

# Lean Six Sigma and the Environment

Taking process improvement to the next level

# Topics

- What is Sustainability?
- Why companies are becoming more sustainable
- Why “Green” needs to be added
- Integrating “green” into Lean Six Sigma activities
- Resources and Next Steps
- Summary

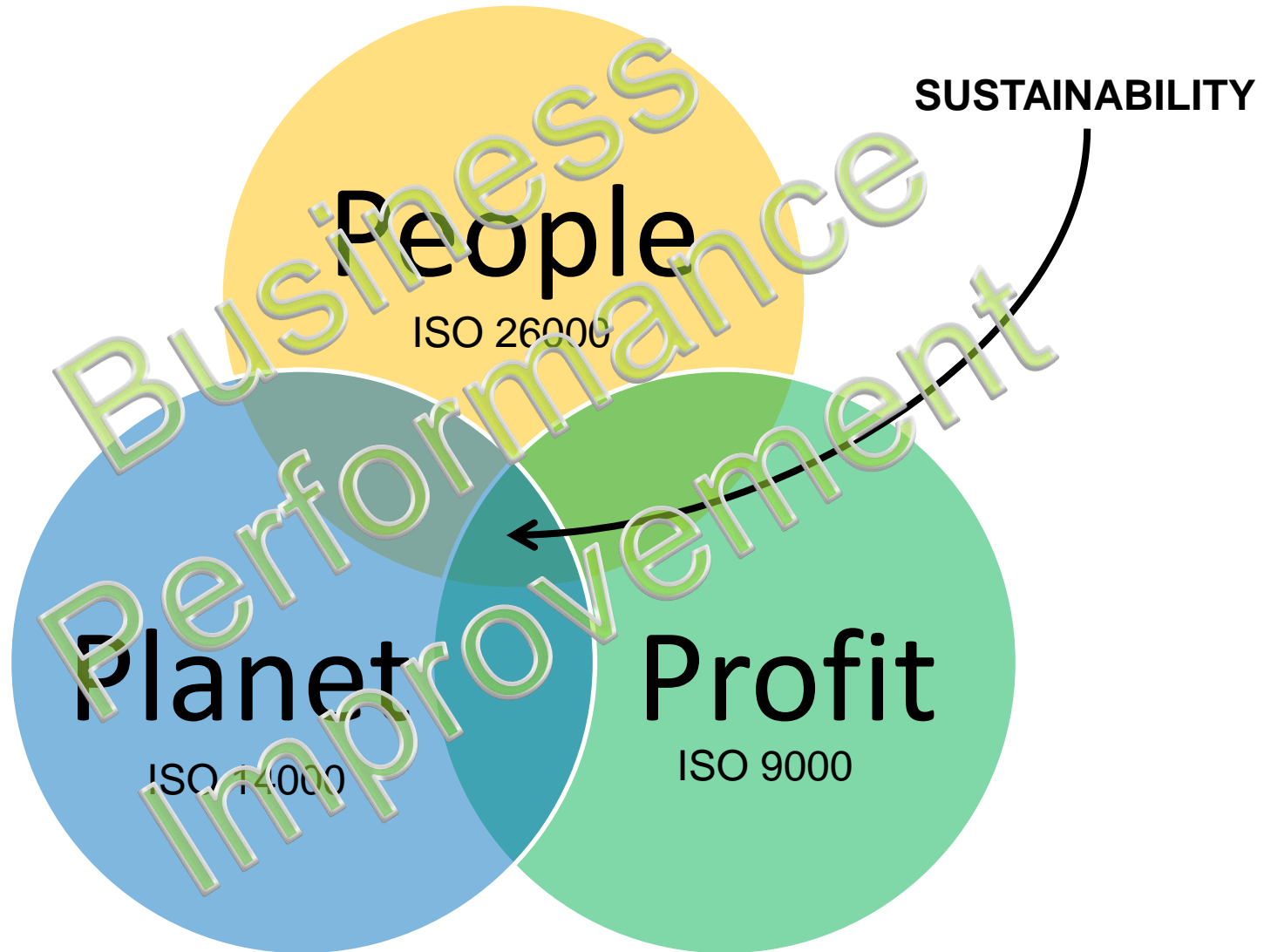
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# What is Sustainability?

- Meeting the needs of the present without compromising the ability of future generations (7 generations) to meet their own needs
  - Many different definitions!
- Companies cannot be successful in long term if they only focus on economic (profit)
  - Must look at environment and social issues



# Triple Bottom Line (3 P's)



# Good for Profits

- If a company or organization goes out of business, they are not sustainable
- Other traits include:
  - Transparency and Disclosure
  - Stakeholder engagement



# Good for People

- Fair working wage
- Safe work conditions
- Anti-discrimination
- Gender pay equality
- Diversity
- Volunteering
- Charitable Giving
- Community leadership



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# Good for the Planet

- Energy from renewable resources
- Made from materials found in nature
- Reduced or no toxins, chemicals, pollutants
- A technology, product or service that saves energy, water or natural resources, or is harvested in a sustainable way over the long term
- Designed to mimic nature
- Recyclable or biodegradable



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# Triple Bottom Line

- Can no longer make decisions based upon economics (cost / price) alone
  - Need to consider social and environment, but difficult to measure
- Example: Shoes
  - Economic – price of shoes
  - Social – labor practices of company
  - Environment – materials used, shipping distance, packaging, recycling options
- What else can you think of?

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# Triple Bottom Line

- Example: Food

- Economic – price listed on the item or the shelf
- Social – nutritional value, calories/fat, cruelty-free, Fair Trade
- Environment – Not quantitative, most only use words (organic, natural, GMO-free, no additives/coloring)

## ECONOMIC



## SOCIAL



## ENVIRONMENT



Carbon Reduction Label courtesy of [Carbon Trust](#)

# Bank Account Review

- If someone in the class looked at your bank account transactions, does it accurately reflect you?
  - Where do you spend your money? McDonald's? Wal-Mart? Home Depot? BP Gas Station?
- Do these businesses align with your values?
  - If not, make different buying decisions today!

**Every dollar you spend is a vote for that company or service**

# What will it look like in the future?

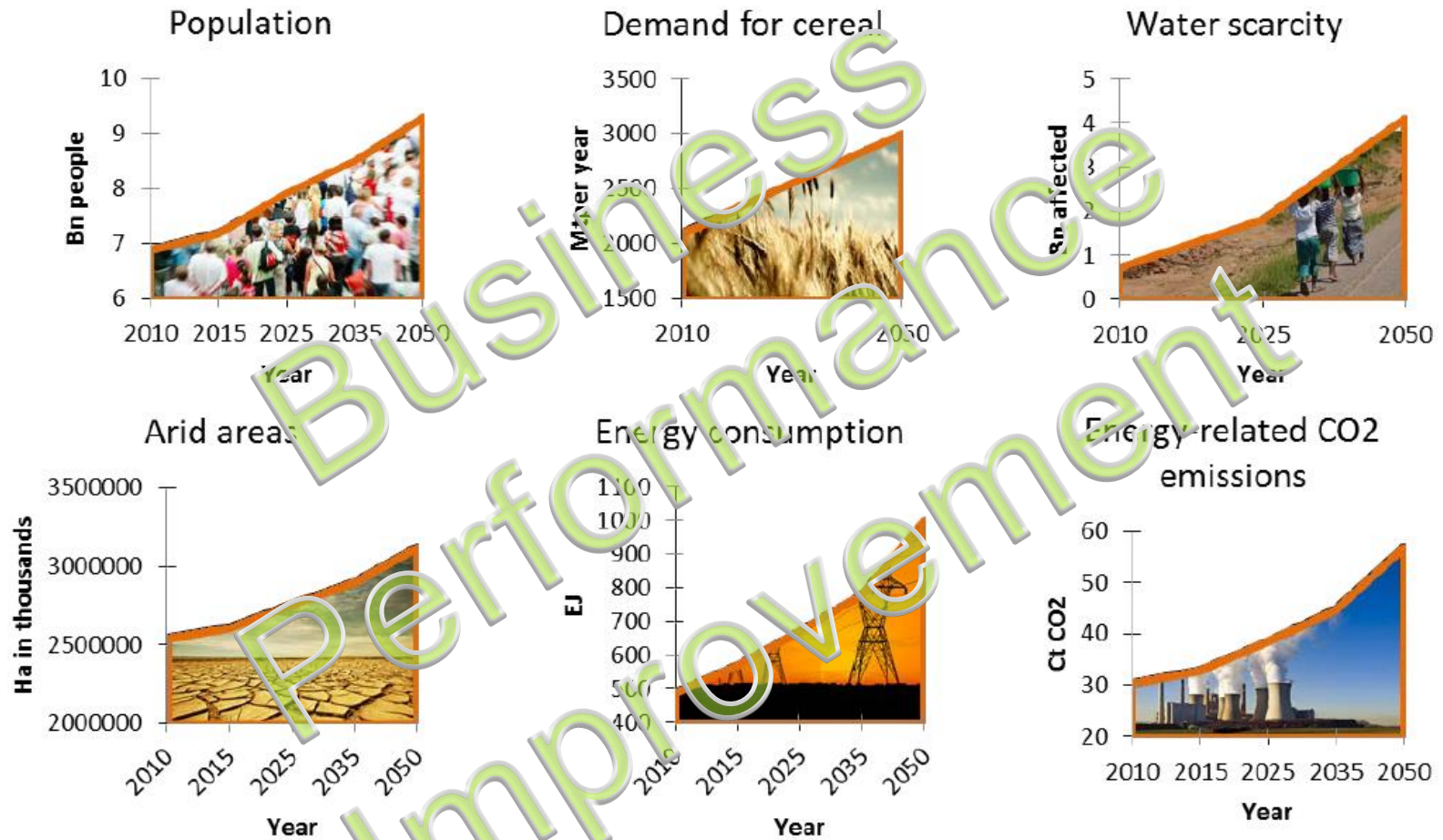
- Consumers will consider these criteria instead of comparing only by price:
  - **Airline tickets:** Aircraft fuel efficiency, total trip distance, organic food options, low VOC seat fabric
  - **House:** Walkability, proximity to public transportation, land use, annual utility costs
  - **Bread:** Local supplier, no preservatives, no bleach, minimal packaging
  - **Cell Phone:** Take back program, lead free, recycled content, compostable packaging
- Consider the long term costs over 5-10-20 years

