experiences issues, energy usage will increase, which will impact OEE

Defect Concentration Chart

- HVAC Issues



Regression Analysis



The regression equation is
KWH Usage = - 740670 + 6500 Avg High Temp - 33.6 Spares Output Qty + 647 Employees

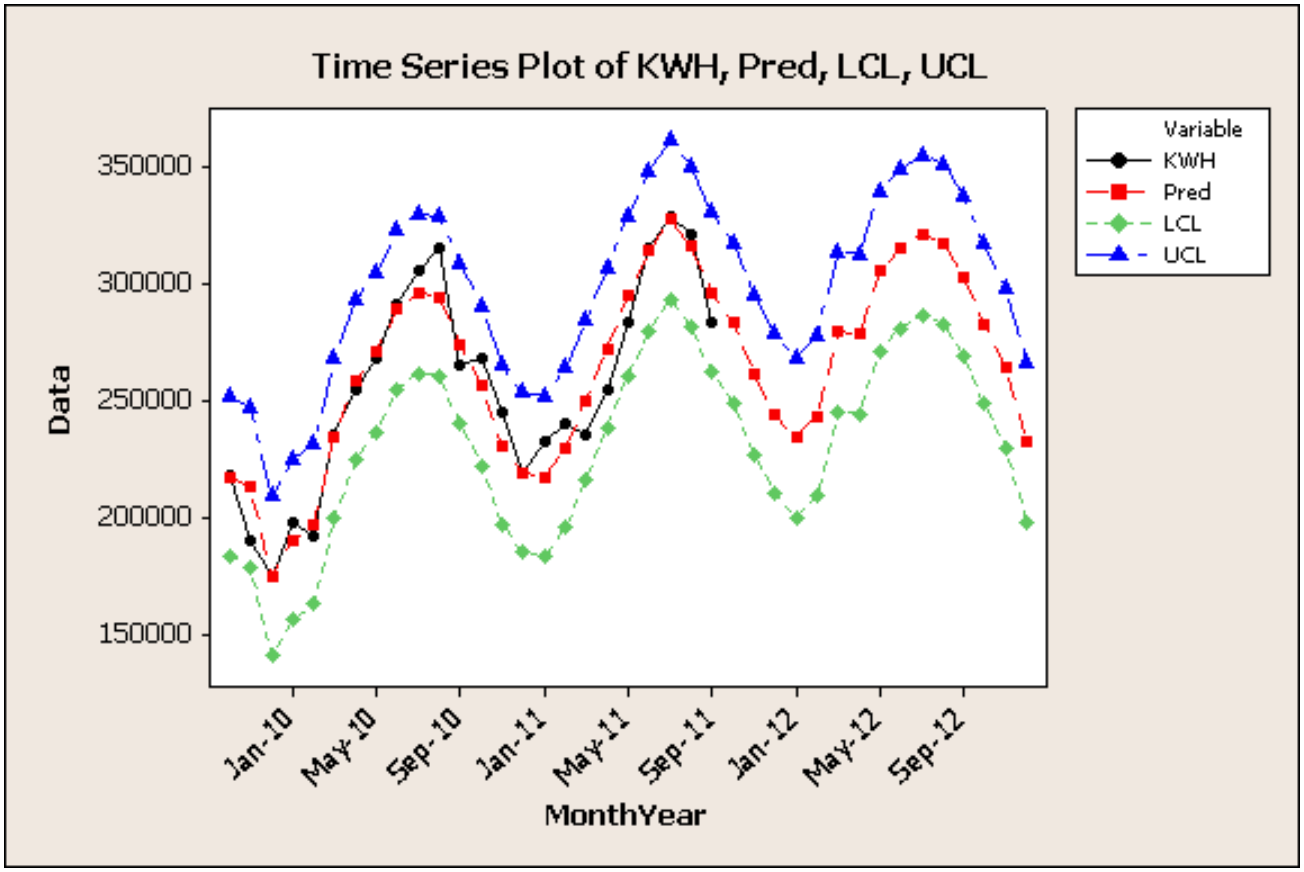
Predictor	Coef	SE Coef	T	P
Constant	-740670	145555	-5.09	0.000
Avg High Temp	6499.6	944.8	6.88	0.000
Spares Output Qty	-33.56	11.17	-3.00	0.006
Employees	646.71	91.93	7.03	0.000

S = 31255.4 R-Sq = 78.1% R-Sq(adj) = **75.6%**

Determine largest drivers of electricity usage

What does this tell you?

