

## Trainer Instructions: Cogeneration

From: *Energizing Cleaner Production – a Guide for Trainers, UNEP/InWEnt, 2007*

<b>Title</b>	<b>COGENERATION</b>																									
<b>Objective</b>	To obtain an understanding of cogeneration, including the types of cogeneration systems used in industry, how to assess their performance and the main areas for energy conservation.																									
<b>Minimum duration and approach</b>	<ul style="list-style-type: none"> <li>▪ 1 session (1.5 hours), including the quiz and workshop exercise.</li> <li>▪ Recommended approach: spend 45 minutes on the PowerPoint presentation, go through the quiz questions as a group, and leave 35 minutes to do workshop exercise because it requires several calculations.</li> <li>▪ Presentation: 25 slides</li> <li>▪ Textbook chapter: 19 pages</li> </ul>																									
<b>Contents</b>	<ul style="list-style-type: none"> <li>▪ Introduction</li> <li>▪ Types of cogeneration systems</li> <li>▪ Assessment of cogeneration systems</li> <li>▪ Energy efficiency opportunities</li> </ul>																									
<b>Assessment of participants</b>	<ul style="list-style-type: none"> <li>▪ Pose questions during the presentation. Some suggested questions are included in the trainer notes underneath each slide.</li> <li>▪ Take the quiz with 10 multiple choice questions.</li> <li>▪ Carry out the workshop exercise. Participants can be asked the following:</li> </ul> <p><i>A process industry has decided to install cogeneration plant. The process requirements are:</i></p> <ul style="list-style-type: none"> <li>- <i>The plant requires 4.5 MW of electrical power</i></li> <li>- <i>The boiler has a maximum steam generating capacity of 31.25 TPH at 63 kg/cm<sup>2</sup> pressure and a temperature of 486 °C</i></li> <li>- <i>The table below gives the process steam requirements</i></li> </ul> <table border="1"> <thead> <tr> <th></th> <th><i>Process steam flow (TPH)</i></th> <th><i>Pressure (kg/cm<sup>2</sup>)</i></th> <th><i>Temperature (°C)</i></th> <th><i>Enthalpy (kCal/kg)</i></th> </tr> </thead> <tbody> <tr> <td><i>Boiler</i></td> <td><i>31.25</i></td> <td><i>63</i></td> <td><i>486</i></td> <td><i>808</i></td> </tr> <tr> <td><i>Process #1</i></td> <td><i>3.25</i></td> <td><i>21</i></td> <td><i>310</i></td> <td><i>669</i></td> </tr> <tr> <td><i>Process #2</i></td> <td><i>8.0</i></td> <td><i>8.0</i></td> <td><i>174</i></td> <td><i>662</i></td> </tr> <tr> <td><i>Process #3</i></td> <td><i>20.0</i></td> <td><i>5.0</i></td> <td><i>160</i></td> <td><i>659</i></td> </tr> </tbody> </table>		<i>Process steam flow (TPH)</i>	<i>Pressure (kg/cm<sup>2</sup>)</i>	<i>Temperature (°C)</i>	<i>Enthalpy (kCal/kg)</i>	<i>Boiler</i>	<i>31.25</i>	<i>63</i>	<i>486</i>	<i>808</i>	<i>Process #1</i>	<i>3.25</i>	<i>21</i>	<i>310</i>	<i>669</i>	<i>Process #2</i>	<i>8.0</i>	<i>8.0</i>	<i>174</i>	<i>662</i>	<i>Process #3</i>	<i>20.0</i>	<i>5.0</i>	<i>160</i>	<i>659</i>
	<i>Process steam flow (TPH)</i>	<i>Pressure (kg/cm<sup>2</sup>)</i>	<i>Temperature (°C)</i>	<i>Enthalpy (kCal/kg)</i>																						
<i>Boiler</i>	<i>31.25</i>	<i>63</i>	<i>486</i>	<i>808</i>																						
<i>Process #1</i>	<i>3.25</i>	<i>21</i>	<i>310</i>	<i>669</i>																						
<i>Process #2</i>	<i>8.0</i>	<i>8.0</i>	<i>174</i>	<i>662</i>																						
<i>Process #3</i>	<i>20.0</i>	<i>5.0</i>	<i>160</i>	<i>659</i>																						

	<ol style="list-style-type: none"> <li>1. Determine the total power that could be generated by a single turbine that meets the process steam requirements.</li> <li>2. Calculate the additional amount of power to be purchased from the grid.</li> <li>3. Calculate the heat to power ratio of the cogeneration plant.</li> </ol> <p>The following data are given:</p> <ul style="list-style-type: none"> <li>- Alternator efficiency: 95%</li> <li>- Transmission efficiency: 95%</li> <li>- Thermal efficiency of turbine: 80%</li> <li>- 1 kW electricity: 860 kCal</li> </ul> <p>Participants may have difficulties to get started on question 1. In this case it may be helpful to give them the 4 calculation steps:</p> <ul style="list-style-type: none"> <li>- Calculate the enthalpy of the steam produced by the boiler (in kCal per hour)</li> <li>- Calculate the enthalpy of the steam taken by the three processes (in kCal per hour)</li> <li>- Calculate the amount of heat remaining after the three processes have taken their steam (in kCal per hour)</li> <li>- Calculate the total amount of power generated from the remaining heat (in MW), taking into account the efficiencies of the turbine, generator and transmission</li> </ul> <p>Once the answer to question 1 is known, participants should have difficulties in solving questions 2 and 3.</p>
<p><b>Other comments</b></p>	<ul style="list-style-type: none"> <li>▪ Case study options from <a href="http://www.energyefficiencyasia.org">www.energyefficiencyasia.org</a> or other sources could be included in this session as an illustration of how other companies are reducing energy consumption and costs.</li> <li>▪ If there are time limitations not all energy equipment sessions need be covered, It is possible to remove the cogeneration session and explain it as an energy efficiency opportunity during the session “Boilers and Thermic Fluid Heaters”. In this case, the quiz and workshop would also be removed.</li> </ul>