Energy Efficiency in Water Supply and Sanitation

Energy Checks, Audits and Surveys for systematic performance enhancements

Prof. Dr.-Ing. Jan Uwe Lieback

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  - Occupational safety & health according to BS OHSAS 18001 and
  - Energy management according to ISO 50001
- ...and verifies (with DAkkS-accreditation)
  - Emission reports in the European ETS
  - Carbon balances , i.e. CO_2-neutrality of companies acc. to ISO 14064
- Further we check...
  - the Status of Sustainable Development of businesses
  - Sustainability of Biomass (according to ISCC, RED-Cert und RSPO)
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  - Education of internal technical and system "Energy managers"
  - Trainings for certified internal and external auditors (UM, QM, EnMS)

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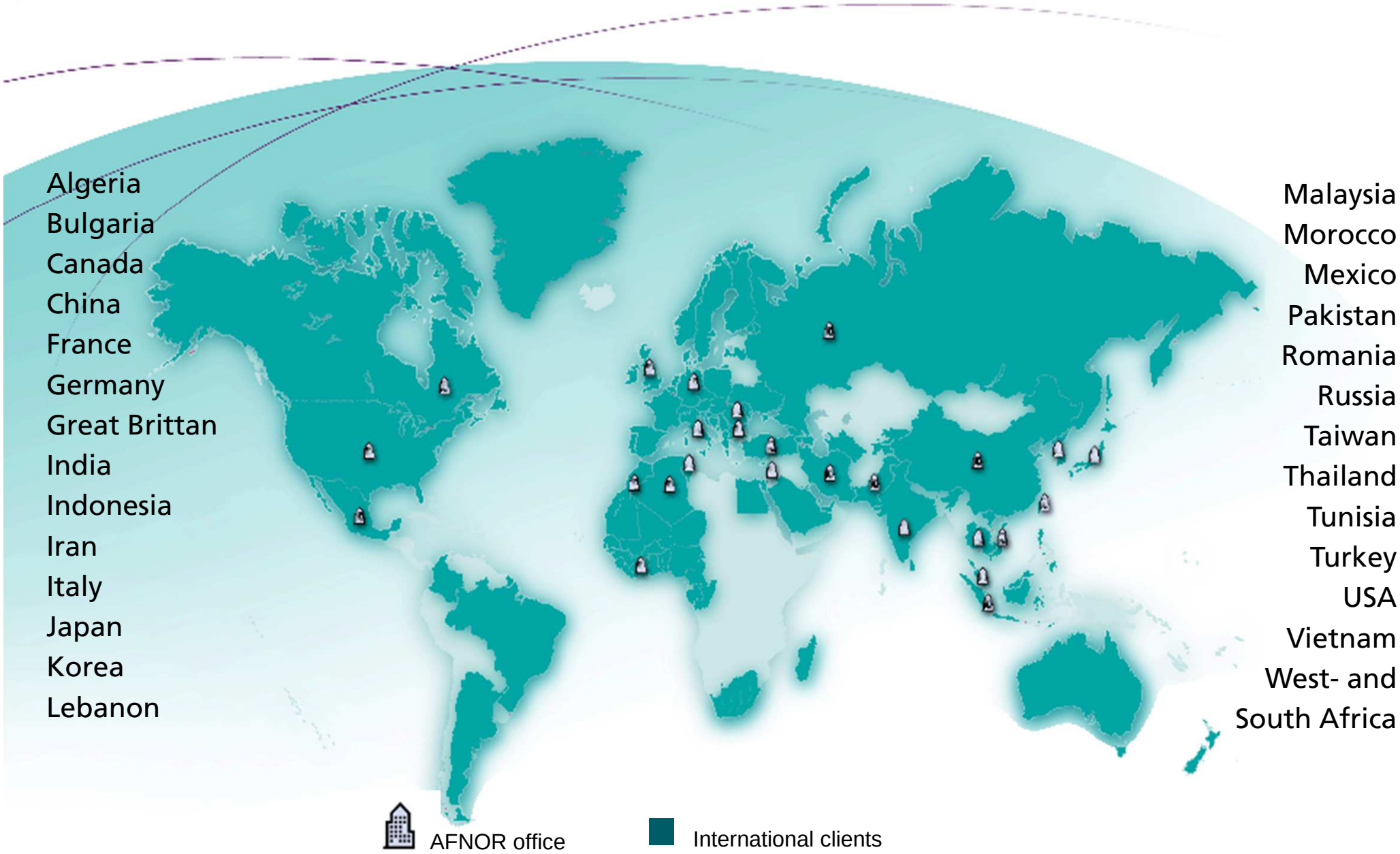

afnor GROUPE

Some of our > 1600 references in EnMS

For further questions please feel free to contact:

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- Prof. Dr.-Ing. Lieback is CEO and major shareholder of GUTcert (a member of the AFNOR groupe)
- He further is a Professor for Environmental Management and Sustainable Development at the ESCP europe, (origin Paris, Campus Berlin)

Outline of the part Prof. Dr. Lieback

- Lecture and discussion I (90-120 Min)
  1. Why save energy? – An Introduction
  2. The energy check a tool for low hanging fruits
  3. Systematic analysis for energy savings potentials
- Lecture and discussion II (90-120 Min)
  4. Organisational structure to detect and develop savings effects
  5. Survey accompanying tasks to enhance its impact
  6. Basics of a formal Management: example EnMS by ISO 50001
- Moderated Planning Seminar (90 Min)
  7. Collective development of a working program, fitting the needs of the members of the ACWUA

1. Why save energy?

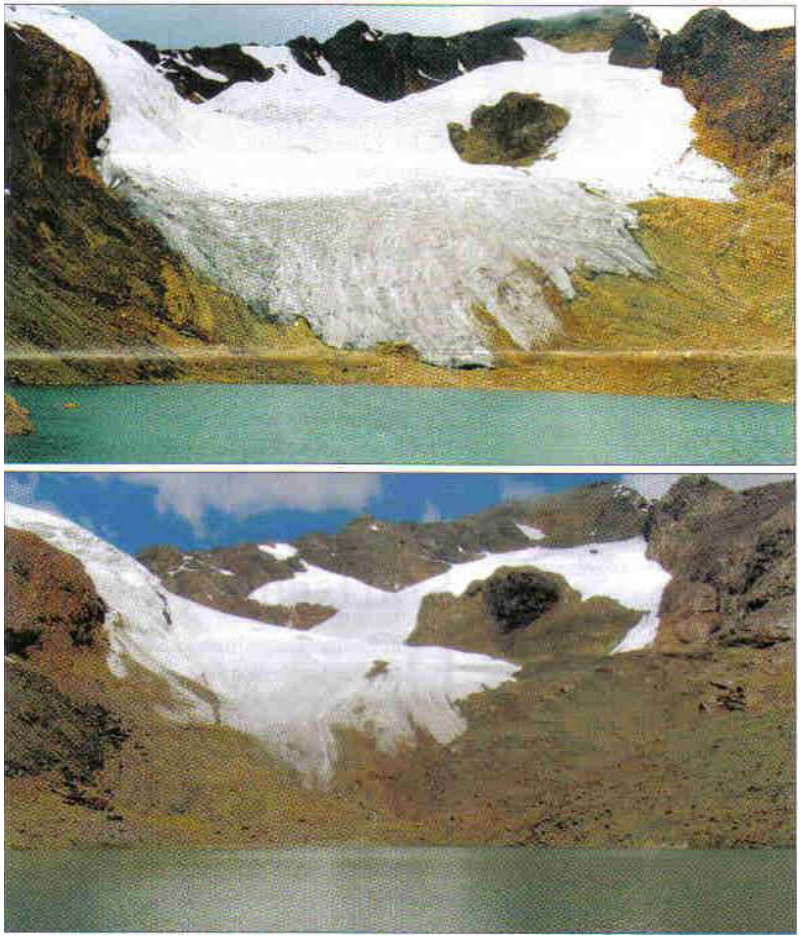
An Introduction

Global warming since hundred years

Global warming increases

Global Warming increases

Peru



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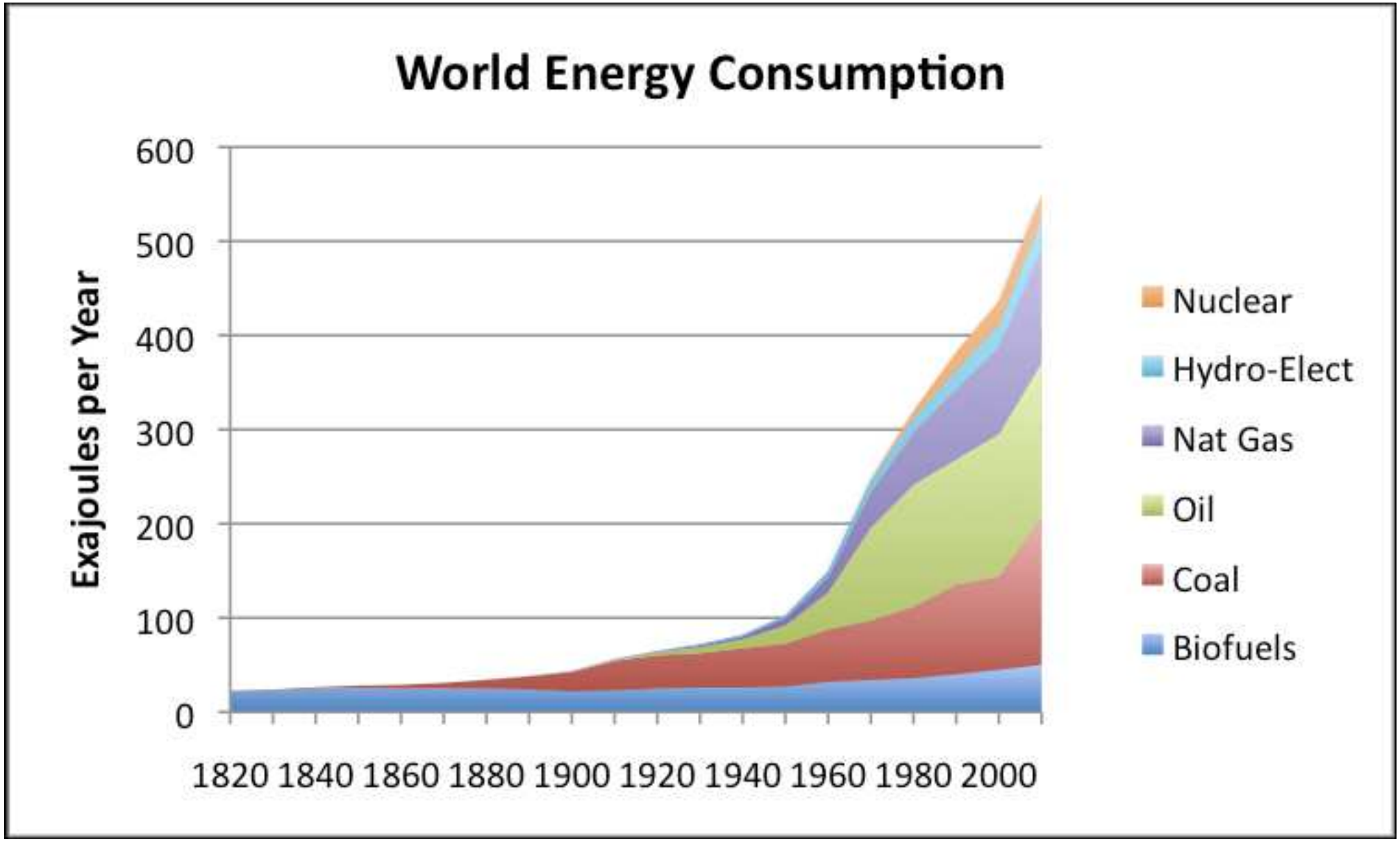
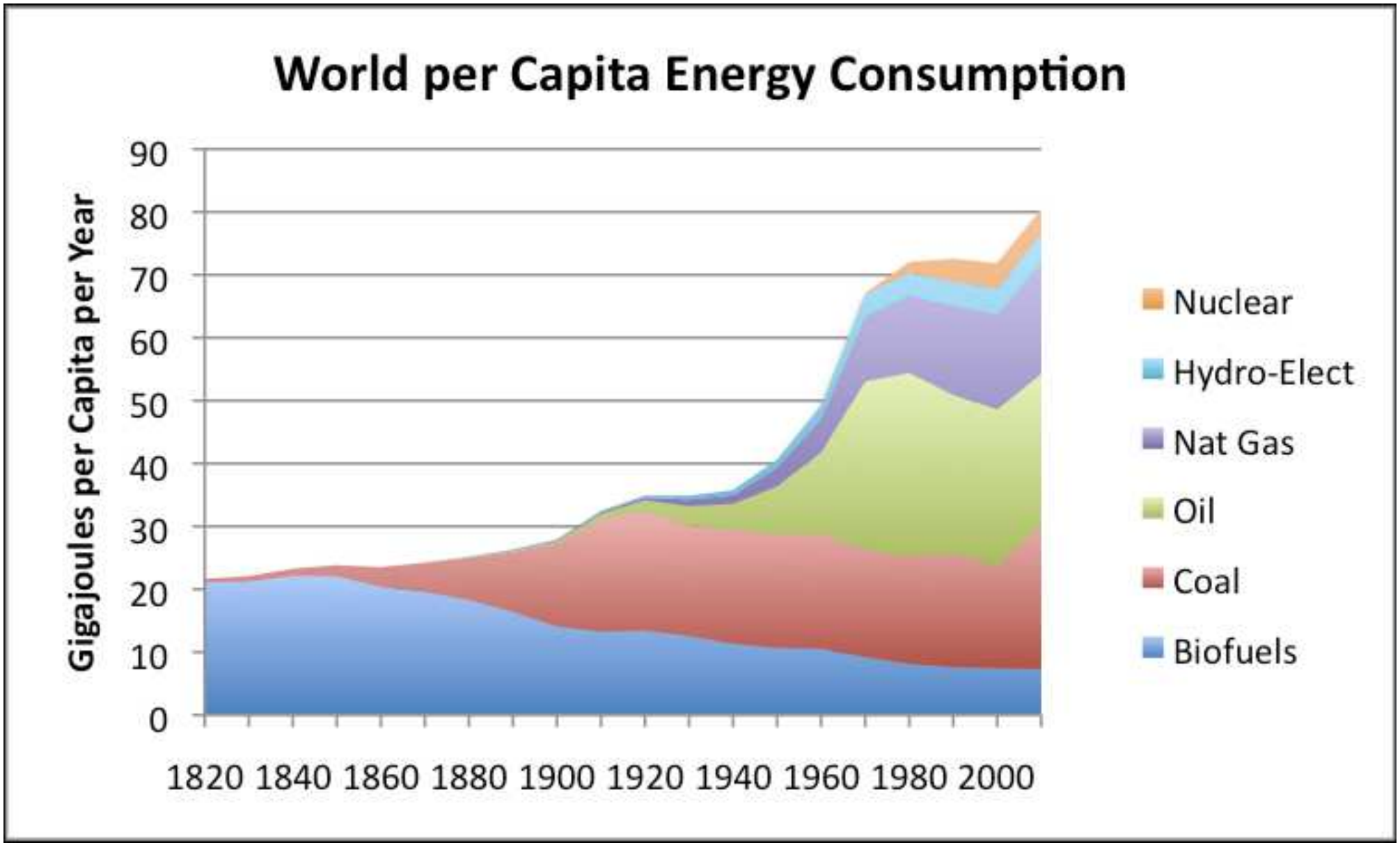
Time period: ~ 7 Years

Energy consumption steeply rises

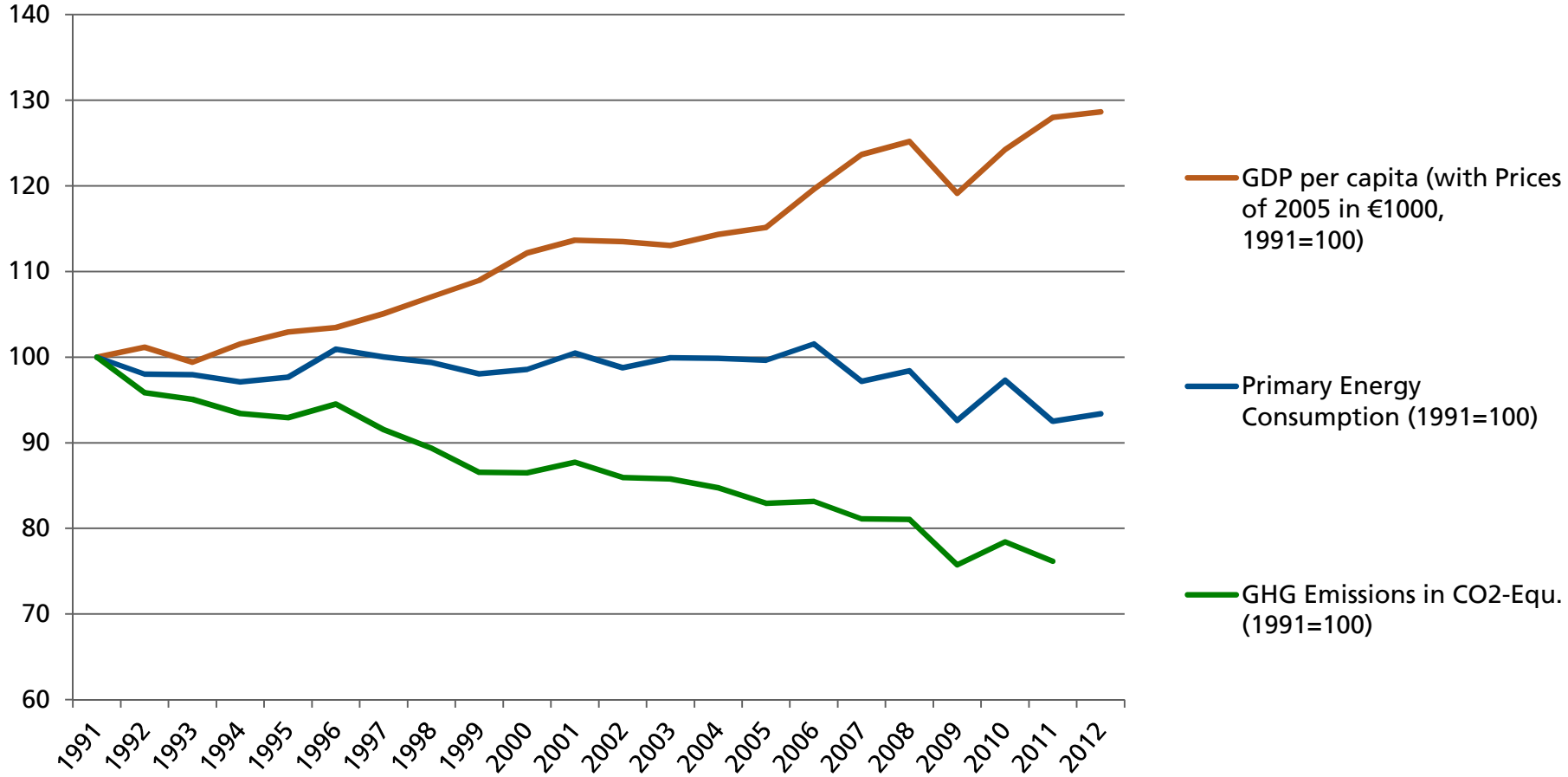


Rising demand per capita



Uncoupling of GDP and Energy use is possible!

