Energy management – a continuous process

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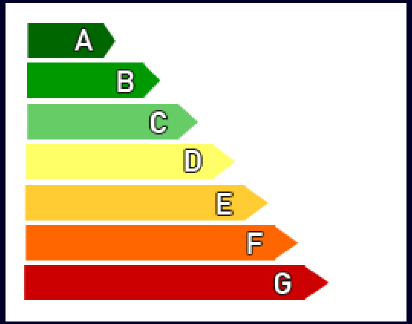
Energy management – a continuous process

Acquired energy data

Checking and evaluation of the measures



Acquisition of the measurement values

Continuous improvement process

Analysis of the data

Planning of energy efficiency measures

Realization of the measures

Improvement according to ISO 50001 with Plan – Do – Check – Act (PDCA)

Energy Audit

Planning and Data Gathering → Site Visit and Detailed Analysis → Analysis and Reporting → Reporting of the Audit

What is Energy Audit

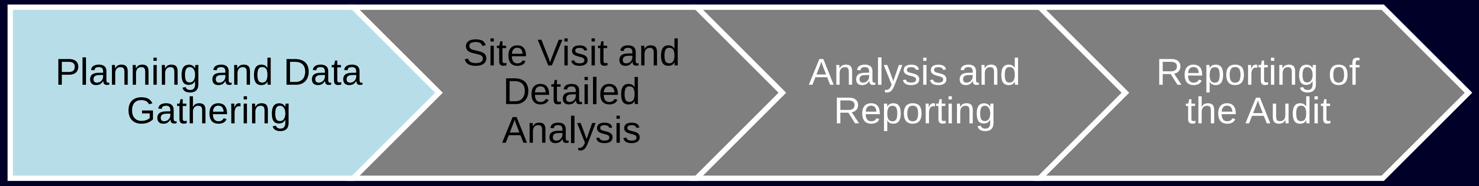
- Inspection survey and analysis of energy flows
- Investigating how energy is used, and where it is wasted
- Finding measures to reduce energy losses
- Cost-benefit analysis to highlighting which energy efficiency measures are best to implement

Areas Analyzed

- Production Areas: Production Machines, Fans, Pumps
- Utilities: Boilers, Pressurized Air, Water Treatment and Wastewater Treatment Units, Cooling Units, Climatization (HVAC), Evaluation of Automation Systems
- Electrical Systems: Lighting Systems, Electrical Motors, Evaluation of Electrical System
- Cogeneration Systems

Steps of the ISO 50002 Compatible Energy Audit Diagram

Energy Audit Methodology
Step 1. Planning and Data Gathering



Planning and Data Gathering via easy-to-handle questionnaires and quick checks of equipment and facilities on site along the production process which lays ground for the focused analysis in the step 2.

A kick-off meeting is done via conference call or web meeting to introduce the project to all involved stakeholders, align expectations and agree timeline. Pre-audit questionnaire is filled by the facility technical team to gather preliminary information and data to prepare on-site visit.

Energy Audit Methodology
Step 2. Site Visit and Detailed Analysis

Planning and Data Gathering → **Site Visit and Detailed Analysis** → Analysis and Reporting → Reporting of the Audit

Site Visit and Detailed Analysis of energy relevant areas identified in the step 1. Evaluation of the operation procedures, maintains protocols, measurement of energy consumption and relevant data (temperatures, volume flows, production outtake etc.). Conducting start-up meeting, on-site measurements, analyses and collecting data incl. interviews with personnel on-site.

Energy Audit Methodology
Step 3. Analysis and Reporting

Analysis and Reporting; Achieving transparency and identifying, assessing & listing energy efficiency opportunities. Elaboration of efficiency improvement measures by optimization of operation procedures and schedules, technical refurbishment and replacement of inefficient equipment hence to optimization of the energy supply considering detailed technical requirements and economic benefits for the facility. The measures are developed in close cooperation with the client to meet his needs in adequate way and the equipment manufacturers and service providers to choose the best option.

