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Industrial Assessment Center

Establishing a Baseline with **Lean Energy Analysis**

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EFFECTIVE ENERGY MANAGEMENT

Develop Baseline

- Utility analysis
- Plant energy balance
- Lean energy analysis (LEA)

Take Action

- Identify and quantify energy saving opportunities
- Prioritize energy saving opportunities
- Implement energy saving opportunities

Measure and Benchmark to Sustain Efforts

- Develop metrics for system energy efficiency
- Measure energy efficiency improvement with sliding NAC
- Compare energy efficiency between facilities with NAC

LEAN ENERGY ANALYSIS

What is it?

Using statistical models to quantify the relationship between energy use and:

- Production
- Weather

What is the benefit?

Deriving actionable information from models

LEAN ENERGY ANALYSIS

Like the well-known principles of lean manufacturing, Lean Energy Analysis identifies energy use which does not directly:

- Add value to the product
- Add value to the plant environment

Our statistical analysis utilizes **actual** temperature data obtained from the Average Daily Temperature Archive

Average Daily Temperature Archive

The UNIVERSITY of DAYTON

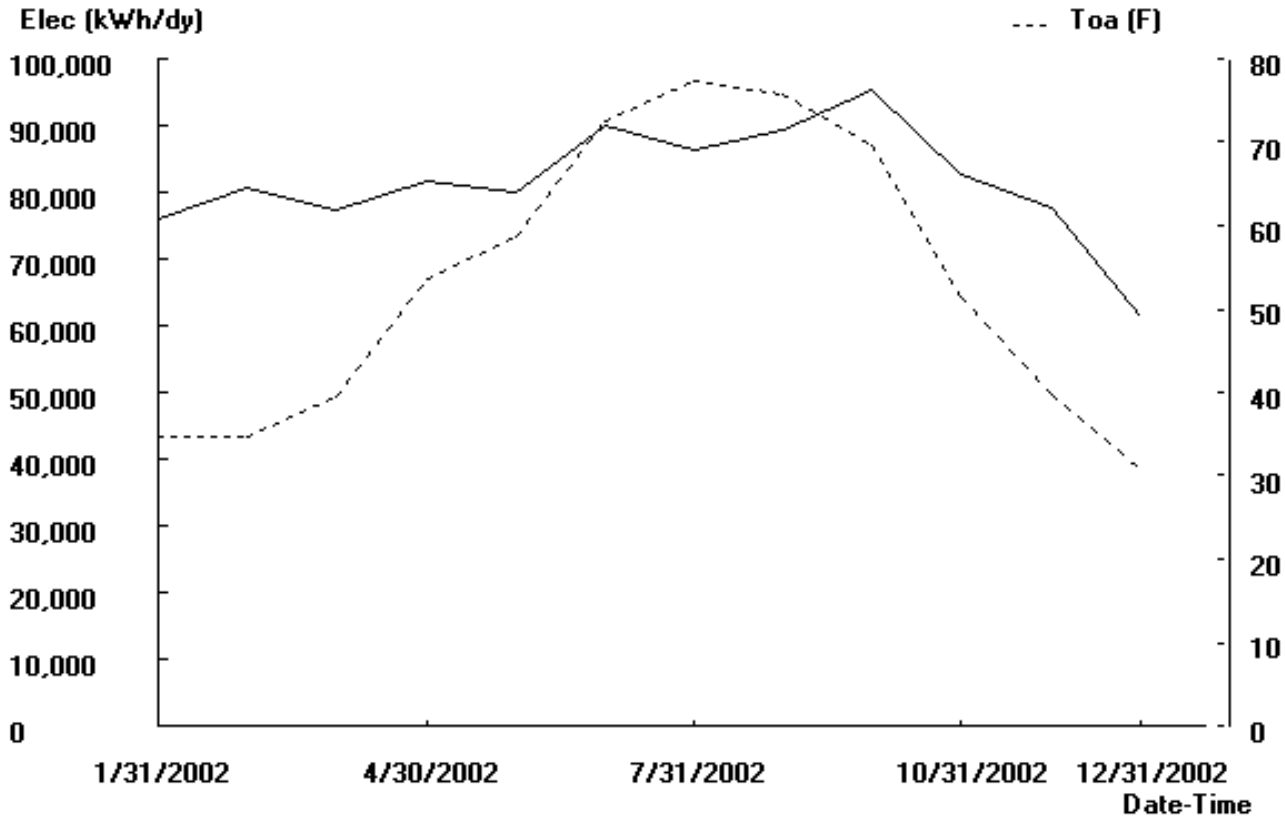
LEA Indicators of Savings Opportunities

- High “Independent” indicates waste
- Departure from expected shape
- High scatter indicates poor control

SOURCE DATA

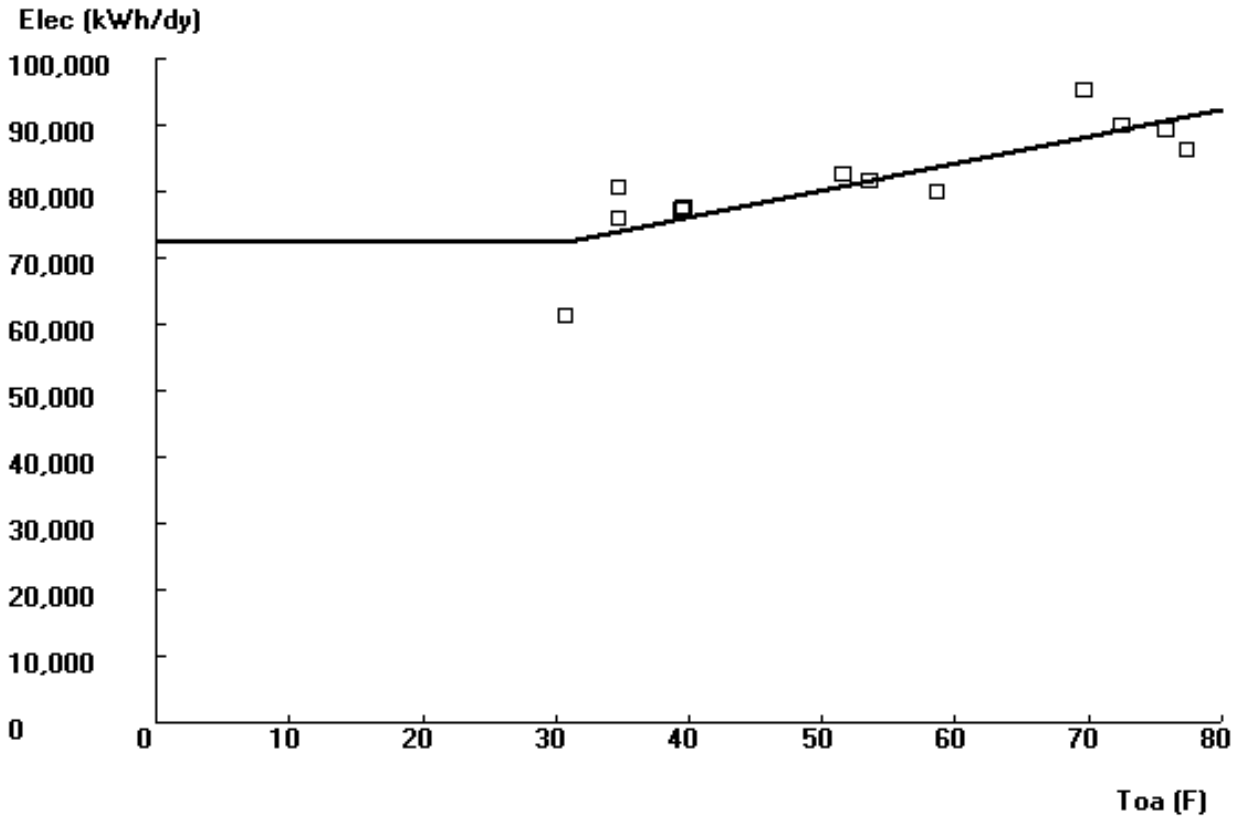
Date	Consumption (kWh/month)*	Production (tons/month)	Temperature (F)
6/16/2010	2,220,207	509	-
7/16/2010	2,226,500	409	71.7
8/16/2010	2,119,355	435	76.1
9/15/2010	1,905,300	460	76.6
10/13/2010	1,822,393	446	68.9
11/11/2010	1,721,793	428	48.1
12/15/2010	1,681,147	381	32.8
1/18/2011	1,610,294	405	24.0
2/16/2011	1,819,966	447	21.3
3/17/2011	1,880,379	526	35.5
4/15/2011	1,850,172	423	44.0
5/19/2011	1,861,500	420	54.3
6/20/2011	1,977,844	510	70.2