- Germany: Energy consumption 2008 to 1991: -2,5 %
- Emissions and environmental impact decline permanently, while economic growth remained stable at the same time



Reference : Statistical Office Germany

Options to reduce overall CO_2-Emissions

Order of action

- **Enhance energy efficiency** and reduce energy consumption - it's the greatest "source" of power (lighting, trains, cycling, IE4 drives, A+++ devices, insulation, no leakage, more vegetables instead of meat, etc.)
- **Balance demand** as constant production is usually more efficient as erratic production with steep slopes
- **Produce** remaining needed **energy renewable** (sun, wind, water, geothermal, waves biomass, nuclear power(?), etc.) and
- **Store** (renewable) over-production (water reservoirs, power to gas, batteries, heat and gas storage)

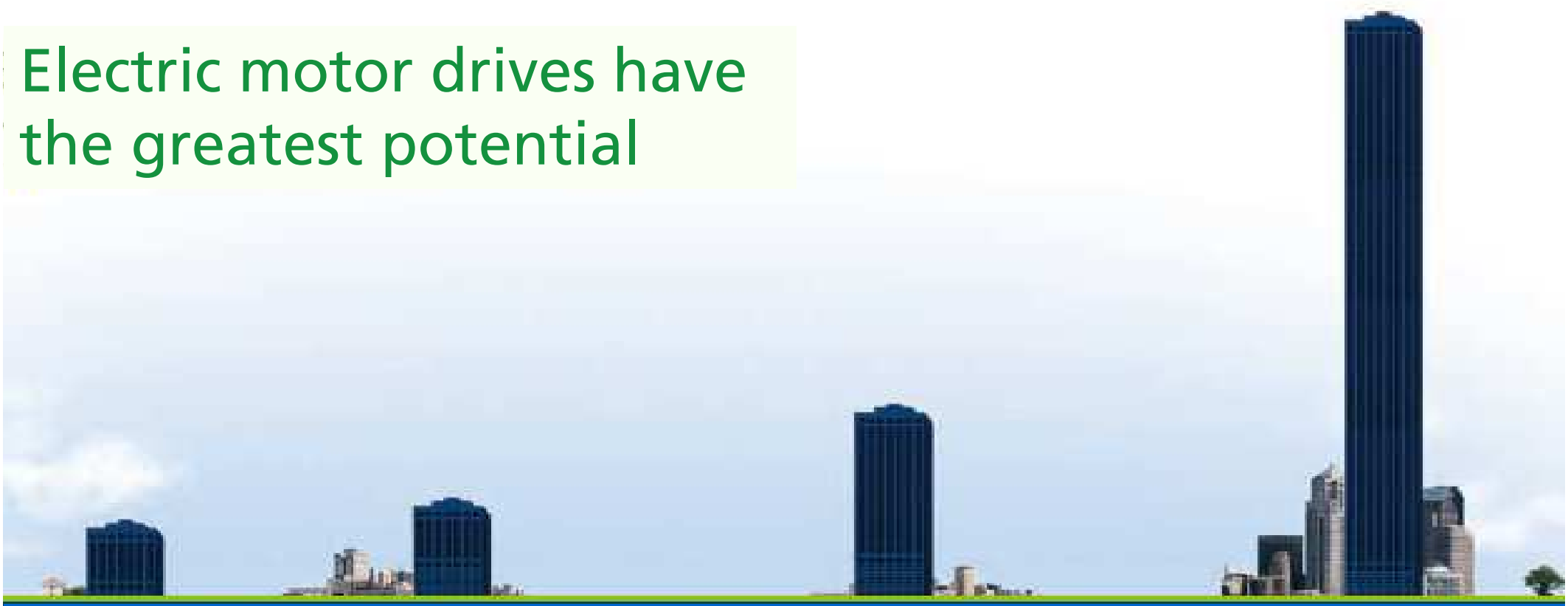
Examples

Energy savings potential

Many do not know, that pumps consume about…

… **10%** of the electricity worldwide

Electric motor drives have the greatest potential

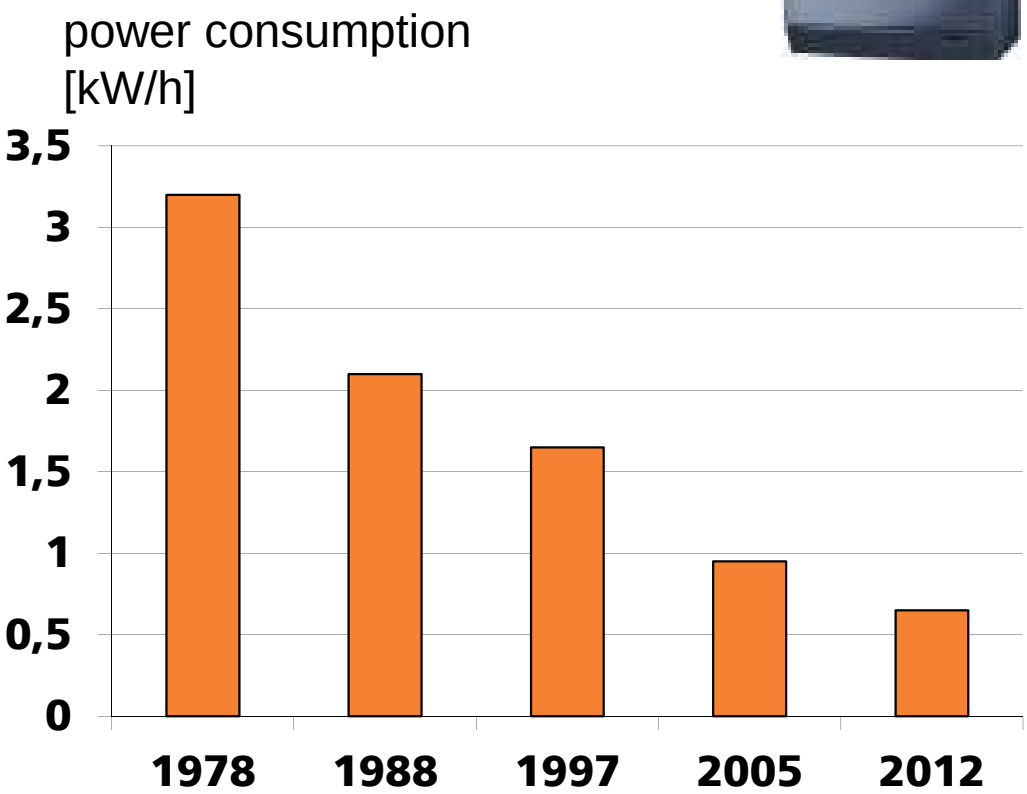


Power using category	use of electricity	annual savings potential
electric Drives	1067 TWH	135 TWH
domestic lighting	84 TWH	39 TWH
domestic cooling	122 TWH	6 TWH
Washing machines	51 TWH	2 TWH
Dishwashers	21,5 TWH	2 TWH

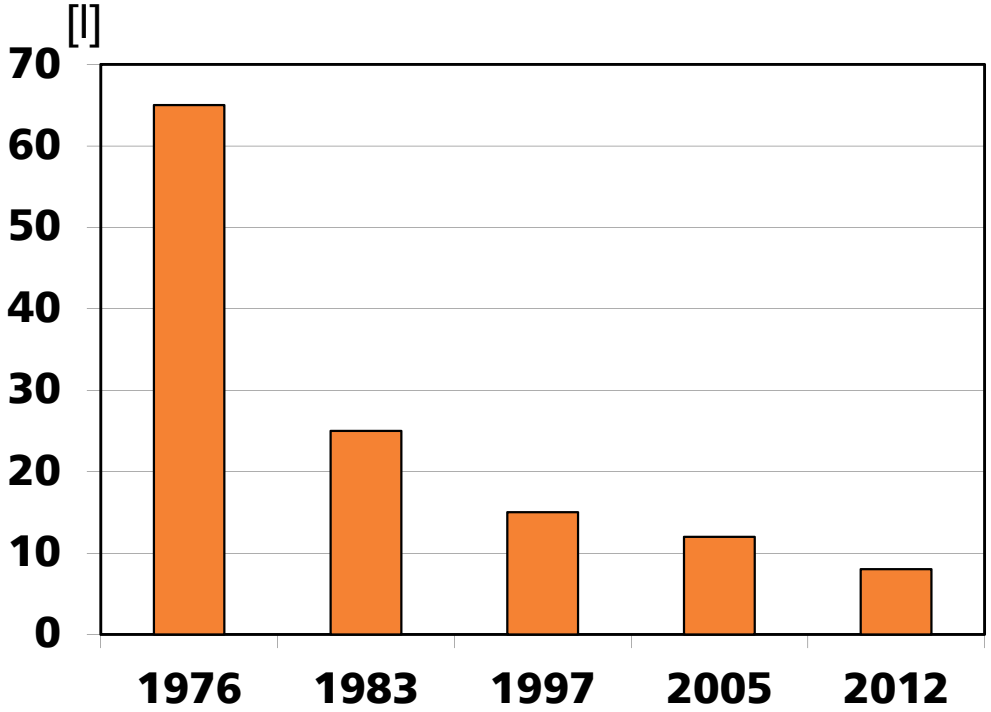
Information by Grundfoss pumps

Energy efficiency development

AEG washing machine



AEG dish washer



Reference : AEG

Efficiency development refrigerators

The differences between energy efficiency classes are great even at a little table refrigerator

energy efficiency class	A	A+	A++	A+++
energy consumption KWh/year	150	120	90	60
operating costs for 15 years in euro (at 0. 23 euros/kWh)	520 Euro	410 Euro	310 Euro	210 Euro
		-20%	-40%	-60%

class B would amount to 760 € and class C up to 1.000 €

Example: fridge-freezer, 290 l cubic capacity (freezer 90 l)

energy efficiency class	A	A+	A++	A+++
energy consumption KWh / year	330	260	200	130
operating costs for 15 years in euro (at 0. 23 euros/kWh)	1.100 Euro	900 Euro	690 Euro	450 Euro
		-20%	-40%	-60%

class B would cost 1.600 € and class C up to 2.000 €

Reference: www.hea.de

2. The energy check

- a tool for low hanging fruits

Energy check:
Assessment of the energetic inventory of components, installations or whole infrastructures in relation to key performance indicators (KPI)

Terms and definitions

- **Energy Check** (in style of DWA):
  - "Assessment of the energetic inventory of components, installations or whole infrastructures in relation to key performance indicators (KPI)"
- **Energy analysis/review** (in style of ISO 50001 and DWA):
  - "Detailed **survey and evaluation** of the past and present energy consumption, **assessing the significant areas** of use **to prioritize optimisation measures** including considerations of **cost efficiency**"
- **Energy Audit** (by EN 16247):
  - "Systematic **inspection and analysis** of energy use and energy consumption of a site, building, system or organisation with the objective of **identifying energy flows** and the **potential for energy efficiency** improvements and **reporting** them"

Audit (3.17 - ISO Annex SL part of HLS, ISO 9001, ISO 14001 etc.)

"Systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extend **to which the audit criteria are fulfilled**"

The Energy Check

- Problem: comparable KPI for complex installations are missing these are usually too different (especially employed in a competitive business environment)
- Though in water and wastewater treatment there are many municipal comparable facilities in Germany. DVGW (drinking water) and DWA (waste water) extracted KPI and benchmarked them – according to their operational size
- But: We already have problems to just compare these KPI with the one of other European countries (because of the legal background, national operational differences, climate differences or cultural habits)
- It would be therefore be more than difficult to use these German KPI (see examples) for an energy benchmarking with ACWUA facilities to expose improvement potentials
  – perhaps they can lead a direction, but not more!
- So can an Energy Check -or only a deeper survey- help ACWUA?

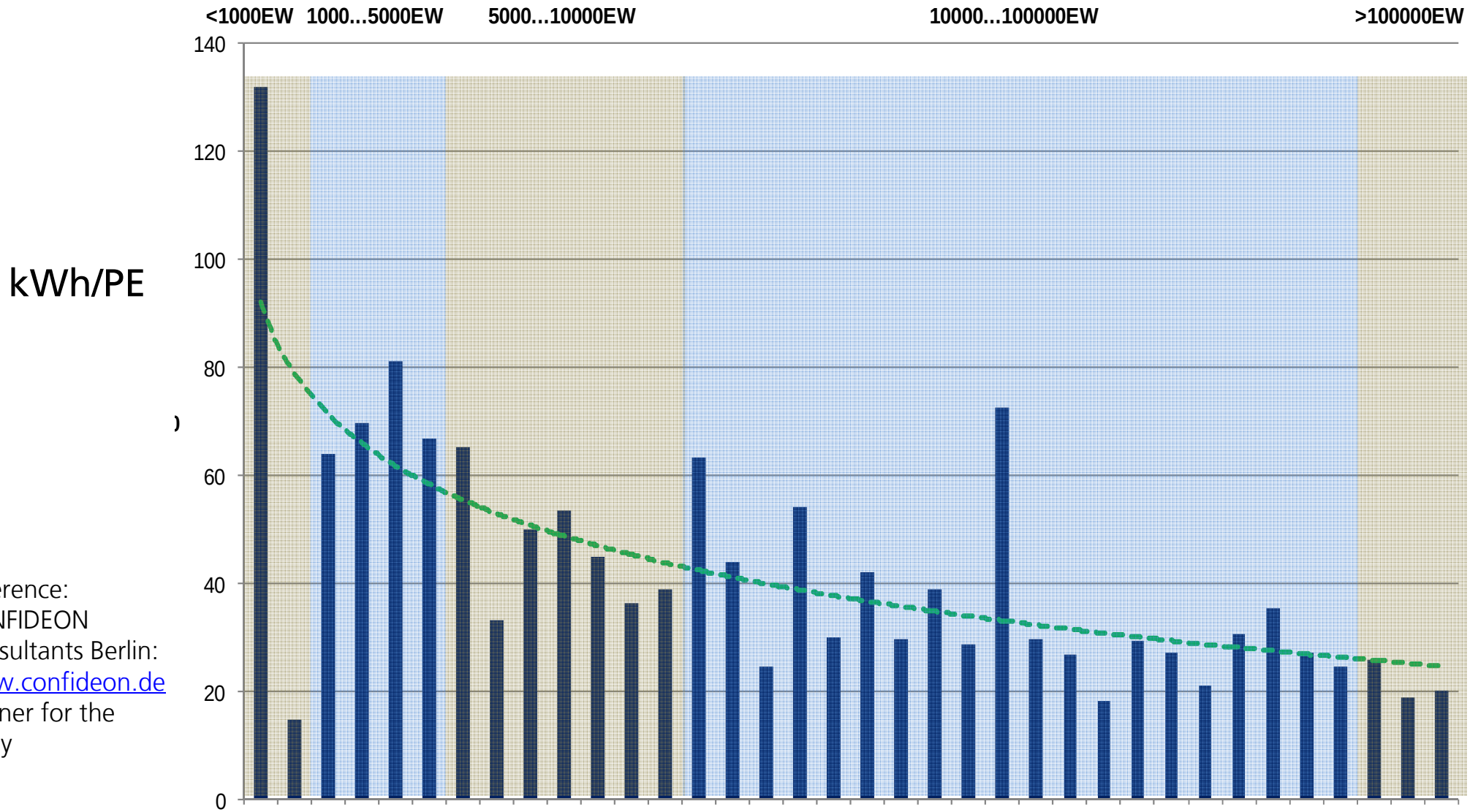
Examples of German Benchmarks (DWA/DVGW)

- Electricity demand of all wastewater treatment plants = 4,2 TWh/a
  - possible savings due to detailed analysis = 1,25 TWh/a (~ 30%)
- Relative electricity demand for wastewater treatment = 30-60 kWh/PE
- Water–loss in sewage networks of bigger cities = < 0,05 - > 0,2 $m^3/km*h$
- Energy demand for pumps < 6 $kWh/1000m^3*m$ (geodetic head)
- Electricity demand of all drinking water plants = 2,4 TWh/a
- Energy demand for drinking water treatment = 0,2-0,6 kWh/m^3
- Energy demand for drinking water transport = 0,1-0,55 kWh/m^3 (depending very much on network size)
- Efficiency of well water pumps in Germany = 0,23 – 0,64
- Efficiency of clean water pumps = 0,52 – 0,74

(CONFIDEON Consultants Berlin: www.confideon.de, partner for the studies**)**

Comparison of waste water plant KPI

Benchmarking energy consumption of waste water treatment plants



Reference:
CONFIDEON
Consultants Berlin:
www.confideon.de
partner for the
study

Solution I: A fast Energy Check - compare KPI of single equipment

- **Help can bring the comparison of single components** (like foreseen in the definition and used widely between different branches)
  - **It is not hard to compare the electric energy input for the production of compressed air and the amount of it produced at a certain pressure level** (and may be the heat recovered from it and used) **against standards**
  - **It is even easy to match the electric power**
    - a pump needs to transport in a given system a m³ of water with that
    - of an other pump in another system

- You get immediate and easy results, comparing elementary components with each other - and with benchmark KPI like:
  - Lighting systems,
  - Compressed air modules and (more complicated) - systems
  - Pumps and (again more complicated) - liquid transport functions
  - Drives (motors) for mixer, compactors, transports, air conditioning etc.
  - Devices for heating or cooling and (again more complex) the insulation of adjoining systems

Examples

1. Behavioural changes
2. Measuring and insulation
3. Pumps (and pump systems)
4. Electric drives (motors)
5. Pressurized air systems

Example: Options for behavioural changes

- Organisational measures for switching off unnecessary devices (low-cost, high-effect, **Amortisation <1a**):

  - **Switching off machines/ devices during brakes and idle times** (needed: intensive awareness training of personnel!),
  - **Power adjustments means reduction of power without loss of capacity** (switching off of redundant, idling or multiple units, 2 instead of 3 pumps, virtual server, 7 instead of 9 bar pressurized air)
  - **Adaptation of cycle times minimizing periods for keeping at energy consuming holds** (melted goods, frozen goods, compressed air in system etc.)
  - **Use of "waste heat" in combination with intelligent extraction** (water-cooling instead of air-cooling, return of condensate, absorption cooling – cooling with waste heat, etc.)…
- …can save usually 10 % of primary energy with no or low cost

Example: Measuring and insulation

- Installation of technically known measuring and control units (mid-cost, high-effect, **Amortisation usually < 2 a)**

  - Intelligent lighting control (day/night) and replacement of light bulbs (saving in many cases up to 70 % electricity for light)
  - Intelligent building automation and equipment control, installing process measuring and control devices
  - Frequency control of drives in case of strong power variability (frequency controls often amortize within the first year of operation)
  - Improvement (installation) of blind current compensation devices
  - Installation of meters, able to record consumption profiles

- Improvement of thermal insulation and heating (high-cost, high-effect, **Amortisation usually < 2 a)**

  - Insulation of pipes, valves and storage units (especially for cold store!)
  - Repair of cold store insulation (soaked by defective vapour barriers)
  - Insulation of buildings , especially production hall ceilings (hot/cold)
  - Infrared radiators instead of hot air heaters (with motion sensor)
  - Replacement of old heating/ or refrigeration units (older than 10a)

Example: Pump-drive-systems

- Life cycle cost of a pump-system depend to > 85 % on the energy used – do not save money on the wrong end!

