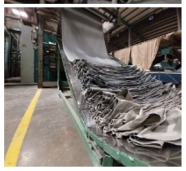




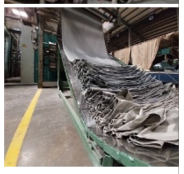


Put energy management into practice

SELECT ENERGY MANAGEMENT MEASURES







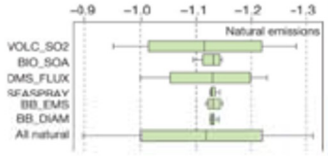
Overall framework
DMAIC/MAIC METHODOLOGY

Measure

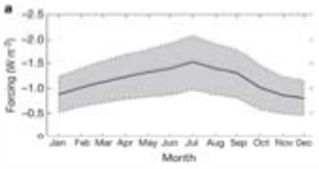
1) Describe the Problem

	IS	IS NOT
What		
Where		
When		
Extent		

2) Measure the Magnitude of a Problem



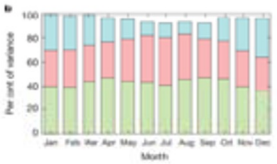
3) Determine when the problem started



Analyse

4) Identify the Root-Cause

5) Analyse Existing Data



6) Construct List of Verified Facts

Facts
Fact 1
Fact 2
Fact 3
Fact 4

7) Compare Causes to Facts

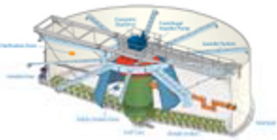
	Fact 1	Fact 2	Fact 3
Cause 1	o	x	o
Cause 2	o	o	o
Cause 3	x	x	o

8) Collect additional data until root cause is identified

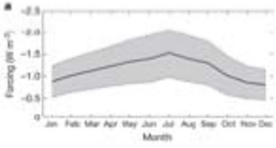
Improve

9) Determine Best Solution

10) Pilot Solution

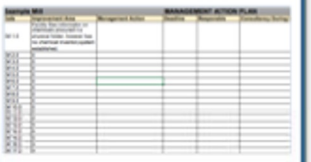


11) Verify Solution Works



Control

12) Control Plan



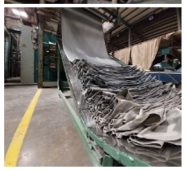
Select energy management measures

ASPECTS TO CONSIDER

- Establish and maintain process for identifying alternative solutions.
- Choose criteria in selection, providing a balanced approach to costs, benefits and risks.
- Obtain complete requirements allocation for each alternative.
- Document the rationale for each alternative.