Regression Analysis



Future months should stay between blue and green lines, otherwise investigate

Event Checklist

- You can't be in every event, so provide this checklist to the teams, so they know what things to consider, and when to call for help

Physical Environment			
As a result of the Lean event, will there be:	**Unk**	**Yes**	**No**
Any changes to the locations where either maintenance work or use of hazardous chemical/material will occur?			
Any changes to your personnel's work zone assignments?			
Any new equipment or modifications to existing equipment, or movement of existing equipment that has the potential to produce air or water emissions (e.g., rinse equipment/operations, cleaning tank, heating ovens)?			
Any changes to the facility (e.g., vents, stacks, floor drains, oil/water separators)?			
Any changes in the location(s) of the current flammable storage locker/areas?			
Any new confined space entry activities or procedures (e.g., personnel entering fuel tanks for cleaning)?			

Event Checklist (cont'd)

Material/Chemical Use and Storage			
As a result of the Lean event, will there be:	**Unk**	**Yes**	**No**
Any changes to the type or volume of materials issued to personnel and/or used? This includes the introduction of new chemicals, elimination of chemicals, etc.			
Any changes to the chemical introduction or issuance procedure for chemicals/materials containing hazardous materials?			
Any changes in the volume of chemicals/materials stored?			
Any flammable materials that are not returned to the storage cabinets at the end of each shift?			
Waste Management			
As a result of the Lean event, will there be:	**Unk**	**Yes**	**No**
Any change(s) to the waste profiles for wastes stored at any initial accumulation points?			
Any change(s) to the location or number of initial waste accumulation points?			
Any change(s) to the volume of waste(s) that require disposal (i.e., wastewater, hazardous or solid waste) or to the volume of material that will be recycled or reused?			

