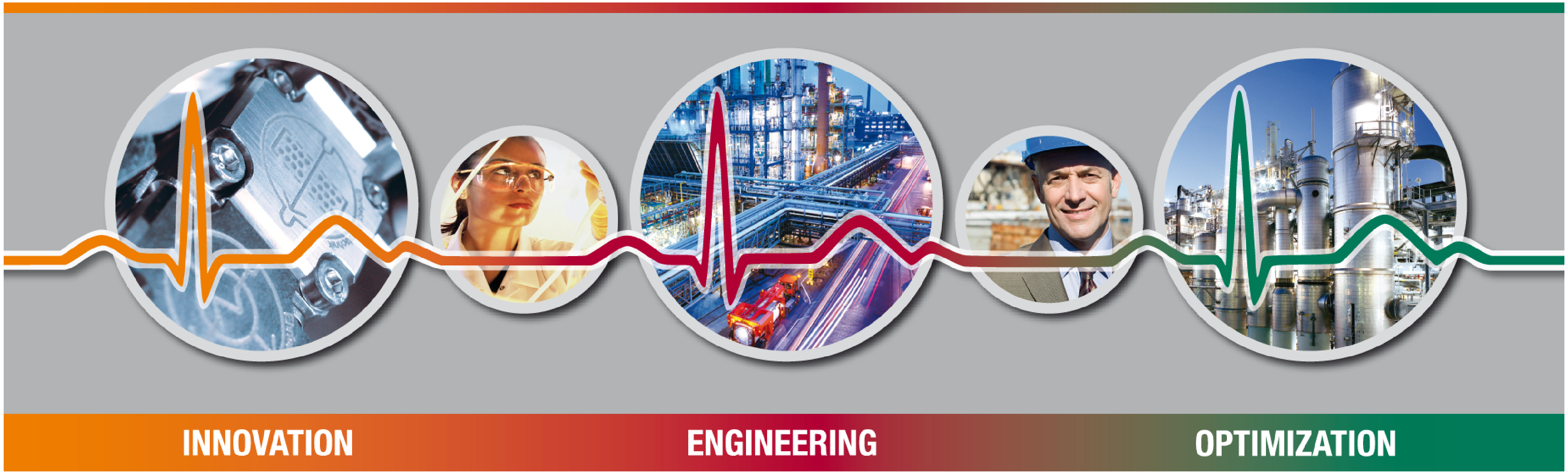
Powering Your Performance



Sustainable Optimization of Energy Efficiency

(in the chemical / pharmaceutical industry)

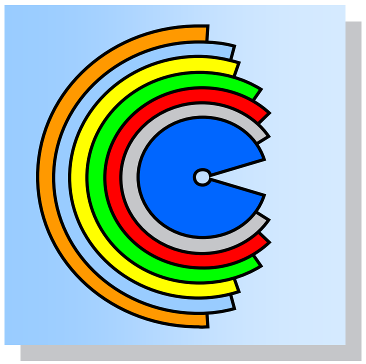
CERAMITEC 2009 – Munich – 22. October 2009

Dr. Philip Bahke

Bayer Technology Services

Agenda

- Introduction
- Energy Efficiency Check
- Climate Footprint®
- Energy Efficiency Management



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Increasing need to optimize energy efficiency and to reduce greenhouse gas emissions

Energy represents increasing share of operating costs at chemical plants

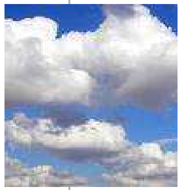
Percentage of total costs increased from ~3 to ~12 over last ten years due to rising energy prices

Reducing energy costs is key lever to increase profitability

Chemical companies contribute significantly to man-made greenhouse gas emissions

Reduction targets defined by several companies

Reducing greenhouse gas emissions is required for economic and social reasons



Increased expectations of governments in energy and CO_2 efficiency

Regulation started (EEG) and implementation of energy efficiency law (EnEfG) expected

Satisfy increasing regulatory requirements by having a management system in place

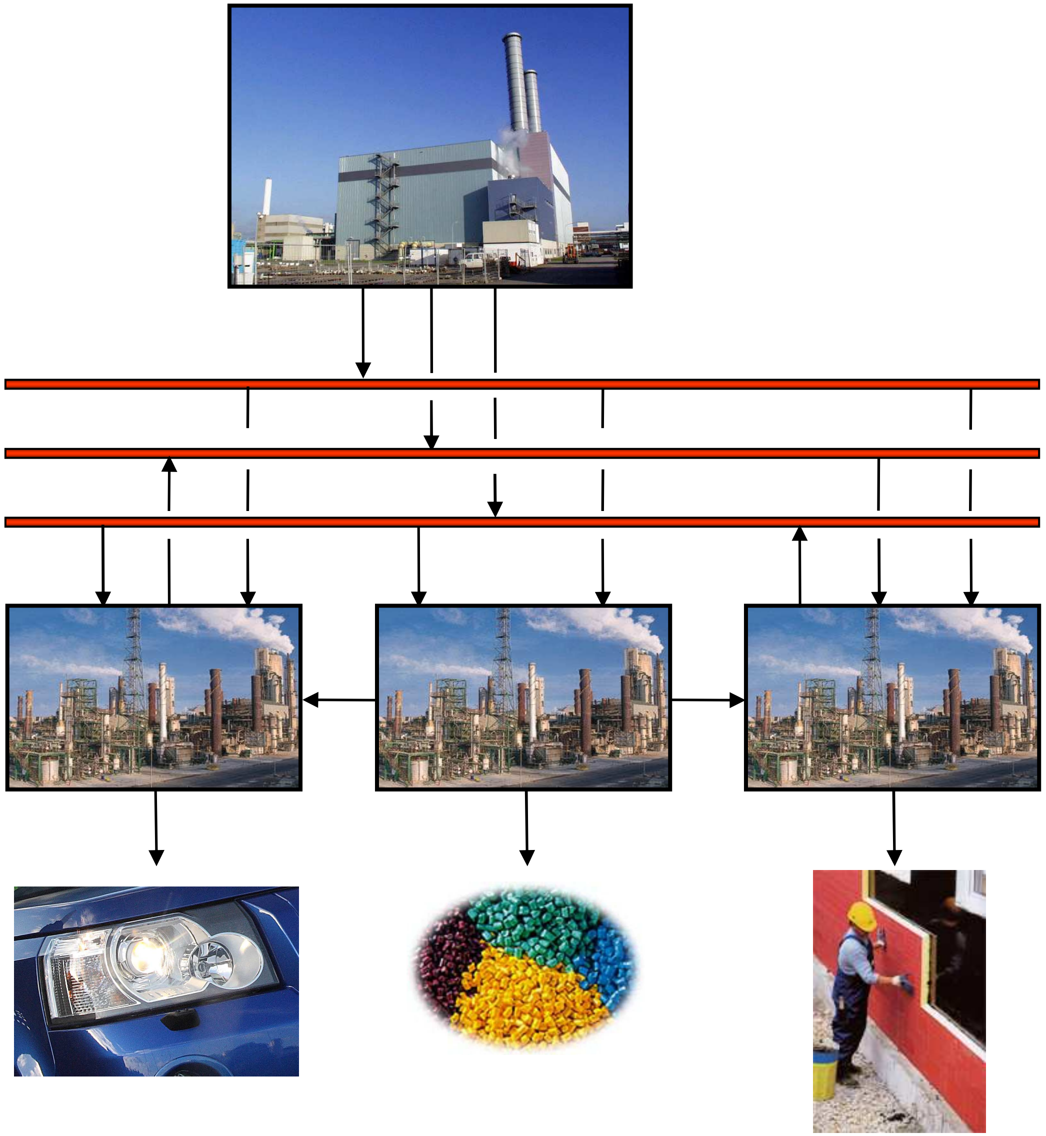
Several levers to improve energy efficiency in the chemical industry

Energy Generation

Site Integration

Production Process

Products



Several levers to improve energy efficiency in the chemical industry

Energy Generation

Co-generation plants – combined heat and power

- Total efficiency incl. heat extraction: ~85%
- Modern power generation efficiency: coal: ~43%, gas: ~55%

Site Integration

Total site integration offers huge potentials

- Energy integration between processes: heat of exothermal processes is used → design of steam pressure levels crucial
- Well balanced material usage, e.g. no by-product flaring (H_2)

Production Process

Best available technology (BAT)

- New type of process technology and equipment design
- Optimized process operation