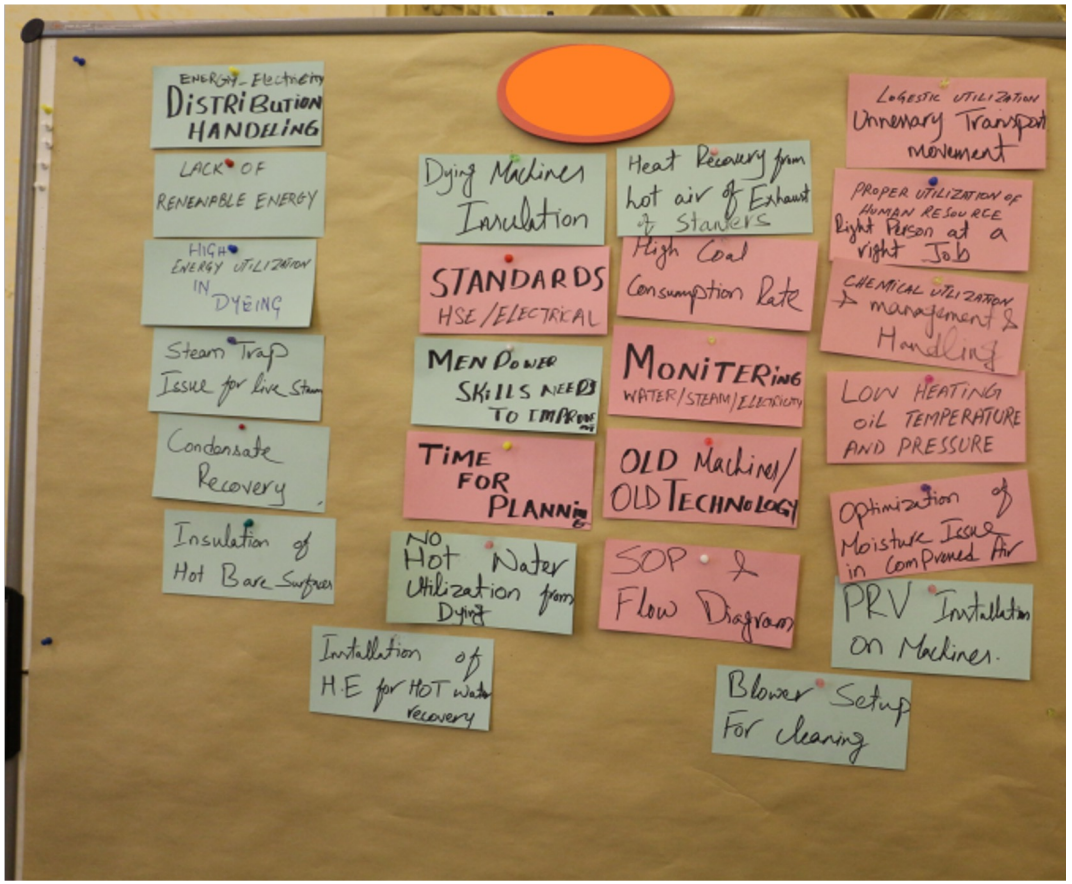




Understanding the situation

Prioritizing NPOs

- Compile list of all energy NPOs and energy saving opportunities



Understanding the situation

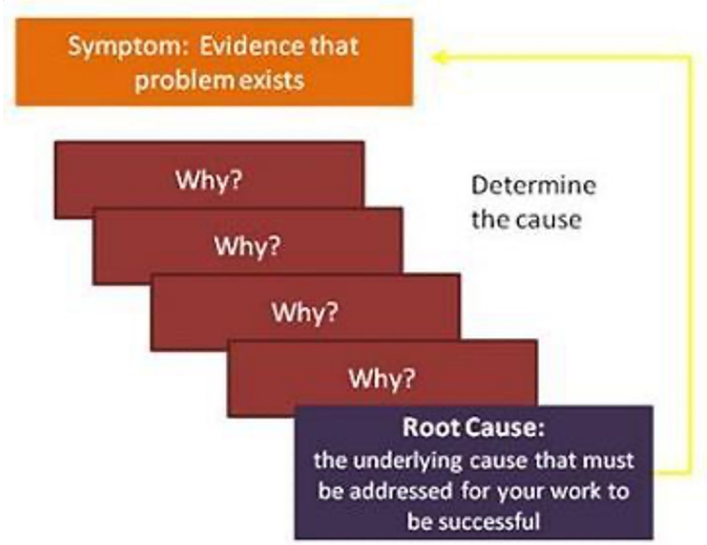
Prioritizing NPOs

- It is important to assess impacts of the energy NPOs /losses /aspects
- Impact assessment can be used for prioritization of NPOs
- Consider evaluating against multiple impact areas and variables

Aspects	**Identification of Impacts** (High=3, Medium=2, Low=1, N/A=0)											
	Results in monetary loss	Causes air Emissions (PM, Sox, NOx, CO…)	Contributes to global Warming, Ozone depletion	Increases fossil fuel use	Effects health of staff/ worker	Contributes to emergencies (fire/,explosion)	Effects relationship with customers	Lead to legal consequences or public reactions	Affects quality/ productivity	Affects working conditions and environment	Increases use of natural resources	Total Impact
Very low condensate recovery	3	0	2	2	0	0	1	0	0	0	3	**11**
Low combustion efficiency of coal fired boiler	3	2	3	3	1	0	2	2	0	1	0	**17**

Understanding the situation

Addressing the roots causes



Examples of common tools for root cause analysis

- 5-Why Analysis
- Failure Mode and Effects Analysis (FMEA)
- Fault/Problem Tree Analysis
- Fishbone or Ishikawa or Cause-and-Effect Diagrams

Really understanding the situation

US railway gauge

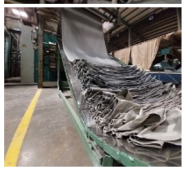
↓

4 foot 8.5 inch or
1.4351 meters

Why?







Understanding the situation

US railway gauge = 4 foot 8.5 inch or 1.4351 meters

WHY Because railways in US were built with the same gauge as the ones in UK.

WHY Because the same people, who built the railways also built the trams in UK.

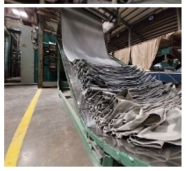
WHY Because they used the same lathe and tools for trams as for horse carriage with the same wheel stand

WHY Because wheel stands had to be adjusted to existing rutes in the long-distance roads in UK

WHY The rutes were created by Roman chariots which had this wheelstand because to make space for horses towing the Roman chariots.







Understanding the situation

But what could that have to do with the space shuttle?

Solid rocket booster (SRB) for the Space Shuttle are produced by M/s Thiokol in Utah. The engineers wanted bigger SRB, but could not.

Because the SRB had to be transported by railroad from the plant to the NASA launch base.

Railway passes through railway tunnel.

Tunnel size is a little larger than rail gauge

WHY?

Conclusion:

An important feature of one of advanced means of space transport has therefore its root in the size of Roman horses‘ ass!

Understanding the situation

Consider the following situation in the factory

What action do you suggest?

You see leakages of compressed air from various joints, valves and pipes. This may result in enormous energy loss.

Understanding the situation

Addressing the roots causes

Consider the following situation in the factory

What action do you suggest?

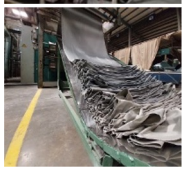
But did you ask yourself why did leakages start?

You see leakages of compressed air from various joints, valves and pipes. This may result in enormous energy loss.

The immediate solution may be to repair all leakages.







Understanding the situation

Plenary exercise

You see leakages of compressed air from various joints, valves and pipes. This may result in enormous energy loss.

Why?

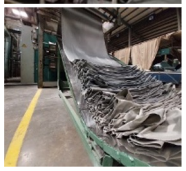
Your task in groups:

- Look beyond the situation and try identifying the possible root causes why the leakages occur.
- Visualise your finding and present to the other groups

Time: 30 minutes







Understanding the situation

Addressing the roots causes

You see leakages of compressed air from various joints, valves and pipes. This may result in enormous energy loss.

Why?

- Leakages are not monitored
- The worn out equipment were not replaced
- Equipment were replaced but leakages occur again
- Workers use compressed air for personal and machine cleaning

Why?

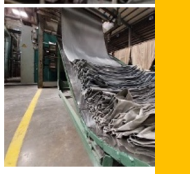
- Not considered necessary
- No funds made available
- Low quality equipment
- No appropriate Cleaning equipment
- Workers have not reported
- Pressure higher than demand
- No enforcement
- No procedure

Why?

- Energy information not available
- EE not considered in design and operations
- EE not considered in purchasing
- Lack of training and awareness







Understanding the situation

Addressing the roots causes

You see leakages of compressed air from various joints, valves and pipes. This may result in enormous energy loss.

Why?

- Leakages are not monitored
- The worn out equipment were not replaced
- Equipment were replaced but leakages occur again
- Workers use compressed air for personal and machine cleaning

Properly analysing the situation will allow you to address the real causes in an effective and sustainable way.

- No funds made available
- Low quality equipment
- No appropriate Cleaning equipment
- Workers have not reported
- Pressure higher than demand
- No enforcement
- No procedure

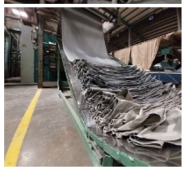
Why?