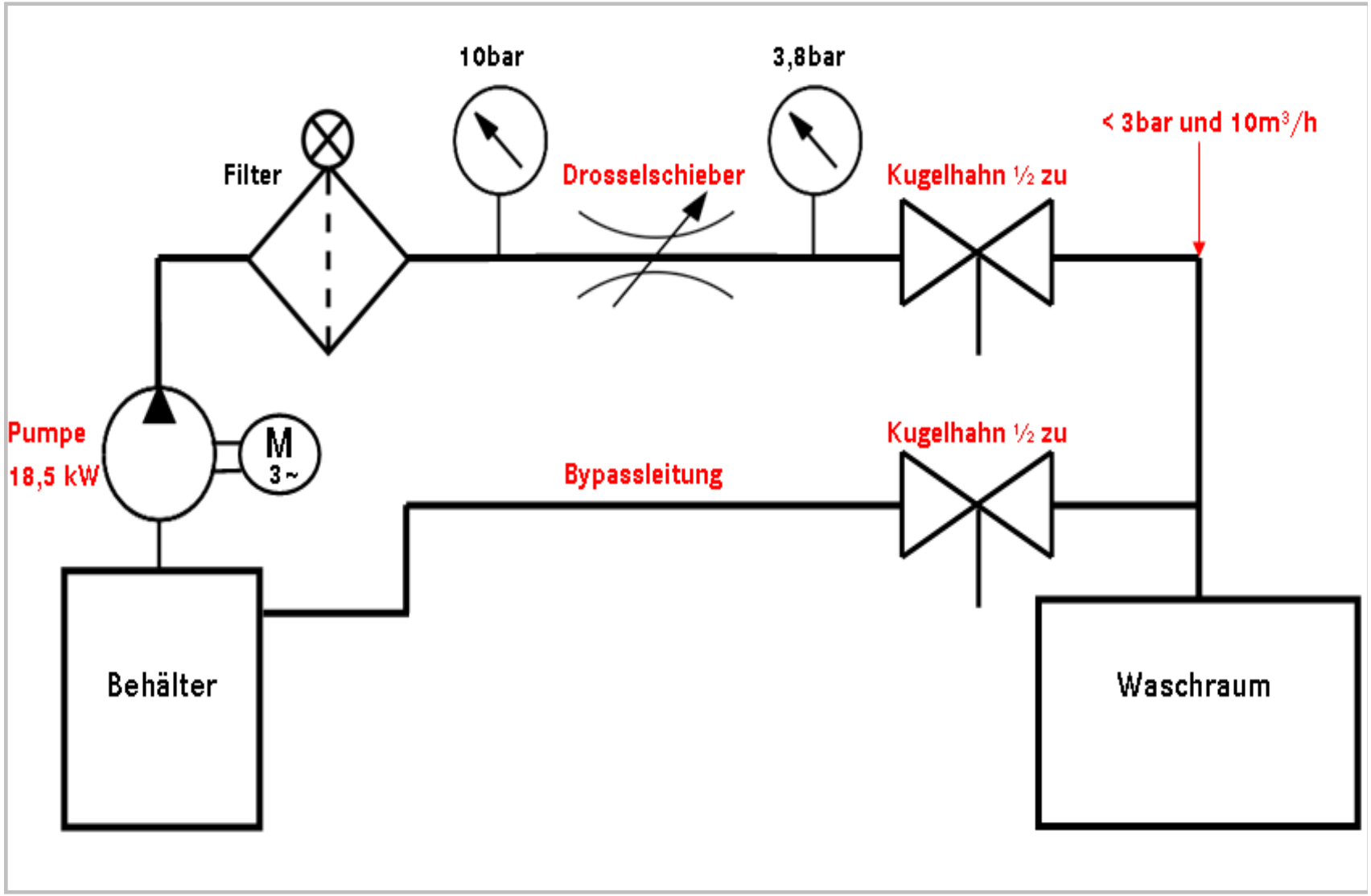
Original cost including installation 5%

Maintenance cost over lifetime 10%

Energy cost in lifetime 85%

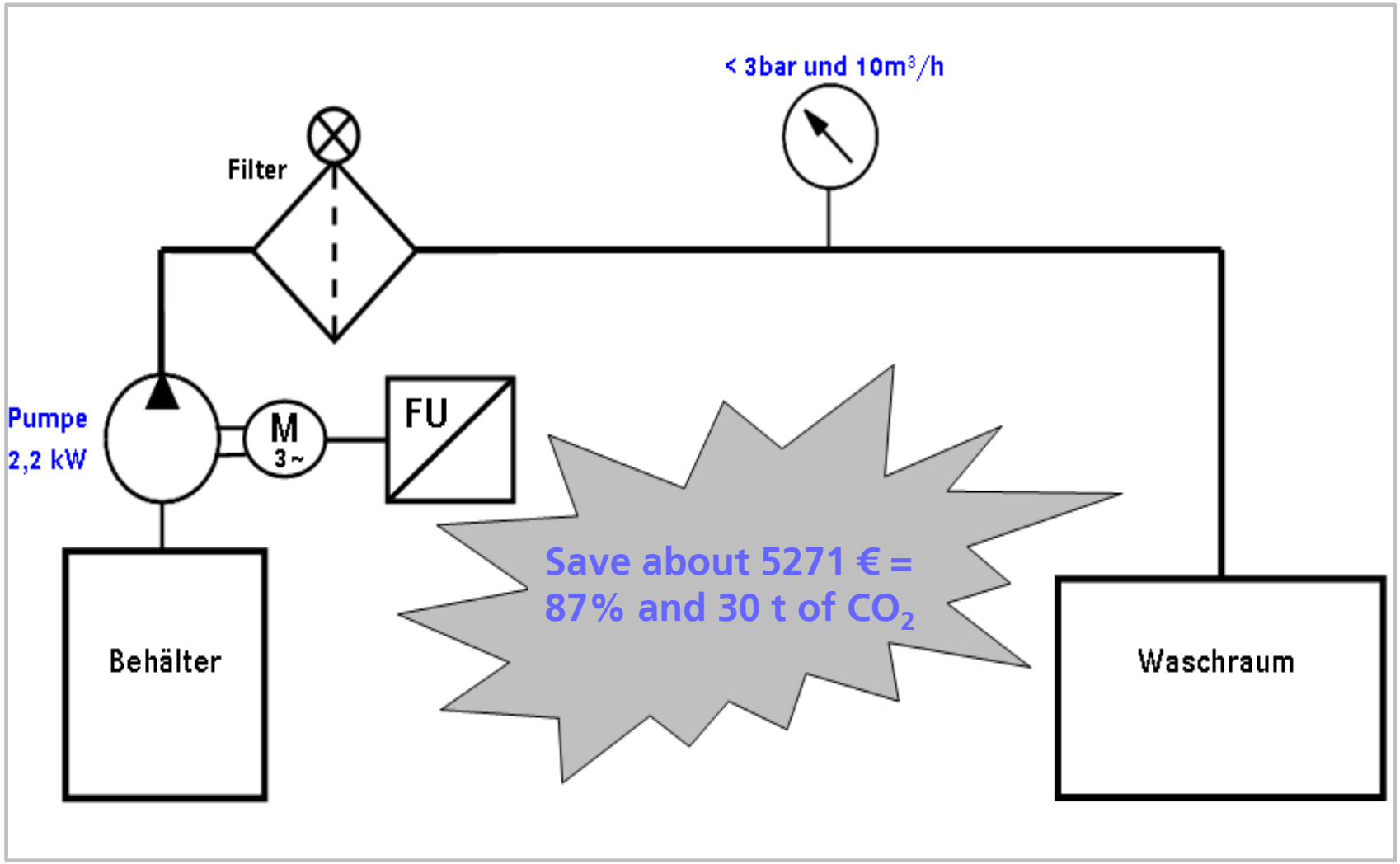
Example: Pump system before optimisation

- Power of Drive = 18.5 kWh
- Power demand = 57.000 kWh
- Energy cost = 6.042 €/a
- CO_2-Emission = 34 t/a



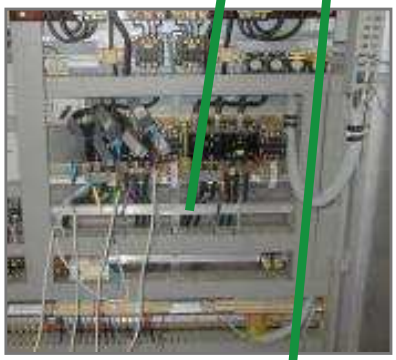
Example: System after energetic optimisation

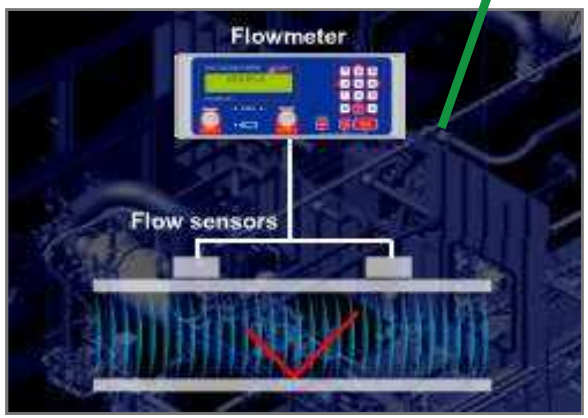
- Power of Drive = 2.2 kWh
- Power demand = 7.266 kWh
- Energy cost = 770 €/a
- CO_2-Emission = 4 t/a



Remember: a change of flow reduces power demand in the 3rd potency!
So reducing flow rate by 50% reduces power consumption to 1/8th

Example for check: “Pump audit” by Grundfoss





Example: Electric drives (Motors)

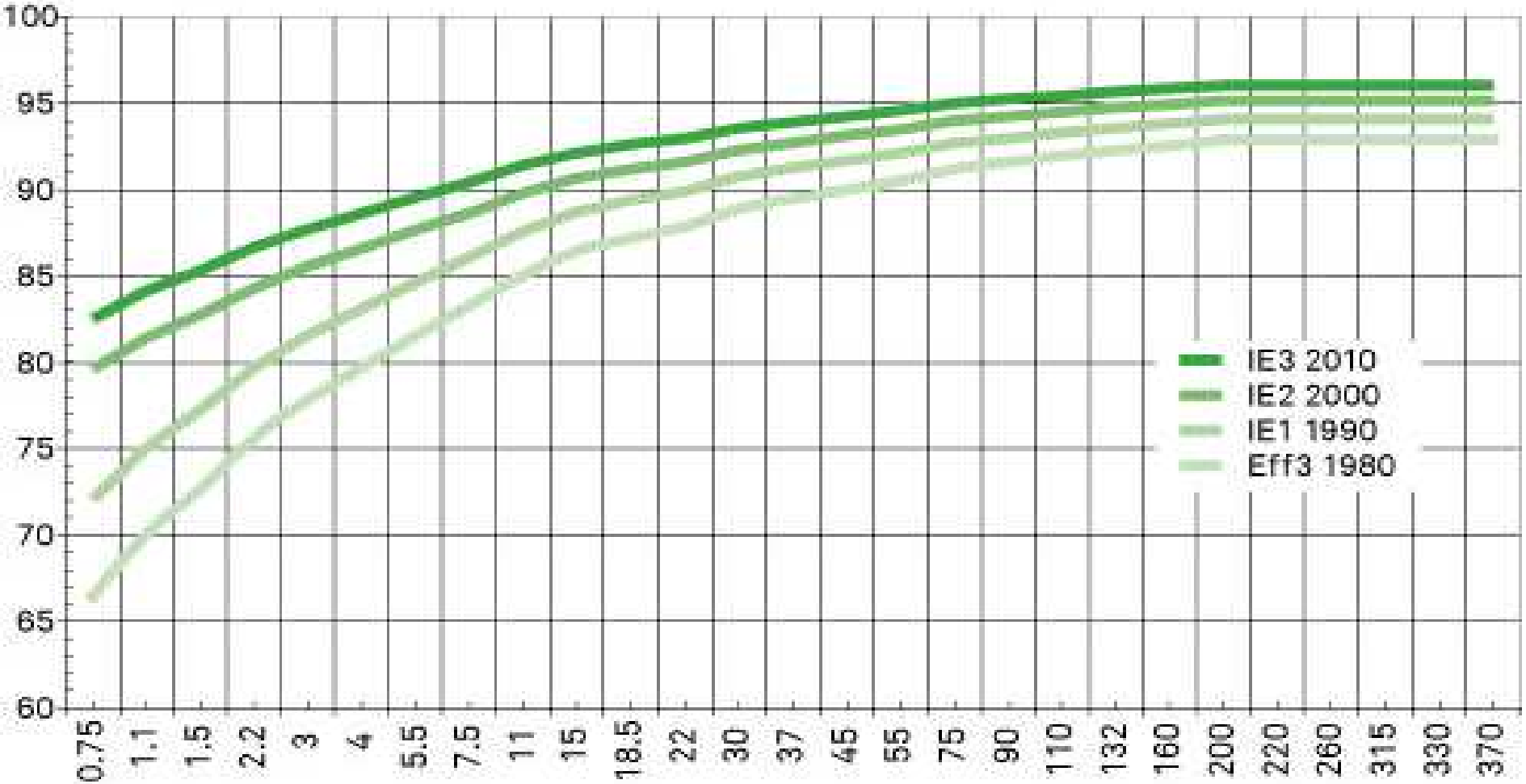
How much time elapses until the energy costs have overtaken the purchase costs of a 3kW-motor in continuous operation) ?

24 days !

So invest in highest electric efficiency IE3 (future IE4)

Efficiency categories of Motors

Efficiency of electric motors (drives) (4 pole) in %



Motor size (capacity in kW)

Example: Electric drives (Motors) in general

- Load management and energy efficient electric drives:
  - Use “intelligent drives” for changing operations adjusting to required load, i.e. install frequency converters (pay back 1-2 years)
  - Avoid peak loads by soft starter, especially when electric drive must start under load
  - Shift heavy electric loads to low tariff periods

- For information only: Energy efficient IT and office technology
  - Utilise power saving modes and switch of at operating end (Example: system with 600 computers has saving potential for 35 MWh/a > 5000 €/a)
  - Optimise server room temperature (modern processors can easy do with 25-28°C in the room, persuade your IT specialist)
  - Concept of “virtual servers” can save 50% if mirror servers are used

Example: Pressurized Air Systems

- **Enromous potentials in optimizing the energy use by pressurized air systems** (those use only about 10 % of the electric power for final purpose)
  - **Minimizing system leakages** (saving potential 5 - > 25%),
  - **Frequency control for reduction of start-up current intensity and stable pressure limits minimizing losses**
    (saving potential 10 - 20 %)
  - **Reduction of network pressure from 9-7 bar**
    (saving potential 7% for each bar means 14 % for two bar)
  - **Switching off network components and production sites during brakes and in idle times**
    (saving potential 5 - 10%)
  - **Recovery of heat resulting from air-compression up to temperature levels > 70 °C**
    (recovery up to 50 % of the energy input as „lost-heat“)

Success stories of energy checks and EnMS

Industry	Timeframe	Energy consumption GWh/a	Savings			
			Cost	Electricity	Gas	CO_2
Municipal waste processing	2010	23	19%	10%	--	3.518 t
Food processing (salted peanuts)	2009-2010	13,2	30%	28%	13%	3.100 t
Shopping centre (mall)	2009-2010	9	2008: 15-20% 2011: +2%	2008: 15-20% 2011: +2%	--	60 t
Synthetic resign plant	2006-2010	25	15%	9%	25%	1.600 t

Conclusion: How perform a quick Energy Check?

- **Is equipment ever run without need?** Idling motors at zero load, compressors of coolers running at night time instead of free cooling, loads working against valves to control instead of frequency controlling of loads etc.?
- **Have a look at all motors**, how long to they operate? Are loads alternating? How old are they? Is drive power in the range of needed one? Could more efficient drives replace old ones? Is frequency control a fast option?
- **How old are your motor/pump systems?** If older than 7-10 years they might be replaced if working hours exceed 3500/a
- **Are reductions in the use of pressurized gases or pressurized air an option?** Can the pressure level and leakages be reduced?
- **How old are lighting systems?** May be lighting time can be reduces and bulbs exchanged against LED
- **How good are your measurement systems?** Are employees able to monitor energy uses any time and adjust loads etc.?