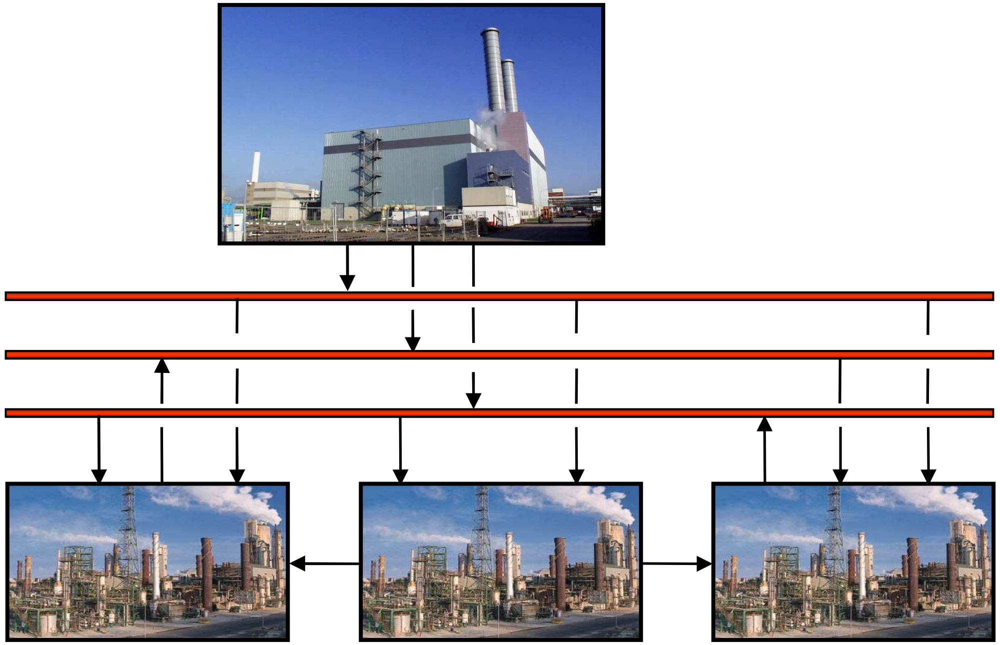
Products

ICCA study: application of chemical products saves more CO_2 compared to production, e.g.:

- Modern insulation materials for buildings or cooling units
- Plastics to reduce weight of cars

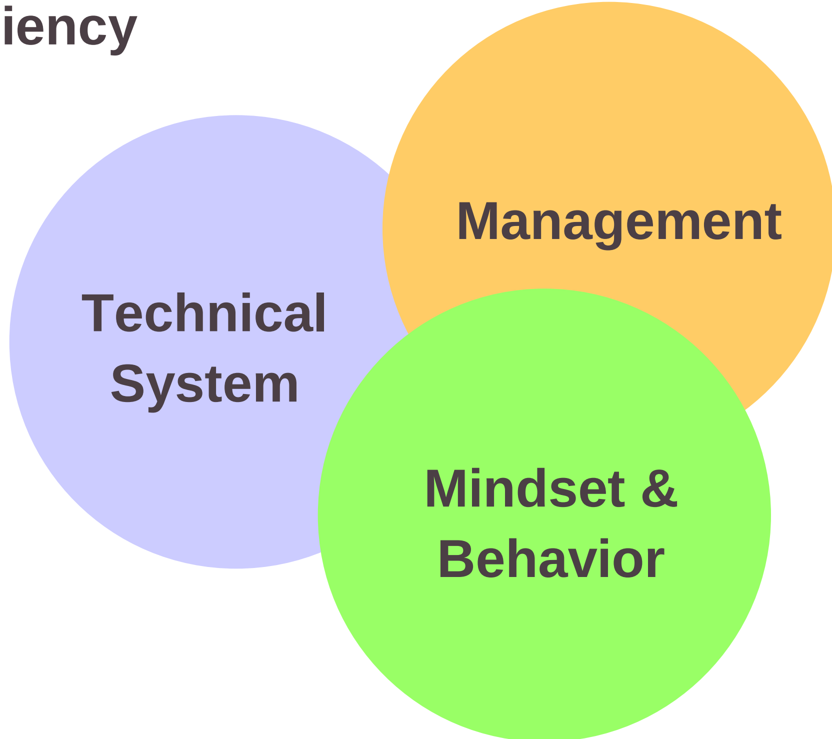
Focus on existing as well as on development of new processes and site networks

Optimization of existing processes and site network	Development of new processes and site network
▪ Potential savings: 5 - 20 %	▪ Potential savings: 20 - 80 %
▪ Short-term implementation possible	▪ Long-term implementation
▪ Low costs	▪ High costs (R&D and investment)



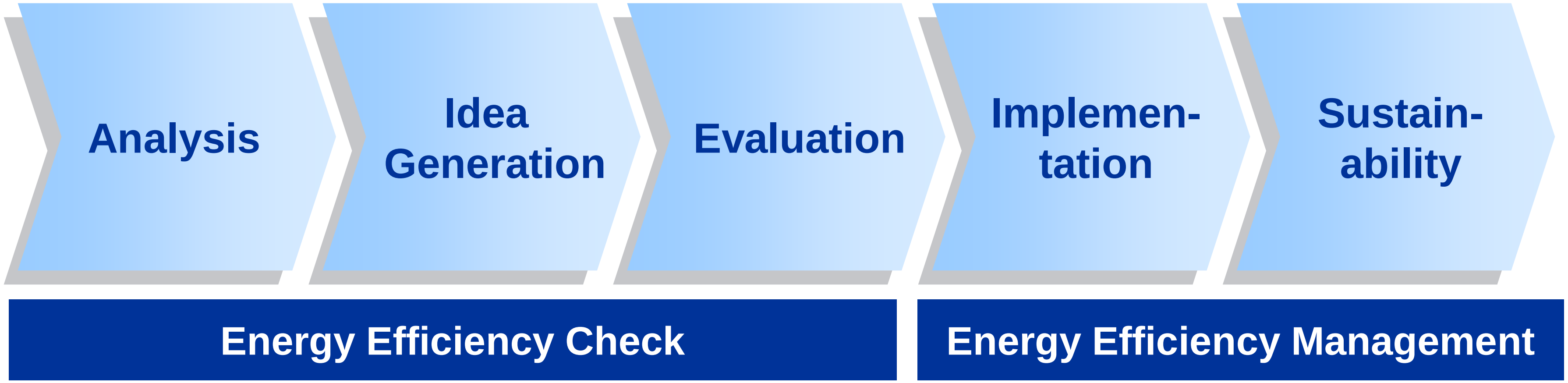
Existing processes: energy efficiency optimization need to consider three elements

Sustainable energy efficiency optimization of existing processes needs to consider three elements…



and requires an efficient workflow.

Sustainable energy efficiency is divided in two parts

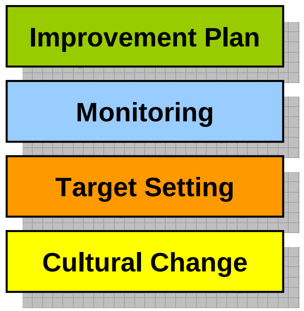


Energy Efficiency Check

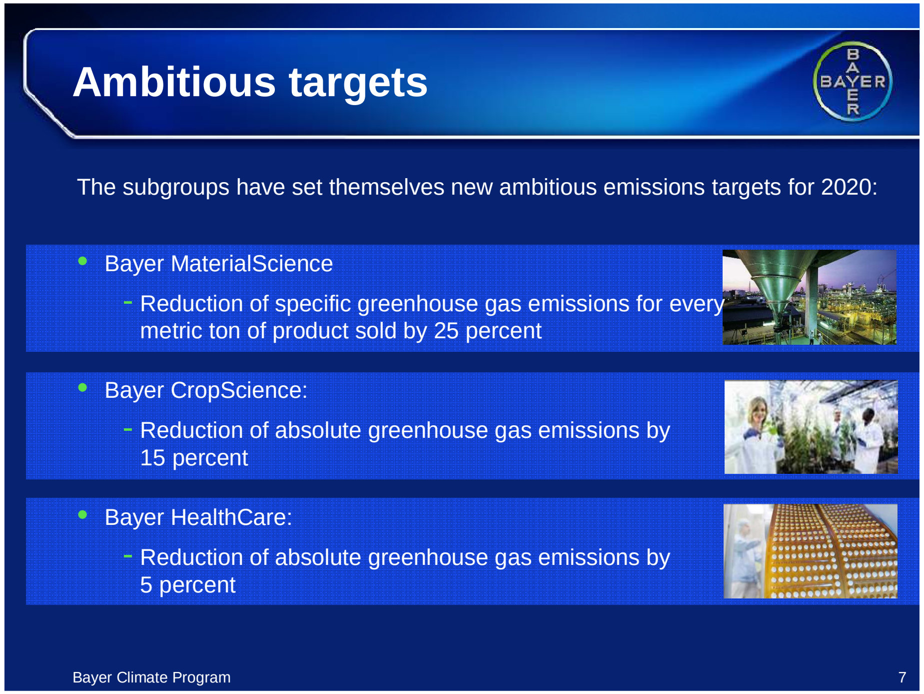
- is a systematic screening
- identifies measures for energy & CO_2 emission reduction
- results in improvement suggestions

