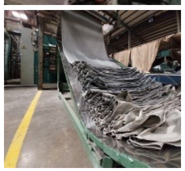


Understand the situation at hand

SETTING TARGETS

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH



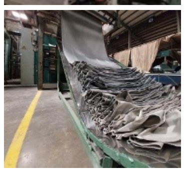


In this session…

- Energy Balance
- Significant Energy Uses
- Energy Performance Indicators
- Energy Baselines
- Normalizing EnPIs
- Exercises







References

- Higg FEM Questions
  - Track and measure energy use from the sources
  - Standardize methods and frequency to track each energy source
  - Establish energy baselines
  - Identify energy intensive processes or operations
  - Set targets for improving energy use
  - Set targets for reduction of GHG emissions (Scope-1 and Scope-2)

Energy Balance

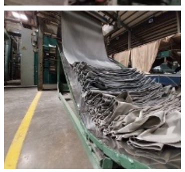
- The purpose of an energy balance is to look at energy consumption on a smaller (individual energy uses) scale
- Using estimates and spot measurements of equipment loads, the energy consumed by each user can be found
  - **Energy Consumption = Nominal equipment rating x Duty Factor x Load Factor x Operating Hours**
- Individual loads are summed and compared to the plant energy input
- Areas of significant energy use (SEUs) are identified. SEUs can be facilities, systems, processes, or equipment
  - This ensures that we focus on biggest energy users first where bigger savings can be achieved
  - Also helps in reducing effort of measurement and monitoring
  - It is important to identify relevant variables affecting SEUs

