

## 4 Teacher's notes – Volume 4 – Energy analysis

Volume 4 – Energy analysis – is the fourth volume of the UNIDO Cleaner Production Toolkit. It introduces the topic of energy analysis and provides various examples. It is designed for trainers, who teach consultants or trainers.

The teacher's notes provide comments on **training units (workshops)**. The background material can be used as described below.

Use of the background material "Energy analysis"	
Material	Comment
<b>Textbook</b>	The textbook provides the basic background information. The trainer should be familiar with the topic before starting the training or workshop. Aspects of energy management in general as well as energy units such as cooling, compressed air, boiler, etc. and the appropriate use of the worksheets are important. The textbook itself can be distributed as training material to the participants.
<b>Examples</b>	<p>The examples provide an overview of typical areas with energy saving potential:</p> <ul style="list-style-type: none"> <li>- <b>Condensate return:</b> In many cases the steam condensate is not completely used and partly drained. The example calculates the amount of energy available in the condensate. The example can also be used as an exercise.</li> <li>- <b>Cooling:</b> Cooling is an area with a high energy saving potential, especially in the food industry. Energy saving measures comprise good housekeeping options as well as technical options such as heat recovery, etc. (illustrated in the example).</li> <li>- <b>Energy saving in a brewery:</b> This example illustrates the development of the specific heat consumption in a brewery and the implemented energy measures, such as vapour compression, cold filtering, heat-power cogeneration, etc.</li> <li>- <b>Heat recovery from an air compressor:</b> This example illustrates how the heat recovered from an air compressor is used for preheating production water. In addition, this example is linked to the exercise with compressed air (see below).</li> <li>- <b>Multistage evaporation and vapour compression:</b> The principles of a multistage evaporation process (e.g. used in the sugar industry) and the resulting energy savings are demonstrated.</li> </ul>
<b>Exercises</b>	<p>Five exercises support the knowledge transfer to the participants. They are designed for group work in a training course, but can also be used as individual exercises. The participants learn to calculate energy options and convert them into ecological and financial units.</p> <ul style="list-style-type: none"> <li>- <b>Compressed air:</b> This exercise is designed for individual or pair work. The first part of the exercise consists of an estimate, in the solution important background information is provided.</li> <li>- <b>Evaporation losses:</b> Here the participants learn to use diagrams which are common in the energy field. This is a group work exercise (for two to three persons).</li> <li>- <b>Heat exchanger:</b> Calculation of a heat exchanger recovering heat from a wastewater stream.</li> </ul> <p>Continued on the next page</p>

Continuation: Use of the background material "Energy analysis"	
Material	Comment
Continuation: Exercises	<ul style="list-style-type: none"> <li>- <i>Hot water production, solar collector</i>: This exercise is based on <i>Exercise 3-3</i> of Volume 3, where the water consumption of an administration building had to be calculated. Now the actual efficiency of the hot water production is calculated. As an alternative, the use of solar collectors is analysed (annual energy yield and costs for collectors may vary from country to country).</li> <li>- <i>Making coffee</i>: This exercise is partly based on <i>Exercise 3-2</i> of Volume 3, but it can be used independently. It is a practical exercise with hands-on activities. If time and equipment in the workshop are available, it is a very valuable group work.</li> </ul>
Slides	The slides can be used for an introductory presentation on energy analysis. They provide a rough overview of different aspects of energy management in general and present specific areas such as cooling, compressed air, steam boiler, drying and lighting. The slides can be completed by own charts, project experience, etc.
Worksheets	<p>The worksheets are used for an energy analysis carried out in a company. As an example, they include the case study of a brewery.</p> <p>The worksheets comprise:</p> <ul style="list-style-type: none"> <li>- <i>Energy data (Worksheet 4-1)</i>: collection of data on energy carriers and conversion to kWh (for the conversion table refer to the textbook or the checklist of Volume 4);</li> <li>- <i>Meters and measuring instruments (Worksheet 4-2)</i>: listing all meters in the company and their recording frequency;</li> <li>- <i>Conversion units and heat consumers (Worksheet 4-3)</i>;</li> <li>- <i>Electric consumers (Worksheet 4-4)</i>: Here the rated power and the operating hours (recorded, calculated, etc.) are entered to calculate/estimate the consumption;</li> <li>- <i>Heat losses (Worksheet 4-5)</i>: listing of known heat losses;</li> <li>- <i>Energy saving options (Worksheet 4-6)</i>: existing and future options.</li> </ul> <p>The worksheets can also be opened as <i>doc.files</i>.</p>
Questions	<p>The questions check the participants' understanding of the information covered during the training course or workshop. Most of the information is included in the textbook, therefore links to the textbook are provided. The trainer can decide if and how he checks the participants' knowledge and if he wishes to use these questions.</p> <p>In addition, the questions can be used as a quick self-check for the trainer.</p>
Checklists	The checklists help the trainer to prepare the training course or workshop and to start the company work. They include conversion tables to convert energy carriers into kWh as well as energy consumption indicators for buildings (heating) and lamps.

