SOLAR PAYBACK - TRAIN-THE-TRAINER
SOLAR HEAT FOR INDUSTRIAL PROCESSES

Energy Efficiency

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Solar Payback

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Content

- Energy Efficiency in Industry
  - Rationale
  - Thermal Processes
  - Best Available Techniques
  - Standards
  - Energy Audit
  - EMS
  - Energy Profile
  - EnPI's

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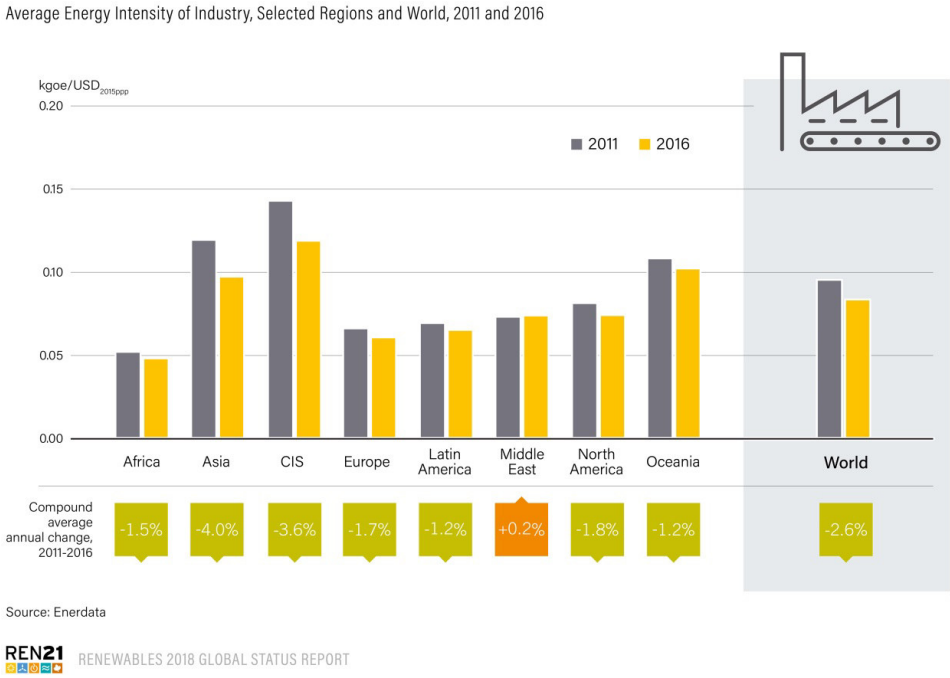
Energy efficiency in Industry
Rationale

- EE regarded as the first step towards a reduction of energy intensity in Industry
  - improving industrial energy efficiency by implementing best practice technologies (BPT) could reduce total final industrial energy demand more than 25% [1]
  - Industry stands for 25% of final energy consumption (EU28, 2017) [2]
  - Specific actions to contribute to EU goal of 20% energy savings by 2020 set by the EU Directive on energy efficiency [3], translated into member States National Energy Efficiency Plans [4]

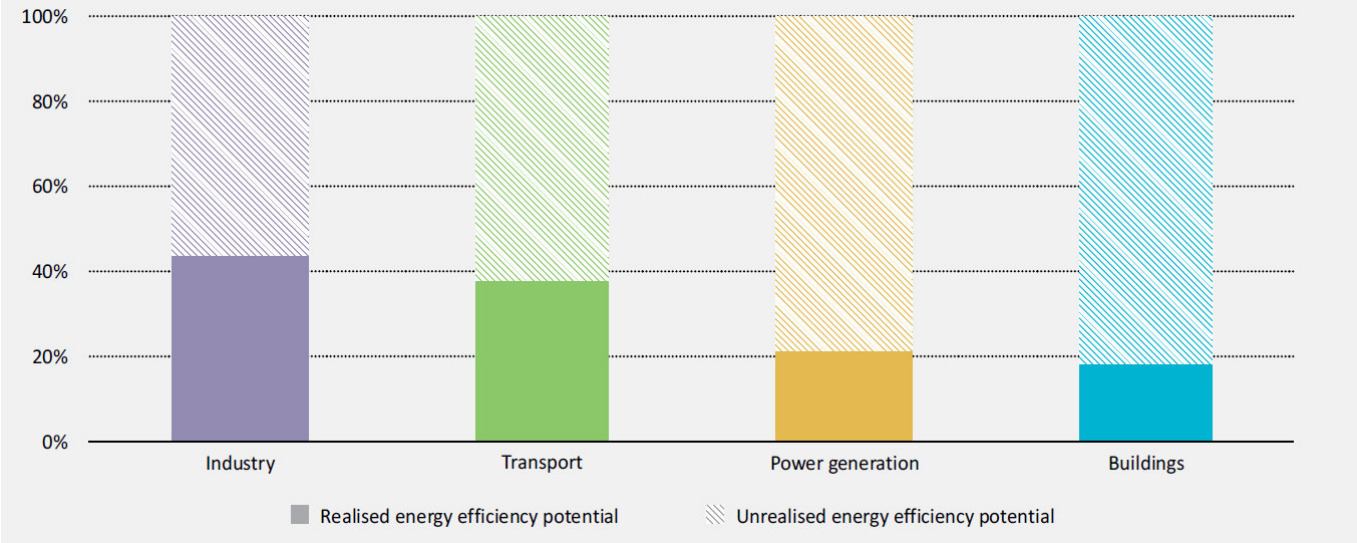


[5]