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Why companies are becoming  
more sustainable

Business  
Performance  
Improvement

# This is not sustainable



**How will your company be affected by these issues?**

Jonas M. Helseth, Bellona Europa, 6/21/12, Energy Efficiency in Industrial Processes conference, Brussels

<http://www.ee-ip.org/index.php?p=eusew12>

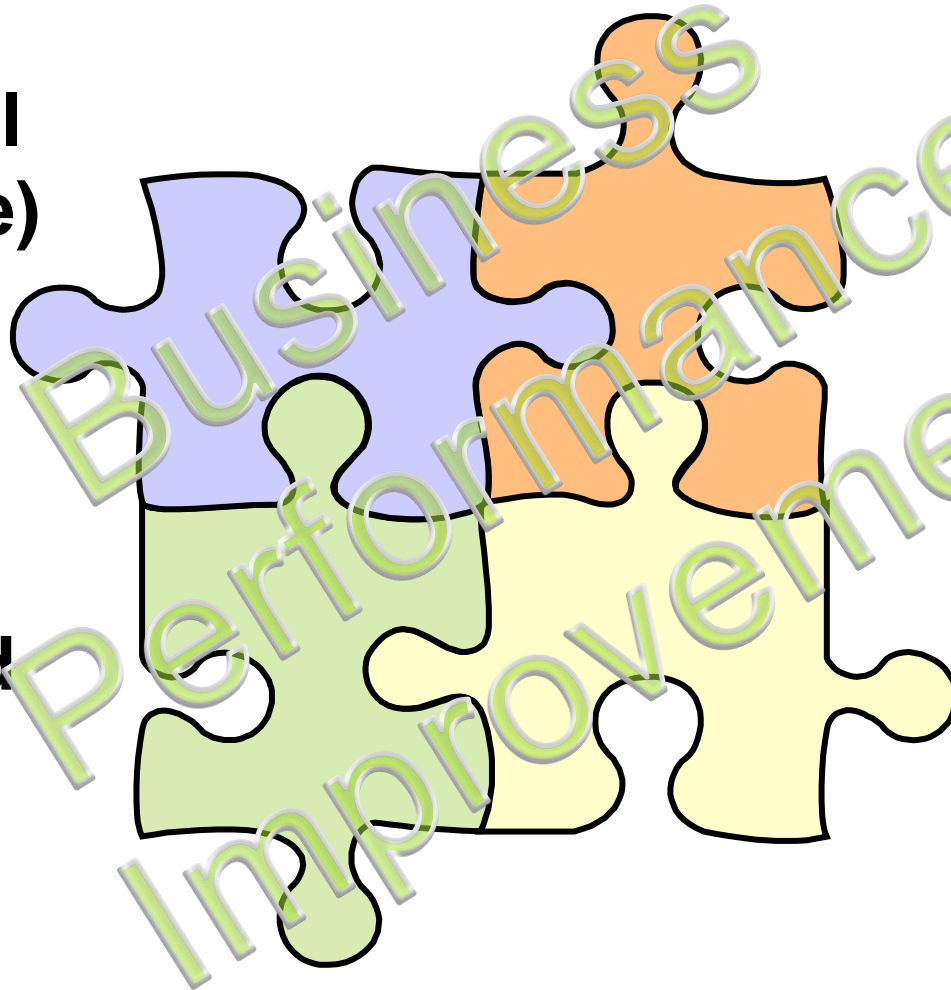
# Why are companies “going green”?

**Financial  
(Revenue)**

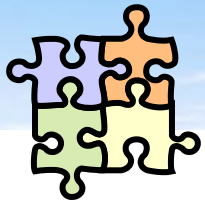
**Employees**

**Risk and  
Legal**

**Customers  
(Sales)**



# Financial reasons for “going green”



- Reduced energy, waste and materials (reduced costs)
- Decision making focused on lifecycle costs
- Drives long term strategic planning
- Incentives and rebates



# Financial reasons for sustainability

- 7 areas of financial benefit for companies

1. Increased revenue

2. Reduced energy expenses

3. Reduced waste expenses

4. Reduced materials and water expenses

5. Increased employee productivity

6. Reduced employee attrition expenses

7. Avoided risk to profit

From Bob Willard <http://www.sustainabilityadvantage.com>

# Business Case Simulator

**Step 1. Enter Your Company's Financial Data**

CHOOSE SAMPLE COMPANY ▼

Simulated Company Data Profile	Annual Amount
Revenue ?	4500000000
Energy expenses ?	200000000
Materials and water expenses ?	
Total salary / payroll expenses ?	
Profit ?	
Average salary, including benefits ?	
Number of employees ?	

1. Enter Company Data

2. Modify Assumptions

**Step 2. Estimate Potential Improvements**

BENEFIT AREAS	% Change
1. Increased revenue	9%
% additional revenue from a more sustainable brand	
0	20
% new revenue from new green products	
	5%
% new revenue from services and leasing	
2. Reduced energy expenses	
3. Reduced waste expenses	
4. Reduced materials and water expense	
5. Increased employee productivity	
6. Reduced employee attrition expenses	
7. Avoided risks to profit	

3. Estimate Benefits

**Step 3. Watch the Profits Improve**

BENEFIT AREAS	Annual Benefit	Profit Increase
1. Increased revenue	\$405,000,000	\$108,000,000
2. Reduced energy expenses	\$15,000,000	\$15,000,000
3. Reduced waste expenses	\$40,000,000	\$40,000,000
4. Reduced materials and water expenses	\$28,000,000	\$28,000,000
5. Increased employee productivity	\$18,000,000	\$18,000,000
6. Reduced employee attrition expenses	\$15,600,000	\$15,600,000
7. Avoided risk to profit	-36%	\$432,000,000
Potential profit improvement	18%	\$224,600,000
Sustainability Capital Reserve, for more projects		\$68,000,000

From Bob Willard <http://www.sustainabilityadvantage.com>

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# Why Finance often overlooks “green”

- “Cost of doing business,” not viewed as opportunity
- Costs and impacts can be blanketed across many areas, hard to isolate data to biggest users
- Environmental and human health risks are often not explicitly considered in business decisions
  - Externality cost
- Side benefits of sustainability efforts not anticipated or factored in
  - Take-back, talent acquisition, employee engagement

# What do manufacturers think?

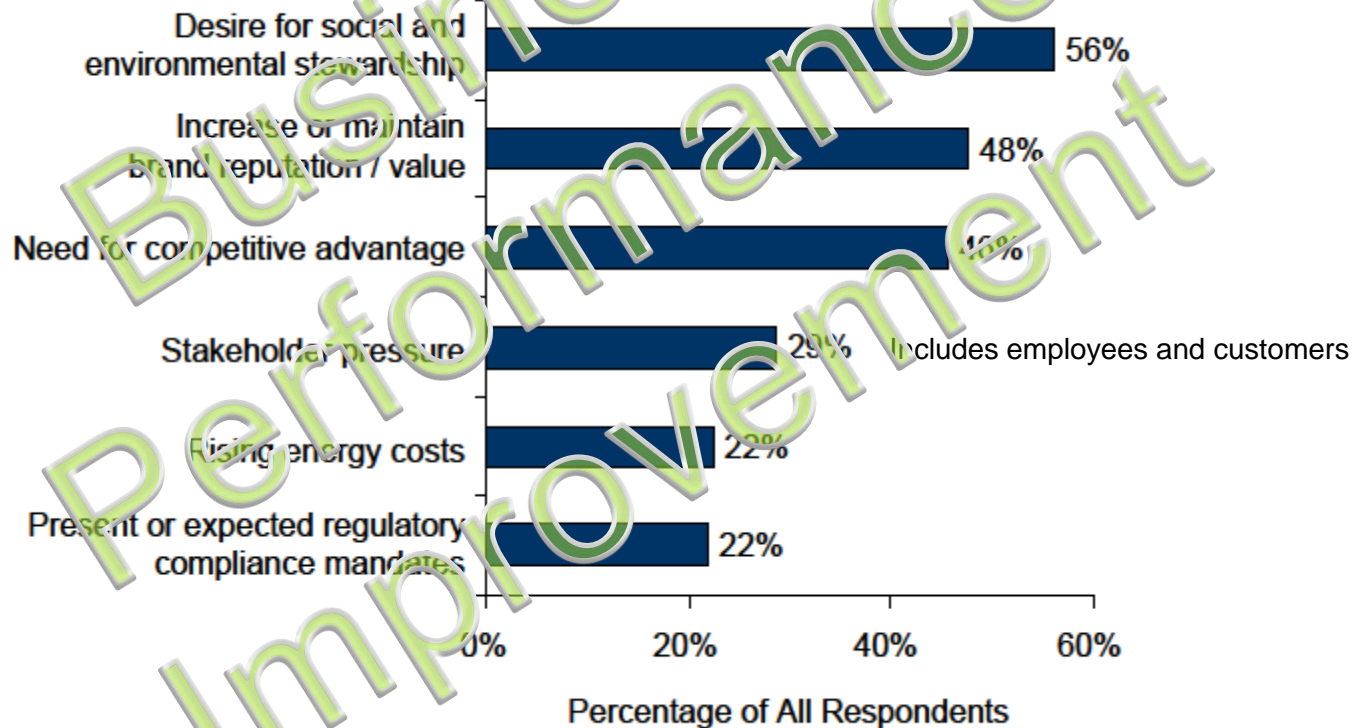
- 81% of manufacturers say sustainability is essential to the success of their business
- 89% say operational sustainability is essential to the success of their business
- 60% still agree that the environment can be profitable
- 67% of manufacturers say they “strongly agree” the environment is becoming more important to consumers
- 53% say consumers are demanding more eco-friendly products that cost the same as their traditional counterparts

UL's 2012 annual global study

<http://www.environmentalleader.com/2012/12/12/over-80-of-manufacturers-call-sustainability-key/>

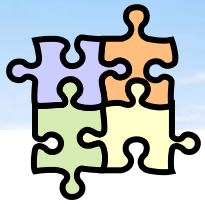
# Pressures driving sustainability

Figure 1: Top 3 Pressures Driving Sustainability Initiatives



Source: Aberdeen Group, May 2009

# Risk reasons for “going green”



- Regulatory compliance (proactive and reactive)
  - Fines and penalties
  - Extended producer responsibility (EPR)
    - “Cradle to Cradle,” not “Cradle to Grave”
  - Permits, Approvals, and Certifications