Solution II:
3. Systematic analysis of energy savings potentials

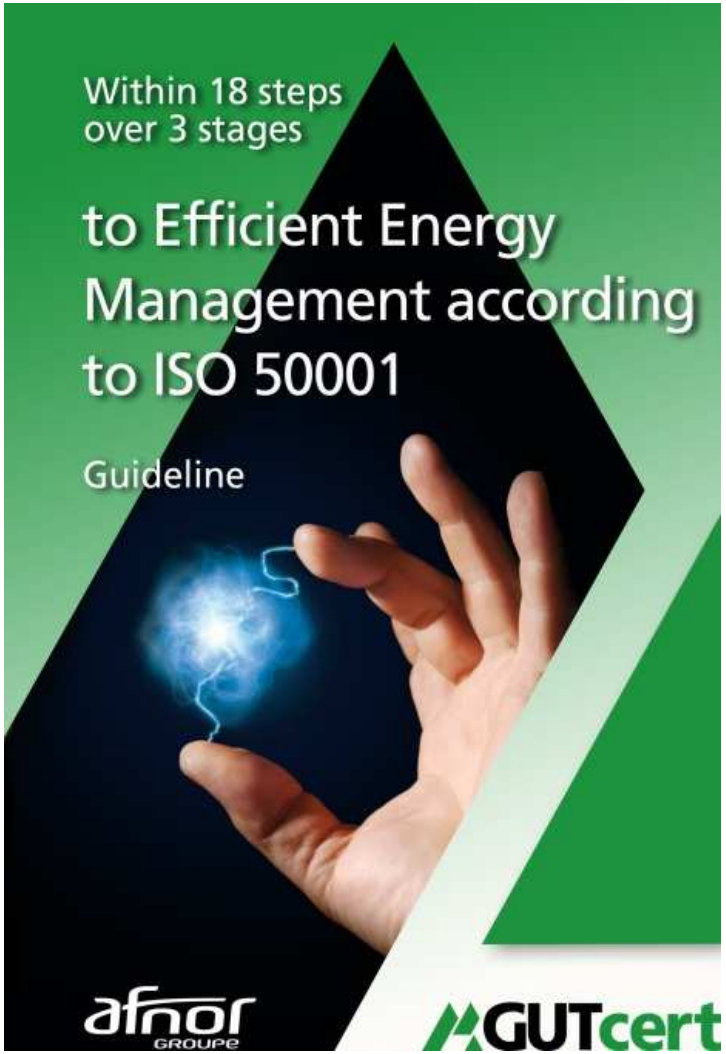
A guided tour in steps 1-6

Energy analysis/review (ISO and DWA):
Detailed survey and evaluation of the past and present energy consumption, assessing the significant areas of use to prioritize optimisation measures including considerations of cost efficiency

Lecture is based on our “GUTcert Energy Guide”

GUTcert issued its latest revision 4.2 of the “Guide to Efficient Energy Management” - available as free download at www.gut-cert.de

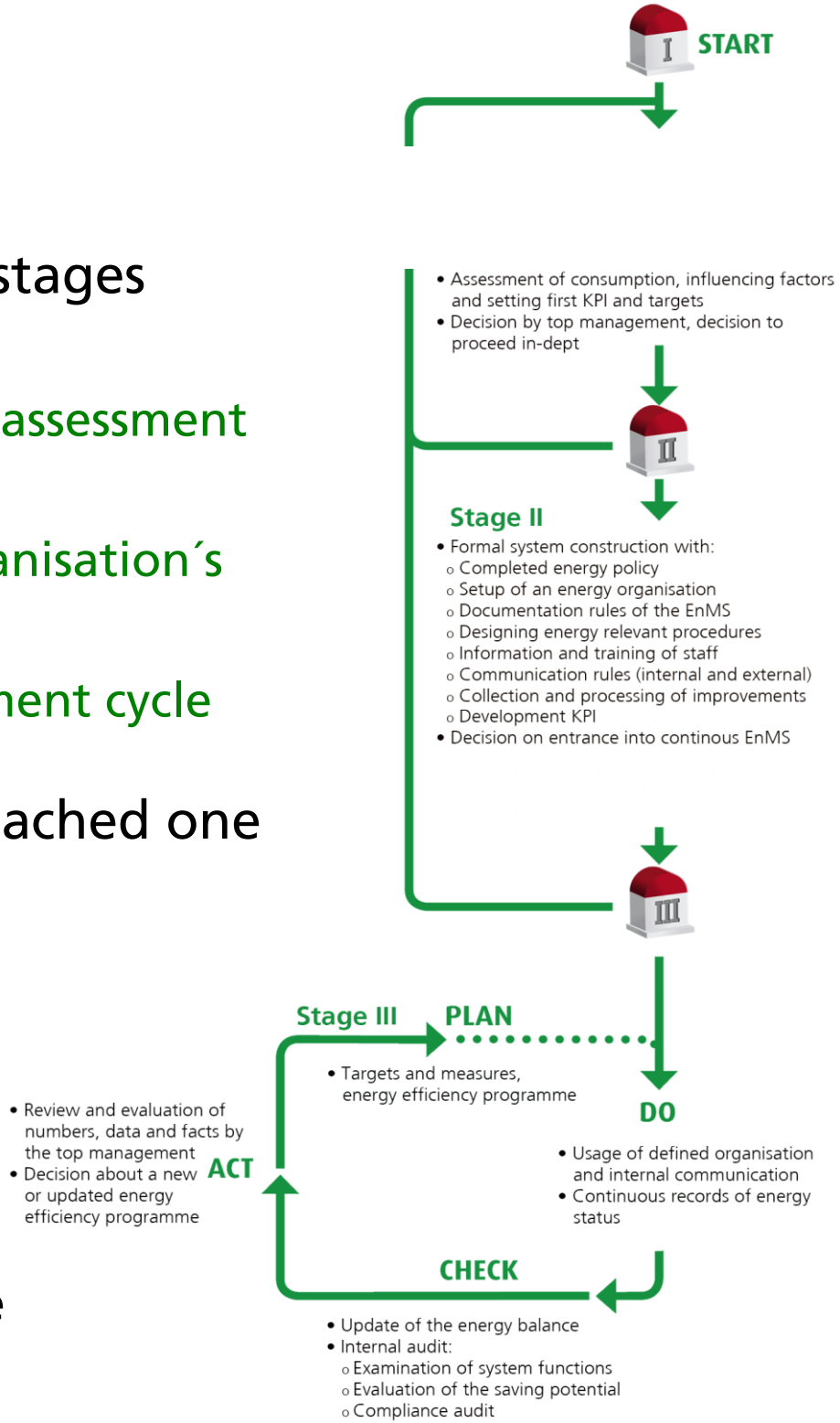
- Our guide is a tool from practitioners to other practitioners, supporting them to implement a system to save energy efficiently
- Above all it aims at organisations (including SMEs) to become aware of how to deal efficiently with energy and is based on the daily life in real enterprises.
- The revised version of the guide ensures "in passing" a systematic introduction as well as complete compliance with the requirements of ISO 50001.
- available in English, German, French, Russian, Bulgarian, Mandarin and Polish



A three-stage approach

- Users of the Guide are led over three stages step by step
  1. From the project idea to initial quality assessment and identification of potentials
  2. Integration and adaption into the organisation´s planning processes
  3. Introduction of a continuous improvement cycle

- Each stage is a consistent entity approached one after another:
  - Stage 1: analysis and Identification of technical energy-saving potentials
  - Stage 2: survey of organisational potentials to save within the structure
  - Stage 3: implementing a management system that could be certified any time



Stage I: Systematic Analysis of energy savings potentials

Step 1: Management decision to invest time and resources into an energy efficiency project and to assign responsibilities

Step 2: Making a systematic project planning what to do - may be even in parallel

Step 3: Definition the system boundaries (!)

Step 4: Evaluation of the historic data base, measurements and consumption calculations

Step 5: Setting energy baselines, energy review, forming of first KPI, define first objectives, setting targets and making an action plan

Step 6: Review and assess results and decide action plan with investments in measures by top management

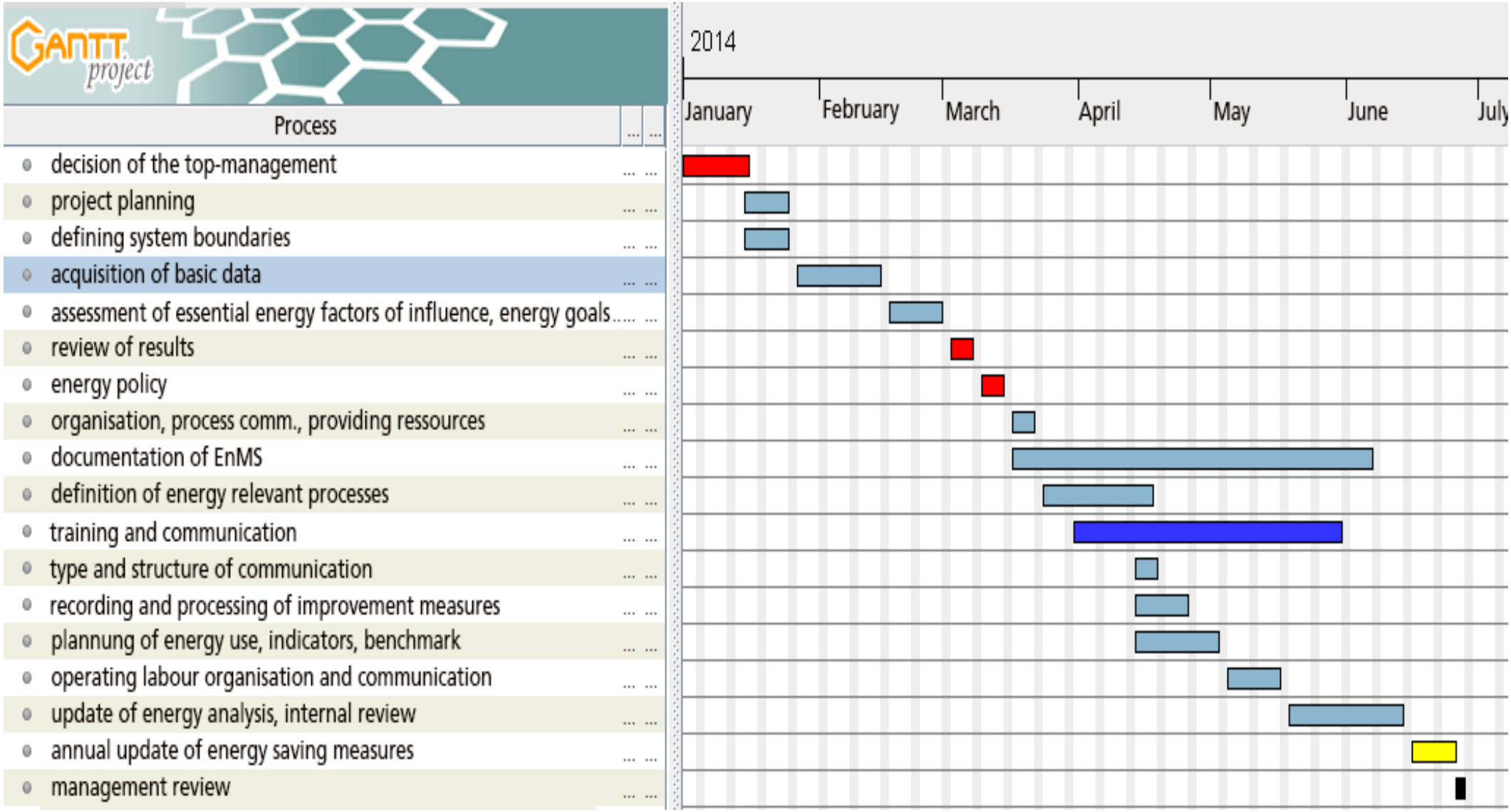
Step1: Management decision to start

Decision of the board/ CEO to start activities for a systematic Energy management should include at least:

- A commitment to analyse and improve the current situation
- Provision of necessary means:
  - Installation of a project management (responsibilities)
  - Establishment of basic communication structures
  - Project deadlines

Step 2: Planning the project systematically

Setup a Project Schedule to coordinate activities and necessary resources



Step 3: System boundaries and energies used

Conducting an energy balance – the first important step!

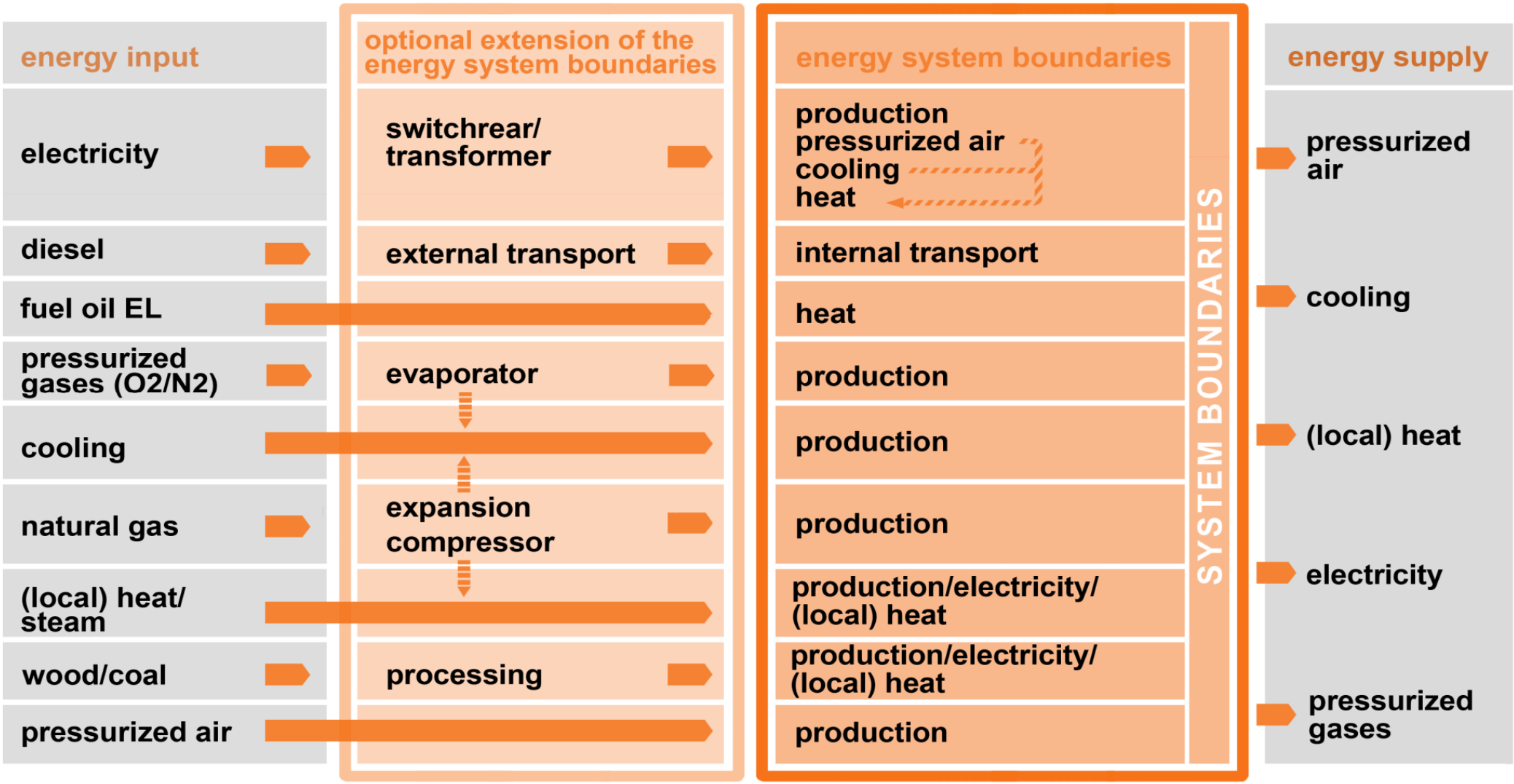
- **Define system boundaries:** Prerequisite for a summary of all employed energies
- Prepare an energy-costs and CO_2-balance - absolute and relative

Energy used / Energy source	Quantity [MWh/ a]	Share of total quantity [%]	Costs [€/ MWh]	Share of total costs [%]	CO_2-Emissions [t]	Share of total CO_2 [%]	Measuring system/ Measuring location / Accuracy

- Compile ALL energy inputs - within balance frame
  E.g. : Electricity, gas, (district) heat, oil/diesel, coke/coal, bio- and Substitute fuels – also compressed gases and cooling water!
- List all energies in comparable units , e.g. kWh/ MWh etc. and determine ratios
- Do the same with cost for economic comparison and with CO_2 for environmental assessment
- Do not forget to consider if (and how) energy leaves balance frame (as product, as waste, as waste heat, or as energy supply for neighbours)

Step 3: Define system boundaries

- Define system boundaries in order to determine the precise scope of the assessment ... (attention transmission).



Step 3: Get a detailed consumption overview

- **Assign energy use in a balance to energy consumption** (Attention: Consider line and transformer losses), i.e. :

Energy consumer				Energies consumed E1, E2,..- [kWh/€/ CO_2/%)				Waste heat (temperature)	Measurement system/ type	Accuracy
No.	Plant/Facility/Part	Year of construction	Power input [kW] (Capacity)	E1	E2	E3	Σ			

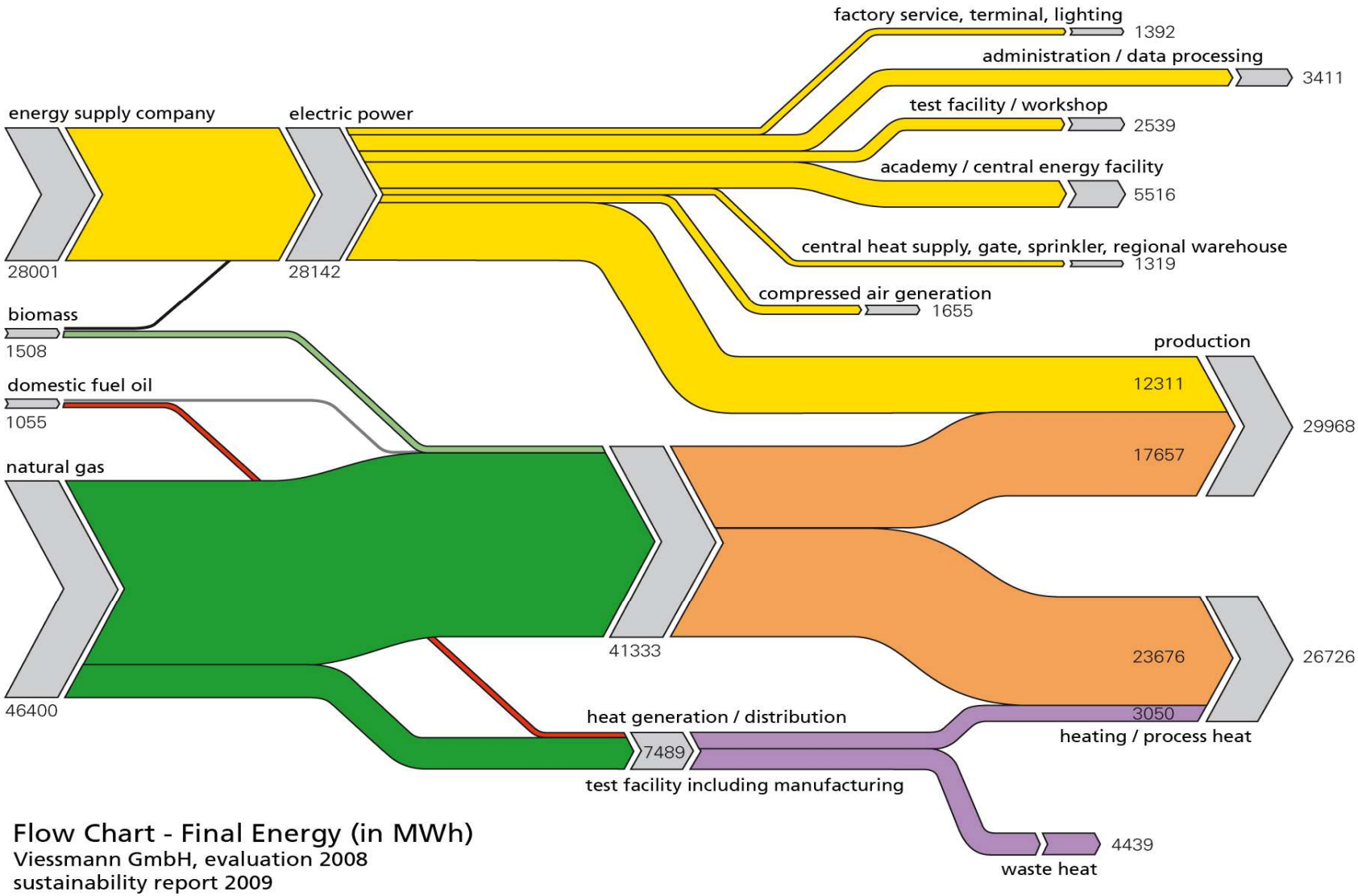
  - **Compile** ALL **consumers** of energy within balance frame
  - **sorted them** by type & magnitude of energy consumption (installations may use electricity, compressed gases, heating/cooling, etc. at once)
  - **Consider** also energy **conversion** (internal generation, compressed air...)
- Compare energy use and relatable energy consumption: **Does it match?** (95% would be good as line and transformer losses have to be considered)

Step 4: Evaluate data base & measurements

- **Energy consumption: -** measure - calculate – estimate!
- **Determination of total energy used** is usually simple (calibrated main meters, standards for CO_2-calulation, costs obvious)
- **Analysis of energy consumption** is fare more complex - but brings in first successes immediately!:
  - Often single measurements with data available (virtual measurements)
  - Clip-on instruments help (record operating status and calculate from there)
  - A good estimate may be better than poor measurement
- **Measuring accuracy** adopt to consumption /bigger=more precise
- **Consumption profile** often key to success
- **„Consumption Baseline“** to be determined during shutdowns
- Early planning of better instrumentation, especially automatic recording devices and a (graphical) evaluation!