[1] Saygin, D., Patel, M.K. and Gielen, D.J. (2010). Global Industrial Energy Efficiency Benchmarking: An Energy Policy Tool, Working Paper, November 2010.
[2] EUROSTAT, Final energy consumption, EU-28, 2017
[3] DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCILof 25 October 2012
[4] https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans
[5] RENEWABLES 2015 GLOBAL STATUS REPORT, REN21 (2018)

Energy efficiency in Industry
Rationale

- EE regarded as the first step towards a reduction of energy intensity in Industry
  - whereas efforts have been developed from the 70´s at both political and technological levels, the remaining potential is still considerable



[1]

Long term energy efficiency economic potential by sector

[1] World Energy Outlook 2013 and Capturing the Multiple Benefits of Energy Efficiency, IEA (2014)

Energy efficiency in Industry
Rationale

- EE regarded as the first step towards a reduction of energy intensity in Industry
  - it is cost-effective and various technologies exist which are suitable for different production processes [1,2]

Table 1 Project returns by sector and lifespan

Sector	Number of projects	Investment (US$)	Payback years	IRR 3 years (%)	IRR 4 years (%)	IRR 5 years (%)	IRR 10 years (%)
Automotive/autoparts	4	98.250	1.93	26	37	43	51
Cement/ceramics	15	43.702.213	2.19	18	29	36	45
Chemicals	14	26.370.874	2.90	2	14	21	32
Equipment manufacturing	16	9.538.587	2.10	20	32	38	47
Food and beverages	9	2.684.000	1.10	74	83	87	91
Metal	14	4.882.517	1.50	45	55	60	66
Paper	12	6.249.000	0.90	96	105	108	111
Textile	22	3.204.540	2.20	17	29	36	44
Others	13	23.602.000	2.40	12	24	31	40
All cases	119	120.332.181	1.95	25	37	43	50

The estimated IRRs are mean values for each respective lifespan

[2]

[1] Worrell, E. et al. (2009). Industrial energy efficiency and climate change mitigation, Energy Efficiency 2, pp. 109-123. *as cited in [6]*
[2] Alcorta, L. et al. (2014). Return on investment from industrial energy efficiency: evidence from developing countries, Energy Efficiency 7, pp. 43-53. *as cited in [6]*

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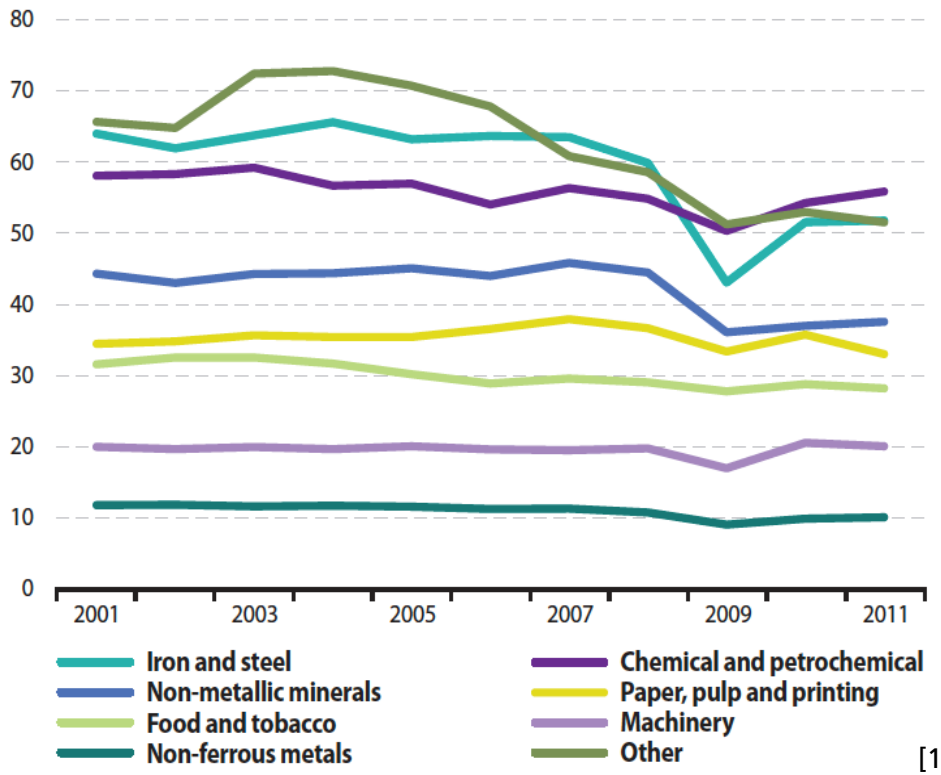
Energy efficiency in Industry
Thermal Processes

- Weight of different Industrial branches: Energy Intensive Industries (EII)
  - Iron and Steel
  - Chemical and Petrochemical
  - Non-metallic minerals
  - Paper & Pulp
  - Glass



Final energy consumption by industrial sector EU-28 (Mtoe). [1]