ELECTRICITY VS. OUTDOOR AIR TEMPERATURE



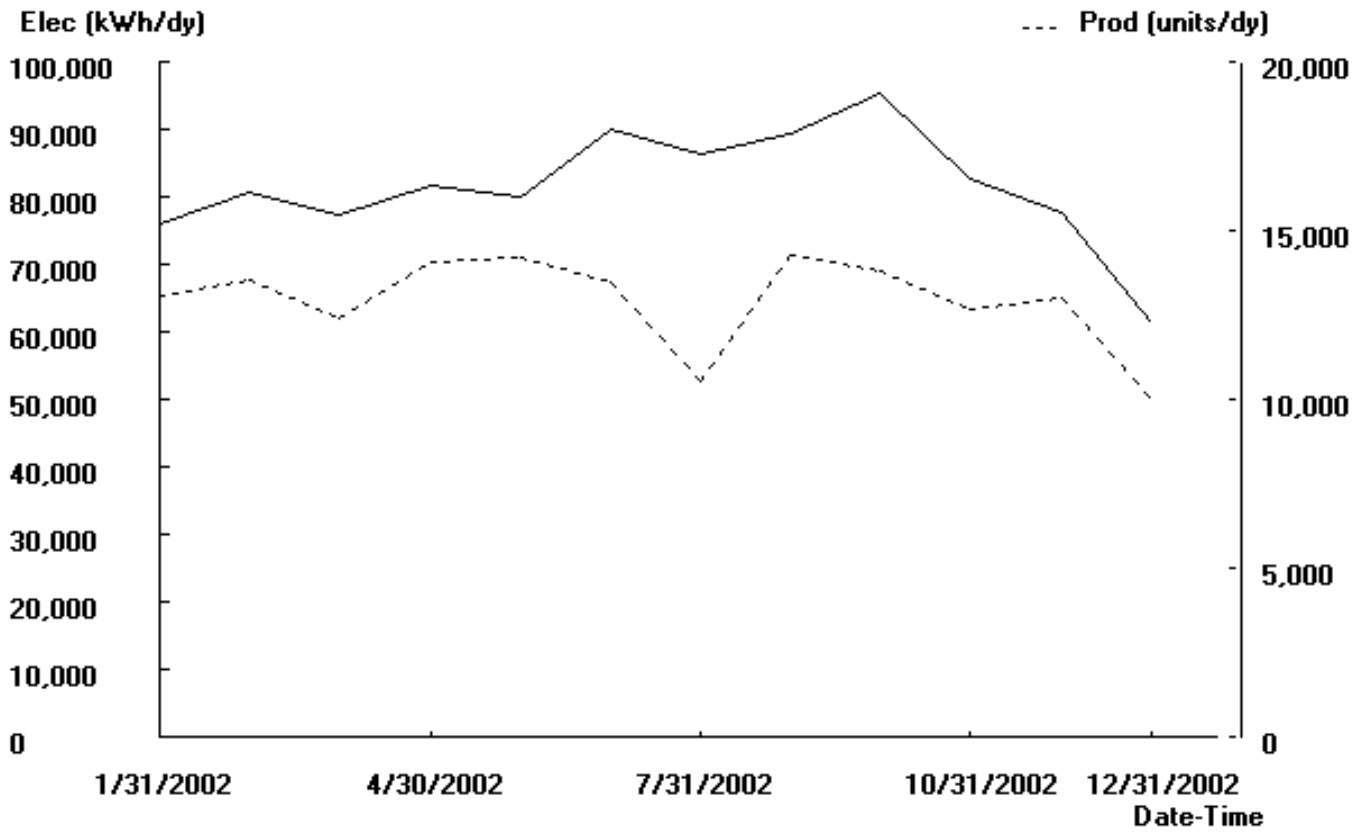
- Electricity and temperature have **direct** relationship
- Note seasonal shift in electrical energy use

ELECTRICITY VS. OUTDOOR AIR TEMPERATURE: 3PC



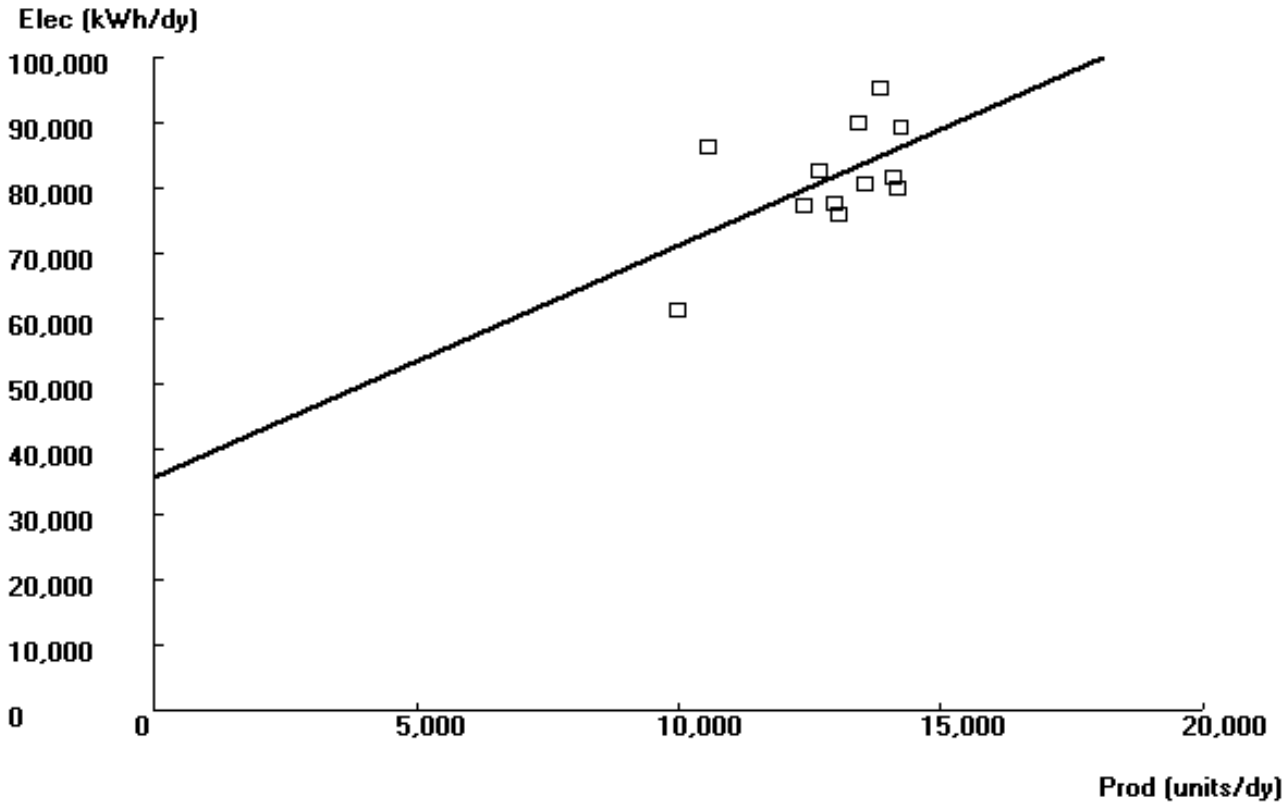
- **R^2** = 0.67 – Accounts for variation in data
- **CV-RMSE** = 6.4% - Deviation from model

