Expert-system for an INtelligent Supply of Thermal Energy in Industry

Review of thermal energy auditing practices and tools

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D2.2 Report: Review of thermal energy auditing practices and tools

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Abstract

The objective of this report is to give an overview of the state of the art of thermal energy auditing in industry. These results will be incorporated in the EINSTEIN methodology and assure an efficient transfer of know-how within the project Consortium. This report gives also to the interested parties outside the Consortium the possibility to find primary sources of information concerning thermal audits in industry.

Therefore, the EINSTEIN Consortium screened hundreds of web-pages, projects, databases and handbooks and evaluated them in order to find relevant information to be used for the improvement of the thermal energy expert system. In this report the results of the survey are presented.

The area of investigation only includes the **heat** supply systems and final uses in **high thermal energy industrial consumers** such as the food, the metal treatment and the wood processing sectors.

Different energy auditing procedures from several campaigns and countries were compared in order to find out the common basics steps as a starting point for development of the EINSTEIN auditing procedure.

Questionnaires for data collection are already available for different technologies and different industrial branches. They deal with CHP, solar heat, buildings, energy management and so on. Chapter 2.2 summarises several forms in use. In the case they contributed to the main goal of quick thermal energy assessment in industry they were integrated in the final EINSTEIN questionnaire.

For generating the EINSTEIN software tool this report (chapter 2.3) gives a well arranged overview of different software tools for energy efficiency in industry already available on the market: from self-assessment, to benchmarking tools and finally special tools for the different technologies used in thermal energy supply and distribution, e.g. for boilers, CHP and solar heat. The concept, features and ways how information is transferred to standardised reports will be analysed by the technical project group and taken into account in the further software development.

To allow a fast standardised access to relevant energy saving measures, information about the best available technologies (BAT) and energy efficient interventions for the different industrial branches are necessary. Therefore chapter 3 summarises relevant sources of information. Furthermore for industrial branches and technologies the most important BAT recommendations are summarised in tables.

For energy auditors handbooks and manuals on industrial processes and viable energy efficiency measures and heat supply systems in industry are essential sources of information before they start an energy audit. Therefore chapter 4.1 presents the literature surveyed by the Consortium of interest for the EINSTEIN scope. From energy auditing guides for different branches to technical handbooks on several energy intelligent technologies.

A lot of projects concerning energy efficiency in industry were already financed by the European Commission. In several projects very interesting results and tools were developed. The summary of the projects are given in chapter 4.2 with information on affected branches and technologies. They covered several topics relevant to EINSTEIN such as energy auditing, benchmarking, sector specific measures and technological specific topics (CHP, solar heat) and financing.

In addition to the reference reported within the specific sections, other interesting websites with a lot of information were documented in chapter 4.3. They deal with energy efficiency, energy management and technologies.

Due the largeness of the topic addressed by this project, the information summarised in this report do not pretend to be representative of the state of the art. On the other hand, this survey can be considered to be a good base for a successful step forward towards a wider diffusion of the energy efficiency practices in industry.

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Introduction

Thermal energy (heat and cold) demand **in industry** constitutes about 20 % of the total final energy demand and produces about 21 % of the CO_2 emissions in Europe. Even if energy efficiency in industry in Europe has improved the last decades, there remains a large unexploited potential for reducing energy demand that could be achieved by the intelligent combination of existing solutions and technologies. This potential of improvement is especially high in the countries of Southern and Central Europe. Nevertheless, frequently the corresponding investments are not realised due to e.g. lack of knowledge and too little budget available for energy auditing.

The EINSTEIN project aims at contributing to a widespread implementation of integral energy-efficient solutions for thermal energy supply in industrial sectors with a high fraction of low and medium temperature heat demand, especially the food, wood processing and metal treatment sectors that will be first addressed within this project.

For optimising thermal energy supply, a holistic integral approach is required that includes possibilities of demand reduction by heat recovery and process integration, and by an intelligent combination of existing affordable heat (and cold) supply technologies, under the given economic constraints.
EINSTEIN uses as a basis available methods and tools that address some parts of these topics, adds missing elements and brings them together into a complete EINSTEIN tool kit for thermal energy auditing, which will be used then in all the project's activities.
This tool kit, based on an expert system software tool, guides the user through the whole procedure from auditing (preparation of visit and data acquisition), over data processing, to the elaboration, design and quantitative (energetic and economic) evaluation of alternative solutions.

The main actions foreseen within the project will be:

- Development and dissemination of the EINSTEIN thermal energy auditing tool kit. An expert system consisting of software tool and guidelines, that helps reducing cost and improving quality of energy audits by using a holistic approach.
- Training of energy auditors, industrial technicians and other relevant actors in the field of industrial energy efficiency for the use of this expert system.
- Realisation of auditing campaigns in at least 90 industrial companies.
- Dissemination activities for awareness raising and widespread dissemination of the project results at EU level.

Within the EINSTEIN project the objective of this report is to offer a critical synthesis of the results from related projects and programs carried out at National, European and International level, of literature and other sources of information, in order to incorporate them into the EINSTEIN methodology and tools, wherever suitable.

Therefore, this report gives an overview of the state of the art of thermal energy auditing in industry. The EINSTEIN-consortium screened hundreds of projects, handbooks, software tools, databases and web-pages, and evaluated them in order to find relevant information to be used for the development of the thermal energy expert system. In this report the results of the study are presented.

The key to successful energy audits is an efficient data acquisition and management. For collecting relevant information in companies different energy auditing procedures, incl. specific questionnaires, were screened. While for the elaboration of these data sets, software tools are required. Therefore, the main features of several products have been reviewed and summarised.

In addition, for the evaluation of the most appropriate energy saving measures an overview of the best available technologies and benchmarks is necessary.

As important information sources handbooks, projects and web-pages were analyzed for finding relevant outcomes and developed tools relevant for the EINSTEIN project.
An on-line database of the EU co-funded projects (under Altener and Save, CIVITAS, Structural and regional funds, LIFE, RTD 2002-2006 and Phare programmes) has been recently finalised and it is available at the following webpage: **http://www.iee-library.eu/.** The collection was not available at the time when this report was finalised therefore for a more comprehensive overview of projects and instruments (tools and guidebooks) available at EU level, it is strongly recommended to search within the IEE-library (see also paragraph 4.3.4).

This review focuses mainly on "*tools for audit*" as "*support documents and applications which are intended to facilitate the work of auditors in the view of both minimising audit costs and maximising audit quality*".
On market and non-technological barriers numerous publications are also available and a comprehensive overview can be found within the BESS WP1 report.

1 Energy auditing procedures

By Pavel Sitny, Enviros s.r.o.

1.1 *Introduction*

Project partners contributed to this part of the report and collected number of examples of projects, initiatives, schemes, bye-laws etc.

The main sources of information are listed below, and a brief summary is also reported in the Annex:

- The AUDIT II project topic report “Energy Audit Models” and the “Guidebook for Energy Audit Programme Developers”.
- The CRES (Centre For Renewable Energy Sources) “Energy Audit Guide**.** Part A: Methodology and Technics”.
- The EPA-NR project final report “Checklist for an intake interview. Preparation for an energy performance assessment of existing non-residential buildings”.
- The POSHIP project final report.
- The BESS project final report.
- The Energy Auditing Made Simple, Indian Guidebook for Energy Audits.
- The UNEP EE CP methodology.
- The EMAS guidebook “Integrating Energy- and Environmental Management”.
- The Styrian Promise project final report.
- The Poland-Japan Energy Conservation Technology Centre Project KAPE S.A..
- The Energy Self-Audit Scheme project.
- The Carbon Trust energy auditing procedure.
- The Energy Management Act/Energy Economy Act (Act on Energy Management of the Czech Republic No. 406/2000).
- The Management Regulations for Energy Consumption (RGCE).
- The Save Energy Now Campaign (United States).
- The New Guidelines for Energy Management in Industry (Japan).
- The Energy Audit Scheme promoted by the National Environment Agency (NEA) under the initiative of the National Climate Change Committee (NCCC).
- The South African Demand-Side Management (DSM) initiative implemented by Eskom.

1.2 *Energy auditing objectives*

The energy auditing in all documents surveyed is considered as a tool for achieving some objectives. The energy audit can be adjusted according the specific objectives. It can result in a big variety of technical and economic reports with emphasis on the current set of objectives. There are many stakeholders around energy auditing with different objectives, but generally three are the main drivers towards an energy audit:

1. Saving of costs.
2. Protection of environment.
3. Conservation of energy sources.

Starting from these main purposes are derived many other specific objectives. An energy audit campaign is usually part of a demand side management project. Sometimes energy audits might be mandatory for certain type of users or subjects. The goal of the energy auditing can be even different from the evaluation of the potential for energy savings. An energy audit might prove the achievement of required targets established for new or innovative projects. It can be used for instance as a basis for a grant application.

Sample of derived objectives

a. Prove parameters of energy saving projects
b. Fulfilment of law obligations
c. Management of investment into power sources and distribution
d. Marketing

1.3 *Energy auditing classification*

An in-depth energy audit that investigates all aspects of the energy consumption, prepares detailed design of energy efficiency improving measures and evaluates their benefits in specific areas, imposes considerable requirements. It is costly, time and expertise demanding. The resources are usually limited and the objectives often do not require the maximum depth.
Based on the level of complexity, energy audits can be classified according three dimensions:

1. Scope.
2. Exhaustiveness.
3. Aim.

Scope

- Specific system/area
- Every system/all site

Exhaustiveness

- General potential assessment
- Detail potential assessment

Aim

- Point out general potential saving areas
- Propose specific energy saving measures

The term energy audit model in this context indicates that there are agreed features or requirements designed for a specific type of an energy audit application.
In a model the actual scope, thoroughness and aim of the audit are defined. The audit model is usually a standardised, commonly known and commonly followed procedure with written guidelines.
In practice three general levels of energy audit complexity are in use:

1. Walk-through audit.
2. Short energy audit.
3. Comprehensive energy audit.

Walk-through audit

This is the simplest level of energy audit. It allows the overall energy consumption of the site to be evaluated to determine whether energy use is reasonable or excessive. It provides initial benchmarks of the site so that the effect of energy measures can be tracked and evaluated. It may be in the form of a desktop study; however the information given to, or gathered by, the auditor needs to be sufficient to enable the overall level of efficiency of the site to be determined. This level of audit is expected to give an overview which provides rough orders of savings and costs.

Short energy audit

Short energy audits identify the energy supply systems, the amount of energy supplied and what the energy is used for. It also identifies areas where savings can be achieved, recommends measures to be taken, and provides a statement of costs and potential savings. Short audit is an energy use survey which is expected to provide a preliminary assessment of costs and savings.

Comprehensive energy audit

This level of audit provides a detailed analysis of energy usage, the savings that can be achieved, and the cost of achieving those savings. It may cover the whole site or may concentrate on an individual item, such as a single industrial process or one of the services. The auditor may often employ a specialist to carry out specific parts of an audit or may need to install local metering and logging.

The report from a comprehensive audit often forms the justification for substantial investment by the owner or an energy performance contractor. Detailed economic analysis with appropriate level of accuracy is required. Comprehensive audit is expected to provide a firm estimate of savings and costs.

1.4 *Energy auditing processing steps*

Generally all energy audits include three basic steps :

- data acquisition,
- calculation,
- reporting of results.

However for various levels of energy auditing different approaches, tools, methods and possibly equipments are used. Whilst simpler energy audits rely more on comparisons with benchmarks, best practices and intuition of energy auditor, more complex energy audits are based on more precise data, calculations and interviews with the technical staff of the company. Simpler energy audits usually use only the total consumption figures, basic information on the technologies in use, the overall production and other specific data. More complex energy audits try to collect more detailed information about the energy consumption breakdown; types, design and operational data about important energy sources; transformations and users; information on energy distribution

networks; more detailed production data, etc. Some procedures define precisely what kind of data is needed, some are more flexible.

In order to evaluate which energy saving measures are applicable, some auditing approaches suggest to use checklists for energy supply technologies or for sector specific energy saving opportunities.

Sometimes, the auditing procedure is structured in blocks enabling the costumer to decide how far to go with the energy auditing.

In some cases, before the energy audit itself, a so called preliminary visit can be useful to fill-in the questionnaire with the basic information required for a first rough evaluation.

1.5 *Energy auditing beneficiaries*

Very important is the question who is the potential buyer of the energy audit and what are the strongest arguments for convincing him to proceed.

Some of the materials collected describe methodologies where energy audits are offered for free to certain type of users (Carbon Trust (UK), Save Energy Now Campaign – United States, 2.1.18 Energy Audit Scheme for Large Consumers of Energy in Singapore).

Moreover, some Countries adopted a law, that oblige specific users to execute energy audit (Czech Republic, Portugal, Japan), as a tool for achieving targets in environmental and energy efficiency areas.

Finally, some of the projects screened developed energy auditing methodologies and tools of different complexity levels, focusing on different sectors, technologies etc.
These tools were then tested on different groups of customers usually reached through information campaigns, contacts with associations, direct contacts etc.

2 Energy auditing tools

2.1 *Introduction*

In the "Guidebook for Energy Audit Programme Developers"[1] , elaborated in the framework of the SAVE project AUDIT II, the following definitions are given that look of interest to clarify what an audit tool is, which the main purposes can be and which auditing instruments can be included in this category.

*The wording "**tools for audits**" or "**auditors' tools**" describes a large family of support documents and applications which are intended to facilitate the work of auditors in the view of both minimising audit costs AND maximising audit quality.*

…They are generally dependant from the Energy Audit Models but may address different stages in the study service as figured underneath and provide help either on technical matters or on marketing aspects.

…Tools for auditors is not THE essential element of an auditing programme, but it is one topic that brings multiple benefits:

- *Some tools can be also **used as marketing instruments** (case studies, fact sheets**...**) or **contribute to the training sessions** (auditing hand book, software tools...);*
- ***Quality control as well as monitoring** may be eased through adequate dispositions within practical tools;*
- *And even **definition of the Energy Auditing Models** can interact with the tools definition or development (although EAM definition should precede tools elaboration).*

…Tools may include:

1. *Information/documentation on technical topics*
2. *Audit guide or audit handbook; energy management handbook*
3. *Energy checks; Check-lists or walk through guides*
4. *Calculation methods and software*
5. *Data collection form(s)*
6. *Report templates*
7. *Check list for quality control of audit reports*
8. *Building ratings, target values or benchmarking*
9. *Data bases on Energy Conservation Options (ECOs).*

This chapter addresses data collection forms (questionnaires), calculation software tools and databases while chapters 3 and 4 summarise information on Energy Conservation Options (ECOs), BATs and audit handbooks.

[1] Väisänen,H. et al. (2003). Guidebook for Energy Audit Programme Developers, AUDIT II, Save Project. Motiva website: http://www.motiva.fi/fi/english/english/energyaudits/auditiiproject.html

2.2 *Questionnaires for data acquisition*

By Hans Schweiger and Stoyan Danov, energyXperts.BCN

2.2.1 Summary

In this section, the questionnaires provided by the EINSTEIN project partners have been summarised and compared.
Especially those features and parameters not already included in the "EINSTEIN Questionnaire draft version" have been analysed and documented in order to be taken into account for the implementation of future improved versions of the Einstein questionnaire.

The questionnaires have been grouped into the following categories:

1. Questionnaires for general energy audits in industry
2. Questionnaires for specific technologies (i.e. Combined Heat and Power applications)
3. Questionnaires for non – residential buildings.

In the table below the main features of the questionnaires surveyed have been summarised and compared while a more detailed description is reported in the next sections.

Questionnaire	Detail level energy consumption data	Detail level information on processes	Detail level information on heat and cold supply equipment and distribution	Type of use
Questionnaires used for general energy audits in industry				
1. EnergyXperts	Annual data	Basic technical data for each process and operation hours (h/day) and days (days/year). Data for possible and existing heat recovery.	Basic technical data for each equipment and distribution branch	Detailed audit and evaluation of new projects. Used from auditors or project engineers.
2. IEA SHC Task 33/IV	Monthly data for energy consumption	Basic technical data for each process. Daily, weekly and annual time schedules.	Basic technical data for each equipment	Detailed audit. Used from auditors.
3. POSHIP detailed	Monthly data for energy consumption	Basic technical data for each process. Daily and weekly time schedules.	Basic technical data for each equipment	Detailed audit. Used from auditor.
4. POSHIP short	Annual data	Basic technical data for each process.	Basic technical data for each equipment	Preliminary audit. Useful to sent to the customer.
5. ST ESCOs (Annex 2)	Annual data	Basic technical data for each process. Typical daily and weekly time schedules.	Basic equipment data.	Preliminary audit. Used in a first visit or sent to the customer.
6. EMS Textile Project	Monthly data the last three years, by type of uses	Flowcharts to be drawn by auditor, building data and installations general data.	Equipment list with basic data.	Promotion of energy management practices. Used from auditors.
7. KAPE Pre-Audit Questionnaire	Annual last four years, monthly last year	Production flow diagram	Equipment list with power ratio and main specifications	Establishing of objectives and preparing the audit. To be sent to the customer.
Questionnaires used for specific technologies (CHP)				
8. Cogenco	Monthly data for electricity consumption per tariffs, totals and monthly maximum of power required.	Monthly data for production hours, divided day, night, weekend and total hours.	Monthly data for thermal and refrigeration energy consumption per day, night and total	Specific for CHP. Used in a first visit or sent to the customer.
9. Micro CHP	Monthly energy consumption, summer / winter consumption, detailed electric tariffs.	Building data only, day/night room temperature difference	Heating system, boilers, hot water tank	Specific for CHP. Preliminary feasibility study. Used from auditors or sent to the customer.
10. CHP Initial Walk Thru Question List	Monthly energy consumption asked and more detailed electric parameters	Consumption data, schedules.	CHP already installed, heating equipment capacity	Specific for CHP. Preliminary questionnaire.
Questionnaires for non-residential buildings				
11. ATISAE	Monthly data for energy consumption	Monthly data for building occupation, no process description	Monthly hours of equipment operation	Specific for large office buildings and hospitals. To be used by auditors.

Table 2.2.1

2.2.2 Questionnaires for general energy auditing in industry

2.2.2.1 EnergyXperts.BCN questionnaire

Comment (brief summary and useful features):
Questionnaire suitable for evaluation of new projects, assuming that detailed data on the equipment and process are available. Well structured, includes thermal and electric data. It requires detailed data on processes, equipments and fuels consumption.
Used as main reference for the EINSTEIN questionnaire.

Questionnaire size: 14 pages.

Level of detail in data acquisition: Annual data.

Questionnaire structure (blocks of inputs requested):
1. General information – contact, economic, products, project (new project)
2. Energy consumption – fuels, electricity
3. Processes – description of processes, heat recovery, heat and cold supply
4. Generation of heat and cold – equipment, distribution
5. Renewables – Solar thermal, biomass
6. Electric motors
7. Lightning
8. Compressors
9. Buildings
10. Economic parameters
11. Rejected solutions
12. Initial state (before project)

Intended use (and users):
Intended for evaluation of new projects and for detailed audits.
To be filled in by the energy auditors or by the project engineers.

Source:
EnergyXperts.BCN. Internal document.

2.2.2.2 IEA SHC Task 33/IV Questionnaire

Comment (brief summary and useful features):
Suitable solar thermal heat for industrial application.
It provides a graphic representation of the load profile (hardcopy and electronic questionnaire).
It provides a library of pre-drawn components for the processes layout and the related energy streams.

Questionnaire size: 8 pages.

Level of detail in data acquisition: Monthly data for energy consumption and cost.
Typical daily, weekly and annual load profile of industrial processes (calculated as percentage of the maximum power).

Questionnaire structure (blocks of inputs requested):

1. General information
2. Solar system
3. Supply system
4. Storage, heat recovery
5. Fuel consumption
6. Electricity consumption
7. Load profiles
8. Process description, low temperature process.

Intended use (and users):
For detailed audits. To be filled in by the energy auditor.

