Lean Thinking and Energy Reduction

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Loureiro Engineering Associates, Inc.

- **Started in 1975**
- **Plainville CT (main), Manchester NH, Exeter RI, Rockland MA, Raleigh NC, Washington DC**
- **Multidiscipline – 170+ employees, 20 PEs**
  - Environmental, Health & Safety, Remediation, Brownfield, SMEP (Structural, Mechanical, Electrical and Plumbing), Energy Services, Construction, Waste Management Broker, Wastewater systems
- **Approved CT Eversource and UI vendor for EUA, BSC, engineering services**
- **Also approved, working in MA, VT, RI, NY**

Presenter – Kevin Vidmar

- VP Energy Services, Loureiro Engineering Associates
- 35 years industry experience, >600 industrial & commercial site visits, 25 countries
- Operated Plating Plant in Richmond VA that won USEPA Pollution Prevention Main Award 1999
- Association of Energy Engineers (AEE) Fellow
- Certified Energy Auditor (AEE)
- Certified Energy Auditor (AEE)
- Certified Professional, Energy Management Systems – Industrial (ANSI, ISO)
- Assisted with Kaizen Energy Treasure Hunts in Vermont

Some General “Rules” in Order for Energy

1. **Safety Always**
   - Not safety first
2. **Function first**
   - It must work, and work safely before all else…
3. **Energy next/only then**

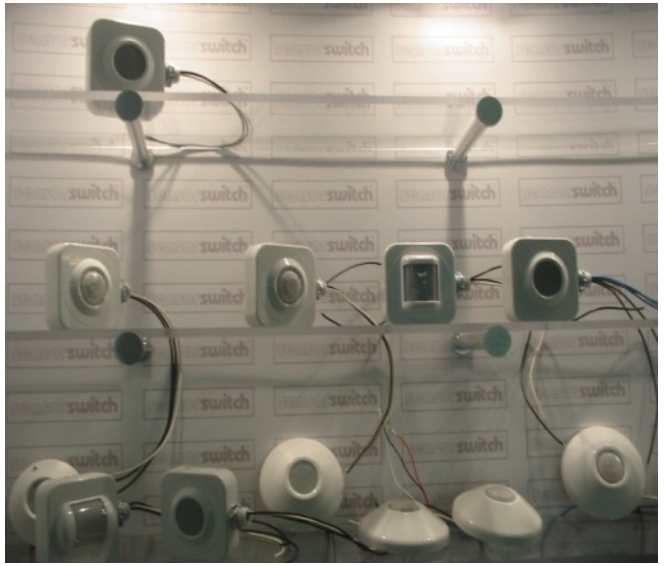
REMEMBER SAFETY ALWAYS

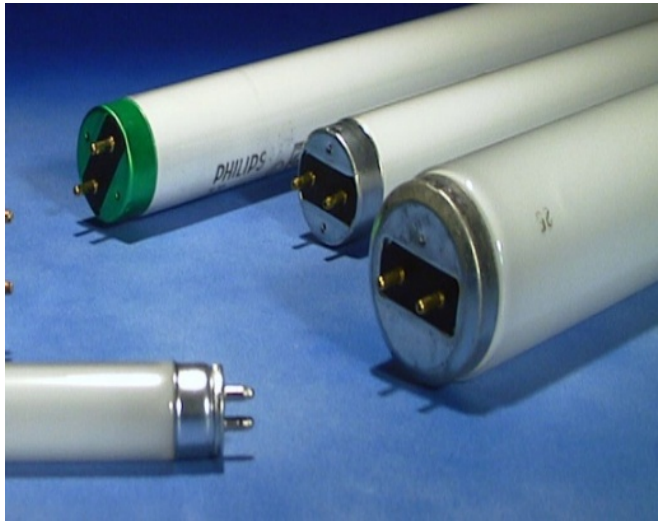
- Wear safety goggles or glasses
- Gloves when needed
- Correct Footwear
- Watch where you walk – carefully!
- Wear no metal
- Assume GFCI not working unless you KNOW otherwise
- Use appropriate ladder in appropriate places

Quick Definitions

Energy use (KWH) = kW (eff) x Hours (cons)

- **Conservation**
  - the preservation and careful management of the environment and of natural resources
  - reduced consumption with reduced results
- **Efficiency**
  - the ratio of output to the input of any system
  - reduced consumption with same results
- **The cheapest KWH or MMBTU is the one not used - conservation!**
- **Lean, Kaizen, 5S, fit well with both of these**



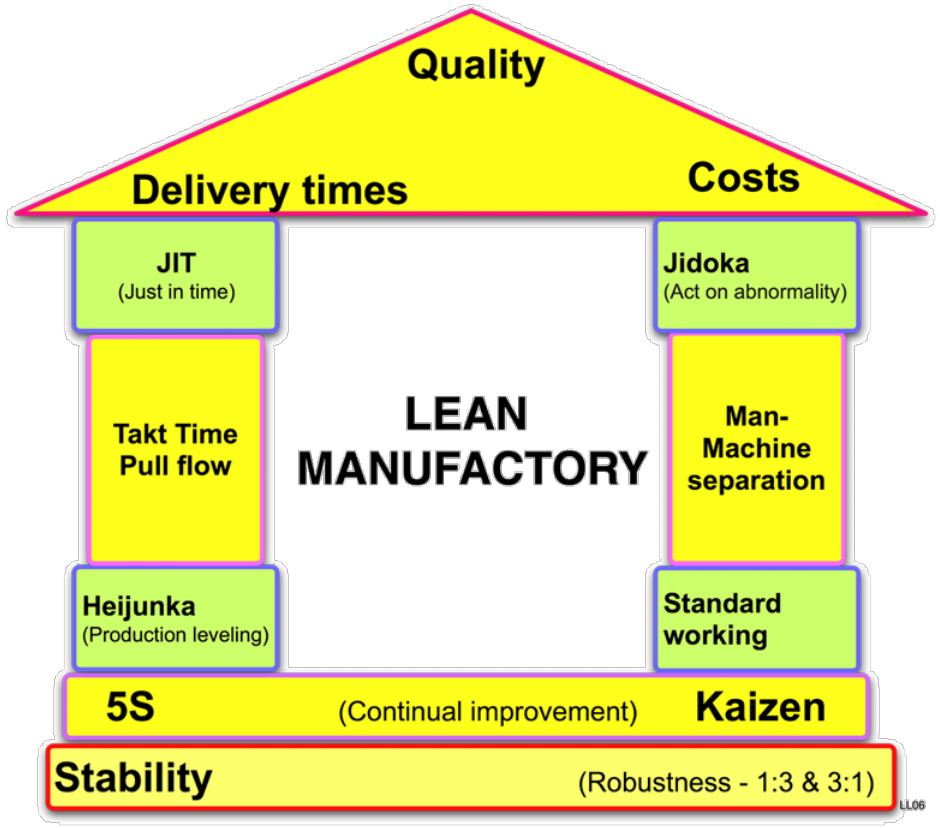


From a site starting the Lean journey

- Posted often at a site
- A good job applied to everything BUT energy
- Cannot see energy being used, only result of its use

Lean Thinking and Energy

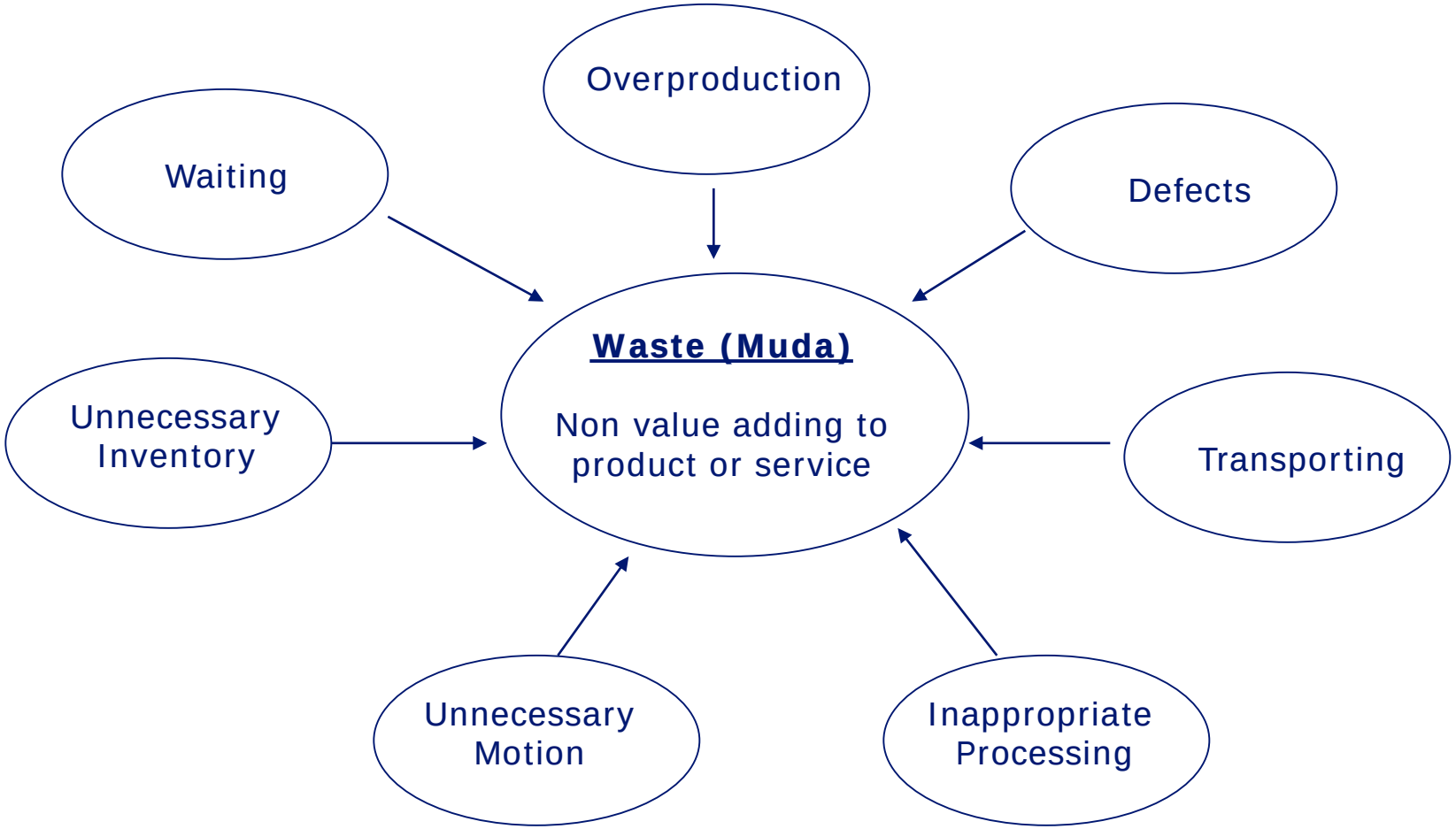
- What is Lean Thinking (manufacturing)
- How this applies to energy
- How this saves energy