http://www.greensuppliers.gov/tech/tools.html?id=lean_clean

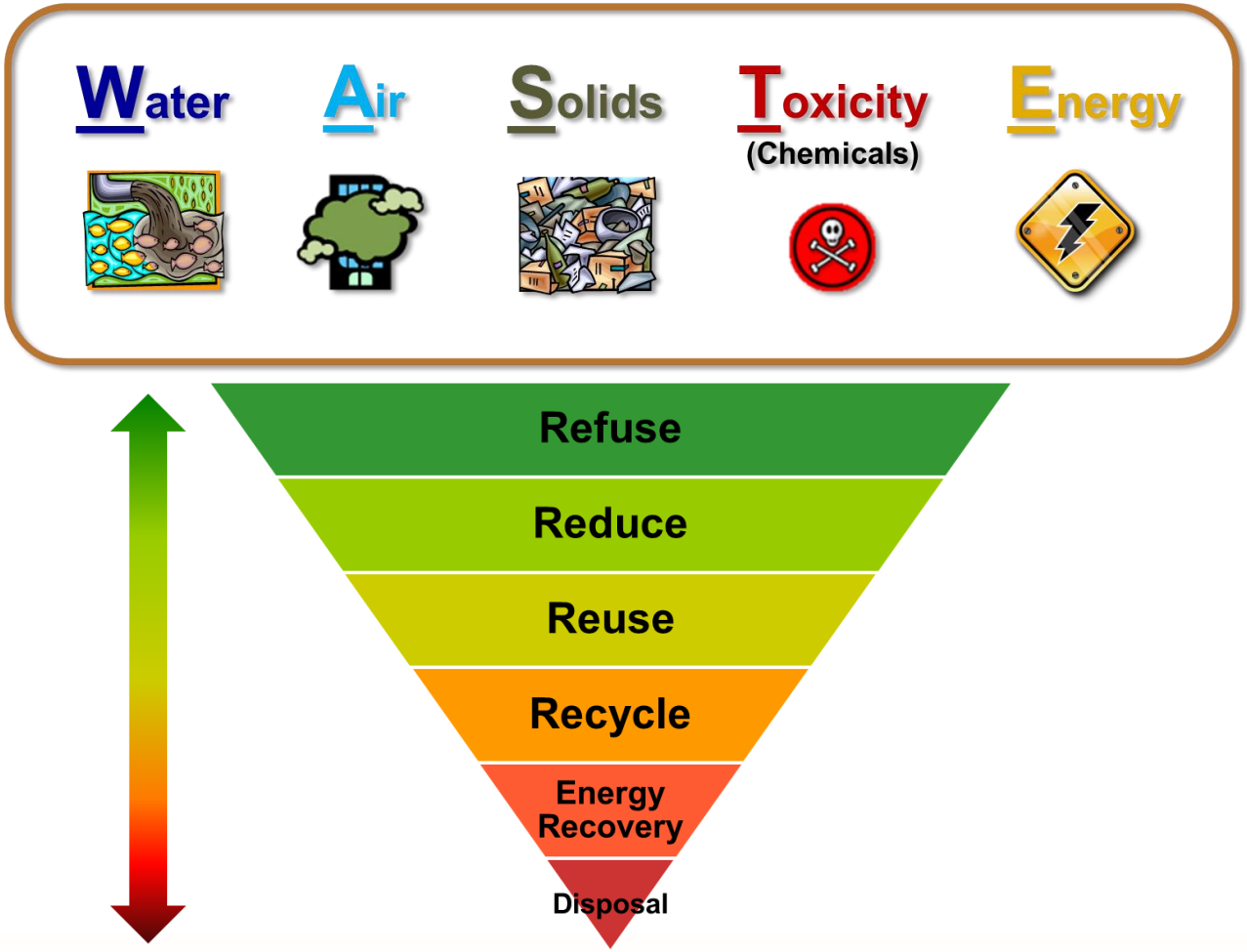
Implementing Green Manufacturing

- Green as part of a lean system
- Green as it's own system
  - Strategic vs. operational

Integrating Green into Lean

- Add Earth/Environment to SIPOC as a Customer
- All process improvements naturally reduce impact on the environment, now capture the environmental benefits!
  - Eliminate non-value added tasks, reduce space allocation, reduce time between processes, reduce raw materials needed
- Add environmental usage and costs to data boxes on Value Stream Maps
- Add energy waste examples to existing definitions
- Relate environmental issues to core business needs and priorities (money, risk, reputation, etc)
- Focus improvement efforts specifically on environmental metrics
- Integrate environmental checklists into event templates
- Communicate Resources slide to Lean and ES&H personnel in your company