- Energy information not available
- EE not considered in purchasing
- Lack of training and awareness
- EE not considered in design and operations

Why?







Understanding the situation

Addressing the roots causes **and effects**

Impacts

- High maintenance cost
- High energy cost
- Demotivation due to bad working conditions

Effects

- Frequent maintenance needed
- High loading factor of compressors
- Bad housekeeping conditions
- ….

Problem

- Compressed air leakage

Possible causes

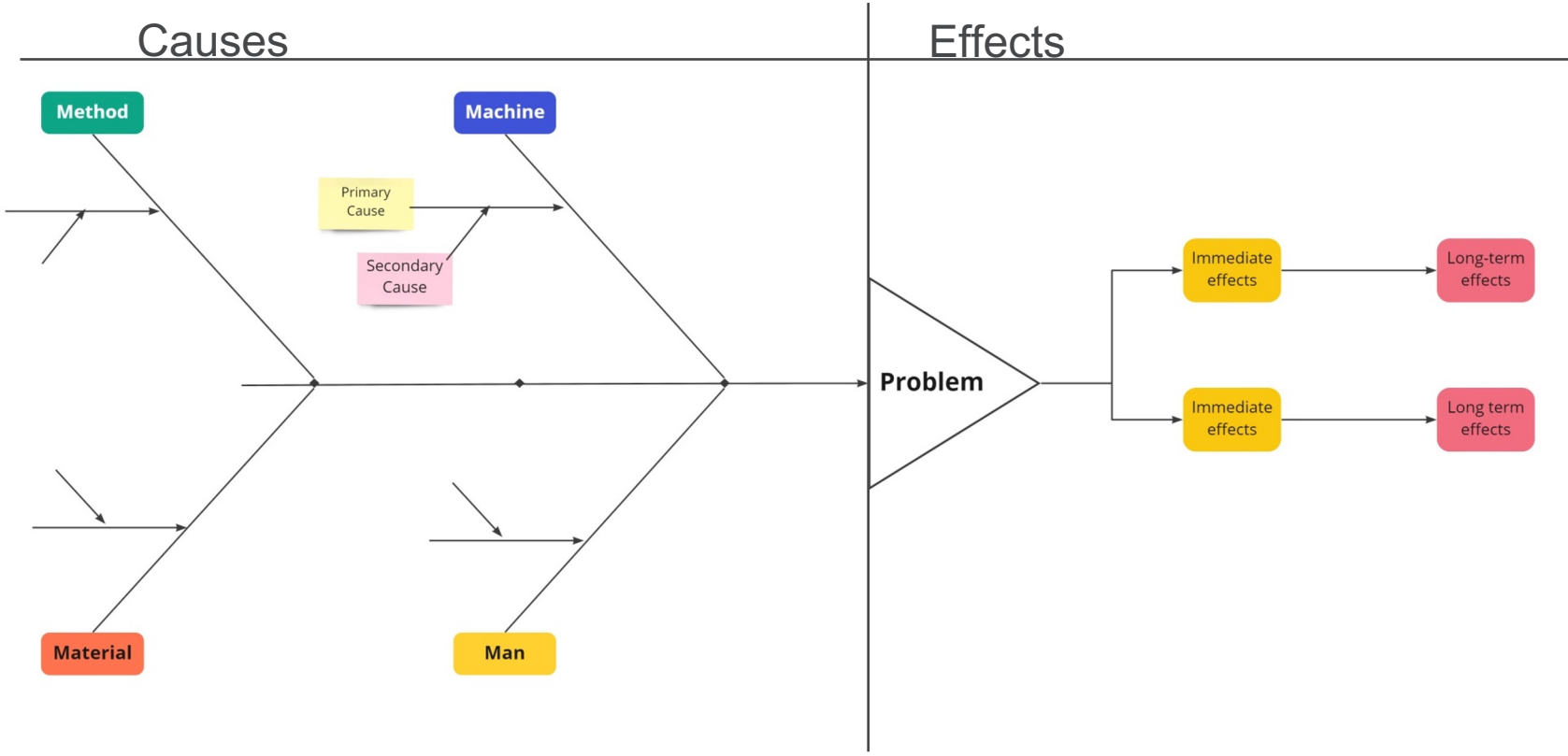
- Leakages are not monitored
- The worn out equipment were not replaced
- Equipment were replaced but leakages occur again
- Workers use compressed air for personal and machine cleaning

Root cause(s)

- Not considered necessary
- No funds made available
- Low quality equipment
- Workers have not reported
- Pressure higher than demand
- No appropriate Cleaning equipment
- No procedure
- No enforcement
- Energy information not available
- EE not considered in design and operations
- EE not considered in purchasing
- Lack of training and awareness

Understanding the situation

Addressing the roots causes and effects



Fishbone or Ishikawa diagram

Select energy management measures - Methods

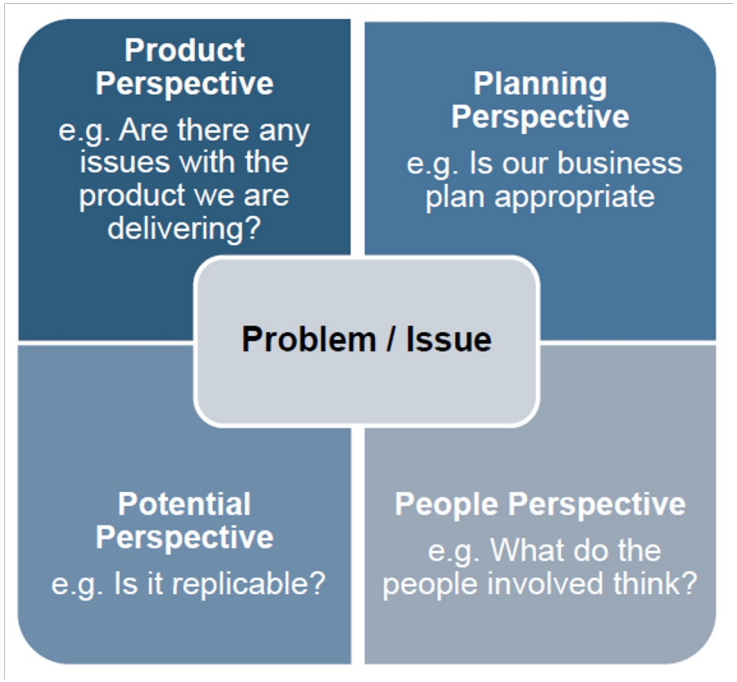
RE-FRAMING MATRIX

Simple technique to look at organisational problems from a number of different viewpoints