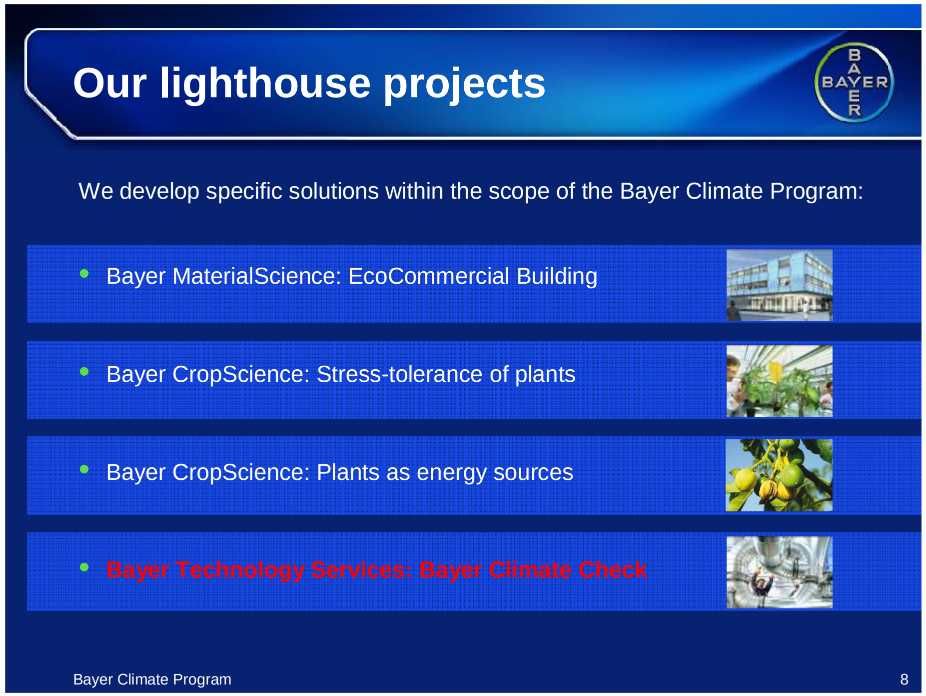
Energy Efficiency Management

- ensures sustainable imple-mentation of improvement measures
- sustains a high awareness level



The Bayer Climate Check is a lighthouse project of the Bayer Climate Program

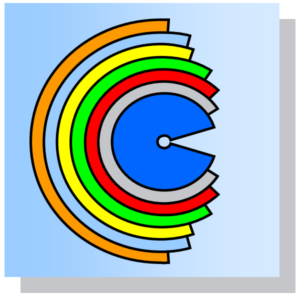




The Bayer Climate Check will be applied to all relevant Bayer production units worldwide

The Bayer Climate Check…

- will be applied to all relevant Bayer production units worldwide
- supports achievement of targeted climate goals of Bayer subgroups
- consists of the two elements:
  - Energy Efficiency Check
  - Climate Footprint®



Scope:

- App. 100 Bayer production plants on 40 sites worldwide will be analyzed by the end of 2009.

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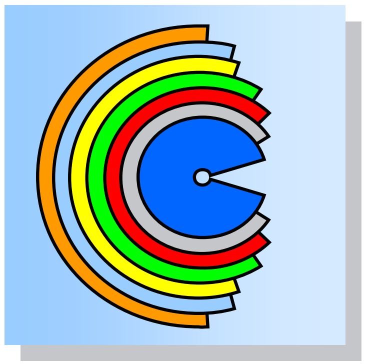
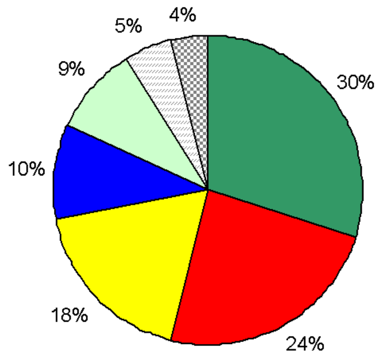



Analysis Phase determines main levers for energy reduction

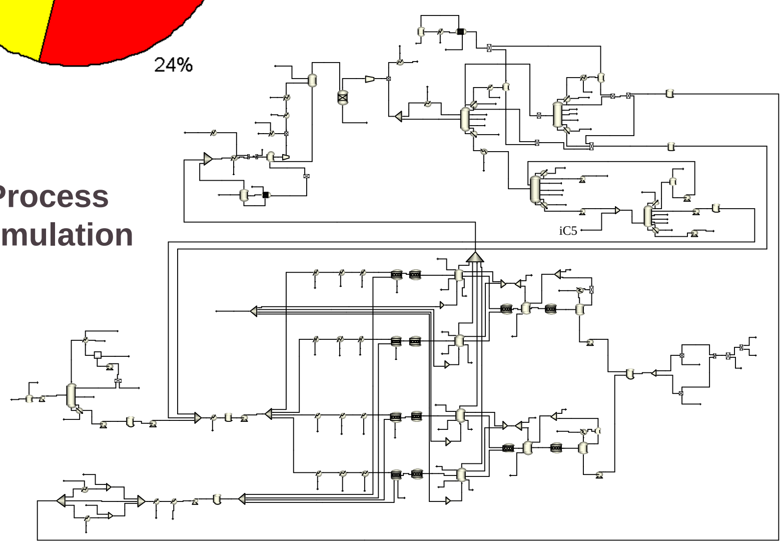
Analysis | Idea Generation | Evaluation | Implementation | Sustainability

Analysis & Data Collection

- Identify **main energy consumers**
- Determine **consumption data** by measurement, balance or process simulation
- Perform **plausibility check**: comparison of measurement vs. theory
- Determine **degree of completeness**
- Collect **energy relevant data**:
  - Operational process data (e.g. power, temperature, flows)
  - Technical equipment data
- Result: **consistent data base**
  e.g. consistent balance of heat sinks and sources by process simulation incl. energy relevant operating parameters



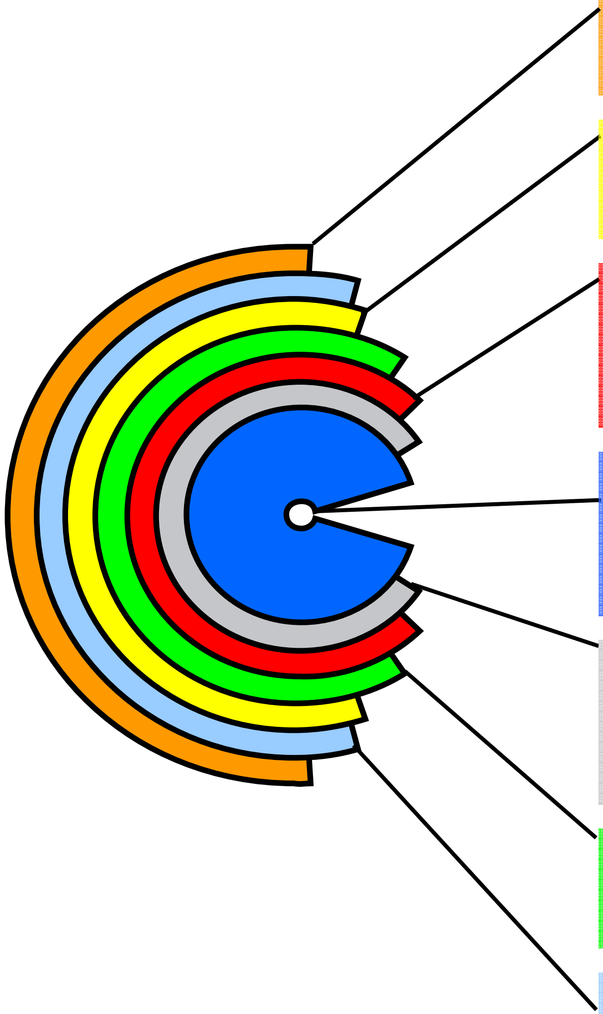
Energy Distribution



Process Simulation

The Energy Efficiency Check considers a wide range of optimization levels

Analysis | **Idea Generation** | Evaluation | Implementation | Sustainability



Energy & Utility Supply
Assess generation and distribution

Raw Materials
Optimize raw material consumption

Heat Integration & Recovery
Perform Pinch Analysis and check waste heat recovery

Equipment Check
Evaluate energy consumers for best practice by checklists

Operational Improvements
Optimize operating parameters and process control

Process Improvements
Optimize design of processes

Buildings & Facility
Assess heating, lighting and HVAC

Idea generation phase determines suggestions for energy & CO_2 emission reduction

Analysis | **Idea Generation** | Evaluation | Implementation | Sustainability

Sources for improvement suggestions:

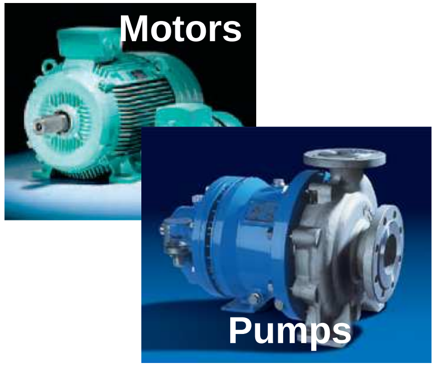
- **Checklists & best practices**
- **Process experts**
- **Discipline experts** of required competences
- **Brainstorming sessions** & Interviews
  to incorporate improvement ideas from plant management and operating employees

