SOLVE FOR X.

Transforming the Battery Room with Lean Six Sigma

Presented by:

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industrial battery innovation

I thought battery rooms were dead?

- The death of the battery room has been greatly exaggerated!
- New technologies and alternate charging methods are expensive and not always appropriate or robust.
- Battery rooms remain the best and right choice for:
  - Heavy duty applications
  - 3 shift applications
  - Cold storage applications
  - Facilities that are growing

Not your grandfather's battery room

- A battery room is very forgiving, robust and adaptable to changing conditions.
- But the battery room must be brought into the 21st century.
- Lean Six Sigma principles show us the way to create the Lean Battery Room.
- The Lean Battery Room is reliable, dependable and *very cost effective.*

Outline

- Lean Six Sigma
  - Processes
  - Tools
- Case Study
  - How we applied Lean Six Sigma to a real site

What you will learn today

- Purpose for this seminar:
  - To show how simple, Lean principles can modernize your battery room and let you run it with less batteries.
- What you should take away from this presentation:
  - How to apply LSS principles to save money in your battery room.
  - The importance of data collection to improvement
    - *You can't fix what your are not measuring.*

Lean Six Sigma History

- Grew out of Deming's and many others work after WWII in the quality movement.
- **Lean** – Identify and Eliminate Waste
  - Gives companies a competitive edge by making them faster, better and cheaper than their competitors
- **Six Sigma** – Process Improvement
  - Helps you find and fix variation, errors and defects
- Merger of Lean and Six Sigma - LSS
  - Universal improvement process

Top 10 ways you know that you need to apply LSS in your battery room

1. You think you are spending too much time and money on batteries.
2. Operators have to pick batteries specifically for certain trucks.
3. You are watering your batteries by hand.
4. You are recording your battery changes on paper.
5. You guess at the number of batteries you need to buy.
6. You don’t know how many batteries you use in day.
7. Long lines in the battery rooms waiting for a battery change
8. Frequent battery changes by drivers.
9. Battery room staff complains they do not have time for maintenance.
10. Drivers complain their batteries are not lasting.

Traditional Lean Categories of Waste

- **Transportation**- Excess trips to battery room
- **Inventory**- Too many batteries
- **Motion**- Inefficient battery changing
- **People**- Underutilizing personnel
- **Waiting-** Lining up for battery changes
- **Overproduction**- Not applicable
- **Overprocessing**- Early return to the battery room
- **Defects**- Using a non fully charged battery

A Different View of the Battery Room

- View your battery room as a production process.

  If you can't describe what you are doing as a process, you don't know what you're doing. ----Edward Deming

- The battery room is integral to the success of the whole facility's operation.

- What is the goal of the battery room?
  - To provide a reliable and low cost source of power for your fleet of fork trucks

Battery Change Process -- SIPOC Diagram

Suppliers	*Inputs*	*Process*	*Outputs*	*Customers*	*Requirements*
• Battery Co. • Exchangers • Fork truck Dealers	• Returning Battery • Charger • Fork truck • Deionized water		•Truck with charged battery • Battery charged • watered battery (if low)	• Operators • Battery Attendants • Operators • Ops Managers	• Battery is watered • Battery is fully charged • Exchange done safely and with minimal delay.

Process Start 1 – ID Need for Battery Change → Process Step 2 – BA Selects next battery to give out. → Process Step 3- Driver prepares truck for change → Process Step 4: BA exchanges battery → Process Step 5 – BA puts battery onto charger

Source: www.iSixSigma.com

Key Outputs for Driver

- Get a battery quickly
- Get a fully charged & properly watered battery
- That lasts as long as possible

Maximize performance

Key Outputs for Management

- Fewer batteries to manage
- Longer battery life
- Less time spent on battery changes
- Reduce time spent on maintenance

Minimize cost

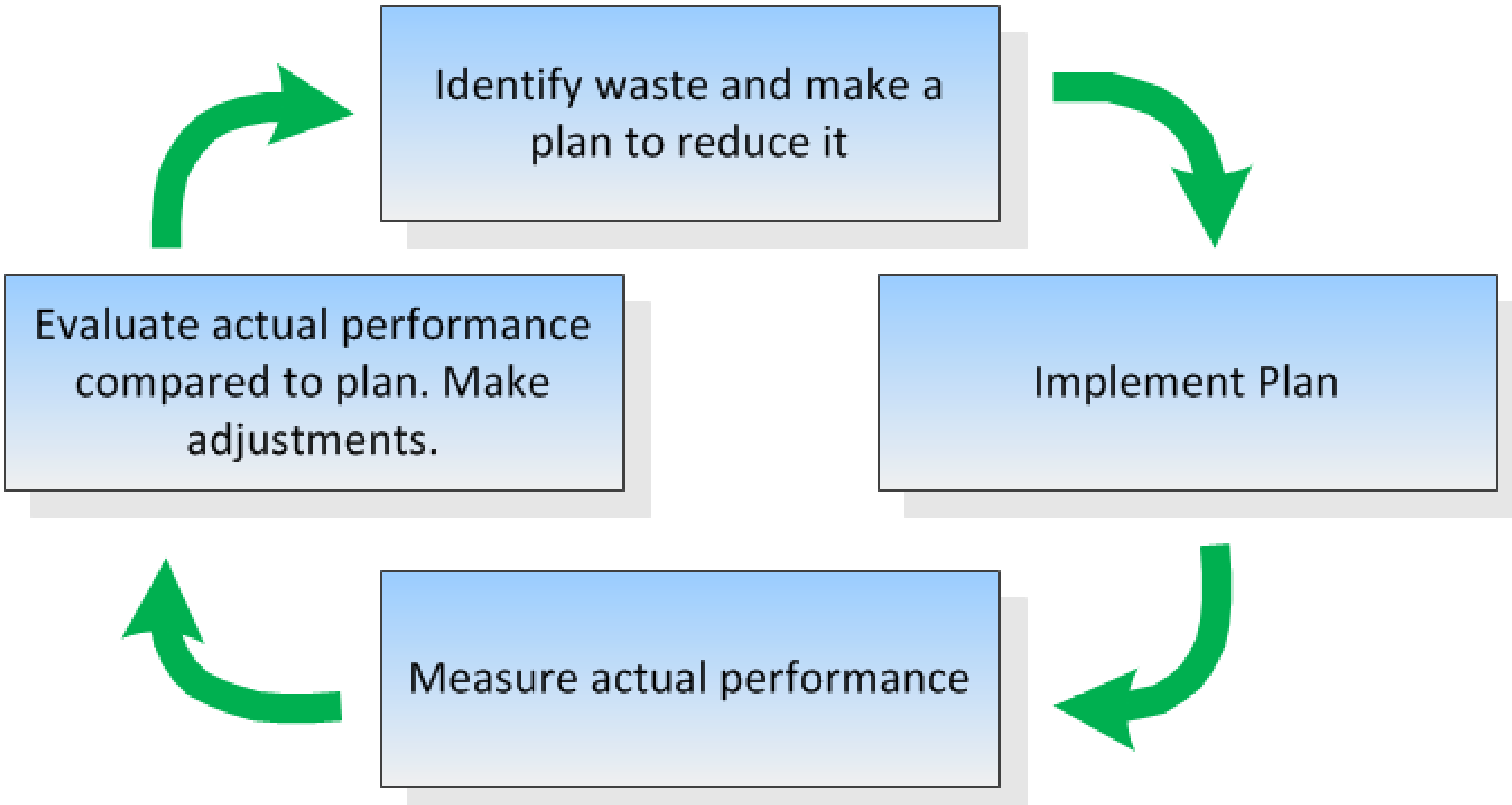
Resolving the Tension

- Maximize performance vs. minimize cost
- This is a common issue in dynamic systems
- Dynamic systems require management tools to keep the two conflicting outputs in balance
- Lean Six Sigma provides us with the methodology