ELECTRICITY VS. PRODUCTION



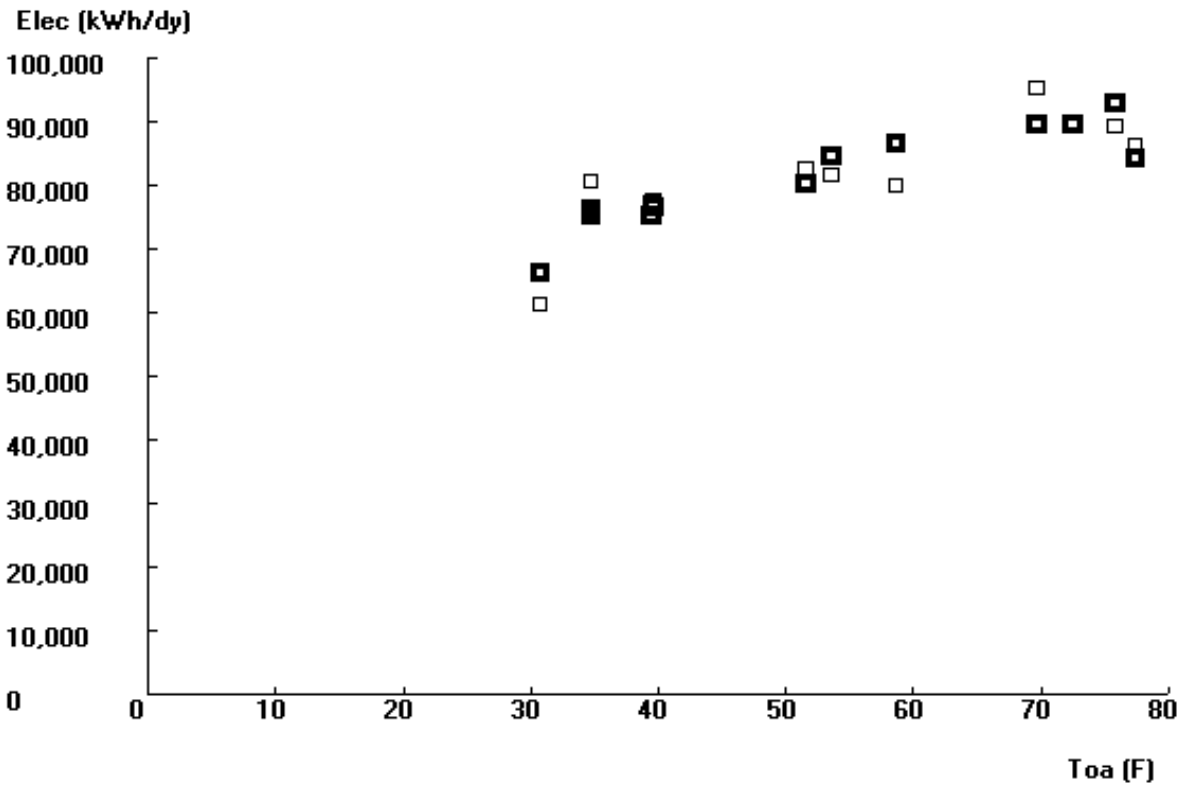
- Electricity and production have **direct** relationship

ELECTRICITY VS. PRODUCTION: 2P



- **R^2** = 0.32 – Accounts for variation in data
- **CV-RMSE** = 9.2% - Deviation from model

ELECTRICITY VS. OUTDOOR AIR TEMPERATURE: 3PC-MVR



- **R^2** = 0.82 – Accounts for variation in data
- **CV-RMSE** = 5.1% - Deviation from model

ELEC = IND + WEA-DEP + PROD-DEP

E (kWh/dy) =

41,589 (kWh/dy)

+ 361.159 (kWh/dy-F) x [Toa (F) – 30.7093 (F)]$^{+}$

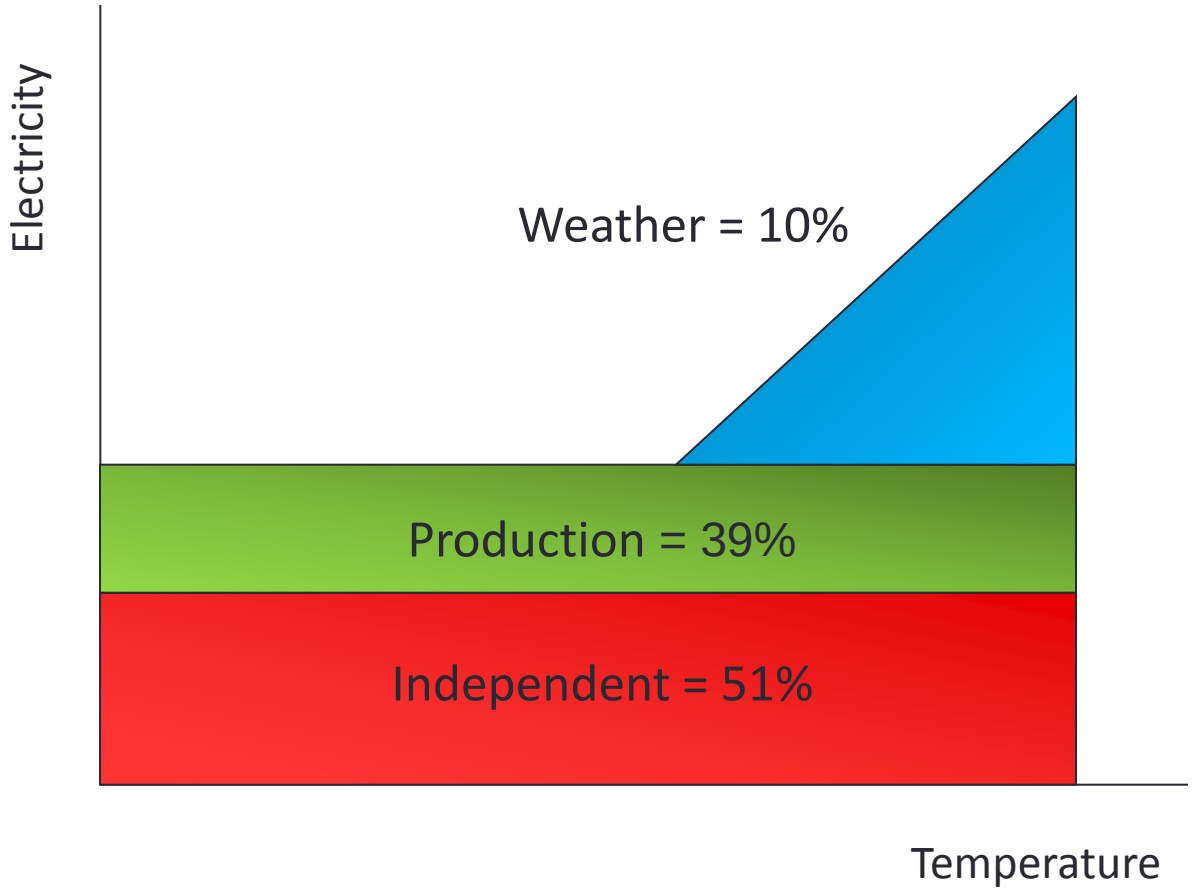
+ 2.4665 (kWh/dy-unit) x P (units)