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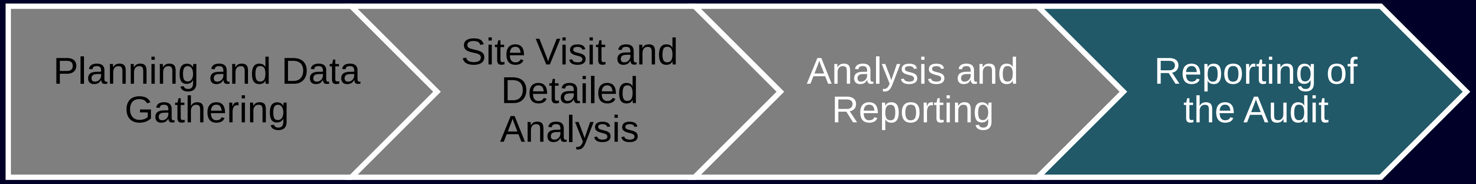
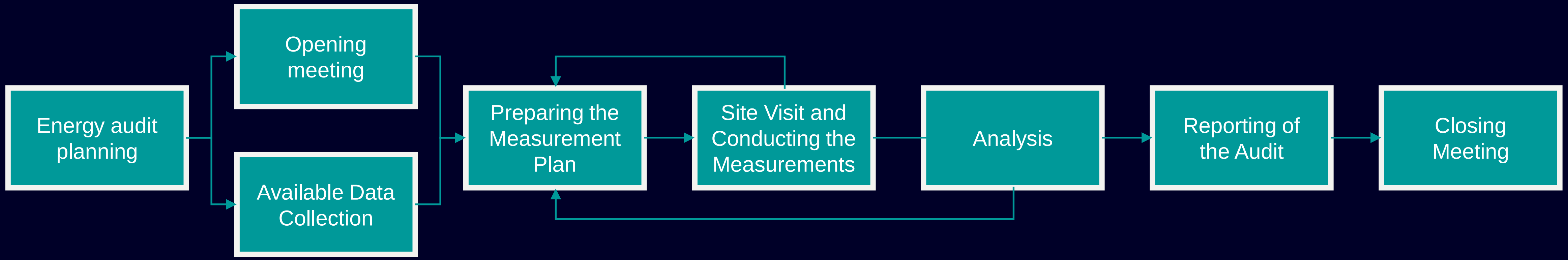
Energy Audit Methodology
Step 4. Reporting of the Audit



Reporting of the Audit; Presentation of findings and discussion of the results of the survey in a workshop together with technical experts, purchasing department and management representatives. This allows to involve all relevant stakeholders and accelerate the commitment and decisions with regard to implementation of the projects.

Audit Methodology based on ISO 50002

Steps of the ISO 50002 Compatible Energy Audit Diagram



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System Analyses to be Completed on the Field;
Detailed Energy Audit:

Utilities

- **Boilers**

  - Combustion efficiency analysis in boilers
  - Boiler efficiency calculation
  - Water analysis
  - Blow down ratio calculation
  - Flue gas losses calculation
  - Isolation checks
  - Waste heat recovery potential analysis
  - Optimization of operating parameters

System Analyses to be Completed on the Field;
Detailed Energy Audit:

Utilities

- Boilers
- **Pressurized Air**

  - Pressure staging of compressors and evaluation in operation
  - Motor checks with the thermal camera
  - Diameter controls of the pressurized air lines
  - Air tanks dimension checks
  - Operation analysis and measurement of air dryers
  - Detection of air leakage with the leakage detection device
  - Measurements of specific energy consumptions of compressors
  - Improvement solutions by air flow rate measurements

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System Analyses to be Completed on the Field;
Detailed Energy Audit:

Utilities

- **Boilers**
- **Pressurized Air**
- **Water Treatment Units**

- Evaluation of pumps and filters in treatment units in order to determine efficiency increasing project potentials
- Evaluation of pumps, fans, blowers, aerators, reactors and automation systems in wastewater treatment units in order to determine efficiency increasing project potentials

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System Analyses to be Completed on the Field;
Detailed Energy Audit:

Utilities

- Boilers
- Pressurized Air
- Water Treatment Units
- **Cooling Units**
  - Efficiency calculation for cooling towers
  - Concentration ratio in water
  - Evaluation of automation and pumps systems
  - Efficiency detection of chiller units in order to determine efficiency increasing project potentials

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System Analyses to be Completed on the Field;
Detailed Energy Audit:

Utilities

- **Boilers**
- **Pressurized Air**
- **Water Treatment Units**
- **Cooling Units**
- **Climatization (HVAC)**