Let's FISH – A Simple Problem Solving Model

- **F**ocus
  - Define the problem & measure the process
- **I**mprove
  - Analysis & Improvements
- **S**ustain
  - Monitor, Manage & Control
- **H**onor
  - Recognize, review & refocus
  - Make it a best practice across your enterprise

Basic Lean Steps



Identify The Problem

- One of the initial key steps is to identify the problem.
  - ***A problem well stated, is a problem half solved.***
    Charles Kettering- inventor and head of research for GM

- The initial problem statement from our case study site came from the operators:

"Why I am waiting so long to get a battery that doesn't last?"

Tools to identify the issues and get fast improvements

- FISH – Method
- Eliminate non-value add activities (Waste)
  - Process Time, Waiting for batteries
  - Detailed Process Mapping
- Apply the 5S – Reorganizing the battery room
  - Organize -Label each battery slot and charger
- Shift Observations and Walk Through equipment inspections
- Interviews with Operators and Maintenance Staff

How to Measure?

- Manual
  - Collect and organize data on the various steps of the process
  - Video the Battery Change Process for detailed analysis
- Automatic
  - Battery management or monitoring system

Measurements: Battery Change Data

- Battery demand per day
  - How do you know when the workload changes?
- Battery change time
  - Are you efficient in the battery room?
- Battery run time
  - Identify good and bad batteries.

Sample: Manual Data Collection Sheet

Instructions: This sheet should be used to record each battery change during the test period.					One sheet per shift or day					
Date:										
Operator Name:										
	Process Time			Change Process						
Battery Change #	Change Start time	Change End Time	Total Time (End-Start) in Minutes	Truck #	Deadman hours (taken from hr meter)	Old Battery	Old Battery Voltage	New Battery	Temp of Battery (1 cold, 3 war, 5 hot)	Water needed? Y or N
ex A	9:20 AM	9:31:00 AM	11	G07	1121	10	35.2	17	2	Y
1										
2										
3										
4										
5										
6										
7										
8										

Battery Demand/ Day

Process Duration

Battery Run Time

Battery DOD Voltage

Automatic System: Battery Run Time

Details

Battery Id	Changes	Average Run time	Times Washed	Last Washed	Times Watered	Last Watered
100	0	N/A	0	N/A	0	N/A
101	14	8.2	0	N/		
102	20	8.4	0	N/		
103	16	8.2	0	N/		
104	14	8.2	0	N/		
105	18	8.3	0	N/		
107	12	8.0	0	N/		
108	14	7.4	0	N/		
109	11	8.6	0	N/		
110	17	8.0	0	N/		
111	18	7.4	0	N/		
112	15	8.4	0	N/		
113	10	7.8	0	N/		
114	13	7.9	0	N/		
115	16	7.2	0	N/		
116	11	7.1	0	N/		
117	0	N/A	0	N/		
118	17	7.7	0	N/		
119	17	6.7	0	N/		
120	12	7.8	0	N/A	0	N/A

#	Event Time Local	Event	Truck ID	Match	Run Time
1	02/09/2015 16:05	Changed	IN65	Yes	11.7
2	02/11/2015 19:17	Changed	IN81	No	-
3	02/16/2015 07:26	Changed	IN83	Yes	7.0
4	02/20/2015 15:09	Changed	IN86	Yes	8.6
5	03/01/2015 10:58	Changed	IN84	Yes	9.6
6	03/02/2015 22:17	Changed	IN05	No	-
7	03/09/2015 10:05	Changed	IN83	No	-
8	03/12/2015 10:23	Changed	IN02	Yes	7.8
9	03/19/2015 07:06	Changed	IN84	Yes	8.8
10	03/21/2015 21:03	Changed	IN87	Yes	8.1
11	03/28/2015 07:36	Changed	IN6	Yes	8.8
12	04/06/2015 04:12	Changed	IN7	Yes	7.0
13	04/17/2015 10:16	Changed	IN15	Yes	5.1
14	04/21/2015 13:54	Changed	IN6	No	-

Measurements: Battery Charging Process Data

- Minimum Charged Batteries Available
  - Are you running out of batteries?
- Charger Utilization
  - Are all of your chargers working?
- Battery Cool Down Time
  - Are your batteries getting enough cool down time?

Sample: Manual Data Collection Sheet

Instructions: Hourly walk through charger status inventory   SOC: 0= No battery, 1=Charging, 2=Fully charged, X=Charger faulted