Independent = 41,589 (kWh/dy)

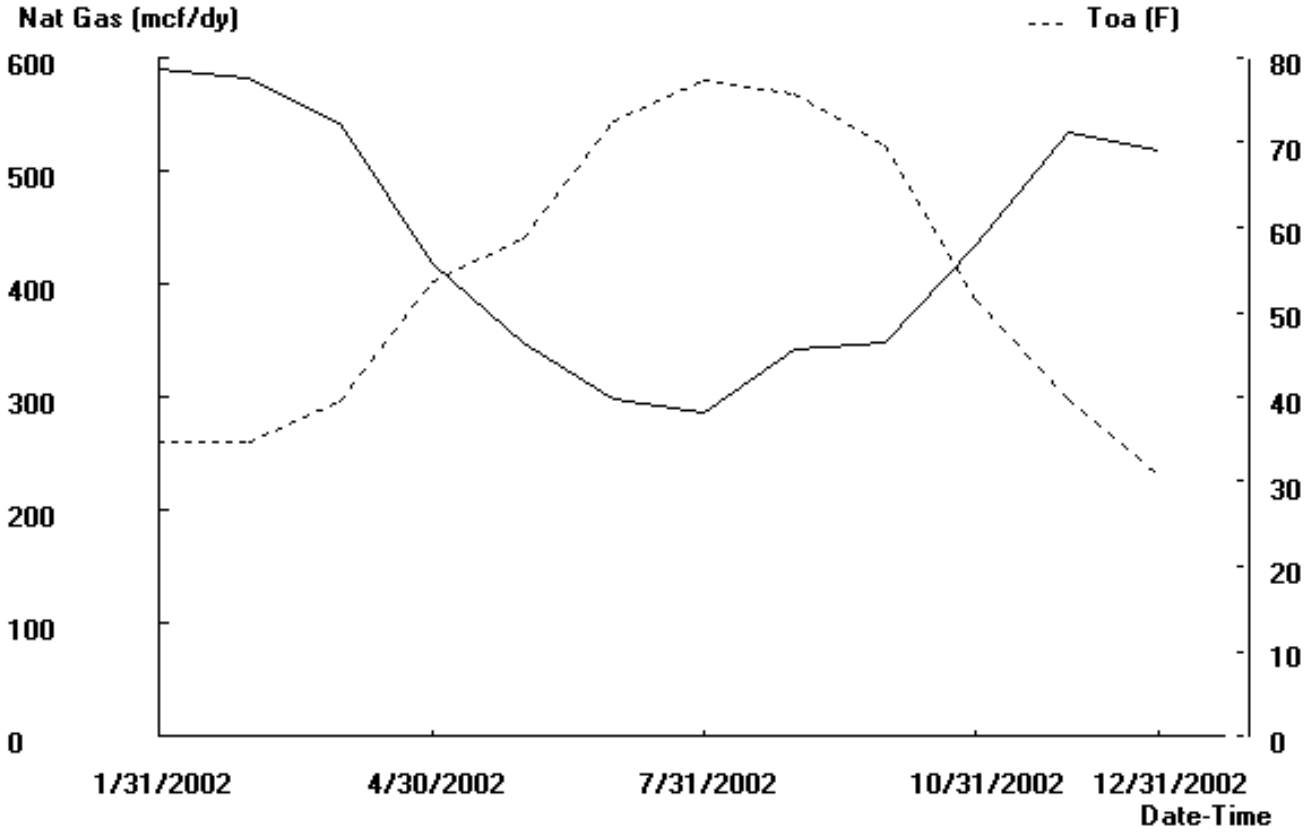
Wea-dep = 361.16 (kWh/dy-F) x [Toa (F) – 30.71 (F)]$^{+}$

Prod-dep = 2.4665 (kWh/dy-unit) x P (units)