[1] EERA JP EEIP, SP1 Presentation, Amsterdam, June 2015

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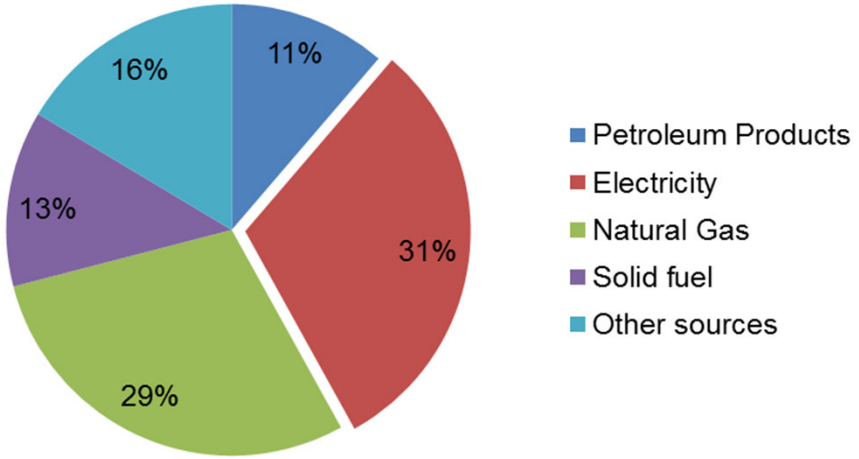
Energy efficiency in Industry
Thermal Processes

- Thermally driven processes present the largest share of final energy use in Industry
  - Electricity stands for 31% of final energy consumption in Industry [1]
  - Electricity driven processes include
  - Surface deposition processes (electroplating, anodization, etc)
  - Melting processes in Electric Arc Furnaces
  - Cooling and vacuum
  - Motor driven systems (compressed air, pumping)
  - Lighting

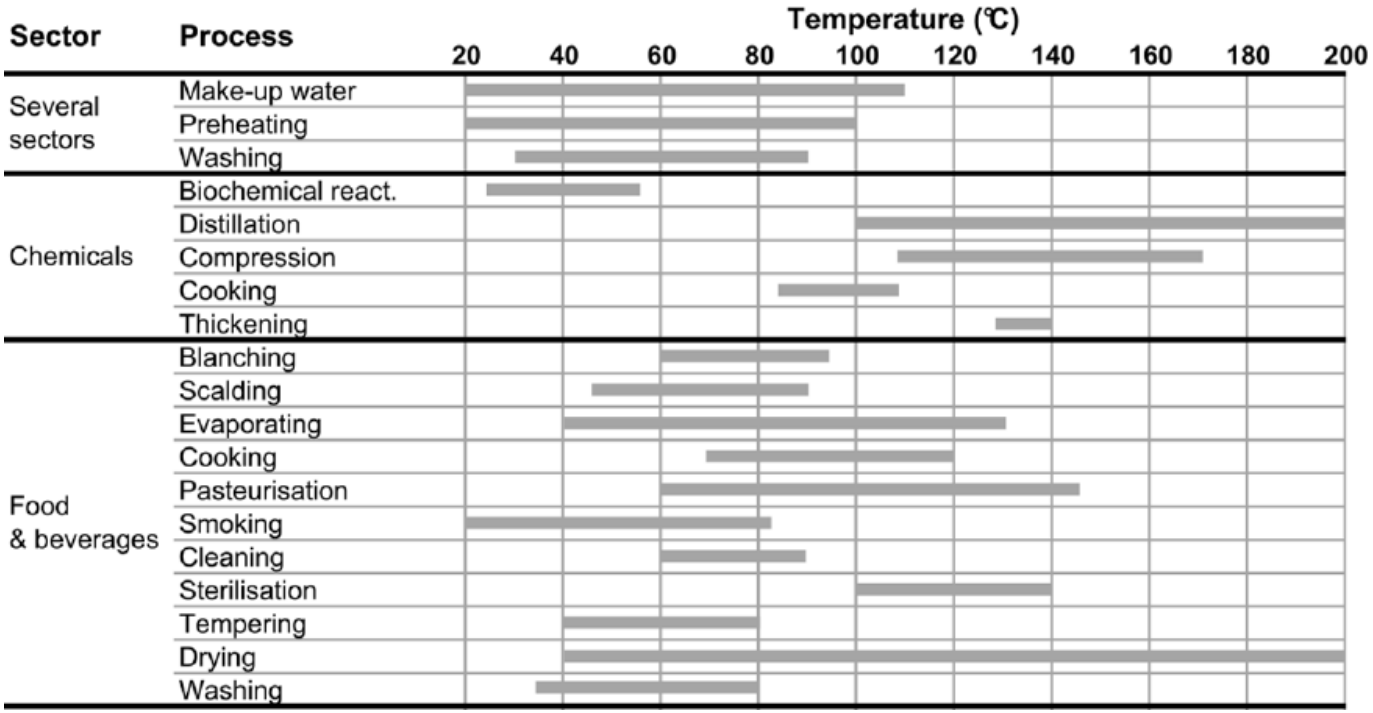


Share of different energy sources in final energy consumptions on the Industrial Sector, 2012 (*adapted from* [1])

[1] Final energy consumption by sector and fuel, European Environment Agency, http://www.eea.europa.eu/data-and-maps/indicators/final-energy-consumption-by-sector-8/assessment-2 (2015)

Energy efficiency in Industry
Thermal Processes

- Low and medium temperature processes mainly in non-EII branches [1]



[1] C. Lauterbach, B.Schmitt, U.Jordan, K.Vajen; The potential of solar heat for industrial processes in Germany; Kassel University; June 2012