Label Chargers with numbers for organizational id

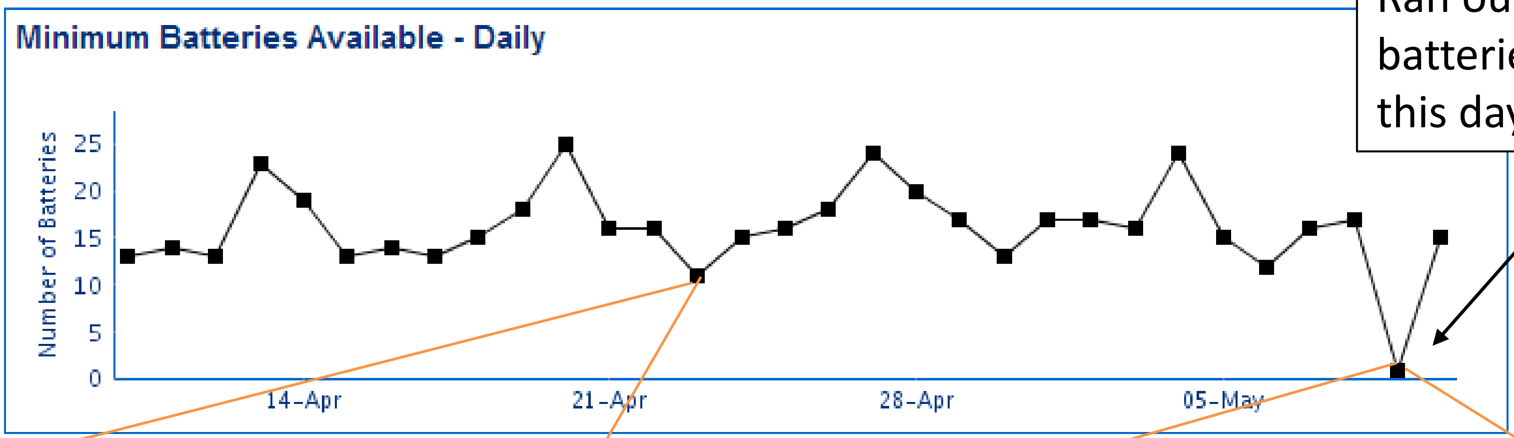
Date:_____________

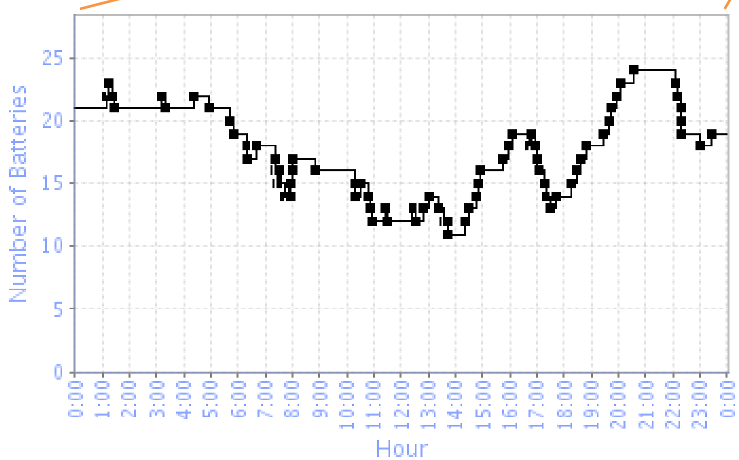
Time		Charger 101	Charger 102	Charger 103	Charger 104	Charger 105	Charger 106	Charger 107	Charger 108	Charger 109	Charger 110
EX:00:00	Battery #	R05		R16	R12	R15	R10	P01	P04	P19	P16
	SOC	1	0	1	2	x	1	1	2	2	1
7:00 AM	Battery #										
	SOC										
8:00 AM	Battery #										
	SOC										
9:00 AM	Battery #										
	SOC										
10:00 AM	Battery #										
	SOC										
11:00 AM	Battery #										
	SOC										
12:00 PM	Battery #										
	SOC										
1:00 PM	Battery #										
	SOC										
2:00 PM	Battery #										
	SOC										
3:00 PM	Battery #										
	SOC										
4:00 PM	Battery #										
	SOC										
5:00 PM	Battery #										
	SOC										

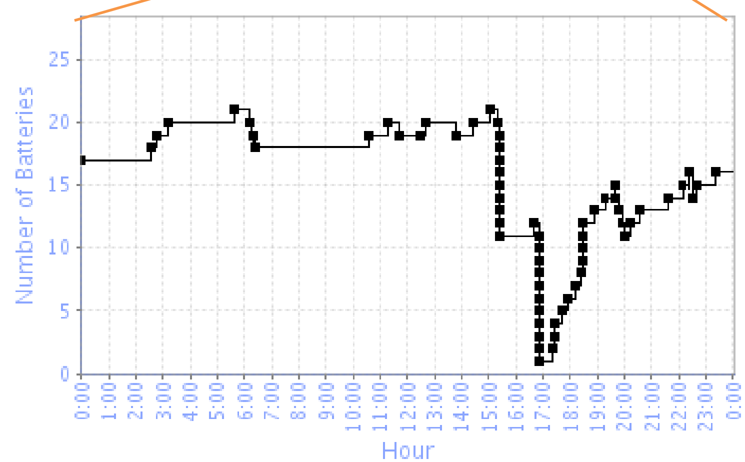
- Min Batteries Available
- Battery Charge Duration
- Charger Utilization
- Battery Cool Down

Automatic System: Battery Room Status

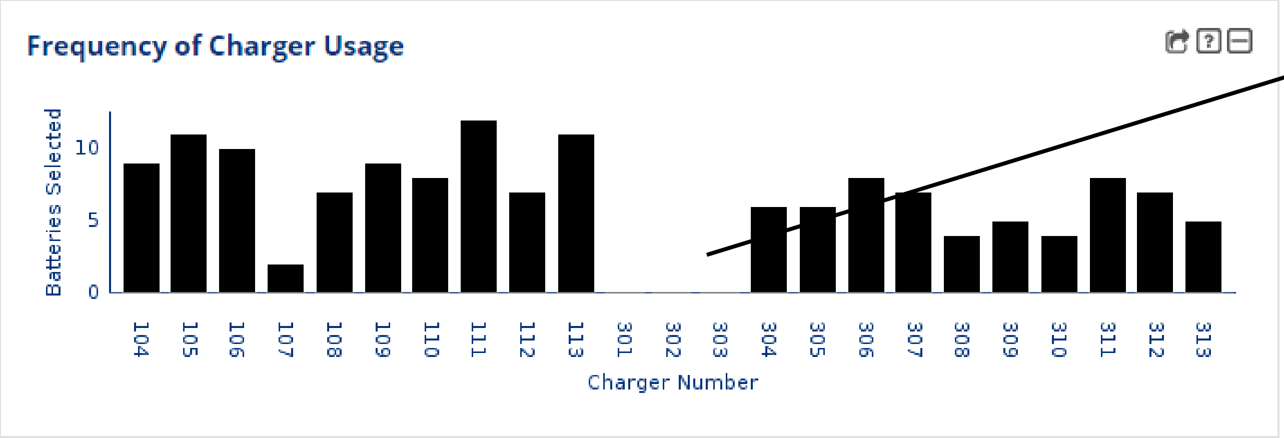
Ran out of batteries on this day







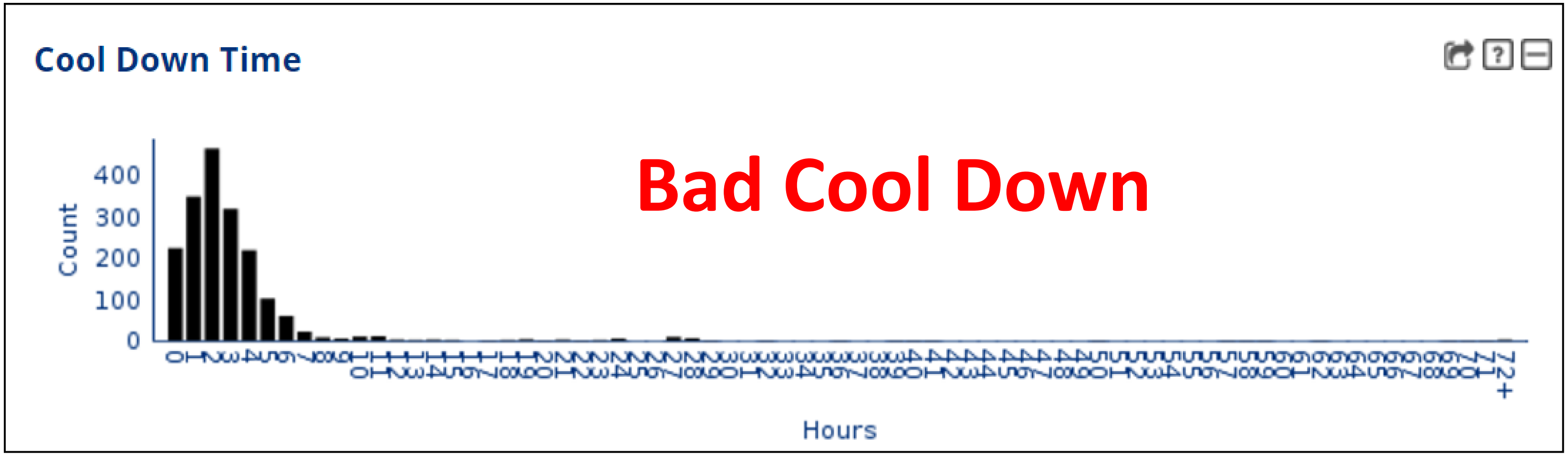
Automatic System: Frequency of Charger Usage