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# Risk and Legal

- Reduce future risks to revenue and expenses
  - Unknown future externality costs (i.e. carbon tax)
  - Increasing energy and utility costs
  - Fines and penalties
  - Bad publicity, protests and impact to reputation
  - Climate change impact to communities



# Price of Externalities

Total Environmental Costs as Percentage of Net Income



If companies had to pay the full cost of their environmental impacts, it would cut profits by ~40 - 50 percent

- These environmental costs (externalities) are being tied back to the contributors (businesses)

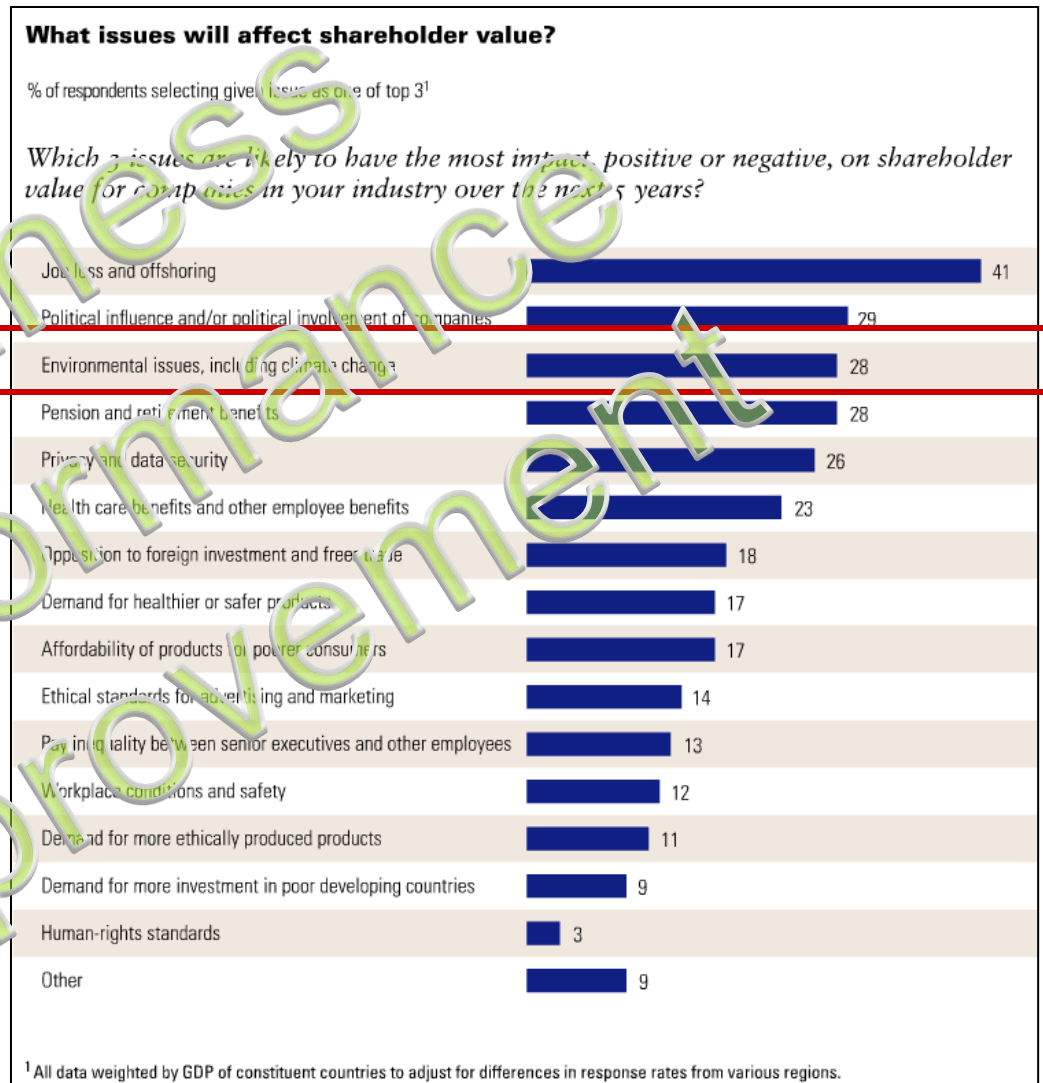
# Earth's Free Ecosystem Services

- Nutrient dispersal and cycling
- Seed dispersal
- Food (including seafood and game), crops, wild foods, and spices
- Water
- Minerals (including diatomite)
- Pharmaceuticals, biochemicals, and industrial products
- Energy (hydropower, biomass fuels)
- Carbon sequestration and climate regulation
- Waste decomposition and detoxification
- Purification of water and air
- Crop pollination
- Pest and disease control
- Cultural, intellectual and spiritual inspiration
- Recreational experiences (including ecotourism)
- And more...

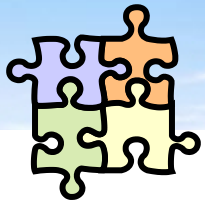
**If we don't protect these services, we will have to spend money to re-engineer them**

# Impact on Shareholder Value

- “Environmental issues, including climate change” is 3rd on the list of top executive concerns



# Employee reasons for “going green”



- More motivated, engaged and inspired workforce
  - Higher productivity and conservation mindset
  - Want to help company save money, motivate co-workers
- Retention and acquisition of employees
  - Reduced costs for advertising, interviewing and hiring new people, productivity lost during transition, loss of knowledge



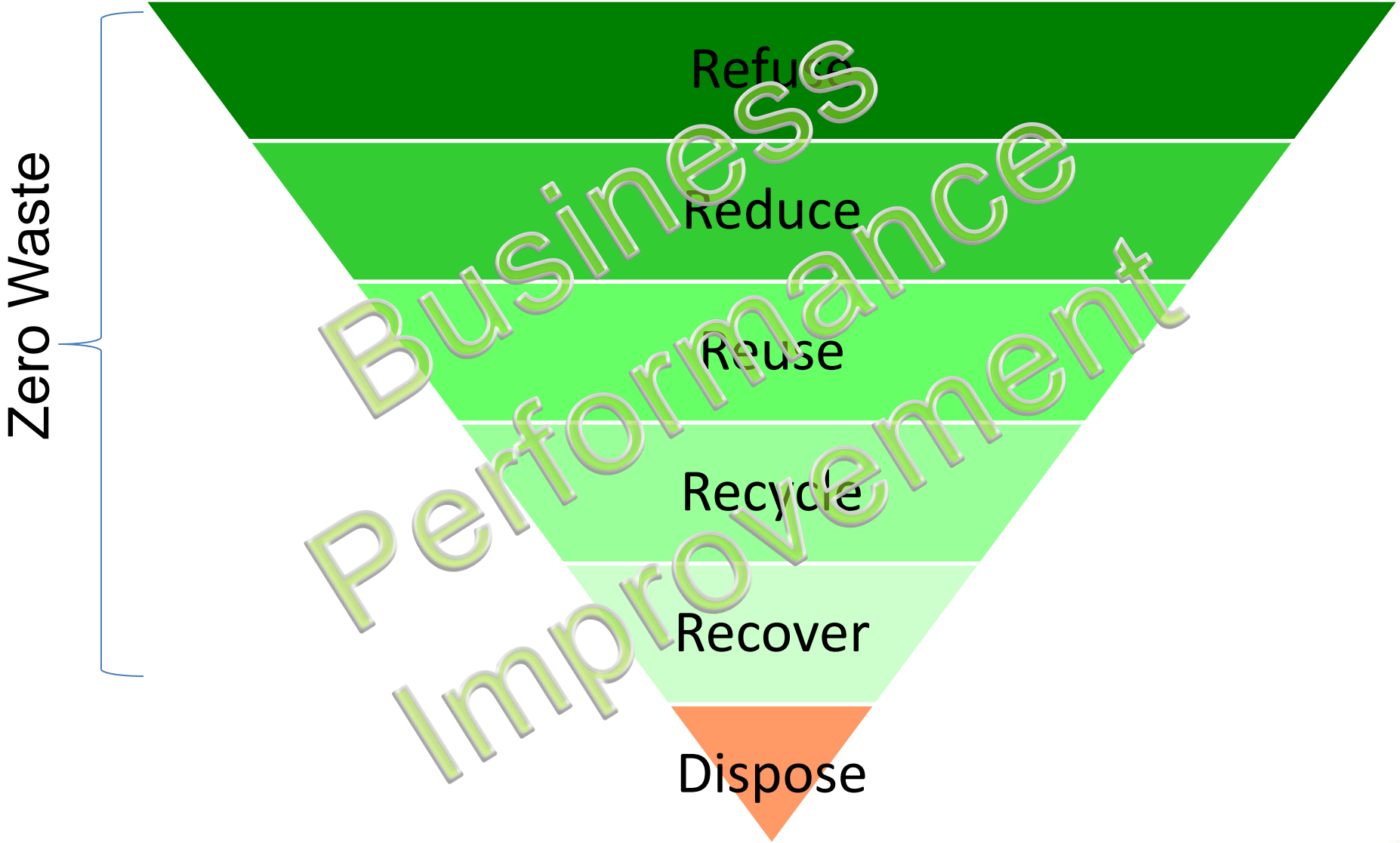
Content from Bob Willard  
<http://www.sustainabilityadvantage.com>

# Employee Mindset Change

- Recycling programs are common across companies, but vary greatly in scope and support
  - Composting food, e-waste, office supplies, etc
- Recycling is just the starting point, not the end goal
  - Need to drive towards no generation of waste!