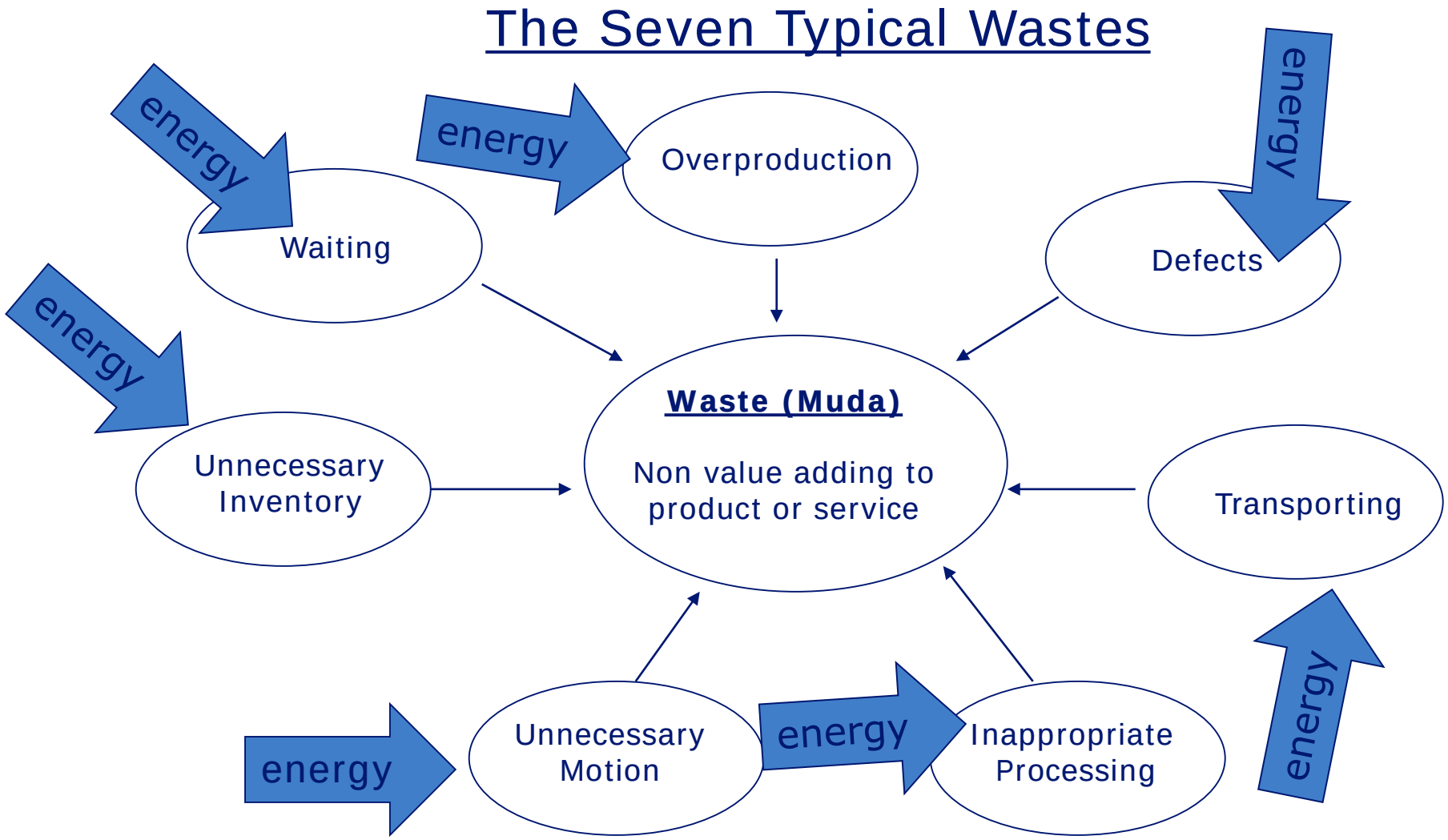
What is Lean Thinking?

- **Many aspects to it, some common themes:**
  - The elimination of waste and non-value-added activities in all aspects of the business (muda)
  - Focus on Value-add activities
  - Single-piece flow
  - ‘Pull’ production process (production based on customer demand rather than forecast)
  - Continuous improvement (Kaizen, 5S, etc.)

The Seven Typical Wastes



Where Does Energy Fit? All of them!



Muda (waste) Types (Non-Value-Add)

Type 1 Muda

Creates **no value** but are currently necessary to maintain operations. They do nothing for the customers, but may well assist the managers or stakeholders.
Type 1 should be reduced through simplification, conservation.

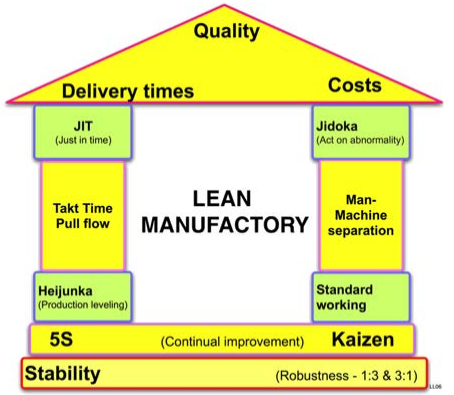
Type 2 Muda

Creates **no value**. Seek to eliminate. Type 2 grows slowly over time due to carelessness, people doing things "their way" (a wrong way, and it catches on), etc.

What is Value Add?

- **“Something the customer is willing to pay for”**
  - Changes form of the part
  - Changes fit or function of the part
  - Changes value of the part
- **Typically, all else is non-value-add to the customer**
- **Might have internal value add – sustaining non-value add**
  - Internal audit required by customer

What does Kaizen Mean?



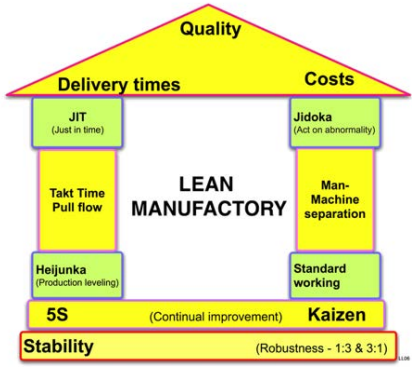
Japanese term

- **Kaizen = Kai [change] + Zen make good or make better]**

- **Really means: take something apart, and consider how to reconstruct it in a better way, and then do this better way!**

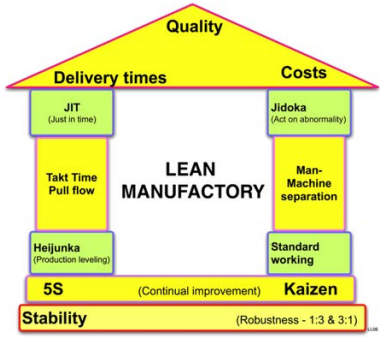
- ***Can easily apply to energy!***

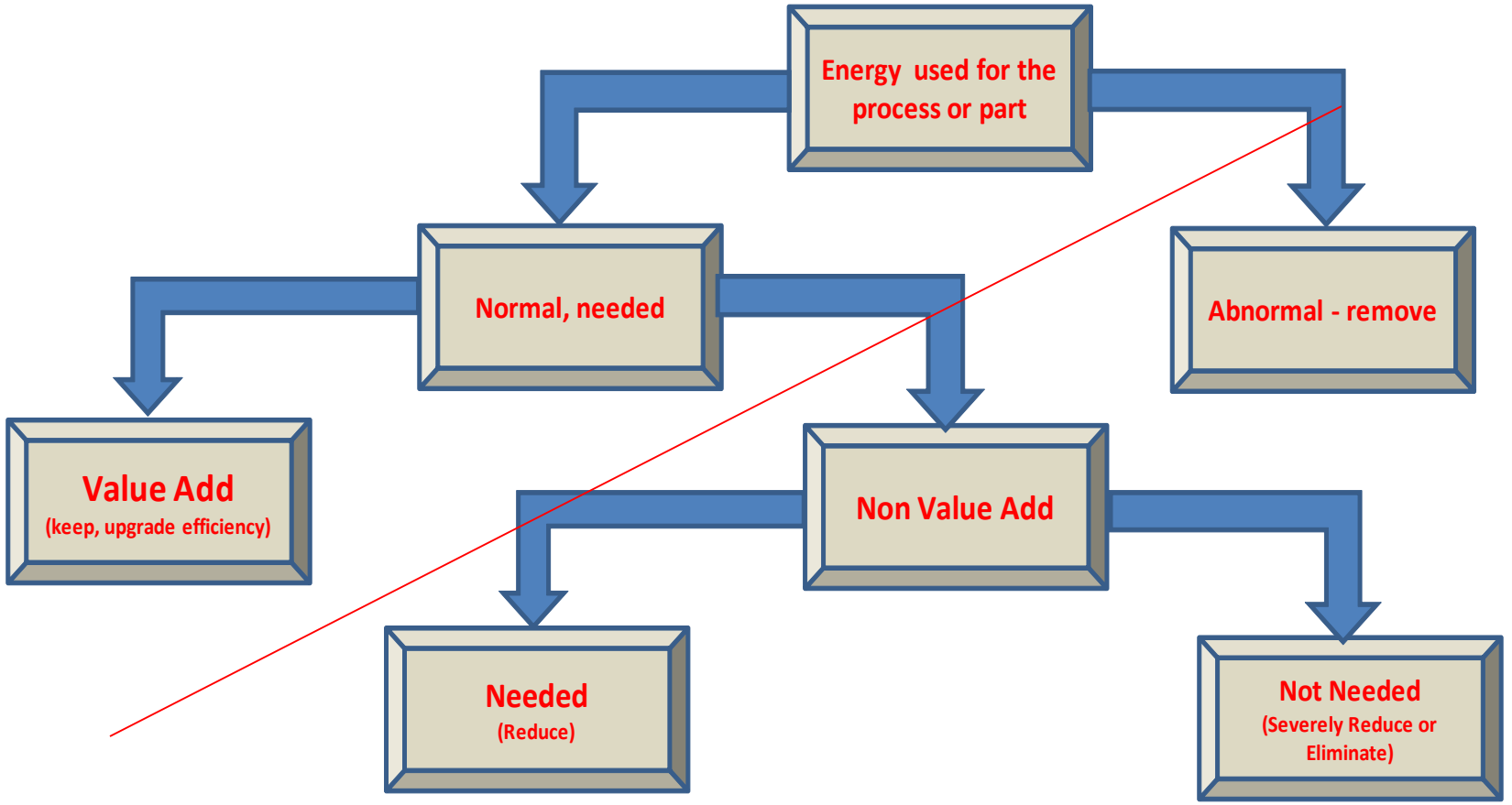
What is 5 S?