Checklist Centrifugal Pump

Equipment check: evaluation of large energy consumers

Analysis | **Idea Generation** | Evaluation | Implementation | Sustainability

Equipment Check



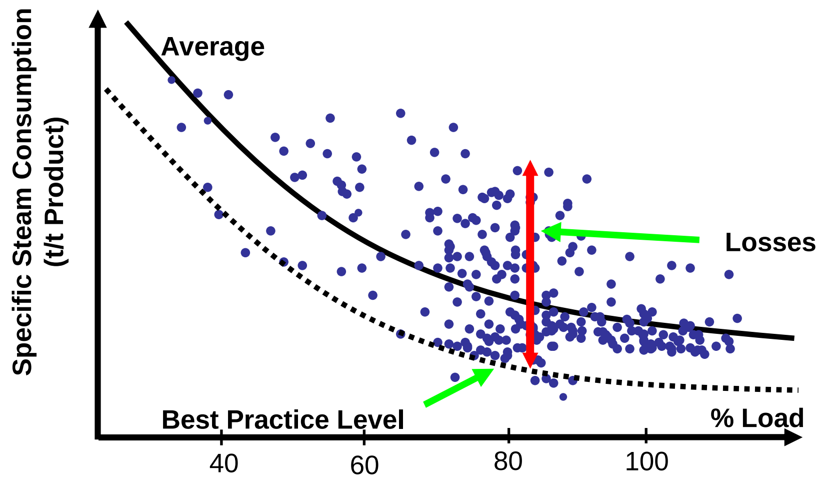
- **Evaluate larger single energy consumers**
- Several checklists for main equipment developed, e.g. centrifugal pump: operating point and control strategy
- What we often see:
  - **Pumps**: up to 50 % of pressure increase is consumed in control valve → implement frequency drive
  - **Heat exchanger for cooling**: cooling media flow is not controlled
  - **Heat exchanger for heating**: steam pressure level is too high
  - **Distillation columns**: replace trays by packing
  - Equipment is always running

Optimize operating parameters and process control

Analysis | **Idea Generation** | Evaluation | Implementation | Sustainability

Operational Improvements & Process Control

- **Improve process operation and process control**
- What we often see:
  - **Distillation columns** are operated at too high reflux flows → improve process control
  - **Reactors** are operated with excess of solvent or reactant leading to large circulation flows → improve operation by e.g. online monitoring of process control (APC)
  - **Batch plants**: high peak demands of utilities → improve production planning
  - Specific energy consumption shows fluctuations
  - Operating parameters are not challenged
  - After failure processes remain in a “save” operating point
  - Processes are operated in a “comfort zone”

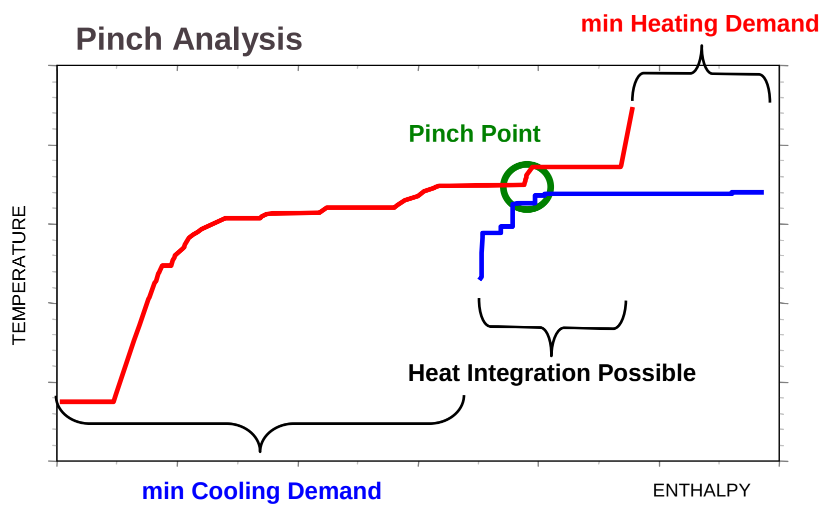


Improve heat integration & heat recovery by pinch analysis and novel technical solutions

Analysis | **Idea Generation** | Evaluation | Implementation | Sustainability

Heat Integration & Heat Recovery

- **Optimize heat integration by applying Pinch Analysis**
  - Consideration of process modification essential,
    e.g. increased pressure in distillation leads to increased condensation temperature
- What we often see:
  - waste heat is "destroyed"
    with cooling water
- **Recover waste heat by:**
  - **Pre-heating** of feed streams
  - Generation of **low pressure steam**
  - **Absorption chiller** to produce
    chilled water
  - Applying **vapor recompression** or
    heat pumps to produce "valuable" heat



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Optimize processes design

Analysis | **Idea Generation** | Evaluation | Implementation | Sustainability

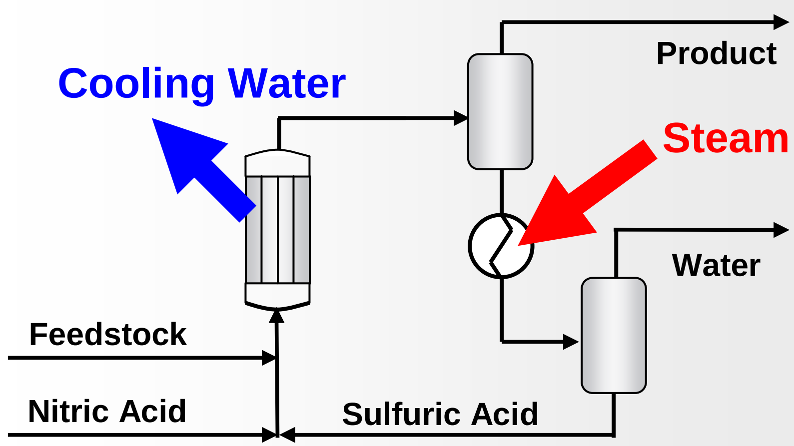
Process Improvements

- **Improve design of process steps / unit operations and complete process**
- Examples:
  - **Evaporation or distillation**: replace single step by multi-effect with heat integration
  - **Product concentration**: replace evaporation steps by membrane
  - **Solvent selection**: replace solvent by component with lower evaporation enthalpy or better separation factor
  - **Reaction**: check for application of innovative technologies like micro technology, process intensification, best catalyst etc.
  - **Spray dryer**: optimize atomization and heat recovery
  - **Waste water stripper**: implement vapor recompression by steam jet pump and feed preheating

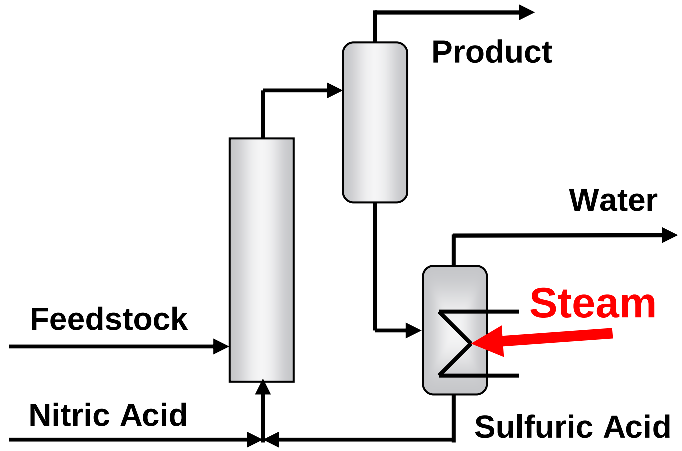
Redesign of production process leads to significantly increased energy efficiency