# Waste Pyramid



# Example #1: Plastic Soda Bottle

- **Need:** Water to drink
- **Refuse** – Drink from drinking fountain
- **Reduce** – Select smaller bottle or bottle with less packaging or materials
- **Reuse** – Fill up the bottle from fountain next time
- **Recycle** – Recycle bottle in recycling bin
- **Recover** – Burn bottle to generate heat
- **Dispose** – Throw bottle into landfill



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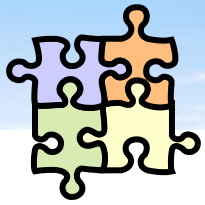


# Example #3: Light Bulbs

- **Need:** Need to complete task in low-light area
- **Refuse** – Don't turn on light, move work closer to natural light
- **Reduce** – Put only half the number of bulbs in fixture, or use a dimmer
- **Reuse** – Use light bulbs for art
- **Recycle** – Put bulbs in recycling bin
- **Recover** – Burns bulbs to generate heat
- **Dispose** – Throw bulbs into landfill



# Customer reasons for “going green”



- Opening up new markets
- More loyal customers
- Product differentiation and innovation
- Managing competitors and industry perceptions
- Customer or stakeholder request



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# Example: Take-back programs

## EXPECTED BENEFITS

- Landfill avoidance (Legal)
- Value in selling recycled material for scrap (Revenue)
- Improved environmental perception of customers and community (Goodwill)

## SIDE BENEFITS

- interaction, feedback and idea generation with customers (Innovation)
  - Builds brand loyalty
- Evaluation of how customers use products (Innovation)
- Opportunity to sell or discount them on newer products (Sales)



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# Biomimicry

- The imitation of the models, systems, and elements of nature for the purpose of solving complex problems
- Key aspect of Production Preparation Process (3P) which focuses on eliminating waste through product and process design development process



Velcro tape mimics biological examples of multiply hooked structures such as burs.

# “Greenwashing”

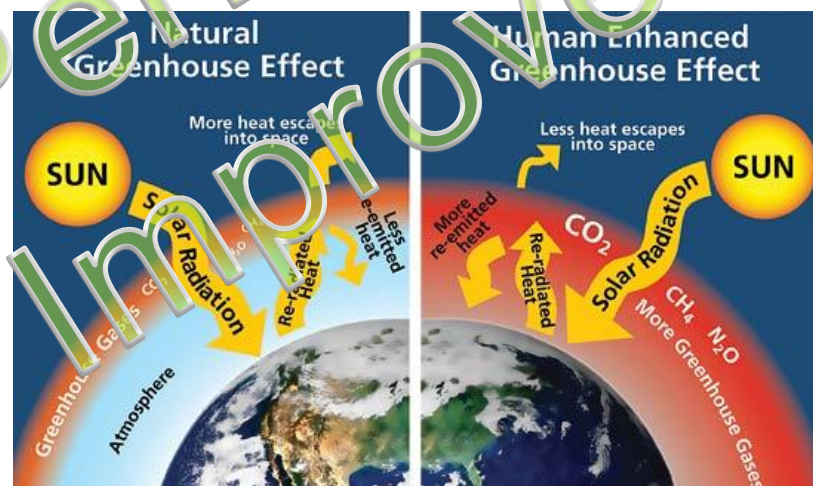
- Act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product or service
- Companies must avoid the 7 deadly sins:
  - Sin of Hidden Trade-off
  - **Sin of No Proof**
  - **Sin of Vagueness**
  - Sin of Worshiping False Labels
  - Sin of Irrelevance
  - Sin of Lesser of Two Evils
  - Sin of Fibbing
- Over 95% of “green” products evaluated had at least one of the sins



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# What is Carbon Footprint?

- A calculation of the effect human activities have on the climate in terms of the total amount of greenhouse gases produced (measured in units of carbon dioxide or CO<sub>2</sub>)
- Greenhouse gases (GHG) trap heat in the atmosphere, leading to climate change



Business Performance Improvement

# Carbon Footprint

- The amount of fossil carbon consumed by a group, area, business or individual, converted to metric tons of CO<sub>2</sub>
  - Metric tons of carbon dioxide equivalent
  - MTCE or CO<sub>2</sub>e
- Relates to amount of energy invested into products and services
- Companies calculate it to provide a summary metric of their impact on climate change
  - **Can identify priority for Lean Six Sigma efforts**

# Why are companies reporting?

- Objective assessment for measuring progress
- Prioritize opportunities
- Increased transparency
- Risk mitigation
- Benchmarking
- **Customers, investors or stakeholders asked them to report!**



Image courtesy of  
[Comply Direct](#)

# Why are companies “going green”?

## Financial

- Reduced energy, waste and materials (reduced costs)
- Decision making focused on lifecycle costs
- Drives long term strategic planning
- Incentives and rebates

## Risks and Legal

- Regulatory compliance (proactive and reactive)
- Reduce future risks to revenue and expenses

## Employees

- More motivated, engaged and inspired workforce
- Retention and acquisition of employees

## Customers and Sales

- Opening up new markets
- More loyal customers
- Product differentiation and innovation
- Managing competitors and industry perceptions
- Customer or stakeholder request

These were not the original intent, side benefit of green efforts

Why “Green” needs to be added  
to your Lean Six Sigma program

Business  
Performance  
Improvement

# Improvement initiatives

- Most companies and organizations have an improvement initiative to help the company improve
  - Save money by eliminating waste and inefficiencies
  - Add value through better align with their customers
- Goes by many names: **Lean Six Sigma**, Lean, Six Sigma, Total Quality Management, Toyota Production System, Continuous Improvement, Business Excellence, etc
- **Don't have one?** Put one in place first!

# Lean and Six Sigma

Characteristics of Lean and Six Sigma (Box 1.3)	
Lean	Six Sigma
<ul style="list-style-type: none"> <li>✓ Focuses on maximizing product flow and velocity</li> <li>✓ Provides tools for analyzing process flow and delays at each process step</li> <li>✓ Centers on the separation of “value-added” from “non-value added” work with tools to eliminate root causes of non-value added activities</li> <li>✓ Provides a means for quantifying and eliminating the cost of complexity</li> </ul>	<ul style="list-style-type: none"> <li>✓ Emphasizes the need to recognize opportunities and eliminate defects</li> <li>✓ Recognizes that variation hinders the ability to reliably deliver high-quality services</li> <li>✓ Requires data-driven decisions and incorporates a comprehensive set of quality tools under a systematic framework for problem solving</li> <li>✓ Provides a highly prescriptive cultural infrastructure effective in obtaining sustainable results</li> </ul>

Source: Michael George, *Lean Six Sigma for Service: How to Use Lean Speed & Six Sigma Quality to Improve Services and Transactions*, (New York: McGraw Hill, 2003).

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

We'll refer to **Lean Six Sigma** going forward (blended approach)

# Lean naturally helps the environment!

Lean Tools



Green Benefits

Green Tools



Lean Benefits

Helping the environment should closely align with business needs, otherwise it will appear disconnected to employees

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# Environmental Impact of Waste

Waste Type	Environmental Impacts
Overproduction	<ul style="list-style-type: none"> <li>• More raw materials consumed in making the unnecessary products</li> <li>• <b>Extra products may spoil or become obsolete requiring disposal</b></li> <li>• Extra hazardous materials used result in extra emissions, waste disposal, worker exposure, etc.</li> </ul>
Inventory	<ul style="list-style-type: none"> <li>• More packaging to store work-in-process</li> <li>• Waste from deterioration or damage to stored WIP</li> <li>• More materials needed to replace damaged WIP</li> <li>• <b>More energy used to heat, cool, and light inventory space</b></li> </ul>
Transportation and Excessive Motion	<ul style="list-style-type: none"> <li>• More energy use for transport</li> <li>• Emissions from transport</li> <li>• More space required for WIP movement, increasing lighting, heating, and cooling demand and energy consumption</li> <li>• <b>More packaging required to protect components during movement</b></li> <li>• Damage and spills during transport</li> <li>• Transportation of hazardous materials requires special shipping and packaging to prevent risk during accidents</li> </ul>
Defects	<ul style="list-style-type: none"> <li>• Raw materials consumed in making defective products</li> <li>• <b>Defective components require recycling or disposal</b></li> <li>• More space required for rework and repair, increasing energy use for heating, cooling, and lighting</li> </ul>
Over Processing	<ul style="list-style-type: none"> <li>• More parts and raw materials consumed per unit of production</li> <li>• Unnecessary processing increases wastes, energy use, and emissions</li> </ul>
Waiting	<ul style="list-style-type: none"> <li>• <b>Potential material spoilage or component damage causing waste</b></li> <li>• Wasted energy from heating, cooling, and lighting during production downtime</li> </ul>

# Why Lean Six Sigma overlooks it

- Improvement opportunities may be found outside of normal working operations or hidden from view
- Many more stakeholders involved which requires more facilitation and communication
  - Community, regulatory, non profit organizations, activists, etc
- Not easy to capture data in events, and appears small at process level
- Full cost impact of environmental issues not calculated
- Environmental data differs than most industries, requires nonparametric and non-detect analysis skills
- Utilities and materials can be considered both value added and non-value added, which can be confusing

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# Go and See

- In order to truly solve problems, you must go to where the problem is, and investigate with your own eyes and talk to the people who do the actual work.
- Also called “Gemba Walk”
  - Gemba – Where the work is being done



Image courtesy of Lean.org

# Go and See

- Can be formal process or informal
- Requires ability to ask good questions, not leading the worker tell you what you want to hear
- Shows respect for worker, empowers them to solve problems on their own in the future



Business Performance Improvement

# Go and See Events

- Formal events can help align departments come together and collect data to help with an environmental issue
  - **Energy** – Look around building at different times of day for opportunities (lights on, equipment running, excess heating/cooling)
  - **Waste** – Collect and sort trash to determine what is being thrown out (recycling, compost, hazardous materials)
  - **Water** – Walk the flow of water pipes in and out of the facility to identify opportunities (leaks, condensation, and wear)

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# Who would be interested?