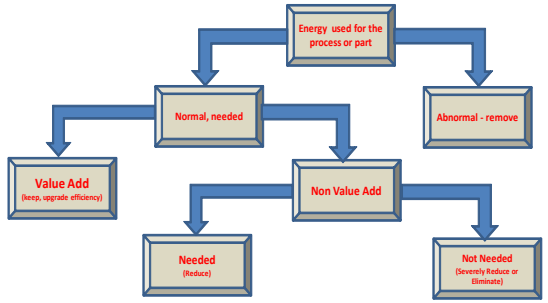
- Systematic process for organization and operation that is one cornerstone of Kaizen, and Lean Thinking
- “A Place for everything, and everything in its place”
- “You want it, you find it”

Lean/Kaizen Process Steps
Identify Waste Flowchart



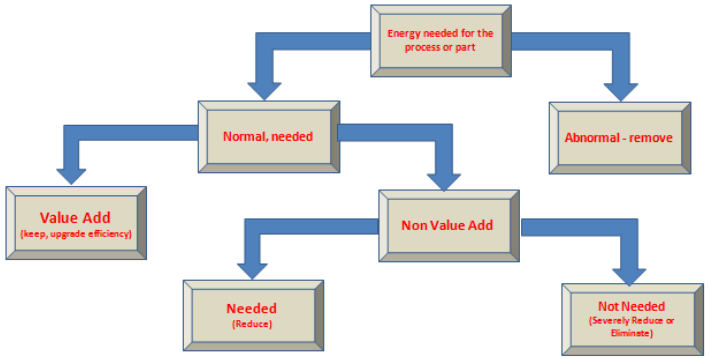


Lean/ Kaizen Process Steps Identify Waste



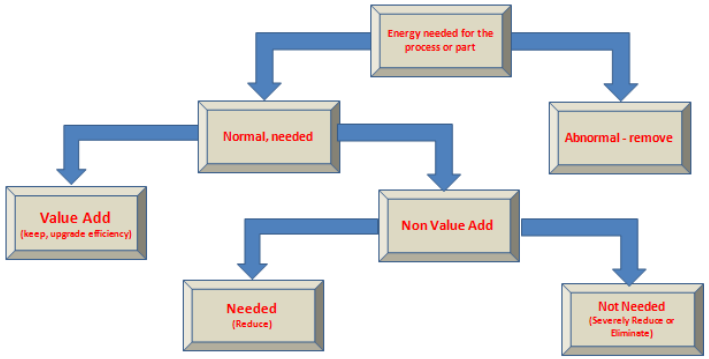
- **Normal energy needed versus abnormal**
  - Normal – afterburner (incinerator) needed at 1400 F whenever the oven is running
  - Abnormal - afterburner (incinerator) running at 1500 F, not 1425 F (ish)
- **Value add versus non-value add**
  - Value add changes the form/fit/function of part
    - Example – oven and its afterburner
  - Non value add is just that
    - Example – oven and its afterburner running when parts are no longer in the oven

Waste Identification – Lighting example



- **Abnormal**
  - Light level is 100 FC
  - Light needed by lighting guidance is only 30 FC
- **Normal non-value add**
  - Lights on when no parts in production, no occupancy
- **Normal value add**
  - Needed when parts in production at right level

Kaizen – Process Analysis Energy Matrix

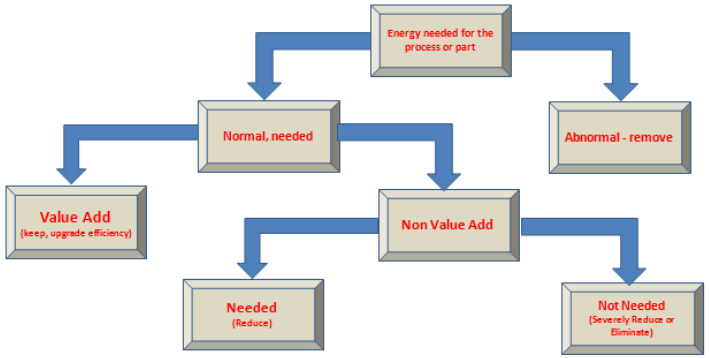


- Breaks down to simple stoplight matrix

Matrix for Energy reduction		Reduction by Efficiency	Reduction - Conservation or Efficiency	Elimination
Not needed/Abnormal			x	X
Needed/Normal	Non value add			
	Needed		x	
	Not needed			X
	Value Add	X	x	

Process Example

- Description of process
- Normal
- Abnormal
- Value add
- Non value add



Filter Example - Matrix

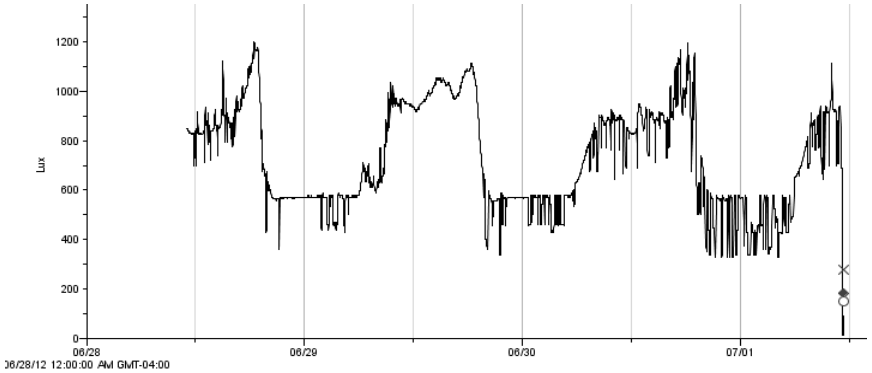
Matrix for Energy Reduction - Filters		Process Specific	Reduction by Efficiency	Reduction - Conservation or Efficiency	Elimination
Not needed/Abnormal		1. Incoming air at line pressure, 100 PSI 2. Air leaks in line, regulator 3. Air on when line not on		Bring to 80 PSI	1. Fix leaks 2. Main solenoid or 5 S manual system to ensure air is off when machine is off
Needed/Normal	Non value add	Air used when no filters present			
	Needed				
	Not needed	Yes		X	Solenoid to shut off air when no parts being presented
	Value Add	Air needed to push slip into filters	Use lower volume air knife		

- **Need to define values of each step**
  - Savings, Costs, Simple Paybacks, etc.
- **Then organize/prioritize**

Type of air knife	Pressure	CFM per inch	Inches	CFM	Force - oz	Sound - dB
Exair - Standard	60	2.7	36	97	2.7	83
Exair - Full flow	60	2.4	36	86	2.6	65
Exair - super	60	2.3	36	83	2.5	69

Lighting example

- Food lighting dimming – big these days
- Daylight harvesting
- “but its LED, so its OK to leave on, no worries”



Matrix for Energy Reduction - Lighting		Process Specific	Reduction by Efficiency	Reduction - Conservation or Efficiency	Elimination
Not needed/Abnormal		FC at 100		1. lower wattage bulbs	1. Delamp
Needed/Normal	Non value add	1. Lights on when no occupancy 2. Lights on outside during day			
	Needed	Yes - internal night lighting only		Dimming when no occupancy	
	Not needed			Photo, occupancy, vacancy sensors	
	Value Add	Lighting during production or use	LED changes	Include sensors for NVA removal as well	

Water Heating/use

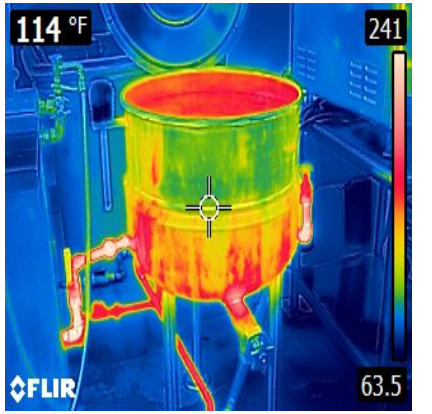
Matrix for Energy Reduction - Water Heating, Usage		Process Specific	Reduction by Efficiency	Reduction - Conservation or Efficiency	Elimination
Not needed/Abnormal		Flow rate above 2.5		1. Install code 2.5 GPM or lower shower head	
Needed/Normal	Non value add				
	Needed	Too Long length of startup to get hot water		Install timer - one minute warmup, or sensor buzzer when temp met	
	Not needed	Shower itself too long		Training or shower timer	
	Value Add	Water used for shower	Change to on-demand system		

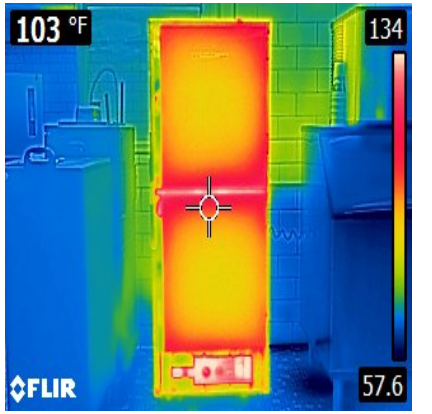
Water heating - base case and changes, if 4 showers per day, 365 days/yr, $2/therm	Water Temp F	UEF	Min for shower	Flow Rate GPM	Cost per shower	Cost/yr	Save/yr from Base Case	% reduction from Base Case	Change Cost	SPB YRS-this item
Base Case	**120**	**70%**	**10**	**4**	**$ 0.62**	**$ 905**				
Base case flow rate - shorter shower	120	70%	5	4	$ 0.31	$ 452	$ 452	50%		
Change to condensing, on-demand water heater	120	90%	10	4	$ 0.48	$ 704	$ 201	**22%**	$ 1,500	**7.5**
Change to condensing - shorter shower	120	90%	5	4	$ 0.24	$ 352	$ 553	61%	$ 1,600	2.9
Change flow rate - low flow	120	70%	10	2	$ 0.31	$ 452	$ 452	50%	$ 50	**0.1**
Change flow rate - and shorter shower	120	70%	5	2	$ 0.15	$ 226	$ 678	**75%**	$ 150	**0.2**
Change flow rate, and condensing boiler	120	90%	10	2	$ 0.24	$ 352	$ 553	61%	$ 1,550	2.8
Change flow rate, shorter shower and condensing boiler	120	90%	5	2	$ 0.12	$ 176	$ 729	81%	$ 1,700	2.3

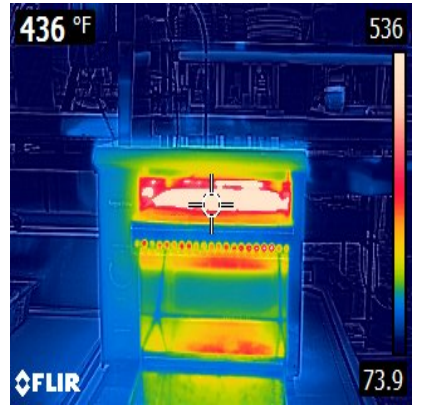
Non-Value-Add – Kitchens?