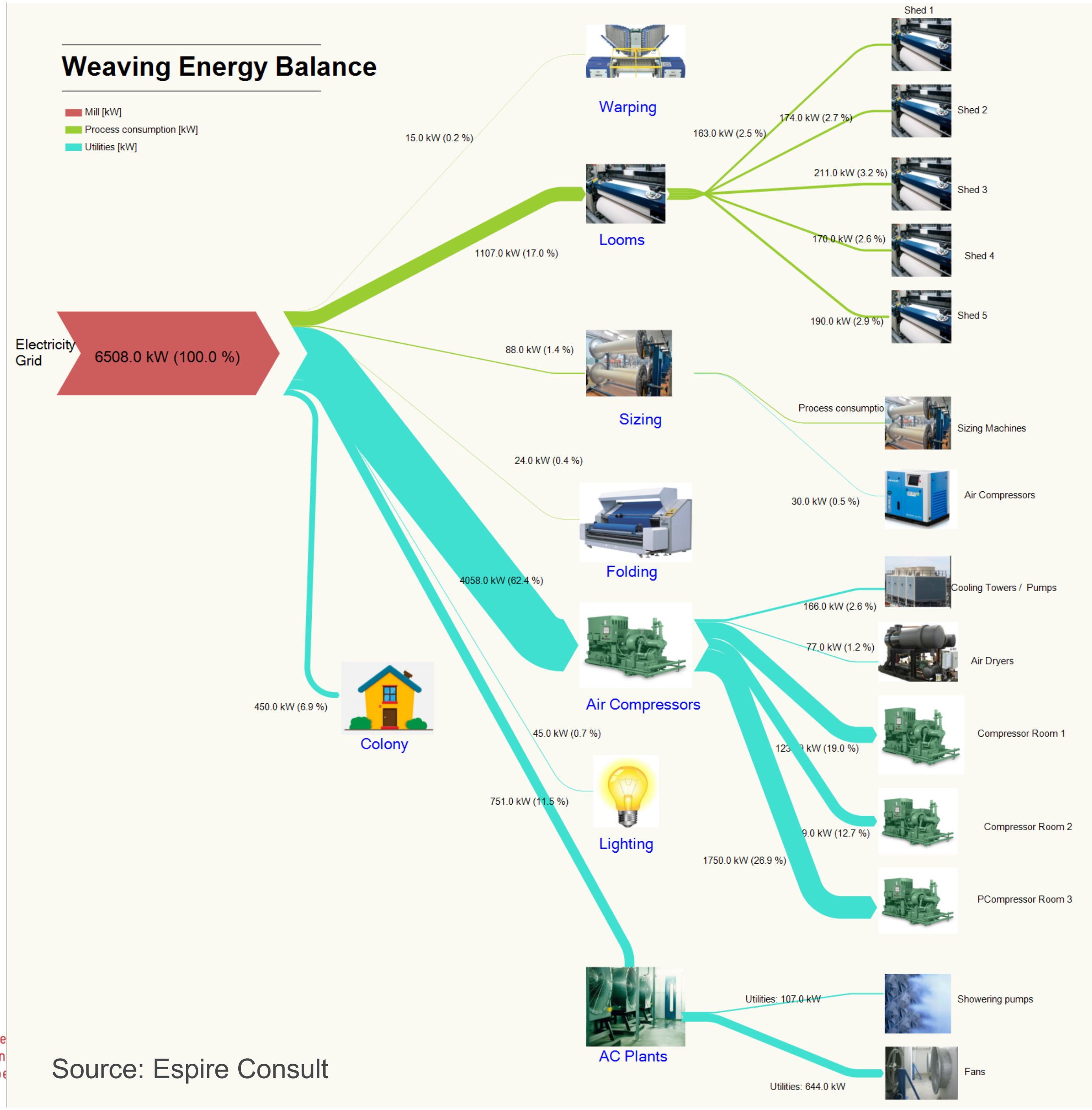
HO 130003_Example Energy Balance

Energy Balance – Example (Weaving)









Source: Espire Consult

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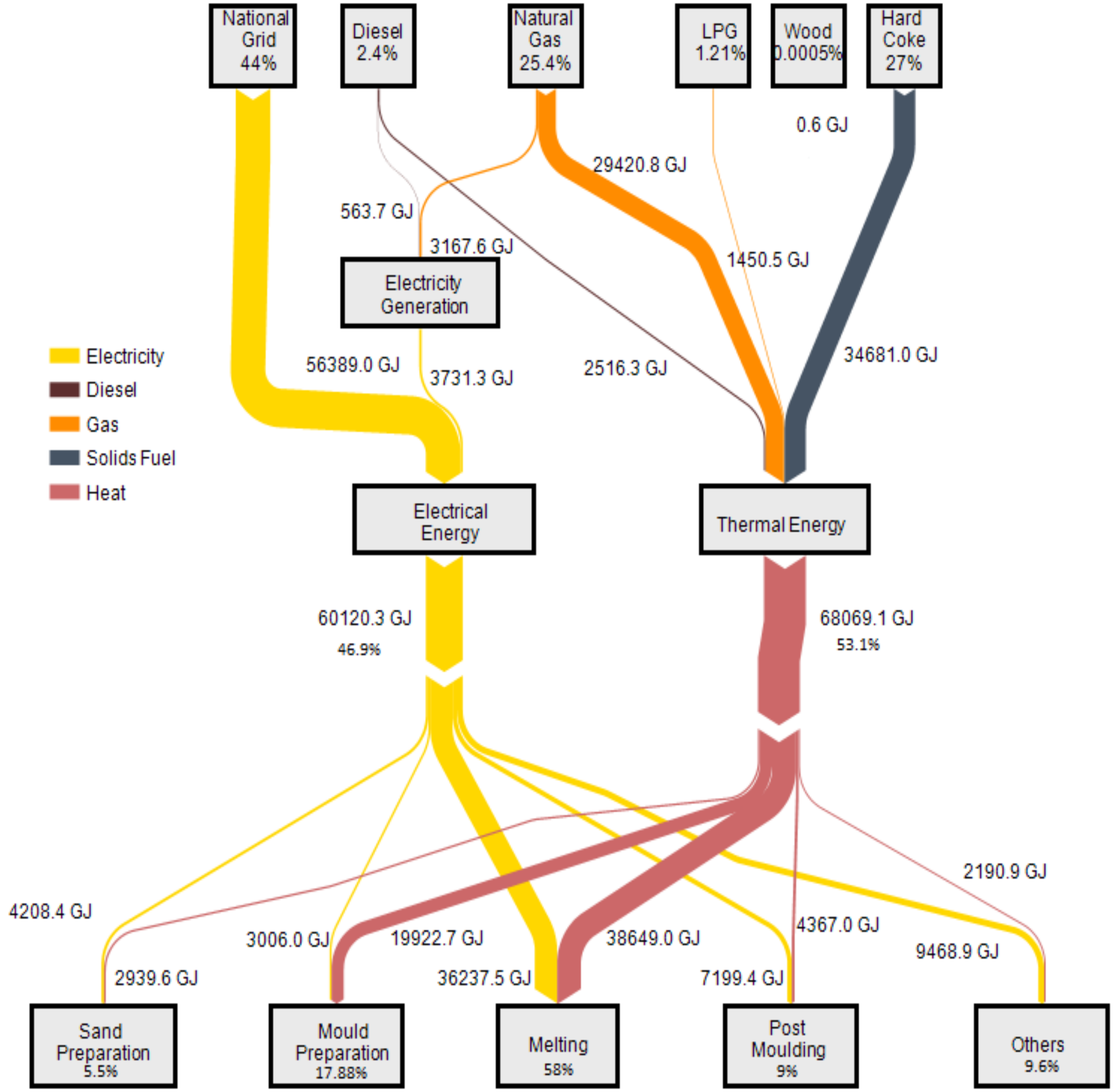
Zusammenarbe