DISAGGREGATE ENERGY USE

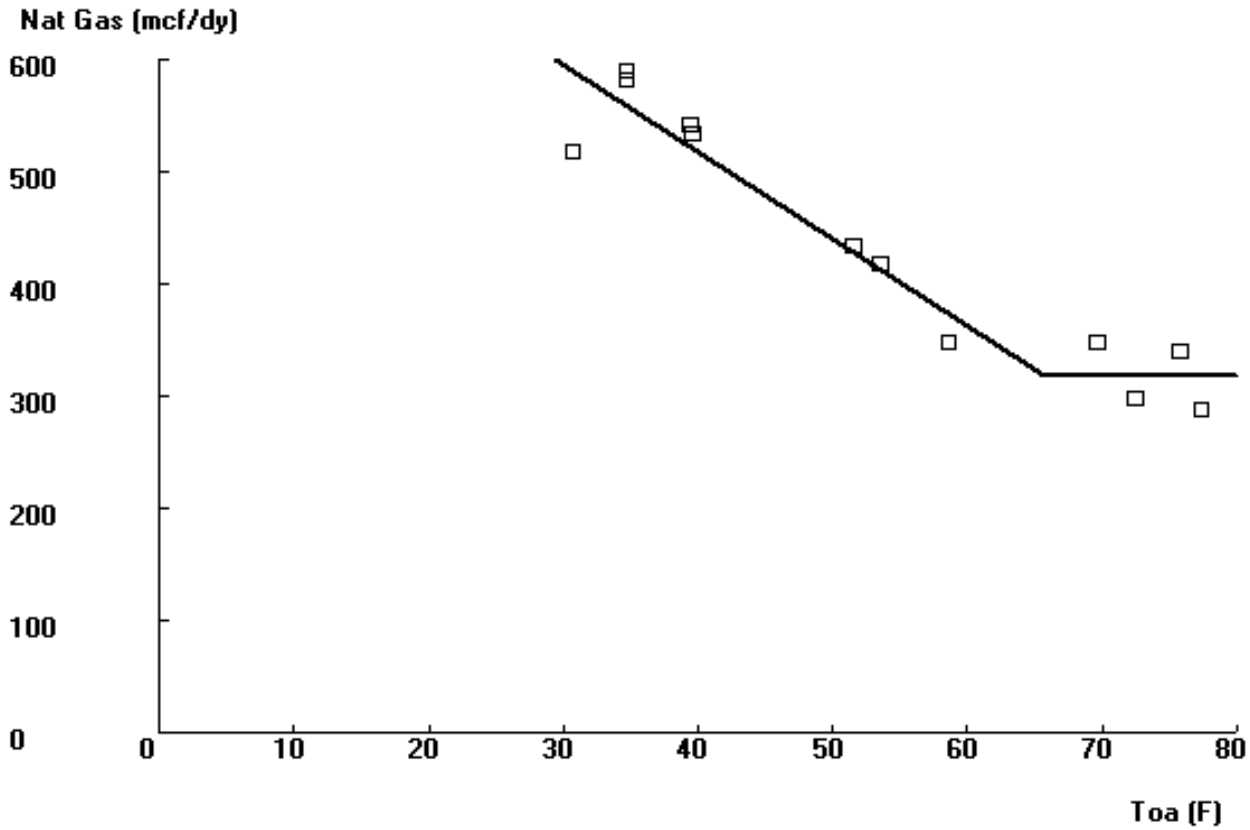


FUEL USE VS. OUTDOOR AIR TEMPERATURE



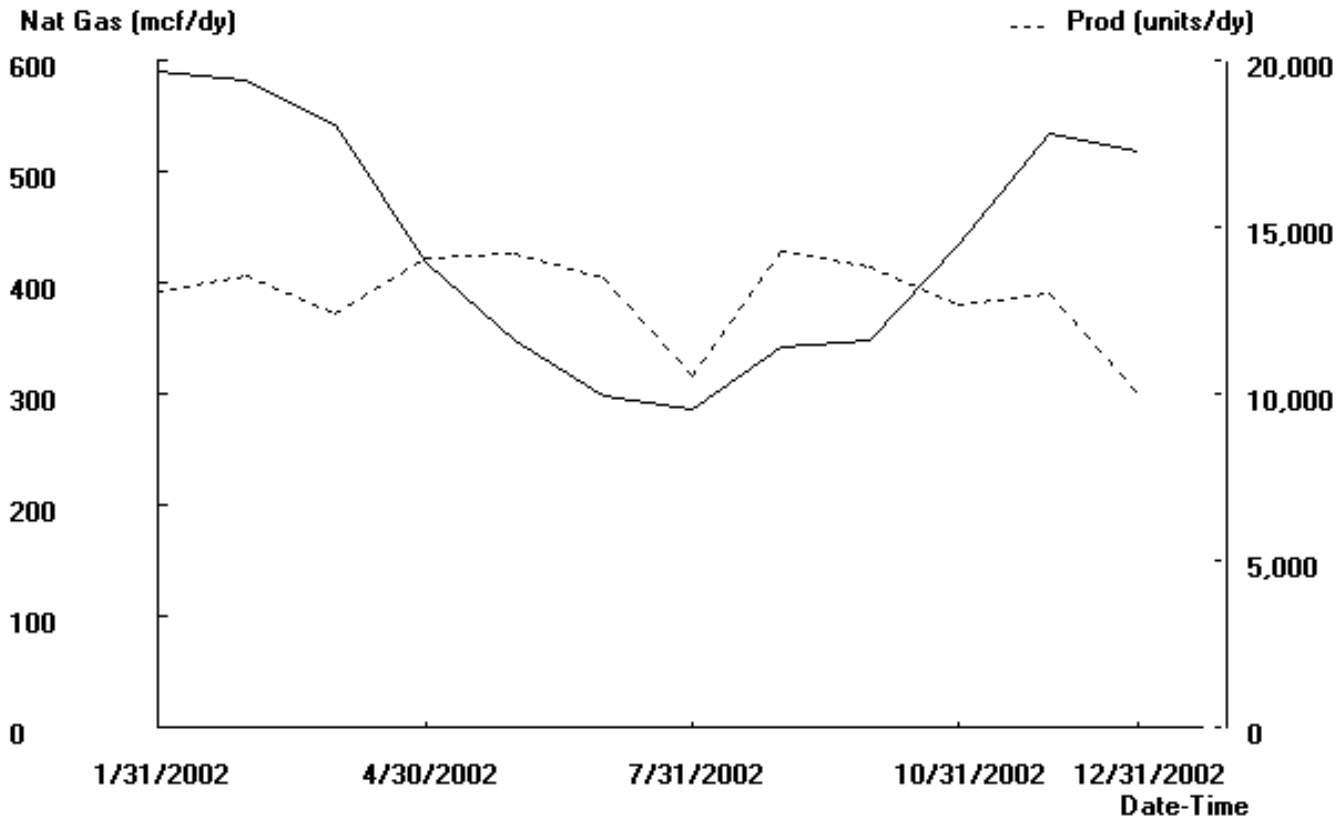
- Fuel use and temperature have **indirect** relationship
- Note seasonal shift in fuel energy use

FUEL USE VS. OUTDOOR AIR TEMPERATURE: 3PH

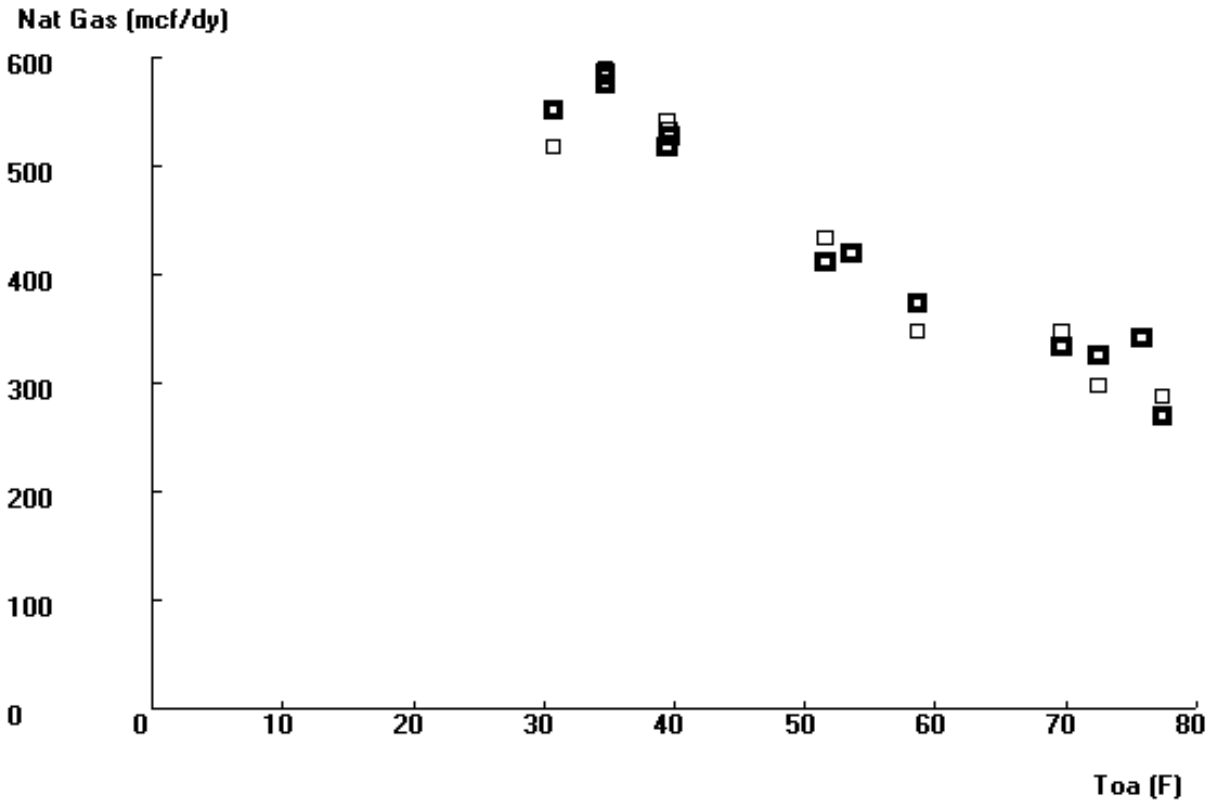


- **R^2** = 0.92 – Accounts for variation in data
- **CV-RMSE** = 7.5% - Deviation from model