Step 1: Draw the grid

Step 2: Decide on the four perspectives

Step 3: Brainstorm factors related to each perspective



Developing and Evaluating Alternative Solutions - Methods

Example

Product Perspective

Look into low liquor ratio automated dyeing machines

Look into changing dyeing process

Planning Perspective

Review technical capabilities

Assess budget availability

Speak with customer regarding product demand

Our energy and water consumption in Dyeing are much higher compared to other suppliers of the Brand Client

Potential Perspective

Modernize the plant

Use low energy and water footprint as marketing tool

Set SBTi Targets

People Perspective

Need to involve production manager

Need to train workers

Need to involve merchandiser

Developing and Evaluating Alternative Solutions - Methods

Basic financial evaluation

- Payback period (months) = Investment ÷ Annual Saving x 12

e.g. Investment = 1,000 USD, Annual Saving = 750 USD, Payback = 1000 ÷750x12= 16 months

- Return on Investment (RoI) = (Gain from Investment - Investment) ÷ Investment

e.g. Investment = 1,000 USD, Total gain over lifetime= 5,000 USD, RoI= (5,000-1000)÷1,000= 400%

RoI only presents overall gain disregarding the length of investment and time value of money

Developing and Evaluating Alternative Solutions - Methods

Advanced financial evaluation

Net Present Value (NPV)

- NPV is the value of all future cash flows (positive and negative) over the entire life of an investment discounted to the present.
- NPV analysis is a form of intrinsic valuation used extensively for determining the value of a business, investment security, capital project, new venture, cost reduction program, and anything that involves cash flow
- An investor should choose the one with the higher NPV.
- Doing it in Excel
  - Arrange net cash flow data in excel
  - Estimate a Rate/discounting factor (e.g. 10%)
  - Formula =NPV(rate,value1,[value2],...)
  - Example: =NPV(10%,B2:B6) = 1,096.92

n	Alternate 1	Alternate 2
0	-2000	-3000
1	800	1600
2	1000	1500
3	1200	1500
4	1100	1500
NPV	1096.92	1677.92

Definition source: corporatefinanceinstitute.com

Developing and Evaluating Alternative Solutions - Methods

Advanced financial evaluation

Internal Rate of Return (IRR)

- The IRR is the discount rate that makes the NPV of a project zero i.e. No-Profit, No-Loss basis
- Any investment at IRR brings Zero financial benefits
- Any investment below IRR causes a financial loss
- Companies usually decide a lowest IRR value below which they are not interested to invest in □ a point to check with client
- An investor should choose the one with the higher IRR.
- Doing it in Excel
  - Arrange net cash flow data in excel
  - Formula =IRR(values, guess)
  - Example: =IRR(B2:B6,30%) = 33.82%

n	Alternate 1	Alternate 2
0	-2000	-3000
1	800	1600
2	1000	1500
3	1200	1500
4	1100	1500
NPV	1096.92	1677.92
IRR	33.82%	36.48%

Definition source: corporatefinanceinstitute.com

Developing and Evaluating Alternative Solutions - Methods

Advanced financial evaluation

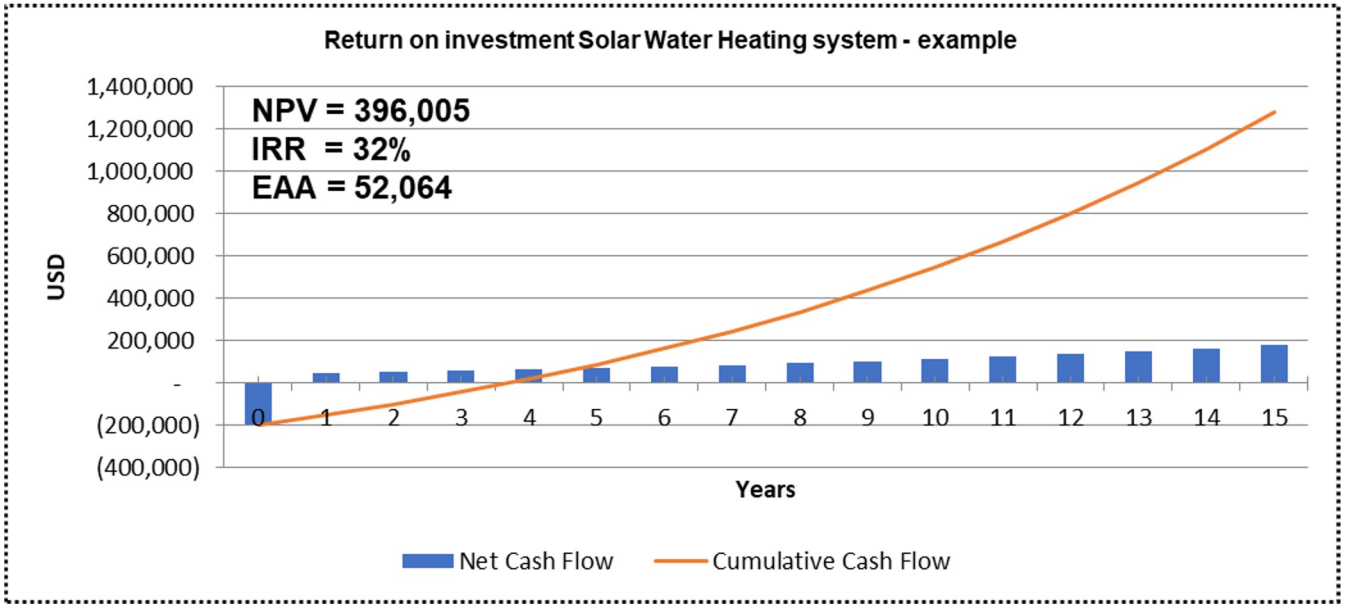
Equivalent Annual Annuity (EAA)