Step 4: Evaluate consumption patterns

- **Example of a graphical analysis of the energy consumption**



Flow Chart - Final Energy (in MWh)
Viessmann GmbH, evaluation 2008
sustainability report 2009

Step 4: Evaluate existing ‘energy-organisation’

Gather existing organisation and communication structure

- In almost all organisations, are already (some) organisational procedures and responsibilities for energy management established, be it only the obligation to check energy bills against meters on site or to determine maintenance intervals…
  - Who is already getting a hold of which kind of energy consumption data (as “habit” of maintenance shops or organised)?
  - Who receives those figures, data and facts of the energy consumption to be checked if appropriate, or for evaluation?

Step 4: Evaluate existing legal requirements

- **Ascertaining legal commitments and further demands (Compliance)**
  1. Collection of all relevant legal provisions, municipal regulations, and organisational commitments, etc.
  2. Identification of those regulations that (might) really apply to the organisation
  3. Listing the details of applying legal provisions and regulations

Nr.	Law/ regulation/ ordinance	Applicable Requirement	Affected process / plant	Implementation responsibility
1				

  4. Comparison of daily procedures with all provisions and regulations of the register (inducing of actions if necessary)

➡ **Summarize all this information to a (first) energy report**

Step 5: Assess energy consumption pattern

Assessment of energy consumers, recording options for savings, benchmarks

- **Allocate all types of energy input** (electric power, gas, coal, heat (&cold), diesel, pressurized air, etc.) **to all consumers** (equipment or processes) **summing up to total energy use/unit**
- **Sort customers by total consumption, total energy cost or total environmental impact, by type of energy, specific pattern of consumption** (load profile, options to influence etc.),
- **Benchmark consumers, internally and -if possible- externally with specific industry sector**
- **Determine general drivers for consumption** (e.g. raw material, weather conditions, shift schedules, production plans etc.)
- **Optimise savings, analysing „ROI“ and „amortisation“** (use short term savings to pay for long term measures)

This way enjoy saving energy!

Step 5: Set priorities for savings

- Example for an analysis surveying the influencing factors for consumption via a decision matrix
  - - criteria with strong influence can be marked by numbers, colours (strong- medium-low) etc.

criteria / e. aspect	consump-tion	consumption fluctuation	planned consump-tion	costs	potential Savings	compliance status	environm. pollution	imple-ment. time	dev. from benchmarks	influence consump-tion
consumer 1	1	3	2	2 (electr.)	1	no need for action	1	3	3	3
consumer 2	3	None	3	2 (gas)	3	need for action	3	2	1	2
consumer x	2	2	1	3 (electr.)	2	2	2	1	2	3
legal requirement	1	1	2 cleaning conditions	3	2	need for action	2 (internal consulting)	3	1	1
work capacity	3	3	3	3	2	none	2	2	3 (bad)	2
mainte-nance	3	1	2	2	3	1	3	1	3	3
shift system	2	2	2	2	1	no need for action	1 (internal consulting)	1	2 (better system)	3
annual mean temperature	3	1	2	2	1	none	2	none	1	1

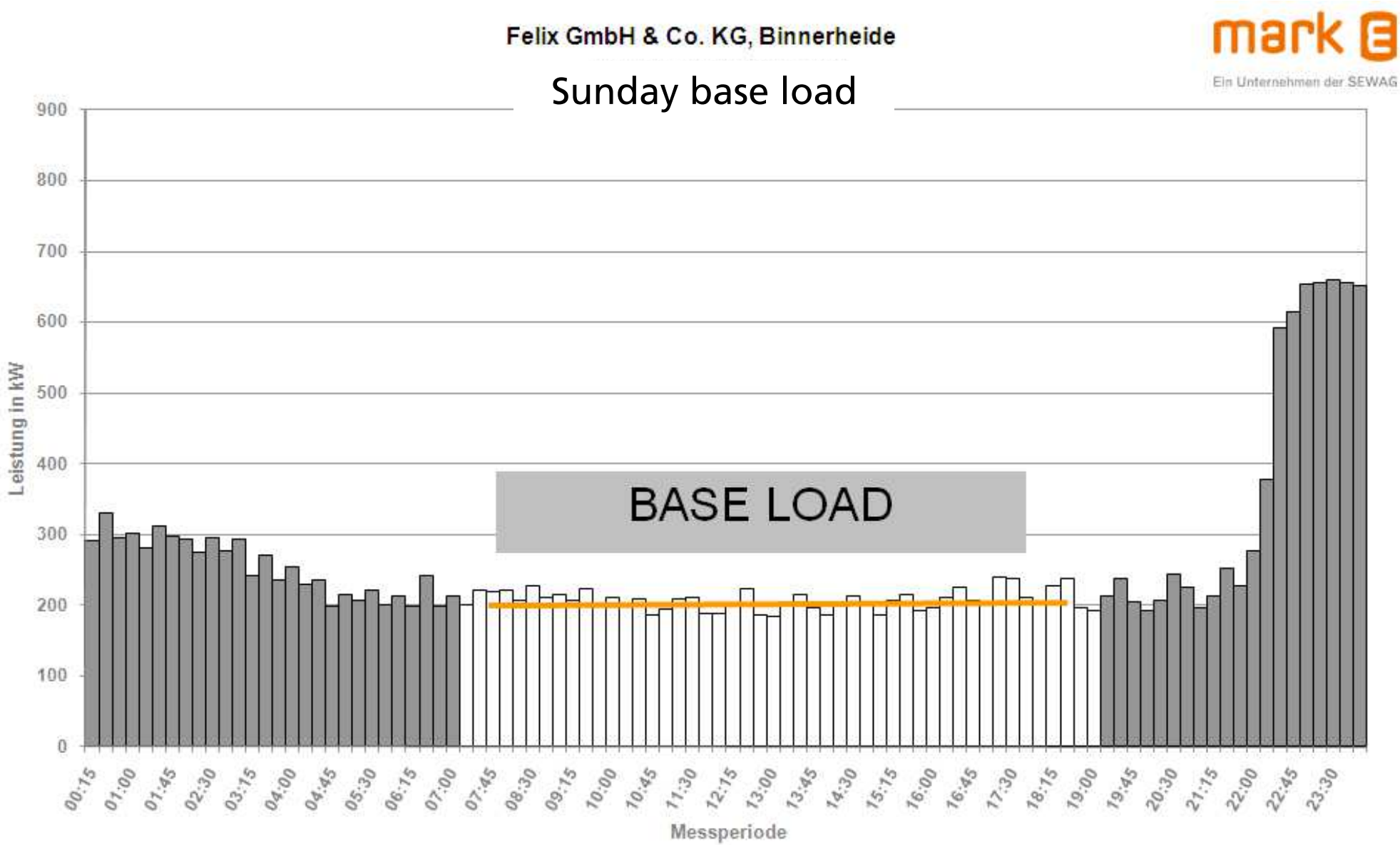
3 =strong influence, **2** = medium influence, **1** = low or no influence

Step 5: Define first action plan with measures

- Examples of first goals for Energy savings from action plan

Saving goal	Measure(s)	Cost in €	CO_2-Saving	Amortisa-tion [a]	Responsibility	Deadline
Electric power saving of 37.400 MWh	Optimizing control systems and replacement of old transformers	3.150 Mio.	16.800 t	< 2	Technical planning	05/20xx
Reduction of Consumption of 690 MWh	Decline of diesel use by 5% employing waste fats instead	0	185 t/ a	instantly 64.000 €/ a	Head of production	07/20xx
Reduction of electric power by 74 MWh	Only allow pumps to run in on automatic	0	48 t/ a	instantly 6.500 €/ a	Technical planning	04/20xx
Reduction of electric power by 50 MWh	Reduction of air pressure for pressurized air by 1 bar	0	31 t/ a	instantly 6.150 €/ a	Technical planning	03/20xx
Reduction of electric power by 350 MWh	Feeding electricity from own hydropower use	100.000	200 t	< 3 35.000 €/ a	Technical planning	04/20xx
Electric power saving of 1.000 MWh	Reduction of losses within the net for pressurized air by condensate drainage (not closing)	10.000	570 t	< 0,2 55.000 €/ a	Head of production	11/20xx
Reduction of natural gas by 300 MWh	Reduction in dryer capacity by 50 %	0	600 t	instantly 8.100 €/ a	Head of production	05/20xx

Example: Collection of energy data – base load

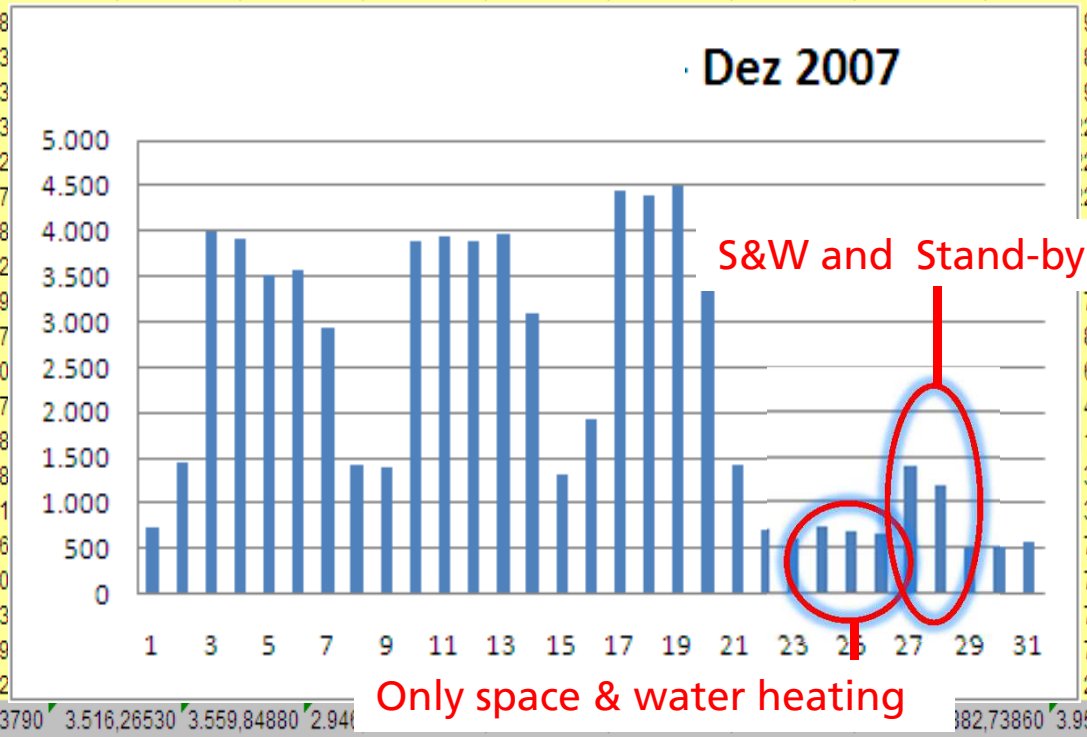


Example: Collection of energy data – load profiles

- Providers often have load profiles available for power and gas (monthly or even online every quarter!)

Abrechnungsjahr:	2007	
Gasmonat:	Dezember	
höchster Tageswert:	4.487,46910	cbm/d Vn
höchster Stundenwert:	243,93300	cbm/h Vn

Tag	1	2	3	4	5	6	7	8	9	10	11	12	13	14
07 Uhr	73,42430	31,26570	224,44350	173,08130	170,64100	200,61420	156,99040	148,54730	24,96920	216,66260	187,54180	181,33320	194,42880	207,91200
08 Uhr	39,73380	22,88890	215,59660	189,17300	173,26370	181,54010	176,17480	169,57880	28,57370	227,89630	201,27070	188,86470	204,75430	201,97110
09 Uhr	32,49310	40,89920	212,44360	184,65110	201,21910	181,61430	188,27890	190,12670	39,28750	211,49610	172,25830	176,86510	214,64470	214,47450
10 Uhr	46,98860	17,97830	222,21120	159,28230	186,81250	164,63270	156,00880	155,23360	10,68480	203,58460	151,72560	174,45550	195,21860	180,01510
11 Uhr	21,68140	30,08320	203,51870	181,48									97,77280	165,24420
12 Uhr	64,00490	39,62240	225,07050	202,23									82,95800	215,71130
13 Uhr	47,16020	13,14330	232,30870	209,63									93,00270	226,87720
14 Uhr	26,56790	32,35560	202,57620	208,63									21,38530	232,89890
15 Uhr	30,19820	35,81260	210,14260	206,12									28,60690	236,58690
16 Uhr	13,29390	15,48600	206,66230	200,17									26,17450	225,45820
17 Uhr	37,42610	35,71870	174,58860	214,78										
18 Uhr	13,24620	29,67540	165,09510	183,32										
19 Uhr	19,27160	17,82410	124,32240	182,09									75,42180	127,93630
20 Uhr	21,70180	39,16510	184,25790	191,87									80,51110	94,45490
21 Uhr	22,89640	14,21530	197,47890	172,40									68,01610	49,71350
22 Uhr	21,70490	27,23000	200,22730	184,67									48,28630	11,14240
23 Uhr	18,09820	139,27940	175,34440	167,88									17,41700	34,78480
24 Uhr	20,48360	121,87760	129,66120	109,28									31,12580	18,61210
01 Uhr	21,73940	123,11750	111,51900	122,71									38,68250	27,25730
2 Uhr	21,72290	106,32520	63,07650	109,26									78,70750	27,29330
3 Uhr	20,47570	94,36730	56,97600	96,90									76,19160	26,03980
4 Uhr	22,88900	130,25860	67,98550	58,83									71,09750	45,88230
5 Uhr	38,64570	150,36250	71,61020	90,59									74,81190	35,91180
6 Uhr	33,77870	136,97790	125,86970	108,62									26,46730	40,83380
Summe Tag:	729,62650	1.445,92980	4.002,98660	3.907,73790	3.516,26530	3.559,84880	2.94					82,73860	3.959,55540	3.098,04530

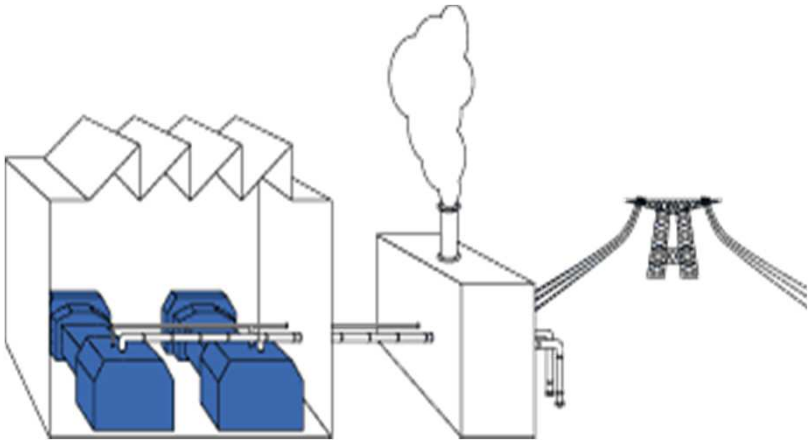


Energy review – energy consumption

- **Switch Equipment off**
  - if not needed (this applies to all energy sectors)
- **Adapt to Requirements, control levels and flows**
  - process conversion, e.g. substitution of compressed air or steam
  - Adapt:
    - **temperature and pressure levels** (heating, cooling, compressed air)
    - air change rates
    - illumination level
    - **process control** (for better visibility and optimisation)
- **Heat Recovery**
  - Sources: exhaust air, cooling water, processes
  - Methods: energy balance, pinch-analysis
- **Electric motors**
  - use energy efficient motors
  - select motor size according to actual demand
  - use variable speed drives (vsd)
  - reduce idle- /partial-load operation losses

Energy review – energy distribution

- **Switch-off pumps, valves…**
  - Example: heating circuit in summer
- **Supply of heat transfer stations, pressurized air networks**
  - automatic shutdown at end of shift
- **Distribution of sub-areas**
  - sections with different requirements (temperature, time) can be switched off separately if circuits are separated
- **Reduction of Losses**
  - efficient leakage fixing (e.g. compressed air, steam)
  - thermal insulation of heating- and cooling pipe networks
  - compensation of watt-less current
- **Reduction of Transportation Energy**
  - control of pumps
  - optimisation of hydraulics
  - optimisation of existing pipe networks
  - change of media



Energy review – energy generation

- **Steam Boiler and Heating stations**
  - minimise exhaust gas losses (e.g. economiser)
  - reduce stand-by-losses (e.g. performance modulation, sequenced actuation of boilers)
- **Combined Heat and Power generation**
  - combined heat and power plants – combustion engines (CHP)
  - steam turbines/-motors
  - fuel selection (natural gas, bio diesel, biomass)
- **Generation of chilled/ cold water**
  - free Cooling
  - control-/hydraulic system
  - chillers as heat pumps
  - heat recovery
- **Compressed Air System**
  - Control of pressure level
  - fix leakages
  - heat recovery

Energy review - energy Supply

- **Delivery Contracts**
  - optimisation of procurement strategy
  - Adjusting contracts to actual demand
  - improve conditions (price, basis of accounting)
- **Energy Related Invoices**
  - adjusting terms of contract and actual accounting
  - optimisation of energy taxes and dues
  - Analysis of consumption
- **Reduction of Peak Loads**
  - Analysis of load curve (electricity and natural gas)
  - Load management (organisational, technological)

Step 6: Review of Top Management

In a management meeting all relevant figures, data and facts are presented, discussed and clarified (energy review)

Following decisions must be taken in the review (at least):

- Formulation of a first **energy strategy** (energy policy etc.)
- Determination of **significant factors influencing the energy consumption**
- Deduction of recognized improvement measures (goals, targets measures) shaping an **action plan** for the near future
- Definition of an **organisational structure** suitable for processing goals, collecting data and the communication of results (energy manager, energy representative, energy team)
- Decision on further procedure:
  - Position the system on a more formal foundation and go on to Stage II?
  - or simply update of the basic facts annually and remain at Stage I for the moment?

First result usually: Measure!