Energy efficiency in Industry
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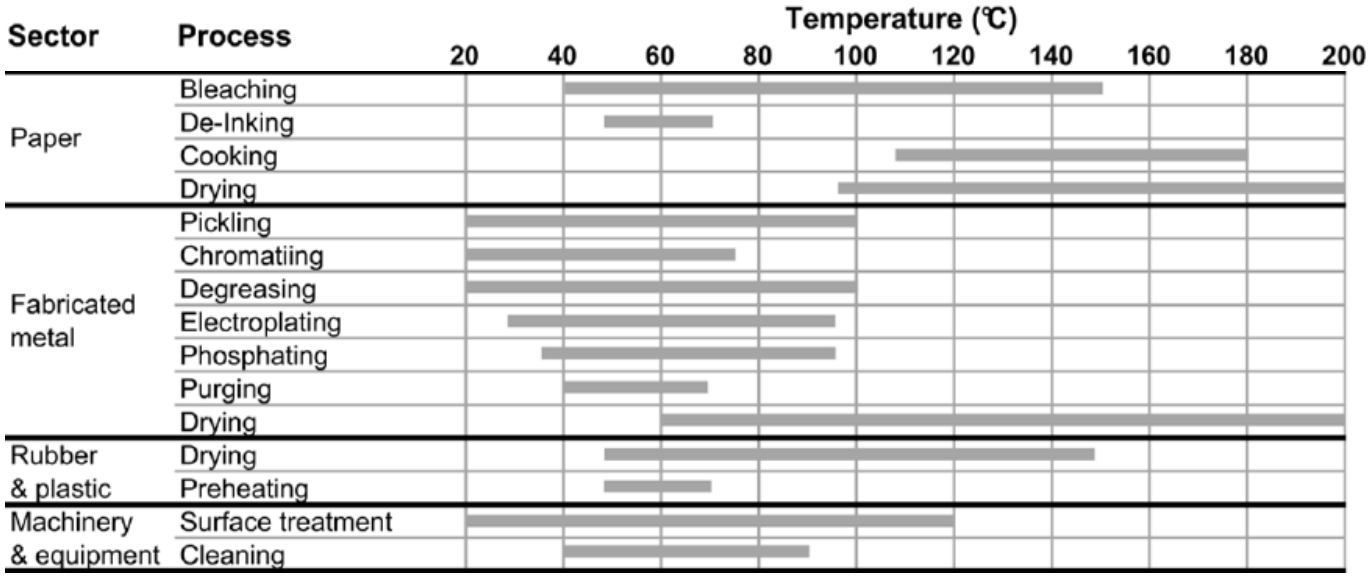

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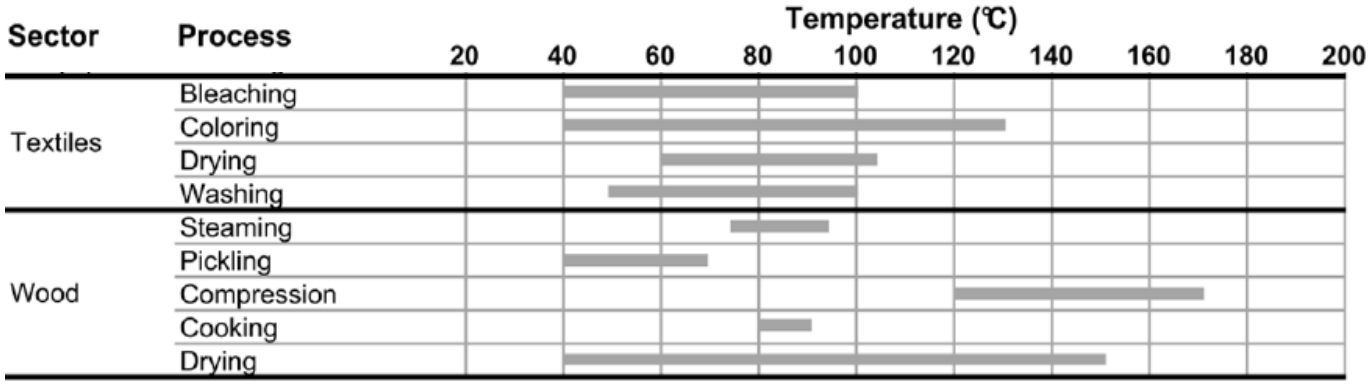

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Energy efficiency in Industry
Best Available Techniques

- Implementation of EE measures is already supported by different technologies and Best Available Techniques (BAT) are identified [1]

  - Combustion:
    - Reduction of flue gas temperature
    - Recuperative and regenerative burners
    - Combustion regulation and control (excess air, burner regulation)
    - Oxy-firing
    - Thermal insulation

[1] Reference Document on Best Available Techniques for Energy Efficiency, Euriopean Commission (2009) http://eippcb.jrc.ec.europa.eu/reference/BREF/ENE_Adopted_02-2009.pdf

Energy efficiency in Industry
Best Available Techniques

- Implementation of EE measures is already supported by different technologies and Best Available Techniques (BAT) are identified [1]

  - Steam systems:
    - Design of steam distribution network
    - Throttling devices and use of backpressure turbines
    - Preheating of feed-water
    - Prevention of scaling on HX surfaces
    - Thermal insulation
    - Re-use of condensate and flash steam

[1] Reference Document on Best Available Techniques for Energy Efficiency, European Commission (2009)
http://eippcb.jrc.ec.europa.eu/reference/BREF/ENE_Adopted_02-2009.pdf