- Examination of operation parameters in production environment, panel rooms and offices
- Efficiency measurements of pumps and measurements of flow rate and pressure, determination of working point based on design data
- Fluid power measurement and simultaneous electricity consumption measurement and pump-motor unit efficiency analysis

System Analyses to be Completed on the Field; Detailed Energy Audit:

Utilities

- Boilers
- Pressurized Air
- Water Treatment Units
- Cooling Units
- Climatization (HVAC)
- **Automation Systems**
  - Evaluation of current automation systems
  - Improvement studies on automation systems

System Analyses to be Completed on the Field;
Detailed Energy Audit:

Production Area

- **Production Machines**
  - Evaluation of the whole production process in order to determine efficiency increasing project potentials
  - Sectional determination and comparison of specific energy consumptions based on energy consumptions and production amounts
  - Evaluation of fans, pumps, compressors and transfer units in production process
  - Efficiency analysis of specific production machines (furnaces, ovens etc.)

System Analyses to be Completed on the Field;
Detailed Energy Audit:

Production Area

- Production Machines
- Fans

  - Energy efficiency analysis on fan units in production processes
  - Evaluation of integration between fans and automation systems and detection of manual control- automatic control conditions
  - Optimization of fan speed by the usage of variable speed drivers instead of dampers

System Analyses to be Completed on the Field;
Detailed Energy Audit:

Production Area

- Production Machines
- Fans
- **Pumps**

  - Efficiency analysis of pumps systems in production processes
  - Evaluation of integration between pumps and automation systems and detection of manual control- automatic control conditions
  - Optimization of pump speed by the usage of variable speed drivers instead of valves

System Analyses to be Completed on the Field;
Detailed Energy Audit:

Other Areas

- **Evaluation of Electricity Units**
    - Detailed audit of electricity distributions boards, panel rooms and transformers
    - Audit of compensation units
    - Efficient motor system analysis, efficiency calculation based on motor loadings and choosing of motors in necessary situations in order to determine efficiency increasing project potentials

System Analyses to be Completed on the Field;
Detailed Energy Audit:

Other Areas

- Evaluation of Electricity Units
- Electric Motors

  - Analysis of loading conditions, efficiency classes and heating problems of the electric motors used in the facility
  - Correct sizing and energy efficiency analysis of electric motors

System Analyses to be Completed on the Field;
Detailed Energy Audit:

Other Areas

- Evaluation of Electricity Units
- Electric Motors
- Lighting Systems

  - Measurement of illumination levels and energy consumptions of armatures used in indoor and outdoor
  - Audit of illumination automation and control mechanisms in order to determine efficiency increasing project potentials

System Analyses to be Completed on the Field; Detailed Energy Audit:

Other Areas

- Evaluation of Electricity Units
- Electric Motors
- Lighting Systems
- **Cogeneration Systems**

  - Total efficiency and electrical analysis of the cogeneration unit
  - Leak proofing for by-pass Dampers
  - Calculation of the waste gas losses
  - Isolation checks
  - Potential waste heat recovery analysis

System Analyses to be Completed on the Field;
Detailed Energy Audit:

Harmonic Analysis

- **Harmonic Measurement and Analysis**

With the increased usage of non-linear electrical loads and automation in industrial units, poor power quality due to harmonic distortion has come up as a serious issue. The goal of harmonic analysis is to quantify the distortion in voltage and current waveforms in the power system of industrial units. The results are useful for evaluating corrective measures and troubleshooting harmonic related problems.

System Analyses to be Completed on the Field;
Detailed Energy Audit:

Harmonic Analysis

- **Harmonic Measurement and Analysis**
- **Effects of Harmonics on Networks**

  - Overloading of neutral conductor
  - Reduced efficiency of motors
  - Malfunctioning of control equipment
  - Poor power factor of the total system due to introduction of distortion power factor
  - Overloading of power factor capacitors
  - Increase in kVA demand of the plant due to increase in rms current drawn