- Three typical examples
- Applying Stoplight analysis – a system to capture and address all muda and change opportunities

Matrix for Energy reduction		Reduction by Efficiency	Reduction - Conservation or Efficiency	Elimination
Not needed/Abnormal			x	X
Needed/Normal	Non value add			
	Needed		x	
	Not needed			X
	Value Add	X	x	







VA/NVA - Heating

- **Non-Value-Add**
  - Heating Building when no need (occupancy or process/condition need)
  - Heating beyond what is needed
    - So pipe's don't freeze – what is temp needed? Any better ways?
  - Heat beyond area actually needed
    - Zones
- **Value Add – by now you should know what this is, and what to do about it.**

Matrix for Energy reduction		Reduction by Efficiency	Reduction - Conservation or Efficiency	Elimination
Not needed/Abnormal			x	X
Needed/Normal	Non value add			
	Needed		x	
	Not needed			X
	Value Add	X	x	

How about the "Free Heater"

- Free Miracle Mantel heater – costs $300
- How can it save?
- What is its power output (5119 BTU/Hr =)
  - One 100 Watt Incandescent light bulb puts out about 341 BTU/Hr
  - Same output as burning 15 100 W incandescent light bulbs
- Can get same level of heat safely by $50 heaters
  - 1500 W is 1500 W!
  - Can get same savings if
    - Heat only room you are in
    - Close-off others, and let go to 50-ish F

Amish man's new miracle idea helps home heat bills hit rock bottom

Miracle heaters being given away free with orders for real Amish fireplace mantles to launch the new invention that slashes heat bills, but Amish craftsmen under strain of Christmas rush impose household limit of 2

Saves money: uses less energy than a coffee maker, so leave it on day and night and never be cold again

A GREAT Heating saver Electric Mattress Cover

- Better than an electric blanket – heat rises
- Preheat – for 10 minutes
- Then Setting – 1-10 (dual side)
- Allows our house heat to reduce to 58 F from 10PM - 6 AM without any complaints
- A bit more electricity, but much less gas, more than worth it
- Great savings AND Comfort
- No real non-value-add – only in use when you are in bed (10 hr timer)

Items	Number	Watts - Standby	Watts - in use	Hours of use per day	Hours of use per year	Hours of standby per year	Cost per kWh	Cost for standy per year	Cost for use per year	Total Cost per year
electric matress cover, preheat	3	0	25	0.2	40	8720	$ 0.15	$ -	$ 0.15	$ 0.15
electric matress cover, low	3	0	10	8	1600	7160	$ 0.15	$ -	$ 2.40	$ 2.40

NVA/VA – Tank Water Flow Rate (water??)

- **NVA – adds no value to the part**
  - Rinse water flowing even when not processing
    - Do you really need to “clean the rinse”
    - Occupancy Sensor to solenoid?
- **Value add**
  - Properly sized flow restrictors – size based upon actual conductivity needs
  - Can flow restrictor also do agitation?
  - Conductivity controllers (do they ever work right, and are they ever used longer term?)

NVA/VA – Water Savings (2) Compounding effect

- **Water must be pumped many times**
  - Pumped from source to water works
  - Pump from water works to site
  - Pumped through RO/DI systems
  - Pumped from RO/DI storage to tanks
  - (Maybe) pump from collection pit to WT
  - Pump through WT to POTW
- **Water is perhaps $10/1000 gallons (in/out – not including pumping at site)**
- **1 GPM always on costs >$5000/yr – without the multiple pumping energy costs**

1 GPM with RO costs another 25%-33% due to rejected water

Defining and attacking Normal and Needed

- **Regulations - e.g., afterburner**
- **Codes/Standards – ASHRAE,**
- **Guidance – e.g., lighting levels**
- **True process definition**
  - Air Pressure, decrease till …….
  - Temp, decrease till……
  - Length of process, decrease till….
- **Great amount of pushback, must be careful, process recertification**

Lean/Kaizen Process Steps Reality Check

- **Been tried before? What happened?**
- **What has changed since last trial?**
  - Rules of Three© here often helps
- **Technical reasons for concern**
- **Human reasons for concern**
- **Savings larger than it should be**
  - Sometimes happens if
    - too aggressive
    - wrong initial cost structures or data

Lean/Kaizen Process Steps
Make Changes

- **Use decision matrix to organize and prioritize ideas**
- **Try demo area, small changes, scale up once you have confidence, track record**
- **Follow your data, team's experience**
  - "push the button" example
- **KISS**
- **Prove concepts, then improve, then Poka-yoke (mistake proofing)**

Use decision matrix to organize and prioritize

Suggested Matrix Rank Criteria				
	1	2	3	4
Cost Savings Rank	>$10,000	$5000 to $10,000	$1000 to $5000	< $1000
Cost rank	< $1000, expense it!	$1000 to $5000, can do with expense	$5000 to $10,000, CP likely	>$10,000, CP required
ROI Rank	Immediate - less than one month	greater than 1 mo, less than one year	1 year to 2 years	greater than two years
Time - Rank	can be done today, quickly, if had the parts	less than one month	one month to six months	greater than six months
Effort - Rank	very Little effort, less than 10 hours total team effort	little effort, 10-20 hours total team effort	some effort required, 20-50 hours	much effort, greater than 50 hours
Emp Accept	employees will like, or won't even notice	employees might accept	employees might accept with expl, reinfocement	will be hard for employees to accept
Env Rank	Good for environment, no issues	No issues, neutral for environment	Some environmental Impact to consider	Could be major environmental issues or permitting
Safety Rank	Good for safety, no issues	No issues, neutral for safety	Some safety Impact to consider	Could be major safety issues or permitting
Prod Rank	Will help production, or no impact	Might have some small production effect to consider	Minor to moderate production impact possible. Need to	Will likely hinder production
Risk of Failure Rank	Little risk, standard technology	some minor risk if installed or operated wrong	Moderate risk, could impact process or credibility	Major risk, Serial # 001

- **Similar to Six Sigma C&E**

Do you have to use a Formal System?

- **Informal versus Formal**
  - Informal can work, but not robust (same result every time)
  - Formal – forcing function, typically finds more
- **Suggest Using formal – at least initially**
  - Until second nature

Matrix for Energy reduction		Reduction by Efficiency	Reduction - Conservation or Efficiency	Elimination
Not needed/Abnormal			x	X
Needed/Normal	Non value add			
	Needed		x	
	Not needed			X
	Value Add	X	x	

What are the 5 S's

English

- **Sort**
- **Set**
- **Shine**
- **Standardize**
- **Sustain**
- **Safety**
- **Energy**

Japanese

- **Seri**
- **Seiton**
- **Seiso**
- **Seiketsu**
- **Shitsuke**

Additional programs commonly added

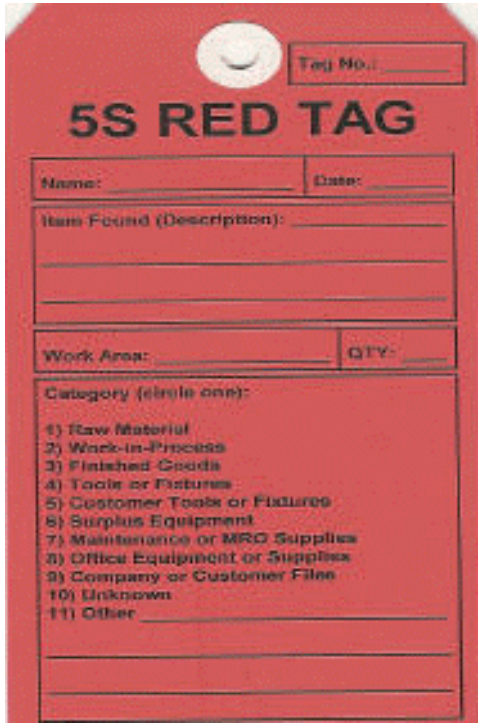
1S – Sort this mess, - easy?

Sorting - Classifying Items & Locations by Frequency of Use

Priority	Frequency of Use	How to Store
Low	Less than once a year	Throw Away!!!
	Once a year or so	Store in distant place
Average	Once every 2-6 months	Store together
	Once a month	somewhere in
	Once a week	factory
High	Once a day	Carry or keep at
	Once an hour	individual work
		place

Red Tag Procedure

- Team Places Tagged items In Red Tag Area
- Team Records All Tags On Log Sheet
- Give All Users & Shifts 48 hours (fixed time) To Review
- Management Response/Action In One Week or Less
- Challenge Yourself. Look at All Items Very Critically
- Watch out for the red tag effect



Red Tag, and Energy?