Energy efficiency in Industry
Best Available Techniques

- Implementation of EE measures is already supported by different technologies and Best Available Techniques (BAT) are identified [1]

  - Heat recovery and cooling:
    - Heat Exchangers
    - Heat Pumps
    - Chillers and cooling systems
    - Cogeneration
    - Space heating and cooling

[1] Reference Document on Best Available Techniques for Energy Efficiency, European Commission (2009)
http://eippcb.jrc.ec.europa.eu/reference/BREF/ENE_Adopted_02-2009.pdf

Energy efficiency in Industry
Best Available Techniques

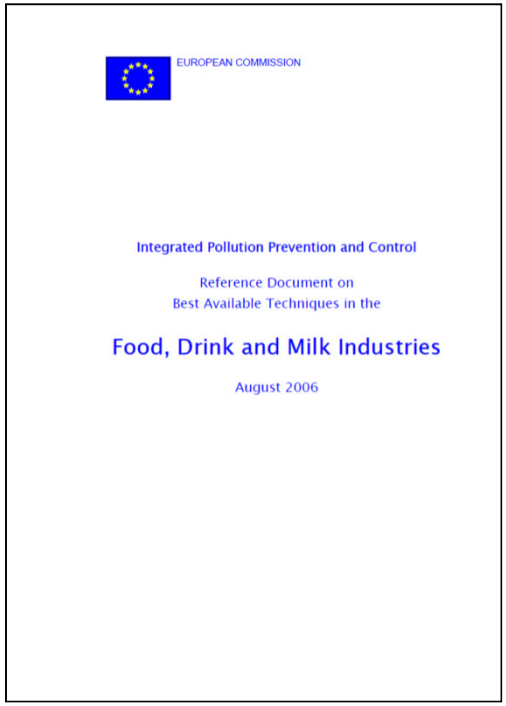
- Implementation of EE measures is already supported by different technologies and Best Available Techniques (BAT) are identified [1]

  - Drying, separation and concentration processes:
    - Mechanical processes
    - Thermal drying techniques
    - Radiant energies

[1] Reference Document on Best Available Techniques for Energy Efficiency, Euriopean Commission (2009)
http://eippcb.jrc.ec.europa.eu/reference/BREF/ENE_Adopted_02-2009.pdf

Energy efficiency in Industry
Best Available Techniques

- Industrial processes descriptions and specific BAT for several branches [1]
  - Ceramic Manufacturing
  - Ferrous Metal Processing
  - Food, Drink and Milk
  - Organic and Inorganic Chemicals
  - Glass
  - Non-ferrous Metals
  - Iron and Steel
  - Pulp, Paper and Board
  - Textiles
  - …



[1] http://eippcb.jrc.ec.europa.eu/reference/

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Energy efficiency in Industry
Standards

- BAT include Energy Management Systems: ISO 50001 [1]
  - Extensive to strategy, procedures, monitoring, management
  - Based on PLAN-DO-CHECK-ACT approach
  - Energy Audit compliance
  - Monitoring systems compliance

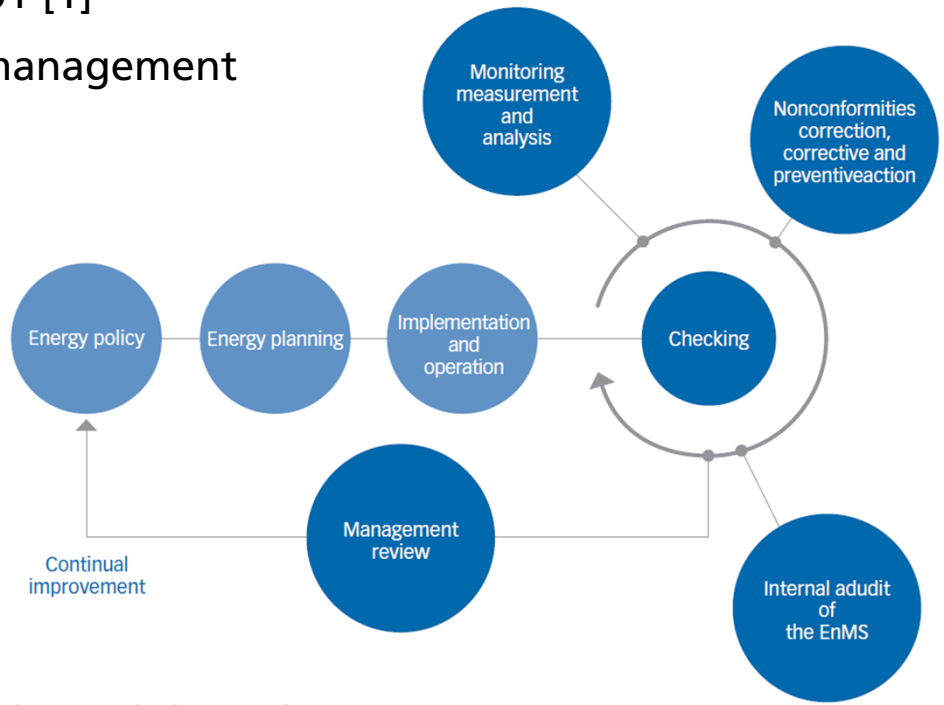

Figure 1. Main Elements of Energy Management System [2]