Energy Audit Report
Some Project Examples

No	Measures	Relevant Facility/Unit	Energy Type	Savings Amount			Investment Cost	Payback Period	Implementation Plan*
				Amount	Original Unit	€/Year	€	Year	Term
1	Using Central Turbo Compressor Unit Instead of Old Screw Air Compressor for Meltshop Compressor Units	Compressed Air	Electricity	1.868.100	kWh	112.086	480.000	4,3	LT
2	Energy Saving by Flow Rate Regulation with Frequency Drive and Automation System for Meltshop Indirect Cooling Circuit	Cooling System	Electricity	4.173.942	kWh	250.437	150.000	0,6	ST
3	Energy Saving by Applying Automation System for Bloom and Slab Caster Primary Cooling Booster Pumps	Cooling System	Electricity	1.966.677	kWh	118.001	40.000	0,3	ST
4	The Using Variable Speed Drives Related with EAF Position on Main Fans	Production Units	Electricity	8.674.545	kWh	520.473	1.000.000	1,9	ST
5	Energy Savings by The Using Preheated Scraps for EAF with Preheating Unit	Production Units	Natural Gas	3.779.588	Sm3	929.779	9.000.000	9,7	NF
6	Energy Savings by Using Efficient Lamp in Lighting Fixures	Lighting System	Electricity	3.928.320	kWh	235.699	1.190.400	5,0	LT
7	Savings by Means of Replacing Electric Motors with New Motors in IE4 Efficiency Class	General	Electricity	3.056.435	kWh	152.822	399.008	2,6	MT
8	The Using ORC System To Produce Electricity By Heat Recovery From Fume Gasses of Outlet The Consteel	Meltshop	Electricity	43.595.120	kWh	2.179.756	13.000.000	6,0	LT
9	The Using Foaming Slag Monitoring And Control System for EAF	Meltshop	Electricity	6.750.000	kWh	337.500	250.000	0,7	ST
10	The Using Electrical Heaters Instead of Diesel Heaters for Drying Oven of Painting Plant	Meltshop	Diesel	580.000	Liter	314.735	165.000	0,5	ST
11	Running The Annealing Furnaces Circulation Fans With Direct-Drive Instead of Belt and Pulley In Order to Achieve Energy Savings	Cold Rolling Department	Electricity	604.800	kWh	38.405	14.000	0,4	ST
12	Energy Saving By The Using VSD on Process Pumps of Pump Station 3	Cooling System	Electricity	577.684	kWh	36.707	37.500	1,0	ST
13	Energy Savings by Replacing of NOKIA 1 and 2 No Cooling Tower Recirculating Pump with New Variable Speed Driven Energy Efficient Pump	Utilities	Electricity	353.080	kWh	22.597	7.000	0,3	ST
14	The Using ORC System To Produce Electricity By Heat Recovery From Fume Gasses of Outlet The Consteel	Steel Plant	Electricity	8.995.193	kWh	392.550	6.000.000	15,3	NF
15	Energy Saving by Replacing Pneumatic Hand Tools with Electrical Tools	Production Units	Electricity	1.204.436	kWh	71.406	248.071	3,5	MT
16	Replacing Existing Chiller Units with New Free Cooling Integrated Chiller Units	Utilities	Electricity	383.985	kWh	22.765	54.762	2,4	MT
17	Enerrgy Savings with Servo Pump Application	Production Units	Electricity	1.225.440	kWh	72.651	350.476	4,8	LT
18	Turbo Compressor Application	Utilities	Electricity	276.469	kWh	1.629	120.476	7,4	NF
19	Enerrgy Savings with Servo Pump Application	Production Units	Electricity	141.557	kWh	10.907	30.885	2,9	MT
20	Energy Saving by Heat Recovery from Hot Flue Gases Discharged from KTL Furnace Chimney	Production Units	Natural Gas	316.800	Sm3	24.409	103.011	4,2	LT
21	Energy Saving with Variable Speed Driver Application For Treatment Section Blower No C102B	Water Treatment	Electricity	24.000	kWh	1.849	3.089	1,7	ST
22	Saving by Using Free Cooling Unit Instead of Tube Cutting Laser Machines Chillers by Benefiting from Outside Air Cold in Winter Months	Production Units	Electricity	204.223	kWh	18.720	54.619	2,9	MT
23	Savings by Means of Replacing Electric Motors with New Motors in IE4 Efficiency Class	Production Units	Electricity	146.192	kWh	13.401	56.960	4,3	LT
24	Energy Saving by Controlling 4110MP30 Pumps with Variable Speed Drive by 100% Opening of the Valve	Production Units	Electricity	129.360	kWh	11.858	238	0,0	ST