- **Printers**
  - 25 people, 50 printers
- **Speakers**
  - Do everyone really need, in cubicles?
- **Redundant task lighting**
- **Floor Heaters**
- **Unnecessary equipment**
  - If its not there, it cannot be used! Guaranteed savings

2S – Set in Order (Straighten)

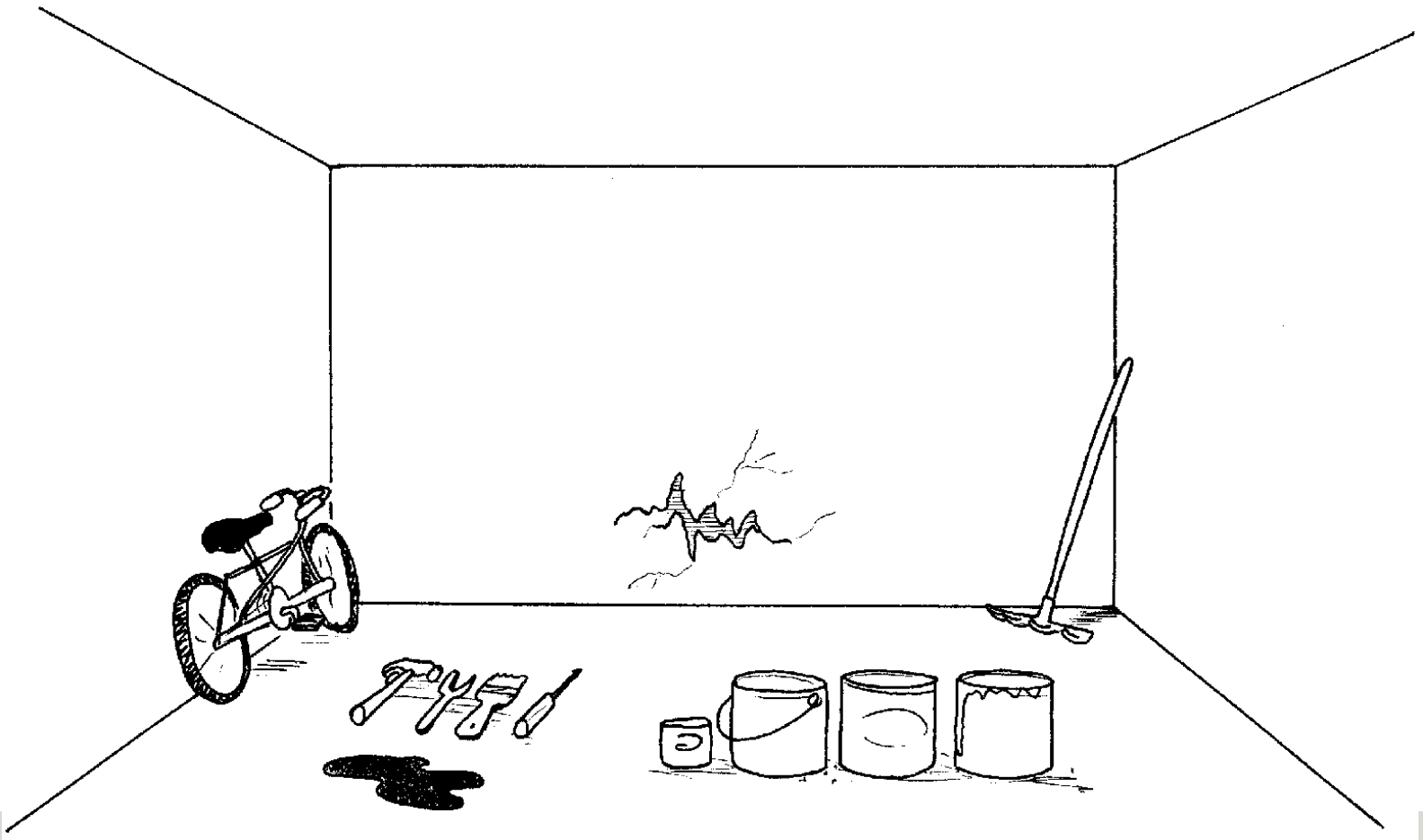
- **Organize**

- **Arrange Items So Easy To Find and Readily Retrieved.**
- **“A Place for Everything and Everything In It’s Place.”**

My Teenager’s Dorm room

2S – Straightened, Set in order -

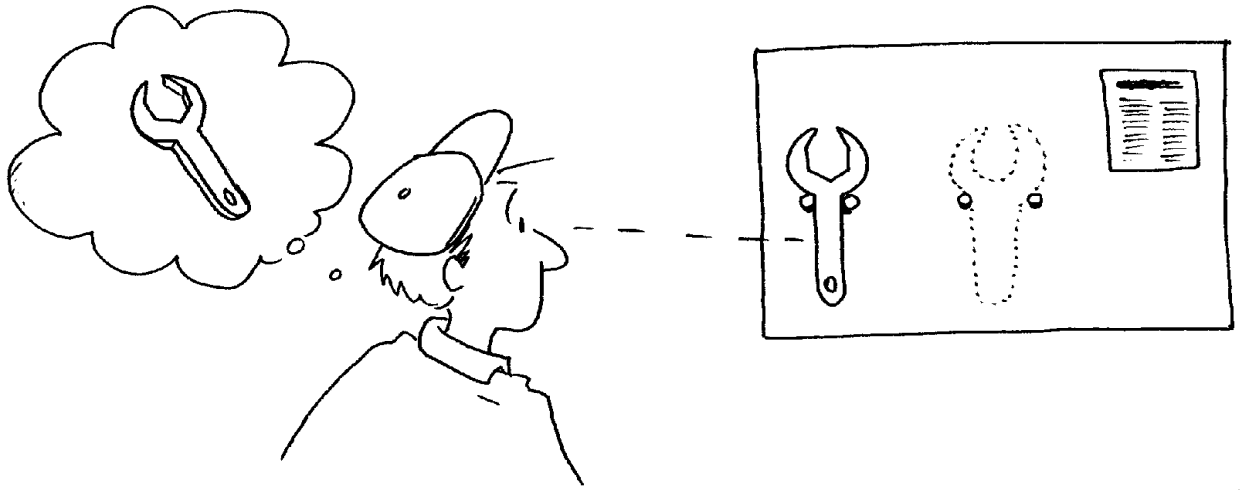
this is better, are we done?



How will you know if good organization is in place? Visual is best method

Can Anybody Immediately:

- See Where, What & How Many?
- Take Item out?
- Return Item After Use?



Examples I have seen – 2S

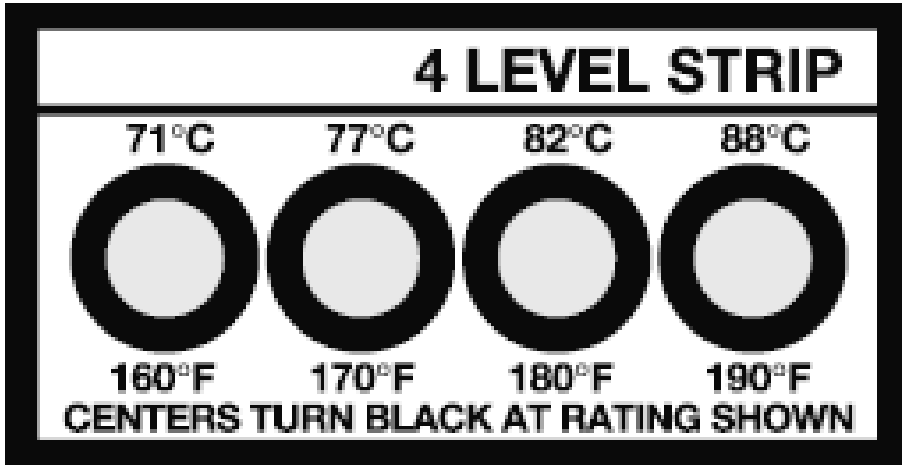
- **Tool Rack from Tower Bridge – made with exact number of holes/slots needed, tagged**

How Can Set apply to Energy?

- Find your Tools, meters
- Find your bulbs, ballasts
- Find your solenoids, repair parts
- Find your connectors, clamps, repair parts
- Find batteries for meters

2S Straighten, and Energy

- **Visual record of performance and use**
- **Gauges marked**
- **Notes on temperatures - motors**
- **All appropriate operating conditions noted/marked**
  - Objective – anyone can tell proper conditions even if one does not know anything else



Examples - Gauges

- **Which is better, uses less energy?**

3S - Shine

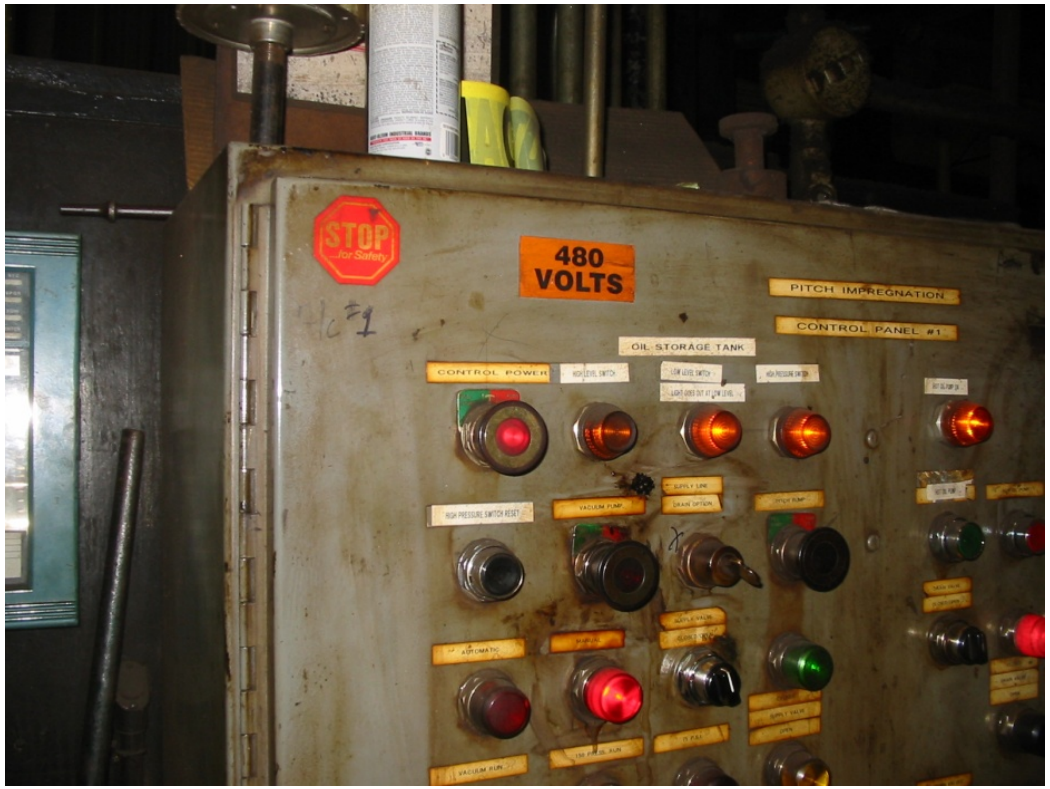
- Identify cleaning activities and routine maintenance required
- Assign responsibility to a team member
- Provide cleaning materials for the area.
- Clean the area and perform all routine machine maintenance each day.

Why Shine?

- Rid Workplace of Undesired Debris, Dirt, Dust, Etc...
- Healthier, Safer Environment for Both Humans and Machines
- Improves visual inspection portion of Preventive Maintenance
- Pride!!
- Saves energy!