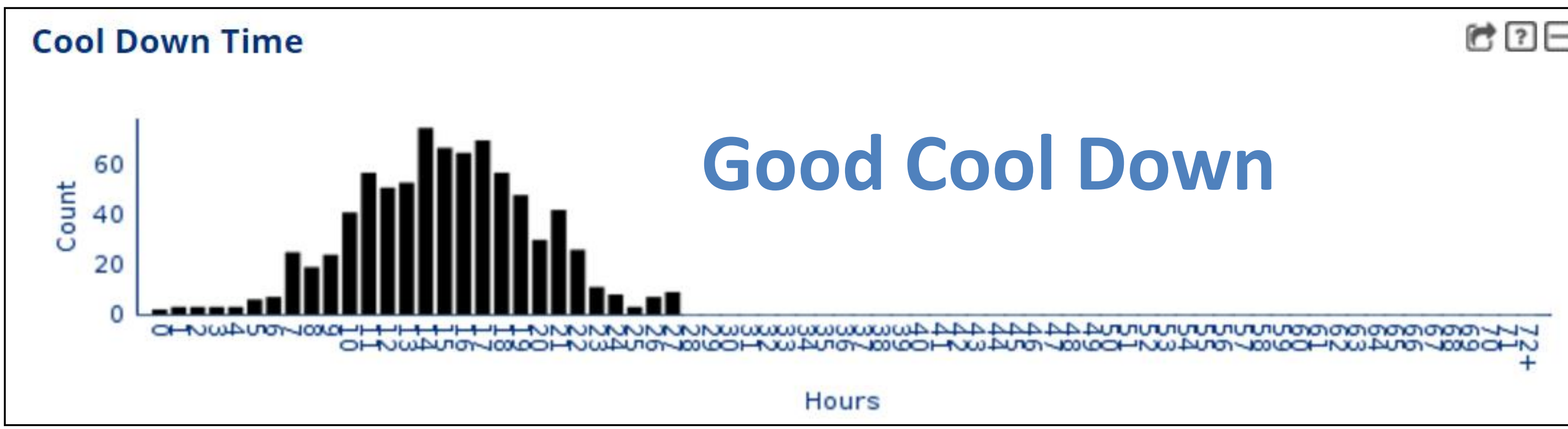


Shows uneven usage and chargers not working

Shows All Chargers working with equal usage

Automatic System: Battery Cool Down Metric

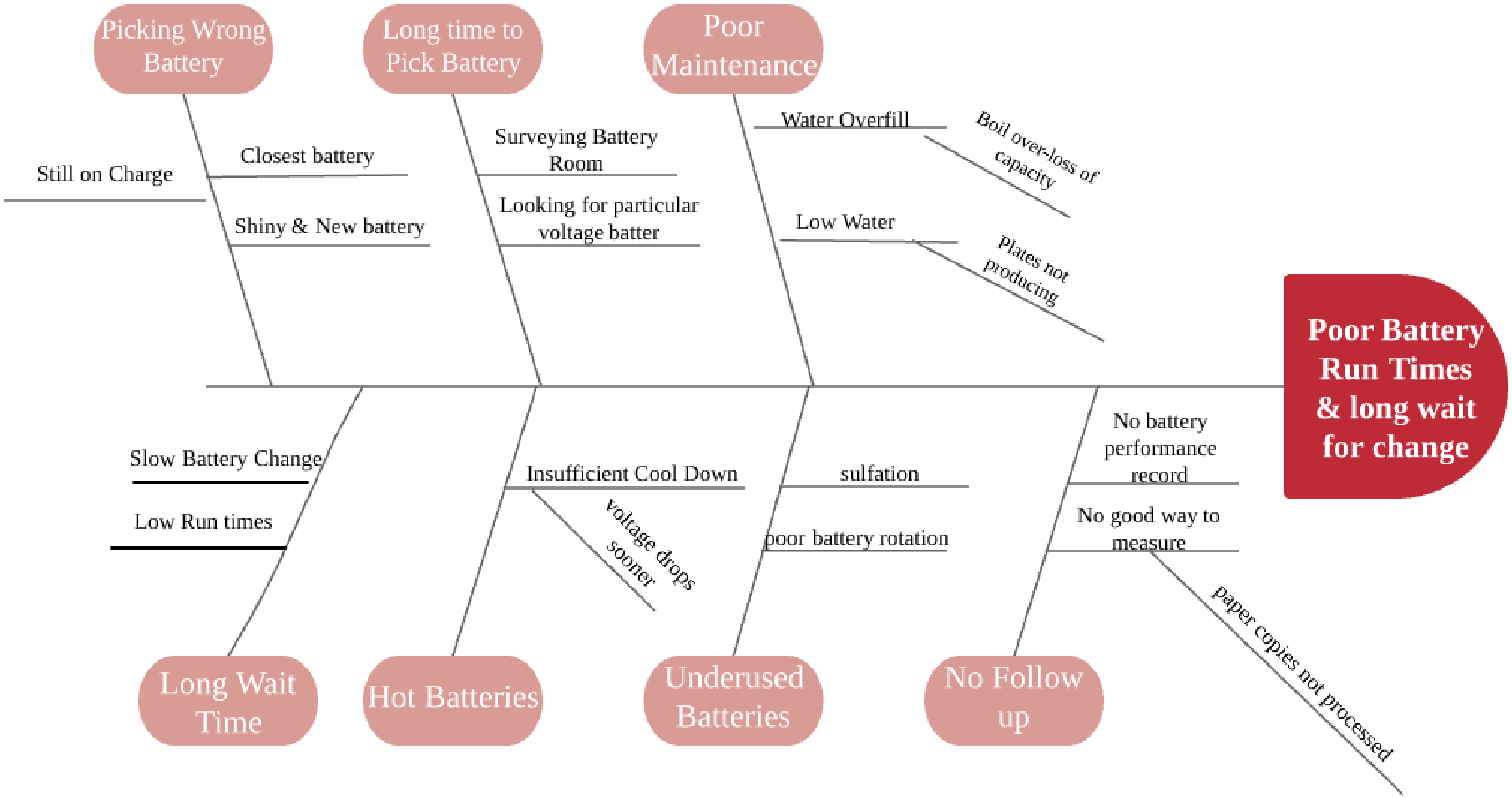




Analyze your Data

- Create graphs based on your data
  - Histograms good for central tendency and variation
  - Control charts for daily variation of the process
- Look for variation in the process
  - What is the expected battery run time?
  - What does your data show you are getting?
- Look for defects in the process
  - Low run time batteries
    - Pareto Sort on Battery Run Time Data (Low to High)
  - Non functional chargers
- Identify patterns to find root causes