Source:
International Energy Agency (IEA), Solar Heating and Cooling Programme (SHC) Task33/IV
Website: www.iea-ship.org

2.2.2.3 POSHIP Detailed Questionnaire

Comment (brief summary and useful features):
Suitable solar thermal heat for industrial application.
Monthly energy consumption (fuel and electricity); graphical representation of the load profile provided; fields for process flowchart provided (hardcopy questionnaire).

Questionnaire size: 11 pages.

Level of detail in data acquisition: Monthly data for energy consumption and costs.
Typical weekly load profile of industrial processes (calculated as percentage of the maximum power).

Questionnaire structure (blocks of inputs requested):
1. General data
2. Fuel
3. Electricity
4. Heat supply
5. Equipment
6. Solar system.

Intended use (and users):
For detailed audits. To be filled in by the energy auditor.

Source:
POSHIP project: *The Potential of Solar Heat for Industrial Processes.* Project funded by the European Commission - Directorate General for Energy and Transport. Programme ENERGIE (5th Framework Programme for Energy, Environment and Sustainable Development), Project No. NNE5-1999-0308.
Website: www.aiguasol.com/poship.htm

2.2.2.4 POSHIP Short Questionnaire

Comment (brief summary and useful features):
Small amount of inputs: only 4 processes and equipments.
Economic data missing.
Useful for preliminary audits by distance, before the visit on-site.

Questionnaire size: 2 pages.

Level of detail in data acquisition: Annual data.

Questionnaire structure (blocks of inputs requested): -

Intended use (and users):
Preliminary energy audits. Checklist to be sent to the company before the visit on-site.

Source:
POSHIP project: *The Potential of Solar Heat for Industrial Processes.* Project funded by the European Commission - Directorate General for Energy and Transport. Programme ENERGIE (5th Framework Programme for Energy, Environment and Sustainable Development), Project No. NNE5-1999-0308.
Website: www.aiguasol.com/poship.htm

2.2.2.5 Solar Thermal ESCOs (ST ESCOs) Questionnaire

Comment (brief summary and useful features):
For the auditing of an industrial process and pre-evaluation of large solar heating plants feasibility. Breakdowns due to maintenance/holidays/other required separately for processes and equipment. Typical daily and weekly load profile required (in % of maximum power)

Questionnaire size: 6 pages

Level of detail in data acquisition: Annual data, typical daily and weekly load profile for processes (in % of the maximum power)

Questionnaire structure (blocks of inputs requested):
1. General data
2. Fuel consumption
3. Electrical consumption
4. Solar system
5. Processes description
6. Equipment for heat (or cold-) generation

Intended use (and users):
To be used in the first visit or sent to the customer.

Source:
ST-ESCOs Guide. Questionnaire for audit of an industrial process, for pre-evaluation of a large scale solar heating plants feasibility.

2.2.2.6 EMS Textile Project Questionnaire

Comment (brief summary and useful features):
Intended for promotion of energy management practices in the textile industries.
Financial data (sales, profit, energy costs) required for the last three years. Ratios calculated for them for the three years.
Energy consumptions for the last three years required.
Space provided for drawing of production, electricity and heat flow charts.
For the equipment: nominal power, year of construction, and operating hours are required.

Questionnaire size: 20 pages

Level of detail in data acquisition: Monthly data for energy consumption the last 3 years. Annual data for sales, net profits and cost of products and energy costs.

Questionnaire structure (blocks of inputs requested):
1. General data
2. Financial data
3. Consumption data
4. Check points: For the last three years: all energy related bills, all consumption measurements, all production data.
5. Production flow: charts
6. Energy flow: electricity and thermal
7. Productive equipment
8. Auxiliary equipment
9. Building data

Intended use (and users):
Audit and promotion of energy management practices.

Source:
EMS-Textile Project: Promotion of Energy Management Practices in the Textile Industries of Greece, Portugal, Spain and Bulgaria, 2005.

2.2.2.7 KAPE Pre-Audit Questionnaire

Comment (brief summary and useful features):
Questionnaire to be used before energy audit in a factory. Interesting feature is the section 2 with questions asking about the reasons for the audit request and the objectives of the audit.

Questionnaire size: 7 pages

Level of detail in data acquisition: Total consumption data for the last 4 years required, monthly consumption and costs for the last year.

Questionnaire structure (blocks of inputs requested):

1. General information
2. Contents of factory's request on energy audit
3. Energy management condition
4. Energy use condition
5. Annual utility consumption
6. Annual production
7. Energy consumption in last year

Intended use (and users):
To establish objectives for the audit and to gather necessary information to prepare the audit.

Source:
Energy Conservation Technology Center – KAPE (Poland)

2.2.3 Questionnaires for Combined Heat and Power (CHP) applications

2.2.3.1 COGENCO Questionnaire

Comment (brief summary and useful features):
Questionnaire to evaluate the feasibility of cogeneration or trigeneration.
For a preliminary data collection.
Data on electricity and thermal energy consumption are collected on a monthly base. Electricity consumption can be entered also per tariff. Default electrical tension (kV) of the used electric energy is asked. Daily and night time thermal energy consumption can be entered separately.

Questionnaire size: 7 pages.

Level of detail in data acquisition:
Monthly data for production hours differentiated per day, night and weekend.
Monthly data for electricity consumption by tariff. The monthly maximum power is required.
Monthly data for day and night time thermal and refrigeration energy consumption.

Questionnaire structure (blocks of inputs requested):
1. General information
2. Production schedule
3. Electrical consumption
4. Thermal consumption
5. Annex A: Working hours industry, monthly (day, night,total)
6. Annex B: Electrical consumption, monthly (per tariffs, total), monthly maximum per tariffs.
7. Annex C: Thermal consumption, monthly (day, night, fuel consumption, total).
8. Annex D: Cold consumption, monthly (day, night, total)

Intended use (and users):
Specific for CHP application.
For a preliminary visit or to be sent to the company before the visit on-site.

Source:
Cogenco s.r.l., Sistemi di cogenerazione (Italy)

2.2.3.2 Micro CHP Questionnaire

Comment (brief summary and useful features):
For the evaluation of the feasibility of a micro CHP unit.
Detailed energy tariffs (min, max, average) and consumptions are required.
Information about the financial support schemes for investment are required.
About the location: height from see level is asked.
About boilers: thermal efficiency, operating time and dimensions are asked.

Questionnaire size: 10 pages.

Level of detail in data acquisition: Monthly energy consumption, summer/winter energy consumption; detailed electric tariffs required; inside day/night temperatures required.

Questionnaire structure (blocks of inputs requested):

1. General information about the lodge
2. General data of the building
3. Information about dimensions, areas and windows
4. Insulation and refurbishment of the building
5. Temperature and domestic hot water
6. Information about the accommodation (occupation)
7. Electric energy consumption
8. Supply of electric energy
9. Heating system
10. Fuel consumption for heating and hot water
11. Information about the investment
12. Fuel prices
13. Taxation
14. General further information (RES systems already installed, miscellanea)

Intended use (and users):
Specific for CHP application. To be filled in by the auditor or by the company.

Source:
Austrian Energy Agency (Austria). By contract with the European Commission and the Federal Ministry of Economics and Labour.

2.2.3.3 CHP Initial Walk Thru Question List

Comment (brief summary and useful features):
For preliminary feasibility analysis for CHP applications.
Among the data required on existing CHP plants: the CHP location; distances from the possible new location of the equipment to electric feeders.
Among the data required in Other Questions: it is asked if there is interest to lease the facility and if there is interest the CHP facility to be third party owned.

Questionnaire size: 4 pages.

Level of detail in data acquisition: Monthly energy consumption is asked to be entered.

Questionnaire structure (blocks of inputs requested):
1. Questions for the facility operator – obtain monthly bills
2. Industrial loads
3. Commercial loads
4. Electric parameters
5. Overall location and Equipment Questions
6. Other Questions

Intended use (and users):
Specific for CHP application. To be filled in by the auditor or by the company.

Source:
U.S Department of Energy. Energy Efficiency and Renewable Energy
Website: http://www.eere.energy.gov/de/docs/walk_thru_checklist.xls

2.2.4 Questionnaires for Buildings

2.2.4.1 ATISAE Questionnaire

Comment (brief summary and useful features):
Excel format for preliminary energy audits in large office buildings, hospitals, etc.
Among the data required on burners combustion gases:percentage of oxygen; temperature of the exhausted gases; percentage of methane equivalent Bacharach index; colour of smoke (black/white). Make, type of control of burners and inlet fuel temperature are also required.
Among the data required on the building (size, type of walls, windows) and on the existing installations: heating, air conditioning, water heating.

Questionnaire size: 22 pages.

Level of detail in data acquisition: Monthly data for building occupation and energy consumption, and monthly hours of equipment operation.

Questionnaire structure (blocks of inputs requested): Not very well structured

1. General information and occupation of buildings
2. Equipment description
3. Building structure and walls
4. Energy consumption

Intended use (and users):
Specific for large non-residential buildings. To be filled in by the auditor during the visit on-site.

Source:
ATISAE

2.3 *Software Tools*

By Claudia Vannoni, Department of Mechanics and Aeronautics - Sapienza University of Rome

2.3.1 Introduction

In this section it is reported a brief description of the main features of the software tools screened by the Consortium in the framework of the work-package 2 of the Einstein project. Therefore, this overview does not pretend to be exhaustive, while it has to be considered a reference for future updates and improvements.

The main purpose of this survey was to collect useful inputs and references for the further development of the EINSTEIN tool-kit, especially the EINSTEIN software tool.

The review includes the following products:

- Software tools for the (self-) assessment of the industrial processes and building energy demand,
- Software tools for benchmarking,
- Design, calculation and simulation software tools for
  - Heat recovery,
  - Heat generation systems,
  - Heat distribution networks.
- Miscellanea of engineering tools and calculators.

2.3.2 Software tools for the (self-) assessment of the energy demand

2.3.2.1 Tools for the (self-) assessment of the overall industrial energy consumption

Software tool: POSHIP Tool for data analysis and (solar process heat) system simulation

Features	Description	Details
Name of the product(s)	-	
Software developer company/institute	energyXperts.BCN (Spain)	
Users/Target Groups	Industrial energy audits and design of solar process heat plants	
Applications	Fast analysis of industrial heat demands, including a module for estimation of missing data. Fast design and feasibility analysis of solar process heat systems	
Main utilities and modules	Questionnaire for data acquisition Module for fast estimate of missing data and consistency checking Analysis of heat demand by temperature level Feasibility study of solar process heat systems (incl. a standard TRNSYS system for system simulation)	Fast analysis limited to small and medium industries with a maximum of 4 processes
Main Outputs	Statistics and graphical presentation of present industrial heat demand Complete and consistent parameter set representing the industry in a standard model Feasibility analysis of solar process heat systems	
Reporting	Automatic generation of graphics and tables (MS Excel format)	
Data libraries	Libraries for all main modules (See above)	
Program	MS Excel	
Demo version	-	
Language(s)	English, Spanish, Catalan	
Free/commercial	Not disseminated. Available on request.	
Available at:	-	
Use for EINSTEIN	The POSHIP tool is for data analysis is the predecessor of the EINSTEIN software tool. The features of this tool will be included (in an improved version) within the new tool	
Additional comments		

Additional information

The POSHIP energy audit methodology foresees eight steps.

In Step 1 the final energy consumption (FEC) is calculated from the data on fuel and electricity consumption delivered in a two-page questionnaire. The distribution of the FEC on the different fuel types is analysed.

In Step 2 the useful supply heat (USH) produced by each of the existing heat supply equipment is analysed. Numbers obtained from equipment data (nominal power, hours of operation) are cross-checked with data obtained from the fuel consumption.

In Step 3 the useful process heat (UPH) consumption is analysed for every process. If data are available, this consumption is directly calculated from process parameters, such as fluid circulation, inlet and process temperature, hours of circulation, parameters for thermal losses of baths, ovens, etc.

These results then are cross-checked with the data from the heat supply system (Step 2).
In the following steps the resulting process heat demand is analysed and classified by the different processes (Step 4) and temperature levels (Step 5). Both the cumulative UPH demand as a function of the process temperature PT and the cumulative USH demand as a function of the process supply temperature (PST) are plotted.

Once the analysis of the process heat demand is available, the processes suitable for coupling of solar energy are selected. Depending on the temperature level of the selected processes an appropriate solar collector technology is chosen.

The input parameters for the standard TRNSYS system are obtained automatically from the MS EXCEL – sheet for data analysis (Step 6) specifying the parameters of the solar system and the characteristic parameters for the process heat demand of each process.

Then a parametric study is carried out varying the solar system size (within the constraints given by the specific case: available roof area and upper limit given by 60 % solar fraction (technical potential). In an iterative way the system size is determined that corresponds to the limits for the technical potential, and for the economic potential (Step 7). The results of this analysis are represented in a summary Table (Step 8).

In a short (about 10 – 15 page) report that can be easily created with the automatically generated Tables and Figures from the tool, the designed can be proposed to the companies, together with a summary sheet. The reports included a description of the proposed systems, an analysis of the monthly energy gains and an economic analysis.

The tool is accompanied by a standard TRNSYS system used for dynamical system simulations. This standard system simulation tool (see also TransENERGY – MEDISCO) can be used simulate solar process heat supply simultaneously for up to 4 industrial processes.

Reference:
POSHIP. The Potential of Solar Heat for Industrial Processes. Final report (Project No. NNE5-1999-0308). Aiguasol website: www.aiguasol.com/poship.htm

Software tool: E-Check tool

Features	Description	Details
Name of the product(s)	E-Check tool	
Software developer company/institute	Consortium of the IEE co-funded project E-CHECK in Craft SME - From Colleague to Colleague: Energy Check in Small and Medium Craft Enterprises	http://www.energy-check.org/
Users/Target Groups	E-Checkers, Small and Medium Craft Enterprises	
Applications	QuickCheck to identify general energy saving potentials, a detailed background consumption check to identify energy saving potentials on crossover technologies as well as a detailed craft specific process consumption check resulting in recommendations for energy saving measures in the craft SME	Final uses: thermal and electricity Braches addressed: BAKERS in Germany BRICKLAYERS/GLAZERS/PAINTERS in Greece BUTCHERS in Spain CARPENTERS in Bulgaria FOOD PRODUCERS in Ireland
Main utilities and modules	MS excel-based tools are customised according the CRAFT branch and include: 1) Quick Check sheet Input: Type of fuel, Annual heat consumption, Fuel price Function: First check 2) Background Consumption sheet 3) Process Consumption sheet Sheet 2 and 3: For each equipment and final use the working sheet includes: a data acquisition mask a result mask including crosschecking with standards and benchmarking a check-list of energy efficiency measures (to be selected) 4) Results Analysis of the Status Quo (energy consumption and costs: total and by equipment/use); Recommendations for setting up an activity plan on energy and costs saving measures according priorities: High priority Medium priority Low priority	2) Equipment included in the Background Consumption sheet: Boiler Cooling of spaces Warn water preparation Insulation Lighting Ventilation Office equipment Vehicles Energy generation **(**PV, **solar thermal, CHP)** 3) Equipment included in the Process Consumption sheet: Key performance indicators (energy benchmarks) Compressed Air Motors and Drivers Fans and pumps Steam systems Branch unit operations (e.g drying, …) Types of recommendation: High priority " - Quick and easy practicable measures (short term, i.e. within the next quarter) - No investment costs, - Assessment of the energy and costs saving potential" Medium priority " - Mid term practicable measures, i.e. within the next year - Low investments - Assessment of the energy and costs saving potential" Low priority " - Long term practicable measures, i.e. within the next two or three years - High investment - Assessment of the energy and costs saving potential."

Features	Description	Details
Name of the product(s)	E-Check tool	
Main Outputs	Analysis of the Status Quo (energy consumption and costs: total and by equipment/use); Recommendations	
Reporting	Result in text and figures.	No graphics.
Data libraries		
Program	MS Excel	
Demo version	In English for fruit processing, bakeries and dairies	
Language(s)	English, Spanish, German, Greek,	
Free/commercial	n.a.	Project coordinator: B.&S.U. Beratungs- und Service-Gesellschaft Umwelt mbH rrieck@bsu-berlin.de www.bsu-berlin.de
Available at:	http://www.energy-check.org/home-ie	
Use for EINSTEIN	Focus on the auditing time reduction (the utilities and the structure of the tool help auditors to perform fast evaluations) The questionnaire for data acquisition is integrated at each auditing step to benchmarks, fast calculators and check-lists able to give intermediate results. The results at each intermediate step is saved and included in the final overall result. Recommendations are divided in high, medium and low priorities Benchmarking include National standards (e.g. for thickness of insulation) List of recommendation for thermal equipment and for processes (Food, dairies,..) At the top of the sheet it can be recall an set of fields	
Additional comments		

Software tool: Internet-Energie-Check

Features	Description	Details
Name of the product(s)	Internet-Energie-Check	
Software developer company/institute	Bremer Energie-Konsens GmbH (Climate Protection Agency of Bremen), Germany	www.energiekonsens.de
Users/Target Groups	Internet-Energie-Check is an online tool oriented to small and medium enterprises of the craft and service sector. The target group are companies that have no or only few access to information on energy savings.	
Applications	The tool is branch specific for a great variety of sectors such as hairdressers, butchers, carpenters, supermarkets, banks (offices), etc.	
Main utilities and modules	The tool performs the energy check in two steps: - A fast check: in this step the energy consumption of the company (annual fuel and electricity bills) is compared to branch average figures (benchmarking). For this purpose the specific electricity and fuel consumption is calculated. Based on this, a rough estimation of the saving potential is given. - A detailed check: check - lists for different subsystems and system concepts exist such as boilers, pumps, hot water preparation, piping, building insulation, office equipments, ventilation, compressed air equipment, lighting, etc.	
Main Outputs	For each sector the following information are displayed usually in three steps: - Basics: general information on energy in the corresponding subsystem - Check: acquisition of detailed data, evaluation and proposals for saving measures - Tips: general recommendations for energy efficiency improvements.	
Reporting		
Data libraries	For several subsystems additional information are made accessible via help-menus or links to other web-sites.	
Program	Web –based application	
Demo version		
Language(s)	German	
Free/commercial	Accessible online	
Available at:	http://www.internet-energie-check.de/index.php	
Use for EINSTEIN	Sectors of interest for EINSTEIN are: - food industry (bakeries, butchers, supermarkets) - metal treatment (metal-mechanic workshops) - wood processing (carpenter workshops, paper and printing) - and in general, office buildings.	
Additional comments	The tool is easy to understand and to handle for non-experts.	

Software tool: Energy Self-Audit Scheme energy and emission calculator

Simple excel based software for calculation of energy consumption and CO_2 emissions (monthly, annually) developed in the framework of the Energy Self-Audit Scheme project.

Input data: fuel, energy and heat consumption, production.
Output: report on energy consumption, CO_2 emissions, characteristics.