How Shine Saves Energy

- **Cleaner surface shows energy use and problems better**
  - Operational Lights



Shine – Lighting Example

- Light level almost doubled when walls painted
- Lights were then off for more portions of the day
- Delamp possible

Shine – Lighting examples

- Change T-12 or T-8 bulbs, notice how much more light
- Change to brighter light color, how much more light it seems
- Clean Fixture
- Clean Bulbs

3rd S – Shine, Inspect While Cleaning

Traditional

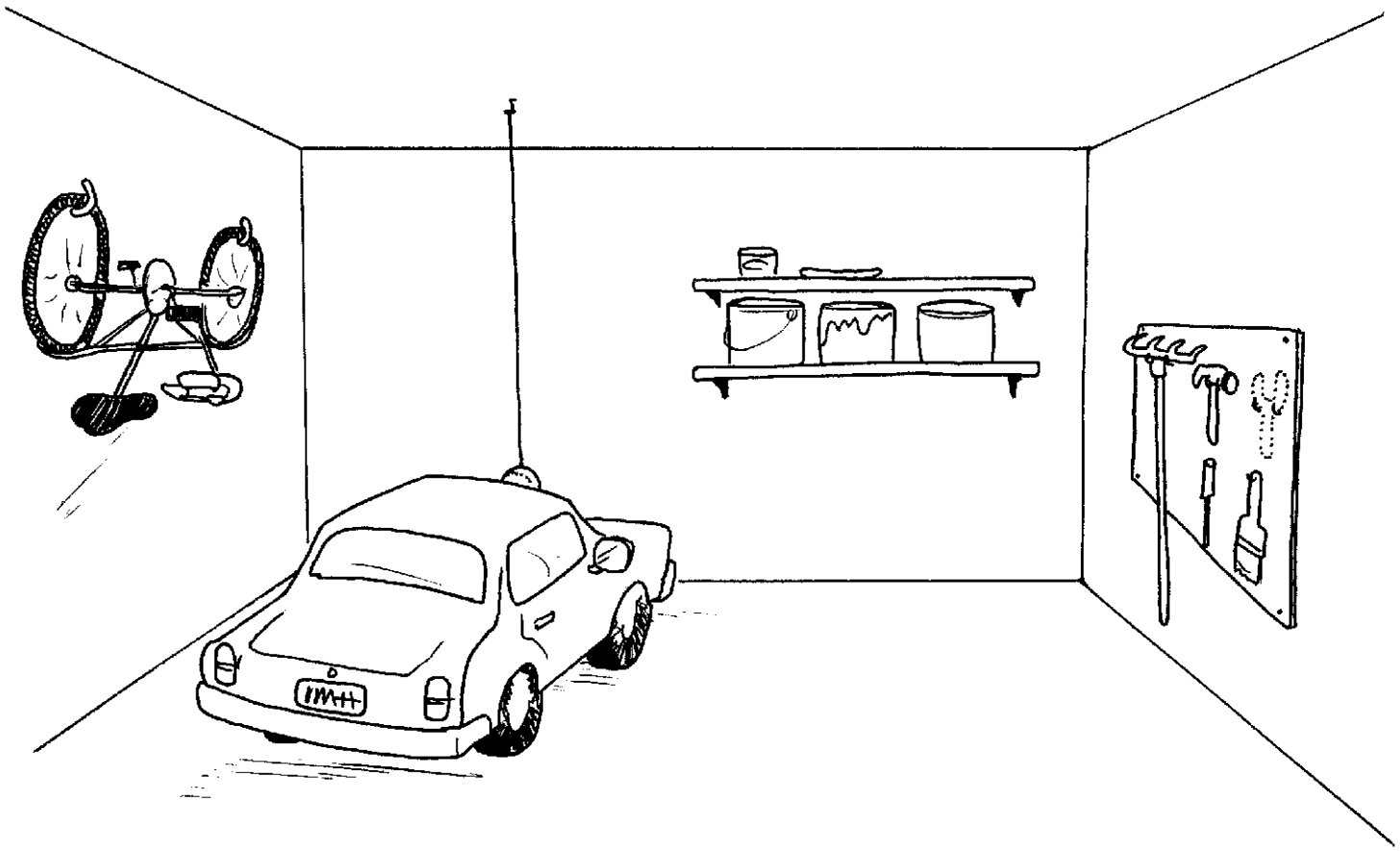
- Faulty Parts
- Hidden, Broken Gauges
- Loose Nuts & Bolts
- Cracked Housings
- Lubricant Levels

Energy Related

- Compressed air leaks
- Light fixture – reflectors and bulbs
- Motor heat, problems
- Belts, bearings

Where are we now with the 5S's ?

(sort, set, shine, standardize, sustain)



4S – Standardize

- **Move On To All Workplace Areas (e.g., go beyond garage to basement workbench)**
- **Implement Best Practices Throughout**
- **Audit**
  - Sort: Elimination Of Unnecessary Items
  - Set: Needed Items in Designated Places
  - Shine: Everything So Clean That Any Dirt or problem is Noticed Immediately

5 S example – Energy separate

ENERGY ISSUES: Starting at 10, deduct 2 points for each infraction
1) **Lighting** - all task lights off at end of shift, and when not in use. Overhead lights off at end of day or shift if appropriate. All pit lights off. Lights inside machine tools are turned off using panel.
2) **Motors** - all personal fans are off at end of shift. All idling motors off as allowed. Machine tools turned off, including hydraulics, if allowed. Pump motors off if pumping not required.
4) **Compressed Air** - all manual valves identified and shut off at end of shift to save air leaks. No audible air leaks when valves open
5) **Plug Load** - all computers and other plug loads are off at end of shift as appropriate. Computers are turned off, or at least in stanby/hibernation (1/2 point off)
6) ***Additional Energy Issues.***

5S – Sustain

- **5S is an organizational habit**

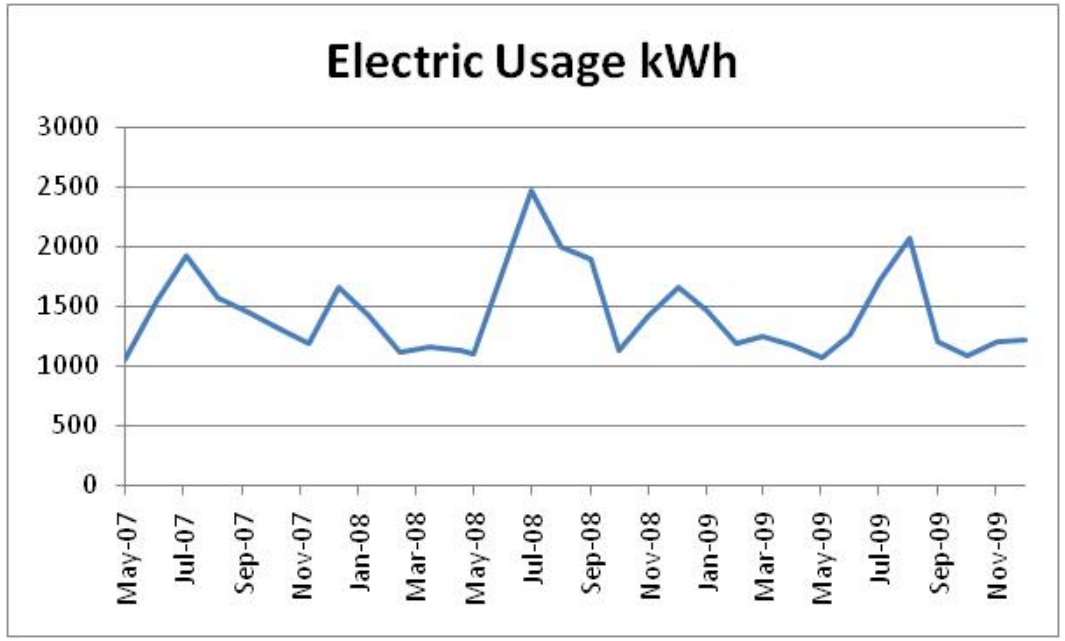
- **Personal Commitment to High Housekeeping Standards**
  - Are All Workers Intolerant Of A Dirty Workplace?
  - Would You Stop To Pick Up A Piece Of Paper On The Floor?
  - Would any worker shut off lights if not needed?

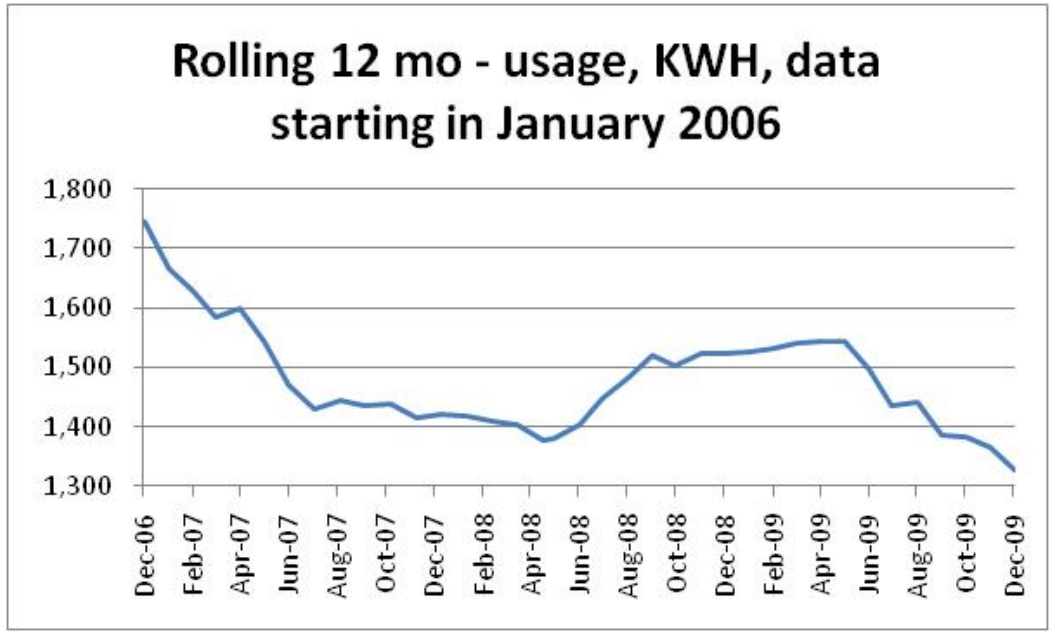
Actual Site Result Just Energy 5 S

Production Comparison			Cost Comparison		
Total Energy per production unit	Total Gas therms per production unit	Total Electric therms per production unit	Total Energy Cost per production unit	Total Gas Cost per production unit	Total Electric Cost per production unit
983.13	950.30	32.83	$ 885.02	$ 788.75	$ 96.27
0.49	0.39	0.11	$ 0.63	$ 0.32	$ 0.31
25.00	8.98	16.02	$ 54.43	$ 7.45	$ 46.97
164.65	137.35	27.30	$ 180.03	$ 103.76	$ 76.27