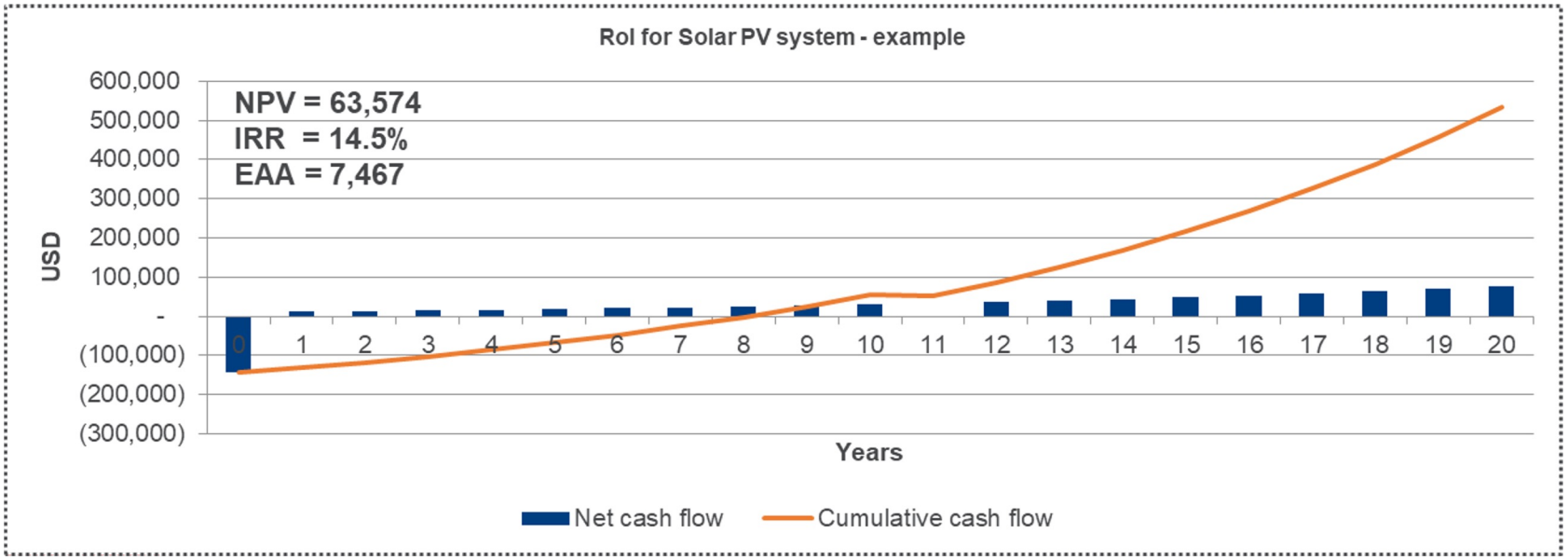
- Used to compare mutually exclusive projects with unequal lives
- Calculates the constant annual cash flow generated by a project over its lifespan if it was an annuity
- When used to compare projects with unequal lives, an investor should choose the one with the higher EAA.
- Doing it in Excel
  - Arrange net cash flow data in excel
  - Calculate NPV
  - Manually apply formula
    $EAA = (r \times NPV) \div (1 - (1 + r)^{-n})$
    - r=discount factor, n=number of periods
  - Example: =(0.1*B9) ÷ (1-(1+0.1)^-4) = 346.05

n	Alternate 1	Alternate 2
0	-2000	-3000
1	800	800
2	1000	1000
3	1200	1200
4	1100	1000
5		1000
6		1000
NPV	1096.92	1203.37
IRR	34%	24%
EAA	346.05	379.63