*ST: Short Term (0-2 years), MT: Medium Term (2-4 years), LT: Long Term (4-6 years)

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Energy Audit Report
Project Scoring and Prioritization

Criteria (c)	Acronym	Scale	Weight
Implementation	I	1,0 – 5,0	25%
Profit	P	1,0 – 5,0	25%
Cost	C	1,0 – 5,0	15%
Saving	S	1,0 – 5,0	20%
Risk	R	1,0 – 5,0	15%

$$\mathbf{Overall\ Score_i} = \sum_{\mathbf{c=1}}^{6} (\mathbf{Note_c} \cdot \mathbf{Weight_c})$$

Implementation (I)		
5	Very easy	Requires no extra manning, no training, and no technical uncertainties. Implementation can be done within less than 1 month
4	Easy	Requires no extra manning, no training. There are some technical uncertainties to be investigated. Implementation can be done within 1 to 3 months
3	Moderate	Requires training of the operators and there are technical uncertainties to be investigated which is time demanding. Implementation can be done within 3 to 12 months
2	Difficult	Requires significant training and there are technical uncertainties to be investigated which may require external consultancy. Extra manning may be required during implementation phase. Implementation can be done within 1 to 2 years
1	Very Difficult	Requires extra manning, extensive training. There are a lot of technical uncertainties. Implementation can be done more than 2 years

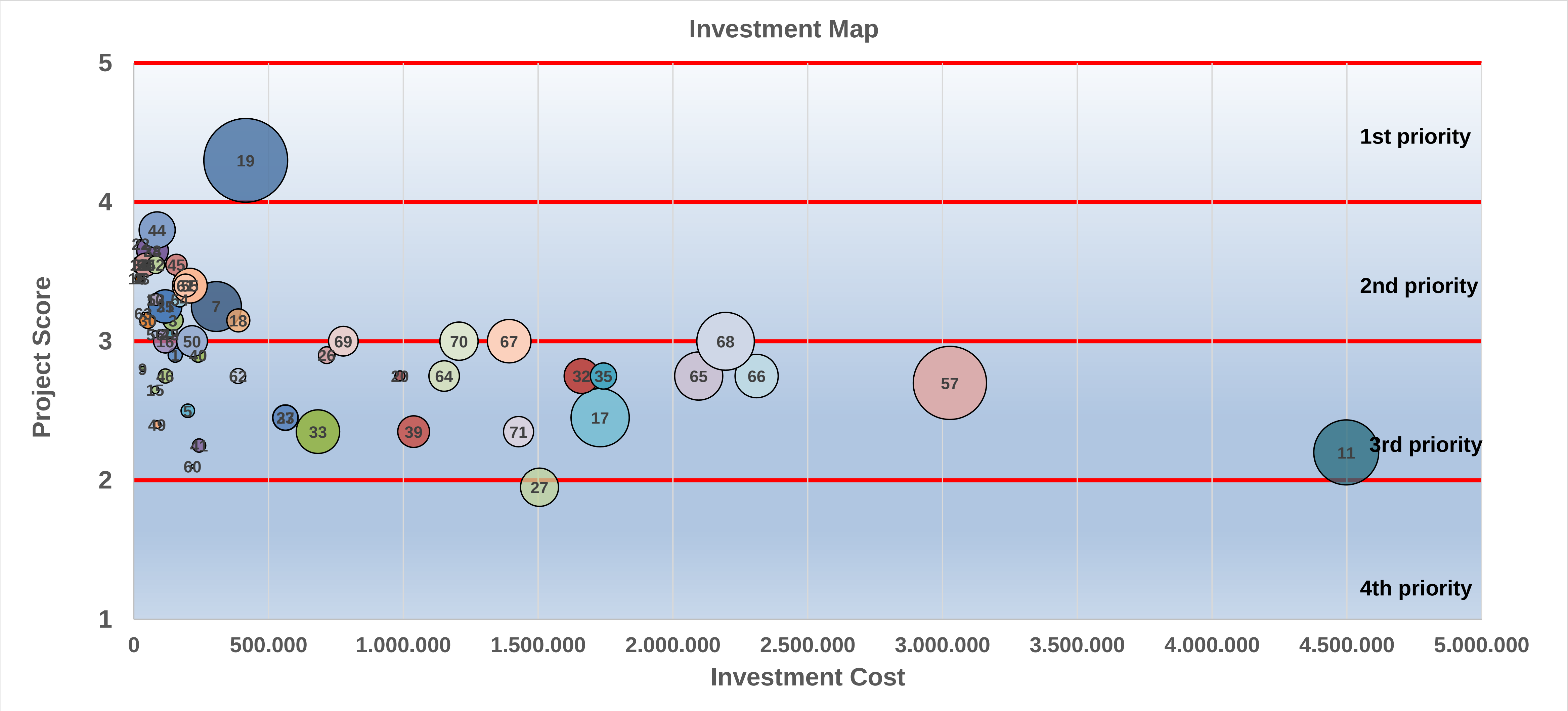
Profit (P)		
5	Very Profitable	Payback period less than 3 months
4	Profitable	Payback period from 3 months to 12 months
3	Moderate	Payback period from 1 year to 2 years
2	Low Profitability	Payback period from 2 years to 4 years
1	Not Profitable	Payback period more than 4 years