- The first result of a review, i.e. the first goal of an energy action plan is usually the decision to install further, different or better measurement equipment
- recently a lot of less expensive but still precise measurement devices where developed to meter the different media involved
- these guarantee not only measurements with a decent quality but also data with high temporal resolution
- which means to employ good storage utilities (data logger) to capture all this data and to prepare it for further investigation and assessment
- especially measurements with higher resolution over time (load curves) often show important improvement potentials

Measuring devices

- balances
- ferraris counter for power
- clip-on ammeter
- water meter
- ultrasonic flow meter
- gas meter
- calorimeters
- engine hour meter (compressors)
- network analyzer
- IR-cam

Tip: even if there is no counter, consumption can be estimated or calculated ! (example: lighting = lamps x h, drives = power x h)

Collection of energy data – types of meters

- reading of stationary existing counters (requirement: available pulse; sometimes switch relay necessary)
- direct Bus counter (M-Bus)
  power: extra pulse converter necessary
  Advantage: more information (frequency, single phase, cos phi, …)

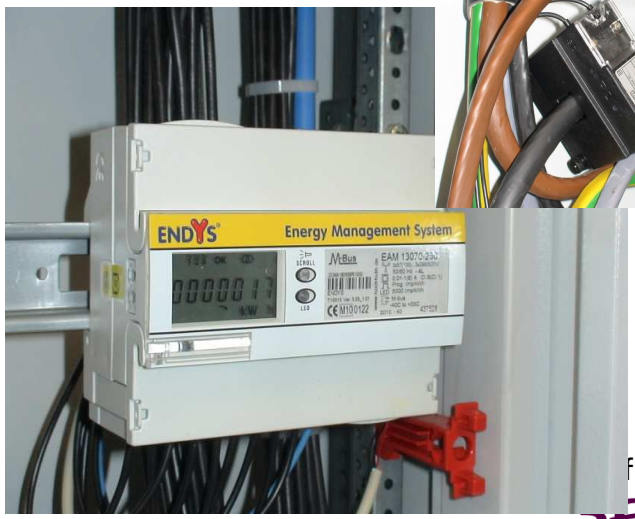


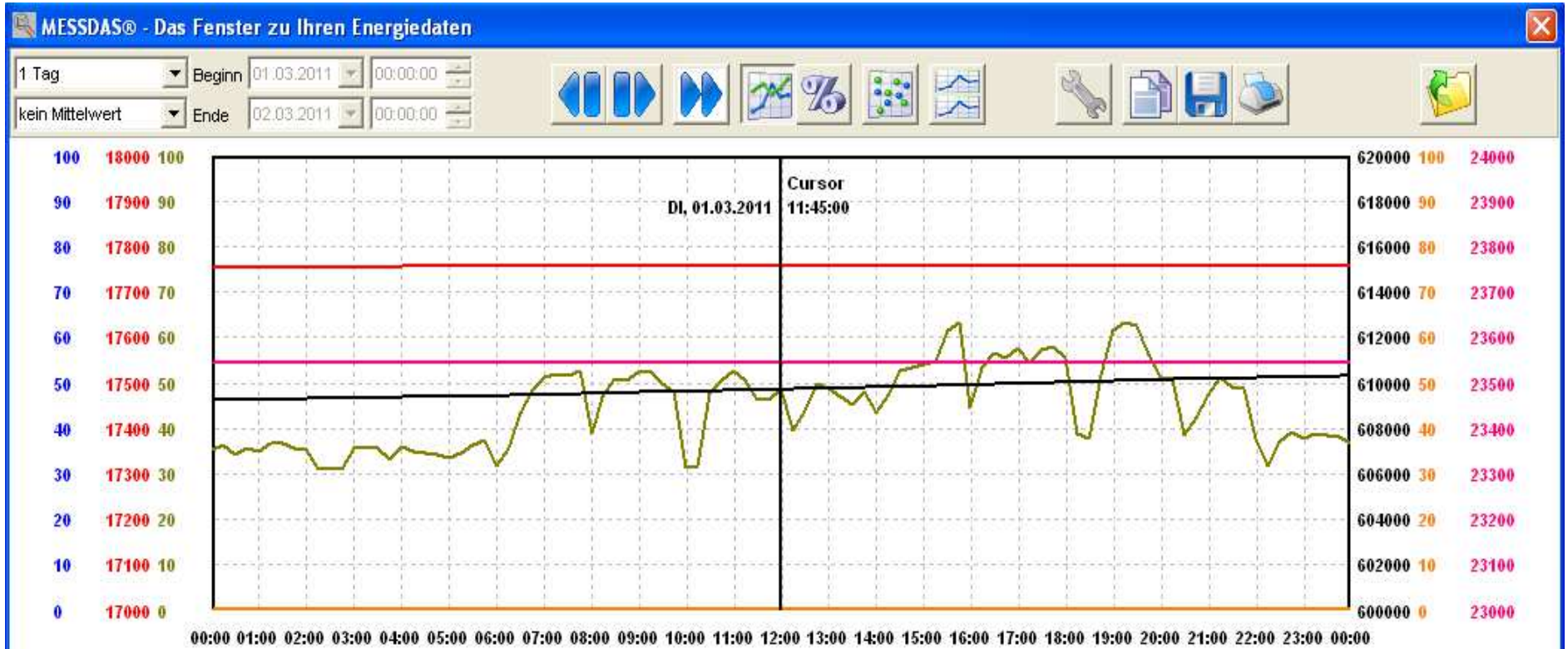
photo: NZR

photo: Actaris

fluids

Assessment of temporal energy consumption

- Grafical discription of Energy consumption

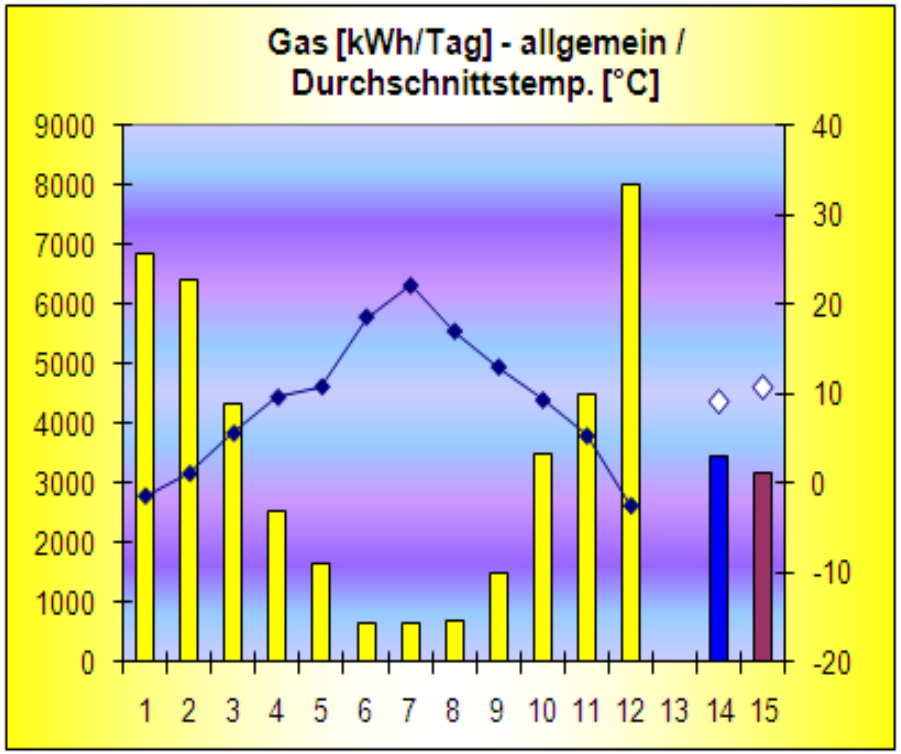


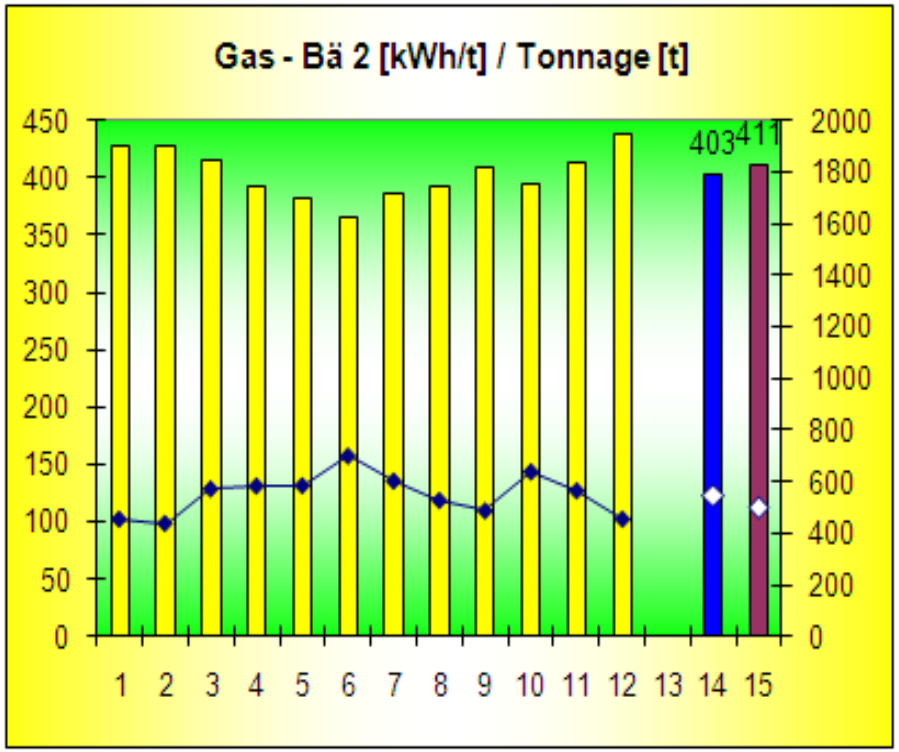
Gewählter Zeitraum: DI, 01.03.2011 00:00 - MI, 02.03.2011 00:00 Basis: 15 min Mittelwerte

Zähler-Nr	Bezeichnung	Einheit	Cursor	Min	Datum/Zeit	Mittel	Max	Datum/Zeit	Menge	02.03.2011 17:30:00
SCH-ST-14i	Schwerte Strom Werk ComAir Rallye□250/5 i	kW	0	0	01.03.2011 09:00	0	0	01.03.2011 23:45	1	0
SCH-ST-14z	Schwerte Strom Werk ComAir Rallye□250/5 z	kWh	17755	17755	01.03.2011 00:00	17755	17756	02.03.2011 00:00	1	17756
SCH-ST-15i	Schwerte Strom Werk Atlas Copco VSD 90□250/5 i	kW	49	31	01.03.2011 02:30	45	63	01.03.2011 15:45	1072	61
SCH-ST-15z	Schwerte Strom Werk Atlas Copco VSD 90□250/5	kWh	609714	609224	01.03.2011 00:00	609738	610297	02.03.2011 00:00	1072	611142
SCH-ST-13i	Schwerte Strom Werk Atlas Copco GA 55□250/5 i	kW	0	0	01.03.2011 07:00	0	0	01.03.2011 17:15	0	0
SCH-ST-13z	Schwerte Strom Werk Atlas Copco GA 55□250/5 z	kWh	23543	23543	01.03.2011 00:00	23543	23544	02.03.2011 00:00	0	23544

Assessment of energy consumption - visualizing

- Find and communicate key indicators by combination of Energy Values with production volume, time or temperature



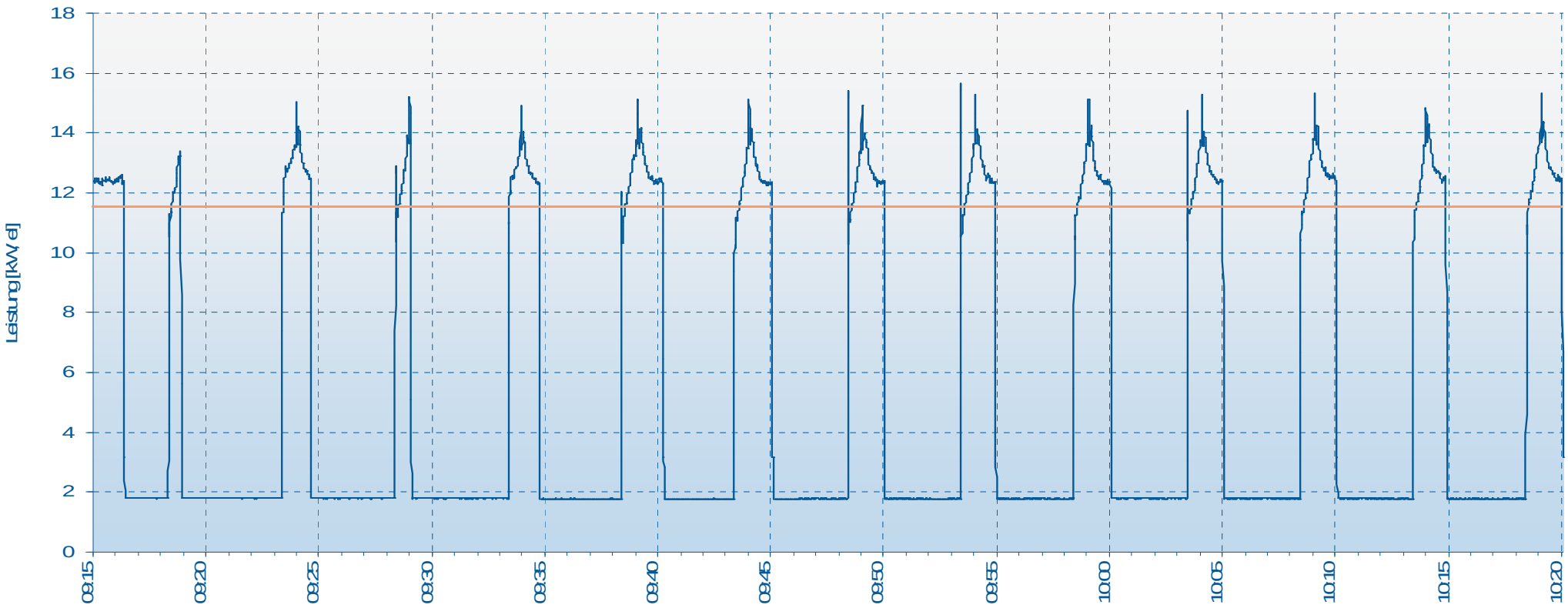


Example: Assessment of consumption – internal benchmark

- Internal (external) Benchmark: important tool do identify energy saving potentials
  - Why does machine A needs less energy that B?
    - different technology
    - year of construction
    - technical status
    - efficiency class
    - regulatory (external requirements)
    - …

Example: Assessment of consumption – chiller dimension, tailored to demand?

- High switching frequency caused by insufficient dimensioned storage buffer and oversized chiller
- increased wearing of the chillers at 100.000 starts a Year (12 starts per hour)



Assessment of energy consumption– energy aspects

- step 5 from GUTcert Guideline (realisation Felix)

Aspekt	Erdgas	Strom	Kosten aus G&S	CO2 aus Strom & Gas
Bäckerei 1	31%	7%	18%	21%
Bäckerei 2	29%	14%	21%	21%
Rösterei	25%	7%	15%	17%
Space & Water	15%	?	7%	9%
Biowäscher	-	14%	8%	4%
Druckluft	-	8%	4%	2%
Verwaltung (incl.)	Teil von S&W	1%	1%	0%
Verpackung	-	10%	6%	3%
Beleuchtung	-	22%	12%	6%
Vakuumpumpen	-	7%	4%	2%
weitere - in Summe <10%	keine weiteren bedeutende Aspekte			
Summe	100%	90%	95%	85%

Action/Future plan
1, 3, 5 and 10 years

Assessment of EnConsumption – EnAspects

- step 5 - GUTcert Guideline (realisation Felix)

Aspekt	Erdgas	Erdgas kWh/t IST	Er kV IST	Strom kWh/t IST	Strom kWh/t IST 2009	Veränd. Strom	Strom kWh/t theo.	Pot. St theo.
Bäckerei 1	31%	185		19	19	0,0%		gering
Bäckerei 2	29%	403		86	90	-4,4%		mittel
Rösterei	25%	246		32	39	-17,9%		mittel
Space & Water	15%							-
Biowäscher	-			15	15	0,0%		hoch
Druckluft	-			0,13 kWh/m³	0,13 kWh/m³	0,0%	0,1 kWh/m³	30%
Verwaltung (incl.)	Teil von S&W							gering
Verpackung	-							gering
Beleuchtung	-							mittel
Vakuumpumpen	-							
weitere - in Summe <10%	keine weite							
Summe	100%							

4. Organisational structure to detect and develop savings effects

Step 7-8

Stage II: Integration of Energy Management into the whole organisation

Step 7: Definition of a consolidated Energy Policy

Step 8: Organisation, communication of procedures, provision of resources

Step 7: Definition of a consolidated Energy Policy

An Energy Policy is the comprehensive objective of the management

- General scope and path of the EnMS
- Defining the basis for the saving activities

Minimum requirements:

- appropriate to the nature and extent of energy use
- scope (goals) for detailed energy targets and measures
- regular reviews
- commitment to continual improvement in energy efficiency,
- commitment to compliance with applicable legal (and other) obligations with regard to energy aspects,
- made known to all persons working for and on behalf of the organisation
- accessible to the public
  (Requirements of DIN EN 50001)

Example for an Energy Policy

Example of an Energy Policy – H.C. Starck GmbH

H.C. Starck GmbH advocates an energy policy that is in full compliance with statutory provisions and the voluntary agreements of German industrial associations as well as with the requirements of ecology and economics

In line with our commitment to a careful handling of non-renewable raw materials and to a sustainable climate protection, an efficient use of energy is essential will also contribute to a long-term improvement of our competitiveness

We will achieve efficient utilization of energy through the continuous improvement of our processes by making use of state-of-the-art technologies.