FUEL USE VS. PRODUCTION



FUEL USE VS. OUTDOOR AIR TEMPERATURE: 3PH-MVR



- **R^2** = 0.97 – Accounts for variation in data
- **CV-RMSE** = 5.1% - Deviation from model

FUEL USE = IND + WEA-DEP + PROD-DEP

Fuel Use (mcf/dy) =

59.58 (mcf/dy)

+ 9.372 (mcf/dy-F) x $[62.06\ (F) - Toa\ (F)]^{+}$

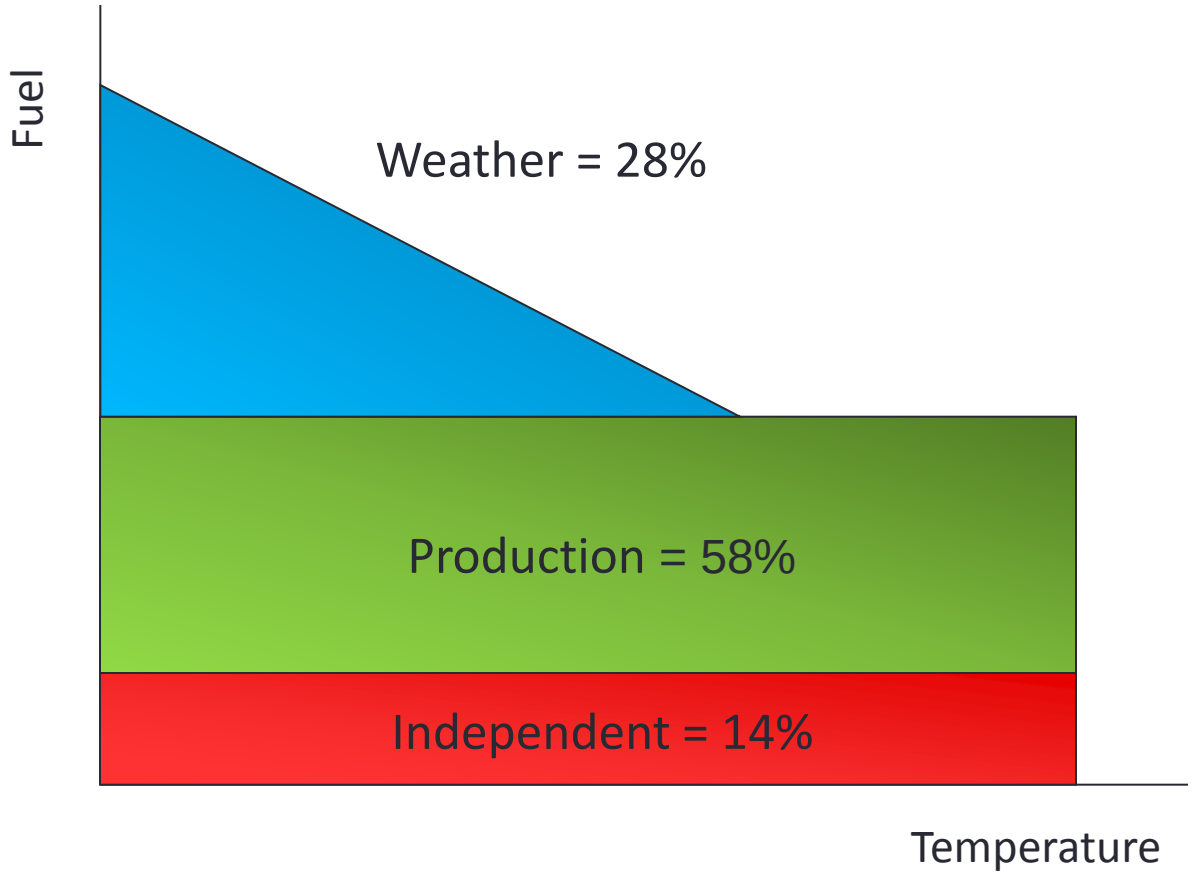
+ 0.0199 (mcf/dy-unit) x P (units)

Independent = 59.58 (mcf/dy)

Wea-dep = 9.372 (mcf/dy-F) x $[62.06\ (F) - Toa\ (F)]^{+}$

Prod-dep = 0.0199 (mcf/dy-unit) x P (units)

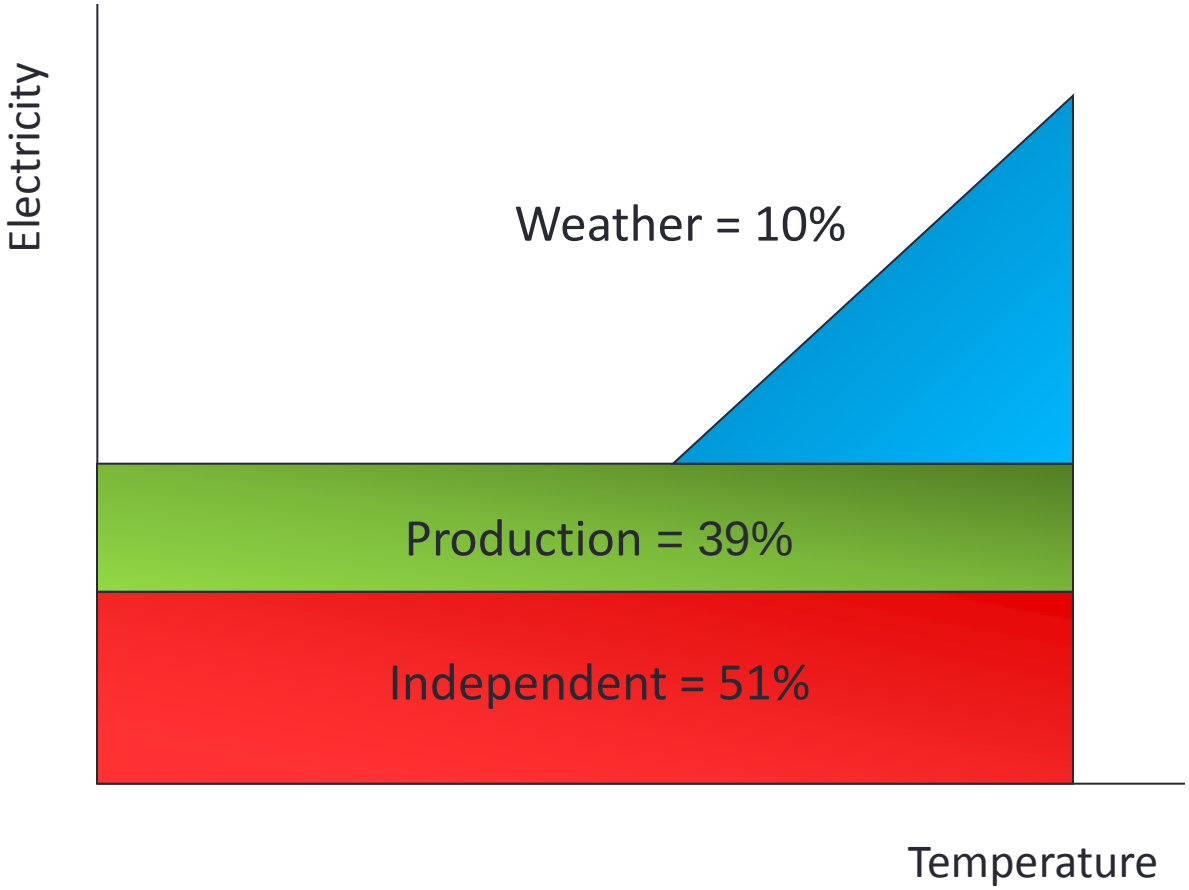
DISAGGREGATE FUEL USE



“LEAN ENERGY ANALYSIS”