[1] ISO 50001 - Energy management. http://www.iso.org/iso/home/standards/management-standards/iso50001.htm
[2] Guidebook for ISO50001 Energy management System, The Hong Kong Electronic Industries Association (2013)

Energy efficiency in Industry
Standards

- **Energy Audits and Energy Management Systems under Article 8** of the Energy Efficiency Directive [1]

- Implementation and Incentives (in Germany)
  - Large Companies >250 employees and/or > 50 Mio. € turnover have to perform an Energy Audit according to DIN 16247 every 4 years or implement an Energy Management System according to ISO 50001
  - SME can receive up to 80 % funding for an Energy Audit according to DIN 16247

- **Introduction to ISO 50002**: How it fits into ISO 50001 family of standards [2]

[1] Eva Hoos, ENER C3 Energy Efficiency Directorate-General for Energy European Commission
[2] Introduction to ISO 50002: How it fits into ISO 50001 family of standards Kit Oung

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Energy efficiency in Industry
Energy Audit

- Energy Audit is a management tool aiming the gathering of information enabling the achievement of improved energy efficiency targets

  - analysis of critical points
  - assessment of the current energy flows
  - assessment of overall energy production
  - assessment of energy consumers (processes and process cycles)
  - determination of enhancement strategies and measures

Energy efficiency in Industry
Energy Audit

- Includes preparation, execution and analysis steps

  - Preparation
  - definition of audit team (leader and members on the auditor and company sides)
  - define targets, scope and audit criteria
  - discuss measurement procedures and feasibility
  - definition of required information and access
  - Schedule
  - Analysis of previous audit results (when existing)

Energy efficiency in Industry
Energy Audit

- Includes preparation, execution and analysis steps

- Execution: **ENGAGE THE COMPANY RESPONSIBLES/TECHNICIANS**
  - Introductory conference
  - Evaluation of scope, audit scheme and schedule
  - Communication control, roles and responsibilities
  - Collection and assessment of information
  - Define energy and environmental relevant areas
  - List of sites to be inspected (major energy users, measuring points, documents, structural alterations, expansions, …)
  - Audit boundaries (production, consumers, profiles)

Energy efficiency in Industry
Energy Audit

- Includes preparation, execution and analysis steps

- Execution: **ENGAGE THE COMPANY RESPONSIBLES/TECHNICIANS**
  - Site visit plans
  - measurements in all relevant areas
  - control energy users with high energy demand
  - check existing measuring systems
  - detect waste of energy
  - examine alternative energy supply
  - documentation (pictures where necessary)

Energy efficiency in Industry
Energy Audit

- Includes preparation, execution and analysis steps

- Analysis:
  - evaluation of processes
  - description of internal and external interfaces
  - prove consumptions with measurement results and key figures
  - analyze energy reports
  - analyze major consumers
  - nonconformities (clarify where necessary)
  - Recommendations (clarify where necessary)

Energy efficiency in Industry
Energy Audit

- The Audit report shall aim:
  - action planning
  - suggestions for the implementation
  - Responsibilities and resources
- Shall include:
  - Aim and scope of the audit (organizational and functional units; processes; period of time)
  - Audit team
  - Description of measurements
  - Audit criteria, findings and conclusions
  - deadlines and implementation sites

Energy efficiency in Industry
Energy Audit

- The Audit report shall detail:
  - Audit scheme
  - Summary of the auditing process (including constraints, problems)
  - Confirmation of audit targets where achieved in compliance with the audit scheme
  - Description of not covered areas, although they are within the scope
  - Unsolved disagreements between the involved parties
  - Recommendations for improvements
  - Concerted plans for follow-up actions (aims)
  - Confidentiality agreement

Energy efficiency in Industry
Energy Audit

- Some references:
  - Guidance Note on Energy Efficiency Auditing: http://www.epa.ie/pubs/advice/licensee/guidancenoteonenergyefficiencyauditing.html
  - EINSTEIN Experts System for an Intelligent Supply of Thermal Energy in Industry and other Large-Scale Applications: http://www.einstein-energy.net
  - Best Available Techniques (BAT) reference documents (BREFs) from the European Integrated Pollution Prevention and Control IPPC Bureau: http://eippcb.jrc.ec.europa.eu/reference/
  - Optimal Audit: http://www.cheme.utm.my/prospect/index.php/software/19?task=blogcategory

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Energy efficiency in Industry
EMS

The cornerstone of good management is:

- Commitment from the top management; and
- Dedication from the operating personnel.

The ISM Code foundation is also based on this paradigm and requires:

- Management commitment.
- Staff/personnel empowerment.
- Continuous improvement.