## Internal

- Owners/investors
- Executive Board
- Management
- Employees

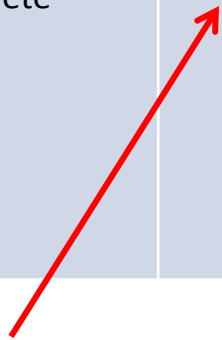
## External

- Customers
- Suppliers
- Industry Groups
- Public and community
- Government agencies
- Environmental groups
- Competitors
- Media Outlets
- Friends/family of employees
- Future employees

Business Performance Improvement

# SIPOC – Community Recycling

Supplier	Inputs	Process	Outputs	Customer
Grocery store	Food and drinks	Purchase Items	Trash	Landfill
Department store	Gifts	Remove from packaging	Recycled Materials	Residents
Farmer's Market	Household items	Sort out waste into bins	Compost Dirt	Community
Gas station	Tools		Greenhouse Gas Emissions	<b>Earth / Environment</b>
Department store	City website	Bins collected	Lechete	
Restaurant		Contents dropped off to correct location		
City Officials				



**Make sure Earth is included as a Customer!**

# Why costs are overlooked

## Product A VSM

Electricity = \$800 per year  
Landfill Charge = \$200 per year  
Hazardous Waste = \$200 per year

## Product B VSM

Electricity = \$1000 per year  
Landfill Charge = \$150 per year  
Hazardous Waste = \$50 per year

## Product C VSM

Electricity = \$600 per year  
Landfill Charge = \$300 per year  
Hazardous Waste = \$1000 per year

## Product Z VSM

Electricity = \$2000 per year  
Landfill Charge = \$50 per year  
Hazardous Waste = \$100 per year

Individual VSMS overlook these costs compared to much larger financial numbers (inventory, labor and material, space, etc)

**Same costs totaled across all 50 products**

Electricity =	<b>\$50,000</b>
Landfill =	<b>\$15,000</b>
Hazardous Waste =	<b>\$20,000</b>

Business Performance Improvement

# 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 labor time**

**+ waste treatment/handling**

**+ disposal costs**

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

# Problems with Environmental Data

- Aberrant values – ozone data
- Undetected – marked as zero or max/min value
- Large amounts of data – lack of purpose
- Large measurement errors – despite efforts
- Lurking variables – not identified
- Inconsistent variance – non-linearity
- Non-normal distributions – seldom Gaussian
- Serial correlation – lack of independence

From Statistics for Environmental Engineers, P. Berthouex, L. Brown

# Identifying value

## • Value added

- ✓ Electricity to automatically place parts on a board
- ✓ Water usage to clean the outside of product
- ✓ Electricity to create bid proposal
- ✓ Heat to keep employees comfortable
- ✓ Chemicals used that enhance the product functionality

**GREENER OPTIONS?**

## • Non-value added

- X Lighting for office area on overtime to fix a document that wasn't done right the first time
- X Air conditioner replacement due to neglect
- X Test equipment left on overnight when not being used
- X Overhead projectors left on in conference room
- X Hazardous chemicals spilled or expired due to neglect

**REMOVE!**

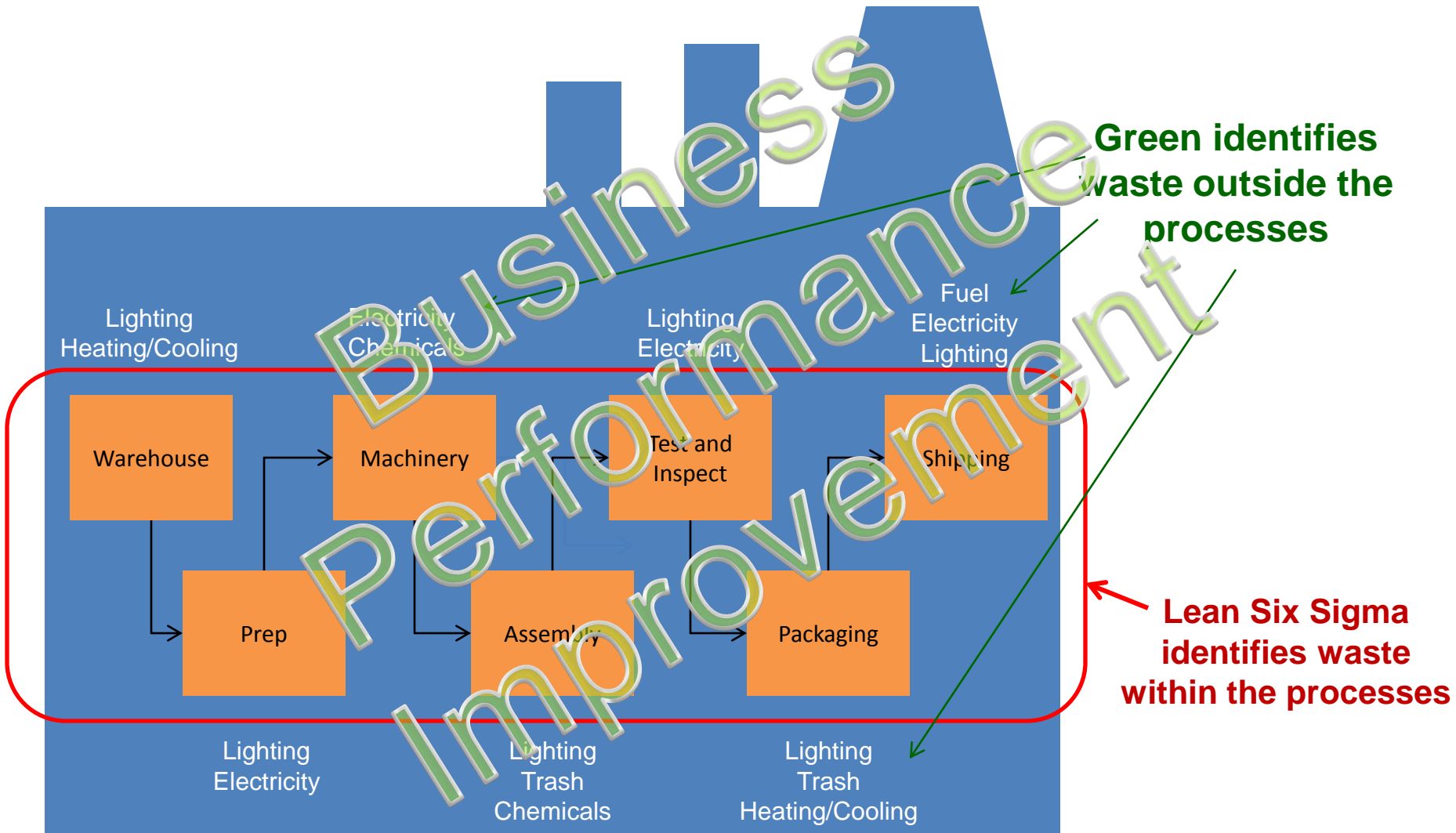
**The customer does not want to pay for non-value added waste!**

# Aligning “Green” into Lean Six Sigma

- Lean Six Sigma addresses the non-value added **within** the process
  - Focus on problems where the value item gets stuck, delayed or fixed
- Green addresses the non-value added **outside** the process, but integral to the process
  - Focus on overall impact of support functions of the process (electricity, lighting, waste disposal, heating/cooling, chemicals, water, etc)
  - Look at aggregate level, not individual process steps (may seem minor or insignificant)

Business Performance Improvement

# Lean Six Sigma and Green



# How to get started with Green

- Save money and reduce risk (without impacting business) by identifying these **W.A.S.T.E.** opportunities



Graphic courtesy Purdue Technical Assistance Program

# 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 Emissions

- ✓ What types and amounts of air emissions are generated by the process?
- ✓ How can you reduce the overall amount or toxicity of air emissions?
- ✓ How far did vehicles travel to deliver parts and supplies?
- ✓ Can you reduce the vehicle miles traveled and emissions from transportation?

## Solid Waste

- ✓ 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?
- ✓ Is there a local composting facility that the waste can be taken to?

\* Courtesy Purdue Technical Assistance Program

# Identify Wastes and Opportunities

## Toxicity (Chemicals/Hazardous)

- ✓ What types and quantities of chemicals/materials are used in the process?
- ✓ How can you reduce the overall amount of chemicals and materials used?
- ✓ Can you switch to less harmful chemicals?
- ✓ Can you eliminate any non-value added use of chemicals or materials from the product or process (excess packaging, unneeded painting, etc.)?
- ✓ What types and quantities of hazardous waste are generated by the process?
- ✓ How can you reduce the amount or toxicity of hazardous waste generated?
- ✓ Can you better isolate and separate hazardous wastes from other wastes?

## 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?

# 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 43,200 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 3 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>

# Suboptimization case study

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 re-packaged 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

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[http://asq.org/quality-progress/2010/03/lean/leaning-toward-green.html?WT.dcsvid=OTA2NDMxNDY0MgS2&WT.mc\\_id=EM118436](http://asq.org/quality-progress/2010/03/lean/leaning-toward-green.html?WT.dcsvid=OTA2NDMxNDY0MgS2&WT.mc_id=EM118436)



# More Case Studies

- Lockheed Martin
- Baxter Healthcare
- General Motors
- DTE Energy
- Del Monte Foods
- City of Irving, TX
- Blue Cross Blue Shield
- Many more...
- JEA Utilities
- Apollo Hardwoods
- Kirkland Air Force Base
- Columbia Paint
- Idaho DEQ
- Lasco Bathware
- Univ of North Carolina

Download over 20 case studies for free at:

<http://www.leansixsigmaenvironment.org/index.php/free-stuff/>

# Integrating “green” into Lean Six Sigma activities

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# Lean Six Sigma Tools

- The same tools and training applies to environmental “green” issues
- Some tools work better when modified
- Newer tools being developed to make wastes and problems easier to find

Tools provided in following slides not an exhaustive list...

# Event Checklist

- Useful when ES&H or Facilities personnel cannot attend event

Physical Environment			
<i>As a result of the Lean event, will there be</i>	Link	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			
<b>As a result of the Lean event, will there be:</b>	<b>Unk</b>	<b>Yes</b>	<b>No</b>
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			
<b>As a result of the Lean event, will there be:</b>	<b>Unk</b>	<b>Yes</b>	<b>No</b>
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?			