Cost (C)		
5	Very Low	Cost of implementation less than 5.000 Euro
4	Low	Cost of implementation from 5.000 Euro to 20.000 Euro
3	Moderate	Cost of implementation from 20.000 Euro to 100.000 Euro
2	High	Cost of implementation 100.000 Euro to 500.000 Euro
1	Very High	Cost of implementation greater than 500.000 Euro

Saving (S)		
5	Very High	Reduction of consumption greater than 2,5%
4	High	Reduction of consumption from 1,0% to 2,5%
3	Moderate	Reduction of consumption from 0,3% to 1,0%
2	Low	Reduction of consumption from 0,1% to 0,3%
1	Very Low	Reduction of consumption less than 0,1%

Risk (R)		
5	No Risk	No risks associated with product quality, health and safety or any other area.
4	Low Risk	Low risk associated with product quality, health and safety or any other area. Risk can be eliminated by simple precautions.
3	Moderate Risk	Moderate risk associated with product quality, health and safety or any other area. Risk can be eliminated by additional supervision.
2	High Risk	High risk associated with product quality, health and safety or any other area. Risk can only be reduced by additional supervision but cannot be fully eliminated
1	Very High Risk	Very high risks associated with product quality, health and safety or other. Risk cannot be reduced to tolerable level even with additional supervision.

Energy Audit Report
Projects Prioritization and Road Map



Handling actions for an energy-optimized drive train

Energy-optimized drive train

- At more than 60% of load torque, the fixed-speed drive is a better alternative than a speed-controlled solution.
- At less than 60% of load torque, the dimensioning of the motor size should be fundamentally reconsidered.
- For loads fluctuating over wide ranges, the frequency converter is a very good solution.

Performance

Emissions

Flexibility

Typical potential savings:		
Speed control	10-50%	For example, for pumps/fans instead of throttle control
IE3/IE4 motors	2-6%	For operating times >5000 h/year
Correct dimensioning	1-3%	Check starting torque / peak loads

Energy-optimized drive solution

Energy efficiency measures and potential energy savings
Empirical data from applications

Measures	Potential savings	Comments
Speed control	10 - 50%	Especially for fans, pumps and compressors and varying loads (painting booths, hydraulic pumps, feedwater pumps, ventilation systems, compressors)
Regenerative feedback	1 - 30%	Presses, high-bay warehouses, cranes, elevators
Use of IE3/IE4 motors	2 - 6%	Direct replacement if operating times exceed 5000 h/yr, generally appropriate starting from 15 kW
Correct dimensioning	1 - 3%	Check starting torque / peak loads
High-efficiency gear units	2 - 10%	Agitators, conveyor systems
Conversion from belt drive to direct drive	2 - 4%	Especially for ventilation systems, compressors, agitators
Conversion from V-belt to toothed belt	0.5 - 2%	Especially for ventilation systems, compressors, agitators