Identify potential root causes: Fishbone Diagram



Correction Strategies: Address each root cause

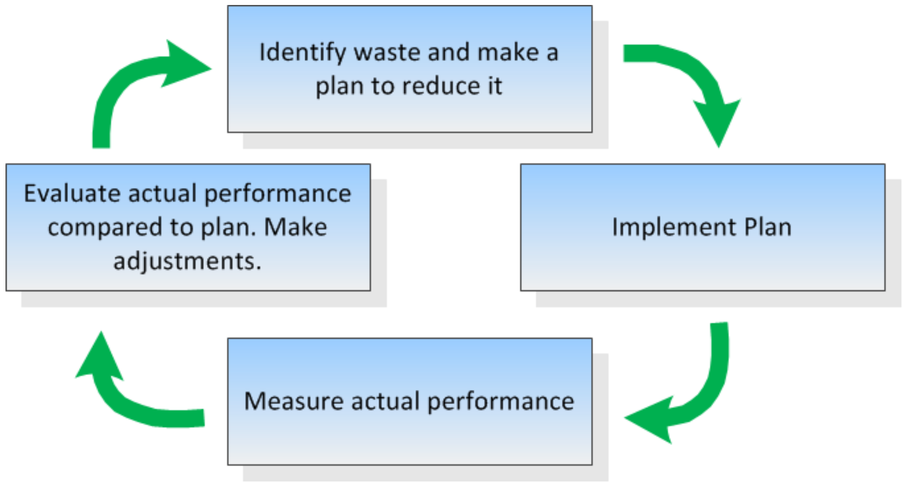
1. **Picking the wrong battery:**
   - Rotate batteries based on completion of charge (Quality Standard)
2. **Taking a long time to pick a battery**
   - Eliminate non value added activity
   - Reduce selection time with a rotation system
3. **Poor Battery Maintenance**
   - Install battery watering systems and battery watering monitors
   - Use water deionizer to product battery water
   - Record watering activity for each battery
4. **Hot batteries resulting in short life and run time**
   - Use a battery management system to maximize cool down time
   - Properly size the battery fleet

Correction Strategies: Address each root cause

5. **Underused batteries** – short life (sulfation)
   - Prevent uneven use by using a battery management system.
   - Remove unnecessary batteries
6. **Long lines in the battery room** (traffic jams)
   - Increased battery run time to minimize number of changes per day.
   - Faster change process to minimize time spent in battery room.
7. **No good way to measure and keep track of batteries**
   - Use a monitoring and measurement system.
   - Require regular inspections of the battery room
8. **No follow-up on issues**
   - Management system keeps track of chargers, run time, mispicks, watering, etc..

Improve Phase - Summary

- Install/implement the corrective strategies.
- Continue to monitor the metrics you established.
- Evaluate if your solutions are working.
- Adjust as necessary.



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Case Study

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Equipment Installed

- Battery management system to manage battery room:
  - 229 Chargers
  - 2 battery extractors
  - 738 Batteries
- Battery Watering Systems and Battery Watering Monitors on 36 V batteries

Timeline

- May 2014: System installed
  - Baseline data collection began
  - No operator guidance

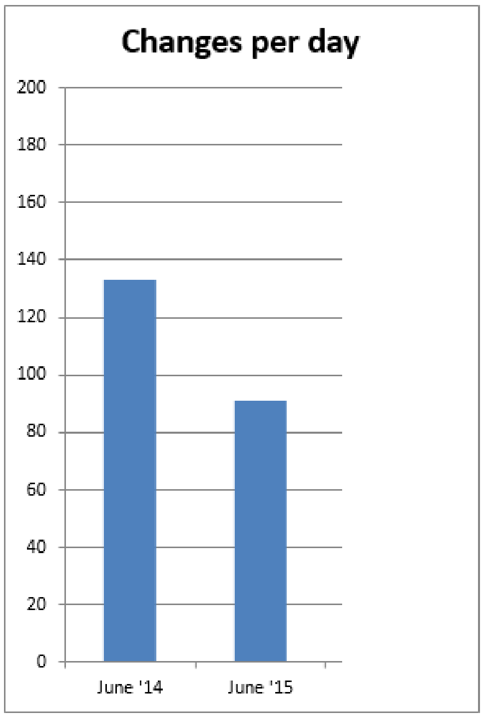
- June 2014: Operator Guidance Began
- June 2015: One year in full operation
- June 2016: Two years in full operation

Actions Taken

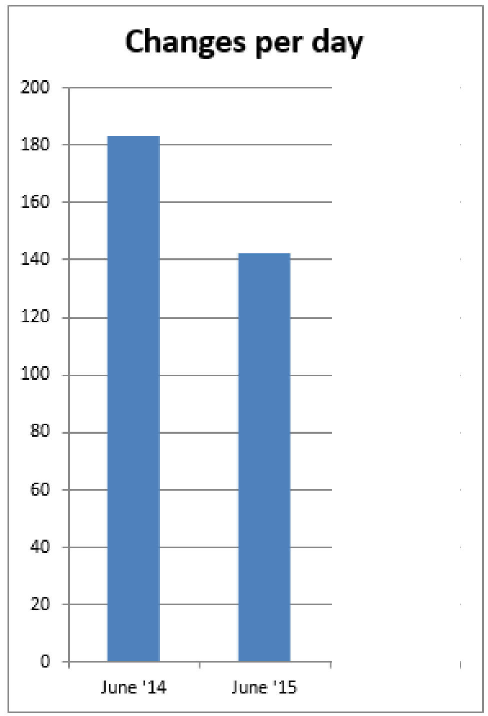
- Using Data from battery management system:
  - Identified batteries to scrap based on run-time.
  - Correctly determined number of batteries needed.
  - Found many chargers that needed repair.
- Batteries are rotated so the coolest battery is used.
- Only fully charged batteries are given out.
- Operator training on the system and battery maintenance practices – when to water etc.
- Batteries (36V) watered in 15 seconds on the rack.
  - Many batteries were very dry.