Definition source: investopedia.com

Financial Evaluation - Example

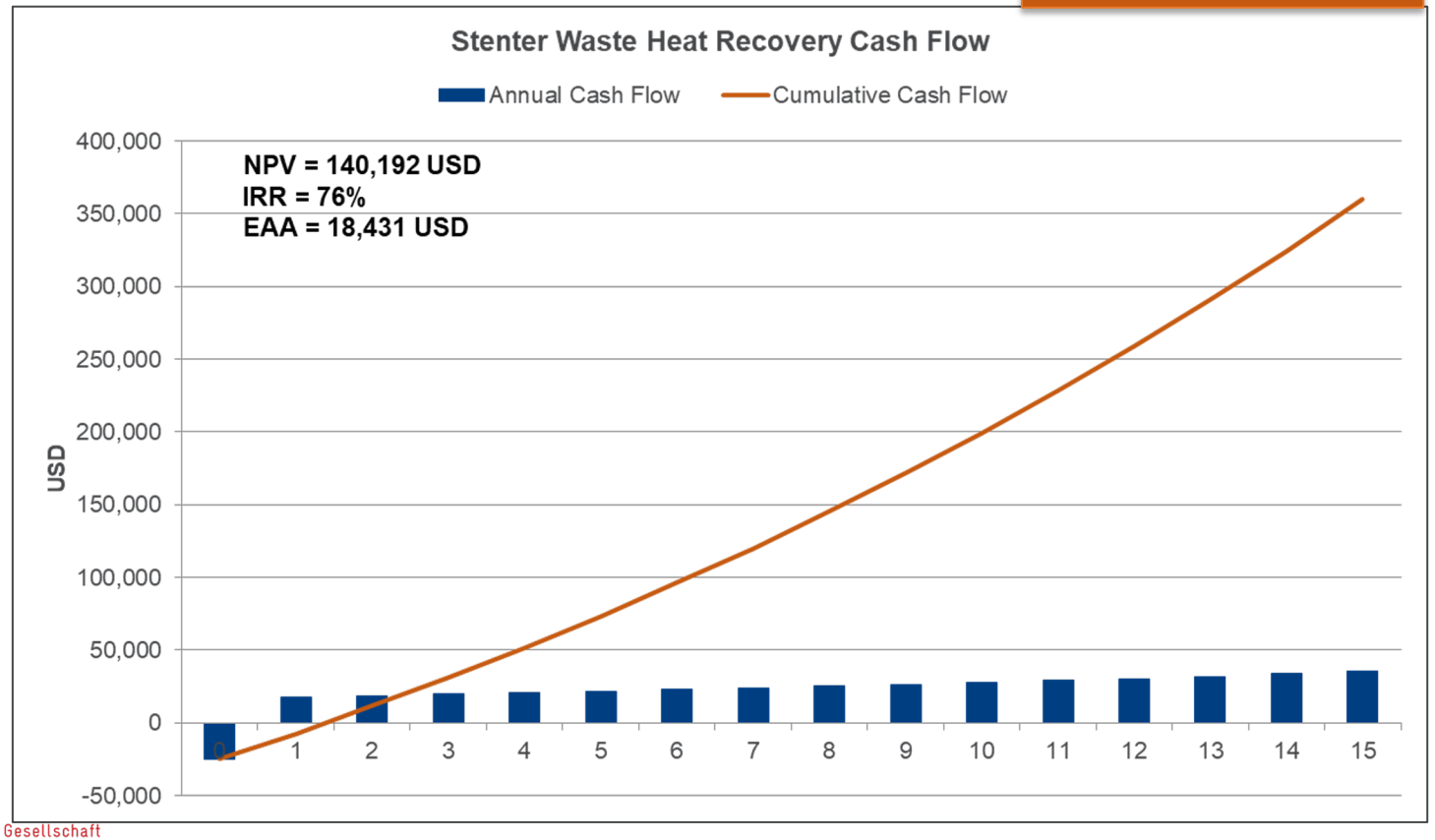




Financial Evaluation - Example

- Do we really need to calculate IRR and EAA here?

Although the payback is very obvious, IRR or EAA might still be needed if bank financing is required.

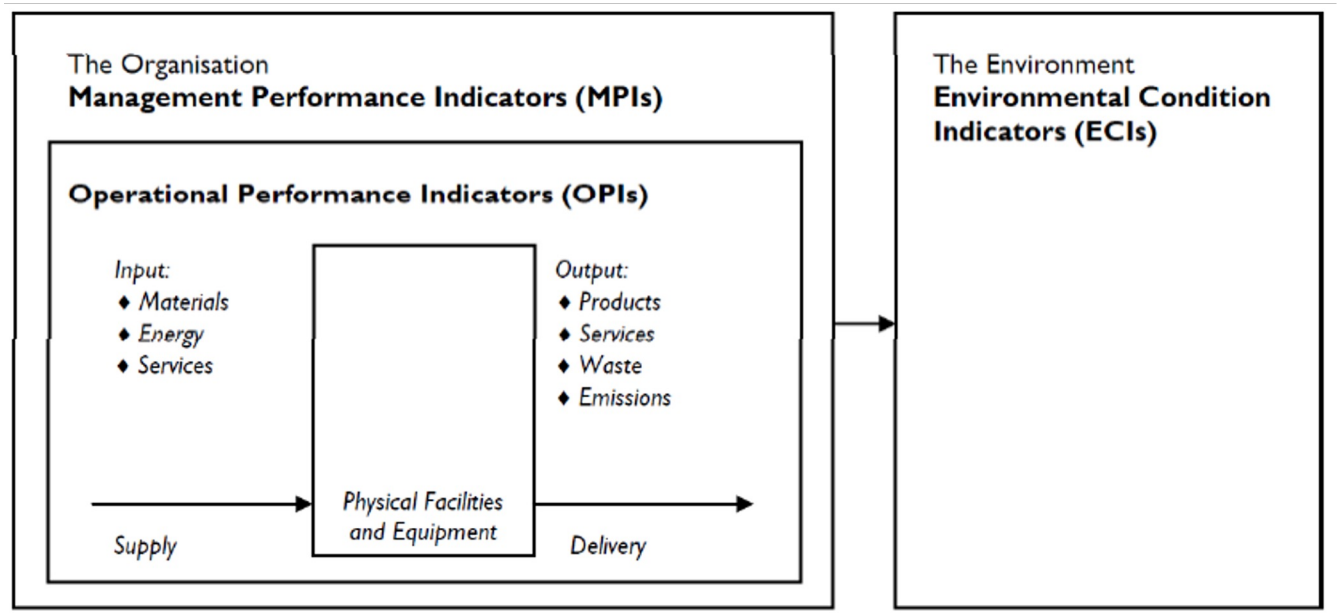


Group Task – The Textile Company

- The Textile Company is planning Installation of a waste heat recovery system at a stenter and has two options;
  - Option-1: Locally made system with investment of USD 30,000. This may result in annual savings of USD 20,000 with an annual O&M cost of USD 2,162. The equipment life is estimated to be 15 years.
  - Option-2: Imported system with investment of USD 75,000 resulting in annual savings of USD 25,000 and O&M USD 1,500. Equipment life is estimated to be 20 years
- Company uses 10% discounting factor in all calculations and does not invest in IRR below 15%.
- Your tasks
  - Create a cash flow for the options in excel
  - Calculate NPV, IRR and EAA
  - Suggest which option should company opt for and why

Total time: 30 minutes

Selecting and setting peformance indicators and goals



For example:
As per ISO 14031: Guidelines for Environmental Performance Evaluation