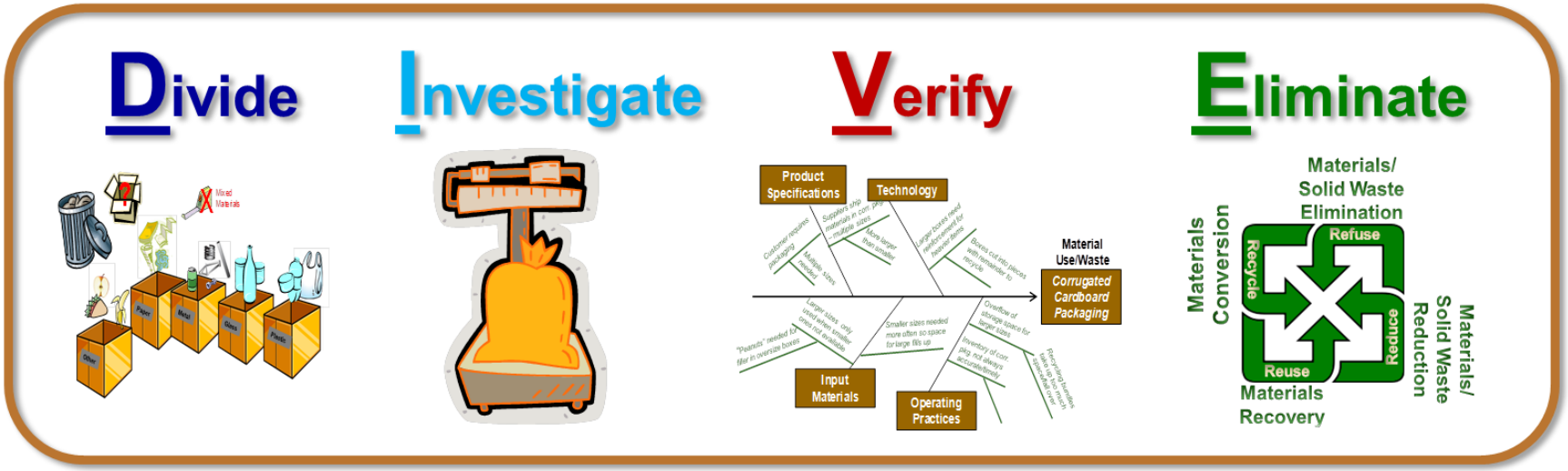
Green Manufacturing System



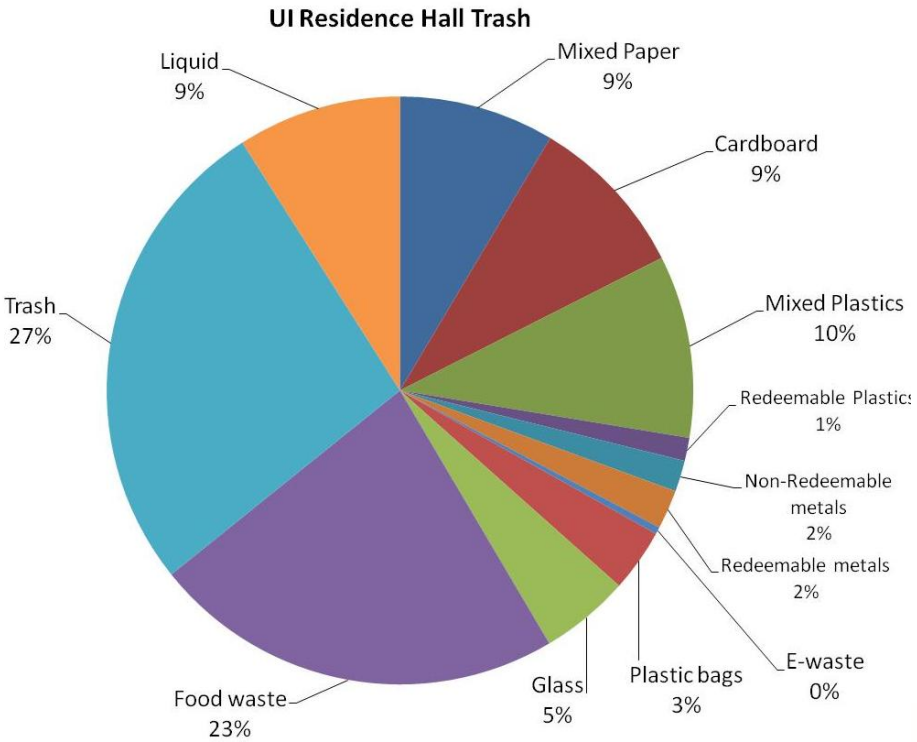
“Green 101” Course (CIRAS)

- Learn green concepts, key environmental issues, and the components of sustainability in a one-day workshop.
  - What is "green"?
  - W.A.S.T.E Tools
  - Sustainability and global conditions
  - Environmental business management
  - Implementation action plan