Available at:
http://www.kape.gov.pl/PL/Programy/Programy_UniiEuropejskiej/SAVE/aP_ESAS/dzialania.html

2.3.2.2 Tools for the energy performance assessment of industrial buildings

Software tool: EPA-NR Software

Features	Description	Details
Name of the product(s)	EPA-NR Software version 1.7.6.19	
Software developer company/institute	EPA-NR (Energy Performance Assessment of Existing Non-Residential Buildings) Consortium	www.epa-nr.org
Users/Target Groups	Energy Auditors, consultants and Policy makers	
Applications	Energy (Electricity, heat and cold) calculation for existing non-residential buildings	Offices; Education buildings; Health care and optionally Hotels and restaurants; Sports facilities; Wholesale and retail trade service buildings; Other types of energy-consuming buildings.
Main utilities and modules	EPA-NR core tool consists of: a calculation engine; input and output interfaces; libraries. The calculation engine - the same for all member states - provides an interface to gain access to an external (country specific) databases. The calculation engine has a modular setup that allows specific modules to be replaced by other (national) modules.	The energy calculation includes: Space heating; Space cooling; Ventilation; Humidification and dehumidification; Hot water; Electrical energy for Lighting; Pumps and fans; Other equipment.
Main Outputs	Building Energy Performance. Building Energy Performance Certificate. Energy and economic savings from alternative scenarios.	
Reporting		
Data libraries	Component database; Climate databases; Constant default values (physical constants, utilisation factor of heat gains); Organisational default values (working hours, internal heat gain).	
Program		
Demo version	Full version for free	Free of charge by downloading, completing and returning the "EPA-NR Registration form and user license"
Language(s)	Core software tool in English	
Free/commercial	Free	
Available at:	http://www.epa-nr.org/115.html	
Use for EINSTEIN	In principle the software is applicable in all European member states by incorporating context dependent data into the core calculator.	Not focused on manufacturing building It has to be checked whether an automatic communication between Einstein tool and EPA-NR (via configuration and load files) would be possible
Additional comments		

Additional information

The main goal of the EPA – NR software is an energy calculation for existing non-residential buildings (ENR) leading to an assessment of the energy performance of the building, as shown in the next figure. Additional goals are the output of an energy-performance certificate, and advice on which measures to take that improve the energy performance, taking into account also the costs.

EPA-NR as a project delivers only one calculation method for the energy performance, according to the mainstream of the EU countries. However, the software of EPA-NR will have a flexible setup, guaranteeing that member states that want to replace certain parts of the method by their own methods can do so with minor effort. This flexibility will consist of three parts:

- The input and output interfaces (respectively for the input of a building and for the output of the calculated results) will be standardised and be as independent as possible of the algorithms in the calculation engine;
- National data is provided through interfaces with national databases or libraries in a standardized matter;
- The calculation engine has a modular setup that allows specific modules to be replaced by other (national) modules. This will be accomplished by breaking up the calculation engine into a fixed set of smaller blocks, each with a well-defined interface towards the other blocks.

For the input of the (project-dependent) building data and the output of the calculated results, the calculation engine will contain a standard input interface and a standard output interface. These interfaces connect to separate pieces of software for pre and post processing. These parts contain all context-specific functionalities as preferred by each member state.

Pre-processing functions can be viewed as mapping functions that translate information as obtained from the user interface into a format that the calculation engine can use. (…)
Post-processing functions use output information from the calculation engine (and perhaps also input information) and transform it into meaningful output for the end user. (…)
Another example of pre-processing and post-processing is the coupling to external applications. A pre-processing function might take the output from another application for use as project input in EPA-NR, probably after some way of data processing. In the same way, the output results of EPA – NR might serve as input for another application, interfaced by a post-processing function. (…)

The project of EPA-NR does not deliver a full calculation tool according to the needs of every country, it only supplies a framework for member states to do so. EPA-NR will deliver a reference implementation, showing the possibilities in one setup. This setup consists of the calculation engine, which is country-independent, a basic user interface in English for the input from and the output to the end user, the structure of all databases, and filled databases for the countries that participate in the project. This is shown in the figure.

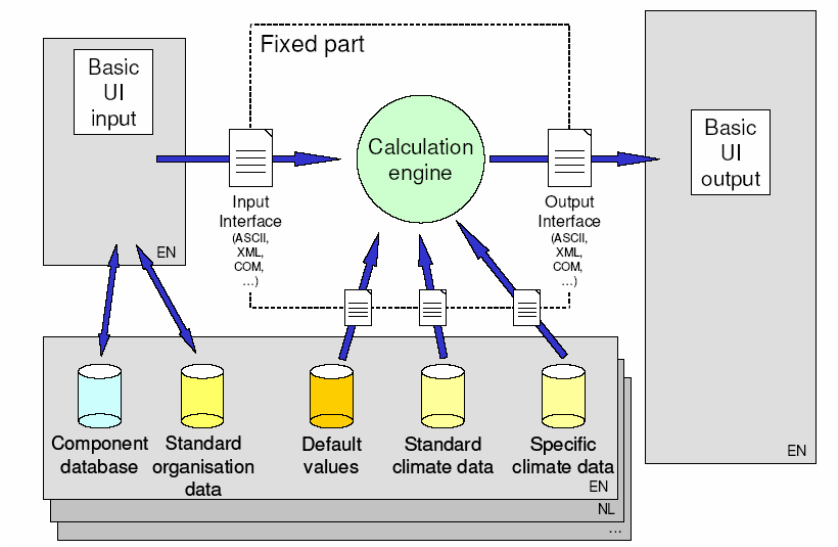


Figure 2.3-1 Structure of the EPA – NR software tool. Source: Final report on functional specification of the EPA-NR software.

Reference:

Luc Soethout, L. et al. (June 2007). *Functional specification of the EPA-NR software.* Final report. EPA-NR Project (EC Contract: EIE/04/125/S07.38651).EPA-NR website: www.epa-nr.org

Software tool: Building Energy Analyzer Pro

Features	Description	Details
Name of the product(s)	Building Energy Analyzer Pro	
Software developer company/institute	InterEnergy Software (U.S.A.)	http://www.interenergysoftware.com
Users/Target Groups	HVAC and Power Generation consultants, HVAC and Power Generation system designers and operators, Facility managers, Gas and electric utility marketers, ESCO engineers and marketers, Equipment marketers, Energy marketers.	
Applications	HVAC and power generation system screening tool for commercial and industrial building	Industrial Applications: Single-story slab on grade industrial facility with three independently controlled zone types (Office, Manufacturing, Process Room). Dehumidification system is selectable for each zone type. Refrigerated Warehouse: Single-story slab on grade construction, with refrigerated storage for meats, deli, produce, and freezer, loading dock and small office. Glazing is not user controllable (fixed amount of glazing is modelled for office only).
Main utilities and modules	Estimate loads and costs associated with air-conditioning, heating, and on-site power generation. Compare the performance of standard and high efficiency equipment.	
Main Outputs	Hating and cooling loads, gas and electricity consumption, system configuration specifics, economics (life-cost), emissions.	
Reporting	Tabular reports: Two levels of details (short and detailed), Baseline and alternative results on annual or monthly basis.	
Data libraries	Generation equipment, HVAC equipments, utility rates, weather, specific building types.	
Program		
Demo version	Not available	
Language(s)	English	
Free/commercial	Commercial	
Available at:	http://www.interenergysoftware.com/BEA/BEA.htm	Brief description and user manual
Use for EINSTEIN	Building energy balances and performance simulation	CHP applications: Hot water, space heating/cooling, thermal storage, dehumidification
Additional comments	U.S. locations, equipment databases and unit of measurements	

Other software tools for the energy performance assessment of buildings are reported in:

Topic report auditors' tools. AUDIT II, Save Project. Motiva website:
http://www.motiva.fi/fi/english/english/energyaudits/auditiiproject.html

2.3.3 Benchmarking software tools

Software tool: BESS - Web based monitoring and benchmarking tool

Features	Description	Details
Name of the product(s)	BESS - Web based monitoring and benchmarking tool	
Software developer company/institute	Developed in the framework of the IEE co-funded project BESS - Benchmarking and Energy management Schemes in SMEs	www.bess-project.info
Users/Target Groups	Companies	
Applications	Energy benchmark in food and drink sector (dairies, meat industry and bakeries) in 11 member countries and in 2 accession countries (Bulgaria and Norway). ExBESS addresses new industrial SME sectors in and beyond the food and drink industry e.g. textile/carpet, machinery, crafts (e.g. installers)	Countries involved in ExBESS: Italy, Belgium and Portugal and 5 new member states: Slovakia, Czech Republic, Poland, Latvia and candidate Romania
Main utilities and modules	The web-based benchmarking procedure foresees 4 steps: Step 1 (Company): selecting country, sector and input weighting factors, Step 2 (Energy): reporting annual energy consumption and boiler efficiency for relevant energy carriers (for 3 years), Step 3 (Production): reporting annual production volume by product, Step 4 (Results): benchmark results in terms of specific energy consumption (3 years).	4 adjustment parameters are foreseen: climate (heating and cooling), capacity utilization, production mix, boiler efficiency.
Main Outputs	Yearly benchmarking of energy data based on national data gathered by national systems	
Reporting	Online (graphic) reporting	
Data libraries		
Program		
Demo version	Web-based tool for public	
Language(s)	English	
Free/commercial	Free	
Available at:	http://bess.bekk.no/bess/AHIntro.aspx	
Use for EINSTEIN	Benchmarking module development and benchmarks database.	
Additional comments		

2.3.4 Design, calculation and simulation software tools

2.3.4.1 Introduction

The software tools reported in this section have been grouped according their main area of application in:

- Heat recovery potential evaluation and heat exchanger network design software tools,
- Software tools for heat generation systems design and simulation software tools,
- Software tools for heat distribution networks design and simulation software tools.

Furthermore, the software tools for design and simulation of heat generation systems have been classified by technology as follows:

- Boilers and Furnaces,
- CHP,
- Solar heat,
- Biomass.

In some cases, software tools can be used to design and to simulate the energy and economical performances of different technologies, and to generate cross-technology results. Such tools have been included in the “multipurpose” software tools category.

Specific bio - fuels and geothermal plants software tools have not been included yet in this survey. The searching activities will therefore continue in order to fulfil the actual lacks of information.

In addition to the software tools described in this report, it is important to mention that a comprehensive review of the existing products on process heat is currently leaded by the energy agency of the Dutch Ministry of Economic Affairs, SenterNovem.
SenterNovem supports the Netherlands Knowledge Network on Computer-Aided Process Engineering (CAPE) in co-operation with CAPE-NL (the Dutch national platform for Computer Aided Process Engineering) and Exergy.nl (the Dutch national working party “Process integration and Exergy analysis”).
In the framework of this network a portal focused on engineering tools for process industries was established.
The current database includes a brief description of the main software features, among which:

- Brief description of the product;
- Product specifications (supplier, hardware, user-friendliness, time to learn, supporting manuals, use categories, services);
- Keywords to identify the related topics and fields of application.

The list of software tools is available at the SenterNovem website (http://www.technology.novem.nl/en/processtools/tools.html) and in November 2007 it included 106 products.

2.3.4.2 Heat recovery systems and heat exchanger networks

Software tool: Pinch Energy Efficiency – PE²

Features	Description	Details
Name of the product(s)	PE²	Pinch Energy Efficiency
Software developer company/institute	JOANNEUM RESEARCH, Institute of Sustainable Techniques and Systems (Austria)	www.joanneum/nts
Users/Target Groups	Industries and Auditors of Industrial Processes	
Applications	Pinch Program for industrial companies	
Main utilities and modules	Pinch analysis, ideal heat exchanger network calculation, Total cost assessment, visualisation in Sankey	
Main Outputs	Potential for Heat Recovery (based on heat exchanger network), remaining energy demand to be supplied by external energy sources and the corresponding temperature levels	
Reporting	MS Excel report	
Data libraries	Library on PE² projects, library on heat exchanger costs and energy costs	
Program	C Sharp	
Demo version	Available in February 2008	
Language(s)	English	
Free/commercial	Commercial	
Available at:	www.styrian –promise.at/PE2	In February 2008
Use for EINSTEIN	Heat Recovery Module	
Additional comments	Batch processes included, total cost assessment tool included	

Software tool: HINT

Features	Description	Details
Name of the product(s)	Hint	
Software developer company/institute	Martin Angel, unknown company	http://www.heatintegration.com/
Users/Target Groups	Industries and Auditors of Industrial Processes	
Applications	Pinch Program	
Main utilities and modules	Pinch analysis, manual heat exchanger calculation, cost calculation and heat exchanger design, possibility to include external utilities	
Main Outputs	Large variety of diagrams, theoretical maximal heat recovery, Heat exchanger design and costs for manually entered heat exchangers	
Reporting	HTML report	
Data libraries		
Program		
Demo version		
Language(s)	English/Spanish	
Free/commercial	Free	
Available at:	http://www.heatintegration.com/	No longer available on the web
Use for EINSTEIN	Heat Recovery Module	
Additional comments	Very good approaches, many mathematical diagrams, however unstable program	

Software tool: SUPERTARGET

Features	Description	Details
Name of the product(s)	Supertarget	
Software developer company/institute	Linnhoff March Targeting House	http://www.linnhoffmarch.com/software/software.html
Users/Target Groups	Industries and Auditors of Industrial Processes	
Applications	Pinch Program	
Main utilities and modules	Extraction of process streams out of process simulation programs possible, pinch analysis, including automatic network design	
Main Outputs	Heat exchanger network design and economic evaluation, emission calculations	
Reporting	Yes	
Data libraries		
Program		
Demo version	Yes	http://www.linnhoffmarch.com/software/supertarget/intro.html
Language(s)	English	
Free/commercial	Commercial	Expensive
Available at:	http://www.linnhoffmarch.com/software/software.html	
Use for EINSTEIN	Heat recovery module	
Additional comments	Long history, well developed, however more suitable for high temperature applications.	

2.3.4.3 Simulation and evaluation software tools for heat generation systems

2.3.4.3.1 Multipurpose software tools

Software tool: EnergyPro

Features	Description	Details
Name of the product(s)	EnergyPro	
Software developer company/institute	EMD (Denmark)	
Users/Target Groups	Designers of heat, cold and combined heat and power supply systems	
Applications	Energetic and economic calculation of complex systems with several demands and several supply equipments	
Main utilities and modules	Fuels Supply Demand profiles Control strategy (incl. periods of priority) Economic and environmental analysis	
Main Outputs	Energetic and economic analysis (yearly, monthly totals, hourly profiles of energy flows,...)	
Reporting	Automatic report generation included	
Data libraries	Libraries for all main modules (See above)	
Program	-	
Demo version	Free demo version	
Language(s)	English, German, Polish, Swedish, Danish, Latvian, Lithuanian, Estonian	
Free/commercial	Commercial	
Available at:	www.emd.dk/energyPRO	
Use for EINSTEIN	Simulation of complex heat and cold supply systems possible. Communication with EnergyPRO can be done via load files Dynamic simulations probably are based on (time dependent) energy flows. No explicit formulation of forward/return mass flows and real temperature differences is done.	Main limitations: Storage (on heat supply side) can be considered, but no heat exchanger network can be modelled. This has to be included into the demand file calculations. It has to be checked whether an automatic communication between Einstein tool and energyPRO (via configuration and load files) would be possible.
Additional comments		

Additional information

The following description is given at the EMD website (www.emd.dk).

energyPRO is a Windows-based modelling software package for combined techno-economic analysis and optimisation of both cogeneration and trigeneration projects as well as other types of complex energy projects with a combined supply of electricity and thermal energy (steam, hot water or cooling) from multiple different energy producing units.

energyPRO is typically used for techno-economic analysis of different energy projects such as district heating cogeneration plants with gas engines combined with boilers and thermal storage, industrial cogeneration plants supplying both electricity, steam and hot water to a site, cogeneration plants with absorption chilling (tri-generation), biogas fuelled CHP plants with a biogas store, biomass cogeneration plants, but other types of projects, e.g. geothermal, photovoltaic or wind energy projects can also be analysed and detailed within the software.

When using energyPRO, it is possible to include the benefits of thermal storage. (...)

When using energyPRO, the user is able to input a wide range of data on different energy plant types, degree day data and other external conditions, demands and profiles, plant operating strategies, tariff structures, revenues and operating costs, investments and finance arrangements, plant depreciation and taxation models within the same calculation.

The software also allows the user to include the relationships between other variables, such as ambient temperatures, solar gain or wind chill, thus allowing very detailed modelling techniques. Based on the inputs, the unique programming in energyPRO optimises the operations of the plant against technical and financial parameters to provide a detailed specification for the provision of the defined energy demands, including heating, cooling and electricity use.

energyPRO also provides the user with a detailed financial plan in a standard format accepted by international banks and funding institutions. This includes presentation of the operating results for the project, monthly cash flows (up to 40 years), income statements (P&L), balance sheets and key investment figures such as NPV, IRR and payback time.

The software enables the user to calculate and produce a report for the emissions (CO2, NOX, SO2, etc.) by the proposed project.

Figure 2.3-2 Screenshot of the software tool. Source: EMD website

The picture above shows the calculated operation periods during a 20 days period for a district heating CHP energy plant with two gas engines, operating on an electrical triple tariff structure, covering a specified heat demand and using a thermal store as buffer. As the electricity price is low during weekends, it has been decided to avoid operation of the engines during the weekend and instead accumulate the surplus heat in a thermal store during normal weekdays to cover for the heat demands in the weekends. This secures a better financial result for the plant. Please notice that the thermal store is full every Friday at midnight.

Reference:
EMD website (www.emd.dk)

Software tool: IPSEpro

Features	Description	Details
Name of the product(s)	IPSEpro	
Software developer company/institute	SimTech Simulation Technology (Austria)	http://www.simtechnology.com/english/SimTech.php
Users/Target Groups	Energy supply, engineering firms and other engineering design offices and consultancies, component manufacturers	
Applications	Quick assessments, detailed engineering, design, retrofitting, repowering, and acceptance testing for: Conventional thermal power plants Cogeneration plants Combined cycle plants Industrial heat and power supply Refrigeration processes Desalination processes District heating systems Waste heat recovery Solar energy Energy from biomass …	
Main utilities and modules	IPSEpro has a modular structure based on the concept of standardized components used to build the model of a process. Most important modules are: MDK (Model Development Kit) to define new models. PSE (Process Simulation Environment) to create a process model based on components from a library (data is entered directly in the graphic flowsheet). PSServer for on-line optimisation and monitoring system. PSOptimize to find the process parameters that optimize given criteria.	New process and component models can be created by the user Output of other software tools can be used as input
Main Outputs	Energetic and economic analysis and optimisation	
Reporting		
Data libraries	Several model libraries for standard applications available.	The database for apparatus/unit operations can be manipulated and customised. Communication with other databases is possible.
Program		
Demo version	Not available online	
Language(s)	English	
Free/commercial	Commercial	
Available at:	http://www.simtechnology.com/IPSEpro/english/IPSEpro.php	
Use for EINSTEIN	Simulation of complex heat and cold supply systems possible. Communication with IPSEpro can be done via load files.	
Additional comments		

Software tool: RETScreen

Features	Description	Details
Name of the product(s)	RETSCreen - International Clean Energy Project Analysis Software	
Software developer company/institute	RETScreen International is managed under the leadership and ongoing financial support of Natural Resources Canada's (NRCan) CANMET Energy Technology Centre - Varennes (CETC-Varennes).	
Users/Target Groups	Anybody analysing Renewable Energy and Energy Efficiency Projects	
Applications	(Preliminary) Feasibility studies for the several clean energy technologies for industrial and non - applications	Clean energy technologies: Energy Efficiency Measures Power Heating Cooling CHP CCP CCHP User defined system.
Main utilities and modules	The RETScreen methodology compares a "base case" (typically the conventional technology or measure) and a "proposed case" (the clean energy technology) in 5 steps/modules: Energy Model Cost Analysis Greenhouse Gas (GHG) Analysis (optional) Financial Sensitivity & Risk Analysis (optional).	Online manual, tools, engineering textbooks, training material available for support.
Main Outputs	Evaluation of the energy production and savings, life-cycle costs, emission reductions, financial viability and risk for various types of energy efficient and renewable energy technologies (RETs).	
Reporting	Available	
Data libraries	Product, cost and climate databases	
Program	MS Excel	
Demo version	Full version for free	
Language(s)	English	
Free/commercial	Free	
Available at:	http://www.retscreen.net/ang/d_o_view.php	
Use for EINSTEIN	Useful for the development the energetic and economic evaluation module. Especially the economic and financial assessment is on the focus. Clean technologies of interest are : Combined Heat & Power Biomass Heating Solar Air Heating Solar Water Heating Ground-Source Heat Pumps.	Information on biogas, biomass including material properties. Production credits, GHG emission reduction credits, incentives and taxes maybe taken into account for the financial assessment.
Additional comments	Case studies collection downloadable from: http://www.retscreen.net/ang/t_case_studies.php	

Additional information

The RETScreen International Clean Energy Project Analysis Software can be used worldwide to evaluate the energy production, life-cycle costs and greenhouse gas emission reductions for various types of proposed energy efficient and renewable energy technologies (RETs). The RETScreen Software has been developed to overcome the barriers to clean energy technology implementation at the preliminary feasibility stage.