Battery Change Results

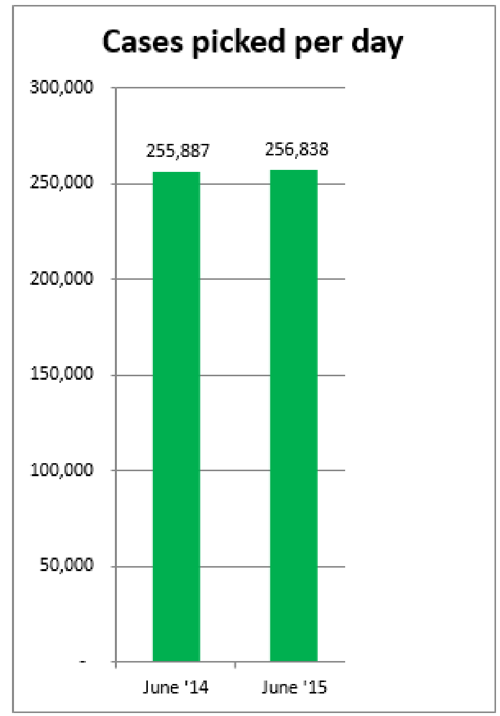
Forklift	Pallet Jack	Cases



32% down



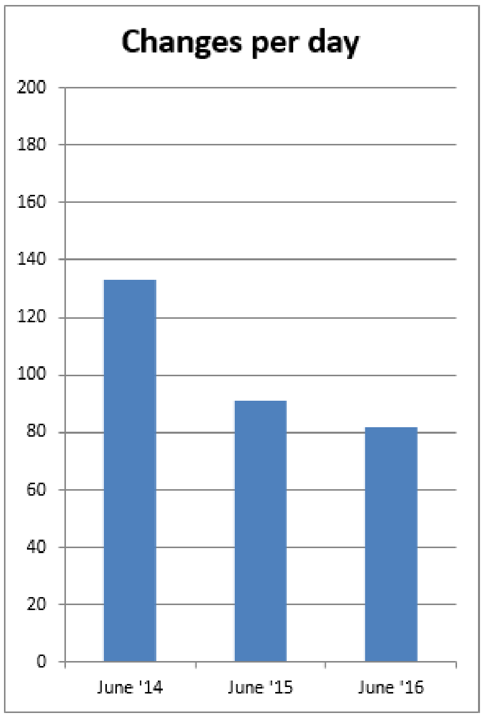
22% down

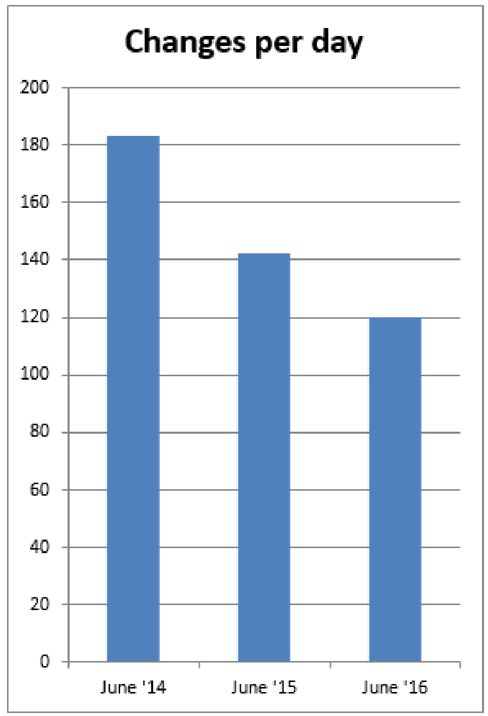


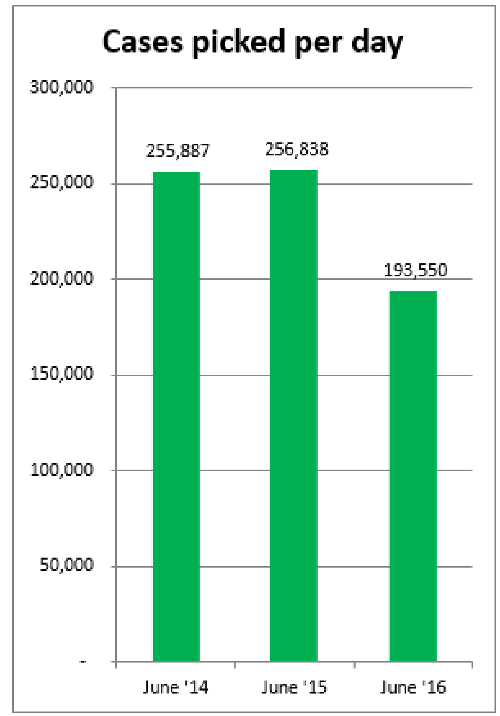
0.4% up

Battery Change Results

Forklift	Pallet Jack	Cases



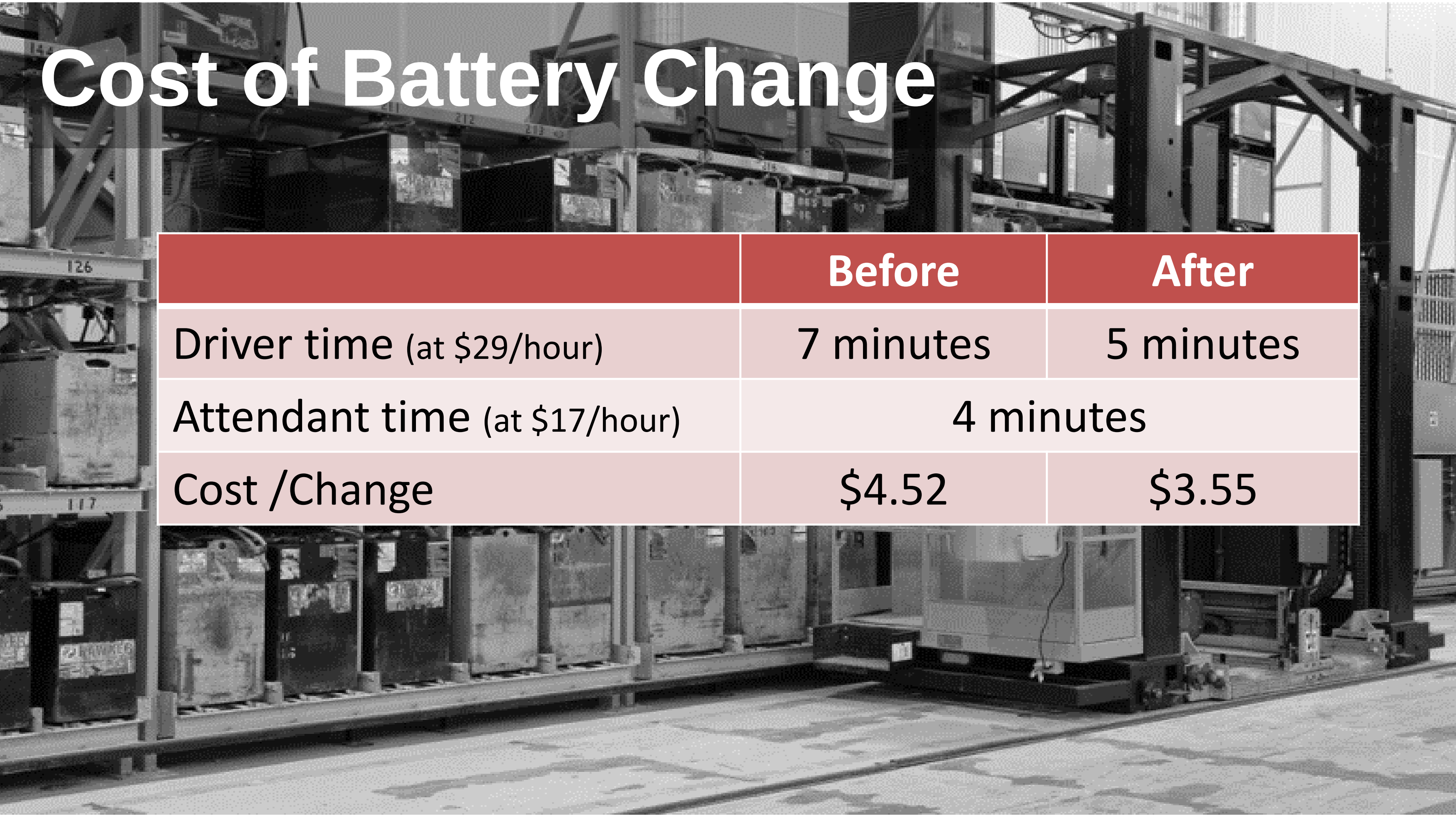




32% down　10% down　22% down　15% down　0.4% up　25% down

Cost of Battery Change

	Before	After
Driver time (at $29/hour)	7 minutes	5 minutes
Attendant time (at $17/hour)	4 minutes	
Cost /Change	$4.52	$3.55



Battery Change Savings

	Before	After