### Training course/Workshop

The participants of a workshop or training course on "Energy analysis" are consultants or trainers.

The following table shows an example schedule of a one-day workshop, which is designed as part of a series of workshops. This schedule has proved to be efficient with different target groups.

The second table comprises the suggested materials, learning objectives and success indicators for the different teaching units.



Example schedule for a training course/workshop "Energy analysis"				
Topic	Content	Time	Min.	Method
<b>Welcome</b>		<b>9.00</b>	<b>15</b>	
	Welcome of participants		5	All
	Programme of the day, organizational matters		5	All, flipchart
<b>Feedback</b>		<b>9.10</b>	<b>20</b>	
	Feedback of the participants regarding experience from the previous workshops and/or company work		20	All
<b>Introduction to energy analysis</b>		<b>9.30</b>	<b>40</b>	
	Introduction to energy management and data collection; tools for analysis such as measuring devices, meters, load analysis, etc.		40	Presentation using overhead projector or beamer (partly slides), (partly textbook)
<b>Energy exercises I</b>		<b>10.10</b>	<b>40</b>	
	Small starting exercises (compressed air, evaporation) (Exercise 4-1), (Exercise 4-2)		30	Group work
<b>Coffee break</b>		<b>10.40</b>	<b>20</b>	
<b>Energy exercises I</b>		<b>11.00</b>	<b>15</b>	
	Evaluation of trainer, using the solutions and background information provided in the exercises		15	Evaluation (trainer)
<b>Energy efficiency</b>		<b>11.15</b>	<b>60</b>	
	More detailed background information on typical applications such as boiler, cooling, drying, lighting, etc. (to be selected and prepared according to the trainer's judgement)		15	Presentation using overhead projector or beamer (partly slides), (partly examples), (partly textbook) and own material
<b>Lunch</b>		<b>12.15</b>	<b>75</b>	
<b>Making coffee</b>		<b>13.30</b>	<b>90</b>	
	Practical hands-on exercise, (good after lunch) (Exercise 4-5)		10 50 30	Explanation Group work Presentation/evaluation
<b>Break</b>		<b>15.00</b>	<b>30</b>	
<b>Exercises II</b>		<b>15.30</b>	<b>50</b>	
	Additional exercises (heat exchanger, hot water – solar collectors) (Exercise 4-3), (Exercise 4-4)		40 10	Group work and evaluation
<b>Discussion, continuation</b>		<b>16.20</b>	<b>40</b>	
	Presentation and discussion of worksheets		20	Presentation (worksheets)
	Discussion of topic of the day, summary of major aspects, continuation of work, explanation of training material and worksheets, homework		20	Plenary discussion
<b>End</b>		<b>17.00</b>		