Energy efficiency in Industry
EMS

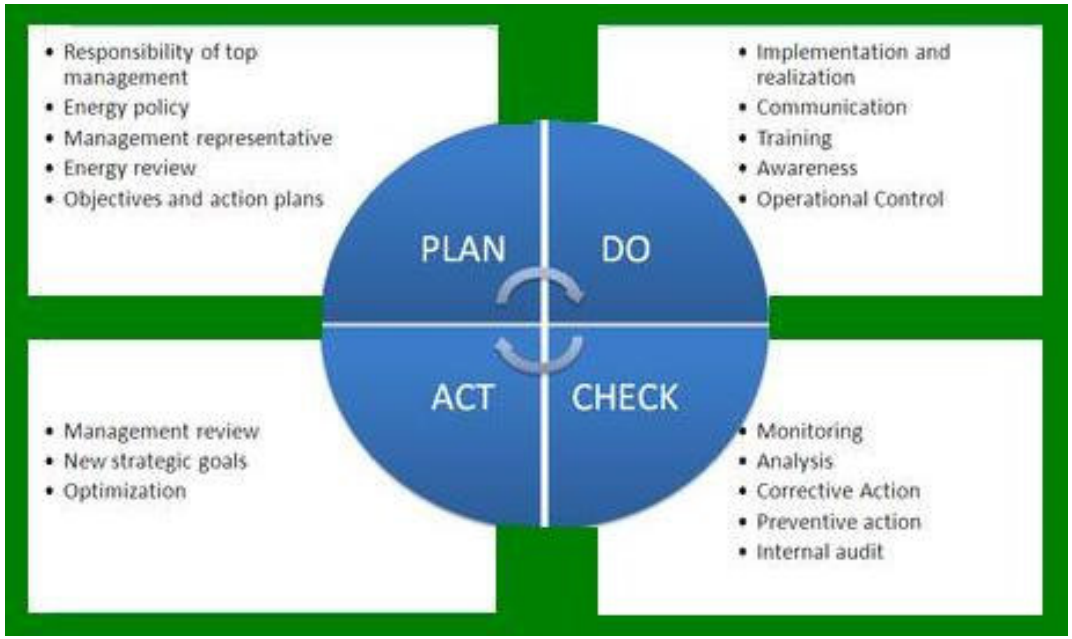
- PDCA is the most basic framework for any management system

Plan: An action plan of the activities that need to be done together with all relevant implementation details.

Do: The implementation of the selected improvement measures.

Check: Monitor the results of the implementation via effective data analysis and assessments.

Act: The effectiveness of the plan is reviewed and new targets are set for next PDCA cycle.

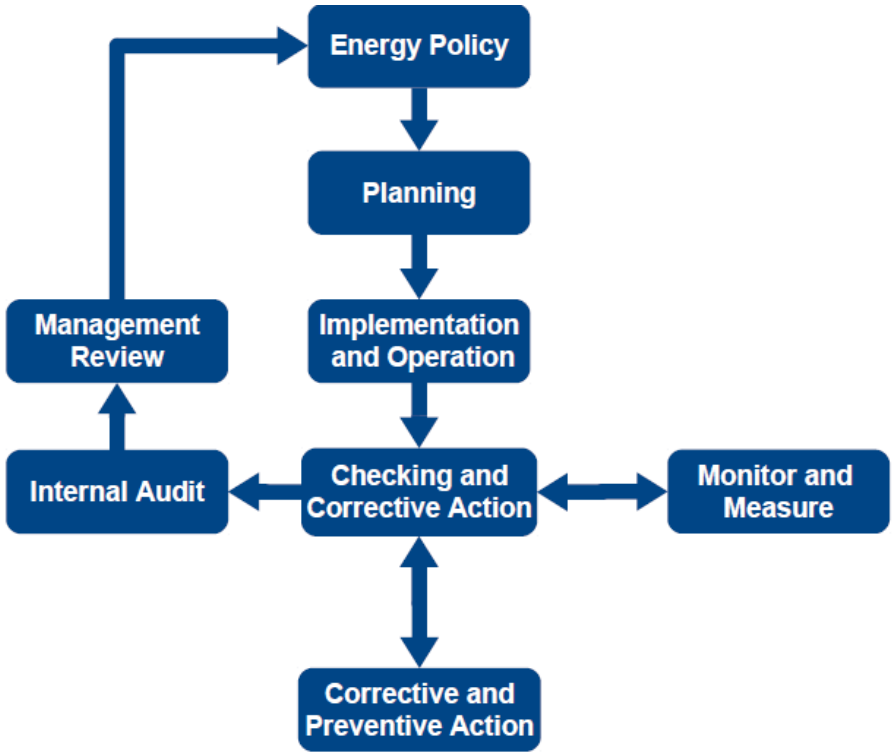


Energy efficiency in Industry
EMS

- Energy Management System ISO 50001 – Central Ideas
  - To offer support in the development of systems and processes which improve energy efficiency
  - Systematic energy management leads to:
    - Reduction of costs
    - Reduction of greenhouse gas emissions
  - Develop a corporate energy policy
  - Define aims and processes
  - Take into account necessary measures to improve output
  - Success is only attainable with the support of all departments, at all levels, including top-level management

Energy efficiency in Industry
EMS

- Energy Management System ISO 50001 – Overview



Energy efficiency in Industry
EMS

- Energy Management System ISO 50001 – Communication / motivation
  - Reduced costs and energy consumption
  - Increase of productivity and competitiveness
  - Reduced CO2 emissions and Environmental protection
  - More efficient workflow
  - Improvement of the external representation of the company
  - Improved communication between different departments of the company
  - Awareness of all, which department needs specific amount of energy
  - Implementation of measurements can be validated with all affected people before

Energy efficiency in Industry
EMS

- Typical obstacles and overcoming actions
  - Insufficient communication between departments → well mixed energy team with people from all relevant departments
  - Inexistent transparency → Analysis of energy flows, energy consumers and their responsible person
  - Ignorance about legal requirements → Development and maintenance of a legal registry
  - Lack of command authority → Must be covered by the energy manager
  - Lack of awareness & Lack of knowledge → Periodical training of employees, conversations with the employees, proposals of employees

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Energy efficiency in Industry
Energy Profile