Analysis | **Idea Generation** | Evaluation | Implementation | Sustainability

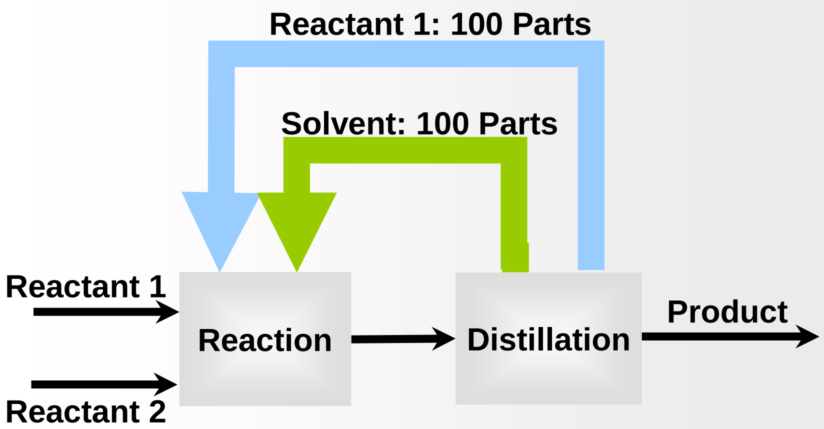
Isothermal nitration



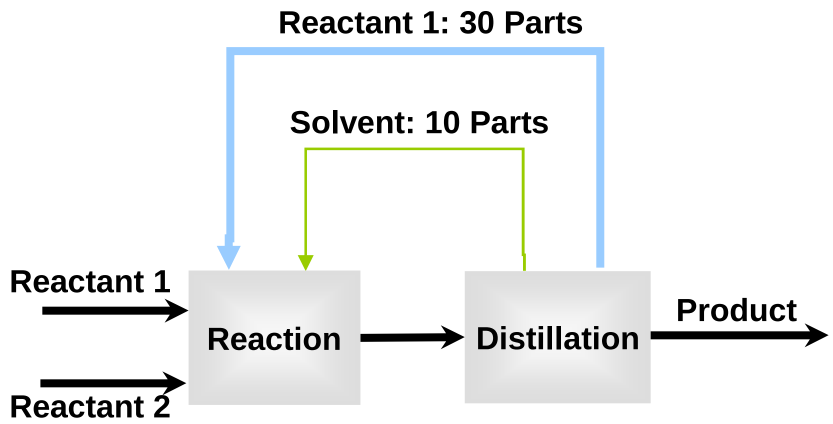
Adiabatic nitration



Liquid phase reaction



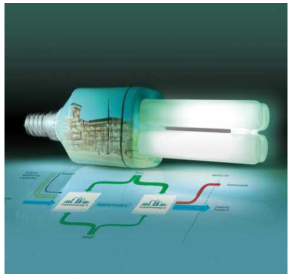
Gas phase reaction



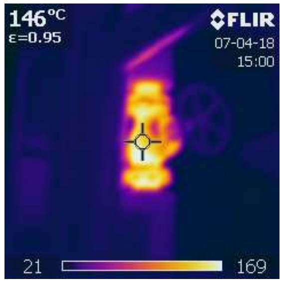
Check buildings and facility

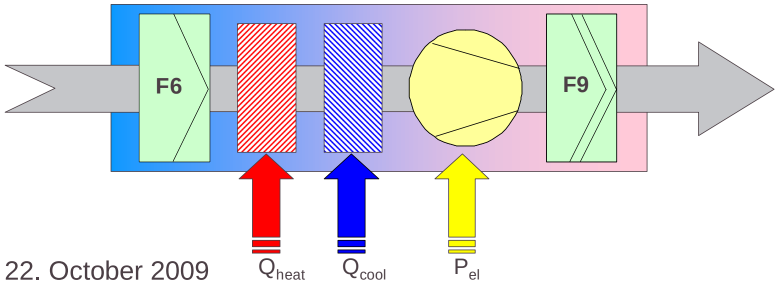
Analysis | **Idea Generation** | Evaluation | Implementation | Sustainability

Buildings & Facility



- Check illumination, insulation and leakages
- Assess specific energy consumption of buildings by benchmarks or balancing
- Assess heating, ventilating and air conditioning (HVAC)
- What we often see:
  - **Insulation** often inefficiencies
    → use IR camera to detect inefficiencies
  - Outdoor **lighting** is always on
  - **HVAC**: air exchange rates and humidity are higher than required; no heat recovery



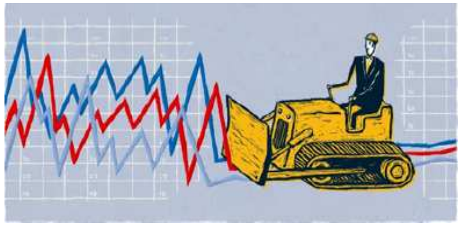


Assess generation and distribution of energies & utilities

Analysis | **Idea Generation** | Evaluation | Implementation | Sustainability

Energy & Utility Systems

- **Improve energy and utility generation and distribution**
- What we often see:
  - Low overall **boiler** efficiency, e.g. due to no pre-heating or inefficient degassing of water → increase heat recovery
  - **Let-down of high pressure steam** to low pressures steam leads to enthalpy losses → implement steam turbine
  - Low level of **condensate return** / reuse
  - Low temperature difference in **circulation systems** → decrease circulation flow
  - No regular **steam-trap maintenance**
  - **Heat tracing** not turned off in summer
  - High **peak loads** → peak demand reduction



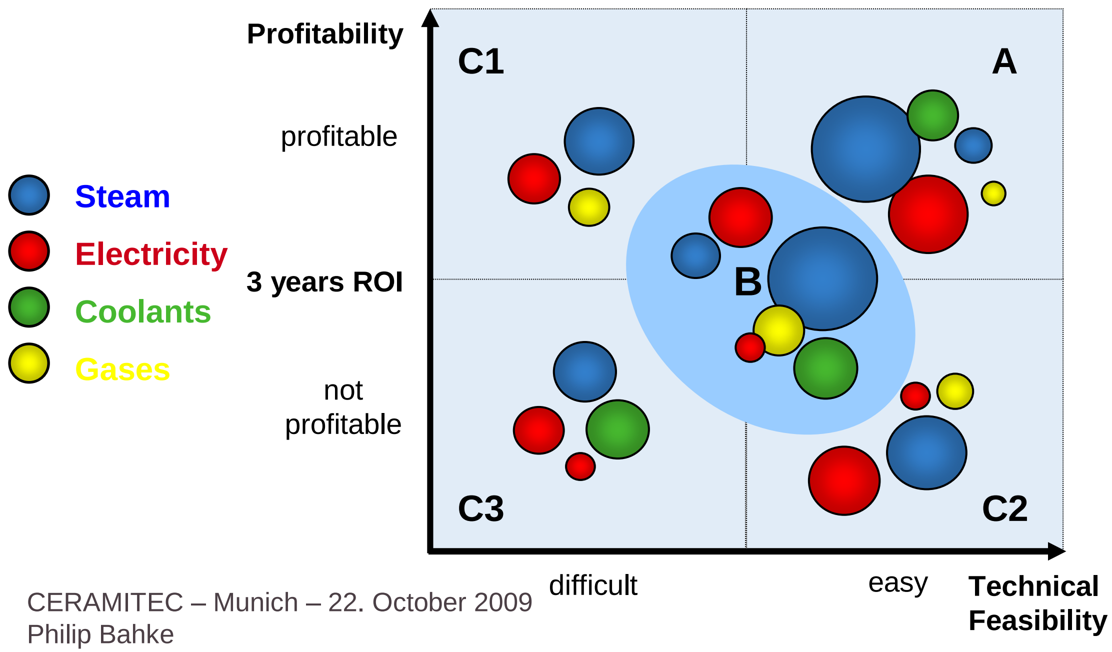
All improvement ideas are evaluated

Analysis | Idea Generation | **Evaluation** | Implementation | Sustainability

All improvement ideas are evaluated with regard to

- Technical feasibility
- Savings potential (CO_2e and costs)
- Costs for implementation (rough estimate)
- Profitability (rough estimate)

and displayed in a portfolio:



Categories
A = feasible and profitable
B = likely feasible and profitable, needs further evaluation
C1 = technically not feasible but profitable
C2 = technically feasible but not profitable
C3 = technically not feasible & not profitable