All clean energy technology models in the RETScreen Software have a common look and follow a standard approach to facilitate decision-making – with reliable results. Each model also includes integrated product, cost and weather databases and a detailed online user manual, all of which help to dramatically reduce the time and costs associated with preparing pre-feasibility studies.

Fundamental to the RETScreen Software is a comparison between a "base case"—typically the conventional technology or measure—and a "proposed case"—the clean energy technology. This has very important implications for how the user specifies costs: RETScreen is ultimately not concerned with the absolute costs, but rather the incremental costs—the costs of the proposed case that are in excess of those for the base case. The user can either enter incremental costs directly or enter both the full cost associated with the proposed case and any credits stemming from base case costs made unnecessary by the proposed technology.

In the RETScreen Software, the energy benefits are the same for both the base case and the proposed case. On the other hand, the costs will not, in general, be the same for the base case and the proposed case: typically, the proposed case will have higher initial costs and lower annual costs (i.e. savings). Thus RETScreen's analysis task is to determine whether or not the balance of costs and savings over the life of the project make for a financially attractive proposition.

While a different RETScreen Clean Energy Technology Model is used for each of the technologies covered by RETScreen, the same five step standard analysis procedure is common to all of them:

- STEP 1 - Energy Model (and sub-worksheet(s))

In this worksheet, the user specifies parameters describing the location of the energy project, the type of system used in the base case, the technology for the proposed case, the loads (where applicable), and the renewable energy resource (for RETs). In turn, the RETScreen Software calculates the annual energy production or energy savings. Often a resource worksheet (such as the "Solar Resource" or the "Hydrology and Load" worksheet) or an "Equipment Data" worksheet—or both—accompanies the Energy Model worksheet as sub-worksheet(s).

- STEP 2 - Cost Analysis

In this worksheet, the user enters the initial, annual, and periodic costs for the proposed case system as well as credits for any base case costs that are avoided in the proposed case (alternatively, the user can enter the incremental costs directly). The user has the choice between performing a pre-feasibility or a feasibility study. For a "Pre-feasibility analysis," less detailed and less accurate information is typically required while for a "Feasibility analysis," more detailed and more accurate information is usually required.

- STEP 3– Greenhouse Gas (GHG) Analysis (optional)

This optional worksheet helps determine the annual reduction in the emission of greenhouse gases stemming from using the proposed technology in place of the base case technology. The user has the choice between performing a simplified, standard or custom analysis, and can also indicate if the project should be evaluated as a potential Clean Development Mechanism (CDM) project. RETScreen automatically assesses whether or not the project can be considered as a small-scale CDM project.

- STEP 4 - Financial Summary

In this worksheet, the user specifies financial parameters related to the avoided cost of energy, production credits, GHG emission reduction credits, incentives, inflation, discount rate, debt, and taxes. From this, RETScreen calculates a variety of financial indicators (e.g. net preset value, etc.) to evaluate the viability of the project. A cumulative cash flow graph is also included in the financial summary worksheet.

- STEP 5 - Sensitivity & Risk Analysis (optional)

This optional worksheet assists the user in determining how uncertainty in the estimates of various key parameters may affect the financial viability of the project. The user can perform either a sensitivity analysis or a risk analysis, or both.

Reference:

RETScreen International - Clean Energy Decision Support Centre. *Clean Energy Project Analysis. RETScreen® Engineering & Cases Textbook.* Third edition. RETscreen website: http://www.retscreen.net

Software tool: GREENIUS - Green Energy System Analysis

Features	Description	Details
Name of the product(s)	GREENIUS - Green Energy System Analysis	
Software developer company/institute	Deutsches Zentrum für Luft und Raumfahrt e.V. DLR – TT – Solarforschung (Germany) Fachhochschule für Technik und Wirtschaft Berlin - FHTW Berlin (Germany)	
Users/Target Groups	Renewable energy plants designers	
Applications	Fast assessment tool for Renewable energy power plants (solar concentrating power plants, PV, Wind farms, Fuel cells) and for solar process heat plants.	Main focus on renewable electricity. The solar process heat simulator is under development.
Main utilities and modules	Main interfaces: Project site (location, meteorological conditions, load curve, energy tariff); Technologies (technical parameters); Economics (costs, timing, financing).	Parabolic trough models, storages and conventional boilers have been implemented to allow calculation of heat balances at temperatures which can be defined by the user. One- and two-shift load profiles are available.
Main Outputs	Annual energy saving and CO_2 saving; cash flow; levelized energy cost	
Reporting	Several tables and graphics can be selected and visualised	
Data libraries	Meteorological data; Technologies.	
Program		
Demo version	Free demo	
Language(s)	English	
Free/commercial	Commercial	
Available at:	http://www.f1.fhtw-berlin.de/studiengang/ut/downloads/greenius/index.html	
Use for EINSTEIN	Generation of alternative proposals: Fast assessment of solar process heat systems at low and medium temperature (concentrating and non-technologies included). Simulation of energy performance and economics.	Industry targeted
Additional comments	Graphic visualisation of the dynamic energy performance and detailed energy and economic parameters available. User can enter customised data. The simulation module for the solar process heat systems is still under development. Non-concentrating collectors is underway.	

Software tool: ProForm 4.0

Features	Description	Details
Name of the product(s)	PROFORM 4.0	
Software developer company/institute	Ernest Orlando Lawrence Berkeley National Laboratory (U.S.A.)	
Users/Target Groups	Anybody analysing Renewable Energy and Energy Efficiency Projects	
Applications	Environmental and economical assessment of Renewable Energy and Energy Efficiency Projects: - Renewable Electricity Generation - Renewable Non-electric - Biomass - Energy efficiency - Cogeneration - Fuel Switching - Landfill methane	Fuel switching projects are projects that substitute the use of a less emissions-intensive fuel for a more emissions-intensive fuel
Main utilities and modules	Environmental assessment module: calculation of the emissions of CO_2, methane, and several other local air pollutants. Financial assessment module: calculation of the Net Present Value (NPV), Internal Rate of Return (IRR), Debt Service Coverage Ratio (DSCR), payback period, and the Annual Cash Flow of a project from the perspective of the investor(s). The assessment is performed in comparison to a base-line scenario.	ProForm requires basic performance and cost data for the technology to be installed, the number of units expected to be installed in each year and data on the baseline technology that will be displaced as a result of the project. In addition to technology cost data, the financial assessment requires data on costs of any fuel inputs for the project, and of fuel use or electricity generation that will be avoided. ProForm is able to accommodate data on carbon credits, grants, or tax credits that may be associated with a project.
Main Outputs	CO_2 balance and economic performance indicators	
Reporting	MS Excel	
Data libraries	Libraries on parameters (e.g. calorific value) etc. for the calculations included.	
Program	MS Excel	
Demo version	Full version for free	
Language(s)	English	
Free/commercial	Free	
Available at:	http://poet.lbl.gov/Proform/	
Use for EINSTEIN	Useful for the development the energetic and economic evaluation module and in particular for: Renewable Non-electric Energy efficiency CHP Fuel Switching.	CHP: only single-cycle gas turbine cogeneration projects
Additional comments	Focus on electricity projects. Comparison to base-line scenario.	Projects that generate electricity to be used on site are treated as energy efficiency projects, as it is assumed that the amount of electricity generated displaces electricity which otherwise would have been purchased. The tool description is given in: Lawrence Berkeley National Laboratory. *PROFORM 4.0 USER MANUAL*. November 2004.

Additional information

ProForm is an MS Excel spreadsheet tool designed to facilitate the assessment of the environmental and financial aspects of clean energy projects. ProForm can assess renewable energy projects which generate electricity and/or produce non-electric energy, energy efficiency projects which save electricity and/or fossil fuels, cogeneration projects, fuel switching projects, and methane capture projects. These projects may involve a single large installation (such as a power plant) or they may include many units of small equipment.

Project Types of interest for EINSTEIN:

- Renewable non-electric calculation module

Only one renewable non-electric technology may be analyzed at a time in ProForm. Units of this technology can be installed over a five-year time period. ProForm considers each unit to be identical with respect to the energy output per unit and the unit operating life. If the project uses biomass for fuel, the conversion efficiency of the biomass to useful energy must be entered.

- Energy efficiency calculation module

ProForm can analyze up to three different energy efficiency technologies at a time. These technologies can conserve electricity, fuel, or both concurrently. Units of each of the three technologies can be installed over a five-year time period. There cells are to input information regarding the energy consumption per unit of technology, either in terms of MWh electricity or in terms of 1000 Gigajoules (GJ000) of fuel.

- Cogeneration calculation module

ProForm enables users to analyze a gas turbine (single cycle) cogeneration project. The cogeneration analysis lets users account for both electricity and heat (steam) production as environmental and economic benefits. In this type of cogeneration project, fuel (usually natural gas) is burned in a gas turbine to produce electricity and the resulting hot air is either used directly or used as a boiler input. The boiler may then use supplemental fuel to provide further heat or produce steam. Supplemental fuel is not always required.

A cogeneration project can displace purchased electricity or electricity sold to the grid. Waste heat from the turbine offsets fuel that would have been used for process heat. The user must input the turbine capacity and capacity factor as well as the yearly steam production. The user must also input the efficiency of energy conversion to electricity and process steam so that ProForm can calculate primary and supplementary fuel use. In calculating fuel requirements for cogeneration projects, ProForm first calculates the fuel necessary to generate the electricity specified by the capacity and capacity factors. The waste heat from electricity generation is then used to heat steam. Supplementary fuel inputs are included if the waste heat from electricity generation is insufficient to meet the steam demands.

- Fuel switching calculation module

Fuel switching projects involve substituting a less carbon-intensive fuel in the place of a more carbon-intensive fuel. Although some fuel switching projects might involve the adaptation of existing technologies so that the cleaner fuel can be used, others may require the installation of completely new technologies. The technologies might use the fuel for production of heat, mechanical work, or electricity generation. To allow for all of these possibilities, the user must enter the number of units upgraded and the annual energy consumption of each unit. Fuel energy conversion factors are required for both the new project technology/fuel as well as for the baseline fuel. Emissions reductions are calculated based on the amount of baseline and project fuels required to produce equal amounts of useful energy.

Reference:

Lawrence Berkeley National Laboratory. *PROFORM 4.0 USER MANUAL*. November 2004.

2.3.4.3.2 Boilers and Furnaces

Software tool: Process Heating Assessment and Survey Tool (PHAST)

Features	Description	Details
Name of the product(s)	PHAST	
Software developer company/institute	Developed by Oak Ridge National Laboratory in cooperation with the Industrial Heating Equipment Association (IHEA) for the U.S. Department of Energy, Energy Efficiency and Renewable Energy	Development supported by E3M, Inc.
Users/Target Groups	Industries and Auditors of Industrial Processes	
Applications	Process Heating Assessment	Focus on heat supply by bolires (direct gas fired/ steam boilers).The tool allows the user to compare the performances of the heater at different operating conditions and test "what-if" scenarios.
Main utilities and modules	Section 1: Data input of all furnaces Section 2: Heat balance and improvement possibilities	
Main Outputs	Heat balance of all heaters of the production, efficiency possibilities for most heat demanding processes	
Reporting	MS Excel report	
Data libraries	Libraries on parameters (e.g. calorific value) etc. for the calculations included.	
Program		
Demo version	Full version for free	
Language(s)	English	
Free/commercial	Free	
Available at:	http://www1.eere.energy.gov/industry/bestpractices/software.html#phast	Available for free on request
Users/Target Groups	Industries and Auditors of Industrial Processes	
Use for EINSTEIN	Useful for data acquisition. Basics for boilers and furnaces module development (especially energy efficiency calculation).	
Additional comments	Interesting methodology: as first an energy balance is drawn and later the improvements can be calculated for every process, that the user wants to elaborate. However detailed information is needed from the user and the elaboration needs specific know-how of furnaces.	The tool description is given in: *Process Heating Assessment and Survey Tool - PHAST. User Manual for Version 1.1.2.* June 2003

Additional information

The Process Heating Assessment and Survey Tool (PHAST) surveys all process heating equipments within a facility, selects the equipment that uses the most energy, and identifies ways to increase efficiency. It can also be used to assess equipment performances under various operating conditions and "what-if" scenarios. The software provides instructions on how to obtain the data for each step with commonly available instruments without affecting the production. It also supplies data on the thermal properties of commonly processed materials.

PHAST serves three specific purposes:

1. PHAST provides easy-to-use tools to calculate the potential savings that a plant can achieve by applying various energy-saving measures. Based on user-supplied equipment parameters, the tools, or "calculators," compare the energy performance of individual pieces of equipment under various operating conditions.
2. PHAST surveys all equipment that uses fuel, steam, or electricity for heating. Based on facility-specific heat input and heater operating data, the tool reports how much fuel, electricity, and steam each piece of equipment uses annually, plus the estimated annual energy costs. Energy efficiency improvements can thus focus on the pieces of equipment that use the most energy.

3. PHAST constructs a detailed heat balance for selected pieces of process heating equipment. The process considers all areas of the equipment in which energy is used, lost, or wasted. Results of the heat balance pinpoint areas of the equipment in which energy is wasted or used unproductively.

PHAST produces a summary report on energy use in specific pieces of equipment and throughout the process heating system. The tool suggests methods to save energy in each area where energy is used or wasted and offers a list of additional resources.

Reference:

Process Heating Assessment and Survey Tool - PHAST. User Manual for Version 1.1.2. June 2003

Software tool: SSAT – Steam System Assessment Tool

Features	Description	Details
Name of the product(s)	SSAT	
Software developer company/institute	U.S. Department of Energy, under contract with the Oak Ridge National Laboratory, by Linnhoff March and Spirax Sarco Inc.	
Users/Target Groups	All engineers who are involved in the operation and/or improvement of steam systems across the full range of process industries.	
Applications	Prediction of energy, cost and emissions savings achievable from the implementation of key steam system improvement measures.	Assessment of steam generation and distribution improvements.
Main utilities and modules	Key features include: Simulations of major equipment items Schematic representations of steam system Estimates of site environmental emissions Calculations of project energy and operating cost savings. Project opportunities which can be evaluated include: Use of alternative boiler fuel Improved boiler efficiency Reduction of boiler blowdown rate Installing blowdown flash system Change of steam generation conditions Installing new back pressure turbine(s) Installing new condensing turbine Installing new heat recovery exchangers to preheat feed water Increasing condensate recovery Installing condensate flash system Reducing steam trap losses and steam leaks Improving pipework insulation.	Major equipment items included: Boiler Back pressure turbines Condensing turbine Deaerator Letdowns Flash vessels Feed water preheat exchangers Steam traps. Items not included are : Detailed gas turbine + heat recovery steam generator (economic assessment only) Multiple turbines between pressure levels Multiple boilers Steam generators using process waste heat “Over the fence” purchasing of steam Detailed combustion efficiency modelling Calculation of likely investment costs for project opportunities.
Main Outputs	Areas for rapid improvements to the steam system.	Key results from the models of both the current operation and the operation after the implementation of one or more of the chosen improvement. When more than one project is selected, SSAT does not report the individual benefit for each project.
Reporting	Available	The results are presented in tabular form, allowing to quickly assess the impact of any changes on the steam system.
Data libraries		
Program	MS Excel	
Demo version	Full version for free	
Language(s)	English	
Free/commercial	Free	
Available at:	http://www1.eere.energy.gov/industry/bestpractices/software.html	
Use for EINSTEIN	Useful for the development the energetic and economic evaluation module for steam boilers. Useful for heat recovery assessment in steam generation and distribution systems	
Additional comments	Difficult to handle, as the tool requires detailed data in American measurement units. Cannot work with SI measurement units.	The tool description is given in: U.S. Department of Energy. *Steam System Assessment Tool. User Guide. Version 2*

2.3.4.3.3 Combined Heat and Power plants (CHP)

In this section some CHP design and simulation software tools are classified and briefly described.

Many of them have been surveyed in the framework of the Distributed Energy – DE - Program (part of the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability) and can be accessed through the DE tools web page (http://www.eere.energy.gov/de/toolbox.html), which includes a list of several CHP calculators and software tools for industrial applications.

Software tool: Cogeneration Ready Reckoner

Features	Description	Details
Name of the product(s)	Cogeneration Ready Reckoner Version 3.1	
Software developer company/institute	The Cogeneration Ready Reckoner was developed as a cooperative exercise between the Department of Industry Science and Resources and the Australian EcoGeneration Association. Developer: Sinclair Knight Merz Pty Ltd	http://www.skmconsulting.com/
Users/Target Groups	Designers and analysers	
Applications	CHP plants	
Main utilities and modules	The main steps followed by the program are: general project information, definition of the benchmark case, definition of the cogeneration case, relevant financial information and results.	It compares a base case with a cogeneration scenario.
Main Outputs	Hourly and annual energy flows, Benchmark and cogeneration case cash flows, Differential cash flow, NPV,I RR, CO2 emissions.	
Reporting	Extensive	
Data libraries	Good database of different basic technologies and fuels. Specific engine manufacturers could be chosen.	
Program		
Demo version	Full version for free	
Language(s)	English	
Free/commercial	Free	
Available at:	http://www.eere.energy.gov/de/toolbox.html	
Use for EINSTEIN	Energetic and economic simulation module on CHP	
Additional comments	Ready Reckoner requests a great number of inputs, which can be confusing for the user. It is very comprehensive in terms of fuel, CHP equipment and financial options, but it only allows a maximum of 12 entries for each load profile, which it is not satisfactory with highly variable profiles.	Reference: Hinojosa, L.R. et al. (2007). *A comparison of combined heat and power feasibility models*. Applied Thermal Engineering 27 (2007) 2166–2172

Software tool: Combined Heat and Power (CHP) Tool

Features	Description	Details
Name of the product(s)	Combined Heat and Power (CHP) Tool Version 1.0.0	
Software developer company/institute	E3M, Inc. for Oak Ridge National Laboratory	
Users/Target Groups	Energy consultants and auditors in industry	
Applications	Evaluation of the feasibility of using heat from power generation equipment in industrial heating applications. The tool analyses the technical and economic feasibility of using gas turbine exhaust gases to supply heat to fluids (air, water, heating oils etc.), to boilers, or to an industrial furnace or oven. The tool allows analysis of the amount of heat that can be obtained from the turbine exhaust gases and the approximate size of the turbine that can supply the required heat for the selected heating process.	Technologies included: fuelfired furnaces, boilers, ovens, heaters, heat exchangers... The three specific cases where the tool can be used for application analysis include: 1. Use of fired heat exchangers to heat gases or liquids 2. Use of the turbine exhaust gases into ovens or heat recovery boilers to recover sensible heat of the exhaust gases. 3. Use of the exhaust gases to supply oxygen (low oxygen content "air") in fuel fired burners for furnaces or boilers
Main utilities and modules	Introduction Technical Analysis: energy process demand and approximate size of the turbine calculation Cost Analysis: project cost, electric revenue, gas cost savings and payback period calculation Report	
Main Outputs	Size of the turbine Economics of the CHP system	
Reporting	1 page summary report	
Data libraries	Database of turbines available on the market	
Program		
Demo version	Full version for free	
Language(s)	English	
Free/commercial	Free	
Available at:	http://www.eere.energy.gov/de/toolbox.html	
Use for EINSTEIN	Heating process demand Heat recovery potential calculation Boilers and furnaces module development Energetic and economic simulation module on CHP.	The complete information about the plant and the technical/cost analysis data can be exported as an MS Access database. Information data can be imported also into the existing database.
Additional comments		

MS Excel CHP calculators

- **CHP Capacity Optimizer**: Developed by Oak Ridge National Laboratory, this software (MS Excel software tool downloadable for free from the website) helps determine optimal prime mover and chiller capacities to maximize CHP cost savings. The accompanying user manual provides easy-to-follow directions.