ergy (REME)

Energy Balance – Example (Foundry)



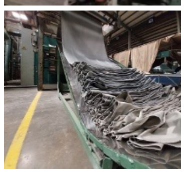




Source: Espire Consult

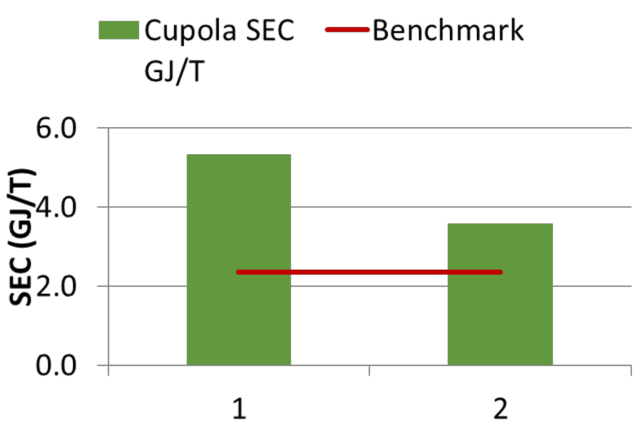


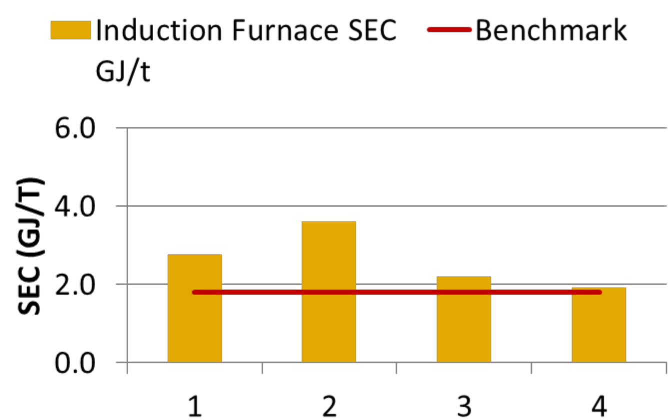




Energy Performance Indicators (EnPIs)

- Energy Performance Indicators are measurable indicators related to energy efficiency, energy use and energy consumption
  - e.g. GJ/Year, or GJ/kg-fabric
- EnPIs must be appropriate for measuring and monitoring energy performance
  - i.e. covering all energy sources and all SEUs
- EnPIs enable the organization to demonstrate energy performance improvement
  - Comparing current values against baseline