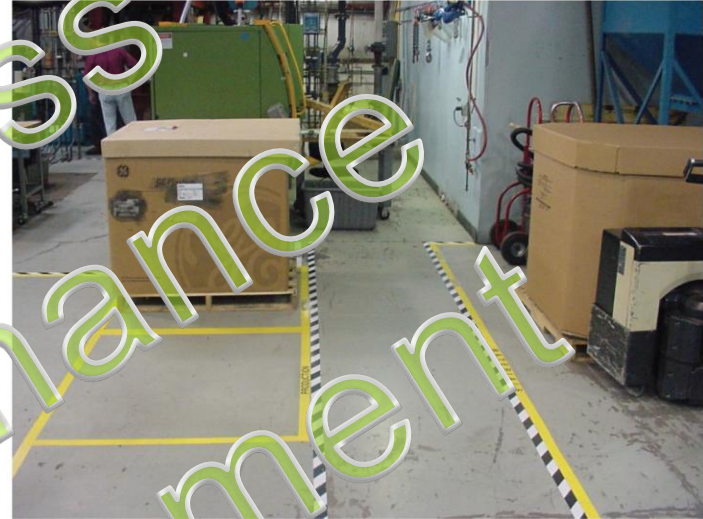
[http://gsn.nist.gov/tech/tools.html?id=lean\\_clean](http://gsn.nist.gov/tech/tools.html?id=lean_clean)

# 5S

**BEFORE**



**AFTER**



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**BEFORE**



**AFTER**

# Overall equipment effectiveness (OEE)

- **OEE = Availability x Performance x Quality**

- Availability = 86.7%

- Performance = 93.0%

- Quality = 95.0%

- **OEE = 86.7% x 93.0% x 95.0% = 76.6%**

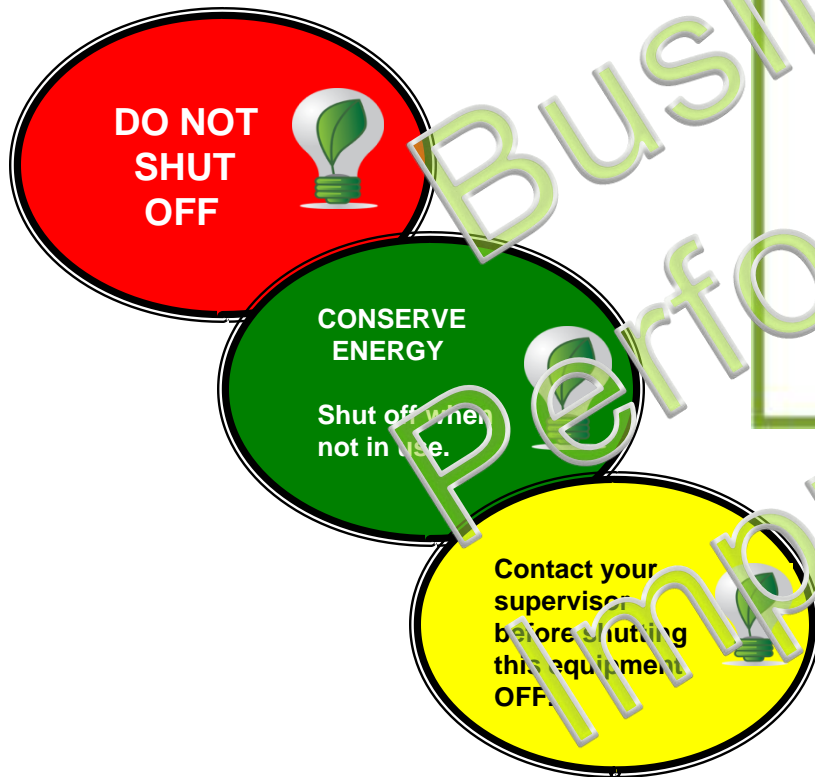
- Infor™ suggests adding **Energy Consumption** to OEE metric

- Measured against the best energy performance for that equipment

- As the equipment experiences issues, energy usage will increase, which will impact OEE



# Visual Controls



Initials: \_\_\_\_\_  
1564

**ENERGY SAVING OPPORTUNITY**  
1564

Checklist:

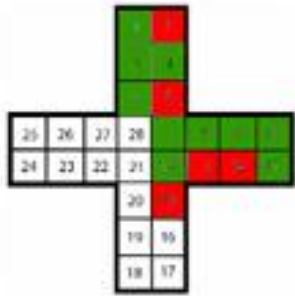
- Turn off or slow down when not in use
- Reduce friction (replace filter)
- Use energy efficient equipment
- Repair /calibrate equipment
- Adjust system balance and set points
- Use proper equip. (replace compressed air)
- Increase throughput / reduce downtime
- Reduce scrap, defects, handling
- Other

Use the back of the tag to explain the details of your energy saving idea

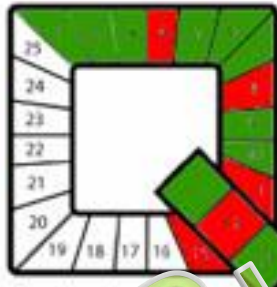
Name: \_\_\_\_\_  
Date: \_\_\_\_\_  
Tag location: \_\_\_\_\_

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# QDIP (SQDC) Board



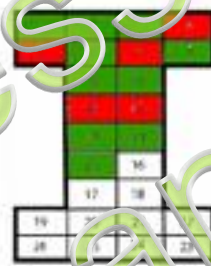
**SAFETY**



**QUALITY**



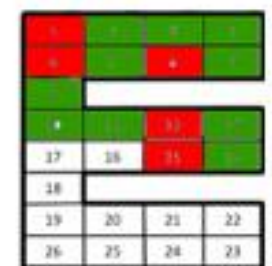
**DELIVERY**



**INVENTORY**



**PRODUCTIVITY**



**ENVIRONMENT**

Safety	Quality	Delivery	Inventory	Productivity	Environment
<ul style="list-style-type: none"> <li>•No missed days</li> <li>•No injuries</li> </ul>	<ul style="list-style-type: none"> <li>•Less than 5 defects per day</li> <li>•DPMO less than 50</li> <li>•Test Yield greater than 95%</li> </ul>	<ul style="list-style-type: none"> <li>•100% on-time to customers, schedule, next process, etc</li> <li>•Complete 10 units per day</li> </ul>	<ul style="list-style-type: none"> <li>•WIP less than 10 units</li> <li>•No more than 3 pieces at each station</li> <li>•WIP less than \$10,000</li> </ul>	<ul style="list-style-type: none"> <li>•\$/hr greater than \$150</li> <li>•Less than 10 minutes of downtime</li> <li>•Team met daily takt time goals</li> </ul>	<ul style="list-style-type: none"> <li>•All equipment shut off at end of shift</li> <li>•No recyclables in trash</li> <li>•100% Hazardous waste adherence</li> </ul>

# Traditional VSM with Water Data

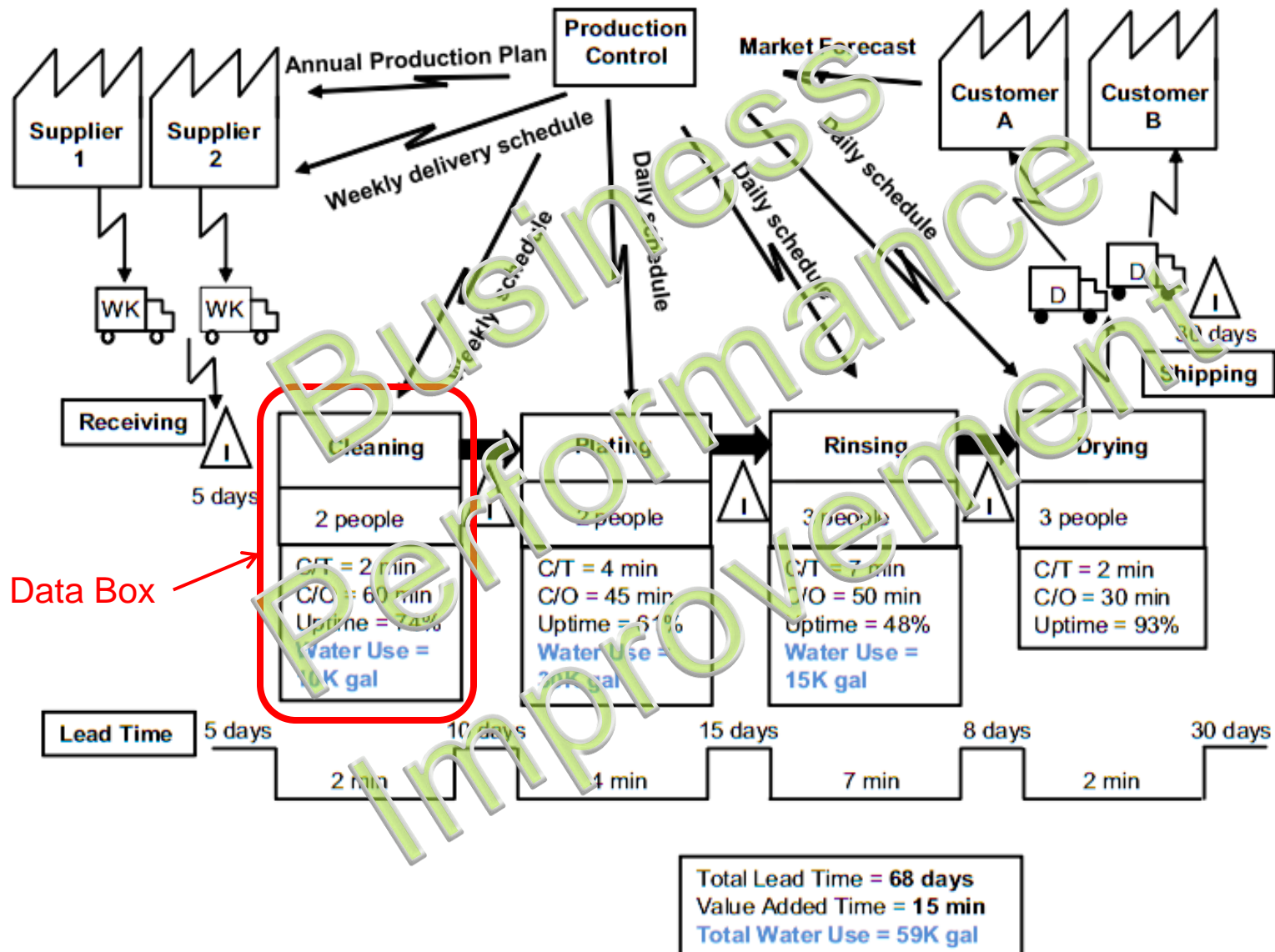
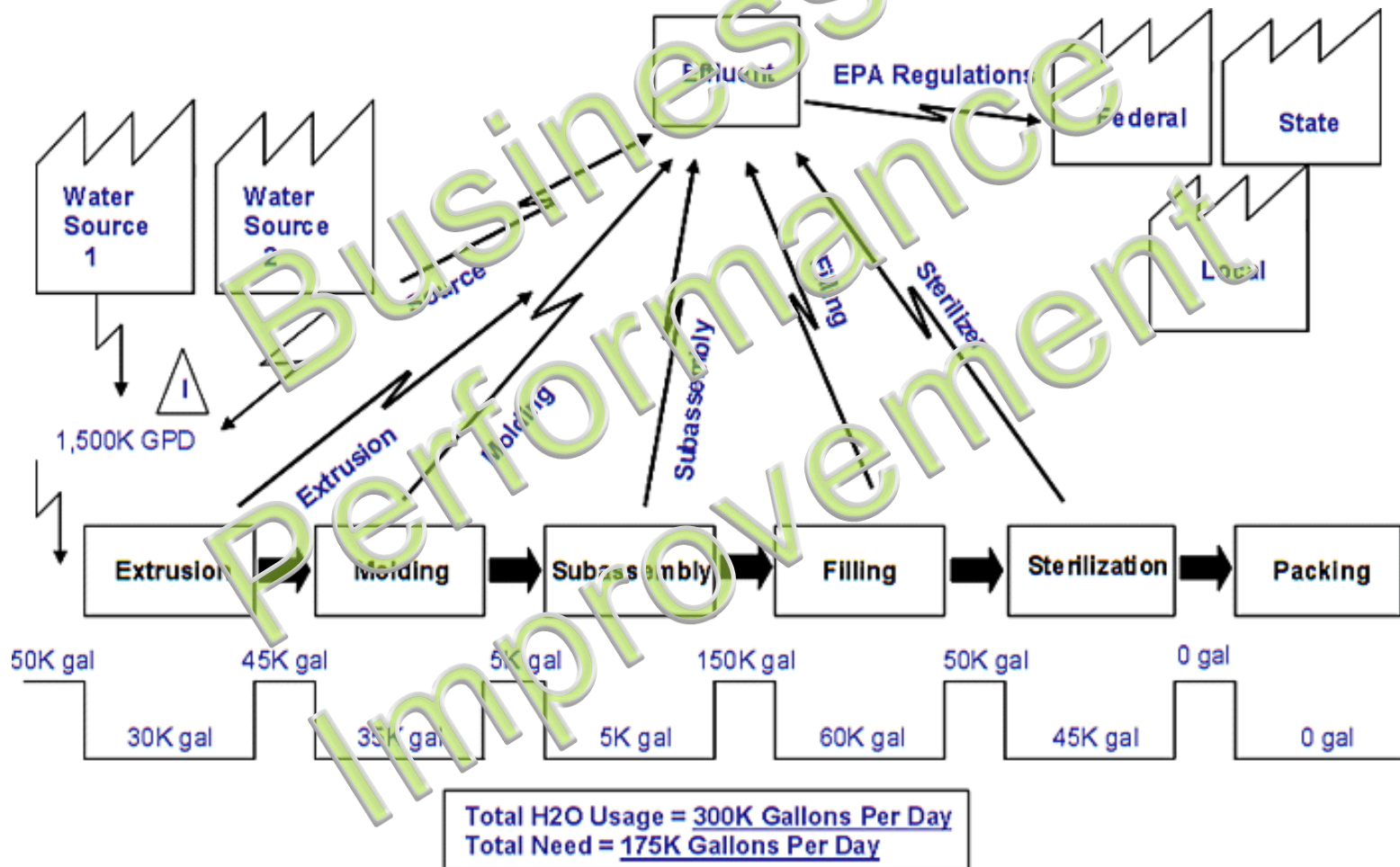