Selecting and setting peformance indicators and goals

SMART or ACCURATE

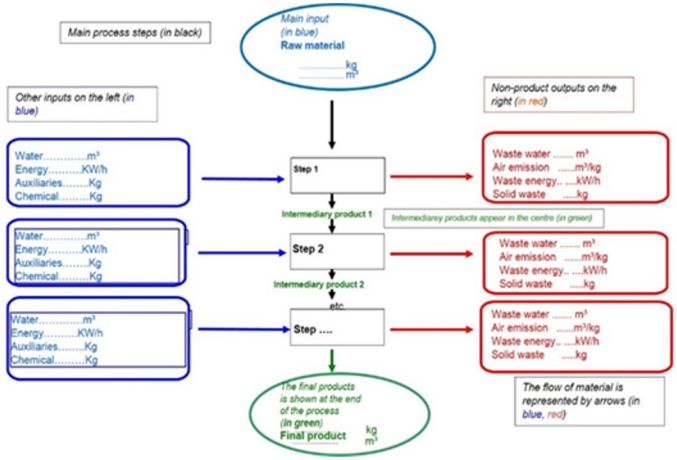
- Assessable or measurable.
- Controllable - able to be changed by what you do in chemical management.
- Central and relevant to what you are trying to achieve.
- Understandable and clear.
- Reliable - providing the same measures when assessed by different people.
- Acceptable to the users as true indicators of performance.
- Timely and
- Efficient to monitor.

Using available information

(1) Energy flow related indicators

- Absolute indicators inputs, outputs, NPOs
  - e.g. GJ energy used, production volume per year, GHG emissions
- Productivity ratios
  - e.g. GJ energy per ton of product
- Intensity ratios
  - e.g. Tonne-CO2/tonne-product

Refer back to your process flow charts



Example of Energy related performance indicators

Performance areas	Possible performance indicators
Energy Inputs	• Share of fossil energy in energy mix • Increase in share of renewable energy in energy mix • Total GHG emissions • Energy consumption per production unit
Demand side	• Individual SEUs energy performances • % of total waste heat recovered • Maintenance cost related to energy use (e.g. leakages, electronics failures…) • Number of health/safety incidents involving energy (e.g. electric shock, hot surfaces, direct exposure to high pressure…) • Number of physical damages involving energy (e.g. electric fire, pressure vessel explosions, gas release…)

Example of Energy related performance indicators

Performance areas	Possible performance indicators
Energy Management	• % of total energy use monitored using meters • Number of internal awareness campaigns • Number of trainings conducted • Number of workers attending training / awareness sessions • Number of workers showing improvement in behaviours after trainings • Number of non-conformances identified during internal EnMS audit • ….

Using energy performance indicators (EnPIs)

Compare Energy efficiency, resource productivity and environmental/safety/health performance over time.

Highlight improvement and optimization potentials.

Identify and follow up on targets.

Discover market opportunities and cost-reduction potentials.

Involve, educate and motivate staff.

Promote organizational learning.

Support decision-making by providing concise information about current status and trends with regard to resource use and performance.

Implement EnMS or EMS and/or generate information needed for your current EnMS/EMS.

Communicate your results to your stakeholders.

Relating performance and management action plans - Example

Energy losses/ critical situation/ identified gap	Proposed measure	Results of proposed measures (Energy, GHG, USD, RoI..)	Necessary action/ activities for implementing measure	Person(s) Responsible	Deadline for completion	Targets/ EnPIs to be monitored
Hot water drained from rope dyeing machine	Install wastewater heat recovery system	Coal Reduction xx T/y Energy reduction at ETP xx kWh Investment xx USD Saving xx USD IRR xx %	Develop technical requirements Hire contractor Install system and conduct first trials Commission the system	Mgr Maintenance Mgr Prcurement Mgr Prooduction	dd/mm/yyyy	Total GHG emissions Energy consumption per production unit

Issues to be addressed; ref. Eco-map, energy balance, energy audit…

Mutually agreed and technically correct measures

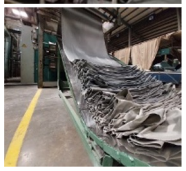
Measurable results of the interventions

Work breakdown, division of measure into tasks /milestones

Selected performance indicators







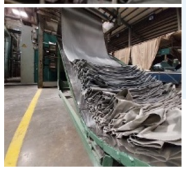
Relating performance and management action plans - Example

Example Energy Management Action Plan			
Objective: Reduce natural gas use by 5% compared to baseline FY 2006			**Original Issue Date:** 12/22/11
Target: Reduce boiler natural gas use 2.5% compared to baseline FY 2006			**Revision Date:**
Energy Management Project: Preheat boiler combustion air from 90°F to 110°F			
Project Planning			
Action Items	**Person Responsible**	**Due Date**	**Required Resources/Comments**
Assign project team	Management Rep.	2/14/11	Design, maintenance and procurement representatives
Collect data	Joe Mechanic	3/1/11	Assistance from maintenance
Design heat exchanger	Ima Engineer	5/8/11	Autocad access
Install system	Acme Contracting	6/14/11	Overhaul boiler during installation (See boiler plan)
Test and commissioning	Joe Mechanic and Ima Engineer	6/28/11	
Savings validation	Ima Engineer	7/1/11 – 6/30/12	Maintenance to collect data daily See Project Verification Plan
Target Verification Plan			
Item			**Information/Resource Requirements**
Calculate EnPI in Btu/lb of product each month for baseline year			Boiler gas meter data and production and temperature data for FY 2006
Calculate EnPI in Btu/lb of product each month for 12 months after installation			Boiler gas meter, production and temperature data for 12 months after installation
Calculate average annual EnPI for each 12 month period			
Calculate percentage difference in average annual EnPI for baseline year and 12 months after installation Calculate average monthly savings for bottom up analysis			M&V requirements, documented savings
Actual Results/Comments: Based on production records and meter readings the project resulted in an energy savings of 300 Btu/lb based on production and a 1,570,000 Btu/hr (25.4 CFM) savings of natural gas.			
Prepared by: *Earnest Brown*			**Date: 12/22/2011**
Approved by:			**Date:**