Energy Baselines (EnBs)

- Quantitative reference providing a basis for comparison of energy performance e.g. Energy consumed in Year 2020
- An energy baseline is based on data from a specified period and/or conditions e.g. January – December 2020
- Baselines can be Absolute (e.g., 120,000 GJ/year) or Normalized (e.g., 6.5 GJ/Tonne-production).
- Relevant variables may significantly affect energy performance requiring normalization, e.g.,
  - environmental temperature
  - Humidity
  - raw material type
- Depending on the nature of the activities, normalization can be a simple adjustment, or a more complex procedure.

Energy Performance

Which one is better?

Company	Energy Consumption GJ/y
A	73,843
B	108,540





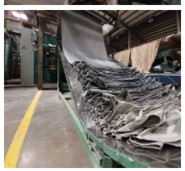
Energy Performance

Which one is better?

Company	**Energy Consumption** GJ/y	**Productio n** T/y	**SEC** GJ/T
A	73,843	13,244	5.58
B	108,540	4,399	24.68







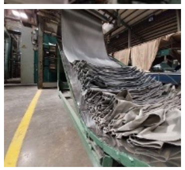
Energy Performance

Which one is better?

Company	**Energy Consumption** GJ/y	**Productio** **n** T/y	**SEC** GJ/T	**Yarn Count** Hanks/lb
A	73,843	13,244	5.58	8.72
B	108,540	4,399	24.68	52.5





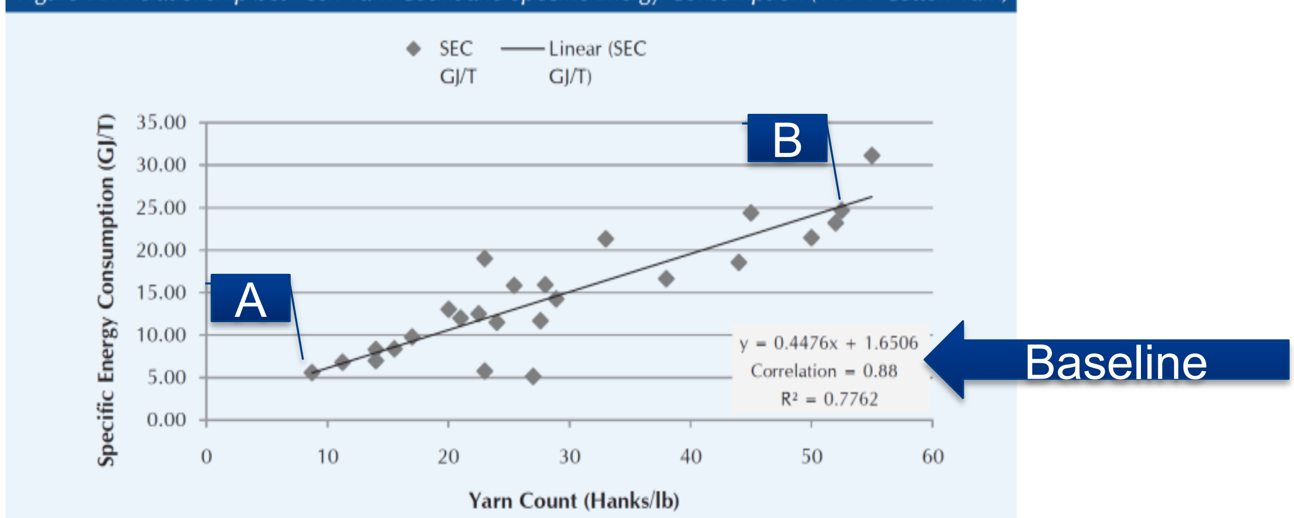


Energy Performance

Which one is better?