Bubble Size = Savings Potential

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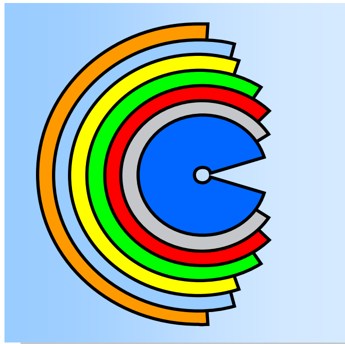
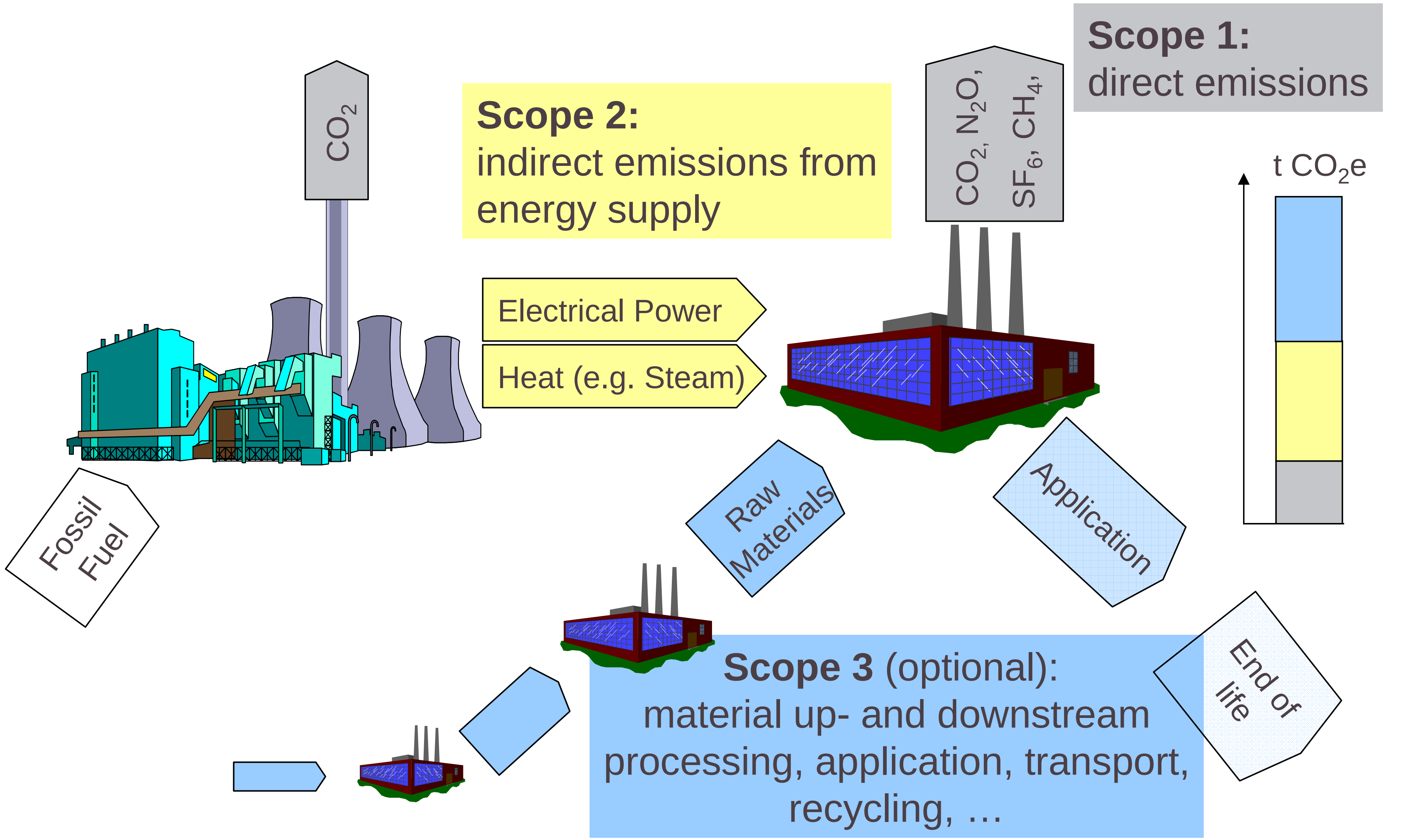


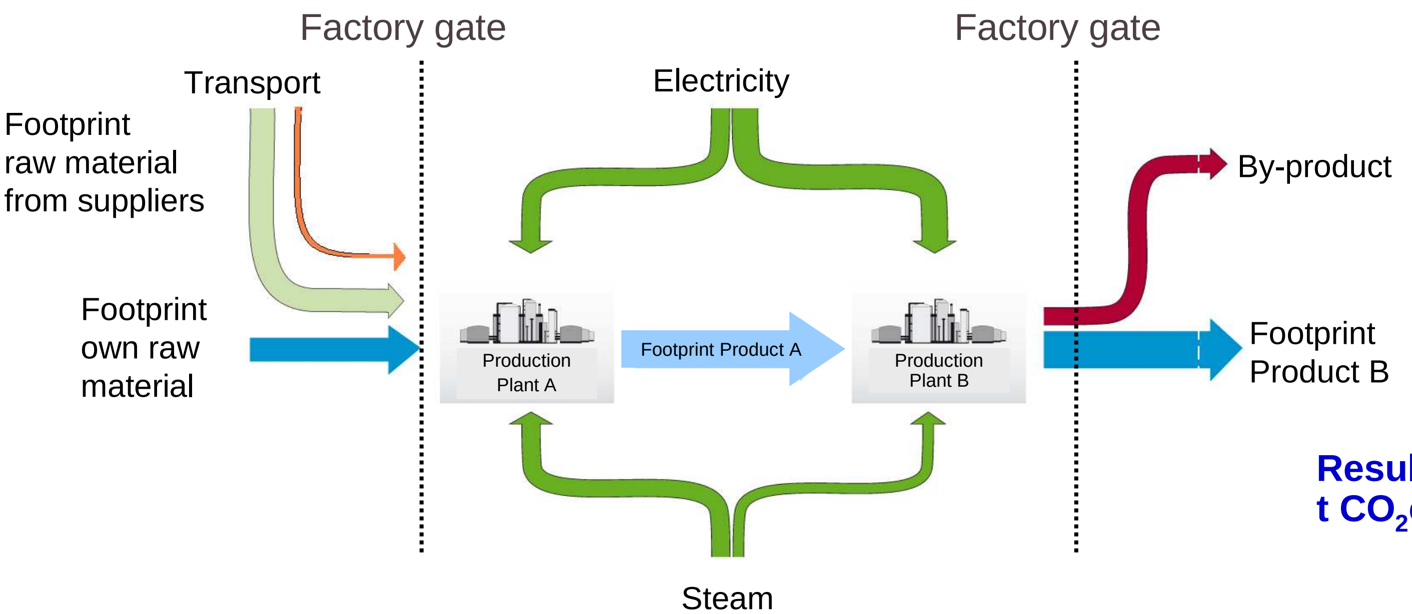
CO_2e emission reporting according to GHG protocol distinguishes 3 scopes



The Climate Footprint® is the indicator to asses the total climate impact of production processes

The Climate Footprint®

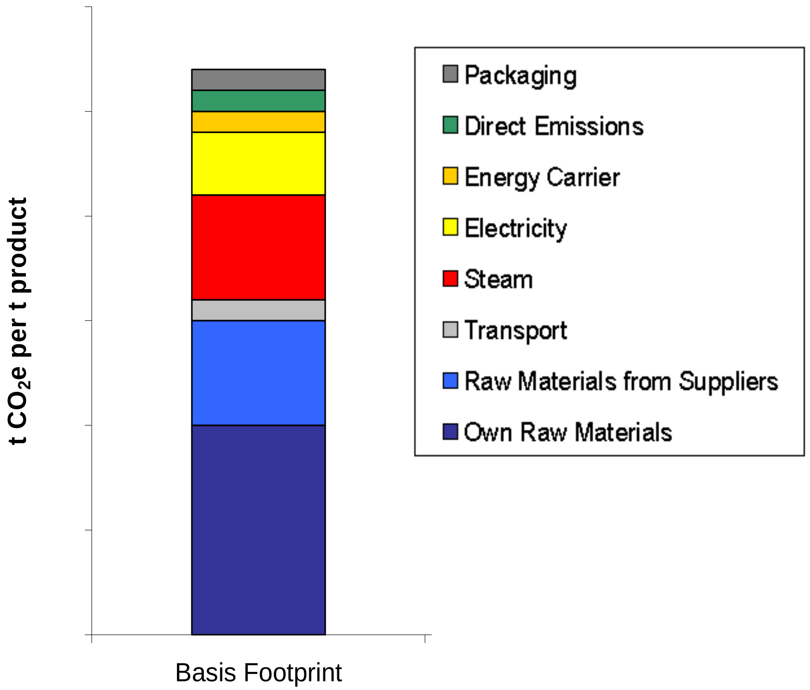
- is based on the Life Cycle Analysis method.
- covers the elements a product supplier could influence.
- summarizes direct emissions and emissions caused by energy consumption, raw materials and transport.



Resulting in:
t CO_2e / t product

The Climate Footprint® visualizes different contributions

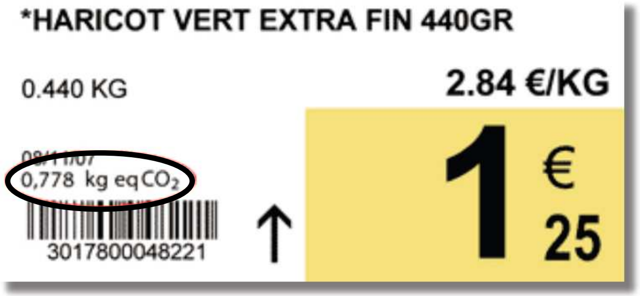
The Climate Footprint® visualizes individual climate impact and different contributions.

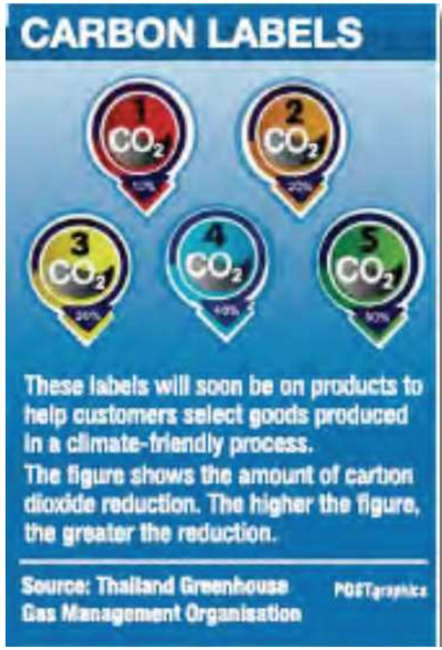


The Climate Footprint® is certified by TÜV Süd.