Figure 11: Value Stream Map Incorporating Water Use Metrics

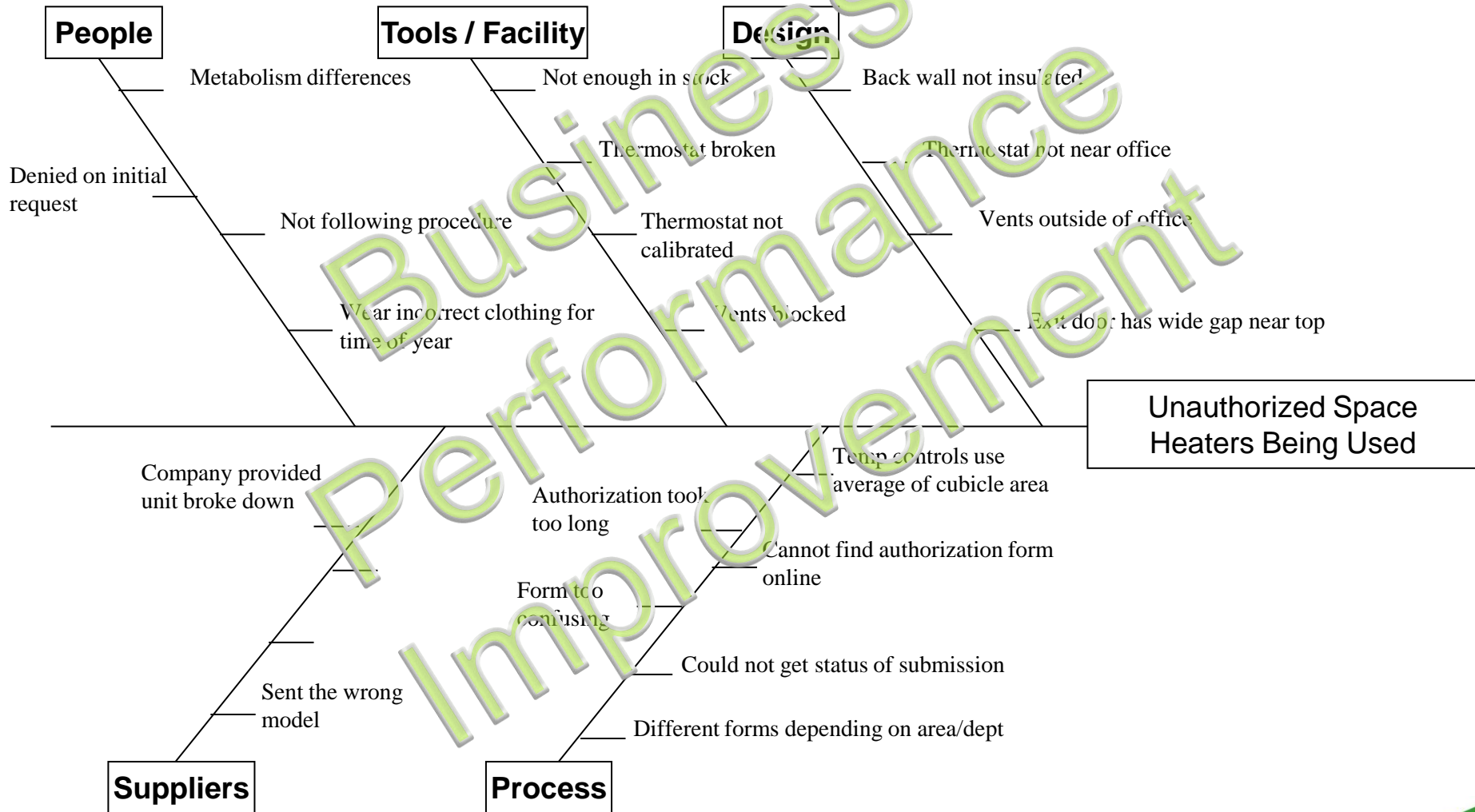
<http://www.epa.gov/lean/environment/toolkits/water/resources/lean-water-toolkit.pdf>