- **CHP Emissions Calculator** (MS Excel one-sheet tool downloadable for free from the website): From the Illinois CHP/BCHP Environmental Permitting Guidebook. Midwest CHP Application Center, January 2003.

- **Cogen Screening Assessor** (MS Excel based tool downloadable for free from the website)

- **FEMP CHP Screening Analysis** (MS Excel based tool downloadable for free from the website)

- **Simple Payback Algorithm: estimation of simple payback for CHP installations**. Online in English at: http://web.ornl.gov/cgi-bin/cgiwrap?user=chpcalc&script=CHP_payback2.cgi

Survey of distributed energy resources (DER)/CHP software tools

This survey identifies and summarises available software tools that evaluate or help design DER/CHP applications for buildings, campuses, industries. It includes nine software tools. The DER/CHP software are classified by intended use; type of calculations; analysis duration and time step; DER/CHP technologies; data libraries; types of CHP processes; cost and availability.

It follows a brief description of five commercial software tools also surveyed in the framework of this study. These tools have been selected for description since of interest for the industrial applications, and they are:

1. RECIPE
2. Heatmap CHP
3. GT Pro
4. Plant Design Expert (PDE)
5. SOAPP-CT.25.

The Cogeneration Ready Reckoner software tool is also included in the DER/CHP survey but it is not reported here since it has been already described in the previous section.

Reference:

Oak Ridge National Laboratory. (February 2003). *Survey of DER/CHP Software*. DE website: http://www.eere.energy.gov/de/toolbox.html

Software tool: RECIPRO

Features	Description	Details
Name of the product(s)	RECIPRO	
Software developer company/institute	Thermoflow, Inc. (U.S.A.)	http://www.thermoflow.com
Users/Target Groups	Plant engineers and consultants	
Applications	Selection and optimization of reciprocating engine power and cogeneration systems for small commercial/industrial applications	CHP applications: Hot water, chilled water
Main utilities and modules	RECIPRO evaluates different operating scenarios, identifying the savings for each.	Daily load profile variations for electrical, heating, and air-conditioning loads (with single daily load curve per month) are considered. The effect of substituting absorption chillers for electrically driven units to make better use of CHP heat is included.
Main Outputs	Fuel flows Electricity production/consumption Heat production/consumption Monthly operating, capital, and tax-related cash flows for reference year	
Reporting		
Data libraries	Reciprocating engines ranging from 70 kW to 6 MW.	
Program	MS Excel	
Demo version	Available on request	
Language(s)	English	
Free/commercial	Commercial	
Available at:	http://www.thermoflow.com/Utilities_RECIPRO.htm	
Use for EINSTEIN	Energy and economic performance simulation on CHP	
Additional comments	U.S. locations, equipment databases and unit of measurements.	

Software tool: Heatmap CHP

Features	Description	Details
Name of the product(s)	Heatmap CHP	Three Versions Available: CHP; Standard; Geothermal
Software developer company/institute	Washington State University Cooperative Extension Energy Program	
Users/Target Groups	Designers, planners, engineers, operators, facility or physical plant managers, and owners	
Applications	Detailed 3-D design simulation of proposed and existing CHP systems (using DOE-2 simulation engine)	CHP applications: Process steam, hot water, chilled water, thermal storage.
Main utilities and modules		
Main Outputs	Estimated annual and peak consumer loads Annual fuel use and cost Capacity & cost of energy plant Size & cost of distribution system Distribution system flow, temperature, pressure, and heat transfer Cost of energy Cash flow and revenue requirements Annual emissions	
Reporting		
Data libraries	Weather, building loads, production equipment, fuels, piping. Interface with GIS software possible.	
Program		
Demo version	Not available	
Language(s)	English	
Free/commercial	Commercial	
Available at:	http://www.energy.wsu.edu/software/HEATMAP/	
Use for EINSTEIN	Energy and economic performance simulation on CHP	
Additional comments	U.S. locations, equipment databases and unit of measurements.	

Additional information

The following description is given at the Washington State University website (http://www.energy.wsu.edu/software/).

This software tool performs a comprehensive simulation of existing and proposed district heating and cooling (DHC)/District Energy systems, including cogeneration and geothermal applications. HEATMAP provides extensive technical, economical, and air emission information about a DHC application that may be used to evaluate existing system performance, model alternative system strategies, or plan the development of a new project.

Reference:
Website of Washington State University (http://www.energy.wsu.edu/software/)

Software tool: GT Pro

Features	Description	Details
Name of the product(s)	GT Pro	
Software developer company/institute	Thermoflow, Inc. (U.S.A.)	http://www.thermoflow.com
Users/Target Groups	Plant engineers and analysers	
Applications	Detailed design of industrial gas turbine applications with/without HRSG and/or combined cycle	CHP applications: Process steam
Main utilities and modules	Numerous modules (GT configuration, cooling system,…)	Additional module: PEACE (Plant Engineering and Cost Estimator)
Main Outputs	Design and operation parameters Heat and mass balances Project economics Preliminary engineering details	
Reporting	Detailed text and graphical output through on-screen Windows and printed reports.	
Data libraries	Gas turbine performance data	
Program		
Demo version	Available on request (CD)	
Language(s)	English	
Free/commercial	Commercial	
Available at:	http://www.thermoflow.com/CombinedCycle_GTP.htm	
Use for EINSTEIN	Energy and economic performance simulation on CHP Focus on design of gas turbine	Most key inputs are automatically created by intelligent design procedures that help the user identify the best design with minimal time and effort. It normally computes a heat balance and simultaneously designs the required equipment in under five seconds.
Additional comments	U.S. locations, equipment databases and unit of measurements.	

Software tool: Plant Design Expert (PDE)

Features	Description	Details
Name of the product(s)	Plant Design Expert (PDE)	
Software developer company/institute	Thermoflow, Inc. (U.S.A.)	http://www.thermoflow.com
Users/Target Groups		
Applications	Preliminary design/screening of industrial cogeneration applications using gas turbines	CHP applications: Process steam, hot water
Main utilities and modules		
Main Outputs	Preliminary conceptual plant design Heat balance Power and energy output capacities Internal rate of return	
Reporting	Includes the preliminary plant (graphical) design	
Data libraries	Gas turbine performance data	
Program		
Demo version	Available on request	
Language(s)	English	
Free/commercial	Commercial	
Available at:	http://www.thermoflow.com/CombinedCycle_PDE.htm	
Use for EINSTEIN	Energy and economic performance simulation on CHP	
Additional comments	Very limited user input; most selections made by program. U.S. locations, equipment databases and unit of measurements.	

The following description is given at the Thermoflow website (www.thermoflow.com):

PDE is an intelligent shell that creates a GT PRO input file based on the user's requirements for the proposed plant.

It then runs GT PRO in the background and displays abbreviated output results. PDE takes away much of GT PRO's flexibility and replaces it by a high degree of automated, expert logic, deciding what type of cycle should be used, its configuration details and the numerical values of its design parameters. PDE provides its user with approximately fifty adjustable inputs to state his/her requirements. The rest of GT PRO's 2200 inputs are generated automatically.

Software tool: SOAPP-CT.25

Features	Description	Details
Name of the product(s)	SOAPP-CT.25	
Software developer company/institute	Electric Power Research Institute (EPRI)	
Users/Target Groups	Plant engineers and analysers	
Applications	Conceptual design of industrial gas turbine applications with/without HRSG	CHP applications: Process steam
Main utilities and modules		Provides baseline comparison in the form of avoided cost
Main Outputs	Individual reports in the seven categories: Design Inputs Heat Balance Results Equipment Design Information Project Schedule Capital Cost Estimate O&M Cost Estimate Financial Analysis and Cash Flow	
Reporting	Detailed text output	
Data libraries	Gas turbine, HRSG	
Program		
Demo version	Not available	
Language(s)	English	
Free/commercial	Commercial	
Available at:	http://www.soapp.com/soapp/dg/	
Use for EINSTEIN	Energy and economic performance simulation on CHP Consistency check module	Intelligent Input Defaults and Validation module SOAPP-CT.25 provides suggested input values, as well as minimum and maximum recommended values based on key input selections made. SOAPP-CT.25 also validates inputs dynamically, generates warnings for inconsistent or inappropriate choices. This sophisticated intelligence facilitates SOAPP-CT.25 use by non-experts
Additional comments	U.S. locations, equipment databases and unit of measurements	

2.3.4.3.3.1 Other Combined Heat and Power software tools (for general and/or non industrial applications)

Software tool: easyCOGEN.xls

Features	Description	Details
Name of the product(s)	easyCOGEN.xls	
Software developer company/institute	Consortium of the IEE co-funded Project COGEN Challenge	http://www.cogen.org/cogen-challenge/index.htm
Users/Target Groups	Non - experts	
Applications	Small-scale cogeneration projects	Technologies included: Natural gas engines Heating oil engines
Main utilities and modules	Load profile, cost and profits calculation	One-page Excel based calculators for first rough assessment
Main Outputs	Profitability of a CHP plant	
Reporting		
Data libraries		
Program	MS Excel	
Demo version	Full version for free	
Language(s)	English	
Free/commercial	Free	
Available at:	http://www.cogen.org/cogen-challenge/support/toolbox.htm	
Use for EINSTEIN	Core software tool development: pre-feasibility study for small-scale CHP. Checklist, technical data on commercial equipments, tailored financing schemes.	
Additional comments		

Other CHP tools

- **CHP Sizer Version 2**: software to conduct a preliminary evaluation of the application of CHP to New and Existing Hospitals, Hotels, University Residences and Leisure Centres.
  Website: http://www.chp.bre.co.uk/chpoverview.html

- **Building Energy Analyzer:** CHP in buildings. More information are reported in the section "Tools for energy demand (self-) assessment".
  Website: http://www.interenergysoftware.com/

- **D-Gen Pro:** CHP in buildings.
  Website: http://www.interenergysoftware.com/

2.3.4.3.4 Biomass

Software tool: HORTEB

Features	Description	Details
Name of the product(s)	HORTEB	
Software developer company/institute	University Hannover, Fachgebiet Biosystem- und Gartenbautechnik (Germany)	
Users/Target Groups	Designers and auditors	
Applications	Design of biomass combustion system	
Main utilities and modules	Entering the cumulative heat demand curve of the current process(es), and the type of biomass available, as well as the full load operating hours – Horteb calculates the combustion system including detail economic analysis.	A CO_2 calculation is also included, relying on the transport of the biomass.
Main Outputs	Design, investment and operating costs of a biomass combustion system depending on the cumulative head demand curve	
Reporting	MS Excel	
Data libraries		
Program	MS Excel	
Demo version	No	
Language(s)	German	
Free/commercial	Commercial	
Available at:	http://www.bgt.uni-hannover.de/index.php?id=horteb	
Use for EINSTEIN	Especially interesting for heat and cold supply module – info on biomass combustion design	
Additional comments		

2.3.4.3.5 Solar heat

Software tool: TransENERGY – MEDISCO

Features	Description	Details
Name of the product(s)	TransENERGY - MEDISCO	
Software developer company/institute	CIMNE/energyXperts.BCN in the framework of the EU (INCO-) project MEDISCO	
Users/Target Groups	Engineers and designers	
Applications	Dynamic system simulation tool for industrial cooling and heating demands based on TRNSYS.	It is specifically designed for simulating solar industrial cooling systems, but due to its modular structure can easily be extended to other energy supplies.
Main utilities and modules	The simulation tool will be able to simulate heat and cold supply systems with the following properties: - heat / cold demands: heat and cold demands are given as hourly data files (required heating/cooling power). Up to 4 demands can be included - heat supply: heat supply can be a solar thermal system and an auxiliary boiler. it would be relatively easy and straightforward to adapt for other heat sources (such as cogeneration engines, heat pumps, etc.) - heat distribution: only a very simple one hot storage module is implemented. in principle more complex heat distribution networks - including heat recovery - could be added - cold generation: only a simple stationary model of a specific absorption chillers is implemented.	
Main Outputs	Evaluation of the energy production, Energy balance of the system, Energy losses analysis,	
Reporting	Standard report sheets included.	
Data libraries		
Program	TRNSYS	
Demo version	Will be available on the web	
Language(s)	English	
Free/commercial	Free	
Available at:	It will be available (End 2008/Beginning 2009) at www.medisco.org	
Use for EINSTEIN	The MEDISCO - version of TransENERGY is too limited for general-purpose use, but it can be used as simulation tool for solar process heating / cooling systems.	
Additional comments		

Software tool: T*SOL

Features	Description	Details
Name of the product(s)	T*SOL	T*SOL Professional T*SOL Expert
Software developer company/institute	Valentin EnergieSoftware GmbH (Germany)	http://www.valentin.de
Users/Target Groups	Solar thermal plant designers	
Applications	Sanitary hot water, space heating	
Main utilities and modules	Pre-Design; demand and system configuration; simulation of solar thermal + backup; reporting.	Additional simulation modules: Swimming pools; large-scale systems
Main Outputs	Energy performance indicators of the system and of the equipments; Economics.	
Reporting	Yes, incl. plant scheme, graphics and main outputs of the simulation	It can be saved as a file at the end of the simulation. Additional graphics and tables are also available for a comprehensive reporting
Data libraries	Worldwide meteorological data; solar thermal collectors; storage tanks; boilers; solar system concepts.	T*SOL allows the definition of new locations
Program		
Demo version	Free demo Online calculation	http://www.valentin.de/index_en_page=downloads http://www.valentin.de/onlineberechnung/solarthermie/index.php?lang=en
Language(s)	German, English, Spanish, Italian, French	
Free/commercial	Commercial	
Available at:	Online shop	http://onlineshop.solar-software.de/product_info.php?cPath=21_40&products_id=36&language=en
Use for EINSTEIN	Generation of alternative proposals: Solar thermal + backup system; Simulation of energy performance and economics.	Focus on residential sector.
Additional comments	Designed for residential sector and for swimming pools: the industrial heat demand has to be calculated offline in terms of litre of SHW. Only the overall process heat demand can be simulated at a given temperature. Pre-design module useful for a first rough assessment of the plant size The report is generated automatically and it can be used for the final reporting to customer.	

Software tool: Polysun 4.0

Features	Description	Details
Name of the product(s)	Polysun 4.0	
Software developer company/institute	Institut für Solartechnik SPF (in collaboration with Velasolaris) (Switzerland)	http://www.solarenergy.ch/ (www.velasolaris.com)
Users/Target Groups	Polysun 4.0 is available in three different user levels covering different range of user (auditors, designers, manufacturers) needs	The "Light" version is useful for home-use and simple installation applications. The "Professional" version, in contrast, allows full control over all parameters of the system and its components. The highest level, Polysun 4 "Designer", allows changing the system hydraulics.
Applications	Sanitary hot water, space heating and swimming pools	
Main utilities and modules	Pre-Design; demand and system configuration; simulation of solar thermal + backup; reporting.	The system layout can be customised: additional equipments can be added
Main Outputs	Energy performance indicators of the system and of the equipments; Economics.	
Reporting	Different types of output reports available	
Data libraries	Catalogues of solar thermal collectors; components (incl. heat exchangers, pumps, pipes…) ; storage tank layouts. Worldwide meteorological data (Meteonorm).	Polysun 4.0 allows the definition of new locations through measurement data.
Program		
Demo version	Free demo	http://www.velasolaris.com/vs/content/view/67/77/lang,en/
Language(s)	German, English, Spanish, Italian, French, Czech, Portuguese	
Free/commercial	Commercial	
Available at:	Shop online	https://secure.velasolaris.com/shop/Order.php?lang=en
Use for EINSTEIN	Generation of alternative proposals: Solar thermal + backup system; Simulation of energy performance and economics. Polysun 4 "Designer" allows changing the system hydraulics. The graphic interface for the system layout configuration is very user friendly	Focus on residential sector.
Additional comments	Designed for residential sector and for swimming pools: the industrial heat demand has to be calculated offline in terms of litre of SHW. Only the overall process heat demand can be simulated at a given temperature. Pre-design module useful for a first rough assessment of the plant size The report is generated automatically and it can be used for the final reporting to customer.	

Software tool: TRANSOL 2.0

Features	Description	Details
Name of the product(s)	TRANSOL 2.0	TRANSOL International under development
Software developer company/institute	Aiguasol Enginyeria (Spain) Centre Scientifique et Technique du Bâtiment (France)	http://www.aiguasol.coop/ http://software.cstb.fr/
Users/Target Groups		
Applications	Sanitary hot water, space heating and swimming pools	Multi-storey and detached houses
Main utilities and modules	Pre-Design; demand and system configuration; simulation of solar thermal + backup; reporting.	Background simulation program: TRNSYS 16 (TRaNsient simulation SYStems)
Main Outputs	Energy and environmental performance indicators of the system and of the equipments; Economics.	Including energy balances for auxiliary systems (pumps)
Reporting	Simplified report in HTML; detailed report in HTML and in MS Excel. Customized reports (including external data and pictures) are also possible.	
Data libraries	Catalogues of solar thermal collectors; components (including insulation materials) ; system concepts including the distribution networks. Metereological data for Spain and Portugal (Meteonorm).	Definition of new locations allowed.
Program		
Demo version	Free demo	http://www.aiguasol.com/index.php?page=341&treeinfo=
Language(s)	Spanish, French	TRANSOL International in English under development
Free/commercial	Commercial	Indicative price: up to 780 € (10 licenses)
Available at:	http://www.aiguasol.coop/index.php?page=64 http://software.cstb.fr/soft/present.asp?page_id=fr!TRANSOL	
Use for EINSTEIN	Generation of alternative proposals: Solar thermal + backup system; Simulation of energy performance and economics. Reporting: Simplified and detailed report in HTML and Customized reports (including external data and pictures)	Focus on residential sector.
Additional comments	Designed for residential sector and for swimming pools: the industrial heat demand has to be calculated offline in terms of litre of SHW. Only the overall process heat demand can be simulated at a given temperature. Pre-design module useful for a first rough assessment of the plant size. The report is generated automatically and it can be used for the final reporting to customer.	

Software tool: ST-ESCO software tool

Features	Description	Details
Name of the product(s)	STESCO software tool	
Software developer company/institute	Aiguasol Enginyeria (Spain) in the framework of the IEE co-funded Project ST - ESCO	http://www.stescos.org http://www.aiguasol.coop/
Users/Target Groups	Energy service companies (ESCOs)	
Applications	Evaluation of the economical viability of solar thermal projects for Energy service companies (ESCOs)	
Main utilities and modules	Energy simulation module - Trnsys based - for the prediction of the energy output of solar thermal plants. Economical module.	
Main Outputs	Solar system energy balance on a monthly basis (radiation, production, thermal losses, solar energy delivered to consumption, auxiliary energy delivered and consumed, etc.). Economical balances for ESCOs and for users	
Reporting		
Data libraries	Technical parameters given only for one predefined solar thermal system	No catalogues of collectors, storage tanks, etc. available. Technical parameters have to be entered manually
Program		
Demo version	Full version for free	
Language(s)	English, Spanish, Catalan, Italian and German	
Free/commercial	Free	
Available at:	http://www.stescos.org/tool0.htm	
Use for EINSTEIN	Generation of alternative proposals: economic evaluation including TPF schemes.	
Additional comments		

2.3.4.3.6 Simulation and evaluation software tools for Heat and Cold Distribution

Software tool: Pfleiderer Novoterm

Features	Description	Details
Name of the product(s)	Pfleiderer Novoterm	
Software developer company/institute	URSA SLOVENIJA Ltd.(Slovenia)	http://www.ursa.si/
Users/Target Groups	Designers and Auditors	
Applications	Calculation of piping thermal insulation	
Main utilities and modules		
Main Outputs	Heat flow, heat transfer (conduction, convection, radiation). Heat flow. Insulation thickness. Economical evaluations (internal rate of return, net present value,...).	
Reporting		
Data libraries		Data base can be upgraded from web site
Demo version	Full version for free	Available on request
Language(s)	Slovenian	
Free/commercial	Free	
Available at:	http://www.ursa.si/	
Use for EINSTEIN:	The tool provides heat transfer calculation, optimal thickness of the pipelines insulation.	
Additional comments:	Developed under the German directive VDI 2055.	