Source: 2011 Georgia Tech Research Corporation and U.S. Department of Energy







Relating performance and management action plans

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

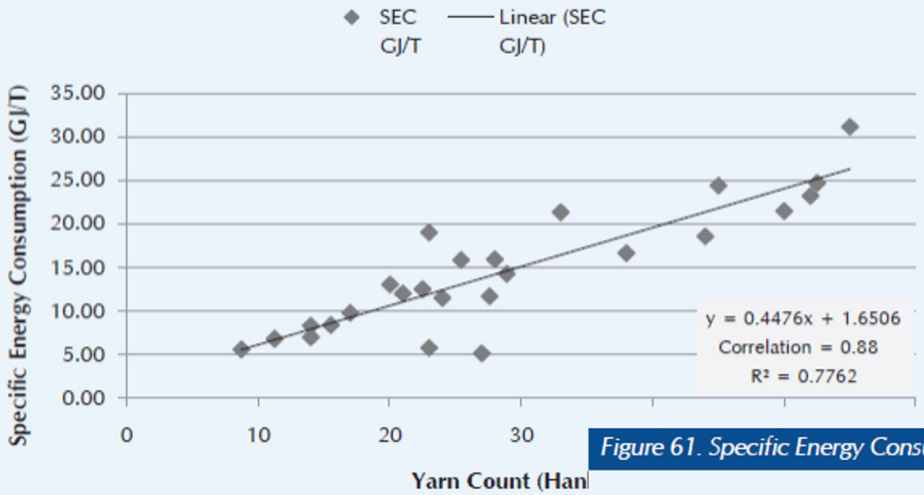
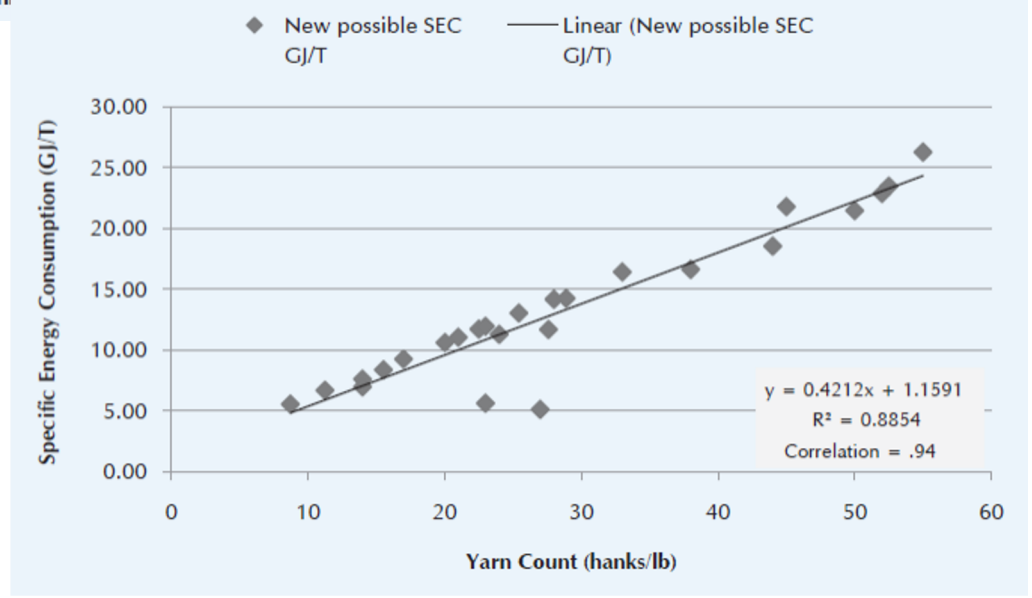


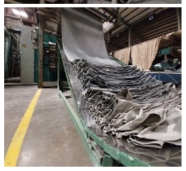
Figure 61. Specific Energy Consumption Trend line based on Possible Savings (100% Cotton Yarn)



Source: Sectoral Analysis on Renewable Energy and Energy Efficiency in 5 sectors of Pakistan - UNIDO







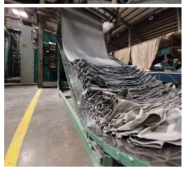
Relating performance and management action plans - Example

Resource	Key performance indicator			Projected Annual Saving	
	Current	Target	% Reduction	Quantity	Monetary (USD/y)
Electricity	1.153	1.145	0.7%	148,133 kWh	11,408
Steam	14.12	14.11	0.05%	131 Tonne	1,568
NG	0.318	0.313	1.8%	111,975 m^3	25,010
Water	86.40	85.2	1.4%	24,015 m^3	2,235
GHG	3.74	3.72	0.4%	310 TonneCO_2	
Total					40,221

Units for KPI: kWh/kg for electricity, kg/kg for steam, m^3/kg for NG, l/kg for water and GHG emission kg/kg







Organising, monitoring and reporting implementation

Example: Using an implementation board

Improvement Board

Goal	Target to be achieved
How	Agreed actions, activities, responsibilities
Follow-up	Decisions in previous meetings.

New issues

- Coal price hike
- New steam leakages
- Engine maintenance overdue

Work in Progress

- Wastewater Heat exchanger installation
- Air leakage repairs
- WHRB Feasibility
- New comp air PRV procurement

On Hold

- Stenter waste heat recovery
- Solar Water Heater

Results / Successes

- Boiler efficiency improvement
- Reduced electric shock incidents
- Energy Policy Approved
- Solar PV commissioned
- KPI Trainings

Monitor

- Trainings
- Leakages
- Condensate recovery %

Exercise – The Textile Company

Action Planning

Tasks in your group

1. Refer to earlier identified energy NPOs (eco maps, flow charts, energy balance)
2. Assess impacts of major NPOs and select 3 top priority NPOs
3. Conduct Root-cause analysis for selected NPOs
4. Develop action plans
5. Present your findings in plenary

Total time: 90 minutes