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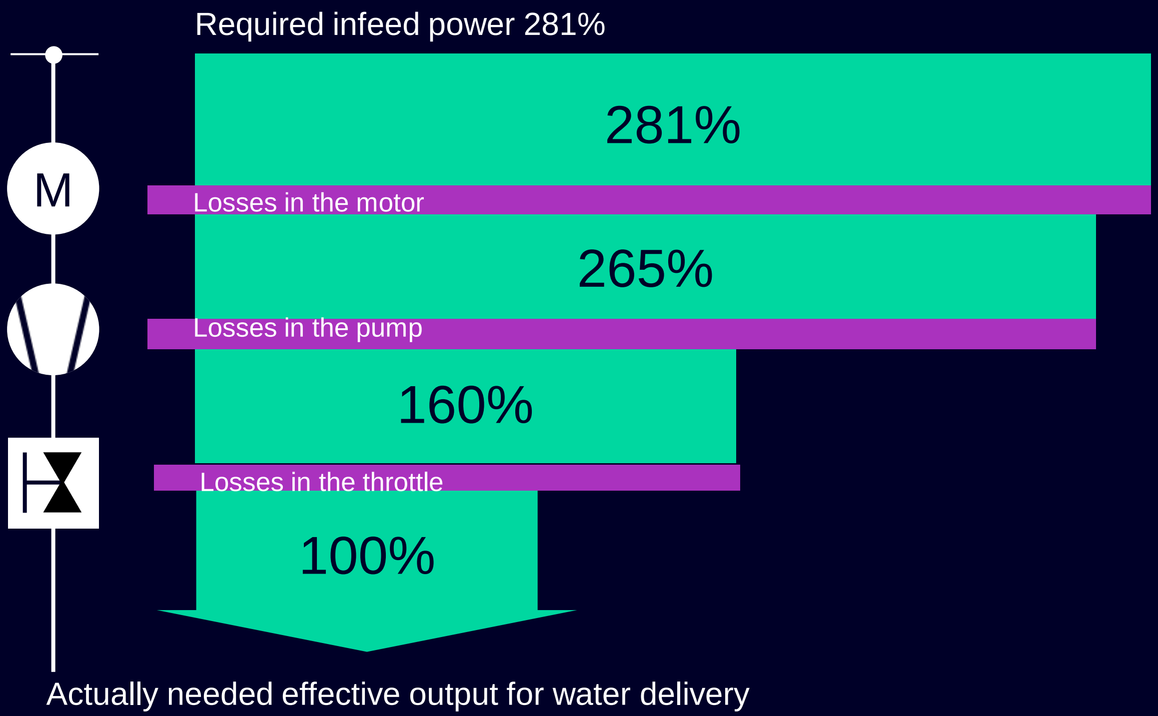
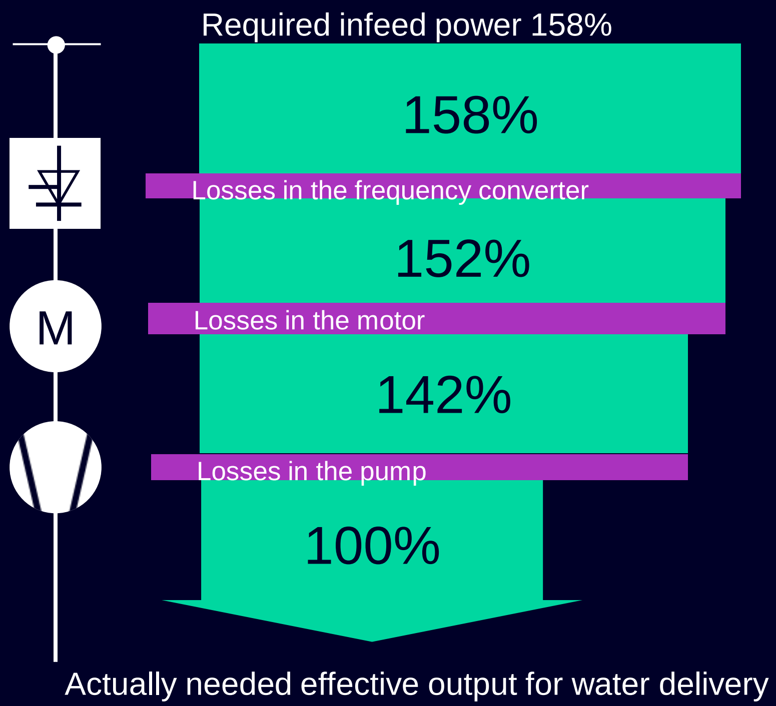
The efficiency chain using the example of a pump

Flow control with throttle



Flow control with frequency converter



The losses in the water delivery application could be reduced by one-third through use of speed control.