# Water VSM using water not timeline



<http://www.epa.gov/lean/environment/toolkits/environment/ch3.htm>

# Fishbone Diagram

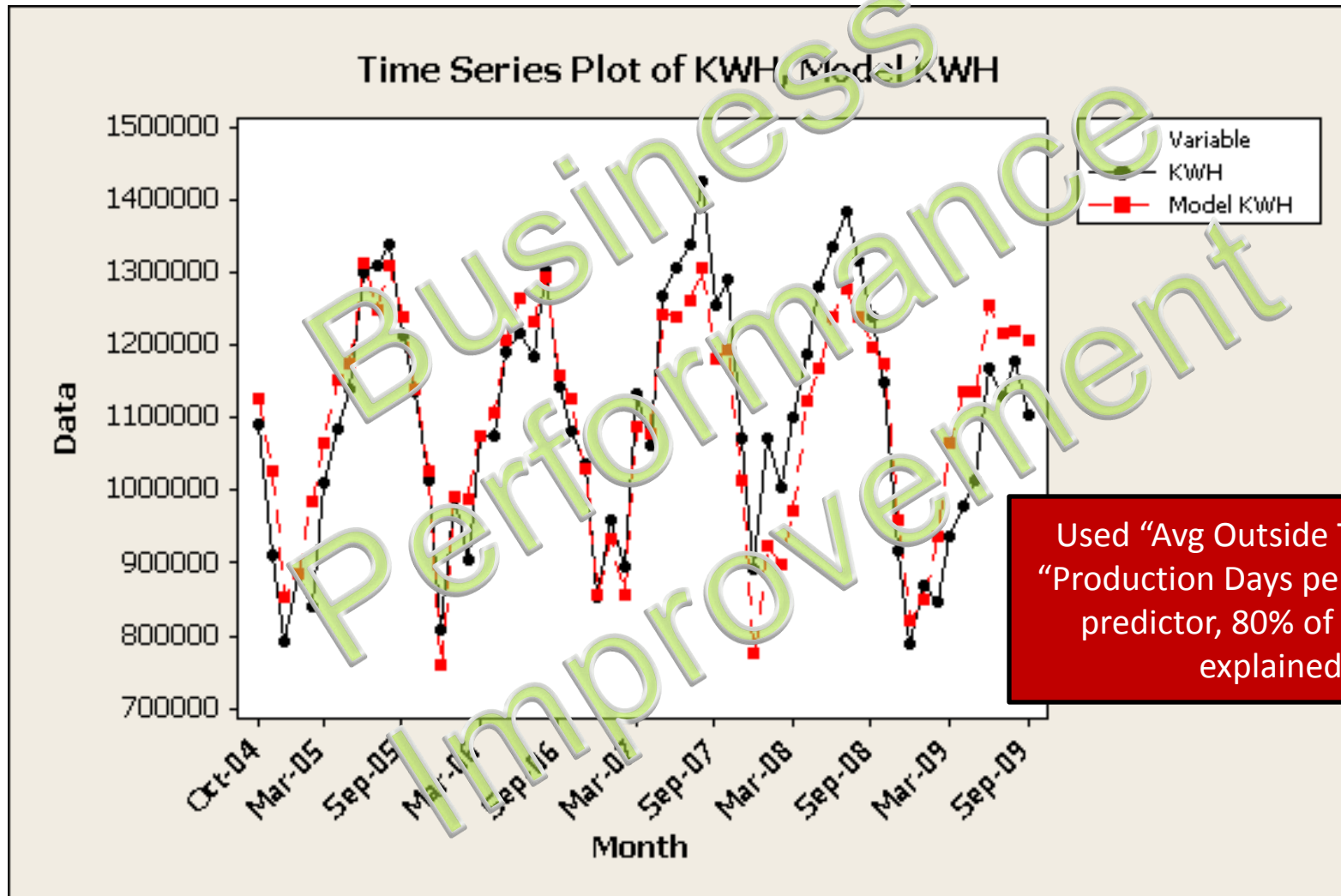


# JEA's DMAGIC roadmap

- JEA added a “Green It Up” step to the DMAIC process, creating “DMAGIC”
  - designed to ensure that every improvement project addresses environmental concern
- In the “Green” phase of each project, the team explores areas such as air quality, water quality, and ecosystem-related issues.
- The team performs the “Green it Up” phase after identifying root causes and before developing any countermeasures.
- 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>

# Regression Analysis



Used "Avg Outside Temp" and "Production Days per Month" as predictor, 80% of variation explained!

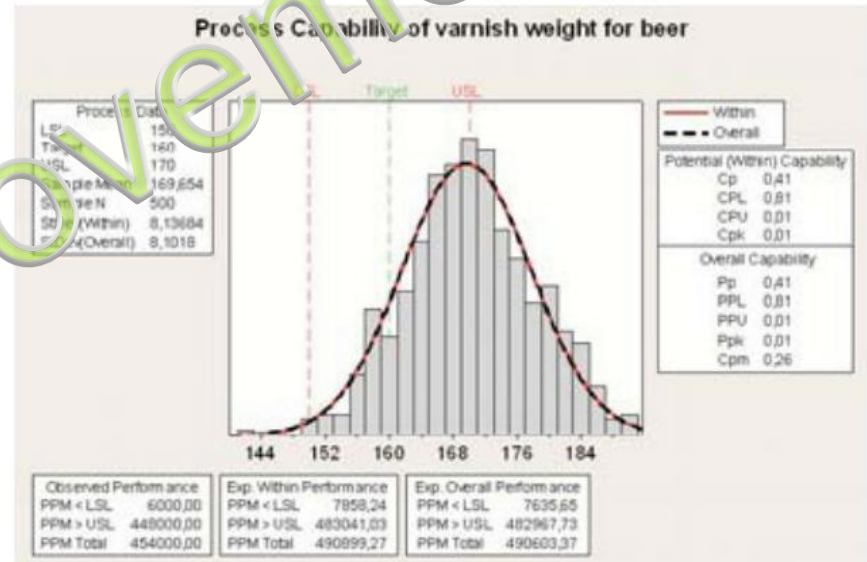
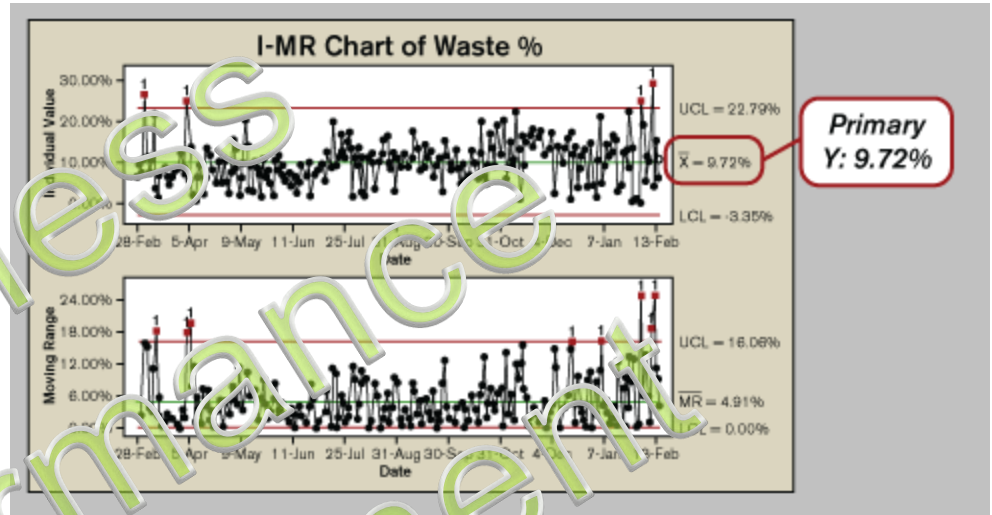
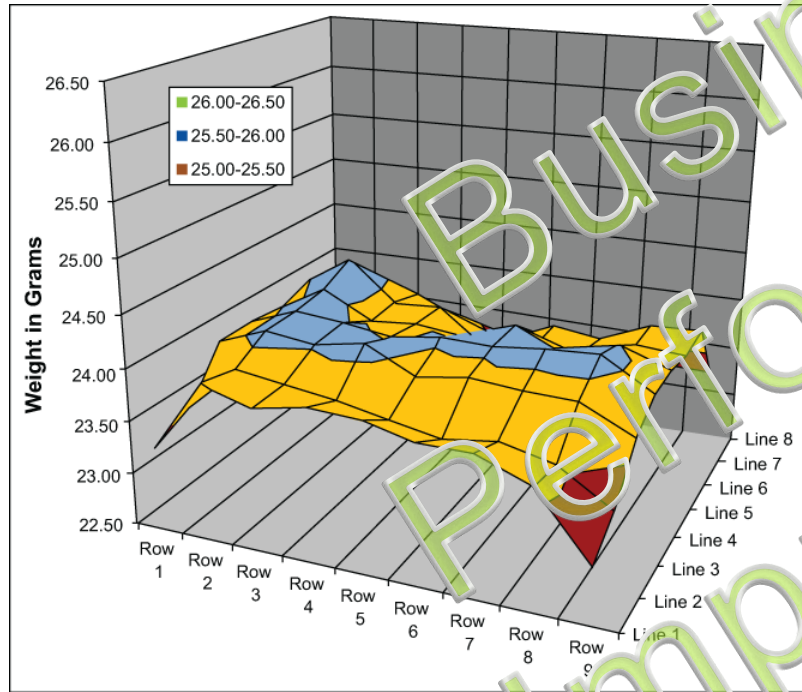
Also considering: Billing Days, Employee Counts, Production Volume, Power Factor, Peak Demand, etc

# Run Charts

## Water Usage on Weekends



# Statistical Analysis



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# Gage R&R

- Purpose of study: to validate that the KWH results coming from either power meter or electrician (measurement process) will not add excessive variation into the data
  - 2 electricians/power meters
  - 3 repeat readings
  - 10 different items
- Perfect situation is the only thing that varies is the 10 different items
  - no variation from meters, repeats, or electricians



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# FMEA

- Include environmental risks into Severity rankings

Table 2 ES&H Severity Level Definitions

Rank	Severity Level	Description
10	<b>Catastrophic I</b>	A failure results in the major injury or death of personnel.
7-9	<b>Critical II</b>	A failure results in minor injury to personnel, personnel exposure to harmful chemicals or radiation, a fire or a release of chemicals in to the environment.
4-6	<b>Major III</b>	A failure results in a low level exposure to personnel, or activates facility alarm system.
1-3	<b>Minor IV</b>	A failure results in minor system damage but does not cause injury to personnel, allow any kind of exposure to operational or service personnel or allow any release of chemicals into environment.

<http://www.semtech.org/docubase/document/0963beng.pdf>

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## Next Steps

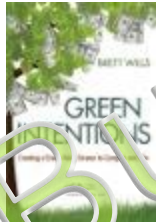
# Resources

- [EPA: Lean and Environment Toolkit](#)
- [EPA: The Environmental Professional's Guide to Lean & Six Sigma](#)
- [EPA: E3 \(Economy, Energy and Environment\)](#)
- [Lean Manufacturing and the Environment \(with Case Studies\)](#)
- [Design for the Environment \(DfE\)](#)
- [Green Supplier Network](#)
- [Zero Waste Network – Case Studies](#)
- [Purdue/SME Green Manufacturing Workshops](#)
- [Lean Ecology: Lean and Green Video Series](#)
- [IAC Industrial Productivity Training Manual](#)

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# “Lean and the Environment” Books

[Green Intentions](#)



[Green to Gold](#)



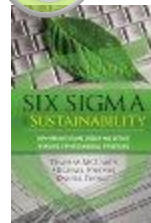
[Green Manufacturing](#)



[Lean and Green](#)



[Six Sigma for Sustainability](#)



[http://www.leansixsigmaenvironment.org/index.php/learn\\_about\\_lean\\_and\\_green/](http://www.leansixsigmaenvironment.org/index.php/learn_about_lean_and_green/)

# Checklist: What can you do?

- All process improvements naturally reduce impact on the environment, now capture them!
- Add energy, material and costs to data boxes on Value Stream Maps
- Add energy and material impacts to current waste definitions
- Focus Lean Six Sigma efforts specifically on environmental issues (W.A.S.T.E.) using traditional and modified tools
- Invite ES&H and Facility department to events and project teams
- Integrate environmental checklist into event templates
- Add Earth/Environment to SIPOC as a Customer
- Share this presentation and list of resources with others in your company

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# Summary

- Companies and organizations that are not aggressively pursuing sustainability goals will fall behind
  - There are strong financial reasons to “go green”
- Companies should focus sustainability on the areas that most impact their business, not to improve perception or make them feel good
- Lean Six Sigma (and other improvement initiatives) provide a good foundation for helping a company become more sustainable

# Contact

- **Earth Consultants (Lean and Green Resources)**
- <http://www.LeanSixSigmaEnvironment.org>
- **Business Performance Improvement**
- <http://www.Biz-PI.com>

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