Production Comparison						Cost Comparison			
Total		Gas		Electric		Total	Gas	Electric	
Total Energy per production unit	%reduction compared to 2009	Total Gas therms per production unit	%reduction compared to 2009	Total Electric therms per production unit	% reduction compared to 2009	Total Energy Cost per production unit	Total Gas Cost per production unit	Total Electric Cost per production unit	Potential Savings compared to 2009
977.79	0.5%	946.33	0.4%	31.46	4.2%	$ 877.72	$ 785.45	$ 92.27	$ 2,149
0.34	30.3%	0.24	37.8%	0.10	3.2%	$ 0.34	$ 0.06	$ 0.28	$ 103,840
16.66	33.4%	10.51	-17.0%	6.15	61.6%	$ 25.42	$ 8.72	$ 16.70	$ 36,100
151.27	8.1%	128.66	6.3%	22.61	17.2%	$ 162.84	$ 99.54	$ 63.30	$ 109,119
									$ 251,208

Lean Metrics - 12 month rolling average

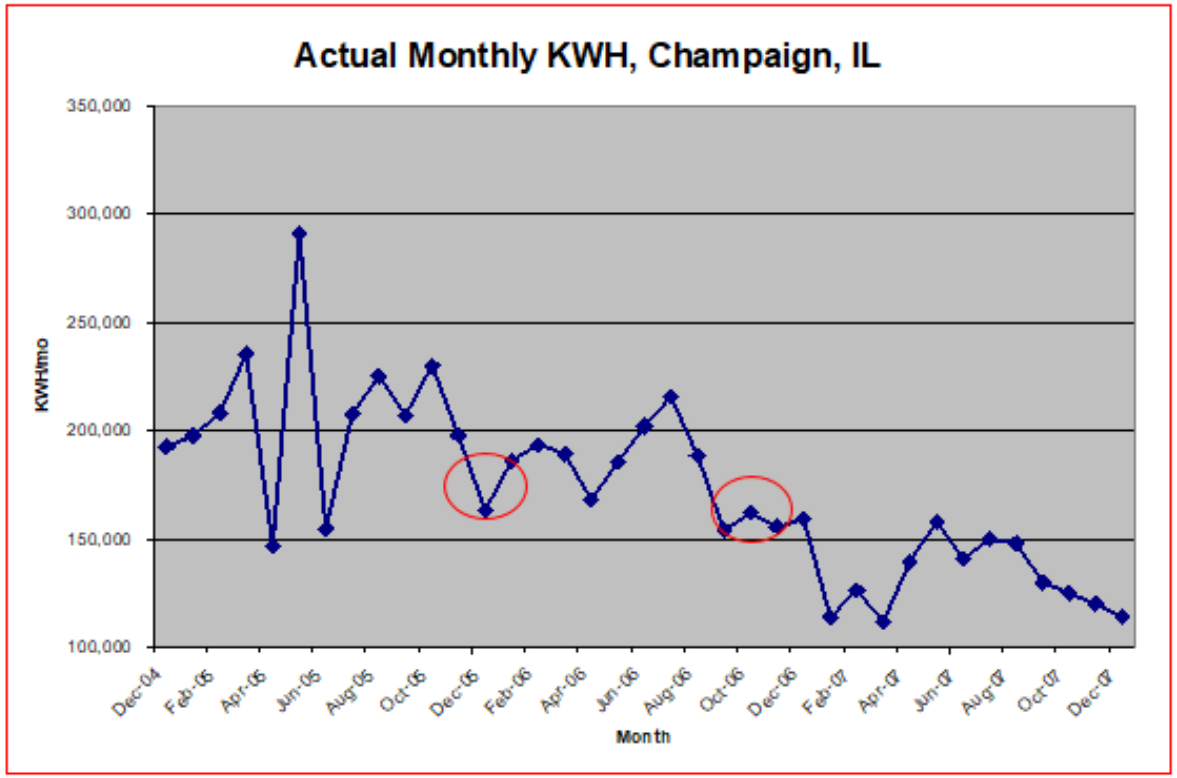




- **Which one tells you more information?**
- **Which can better be used as a control chart?**
- **What might a next step be?**

Use of 12 month average Lighting Results – Monthly Data

- Changed office lights in late 2005, some in 2006
- Changed all factory lights Q4 2006
  - Was 460 W HID MH
  - Now 160 W LF T-8
- Not production or weather normalized!!
- Facility 24x7
- What is savings?



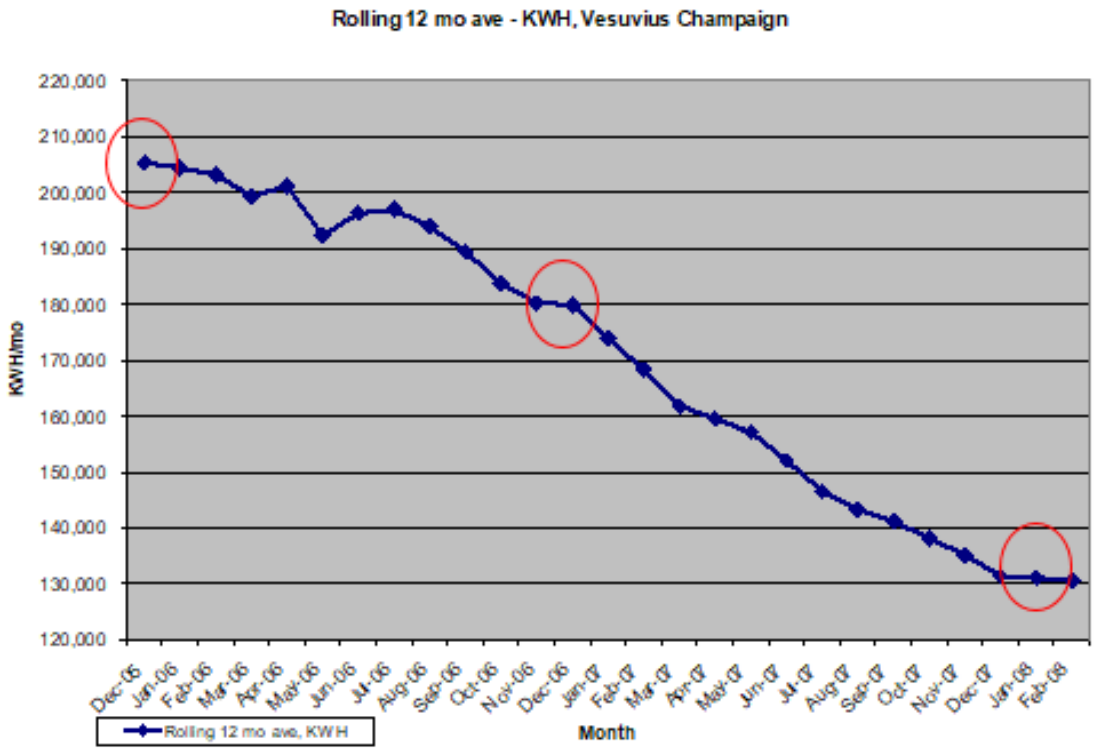
Lighting Results - 12 mo rolling average

- Changed office lights in late 2005, some in 2006
- Changed all factory lights Q4 2006
  - Was 460 W HID MH
  - Now 160 W LF T-8

- Ave 2005 = 205,000 KWH/mo
- Ave 2006 = 180,000 KWH/mo
- Ave 2007 = 133,000 KWH/mo