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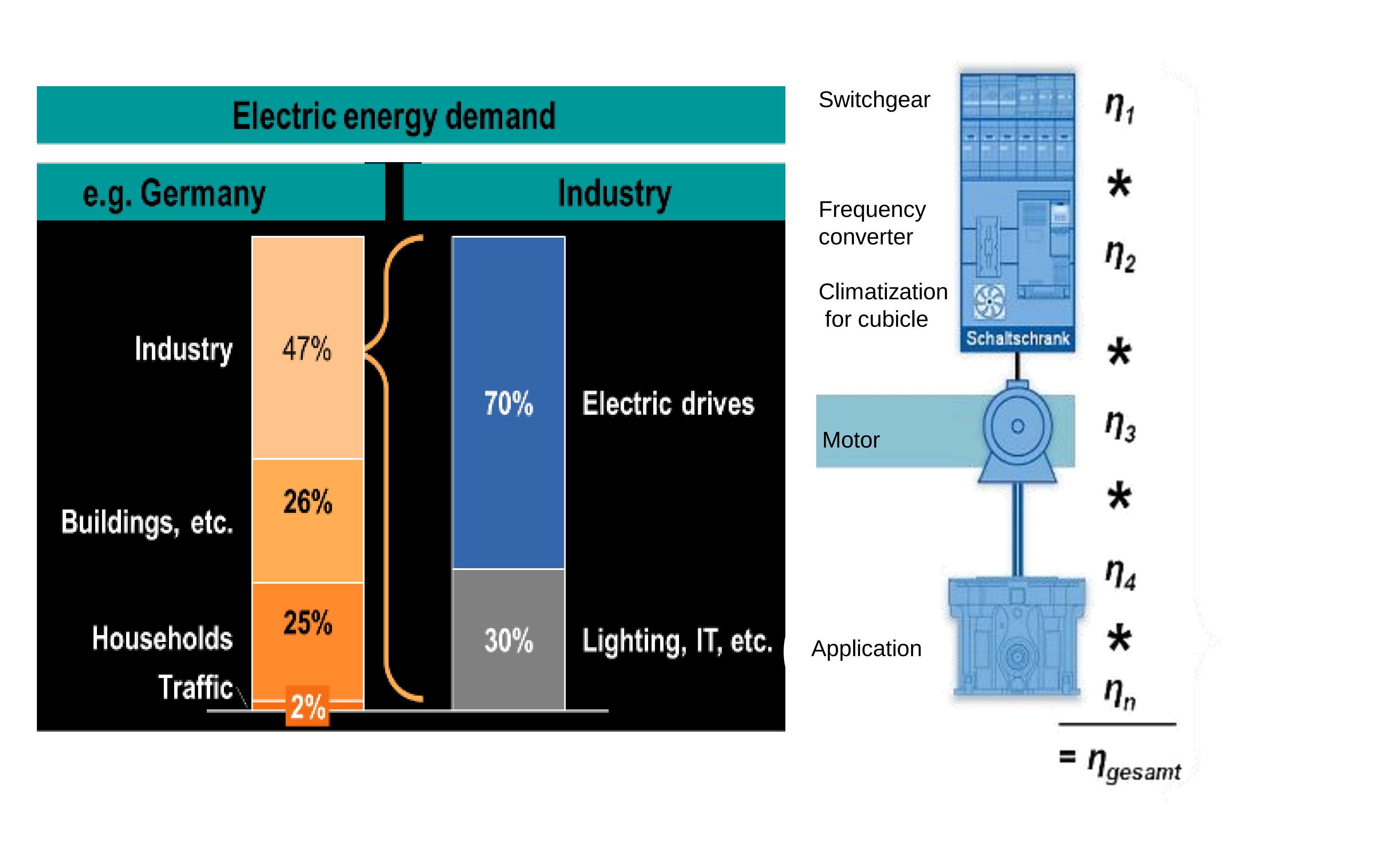
Keep in mind the efficiencies of the entire drive train!



Review the whole drive train to reduce the energy demand.

4 devices with a **super** efficiency of **90%** in series in the drive train yield an efficiency of ?

65.6%

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Energy Efficiency…

… has the shortest payback period among all energy investments

Solar PV 5 yr. ROI
Wind 7 yr. ROI
Energy Efficiency < 2 yr. ROI

…the cleanest, cheapest and most domestic energy source