Battery changes / year	115,340	85,045
Cost of battery change	$4.52	$3.55
Cost per year	$466,403	$271,676

Yearly Savings

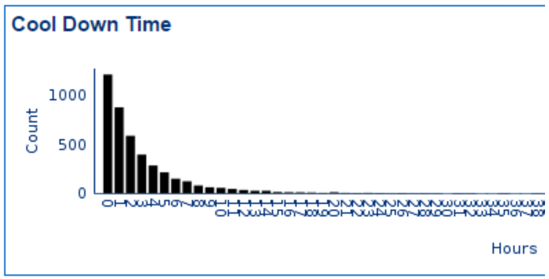
$194,728

Battery change savings continued in 2016.

Cool Down Time

Pallet Jack

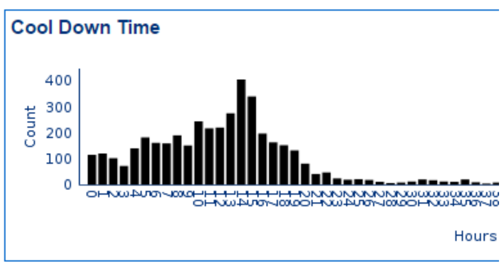
2014



3.3

Hours Average

2015

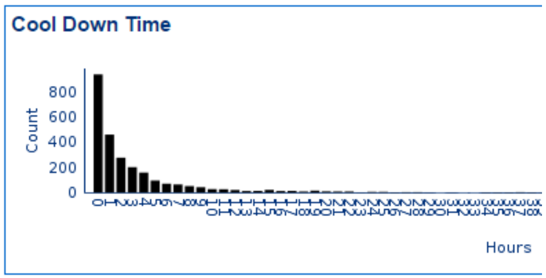


11.8

Hours Average

Forklift

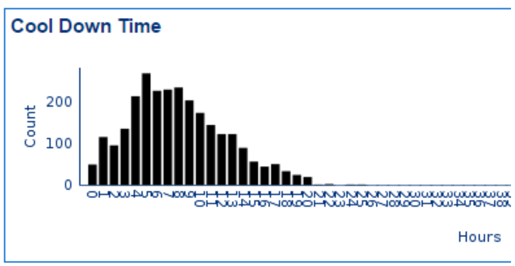
2014



3.4

Hours Average

2015



8.5

Hours Average

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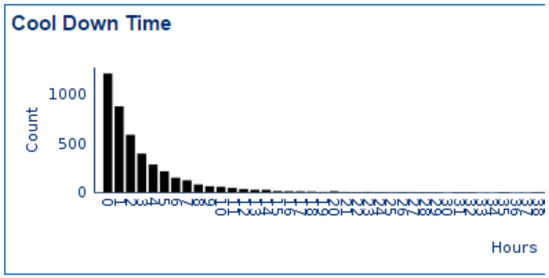
Cool Down Time