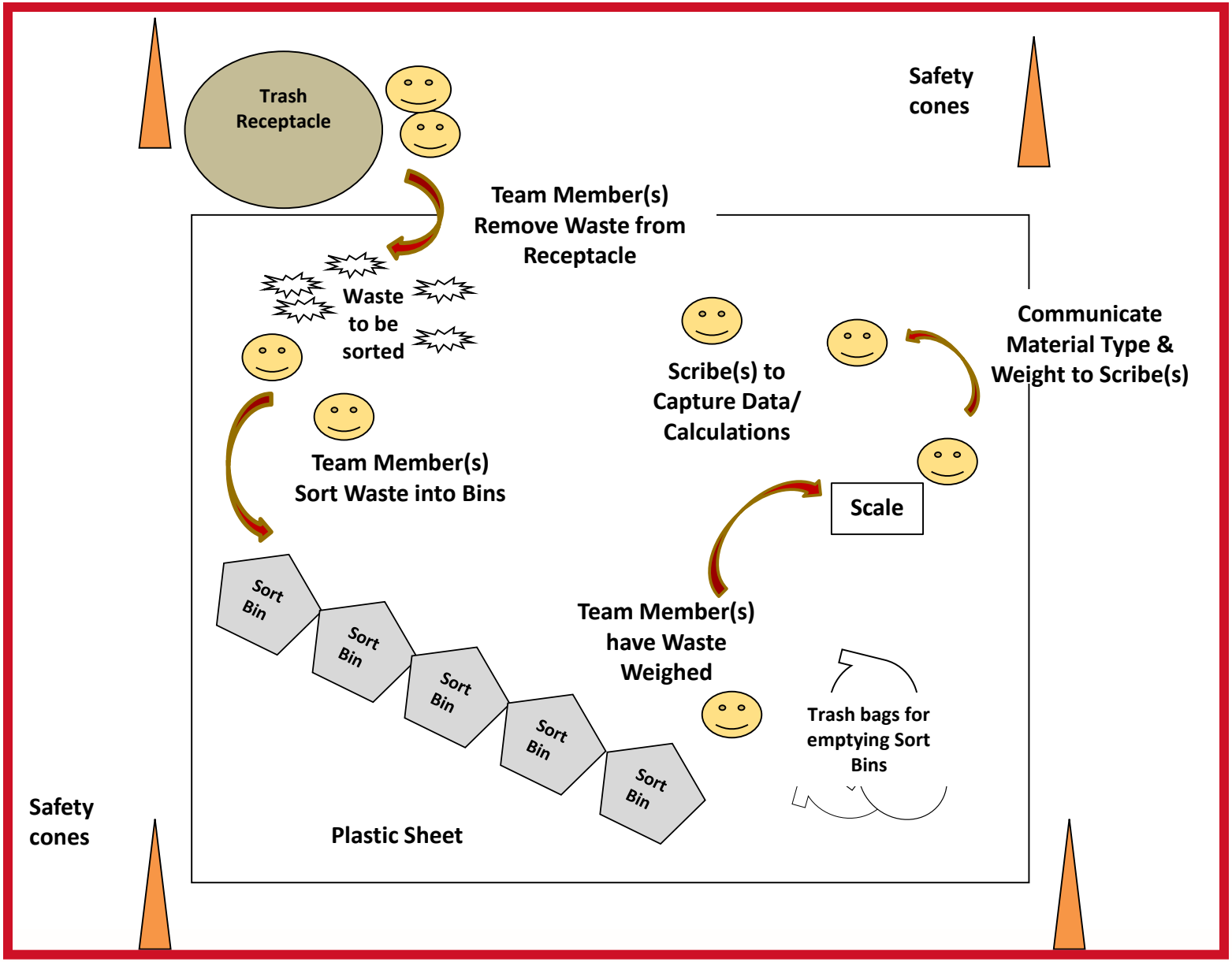
Dumpster Dive



- Solid waste is very easy first step in green
- Aligns well with existing lean efforts
- Cost of waste is 5-20 times the cost to throw it away



Courtesy of Univ of Iowa Office of Sustainability and ECO Hawk



Resources

- Iowa State University - Center for Industrial Research and Service (CIRAS)
  - http://www.ciras.iastate.edu
- Engineering US Environmental Protection Agency (EPA)
  - "Lean and Energy Toolkit"
    - http://www.epa.gov/lean/environment/toolkits/energy/index.htm
  - "Lean and Environment Toolkit"
    - http://www.epa.gov/lean/environment/toolkits/index.htm
  - "The Environmental Professional's Guide to Lean & Six Sigma"
    - http://www.epa.gov/lean/environment/toolkits/professional/resources/Enviro-Prof-Guide-Six-Sigma.pdf
  - Green Supplier Network
    - http://www.greensuppliers.gov/tech/tools.html?id=lean_clean
- IBM "Green Sigma"
  - http://www.ibm.com/green
- Zero Waste Network – Case Studies
  - http://zerowastenetwork.org/success/index.cfm?regionalcenter=
- GE "Ecomagination"
  - http://www.ecomagination.com
- UTC Energy Management Guidebook
  - http://www.utc.com/StaticFiles/UTC/StaticFiles/utc_energy_management_guidebook.pdf
- Purdue/SME Green Manufacturing
  - http://www.greenmanufacturing.purdue.edu

Green Manufacturing Simulations

- Lean & Green Micro Wind Turbine Manufacturer: Before
- Dumpster Dive: Furniture Manufacturer
- Lean & Green Micro Wind Turbine Manufacturer: After

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