Company	Energy Consumption GJ/y	Production T/y	SEC GJ/T	Yarn Count Hanks/lb
A	73,843	13,244	5.58	8.72
B	108,540	4,399	24.68	52.5

Figure 55. Relationship between Yarn Count and Specific Energy Consumption (100% Cotton Yarn)



Source: UNIDO Sectoral Analysis on Renewable Energy and Energy Efficiency, July 2019





Normalizing the EnPIs

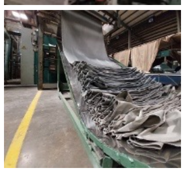
Finding the significant variables - Example

Multiple Variables may be listed based on experience or expert advice

Sr. No	Type of Metering	EnPI	Department	Relevant Variables
1	Electricity	kWh/meter	Sizing	1. Yarn Count. 2. Beam width. 3. No. of Ends
2	Steam	kg./1000 meters	Sizing	1. Yarn Count. 2. Beam width. 3. No. of Ends
3	Electricity	kWh/1000 meters	Warping	1. Yarn Count. 2. Beam width. 3. No. of Ends
4	Electricity	kWh/meter	Weaving	1. GSM 2. Fabric width.
5	Electricity	kWh/meter	Folding	1. GSM 2. Fabric width
6	Electricity, Air Flow	kWh/m^3	Compressed Air	1. Working Pressure 2. Ambient Temperature 3. EnPI of compressor
7	Air Flow	m^3/1000 meters	Weaving Shed	1. GSM 2. Fabric width.







Normalizing the EnPIs

Seasonal Variation

- Seasonal variation can be converted into quantified variable i.e. HDD or CDD
  - "Heating degree days", or "HDD", are a measure of how much (in degrees), and for how long (in days), outside air temperature was lower than a specific "base temperature" (or "balance point").
  - "Cooling degree days", or "CDD", are a measure of how much (in degrees), and for how long (in days), outside air temperature was higher than a specific base temperature
- Degree days are based on the assumption that when the outside temperature is (say) 24°C in Pakistan we don't need heating or cooling to be comfortable.
- Degree days are the difference between the daily temperature mean, and 24°C.
  - If the temperature mean is above 24°C, we subtract 24 from the mean and the result is Cooling Degree Days.
  - If the temperature mean is below 24°C, we subtract the mean from 24 and the result is Heating Degree Days.

Normalizing the EnPIs

HDD and CDD Examples

- The high temperature for a particular day was 37°C and the low temperature was 22°C. The temperature mean for that day was:

  (37°C + 22°C) / 2 = 29.5°C

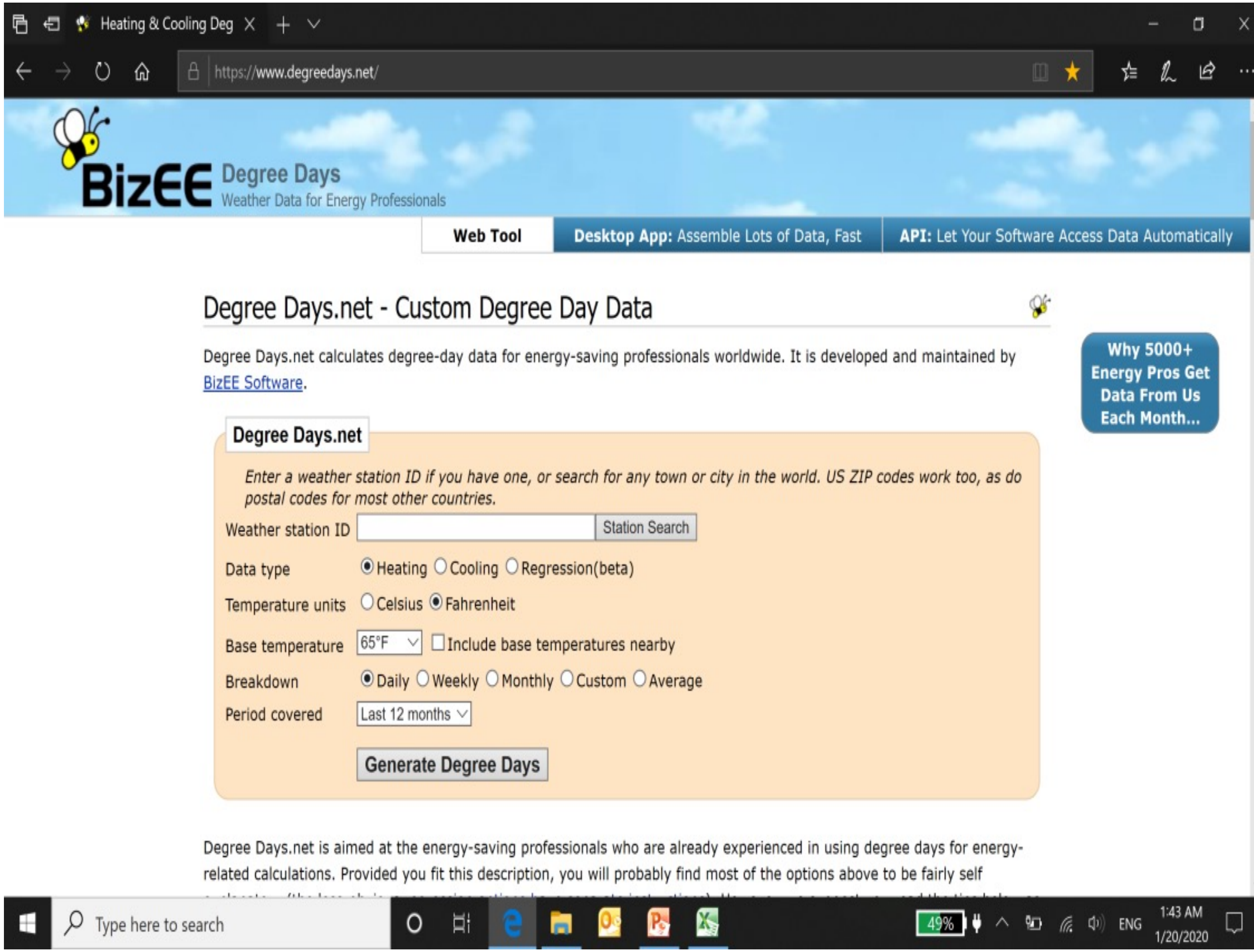
  Because the result is above 24°C

  29.5°C - 24°C = 5.5 Cooling Degree Days

- The high temperature for a particular day was 13°C and the low temperature was 7°C. The temperature mean for that day was:

  (13°C + 7°C) / 2 = 10°C
  Because the result is below 24°C:
  24°C - 10°C = 14 Heating Degree Days

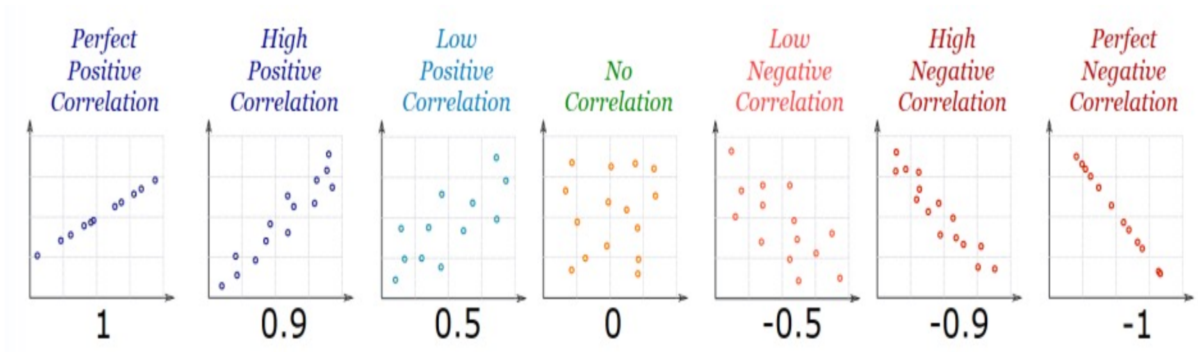
Normalizing the EnPIs

- 

Normalizing the EnPIs

What is Correlation?