Software tool: TERMIS – District Energy Management System

Features	Description	Details
Name of the product(s)	TERMIS – District Energy Management System	District Energy Management System
Software developer company/institute	7-Technologies	http://www.7t.dk/company/default.asp
Users/Target Groups	Designers and energy services companies	
Applications	Tool for optimizing design and operation of district energy network	
Main utilities and modules	Basis – for complete system overview Surge – protecting piping Steam module Model Manager Demand Manager Calibration Financial Temperature Optimization Real Time Pump Optimization Production Optimization Result Manager	Tool for running feasibility studies and scenarios to evaluate the effect of: new residential areas; increased demands; maintenance jobs; fluctuations in consumption; installation of new equipments; changes in operation scheme.
Main Outputs	Simulation of the network operation	GIS/mapping data Demand data/consumption profiles/ elevation data ect.
Reporting	With the Termis Result Manager: database (SQLserver or Access) plus advanced geographical presentation tools	Can be applied to Termis Real-Time and Termis engineering tools.
Data libraries		
Program		
Demo version	http://www.7t.dk/Company/OrderDemoForm.asp	
Language(s)	Polish, Danish, English, German,	
Free/commercial	Commercial	
Available at:	No online sales	
Use for EINSTEIN	Special applications: centralised heating systems in industrial districts	
Additional comments	A complex tool addressed to district heating companies	

Software tool: Audytor SCW

Features	Description	Details
Name of the product(s)	Audytor SCW	
Software developer company/institute	Authors: dr inż Olgierd Niemyjski, dr inż. Stefan Turlejski from The Institute of Heating and Ventilation at the Warsaw University of Technology	Production and Distribution: ThermoCAD bpw@termocad.pl
Users/Target Groups	Designers and energy services companies	
Applications	District heating	
Main utilities and modules		
Main Outputs	Heat demand, heat losses in the network	
Reporting	In form of tables or graphs or directly on the map	
Data libraries		
Program		
Demo version	No demo version available at the website	
Language(s)	Polish	
Free/commercial	Commercial	No information on the price, to be ordered at the distributor
Available at:	No online sales	
Use for EINSTEIN	Special applications: centralised heating systems in industrial districts	
Additional comments		List of examples available at the website www.thermocad.pl

2.3.5 Miscellanea of engineering tools and calculators

The engineering tools and calculators listed in this section are mentioned in the Cleaner Production and Energy Efficiency Manual from UNEP.

- **Engineering calculators**

Free on-line calculators and manuals for physical properties (air and gaseous pollutants); steam properties and approximations; power cycle analysis (carnot, cycle, brayton, otto, and diesel cycles); power cycle components/processes (compression, combustion, expansion), compressible flow (nozzle, etc.), unit conversion, engineering equations and miscellaneous engineering tools. Available in English at:
http://members.aol.com/engware/calcs.htm

- **Mechanical engineering calculators**

Free on-line engineering conversion factors; hydraulics tools (fluid flow calculator, water pump calculator, and pump tables and charts for valve sizing); and heating and air conditioning tools (psychometric calculator, saturated steam tables and air duct calculator).
Available in English at:
http://www.ifigure.com/engineer/mechanic/mechanic.htm

- **FireCAD**

User-friendly FireCAD design software products and online calculators are available, developed using the latest boiler and software technologies, for fire tube boiler, water tube package boiler, economizer, air heater and superheater. Trial versions of these software packages can be downloaded.
Available in English at: http://www.firecad.net/

Reference:

United Nations Environment Programme, Division of Technology, Industry and Economics: *Cleaner Production – Energy Efficiency Manual*. pp276-286. UK, 2004. UNEP website: http://www.uneptie.org/energy/projects/cp-ee/cpee_project.htm.

2.4 *Databases*

By Damjan Krajnc, Faculty of Chemistry and Chemical Engineering, University of Maribor

2.4.1 Introduction

In order to improve the EINSTEIN tool-kit, well defined and representative databases are needed mainly on the following technologies:

- Cogeneration of Heat and Power
- Steam boilers and burners
- Heat pumps
- Cooling machines
- Solar thermal equipments
- Biofuels
- Biomass.

Energy benchmarks by industrial branches are also required.

Project partners provided several references on equipments and fuels databases while energy benchmarks are still too scarce. Therefore, a further exploration of benchmarks for specific industrial sectors is needed.

2.4.2 Screening and collection of databases and benchmarks

Title	**Energy solutions Database**
Short Summary, incl. Activities	The Washington State University Energy Program is under contract with the Western Area Power Administration to create and provide resources and tools for their utility customers and their end-users. This website reports on tools to compare air conditioning and heating systems, previously answered questions, reports, news, links, fact-sheets, many other tools included into the Energy Solutions Database, innovative utility programs into the Utility Options Database
Targets addressed	
Industrial Branches addressed (SMEs)	All
Energy Sectors addressed	Steam, Heat Recovery, Cooling, Steam Systems
Outcomes	Software tools, best cases, guidelines,…
References	http://energyexperts.org/energy_solutions/

Title	**Optipolygen** OPTimum Integration of POLYGENeration in the Food Industry
Short Summary, incl. Activities	The OPTIPOLYGEN project has the goal to reveal the potential of polygeneration in the European food industry, determines possible technical and non technical gaps related with polygeneration and promotes the applications of polygeneration as a route to sustainability in the food industry.
Targets addressed	Companies
Industrial Branches	Food industry
Energy Sectors addressed	Polygeneration
Kind of data reported	
Methodology adopted	
Outcomes	Freely accessible database with operating polygeneration plants with classified plant data. Identification of technical barriers which might exist in the use of renewables in hybrid systems with conventional CHP and trigeneration in the food industry and solution proposals. Sub - sectors specific calculator for feasibility studies (criteria list for CHP)
References	http://www.optipolygen.org/

Title	**Energy benchmarking at the Company Level, Company Report Dairy**
Short Summary, incl. Activities	/
Targets addressed	Benchmarking at plant level
Industrial Branches	Dairies
Energy Sectors adressed	Dairies
Kind of data/benchmarks reported	Energy intensity, Specific Energy Consumption, Energy cost
Methodology adopted	Performance metrics based on selected indicators
Outcomes	Report
References	http://www.energyagency.at/(en)/publ/pdf/ideen2_diary_en.pdf

Title	**NorthWrite, Inc. – a US-company providing benchmarking services for energy**
Short Summary, incl. Activities	NorthWrite has developed a useful tool, Energy Benchmarking, to help the user to better understand what the energy savings opportunities may be.
Targets addressed	Energy Benchmarking allows to compare the energy use among the different divisions of a business, or to similar businesses.
Industrial Branches	Education, public assembly, offices etc.
Kind of data/benchmarks reported	/
Methodology adopted	This easy-to-use but powerful tool allows to measure energy use. Clear instructions guide the user through a process of entering facility square footage, energy use data (electric and gas), state (of the United States), and building function (education, public assembly, etc.). The Energy Benchmarking tool then automatically calculates the *Energy Utilization Index (EUI)* and allows to compare a facility to a national average, and to determine if energy savings opportunities exist.
Outcomes	Energy Benchmarking tool
References	http://www.northwrite.com/energybenchmarking.asp

Title	**EPA –NR database on non-residential building**
Short Summary, incl. Activities	The document reports country specific figures to benchmark and to calculate the energy performances (heat losses and heat and cold supply systems) of non-residential buildings.
Targets addressed	Data available for the following Countries: -France -Austria -Italy -Germany -Denmark -Greece -The Netherlands
Industrial Branches	Non-residential buildings
Energy Sectors addressed	Non-residential buildings
Kind of data/benchmarks reported	U values Internal heat sources (internal gains) Heating system devices incl. control systems and solar collectors Heating emission system Heating distribution system Heating generation system Solar collectors as part of the heating generation system Auxiliary energy for heating DHW system devices incl. control systems and solar collectors DHW distribution system DHW generation system Solar collectors as part of the DHW generation system Auxiliary energy for DHW Ventilation system devices incl. control systems Cooling system devices incl. control systems and de-humidification systems Cooling distribution system Cooling generation system Auxiliary energy for cooling Humidification system devices incl. control systems Lighting system devices incl. control systems Day - lighting systems Electrical gains from photovoltaic systems and CHPs (combined heat and power generators) Damages and age dependent necessary renewals to the existing building and systems
Outcomes	Country specific figures to benchmark and to calculate the energy performances
References	Erhorn, H. et al. (June 2007). Inspection Protocol. Guidance for the data acquisition during the building inspection incl. an inspection checklist and international and national tips. Final report. EPA-NR Project (EC Contract: EIE/04/125/S07.38651).EPA-NR website: www.epa-nr.org

Title	**Industrial Assessment Center (IAC) Database**
Short Summary, incl. Activities	The Industrial Assessment Center (IAC) Database contains the actual results of approximately 7,000 assessments. The database includes details such as the fuel type, the base plant energy consumption, the recommended energy-efficiency improvements, the projected energy savings, cost savings, implementation costs and simple payback. Top Ten lists of assessments and recommendations can be generated for specific criteria. The database can be retrieved by: -Assessments: Industry Type, Size, Year, Energy Costs, Products -Recommendations: Type, Savings, Cost, Implemented -Industry Type
Industrial Branches	Various
Energy Sectors addressed	Various
Kind of data/benchmarks reported	Electricity and heat demand
Methodology adopted	Database in Ms excel
Outcomes	Information on the type of facility assessed (size, industry, energy usage, etc.) and details of resulting recommendations (type, energy & dollars savings etc.).
References	http://iac.rutgers.edu/database/index.php

Title	**National Dairy Council of Canada (2001) Energy Performance Indicator Report: Fluid Milk Plants**
Short Summary, incl. Activities	Objectives of this study are: -develop benchmarks for energy efficiency that address consumption, composition and costs in the Canadian fluid milk plants; -develop and apply benchmarks at the plant level and by unit operation; -establish a methodology for examining energy performance of fluid milk plants; -and review potential energy savings ideas for fluid milk plants that arise from this and other studies.
Targets addressed	Milk plants (in Canada)
Industrial Branches	Milk and food industry
Energy Sectors addressed	Energy management, benchmarking at plant level
Outcomes	Methodology for developing and applying energy efficiency and cost-related benchmarks, established at plant level and by unit operation. Outline of benchmark targets, results for the 17 participating plants Analysis of data from the participants by 8 categories (5 stages of production and 3 plant services) at sub-plant level Benchmark targets on efficiency and unit costs are estimated. Brief summary of potential energy saving ideas
References	http://oee.nrcan.gc.ca/infosource

Title	**Intelligent Energy Europe Project (2006) EMS-Textile Project: Promotion of Energy Management Practices in the Textile Industries of Greece, Portugal, Spain and Bulgaria BENCHMARKING INFORMATION V.4**
Short Summary, incl. Activities	This report summarizes EMS-Textile Benchmarking data from several countries (average energy consumption). It provides the EMS Textile Energy Management Benchmarking Matrix.
Targets addressed	Textile Industries
Industrial Branches	Textile sector
Energy Sectors addressed	Energy management, benchmarking at plant level
Outcomes	Benchmarking data for the textile industry
References	http://www.ems-textile.net/

Title	***Prime Contractor Quantum Consulting Inc., California National Energy Efficiency Best Practices Study Volume M – Methodology***
Short Summary, incl. Activities	This study intends to identify and to communicate best practices on energy-efficiency achievements on national basis. The study does not expect to produce a census of best practices across all types of programs. Such an approach would be neither practical nor useful given the number of programs that exist; the many differences in policies, goals and market conditions around the country. Unique aspects of the study are its comprehensiveness, its use of a program decomposition approach and its focus on development of a database and user-driven website. In the current study, data were collected from roughly 90 programs in total across a range of program types.
Targets addressed	Industrial companies
Industrial Branches	Cross cutting
Energy Sectors addressed	Information and Training
Outcomes	Definition of Terms Program Decomposition Model Cross-Cutting Outcome Metrics Program Context Characteristics Program Benchmarking Process Benchmarking Considerations Program Screening & Selection Literature Review Data Collection Instrument Program Benchmarking Data Collection
References	http://www.eebestpractices.com/pdf/methodology.pdf

Title	**Michael Ruth, Ernst Worrell, Lynn Price (2001)** A Process-Step Benchmarking Approach to Energy Use at Industrial Facilities: Examples from the Iron and Steel and Cement Industries. ***ACEEE Summer Study on Energy Efficiency in Industry***
Short Summary, incl. Activities	This paper looks at the use of the benchmarking approaches for evaluating the industrial energy uses. Benchmarks have been used for comparing industrial facilities or entire sectors, or for making temporal comparisons. Of interest it is a 'process-step approach' to benchmarking energy-intensive industries, which accounts for the process differences between industrial facilities or sectors.
Targets addressed	Industrial facilities
Industrial Branches	Iron, steel and cement Industries
Energy Sectors addressed	Energy benchmarking and auditing
Outcomes	Process-step approach to benchmarking energy-intensive industries
References	

Other databases and benchmarking websites are listed in the table below.

References	Brief description
http://www.internet-energie-check.de/index.php?m=dena	Internet Energy Check for Small Companies
http://www.ebmconsulting.com/	EBM Consulting, Inc. – an American consultancy organisation, specialised in dairy benchmarking
http://www.meniscus.co.uk/	Meniscus Systems Ltd – a British consultant company, expert in optimising processes developed an Internet based solution - IPMS
http://www.benchmarkingnetwork.com/energy/	Energy Benchmarking Group™ is an association of companies that conducts benchmarking studies to identify the best practices surrounding the energy industry that improve the overall operations of the members.
http://www.ptm.org.my/mieeip/	Malaysian Industrial Energy Efficiency Improvement Project – one of the eight components is the developed a Mobile Energy-Use Benchmarking Kit.
http://www.greenglobe21.com/	Greenglobe 21 – A report: Travel and Tourism Industry Benchmarking
www.promain.fi (site in Finnish only)	Promain – a Finnish company providing web-based monitoring and benchmarking services

3 Best available technologies and measures for improvement of energy efficiency

By Bettina Slawitsch, Joanneum Research

3.1 *Introduction*

The following chapter summaries literature references on best available technologies and measures for improvement of energy efficiency. At first an overview is given on available compendia that embrace several documents on energy efficiency for different industry sectors. The second part of this chapter is divided in industry branches and energy supply technologies. Here literature sources are stated and the most important BAT retrieved from this literature is presented. Literature search (including case studies) will continue to finalise the currently available list of best available technologies and energy efficiency measures.

3.2 *Information Sources/Programmes/Collections on BAT on several sectors*

3.2.1 EU BAT Reference Documents

The EU has a set of common rules for permitting and controlling industrial installations in the IPPC Directive of 1996.
In essence, the IPPC Directive is about minimising pollution from various industrial sources throughout the European Union. Operators of industrial installations covered by Annex I of the IPPC Directive are required to obtain an authorisation (environmental permit) from the authorities in the EU countries.
New installations, and existing installations which are subject to "substantial changes", have been required to meet the requirements of the IPPC Directive since 30 October 1999. Other existing installations must be brought into compliance by 30 October 2007.
The permit conditions including emission limit values (ELVs) must be based on Best Available Techniques (BAT) , as defined in the in the Article 2.11 of the IPPC Directive : “best available techniques” shall mean the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole. “Techniques” shall include both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned; “available” techniques shall mean those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator; “best” shall mean most effective in achieving a high general level of protection of the environment as a whole.
To assist the licensing authorities and companies to determine BAT, the Commission organises an exchange of information between experts from the EU Member States, industry and environmental organisations. This work is co-ordinated by the European IPPC Bureau of the Institute for Prospective Technology Studies at EU Joint Research Centre in Seville (Spain). This results in the adoption and publication by the Commission of the BAT Reference Documents (the so-called BREFs).
It is the intention to develop a series of reference documents so as to cover, as far as practicable, the activities listed in Annex 1 to the Directive.

BREFs concern with both specific industrial sectors such as iron and steel production, ceramics, pulp and paper, chemicals, food and Drink processes, textiles and horizontal activities such as cooling and large combustions plants.
All updated documents can be downloaded from: http://eippcb.jrc.es/pages/FActivities.htm

Of particular interest for the scope of this project are the BREF reports on

1. Energy efficiency:

- Integrated Pollution Prevention and Control, Draft Reference Document on Energy Efficiency Techniques, Draft April 2006

2. Heat and cold supply systems:

- Integrated Pollution Prevention and Control (IPPC), Reference Document on the application of Best Available Techniques to Industrial Cooling Systems, December 2001

- Integrated Pollution Prevention and Control, Reference Document on Best Available Techniques for Large Combustion Plants, July 2006

3. Food:
- Integrated Pollution Prevention and Control Reference Document on Best Available Techniques in the Food, Drink and Milk Industries, August 2006

Reports can be downloaded from the following website: http://eippcb.jrc.es/pages/FActivities.htm

3.2.2 National versions of the BAT Reference Documents

Some national Ministries have elaborated national version of the EU BAT Reference Documents to adapt the document to the particularities of the sector and the legal framework in the specific nation.

In the framework of EINSTEIN, the review of the national reports is currently still on going. Therefore only BAT Reference Documents for Spain and Germany have been screened and summarised above.

3.2.2.1 Spanish versions of the BAT Reference Documents

The collection of "Guides of best available techniques in Spain" (Guía de Mejores Técnicas Disponibles en España. MMA) includes the following reports:

- BAT Guide in Spain for fine organic chemicals
- BORRADOR FINAL BAT GUIDE for the treatment of superficial metals and plastics
- BAT Guide in Spain for meat processing
- BAT Guide in Spain on poultry breeding
- BAT Guide in Spain on pork processing
- BAT Guide in Spain for the sector of sea products
- BAT Guide in Spain for PVC and other plastics
- BAT Guide in Spain on slaugterhouses and processing of chicken
- BORRADOR FINAL BAT GUIDE for the glass industry
- BAT Guide in Spain for processing of vegetables
- BAT Guide in Spain for the leather sector
- BAT Guide in Spain for the cement industry
- BAT Guide in Spain for the sugar industry
- BAT Guide in Spain for the meat processing industry
- BAT Guide in Spain Sector for the leather industry
- BAT Guide in Spain for the milk industry
- BAT Guide in Spain for refinieries
- BAT Guide in Spain for the textile industry

Website: http://www.eper-es.es/ver.asp?id=1046&Doc=1111&index=6

The collection of "Guides of best available techniques in Catalonia" (Millors tècniques diponibles) includes the reports on the following topics:

- The cement industry
- The glass industry
- Chlor-alkaline industry
- General principles for improvement

- Iron and steel industry
- Tanning industry
- Pulp and paper industry
- Ferrous metal processing industry.

Website:
http://mediambient.gencat.net/cat/empreses/mtd/documents_referencia.jsp?ComponentID=41615&SourcePageID=59491#1

3.2.2.2 German versions of the BAT Reference Documents

The Austrian and the German environmental agencies cooperate in translating national BAT documents.

All relevant files can be downloaded from the webpage of the German institute:
http://www.bvt.umweltbundesamt.de/kurzue.htm

3.2.3 Canadian Industry Program for Energy Conservation

The **Canadian Industry Program for Energy Conservation (CIPEC)**, sponsored by Natural Resources Canada (NRCan) has developed a benchmarking and best practices program for Canada's industrial sectors. The program is designed to help industry achieve significant energy efficiency gains.
CIPEC, in collaboration with its association partners, has established indicators to enable industrial companies to compare their energy use, greenhouse gas emissions and practices with similar operations.
Through the CIPEC benchmarking initiative guides to Energy Efficiency and benchmarking reports have been produced for a growing number of industrial sectors among which Food (e.g. dairies, fish processing etc.), pulp and paper, wood products, aluminium, cement production, foundries, construction, automotive parts industry, mining, petroleum refining and rubber.