- 35% reduction over last two years
- 26% reduction over last year

- At $0.09/kwh, saving $78,000/yr compared to 2005

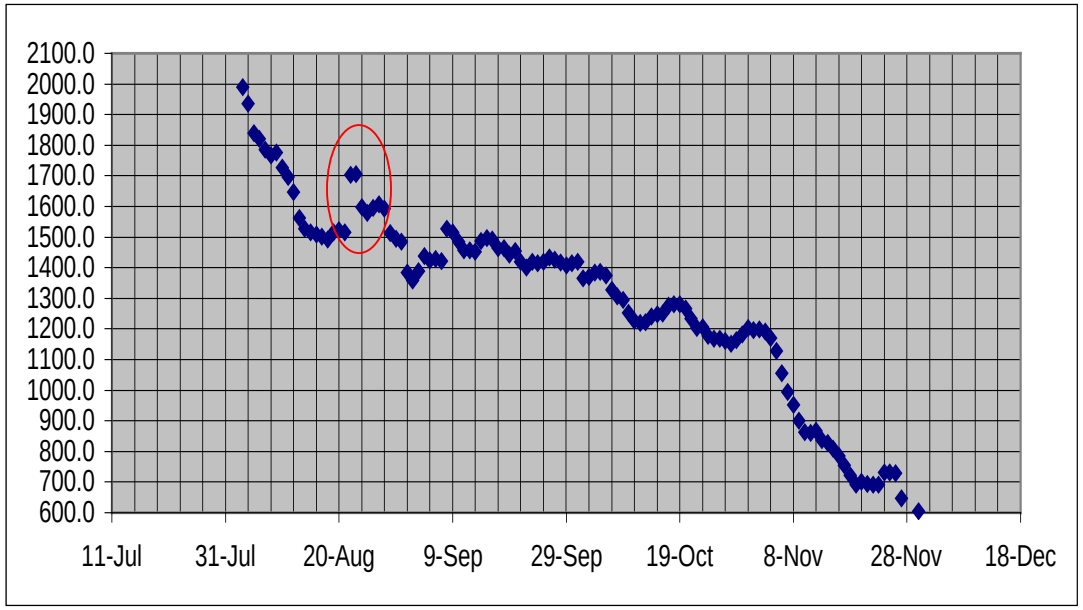


Note inflection points

Not production or weather nomralized

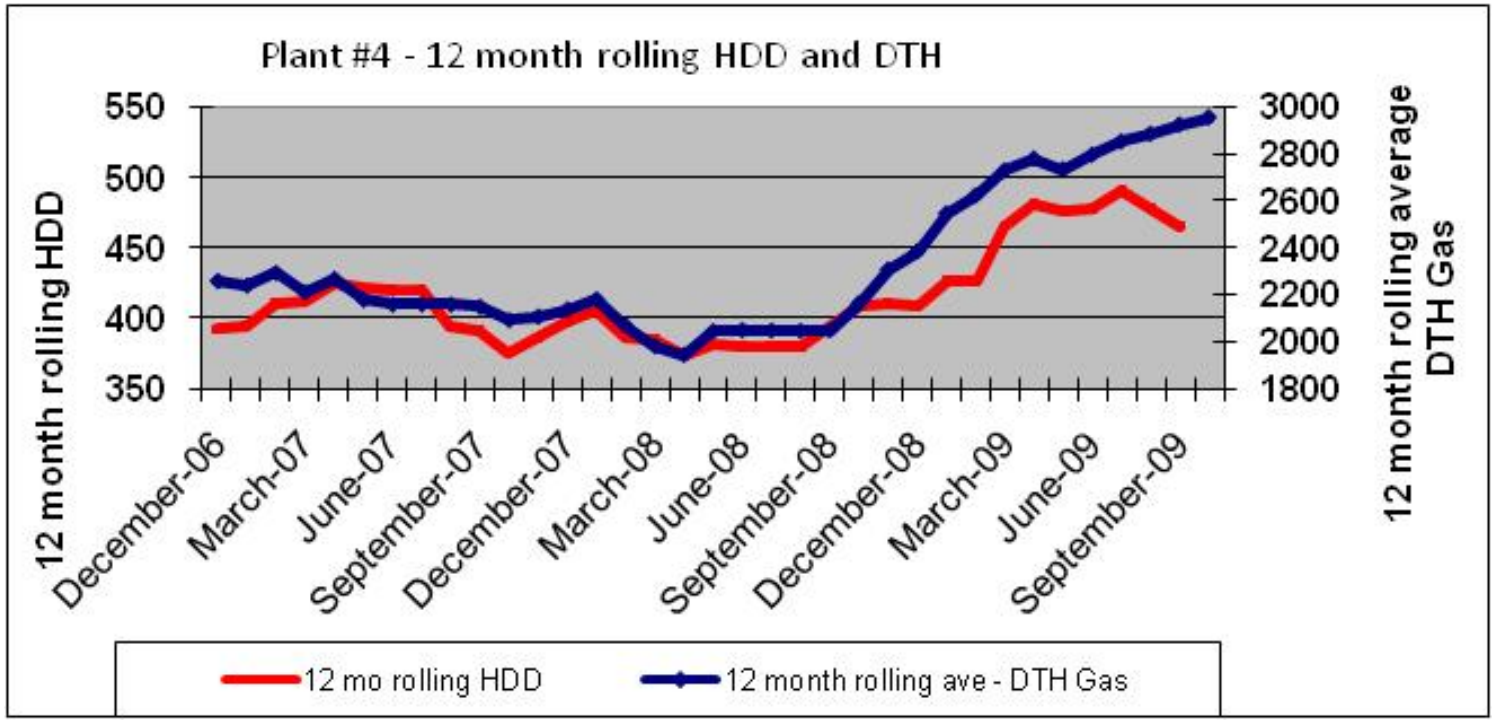
7 day Rolling Average

- From 2000 kWh/day to 1200 – with primarily just conservation BEC, Six Sigma– DMAIC, asking why!
- Drop from 1200 to 700 kWh/day with VFDs install
- 2009 was 50% less than 2008 with conservation and efficiency BEC
- Note red circle – problem found immediately taking daily reading



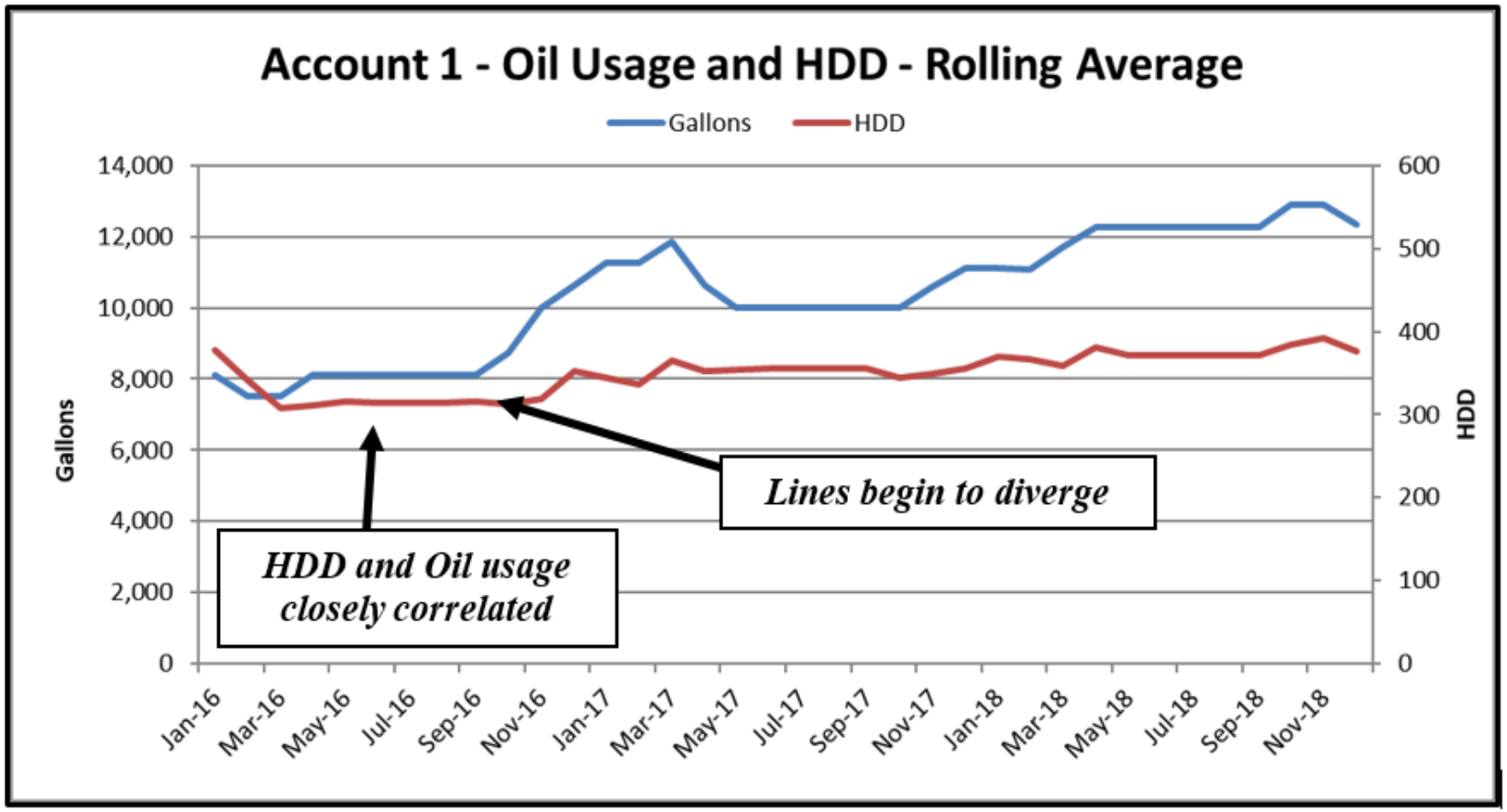
7 day rolling average

Combining Metrics as makes sense



- **Note system change September 08, and even a bit stronger change since June 09**
- **Should ask – why/what changed**
- **Found large boiler used for small space humidity need in September 2008**

12 Month Rolling Averages - Combined



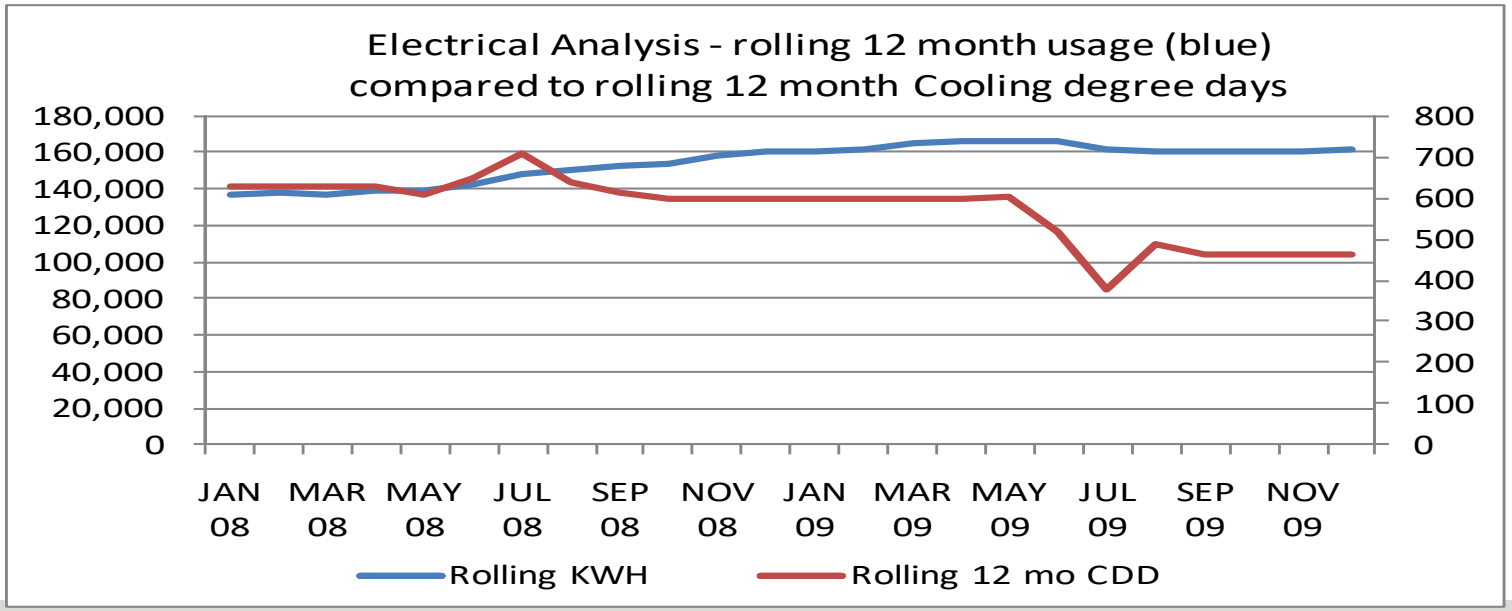
What Happened?

What if you took 2018 as baseline?

What should control limit be?

Combining Metrics As Makes Sense

- Example combined 12 month electrical usage compared to 12 month cooling degree days
- Notice change in July 2008, need to critically evaluate
- Found changed HVAC contractor Late May of 2008, they did not do good job
- Fired contractor in May 2009, got another who did better with BMS, systems



Questions

Lean Thinking and Energy Reduction

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