- When two sets of data are strongly linked together we say they have a High Correlation.
  - Correlation is Positive when the values increase together, and
  - Correlation is Negative when one value decreases as the other increases
- A correlation is assumed to be linear (following a line).



- Correlation can have a value:
  - 1 is a perfect positive correlation
  - 0 is no correlation (the values don't seem linked at all)
  - -1 is a perfect negative correlation





Normalizing the EnPIs

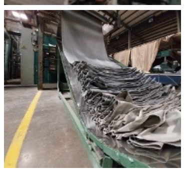
Finding Correlation

- First step is to find out if a variable has significant impact on the energy consumption or not
- Arrange all the variables in excel columns ensuring they have same timeline
- A Correlation Matrix can be created using advanced add-ins like SPC-XL or using the Excel Analysis tools

	Natual Gas Consumption [m3]	*Electricity Consumption [kWh]*	*Monthly Production [tonne]*	*HDD's @15°C*
Natual Gas Consumption [m3]	1			
Electricity Consumption [kWh]	0.302968912	1		
Monthly Production [tonne]	0.247655351	0.964633525	1	
HDD's @15°C	0.81145471	-0.213378671	-0.290101427	1







Normalizing the EnPIs

Regression Analysis

- Next step is to conduct the regression analysis
- The resultant regression formula (Slope) can be used to calculate the future energy consumption based on significant variables





Normalizing the EnPIs

Regression Analysis

Regression Summary

Regression Statistics	
Multiple R	0.955640108
R Square	0.913248016
Adjusted R Square	0.893969797
Standard Error	10450.77679
Observations	12

Resultant Regression Formula
Energy = a + b x Production + c x HDD

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	10347822609	5173911304	47.37201248	1.66824E-05
Residual	9	982968620.2	109218735.6		
Total	11	11330791229			

		Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
a	Intercept	81099.42339	9569.198139	8.475049028	1.39212E-05	59452.39327	102746.4535	59452.39327	102746.4535
b	Monthly Production [tonne]	61.79912058	12.02015814	5.141290145	0.000610237	34.60763375	88.99060742	34.60763375	88.99060742
c	HDD's @15°C	209.4677494	22.28114615	9.401120929	5.96824E-06	159.064295	259.8712038	159.064295	259.8712038

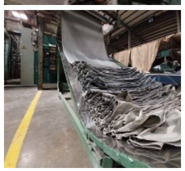
R = Correlation coefficient

P-value < 0.05 → Significant

R^2 reaching 1 → Significant







Setting Target

- Regression Slope can also be used for forecasting, budget setting, target setting etc.
- E.g. If the target is to reduce energy consumption by 10%; the values of constants shall be reduced by 10% in the regression formula; Energy = a*0.9 + b*0.9*Production + c*0.9*HDD

Individual task

Try regression on data provided in HO 130004

- Test if HDD has significant correlation on Electricity and Gas Consumption
- Conduct Regression Analysis and derive the Slope for Electricity and Gas Consumption
- Present your results in plenary

Time: 30 min





Data requirements for Deep-dive energy assessment

- How detailed data do you gather for energy balance?
  - Energy sources
  - Major departments
  - Machinery / equipment
  - Generally at department level and for some significant machines
- Why?

Task – The Textile Company

Develop an energy balance of The Textile Company using provided energy data

Your tasks as a groups are;

- Develop an energy balance of The Textile Company using provided energy data
- Update Material/Energy Flow Charts with energy values
- Is any data missing or incorrect?
- Identify Significant Energy Uses (SEUs)
- Calculate Energy Baseline values
- Enlist significant variables for SEUs
- Present your results in plenary

Time: 60 min