Of particular interest for the scope of this project are the following branch guides.

1. On dairies:

- Energy Performance Indicator Report: Fluid Milk Plants
  Website:http://oee.nrcan.gc.ca/Publications/industrial/fluid-milk-plants/BenchmDairy_e.pdf
- Guide to Energy Efficiency Opportunities in the Dairy Processing Industry
  Website:http://oee.nrcan.gc.ca/infosource/pdfs/M27-01-827E.pdf

2. On breweries:

- Energy Efficiency Opportunities in the Canadian Brewing Industry
  Website: http://oee.nrcan.gc.ca/infosource/pdfs/M27-01-945E.pdf

3. On wood processing:

- Energy Cost Reduction in the Pulp and Paper Industry: An Energy Benchmarking Perspective
  Website:http://oee.nrcan.gc.ca/publications/infosource/pub/cipec/pulp-paper-industry/pdf/pulp-paper-industry.pdf
- Energy Efficiency Opportunities in the Solid Wood Industries
  Website:http://oee.nrcan.gc.ca/infosource/pdfs/M27-01-828E.pdf

3.2.4 The U.S. Industrial Technologies Program

The **Industrial Technologies Program (ITP)** is established by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.
The Industrial Technologies Program is (1) developing tools to help industry identify energy savings opportunities; (2) conducting cost-sharing R&D on combustion and heat recovery; and (3) working to improve systems, components, and materials that are essential to saving energy in manufacturing-from mining and primary metals to downstream product finishing.

A comprehensive collection of manuals and guides can be found surfing on the following website:
http://www1.eere.energy.gov/industry/index.html

3.2.5 CO_2 minimisation and energy efficiency – projects of the Bavarian environment agency

The Bavarian environment agency conducted several projects on energy efficiency and CO2 reduction in different industry sectors.
All available final reports can be downloaded from the homepage:
http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/

Projects are always set up with an industry partner, analysing this production process in detail and identifying energy saving possibilities. The results are then further evaluated for the usability for the industry sector in general.

3.2.6 The BESS Handbook

The BESS project is supported by the Intelligent Energy – Europe (EIE) programme of the European Union (contract nr.: EIE/04/246/S07.38678).
The primary project objective is to further develop and promote the widespread application of benchmarking and energy management in order to improve energy efficiency in industrial SMEs (small and medium-sized enterprises), with particular focus on the food and drink industry.

The project handbook include a comprehensive compilation of BATs and it is dowloadable from the following website:
http://alpha.cres.gr/bess/en/downloads/Handbook_final_version_new_22022007.pdf

3.2.7 Sectorial Documents for the Spanish strategy on energy efficiency 2004-2012 (Ministry of Industry, tourism and commerce)

Reports available for industrial branches are:

- Pulp and paper,
- Chemical processes
- Transport equipments
- Non ferrous metallurgy
- Steel and melting
- Non ferrous minerals
- Ferrous products
- Textile and Tanning

- Food, tobacco and beverages
- Wood processing.

Website: www.mityc.es/Desarrollo/Seccion/EficienciaEnergetica/Estrategia/Documentos/

3.2.8 Reports and technical studies for the Energy Plan of Catalonia

(Pla de l'energia de Catalunya 2006-2015, Generalitat de Catalunya - Departament d'Economia i Finance)

Reports and technological studies that have been used as information base for the elaboration of the energy plan (industrial sector):

- Energy efficiency of combutsion and situation in Catalonia (Eficiència energètica de la combustió i situació a Catalunya), Jordi Roca i Serradell. May 2005.
- Energy efficiency in motors and drives and situation in Catalonia (Eficiència energètica en motors i accionaments i situació a Catalunya), David Rillo Sobrino, Andreas Sumper i Roberto Villafáfila Robles - Centre d'Innovació Tecnològica en Convertidors Estàtics i Accionaments Universitat Politècnica de Catalunya. January 2004.
- Energy efficiency in the ceramics sector and situation in Catalonia (. Eficiència energètica en el sector ceràmic i situació a Catalunya), Pere Dámaso – Assessoria Técnica Cerámica. February 2005.
- Energy efficiency in the animal food production sector and situation in Catalonia (. Eficiència energètica en el sector de fabricació de pinsos i situació a Catalunya), Lorenzo Alvarez i Eduard Hernández - Departament d'Enginyeria Agroalimentària i Biotecnologia de la Universitat Politència de Catalunya i Escola Superior d'Agricultura de Barcelona. March 2005.
- Energy efficiency in the tanning sector and situation in Catalonia (. Eficiència energètica en el sector de l'adobament de pells i situació a Catalunya), Ester Bartolí i Josep Mª Morera - Consorci Escola Tècnica d'Igualada. February 2005.
- Energy efficiency in the pulp and paper industry and situation in Catalonia (Eficiència energètica en el sector paperer i situació a Catalunya), Joaquim-Lluís Almirall – CTP S.L. April 2005.
- Energy efficiency in the chemical industry and situation in Catalonia (Eficiència energètica en el sector químic i situació a Catalunya), Centre d'Innovació SIMPPLE.January 2005.
- Energy efficiency in the subsector of metal transformation and situation in Catalonia (Eficiència energètica en el subsector de la transformació de metalls i situació a Catalunya), Jordi Tartera - UPC. May 2005.
- Technological study of cold production in the agro-food industry and best available technologies with respect to energy consumption (Estudi tecnològic del fred a la indústria agroalimentària i les seves millors tecnologies disponibles en consum d'energia), Antonio López, Arturo Esnoz, Joan Carles Bruno i Alberto Coronas – SECYTEF, Universidad Politécnica de Cartagena i CREVER Universitat Rovira i Virgili. March 2005.
- Technological study of industrial cooling and best available technologies with respect to energy consumption (Estudi tecnològic del fred industrial i les seves millors tecnologies disponibles en consum d'energia) Joan Carles Bruno, Alberto Coronas - CREVER Universitat Rovira i Virgili. January 2005.
- Energy efficiency in the meat processing industry and situation in Catalonia (Eficiència energètica en el sector carni i situació a Catalunya), Israel Muñoz Moreno - Investigador del Centre de Tecnologia de la Carn (IRTA). May 2006.
- Energy efficiency in the sector of textile finishing and situation in Catalonia. (Estudi d'eficiència energètica en el sector d'acabats tèxtils i situació a Catalunya), May 2006.

Website:
www.gencat.net/economia/ambits/energia_mines/energia/pla_energia/informes/index.html

3.3 *BATs by industrial branches*

In the following chapters the BREF Documents (best available technology reference documents being developed by the European Integrated Pollution Prevention and Control Bureau – see above) are not explicitly mentioned again for each sector.

3.3.1 General

Summary Table of documents including general BAT recommendations

Manuals are described in further detail in chapter 4.1.

G	Fast references	Short description	Language	Availability
1	United Nations Environment Programme, Division of Technology, Industry and Economics: Cleaner Production – Energy Efficiency Manual. UK, 2004.	*Elaborated in India, China, Hungary, Czech Republic, Slovak Republic and Vietnam, tested in 100 companies. Content: CP EE methodology, Technical modules (identifying focus areas; information on energy efficient technologies), tools and resources (checklists, quick calculation rules etc.)*	English	www.uneptie.org
2	Austrian National Ministry for environment, Austrian Energy Agency: Manual for energy management in industry. Austria, 1999	*Including checklists on quick saving measures and sector specific saving potentials (including figures of savings in %)*	German	http://www.energyagency.at/(de)/publ/pdf/bemas.pd
3	Hensler G. et al. (2004): Manual for the efficient use of energy use in industry and SMEs. Munich: Bayrisches Landesamt für Umweltschutz.	*Checklists on (simple) energy efficiency measures in compressed air systems, process heating, cooling, HAVC systems, drying, energy supply systems, logistics etc*	German	http://www.bestellen.bayern.de/application/stmugv_app000003?SID=1428933592&ACTIONxSESSxSHOWPIC(BILDxKEY:lfu_klima_00022,BILDxCLASS:Artikel,BILDxTYPE:PDF)=X
4	Layer G. (1999): Identification of energy benchmarks for plants, production processes and products. Munich: Forschungsstelle für Energiewirtschaft (der Gesellschaft für praktische Energiekunde e.V.).	*Energy benchmarks for different plants and processes based on German companies*	German	www.ffe.de

G	Fast references	Short description	Language	Availability
5	Berger H et al. (2005): Energy efficient technologies and measure for increasing efficiency – proven applications and innovations. Vienna: Österreichisches Umweltbundesamt, Fa. Allplan.	*Efficient technologies for heat recovery, ventilation, motors, cooling systems, steam supply, compressors, vacuum plants etc; case studies; possibilities for assessment of energy efficiency measures*	German	http://www.umweltbundesamt.at/fileadmin/site/publikationen/M172.pdf
6	Duschl G. (2002): Reduction of CO2 Emission through rational use of energy for the use of air conditioning plants. Munich: Bayrisches Landesamt für Umweltschutz.	*Optimization of air conditioning systems at the example of one specific plant, compilation of a catalogue of optimisation measures, economic considerations, benchmarks*	German	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/
7	Austrian Energy Agency (1998): Energy Efficiency in industry and trade. *Energy*. Vienna: Austrian Energy Agency. Nr. 3/98.	*Several articles on energy efficiency in industry, including energy management systems (EMAS), energy audits, case studies and instruments*	German	
8	CRES (2000): Energy Audit Giude, Part B: System Retrofits for energy efficiency. Athens: Centre of renewable energy sources (CRES).	*Improvements for heating systems, cooling systems, electrical equipment, HVAC, energy conservation measures in industry, focus on iron&steel, ceramic and cement industry.*	English	
10	CRES (2000): Energy Audit Giude, Part C: Best practice case studies. Athens: Centre of renewable energy sources (CRES).	*Case studies in a sesame processing company, one hotel and one office building*	English	
11	Szednyj I. et al. (2004): European Conference Paper Compendium: Energy Efficiency in IPPC installations. Vienna: Umweltbundesamt GbmH.	*Compendium of papers from the conference, including sessions on energy efficiency in industry – cross cutting issues, focus sessions on pulp&paper, sugar, metal, petrochemical and cement industries.*	English	
12	European Comission (2007): Draft Reference Document on Best Available Techniques in Energy Efficiency. Sevilla: European IPPC Bureau.	*Draft document on energy efficiency, including BAT technologies for energy supply and energy efficiency measures.*	English	
13	NN (2000): Renewable Energy and Energy Efficiency in Mexico - Barriers and opportunities. Washington: US Department of Energy.	*Including project report on energy efficiency and renewable energy use in industrial plants*	English	
14	Jasinowski et al (n.d.): Energy Efficiency Toolkit for Manufacturers. Eight proven ways to reduce your costs. No place: U.S. National Association of Manufacturers.	*Some basic measures to reduce energy costs (mainly electrical), links to tools and resources*	English	
15	Poland-Japan Energy Conservation Technology Centre Project KAPE S.A	*Elaborated by The Poland-Japan Energy Conservation Technology Centre Project KAPE S.A basing on the experiences of experts from he Energy Conservation Centre, Japan.* *List of energy efficiency measures for energy supply (thermal and electric energy)*	Polish	

G	Fast references	Short description	Language	Availability
16	N.N. (2002) Good Practice Guide 316 - Undertaking and industrial energy survey – Advice for end users on finding energy cost savings. Energy Efficiency Best Practice Programme. Nifes Consulting Group.	*With regard to BAT there's a section (1.2) where examples of low, medium and high cost measures with their estimated annual savings and simple payback years can be found.* *All topics discussed are illustrated with very short case histories.*	Polish	
17	N.N. (2006) Japan Energy Conservation Handbook 2005 / 2006. ECCJ	*Check points concerning technical energy conservation measures by business type with the following issues taken under consideration:* *1. Operation management;* *2. Additional facilities (thermal and electrical)* *3. Production facilities* *4. others*	English	
18	N.N. (2003). Guidance Note on Energy Efficiency Auditing. Byrne O Cleirigh Limited on behalf of Environmental Protection Agency Ireland.	*Energy Audit Checklist on 14 topics such as refrigeration, process heating and cooling, buildings, energy conservation plants etc.*	English	
19	N.N. (2000).Energy Management in industry. Planning of the investments (teaching material). Warsaw, KAPE S.A./BAPE S.A. SAVE II, Energy Self-Audit Scheme	*List of energy related problems sorted grouped in three categories by the cost of the measures recommended as a solution.):* ▪ *no investment measures* ▪ *low investment measures* ▪ *high investment measures*	Polish	
20	N.N. (2005) Efficiency and innovation in U.S. Manufacturing Energy Use. Booklet of the National Association of Manufacturers.		English	
21	N.N. (2007). Renewables for heating and cooling. Untapped potential. International Energy Agency.		English	

The summary table of the most important recommended BAT that are valid generally for all sectors are allocated to the later topics on energy supply, such as heat recovery, boilers and burners etc.

General basic measures	
Measure	**comments**
Load Management	Reduced energy loads can limit impacts of energy restrictions or high energy costs imposed by the energy supply companies; in case of insufficient capacities efficient load management can eliminate need for investments in new systems; reduced energy loads reduce problems due to overloaded equipment; etc.
Installation of metering devices	Installation of metering devices is essential for monitoring and understanding the energy usage within the company
Performance monitoring systems (KPI)	Key Performance Indicators (KPIs) for energy efficiency involve three data sets: 1) energy consumption, emissions and costs; 2) service system performance measures (energy losses, base load needs etc.); 3) process performance measures (units/time, energy/unit etc.)
Environmental Management Accounting	Combination of energy balance with economic data shows processes that have from the economical point of view the largest saving potential.
Good Housekeeping	Ensure regular repair and maintenance, structured service shutdowns, monthly monitoring of energy accounts etc.

3.3.2 Food industry

Summary Table of documents including BAT recommendations for the food industry

Manuals are described in further detail in chapter 4.1.

FI	Sub-sector	Fast references	Short description	Language	Availability
1	Bakery	N.N (2000): Reduction of ecological and climate harmful emissions through rational use of energy - bakeries.Munich: Bayrisches Landesamt für Umweltschutz	*Optimization of bakeries at the example of one specific plant, compilation of a catalogue of optimisation measures, economic considerations, benchmarks*	German	
2	Brewery	McCubbin B., Flemington R. A. et al.(1999): An Action Plan for reducing greenhouse gas emissions. Saint John: Moosehead Breweries Limited and Canada's Climate Change Voluntary Challenge and Registry Inc.	*Company's action plan including figures and benchmarks*	English	
3	Brewery	Galitsky C. et al.(2003): Energy Efficiency Improvement and Cost Saving opportunities for Breweries – An Energy Start Guide for Energy and Plant Managers. California: Energy Analysis Department, Environmental Energy Technologies Division, University of California.	*Process specific optimisation measures in the brewing plants, general efficiency measures, energy consumption figures.*	English	
4	Brewery	Galitsky C. et al.(2001): Energy Efficiency Opportunities and Potential Cost Savings for United States Breweries. California: National Laboratory Berkley, CA, USA. (In Technical Quarterly Nr. 189.)		English	
5	Brewery	N.N. (1998): Energy Efficiency Opportunities in the Canadian Brewing Industry. Ottawa: Brewer Association of Canada and the Canadian Industry Program for Energy Conservation (CIPEC)	*Energy efficiency opportunities for breweries: energy consumption data, potentials improving the brewing process, potentials for all heat/cold supply processes and also waste water and solid waste*	English	
6	Brewery	Worrell E. (2002): Energy Efficiency opportunities in the brewery industry. California: Lawrence Berkeley National Laboratory, University of California.		English	

FI	Sub-sector	Fast references	Short description	Language	Availability
7	Meat processing	N.N (2001): Reduction of ecological and climate harmful emissions from industrial plants through rational use of energy - meat processing. Munich: Bayrisches Landesamt für Umweltschutz.	*Optimization of metal processing plants at the example of one specific plant, compilation of a catalogue of optimisation measures, economic considerations, benchmarks*	German	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/
8	Meat processing	N.N. (2004): Technical bases for the evaluation of imissions that can be generate during the operation of cooking, steaming, frying and baking plants and possibilities for remediation. Vienna: Austrian National ministry of economy and labour.	*Operational parameters of specific processes (incl. some basic energy data or data for calculation of heat demand), generated emissions and measure to mitigate the consequences/reduce the emissions*	German	
9	Dairy	CRES (n.d.): Solar Systems Application in the Dairy Industry. Athens: Centre of renewable energy sources (CRES).	*Overview on possibilities, examples and short technical description*	English	
10	Dairy	N.N (2000): Reduction of ecological and climate harmful emissions from industrial plants through rational use of energy - milk processing companies. Augsburg: Bayrisches Landesamt für Umweltschutz.	*Optimization of dairies at the example of one specific plant, compilation of a catalogue of optimisation measures, economic considerations, benchmarks*	German	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/
11	Dairy	N.N. (1997): Guide to Energy Efficiency Opportunities in the Dairy Processing Industry. Ontario: National Dairy Council of Canada.	*Energy data of dairies, improvement opportunities, new technologies*	English	
12	Brewery	Armenakis A.(n.d.): DECENTRALIZED CO-GENERATION AND PEAK-LOAD MANAGEMENT, THE CYPRUS CARLSBERG BREWERY CASE STUDY. Cyprus Carlsberg Brewery.	*Cogeneration for brewing processes, general discussion, case study Cyprus Carlsberg*	English	
13	Brewery	Mezger R. et al.(2003): Seperation of wort cooking in two steps. In Brauwelt Nr. 33/2003 pages 1055-1061. Nürnberg: Hans Carl Verlag.	*Description of a energy efficient process for wort cooking*	German	paper
14	Meat processing	Naftz, Ebner (1996): energy benchmarks and saving potential for meat processing companies. Linz: O.Ö. Energiesparverband, Ökologische Betriebsberatung, Wirtschaftskammer Österreich	*Energy data of 344 companies are given (thermal and electrical energy demand); some statements and recommendations are given for the energy supply, however no details on renewable energy*	German	Web

FI	Sub-sector	Fast references	Short description	Language	Availability
15	Breweries	N.N. (2002): Pasteurisation options for breweries. Big Energy Project Innovation Workshop Report. Australian ministry of industry, tourism and resources.	*This report provides a summary of outcomes of a two-day BEP (Big Energy Project) innovation workshop under the Beverage Industry Innovation, Training and Benchmarking project. Different pasteurisation techniques are presented and their potential for energy savings and innovation is discussed.*	English	Web
16	Wine Industry	N.N. (2002): A guide to energy efficiency innovations in Australian wineries. Australian ministry of industry, tourism and resources.	*Information on Energy Management, best practices, benchmarks, system approach to optimisation, best practice for new winery developments*	English	Web

Most important BAT recommendations for the food sector

Breweries		
BAT	**comments**	**Sources (see reference list above)**
Capture of waste energy from mashing		FI3, FI4
Use of compression filter in mashing	Air cleaning reduced cleaning costs	FI3, FI4
Vapour condensers in wort boiling	Production of hot water from condensate	FI3, FI4
Mechanical vapour compression		FI3, FI4
Merlin system	Thin film heat transfer in cooking	FI3, FI4
High gravity brewing	Brewing at higher gravity and later dilution leads to considerable savings	FI3, FI4
Low pressure wort boiling	Reduction of boiling temperature	FI3, FI4; FI13
wort stripping	Can reduce evaporation to 2% of the wort volume	FI3, FI4
Heat recovery from wort cooling		FI3, FI4
Immobilised yeast fermentation	For accelerating fermentation	FI3, FI4
CO2 recovery systems		FI3, FI4
Microfiltration for clarification or sterilization	Filtration as an alternative to pasteurization	FI3, FI4
Flash pasteurization	Estimated to use only one third of the energy required in tunnel pasteurization. Energy Use for sterilizing containers closes this gap. Non heating options for sterilizing containers can save energy.	FI3, FI4 FI15
Heat recovery in pasteurization		FI3, FI4