For the operational implementation of its energy policy, H.C. Starck appointed an Energy Manager, who will coordinate the worldwide activities to minimize the use of energy by actively involving all employees. He will receive all the necessary financial and human resources to coordinate the company's energy management

Among the main duties of energy management are the systematic recording and assessing of energy fluxes and then ascertaining and implementing the respective energy-saving measures. All steps to increase energy efficiency will be continuously monitored

Energy management will be supported by the introduction of a system that will be integrated into the structure of the already existing management system

Goslar, March 2013

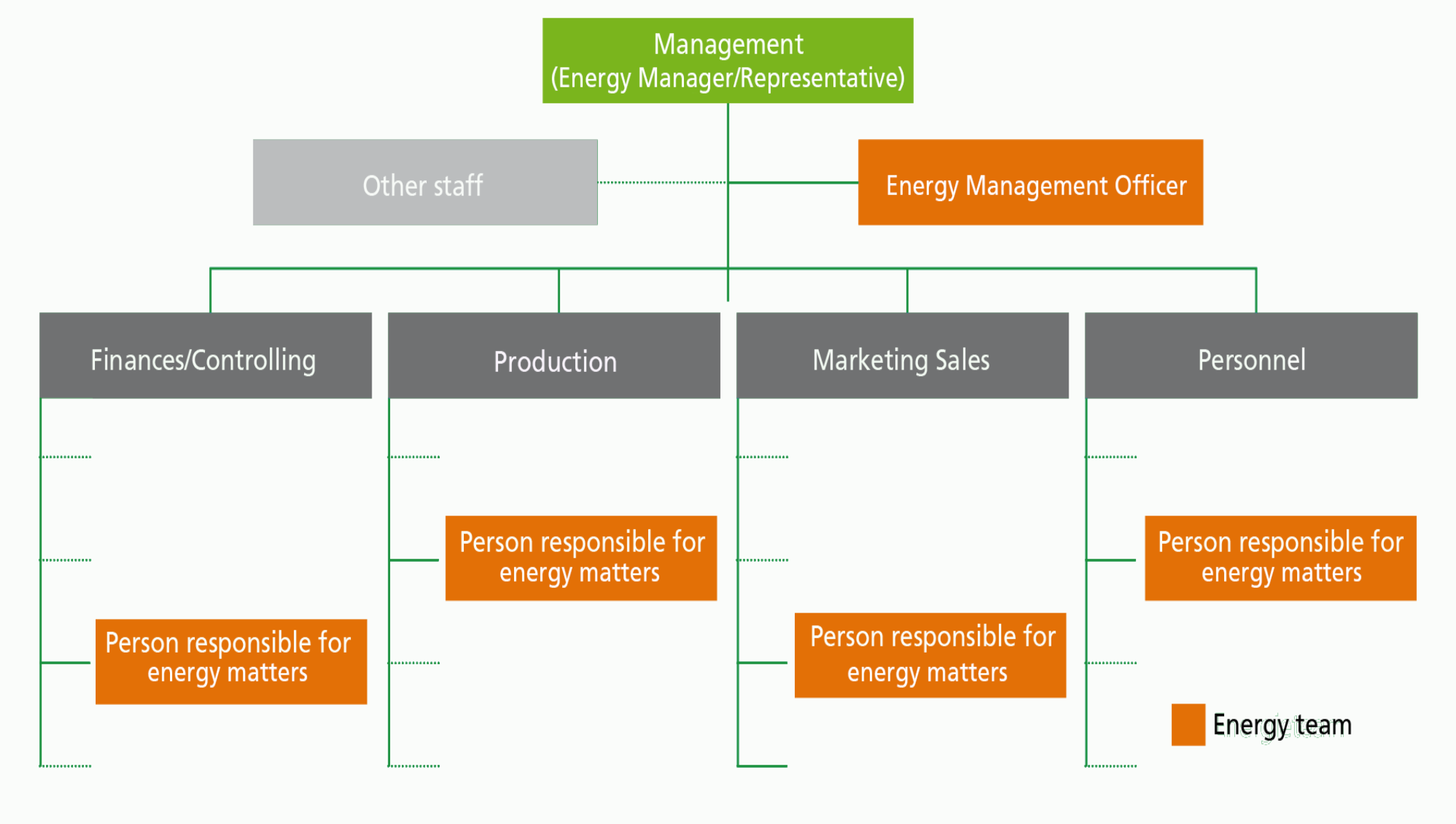
Step 8: Organisation, communication & resources

- Example: Documentation of the Energy Management - displaying the organisation as a matrix of responsibilities

Available roles:
R - responsible
A - assistance
I - information

	Energy officer	Energy team	Top management	Sales management	Production management
Data collection and monitoring	R	A I		A	A
Energy report	R	A I	I		
Energy management programme	A	I	R		
Evaluation	A	R	R		
Training and awareness	R A	A I	I	R	R
Purchase of energy efficient components	A	A I	I	R	
Technical improvement measures	A	A I	I	R	R
Energy input in production	A	A I	I		R

Step 8: Organisation, communication & resources



5. Systematic managed search for energy savings potentials

Steps 9-14

Stage II: Integration of Energy Management into the planning processes

Step 9: **Documentation of the EnMS** (required documents and records by ISO 50001)

Step 10 : Designing energy relevant processes

Step 11: Awareness, skills and training

Step 12 : Way and structure of communication

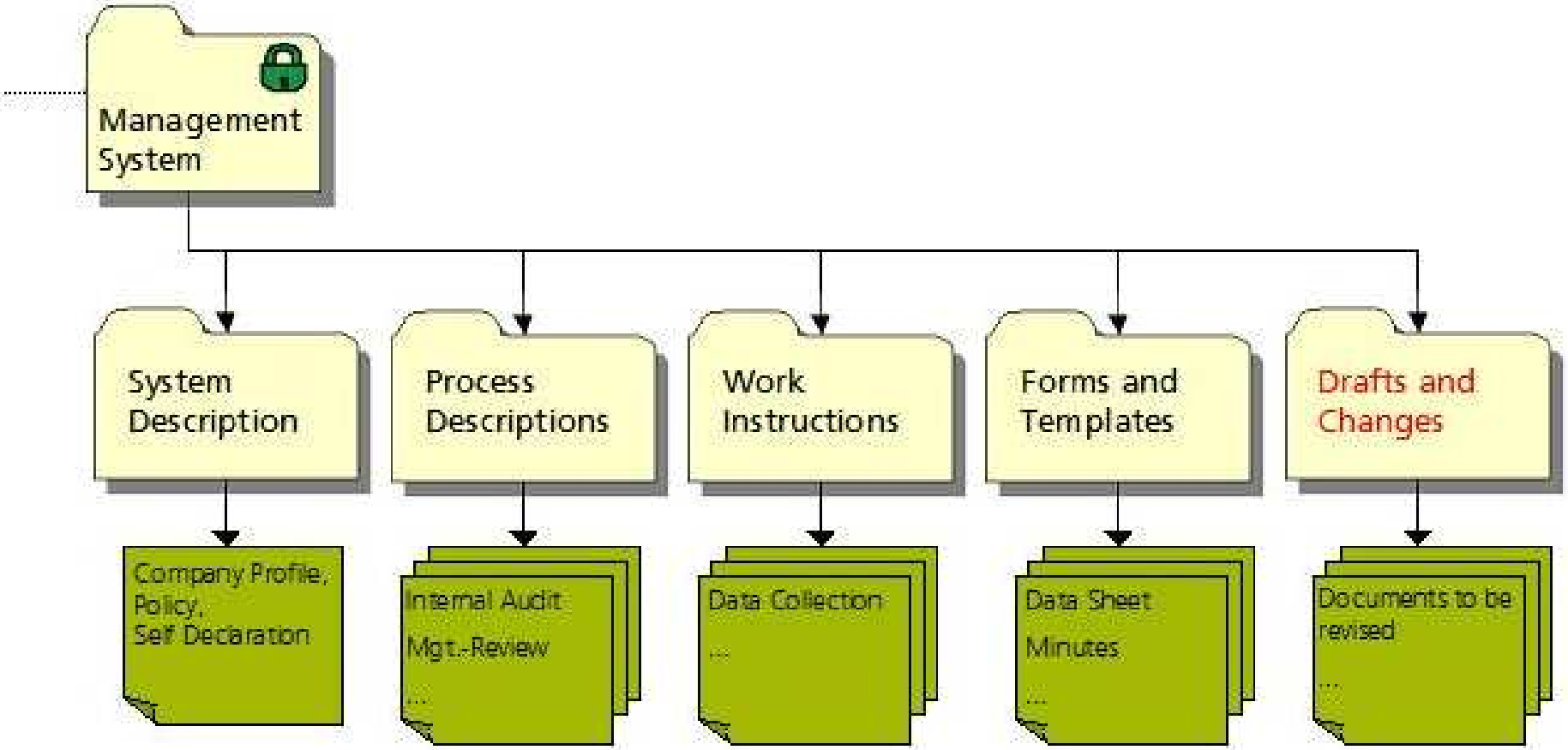
Step 13 : Collection and control of improvements

Step 14: Energy performance indicators (EnPI), Benchmarking and energy planning

Step 9: Documentation of the EnMS

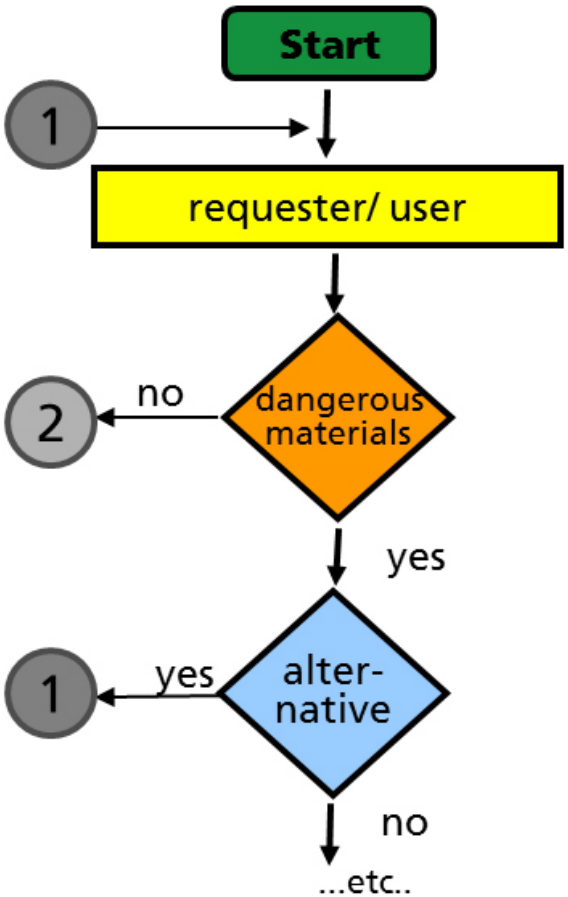
Documentation of EnMS core elements –
only that which is documented can be improved !

- Determining the type of documentation
- Example of a system structure



Example: Documentation of the EnMS

Process scheme



Responsibility Matrix

R - Responsible execution
D-Duty to cooperate
I-Information

Tasks	Executive Board	Technical Management	Financial Management	Administration/ Procurement	EMS-Manager	Employees
Determination and documentation of the environmental impacts with new and changed facilities	I	R	D		D	D
Granting external document access	R	D	I		I	D
Keeping a list of residuals	I	I	D	R	D	
Keeping a record about the whereabouts of the residuals			I	I	D	R
...etc.						

EnMS documentation as required by ISO 50001

Documents of the EnMS	Records on/ about
Documentation of the EnMS 4.1 a/4.5.4.1	Appointment of an energy manager and energy team 4.2.1 b/(4.2.2)
Scope of application and system boundaries 4.1 b	Results of the energy evaluation 4.4.3
Energy policy (4.2.1 a)/4.3 g	Current energy starting point 4.4.4
Method for an energy planning process and decision regarding its implementation 4.4.1	Training requirements/training plan for employees and all those working with a view to energy demand in their name 4.5.2
Methodology and criteria for the „Energy Evaluation“ 4.4.3	Results of the design of buildings, facilities and processes 4.5.6
Methodology for determining and updating the EnPIs 4.4.5	Results of the monitoring and measurement of the main features of their activities with an influence on their energy performance Calibration and other measures to demonstrate reproducibility and accuracy of the measurements Results of the examination of the major deviations in energy-related performance 4.6.1
Strategic and operative energy goals with action plans for pursuit 4.4.6	Results of the compliance evaluations 4.6.2
Decision as to whether the energy policy or the EnMs should be communicated on externally 4.5.3	Results of the internal audit 4.6.3
Define energy purchasing specifications 4.5.7	Corrective and preventive measures (plan) 4.6.4 e
Plan for the energy measurement 4.6.1	Amongst those elements necessary to demonstrate 4.6.5 1) Conformity of the EnMS with the standard 2) Results of the energy-related service
Audit plan 4.6.3	Results for the management review 4.7.1

Chart: obligatory documents and records for ISO 50001

Step 10: Design and content of energy relevant processes

- Determination and description of activities that have a significant influence on the energy consumption in order to define the present "best practice" known…

  … and thus in future be able to systematically improve processes

- This for example includes specifications for:
  - defined plant operating standards (heating cycles)
  - maintenance and service intervals and tasks
  - organisational arrangements like shift plans
  - facility management

- Also consideration of significant energy related processes like:
  - the **design of processes**, equipment and buildings
  - **procurement tasks** like selection of energy efficient products and installations, energy efficient raw materials and services (**supplier information** on preferring energy efficient products
  - Research and development of energy efficient products

Purchasing: Remember life cycle costs /TCO

- Example Lighting
  - Investment 15 % (conventional) - 40 (LED)
  - Maintenance / servicing 10-15 %
  - Use of electricity 70 % (conventional) – 50 (LED)
- Example electric drives
  - Investment 2-7% (depending on annual use)
  - Maintenance / servicing 3-7% (depending on working environment)
  - Use of electricity up to 95%!
- **Example Pumps: similar to plain electric drives** (about 85 % operation and maintenance)

Step 11: Raising awareness, training of skills

- A system lives from the commitment of all members (employees)
- Without the commitment or even "against" the employees energy management is impossible
- thus to begin of an EnMS they first have to be interested in the subject and trained (training schedule, trainings, knowledge control)
- Components of this step are:
  - Raising first interest by examples and the comparison of figures
  - influencing and enhancing awareness of personnel, using information campaigns to in mid-term change behaviour
  - determination of the knowledge base (with this the need for trainings) within the whole organisation,
  - provision of trainings and supplementary information
  - monitoring of behaviour, and knowledge (i.e. supplementary trainings)
  - survey on all potential savings (suggestion book etc.)

Step 12: Type and structure of communication

- Determination of the desired (internal and external) communication on the EnMS
- Minimum stakeholders to be included in the communication on EnMS:
  - Employees
  - Public (stakeholders)
  - Shareholders
  - Customers
  - Suppliers / service providers
  - Energy providers
  - Energy consultants / public energy agencies
  - Public authorities

Step 13: Acquisition and implementing improvement measures

Nr./ Source	Problem/ Idea	Action	Respons-ibility	Date	Status	Remarks
1 Internal Audit	Turn off machinery during breaks	Test where applicable while maintaining quality	Technical service	09/ 200X		Testing only possible step-by-step
2 External Audit	Hazardous materials in painting shop lying around	Set-up of a gathering point over trays and with ventilation	Paint shop	07/ 200X		Technical review still missing
3 Shop floor walk	Risk survey is unfinished	Systematic risk survey and evaluation	EMS-Manager	III. Q./ 200X		Check-up and tour done
4 WC - Tip	Noise-limits are going to be reduced by regulator	Assessment of problem zones by measure-ments (i. a. new measures)	H&S qualified person	IV. Q/ 200X		New noise measurements available, action plan finished

Planning started
Process started
process fully running
process finished
effectiveness control

Step 14: Energy performance indicators (EnPI) Benchmarking and energy planning

- Development of energy (key) performance indicators to monitor the progress
- As fundament for a benchmarking and
- An annual pre-planning of the anticipated energy use

Energy-related indicators	
Specific energy consumption	$\frac{\text{total energy consumption}}{\text{production quantity}}$ $\frac{\text{kWh}}{\text{production unit}}$
Percentage of energy source	$\frac{\text{consumption per energy source}}{\text{total energy consumption}}$ [%]
CO_2 sensitivity/CO_2 efficiency	$\frac{\text{energy-related } CO_2 \text{ emissions}}{\text{production output}}$ [kg CO_2/product]
Share of heat recovery	$\frac{\text{energy from heat recovery}}{\text{total energy consumption}}$ [%]
Operating energy indicators	
Energy unit costs	$\frac{\text{total energy costs per product}}{\text{total energy per product}}$ $\frac{€}{[\text{kWh}]}$
Energy sensitivity/energy efficiency	$\frac{\text{added value in €}}{\text{energy consumption in kWh}}$ [€ / kWh]
Energy share in turnover	$\frac{\text{energy costs in €}}{\text{turnover in €}}$ [%]

Step 14: Closes with review of top management

- Top management decision:
  - Go back to stage 6 and stay at “small management cycle” of annual measurements and annual improvement plans or…
  - …implement these procedures 7-14 and adapt the documentation (or go back to 7 and review them because to complicated etc.) and…
  - …now tackle the real EnMS-PDCA cycle (step 15-18)

6. Basics of a formal Management

Steps 15-18 and
Basic structure of ISO 50001

Stage III: Starting a Continuous Improvement

Step 15: Application of the regulations concerning organisation and communication (DO)

Step 16: Annual update of the energy monitoring and conduction of annual internal energy audits (CHECK)

Step 17: Annual revision of the energy goals and targets and the action plan (programme), based on results of updated figures, data, facts and of the internal audits (PLAN I)

Step 18: periodical management review of EnMS and its performance by top management, to ensure:

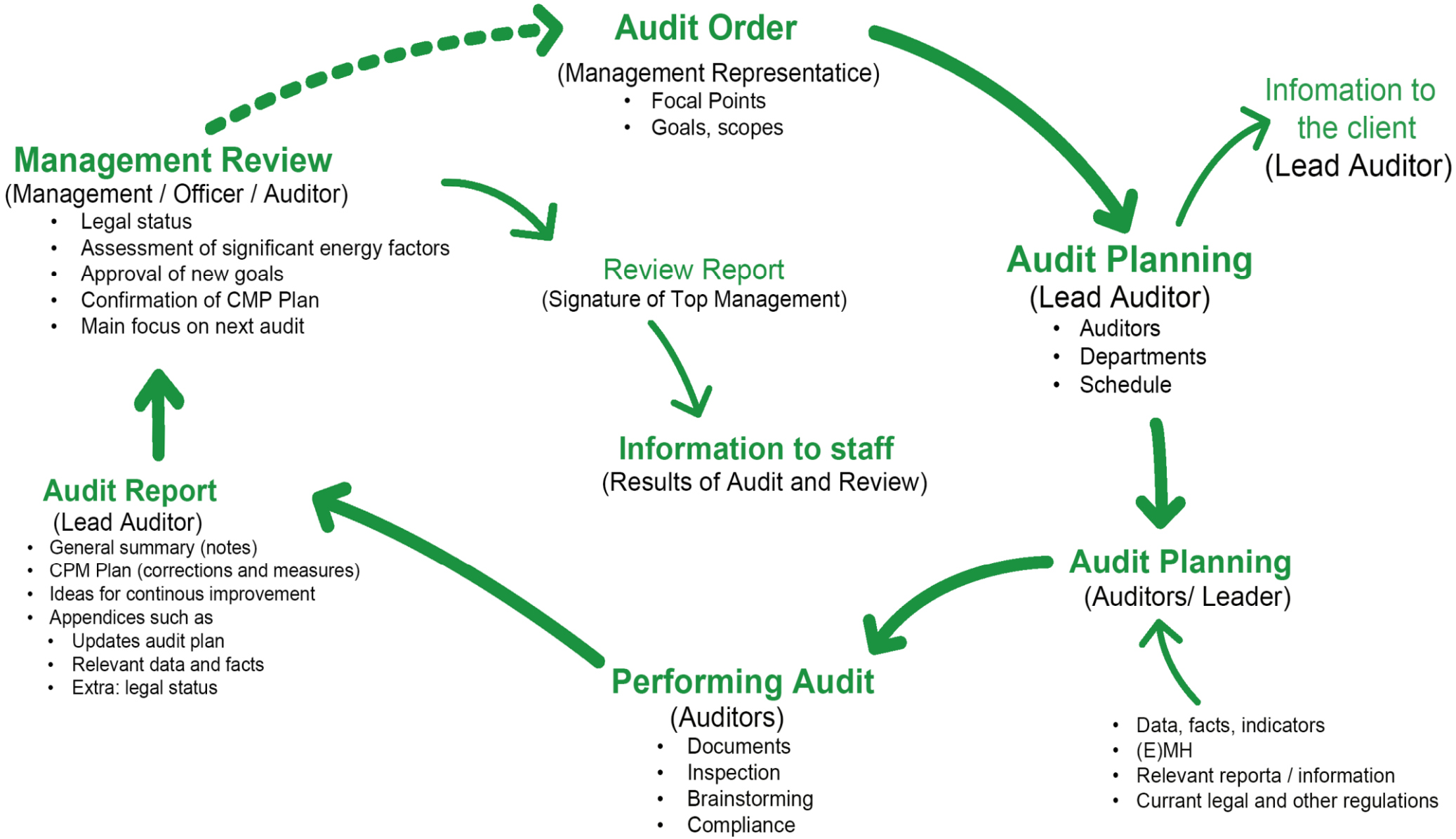
- Compliance with all legal requirements
- changes of energy policy principles and energy aspects if necessary
- status of the old energy action plan and formulation of a new one based on the updated energy review
- the continuous pursuit of the measures for improvement (ACT and PLAN II)

Step 15: Application of regulations concerning organisation and communication

- Routines of Stage I and processes of stage II have now to be adopted into daily operation
- Most important is the pursuit of the objectives and measures for **improvement** (for example carried out at regular meetings of the energy team, also serving the general exchange of information)
- Start of systematic energy network controlling - based on historical data of the energy report in conjunction with current data and indicators (monthly values, load profiles of big consumers etc.)