Explanation of the topics of the training course	
Topic	Materials/learning objectives/success indicators
Introduction to energy analysis	<p><i>Material:</i></p> <ul style="list-style-type: none"> <li>- Some <b>transparencies</b> from the background material and additional own transparencies;</li> <li>- <b>Textbook</b> of this volume.</li> </ul> <p><i>Learning objectives:</i></p> <ul style="list-style-type: none"> <li>- Make the participants familiar with the concept of energy management;</li> <li>- Provide an overview of the different aspects of saving energy;</li> <li>- Provide an overview of tools for energy analysis, such as analysing energy bills, using simple measurement devices, peak load analysis, etc.</li> </ul> <p><i>Success indicator:</i></p> <ul style="list-style-type: none"> <li>- The participants have an overview of major aspects of energy management/analysis and the discussion shows that they are interested in this subject and motivated.</li> </ul>
Energy efficiency	<p><i>Material:</i></p> <ul style="list-style-type: none"> <li>- Some <b>transparencies</b> from the background material and additional own transparencies;</li> <li>- <b>Textbook</b> of this volume;</li> <li>- <b>Examples</b> of this volume.</li> </ul> <p><i>Learning objectives:</i></p> <ul style="list-style-type: none"> <li>- Demonstrate in more detail energy saving aspects for selected areas: e.g. for Cooling/refrigeration Compressed air Insulation Steam/boiler Lighting Heat recovery Heating, etc.</li> </ul> <p><i>Success indicators:</i></p> <ul style="list-style-type: none"> <li>- The participants understand the basic principles of the selected areas, e.g. the basic energy balance or where losses can occur (e.g. in a boiler, in the cooling process, etc.);</li> <li>- The participants can identify energy saving options in the selected areas.</li> </ul>
Group work energy Exercises I and II	<p><i>Material:</i></p> <ul style="list-style-type: none"> <li>- <b>Exercises 4-1 to 4-4</b> from the exercise section.</li> </ul> <p><i>Learning objectives:</i></p> <ul style="list-style-type: none"> <li>- Apply the acquired knowledge on energy analysis to small examples;</li> <li>- Make the participants familiar with calculations in the field of energy;</li> <li>- Learn to use diagrams;</li> <li>- Participants learn to convert energy savings into financial terms;</li> <li>- Make the participants familiar with the energy saving potential for compressed air, evaporation losses, heat exchange of wastewater, etc.</li> </ul> <p><i>Success indicators:</i></p> <ul style="list-style-type: none"> <li>- The participants can work with energy units;</li> <li>- The participants can use diagrams to estimate losses;</li> <li>- The participants understand the potential of energy losses;</li> <li>- The participants can apply the calculations and solutions of the exercises to other similar energy situations.</li> </ul>

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Explanation of the topics of the training course	
Topic	Materials/learning objectives/success indicators
Exercise: Making coffee	<p><i>Material:</i></p> <ul style="list-style-type: none"> <li>- See background material (<a href="#">Exercise 4-5</a>), flipchart, equipment and tools (for a detailed description see Exercise 4-5).</li> </ul> <p><i>Learning objectives:</i></p> <ul style="list-style-type: none"> <li>- Simulate the energy analysis and energy problems of a production process;</li> <li>- Learn to use simple measuring equipment;</li> <li>- Experience the use of energy consumption (kWh) and power (kW).</li> </ul> <p><i>Success indicators:</i></p> <ul style="list-style-type: none"> <li>- The participants recognize energy saving options;</li> <li>- The participants can use the measuring equipment and understand the difference between consumption (kWh) and power ( kW);</li> <li>- The participants can convert this production and energy simulation into their own production and company "language".</li> </ul>
Worksheets	<p><i>Material:</i></p> <ul style="list-style-type: none"> <li>- See background material (<a href="#">worksheets</a>).</li> </ul> <p><i>Learning objective:</i></p> <ul style="list-style-type: none"> <li>- Understand the different worksheets.</li> </ul> <p><i>Success indicator:</i></p> <ul style="list-style-type: none"> <li>- The participants can apply the worksheets to a real company situation.</li> </ul>