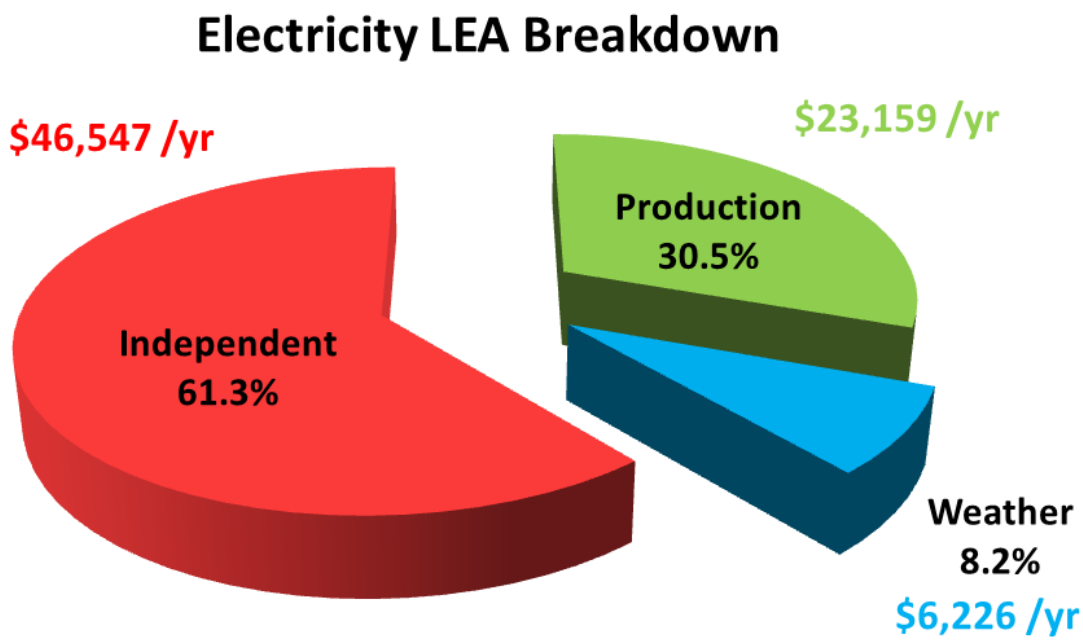
- Called “lean energy” analysis because of its synergy with the principles of “lean manufacturing”.
- In lean manufacturing, “any activity that does not add value to the product is waste”.
- Similarly, “any energy that does not add value to a product or the facility is also waste”.

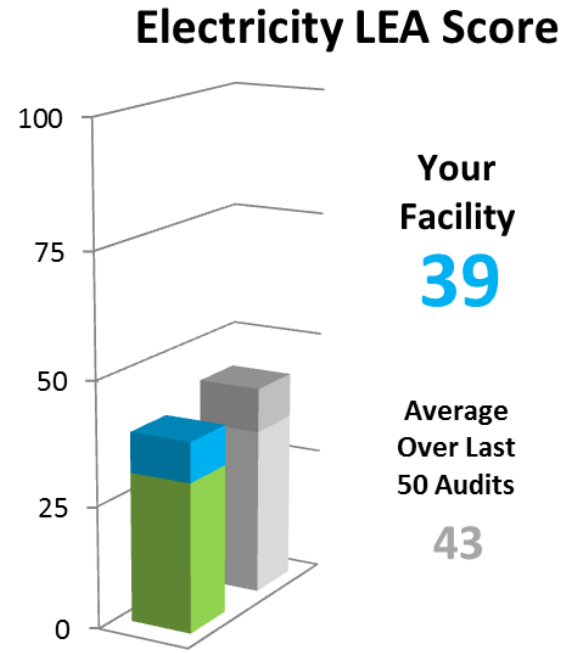
QUANTIFIED "LEANNESS" OF ENERGY USE



- "Independent" is energy not added to product or space environment
- Perfectly "lean" is when independent energy use = 0%

LEAN ENERGY ANALYSIS SCORE

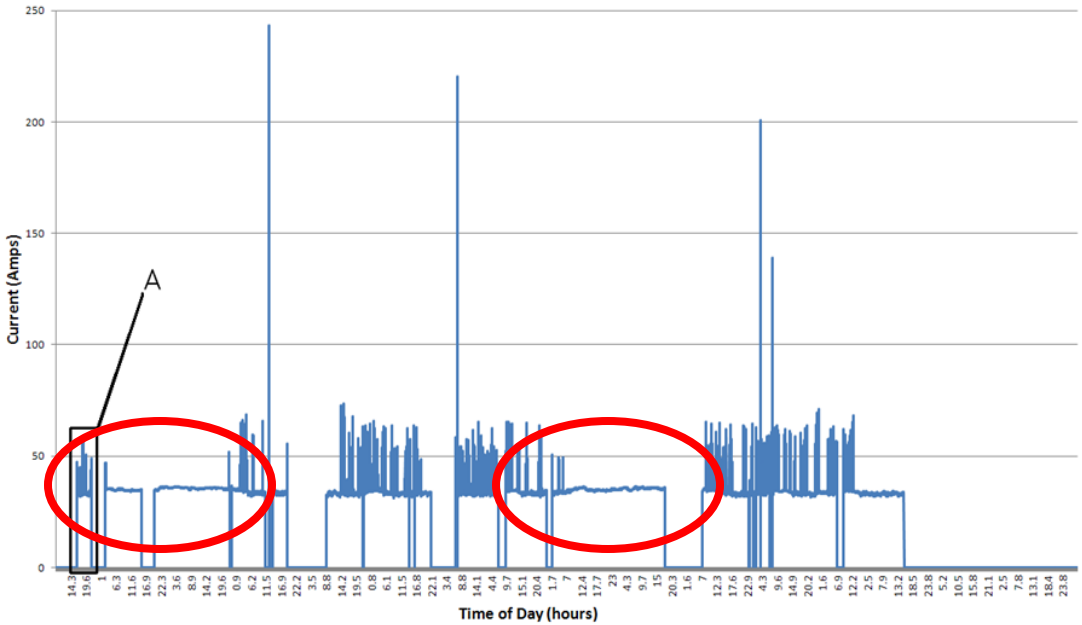




IDENTIFYING SAVINGS OPPORTUNITIES WITH LEAN ENERGY ANALYSIS

- High “Independent” indicates waste
- Departure from expected shape
- High scatter indicates poor control