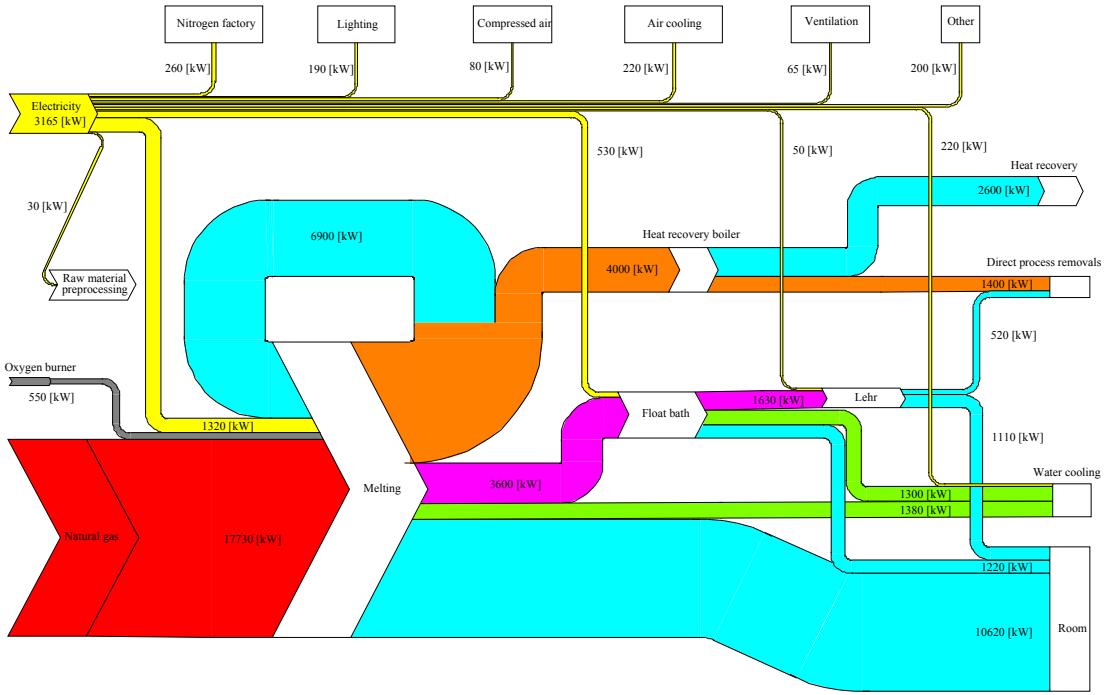
- The purpose of developing an energy profile of the organization is to understand the areas of significant energy consumption
  - I.e. the buildings, equipment and processes which account for the greatest energy use or which offer the most potential for energy savings
  - The identification of the energy profile is critical in understanding where energy is used within the organization and forms the basis for prioritizing the efforts to reduce energy consumption.
  - The organization that intends to implement an energy management system should start by establishing its current position.

Energy efficiency in Industry
Energy Profile

- Analyze energy use based on measurement and other data
  - How much energy the organization consumes and its trends, changes, etc.
  - Estimate how much energy will be consumed in the coming period, typically the next financial budget period.
  - Examine where energy is currently being sourced which will typically be a local utility company and examine other potential sources including e.g. internal waste heat.
- Based on energy use analyses, identify the areas of significant energy use
  - Where the energy is being used, i.e. what are the significant consumers?
  - What is driving the energy use? This is often difficult to determine but is very important.
  - Which people have significant impact on energy use and identifies their relevant training needs.

Energy efficiency in Industry
Energy Profile

- Energy consumption breakdown: Sankey diagram



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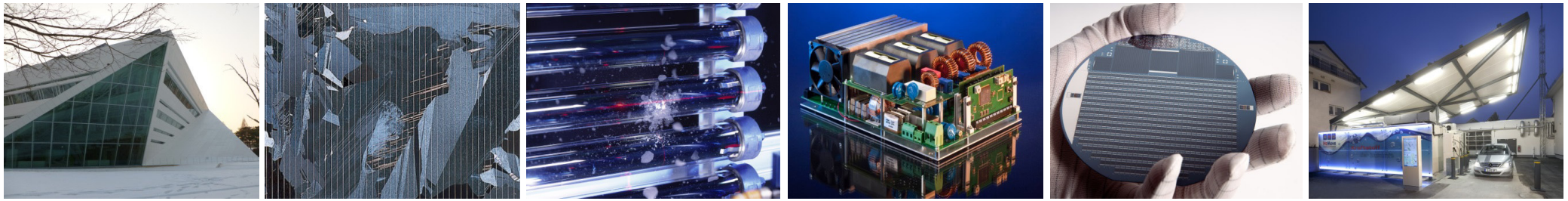
Energy efficiency in Industry
EnPI's

- EnPIs are a quantitative index of energy performance as defined by the organization. The concept of an EnPI can be used to compare organizational performance at different points in time
  - The organization shall identify EnPIs to be used to determine energy performance and to subsequently evaluate progress towards objectives and targets.
  - The method(s) used for definition and update of the EnPIs shall be recorded.
  - EnPIs shall be reviewed and compared to the energy baseline on a regular basis.
- Methods for defining EnPI will vary depending on the organization's operations and complexity. EnPI should be easy to understand which will aid its usefulness for sharing
- information and improving motivation to make improvements.

Thank you for your Attention!



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