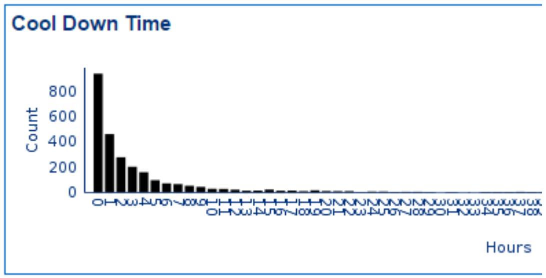
Pallet Jack		Forklift	

2014



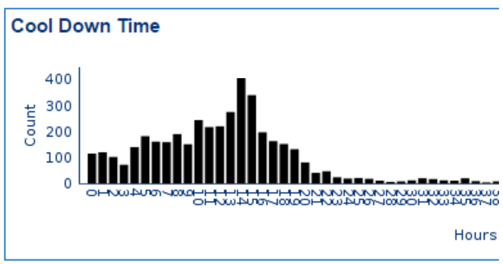
3.3
Hours Average

2014



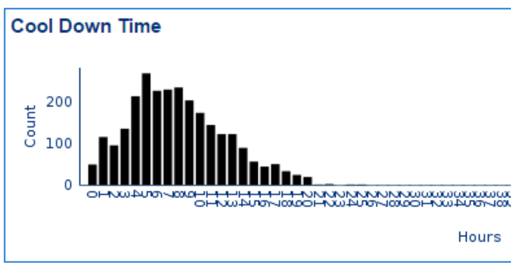
3.4
Hours Average

2015



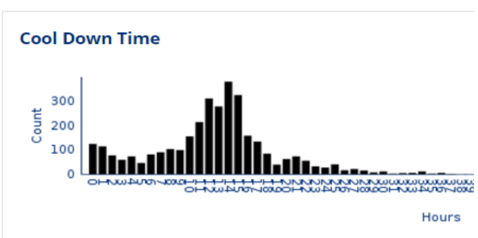
11.8
Hours Average

2015



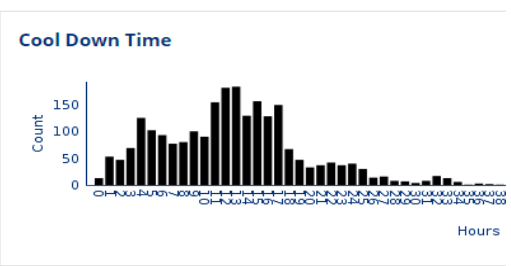
8.5
Hours Average

2016



12.3
Hours Average

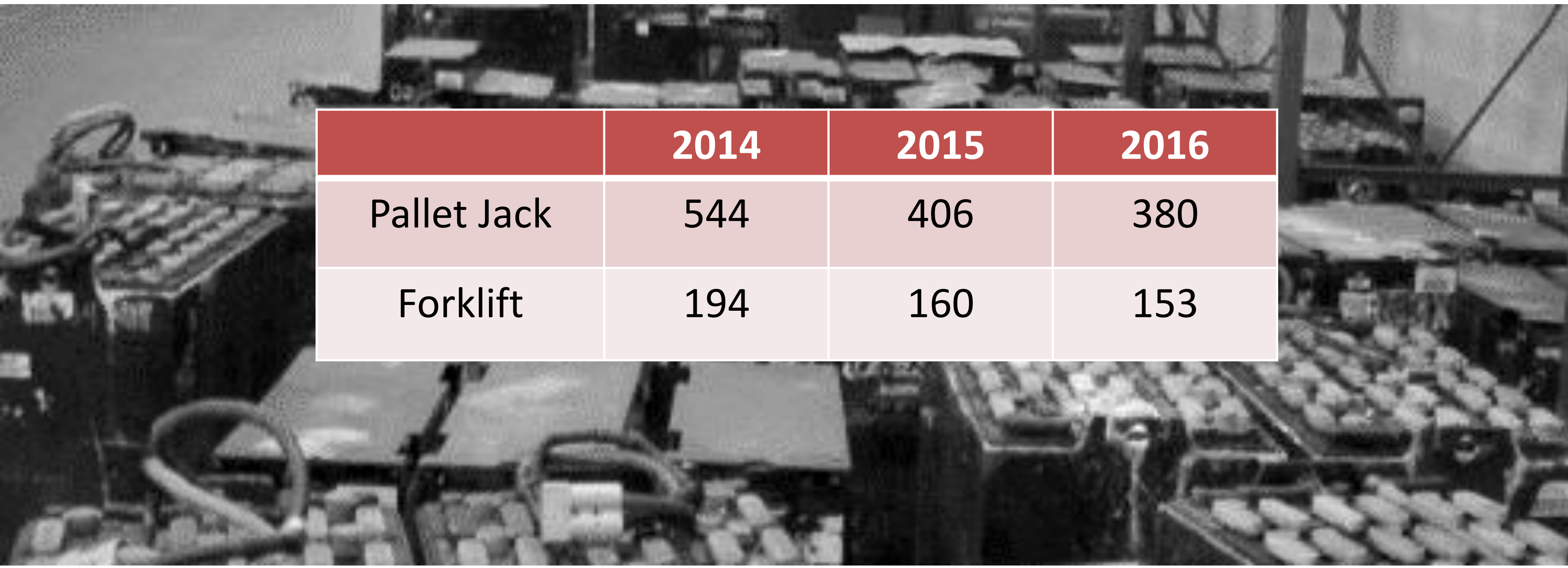
2016



12.2
Hours Average

Reduction in Battery Fleet

Using management system data

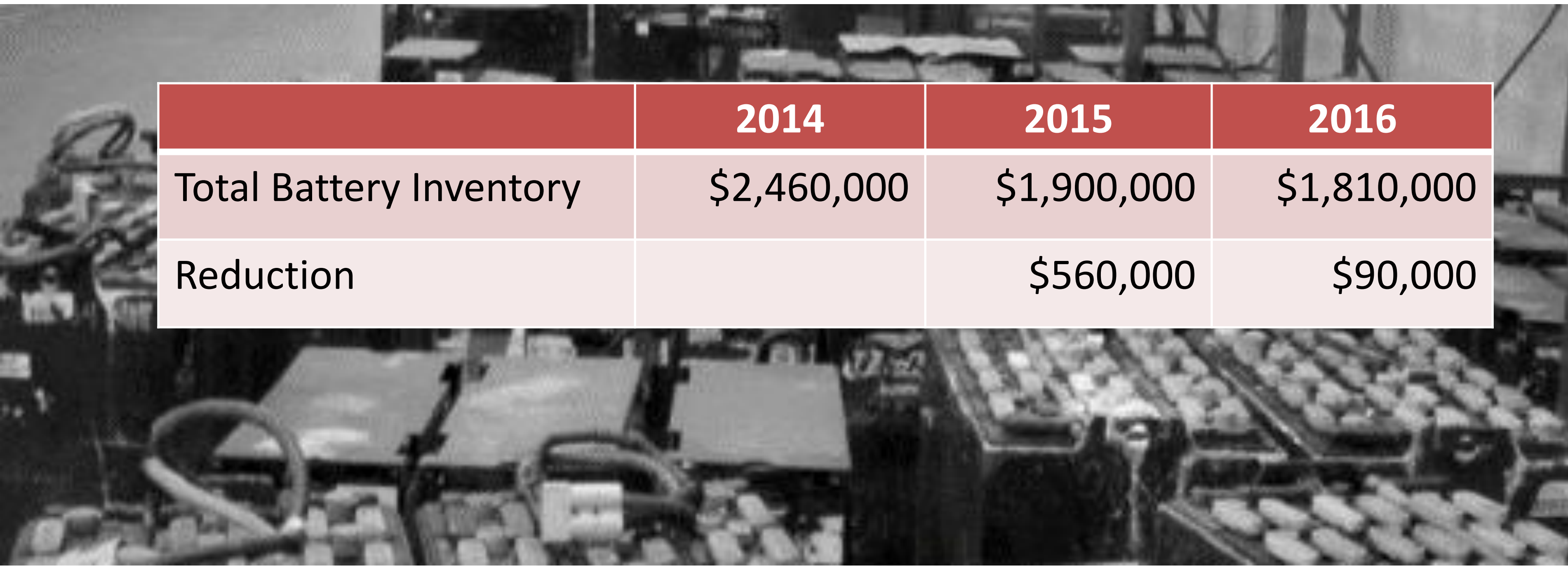


	2014	2015	2016
Pallet Jack	544	406	380
Forklift	194	160	153

Batteries identified as short run-time were removed.

Reduction in Battery Fleet

Using management system data



	2014	2015	2016
Total Battery Inventory	$2,460,000	$1,900,000	$1,810,000
Reduction		$560,000	$90,000

Value of Scrapped Batteries

	24V	36V
Reduction in number of batteries	138	34
Scrap value of battery	$400	$761
One-time scrap payment to customer	$55,200	$25,874

Total scrap value = $81,074

Reduced Battery Purchases

- Average battery purchase before LSS:
  - $213,000 per year
- Projected Annual Savings
  - $42,600 per year
  - Battery life increase from 4 to 5 years = 20% decrease in battery purchases
- Actual battery savings for 2016
  - **$75,227** (35% Less)

Return on Investment

- Cost of equipment = ($58,000)
  - Cost of management system = ($100,000)
  - Cost of watering systems = ($39,000)
  - Money for scrap = $81,000
- Yearly savings = $237,600
  - Labor = $195,000
  - Equipment = $42,600
- Payback period = 3 months

Case Study Summary

- Management system paid for itself in 3 months.
- Annual savings have continued and improved in year 2 of operating the system.
- Facility is running effectively with less assets.
  - Batteries lasting longer due to improved cool down.
  - Run times are longer due to proper charging and rotation.
- Data generated from the system allows confidence to reduce batteries and adapt to changes in DC business.

Conclusion

- LSS can transform battery rooms when viewed as a process to be improved.
- Continuous data collection is critical since facility and business conditions continually change.
- The cost of implementing LSS should be considered an investment as the returns are justified.
- Even small changes can add up to big savings over time.

For More Information:

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