LOW ELECTRICITY LEA IDENTIFIES EQUIPMENT TURN-OFF OPPORTUNITIES



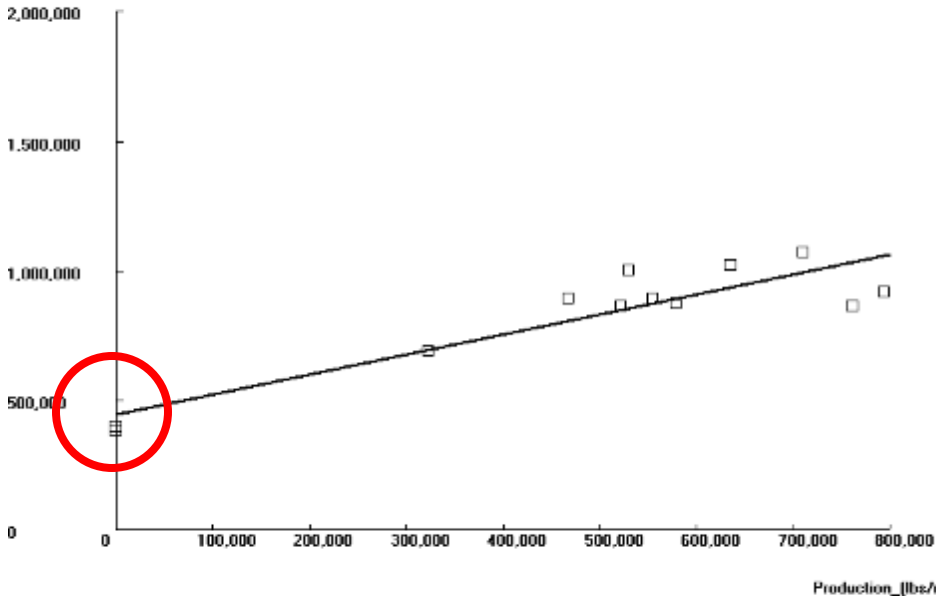
Observation: Very high electricity independent use (99%)

Company thought presses stamp 95% of time

Data show presses stamp 50% of time; use 66% of peak power when idle

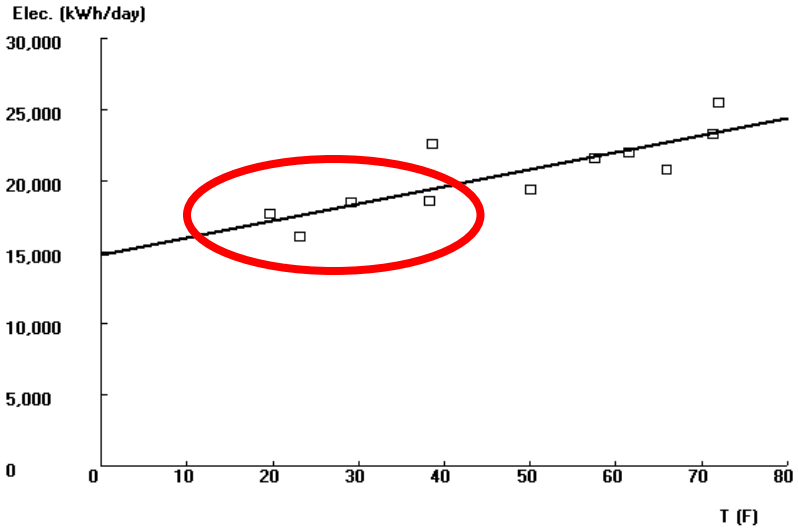
Turning off presses saves 40% press energy use and dramatically increases plant LEA score

LOW FUEL LEA SCORE IDENTIFIES INSULATION OPPORTUNTIES



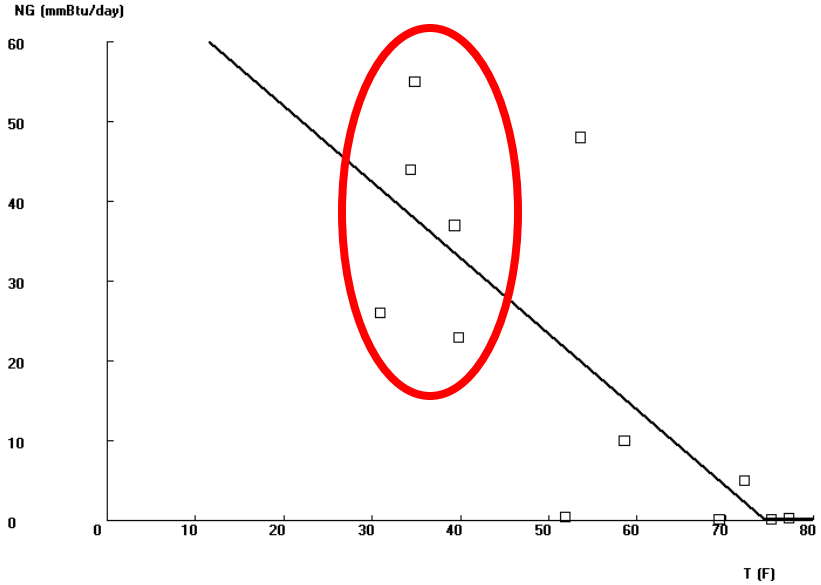
- **Observation:** High independent fuel use did not vary with production
- **Discovery:** Furnaces were poorly insulated

DEPARTURE FROM EXPECTED SHAPE IDENTIFIES MALFUNCTIONING ECONOMIZERS



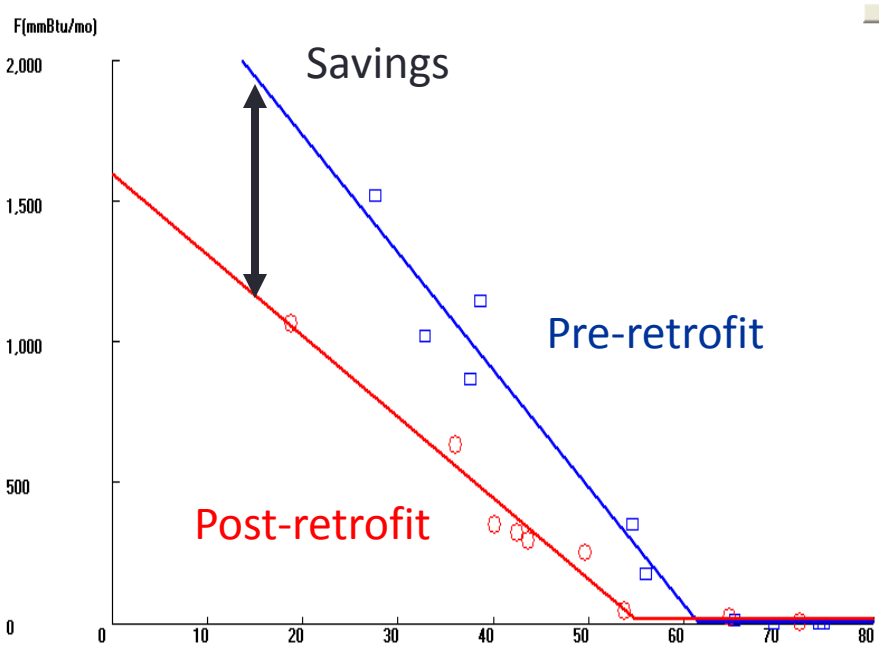
- **Observation:** Air conditioning electricity use should flatten below 50 F
- **Discovery:** Malfunctioning economizers

HIGH SCATTER IDENTIFIES CONTROL OPPORTUNITIES



- **Observation:** Heating energy varies by 3x at same temp
- **Discovery:** Shipping doors were left open

HIGH HEATING SLOPE IDENTIFIES EXCESS VENTILATION



- **Observation:** High heating slope compared to similar industries
- **Discovery:** Plant was exhausting too much air
- Reducing excess ventilation lowers heating slope, balance temperature and fuel use

LEAN ENERGY ANALYSIS

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QUESTIONS?

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