Carbon footprints are in public discussion.

Examples for Carbon Footprints





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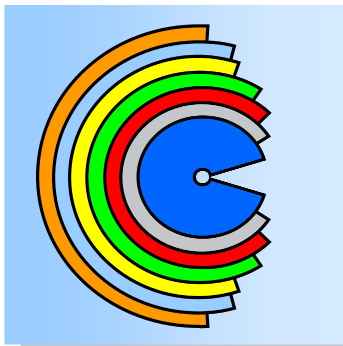
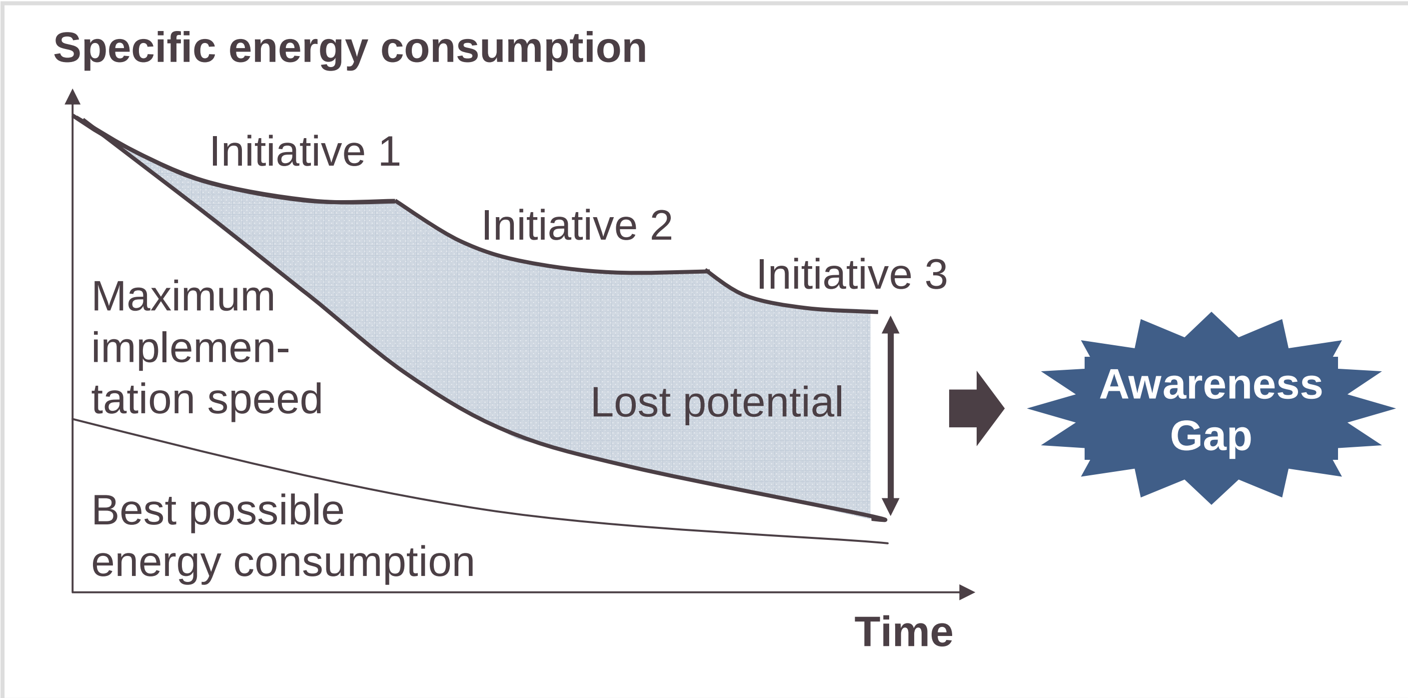



Closing the awareness gap is a challenge

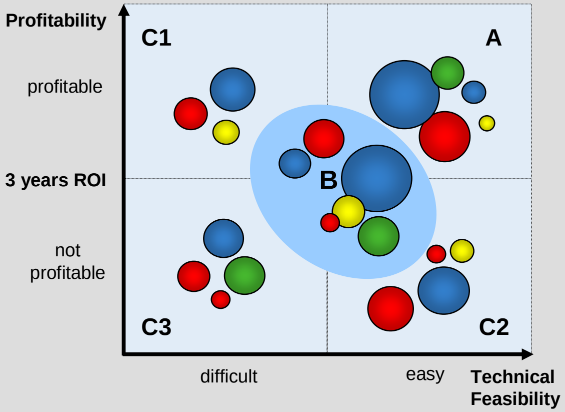
Analysis → Idea Generation → Evaluation → **Implementation** → **Sustainability**



Individual energy savings initiatives cannot sustain a high awareness level over time.

Improvement of energy efficiency is achieved by optimized design and optimized operation

Analysis → Idea Generation → Evaluation → **Implementation** → **Sustainability**



Improvement Measures

Optimized Design

Optimized Operation

By Automation

By Operator

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Energy efficiency management comprises four elements

Analysis → Idea Generation → Evaluation → **Implementation** → **Sustainability**

Four elements for sustainable implementation of energy efficiency:

Improvement Plan	Improvement plan to manage implementation of design measures (capex projects).
Monitoring	Monitoring (e.g. online) to visualize the status of a plant. → Ability to change
Target Setting	Reporting, target setting and responsibilities to motivate to leave the „comfort zone". → Motivation to change
Cultural Change	Cultural Change to increase awareness for energy-conscious behavior and mindset. → Awareness to change

To ensure implementation of design measures an improvement plan need to be managed

Analysis → Idea Generation → Evaluation → **Implementation** → **Sustainability**

Elaboration and implementation need to be managed!

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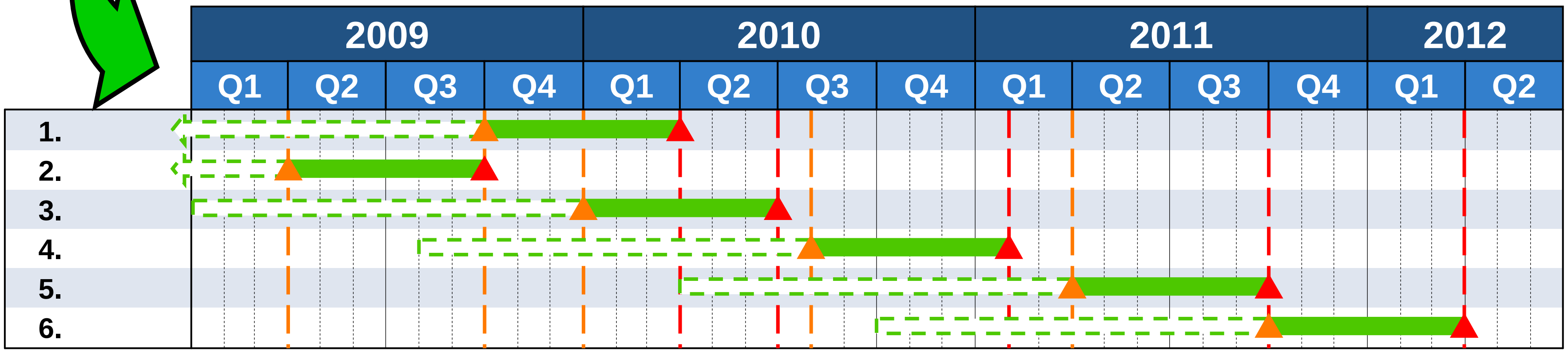
Update | Jump to selected Sheet | Compact | Add new Project Sheet | Enumerate | Euro BMS | Change

Improvement Plan

Energy-Efficiency-Check for Process / Plant:

Active?	Project No.	Title	Unit/AKZ	Rating	Cost Saving Potential AP	Total Investment	Payback Time	Loss Code	Lead Responsable
	[-]	[-]	[-]	[-]	[l/a]	[l]	[yr]	[-]	[-]
	1			A	78666,00	not calculated	not calculated	Op Par	Triebeneck
	1b			A	51863,37	not calculated	not calculated	Op Par	de Bruyne
Y	2			C2	1242423,00	5500000	4,43	Eq large	Wuytack
Y	3			C2	166142,59	927500	5,58	Eq large	anden Eynde/Trieben
Y	4			-	0,00	0	not calculated	---	Triebeneck
Y	5			B	35961,60	0	0,00	Op Par	Kahnis
Y	6			-	0,00	not calculated	not calculated	---	-> Project 1
Y	7			A	8035,17	5000	0,62	Op Par	Kahnis/Heylen
Y	8			B	100623,20	10	0,00	Op Par	Kahnis/Braun



Start of construction work

Completion of project

Budget decision, detail planning, equipment ordering, work preparation

Construction work in the plant

More efficient operation requires transparency

Analysis → Idea Generation → Evaluation → **Implementation** → **Sustainability**