➡ Start of a process that is **continually** revised, improved and supplemented by all parts of the organisation involved

Step 16: Annual update of the data monitoring conduction an internal energy audit



The Internal Audit – by ISO definition!

- An internal audit is the comparison of a **"target "** to an **"actual situation"** based on external and/or internal specifications
  It is NOT a „control", but a common survey for improvements by auditor and auditee!

A internal audit covers three essential parts:

- **I. Preparation**
  - Selecting the audit team
  - Preparation of an audit program
- **II. Realisation**
  - Recording and assessment of energetic improvements and management regulations
  - Sampling and assessment of evidence and its documentation
  - Searching for improvements
  - Working out corrective measures and new targets
- **III. Follow-up (Report)**
  - Status report and corrective & preventive measures

Audit documents:

- ✓ Audit program
- ✓ Audit report
- ✓ Corrective action & measure plan

Step 17: Annual revision of the action plan with goals, targets and measures

- The implementation of the **energy action plan** (efficiency program) in the first phase of data acquisition is regularly checked in the course of the management and communication structure like the meetings of the energy team
- Revision of the energy action plan in the cause of the results of the updated data, facts and figures, as well as the informations coming from the internal audits
- Attention: Proposals for further improvement or useful adaptions of targets and measures must be welcome at any time during the year and documented in the improvement plan!

Step 18: Review of the top Management

- Regular review of the EnMS by top management ensure that:
  - any necessary changes to the energy policy are taken
  - all legal requirements are fulfilled
  - the energy aspects are reviewed and if applicable adapted
  - the old energy action plan was fully implemented and
  - a new energy action plan was set up and adopted
  - the corrective actions are worked on and can be confirmed

Step 18: Review of the top Management

INPUT

- results and report of last review
- summary of audit report with improvement actions plan (internal and external audit)
- recent data and facts
- annual reports of qualified persons/ representatives
- feedback of customers
- requirements of relevant interested parties
- market research results / new informations

PROCESS

- presentation of essentials information (qualified persons etc.)
- discussion (all participants)
- decision making (executives and line managers)
- by executive chairman (CEO) signed protocol with appendices (all background informations, details decisions are based on)

DECISIONS

- necessary **changes of policy and/or strategy** (if needed new ones)
- survey and **assessment of legal status**
- identification of the **relevant management aspects** of the given system
- definition of **new goals and targets** and the management program
- **confirmation** of the content of the **corrective action plan**
- Necessary changes of processes
- determination of the focus of next audit cycle

ISO 50001: Energy management system requirements

- **4.1 General requirements**
- **4.2 Management responsibility**
  - 4.2.1 Top management
  - 4.2.2 Management representative
- **4.3 Energy policy**
- **4.4 Energy planning**
  - 4.4 Energy planning
  - 4.4.2 Legal and other requirements
  - 4.4.3 Energy review
  - 4.4.4 Energy baseline
  - 4.4.5 Energy performance indicators
  - 4.4.6 Energy objectives, targets and energy management action plans
- **4.5 Implementation and operation**
  - 4.5.1 General
  - 4.5.2 Competence, training and awareness
  - 4.5.3 Communication
  - 4.5.4 Documentation
    - 4.5.4.1 Documentation requirements
    - 4.5.4.2 Control of documents
  - 4.5.5 Operational control
  - 4.5.6 Design
  - 4.5.7 Procurement of energy services, products, equipment and energy
- **4.6 Checking**
  - 4.6.1 Monitoring, measurement& analysis
  - 4.6.2 Evaluation of compliance with legal requirements and other requirements
  - 4.6.3 Internal audit of the EnMS
  - 4.6.4 Nonconformities, correction, corrective and preventive action
  - 4.6.5 Control of records
- **4.7 Management review**
  - 4.7.1 General
  - 4.7.2 Input to management review
  - 4.7.3 Output from management review

Your way to ISO 50001 Certification

- If the third stage is taken you have in “passing by“ implemented all necessary requirements of ISO 50001 along your work done and are now -if you are interested- ready to apply for a certification at any time!
- This would be a final step to make the improvement in energy efficiency a continuous process and to achieve additional public recognition

  Furthermore, qualified energy management system auditors will always point out new and exciting opportunities, helping you to save even more energy – and money

If you are interested, GUTcert or the AFNOR country offices will be pleased to offer you certification an provide you with an ISO 50001 Energy Management Certificate

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7. Collective development of a working program

Together we will discuss a working program alongside the energy guidance
Discussing the special situation and needs of the members of ACWUA

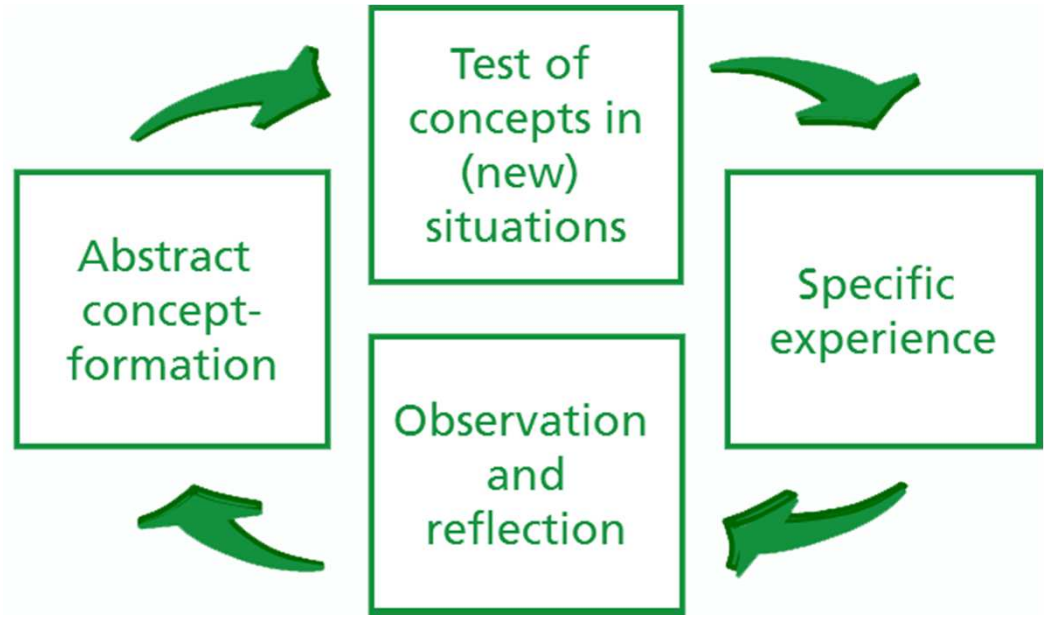
Goal of modern management system approaches

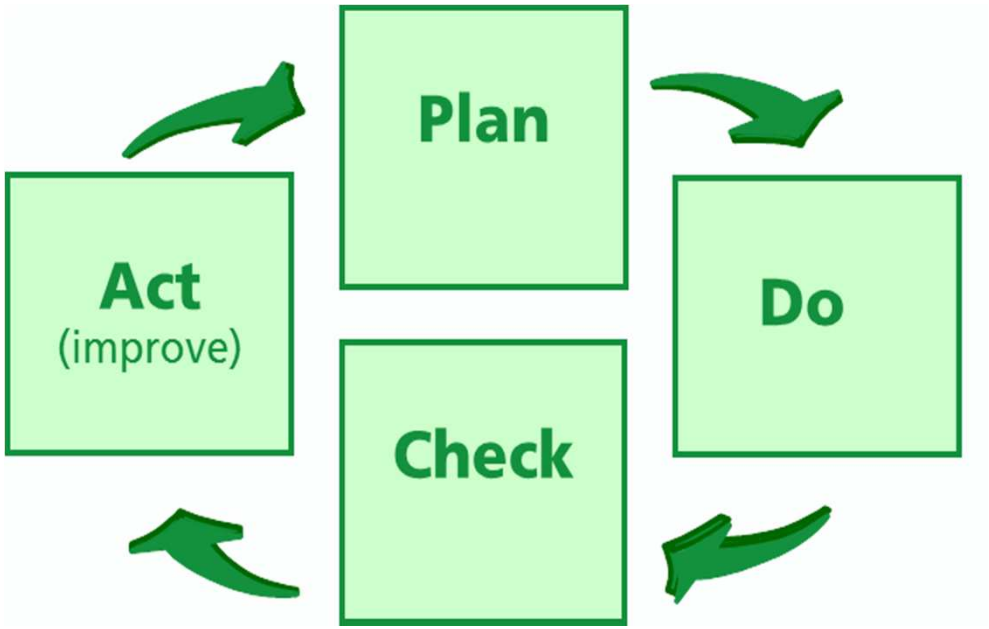
- Continuous control of processes and procedures (of the system)
  1. Deduction of improvements **(Act)**
  2. Planning of measures **(Plan)**
  3. Establishment of a working environment and realization of goals **(Do)**
  4. Control of the success and the current situation **(Check)**
  ➥ Go to 1. and start over
- This leads to continuous and controlled improvements...
  - of the results of the organization and it's efficiency
  - of the quality of its processes
  - of the quality of its products
- ...from within the company itself, because:
  - Solutions from external consultations are quickly „forgotten", or
  - would need to be adjusted with forthcoming time and
  - as a result are rarely successful implemented in the long run
- Currently sectorial management system(-approaches) predominate (UMS, QMS, OHS, HACCP, Information security)
  However, integrated approaches are on the rise

Learning behaviour of individuals and organizations

Individuals learn within the "Kolb-Cycle", teaches us the social-learning theory

Organisations „ learn" and develop within the PDCA-cycle, teaches Deming et.al.



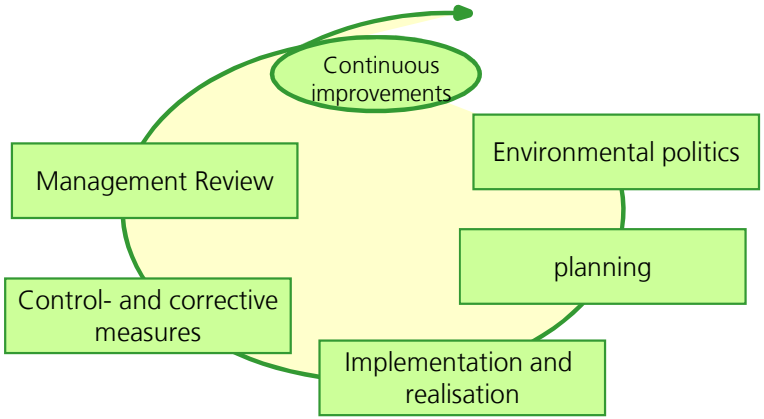


For individuals and organizations it is identic:

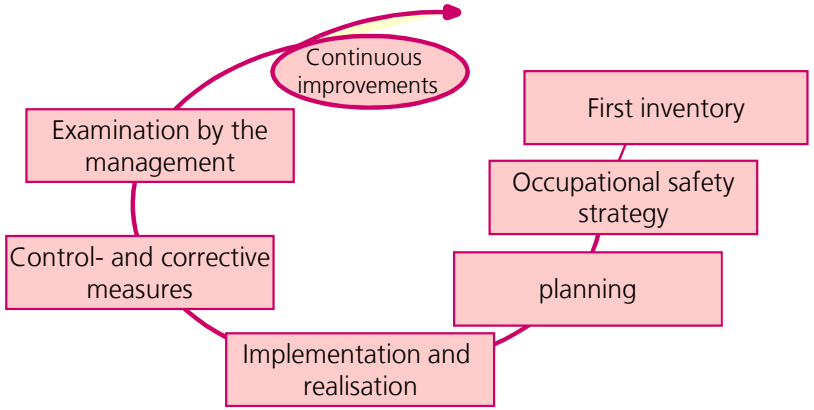
- Learning is a systematic, continuous process

Cycles of important management systems

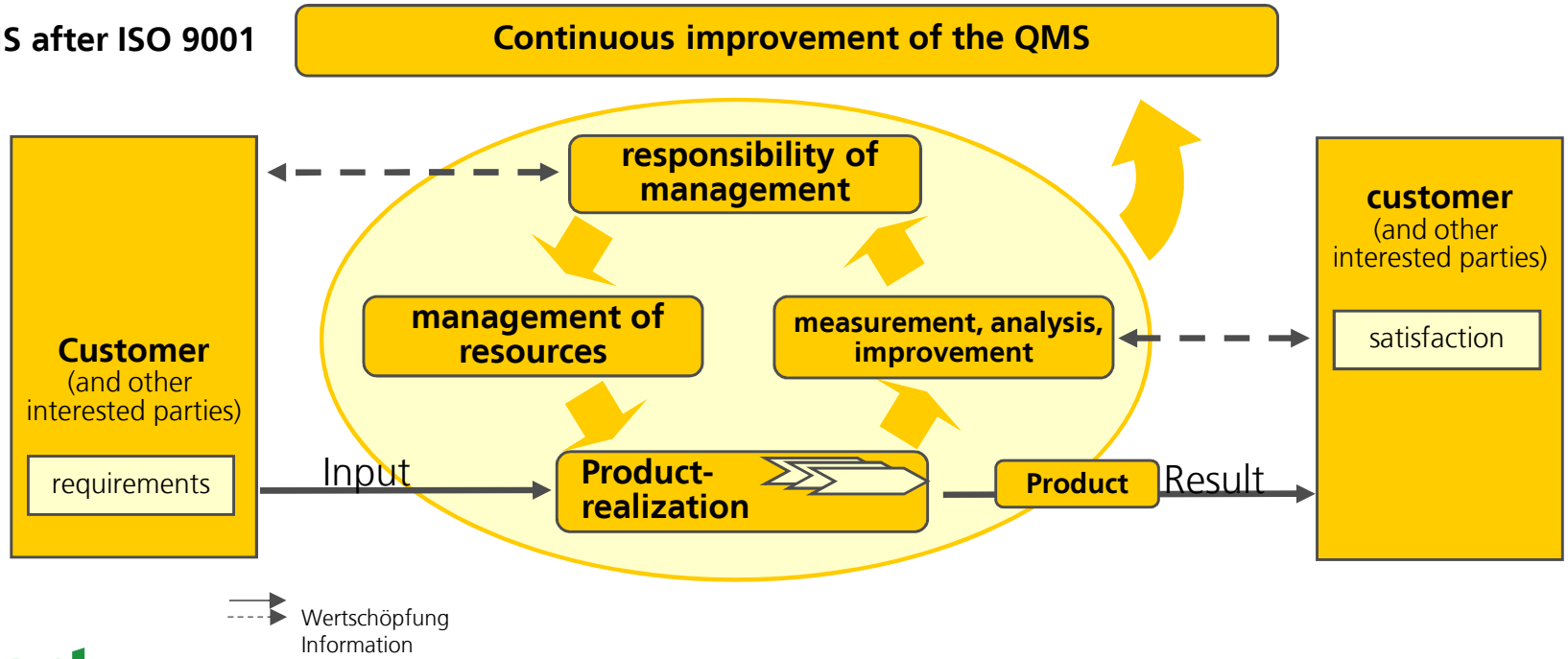
UMS after ISO 14001



AMS after OHSAS



QMS after ISO 9001



Example: Financial planning cycle is very similar!

- Cashing up,
- Financial organization
- Tax status

plan

- Business strategy
- budget
- budgeting of expenditures
- margin goals

do

- Accounting system
- planning expenditures and approval process
- controlling of goals and expenditures

check

- Internal revision
- cost-cutting programs
- evaluation by analysts, accountants and consultants

act

- Management evaluation
- short-term corrective measures
- long-term strategy and financial planning

Annual financial planning cycle

Drawing a working programme for ACWUA

- Let us together define the next steps to take
  - with the background of your personal experience
  - in front your plant conditions and
  - the financial and operational situation of your organisation…
  - …always keeping in mind the turns of real life!

- What do you think, where would you start?

Further development takes place on a flip chart

Conducting a first Energy Efficiency Analysis
(Step 3-6 in detail! Where appropriate with external help)

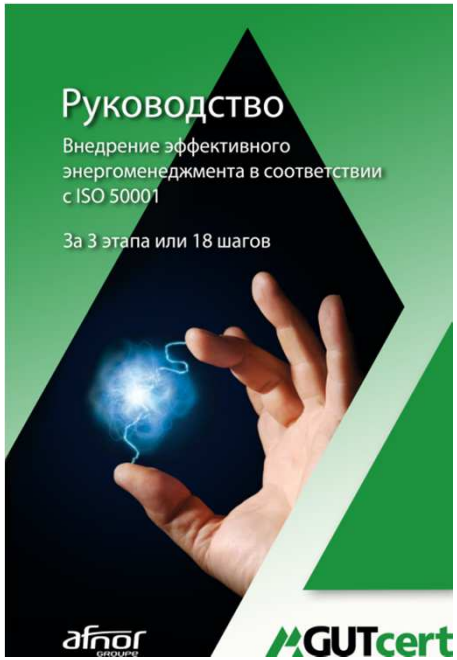
This corresponds in general to Step 3 - step 6 and is just more detailed

1. Inspect the installation /company (walking around)
2. Examine deeply the energy consumption and costs (measurements if necessary with portable devices)
3. Identify indicators, try to benchmark (internally and externally)
4. Identify the major consumers (kW peak, kWh total consumption, cost)
5. Create an energy balance (between total use and all users)
6. Determine the base load
7. Evaluate major consumers for example by…
8. …analysing loads curves taken by portable devices
9. Look for potentials and set goals and targets
10. Analyse profitability of goals for energy savings and…
11. …set up priorities

… besides German also available in…

Bulgarian

French



Russian

Mandarin

A Polish version is coming soon…


GUTcert
Thank you for your interest

Examples in case of questions

Abbreviated History of Fossil Fuels

Comparing alternatives

	Power [W]	Life-time [h]	Light current [Lumen]	Lumen/ Watt	Price/ Unit [€]
Light bulb	60	2.000	710	11.8	0.84
Halogen lamp 1	42	1.000	630	15.0	1.39
Halogen lamp 2	42	1.500	630	15,0	2.51
Halogen lamp 3	42	2.000	580	13.8	2.76
LED	10	30.000	550	55	22.65
Energy saving l.	8	10.000	400	50	5.03
T5 HE-Tube	25	20.000	2.900	116	7.50

Costs for 30.000 hours light

	Power [W]	Life-time [h]	Replacement rate	Total cost [€]	Energy cost (10ct/kWh) [€]	[€/lm]
Light bulb	60	2.000	15	12.8	180	0,27
Halogen lamp 1	42	1.000	30	41.7	126	0,27
Halogen lamp 2	42	1.500	20	50.2	126	0,28
Halogen lamp 3	42	2.000	15	41.4	126	0,29
LED	10	30.000	1	22.7	30	0,10
Energy saving I.	8	10.000	3	15.1	24	0,10
T5 HE-Tube	25	20.000	1.5	11.3	75	0,03

Comment: Without correction for light current (Lumen)
Assumption of energy cost: 10 Ct/kWh (in industry still possible) 30.000h