First requirement for more efficient operation is:

Ability to change

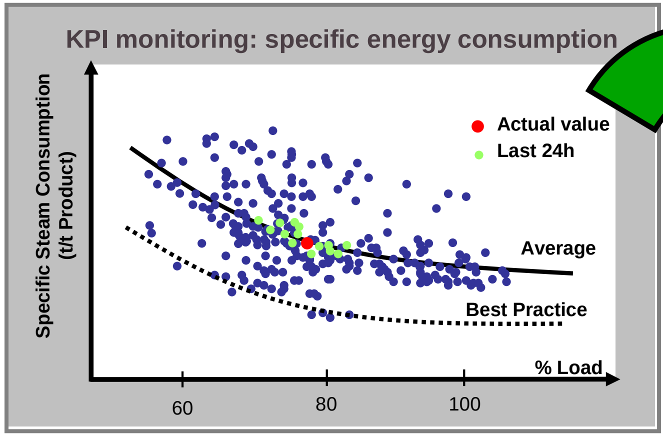
Monitoring

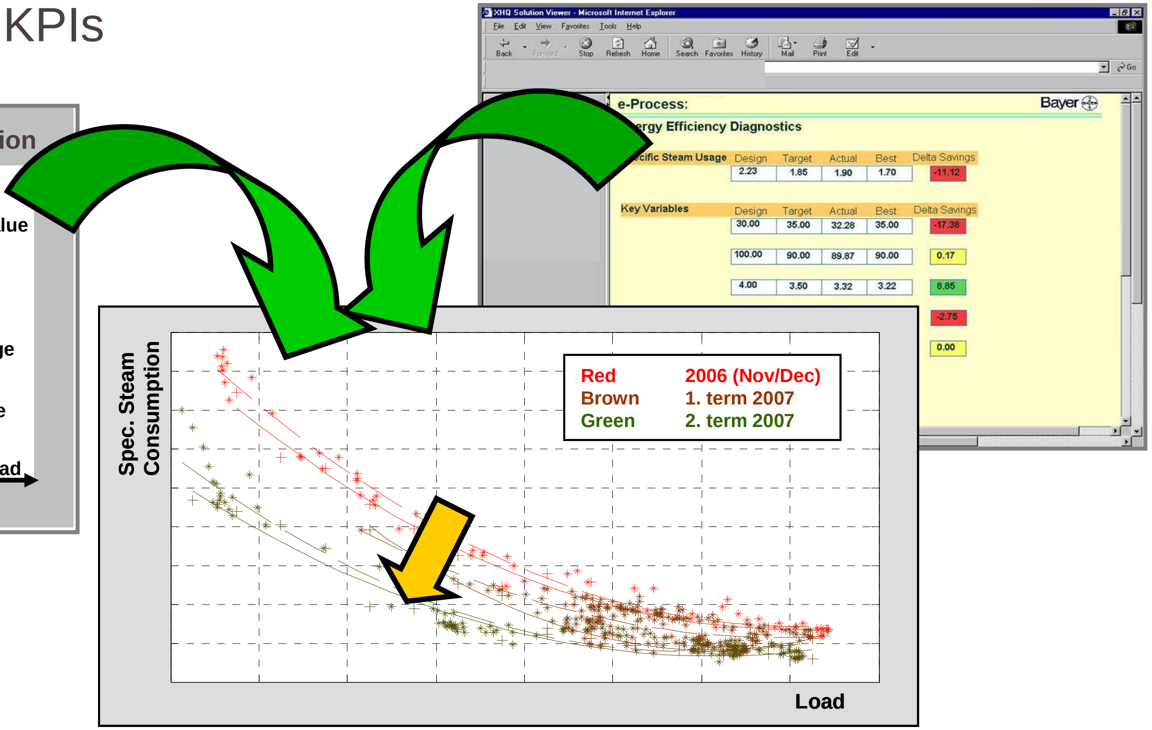
→ Create Transparency

→ Let the operator know in which status the plant is

→ Visualize energy influencing operating parameters (target vs. actual)

→ Define and visualize KPIs





More efficient operation means motivating the operator to leave the “comfort zone”

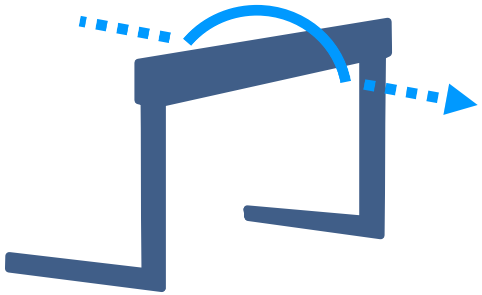
Analysis → Idea Generation → Evaluation → **Implementation** → **Sustainability**

Second requirement for more efficient operation is:

Target Setting

Motivation to change

- → Motivate / force the operator to leave the „comfort zone“
- → Set targets and track results
- → Ensure daily reminding and reporting, e.g. in shift meeting
- → Define responsibilities and reporting structure
- → Give clear leadership commitment
- → Give incentives for targets achievement



Cultural Change increases awareness for energy-conscious behavior and mindset

Analysis | Idea Generation | Evaluation | **Implementation** | **Sustainability**

Third requirement for more efficient operation is:

Cultural Change

Motivation to change

Goal: **Stimulate awareness and mindset of employees regarding energy-conscious behavior**

→ Give commitment of upper management

→ Train employees, e.g. best practice, guidelines, SOPs, maintenance plans

→ Give examples for model type behavior, e.g. "turn it off if not needed"

→ "Translate" savings into understandable figures

→ Improve cost awareness

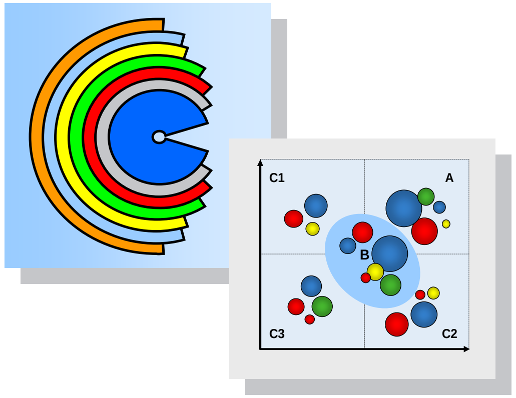
→ Create an internal climate change / energy efficiency award

Conclusion

Sustainable energy and climate efficiency requires…

- an indicator to determine the climate impact

- a comprehensive identification of measures for energy & CO_2 emission reduction



- and an integrated energy management approach

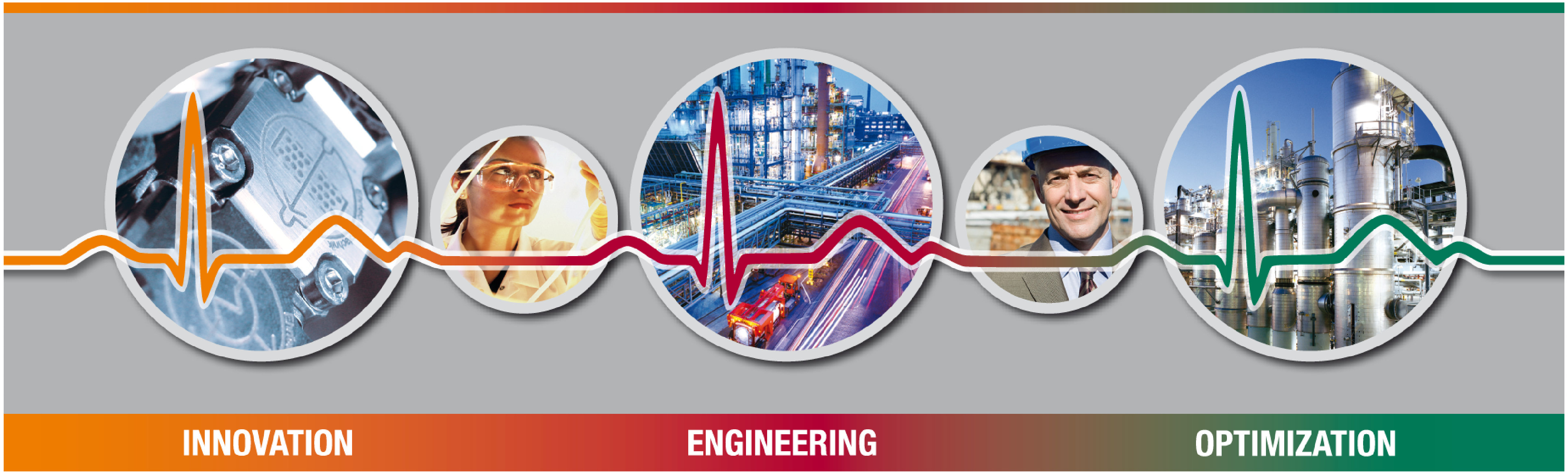
Improvement Plan

Monitoring

Target Setting

Cultural Change

Powering Your Performance



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