Breweries		
BAT	**comments**	**Sources (see reference list above)**
Tunnel pasteurization – reduction of energy losses	Use store heat / solar heat for heating system for start up High efficiency pumps, VS drives Preheat incoming containers (ambient air, solar) Local generation of hot water Use of hot water instead of steam (no distribution losses, no HEX losses etc.) Insulating high temperature zones of unit Thinner glass / more conductive materials lower the driving temperature (temp drop across glass now: 5-15°C) Even heating/cooling increase heat transfer and shorten process times Immersion, spraying from below, or other heat transfer systems may increase internal convection and allow process time to be shorter Aiming at very little temperature increase of containers leaving the unit (normally +20°C compared to entrance temp) Evaporatively cooled water, absorption or ejector cooling with waste heat or other strategies may be used for cooling, if necessary	FI15
Microwave pasteurisation	Possible use in conjunction with heat recovery or at variable basis to achieve specified temperatures where variable heat sources are available or flow rates vary. Efficiency at 90% (conversion from electricity). Power from cogeneration can enhance economic/ecological performance.	FI15
Mechanical pasteurisation	Three main types of filters: Kieselguhr, membranes, cellulose mesh sheet filter. Reducing pressure drop over filters is decisive. Strategies using centrifuges	FI15
Irridation for pasteurisation		FI15
Ultrasonic pasteurisation		FI15
Membranes for alcohol free beer production		FI3, FI4
Low temperature detergents in washing		
Cascaded Use of wash water		EU BREF for food industry

Meat processing		
BAT	**comments**	**Sources (see reference list above)**
Dew point regulation for cooling processes	Reduction of air ventilation to the necessary minimum for an efficient process increases the operation efficiency (less excess air); saving potential up to 5%	G5
Closed smoking and cooking operation	Reduction of energy demand in closed smoking/cooking compared to open systems	FI8, statements of supplier
Drying with low air flow	500 – 600 m³/h air flow in drying is common in most modern chambers	FI8
Use of waste heat of cooling machines and compressors	High potential if a low temperature heat demand exists	FI14, FI7
Thawing in air		EU BREF for food industry
Thermal heating of smoking and cooking chambers	Thermal heating instead of electrical heating saves energy costs and primary energy input	FI7
Alternative cooling concepts	a) Gas motor driven cooling machines b) absorption cooling with waste heat (from a CHP plant) both options not rated economically in the report	FI7

Dairies		
BAT	**comments**	**Sources (see reference list above)**
Dew point regulation for drying processes	Reduction of drying air to the necessary minimum for an efficient process increases the operation efficiency (less excess air); saving potential up to 5%	G5
Fermenter: Heat exchange between cold milk and hot whey	This heat exchanger is in modern plants state of the art and can save a large amount of energy demand for milk heating	ST3
Mechanical or thermal multi-stage vapour compression for evaporation in whey drying	Generally a multistage compression system reduces steam demand considerable (1 stage = 100%, 2 stages = 33%). Mechanical vapour compression is now seen as best available, as it further reduces energy, especially thermal energy, consumption. The reduction reaches a demand that is only 1/5 of the primary energy demand for thermal vapour compression.	www.gea.at
Reverse Osmosis /Filtration prior to thermal evaporation techniques (such as vapour compression)	A mechanical concentration step of the whey reduces necessary thermal energy demand (or electrical for mechanical vapour compression) in the subsequent process step	EU BREF for food industry
Reuse of waste condensate streams	Reuse of waste condensate streams either directly if possible (in the lye of the CIP system) or via heat exchange for heating process water (wash water in fermentation, manual cleaning water etc.)	
Use of waste heat streams from washing processes	e.g. vapours of sterilization processes for water pre-heating, use of heat from the spray lye in the main lye bath in bucket washing systems	FI10
Use of waste heat from cooling machines and compressors	High potential if a low temperature heat demand exists	FI10, EU BREF for food industry
Homogenisation a branch current	Homogenising only one branch of the total process streams can save up to 60% of energy. Applied for milk and cream homogenisation.	FI10
Closed, self cleaning seperators of cream	Combined closed systems for taking out the cream and cleaning	FI10
Alternatives for pasteurisation	a) UV radiation b) ohmic heating using the product as resistance c) high pressure operation (2000 – 6000 bar and 40 -60°C) d) ultrasonic treatment e) micro wave heating	FI10
UHT treatment for milk sterilization	Indirect units, where no direct contact between steam and milk is established, can recover more waste heat (88-90%) than direct operation modes (44-50%).	FI10

	Wineries	
BAT	**comments**	**Sources (see reference list above)**
Increasing refrigeration efficiency	See also below in chapter refrigeration; refrigeration is one of the largest energy consuming units in wine production	FI16
Refrigeration heat output use	See below in refrigeration	FI16
Off peak cooling and night over-chilling	Reduction of energy costs through re-arrangement of cooling hours	FI16
Dedicated cold stabilisation area		FI16
On-site warehousing to decrease transport		FI16
Cogeneration	See also below in chapter cogeneration; possibly in combination with absorption cooling	FI16
Drainage optimisation (recycling excess rain)		FI16
Reuse steam from stills (distillation equipment)		FI16
Winemaking decisions	Sensible determination of process parameters such as allowable temperature of grapes, minimum must temperature, rate of cooling desired etc.	FI16
Pre-cooling grapes with chilled water	Pre-cooling grapes prior to must chilling reduces peak load on the refrigeration plant;	FI16
Evaporative cooling or chilled water to control fermentation	fermentation could be controlled by chilled water at 4-6°C; evaporative condensers can also provide low enough temperatures to prevent wild fermentation prior to controlled fermentation.	FI16
Thermal storage	During night temperature could be pulled down to the allowable band, decreasing daytime refrigeration demand by allowing wine temperature to rise to the top of the allowable band by the late afternoon. Advantage: running at lower temperature during the night enhances condenser efficiency.	FI16
Product-product heat exchange	Large wineries practice heat exchange into and out of cold vessels – especially valuable when avoiding switch in another compressor to handle cold stabilisation - heat recovery efficiency ~ 80%. Larger transfer volumes improve effectiveness of heat exchange.	FI16
Centrifuge driven separation methods	Replacing cold settling by mechanical alternatives such as centrifuge driven separation methods can significantly reduce the load on the refrigeration plant.	FI16
Heating of juice using solar hot water	Use of solar heat (in combination with waste heat from compressors) for heating juice imported to site from tankers.	FI16
Cross flow filters instead of centrifuge	Stainless steel and titanium metallic membranes are robust and have self cleaning properties; final separation can be done via decanters or belt press. Energy savings compared to centrifuges up to 50%.	FI16

	Cleaning in the food industry	
BAT	**comments**	**Sources (see reference list above)**
Low temperature detergents in washing		
Cascaded Use of wash water	Use of final rinsing water for pre-rinsing, intermediate rinsing or the preparation of cleaning solution (often used in CIP systems); turbidity detectors can optimize the reuse of water	EU BREF for food industry
Use of vapour condensate from vapour compression for preparation of cleaning solutions	In diaries it can be possible to reuse vapour condensates which are not highly polluted for lye preparation	
Internal recycling of water and chemicals		EU BREF for food industry
Dry cleaning	Dry cleaning prior to wet cleaning saves water and energy costs	EU BREF for food industry
Catchpots	Catchpots prevent solid material entering the waste water flow while cleaning, reduced water contamination	EU BREF for food industry
Pre-soaking	Loosen the dirt and subsequent easier cleaning; reduced water and energy demand	EU BREF for food industry
Pressure cleaning	Reduced water and energy consumption as nozzles can be ideally adjusted and cleaning is done by mechanical effect; concern in the food industry about hygiene implications of over splash and aerosols from high pressure cleaning. Cost savings in steam, water, waste water of high pressure/low volume systems compared to low pressure/high volume systems are 85%.	EU BREF for food industry
Low pressure foam cleaning	The foam cleaner is sprayed on the surface, adheres to it, is left for 10-20 min and is then rinsed away. Water consumption reported to by 40% compared to manual cleaning. Cold water use (10°C) possible.	EU BREF for food industry
Cleaning with gels	Similar to foam cleaning, gels may adhere better to the surfaces; no aggressive chemicals, less water compared to traditional cleaning as gels are easy to rinse.	EU BREF for food industry
Using metered water dispensers and/or high pressure low volume (HPLV) sprays for cleaning trucks	Used in the wine industry: leads to reduced water consumption for truck cleaning	EU BREF for food industry
Volume based control on rinsing in CIP systems	Volume based control can save more energy than time based control system	FI11
Nozzle optimisation and maintenance		FI11

3.3.3 Metal treatment industry

Summary Table of documents including BAT recommendations for the metal treatment industry

Manuals are described in further details in chapter 4.1.

MI	Sub-sector	Fast references	Short description	Language	Availability
1		Bayer H. et al (2005): Use of waste heat and integration of renewable energy sources in a metal treating company. Vienna: Austrian National Ministry of Innovation and technology.	*Energy screening of a metal treating company in Austria, including heat demand calculations and basic measures for improvements*	German	
2	Galvanising	N.N. (2003): Efficient Use of Energy in the galvanising industry. Augsburg: Bayrisches Landesamt für Umweltschutz.	*Optimization of galvanizing plants at the example of one specific plant, data acquisition, analyses, compilation of a catalogue of optimisation measures, economic considerations, benchmarks, results for the sector in general*	German	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/
3		Flanagan J.M. (1993): Learning from Experiences with Process Heating in the Metal industry. Maastricht: CADDET Energy Efficiency (Centre for the analysis and dissemination of demonstrated energy technologies).	*Technology review on burner types, energy efficiency measures and economics, demonstration case studies*	English	
4		N.N. (2006): Energy savings in painting companies. Augsburg: Bayrisches Landesamt für Umweltschutz.	*Optimization of painting plants at the example of one specific plant, data acquisition, analyses, compilation of a catalogue of optimisation measures, economic considerations, benchmarks, results for the sector in general*	German	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/

Most important BAT recommendations for the metal treatment industry

Metal treatment		
BAT	**comments**	**Sources (see reference list above)**
Heat recovery from cooling of rectifiers	When water cooling is used for cooling rectifiers, waste heat can be recovered through air-water-heat exchangers e.g. for heating of halls or drying of hydroxid-sludges in summer; Using oil cooling, also oil-water heat exchangers can give access to the waste heat for recovery	MI2
Rectifier: Change of selenic plates to silica plates	This change can minimize tension losses in rectifiers; savings 10-20%	MI2
Rectifier: increase of conductivity of the electrolytes	Costs for supply of co-current flow amounts to 20-80% of all production costs	MI2
Rectifier: Reduction of distance anode-cathode	Costs for supply of co-current flow amounts to 20-80% of all production costs	MI2
Rectifier: suitable anode for product carrier	Costs for supply of co-current flow amounts to 20-80% of all production costs	MI2
Minimizing off gas volume	Minimized off gas volumes that go conform with working and emissions regulations save heating demand and ventilation energy; off gas can be reduced via partly covering / full covering that can be moved by transportation wagon	MI2
Heat recovery of off gas	Heat release from company occurs mainly over off gas; air-to-air/water heat exchange can save (process) heating costs	MI2
CHP	Electricity demand and thermal energy demand are steady throughout the year	MI2
Heat recovery for process baths		MI2
Drying regulation	Regulated covers for the drying system allow minimized opening times and reduction of energy losses; optimisation is done by measuring humidity and regulation of drying air	MI2
Spray-pretreatment in painting: shut down off spray pumps in operation stops	Reduction of energy losses while spraying	MI4
Spray-pretreatment in painting: use of low-temperature chemicals	Reduced heating demand	MI4
Spray-pretreatment in painting: condensation of off gas	Condensation of off gas and installation of heat recovery, 36 kW savings	MI4
Abandonment of wet chemical pre-treatment	Possible e.g. in combination with minimized oiling and blasting, 160 kW savings	MI4
Water dryers: Minimized openings in dryers; minimal off gas for drying	Reducing heat losses and excess air intake in dryers	MI4
Water dryers: Use of “A sluices” or sluices that are operating with circulating air	“A sluices” ensure minimized cold air intake and reduce losses	MI4
Water dryers: Temperature reduction and dehumidification of circulating air	Reduction of heating demand of drying air	MI4
Water dryers: Direct Use of off gas from paint dryer		MI4
Painting cabins: reduction of over spray	Reduction of air sinking velocity	MI4
Use of paint without necessary humidification of painting cabins		MI4
Painting cabins: heat recovery from off gas		MI4
Painting cabins: operation with circulating air	Only partly use of fresh air; only in automatic regulated systems possible	MI4

Metal treatment		
BAT	**comments**	**Sources (see reference list above)**
Painting cabins: Use of powder paint		MI4
Painting cabins: Reducing number of paint layers	Testing of new process is necessary	MI4
Paint dryers: Use of paint with low hardening temperatures		MI4
Paint dryers: direct heating of circulating air	(Instead of indirect heating)	MI4
Paint dryers: Heat recovery of off gas stream		MI4
Paint dryers: Reduction of drying temperature and dehumidification of circulating air	Possible for water-soluble paints	MI4
Paint dryers: Shortening of annealing time	Of gas flowing through double wall interior panel	MI4

3.3.4 Wood processing industries

Summary Table of documents including BAT recommendations for the wood processing

Manuals are described in further details in chapter 4.1.

WI	Sub-sector	Fast references	Short description	Language	Availability
1		US Department of Energy, Energy Efficiency and Renewable Energy (2004): Forest Products – Industrial Technology Program. Washington DC.	*Annual report of the Industrial Technologies Programme for boosting the productivity and competitiveness of U.S. industry, incl. improvements in energy and environmental performance*		
2		N.N (n.d.): USAID BAT Wood Processing and Furniture Making: Cleaner Production Fact Sheet and Resource Guide.			

Most important BAT recommendations for the wood processing sector

Wood processing		
BAT	**comments**	**Sources (see reference list above)**
Dew point regulation for drying processes	Reduction of drying air to the necessary minimum for an efficient drying process increases the operation efficiency (less excess air is heated); saving potential up to 5%	G5

3.3.5 Other industries

Summary Table of documents including BAT recommendations for other industry sectors

Manuals are described in further details in chapter 4.1.

OI	Sub-sector	Fast references	Short description	Language	Availability
1	Plastic processing	N.N. (2002): Reduction of CO2 emissions through rational use of energy in the plastic processing industry. Augsburg: Bayrisches Landesamt für Umweltschutz.	*Optimization of plastic processing plants at the example of one specific plant, data acquisition, analyses, compilation of a catalogue of optimisation measures, economic considerations, benchmarks, results for the sector in general*	German	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/
2	Machinery	N.N. (2002): Reduction of CO2 emissions through rational use of energy in the machinery industry. Augsburg: Bayrisches Landesamt für Umweltschutz.	*Optimization of the machinery industry at the example of one specific plant, data acquisition, analyses, compilation of a catalogue of optimisation measures, economic considerations, benchmarks, results for the sector*	German	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/
3	Paper	Papiertechnische Stiftung München (2003): Climate protection through efficient use of energy in the paper industry – Use of low temperature waste heat. Augsburg: Bayrisches Landesamt für Umweltschutz.	*Optimization of the paper industry at the example of one specific plant, data acquisition, analyses, compilation of a catalogue of optimisation measures, economic considerations, benchmarks, results for the sector*	German	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/
4	Paper	Brand J. et al. (2005): Chances of the paper industry in the framework of the climate strategy. Vienna: Austrian Energy Agency.	*Energy data of paper plants, benchmarking, potential for improvements, CHP in the paper industry, concrete examples of measures and calculation of savings*	German	Web

OI	Sub-sector	Fast references	Short description	Language	Availability
5	Textile	EnviroTex GmbH (2000): Potential for the reduction of CO2 emissions through rational use of energy in the textile finishing industry. Augsburg: Bayrisches Landesamt für Umweltschutz.	*Optimization of the textile finishing industry at the example of one specific plant, data acquisition, analyses, compilation of a catalogue of optimisation measures, economic considerations, benchmarks, results for the sector*	German	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/
6	Textile	Schlachta et al. (2004): Reduction of emissions at textile finishing plants. Augsburg: Bayrisches Landesamt für Umweltschutz, Landesanstalt für Umweltschutz Baden Württemberg.	*Emission standards, the current emission situation, mitigation measures and measure to reach the limits set by regulations – based on emissions some figures on energy*	German	Web
7	Textile	UK Best Practice Programme (n.d.): Monitoring and targeting in the textiles industry. Oxfordshire: ETSU and Cheriton Technology Management Ltd. for the Department of Environment transport and the Regions.	*Basic information on energy data monitoring for energy management, including some industry figures*	English	web
8	Textile	UK Best Practice Programme (n.d.): Cutting your energy costs – A guide for the textile dying and finishing industry. Oxfordshire: ETSU and Cheriton Technology Management Ltd. for the Department of Environment transport and the Regions.	*Energy data and energy efficiency opportunities for specific steps in manufacturing of the textile dyeing and finishing*	English	Web
9	Textile	Swiss Textile Association (N.N.): Luft und Textil. Retrieved from http://www.swisstextiles.ch/boxalino/files/Document187file.pdf. November 2007		German	Web

Most important BAT recommendations for other industry sectors

Paper		
BAT	**comments**	**Sources (see reference list above)**
Dew point regulation for drying processes	Reduction of drying air to the necessary minimum for an efficient drying process increases the operation efficiency (less excess air is heated); saving potential up to 5%	G5
Textile		
BAT	**comments**	**Sources (see reference list above)**
Dew point regulation for drying processes	Reduction of drying air to the necessary minimum for an efficient drying process increases the operation efficiency (less excess air is heated), saving potential up to 5%	G5

3.4 *Heat recovery systems*

Summary Table of documents including BAT recommendations for heat recovery systems

Manuals are described in further details in chapter 4.1.

HR	Sub-sector	Fast references	Short description	Language	Availability
1		Morand R. et al. (2006): Process Integration using the Pinch Method – Manual. Bern: Swiss National ministry for Energy.	*Handbook on process integration and the pinch method Several case studies are available from the project pilot phase "Pinch Methodology" 2006/07 from the homepage.*		
2		National Productivity Council of India – National Certification Examination for Energy Managers and Energy Auditors: Guidebook on Energy Efficiency in thermal utilities, Waste Heat Recovery. India. In http://www.em-ea.org/gbook12.asp, November 2007.	*General document on waste heat recovery from the examination programme*		
3		European Comission (2007): Draft Reference Document on Best Available Techniques in Energy Efficiency. Sevilla: European IPPC Bureau.	*Draft document on energy efficiency, including BAT technologies for energy supply and energy efficiency measures.*		
4		N.N. (2002) Good Practice Guide 316 – Undertaking and industrial energy survey – Advice for end users on finding energy cost savings. Energy Efficiency Best Practice Programme. Nifes Consulting Group.	*Checklist on heat recovery including recommendations and potential*		

Most important BAT recommendations for Heat Recovery Systems

Heat Recovery		
BAT	**comments**	**Sources (see reference list above)**
Rotating heat exchanger (heat wheel)	Rotating wheel that continuously exchanges heat of hot and cold air streams with 85% efficiency, smooth regulation possible; humidity exchange possible; limits: little leakage between streams, high space demand	G5
Heat pipe	Closed pipe in which a heat carrier (cooling agent) is evaporated in the lower heating zone; the carrier travels up in the cooling zone where transfers the condensation heat to the environment and runs back into the heating zone.	G5
Increasing surface area of heat exchange – suitable temperatures in ingoing/outgoing streams	Larger surface areas allow cold media to reach temperatures very close to hot (waste) heat temperature, enhancing the efficiency of heat recovery and reduce running costs.	FI16, HR1

3.5 *Heat supply systems*

3.5.1 Boilers and burners

Summary Table of documents including BAT recommendations on boilers and burners

Manuals are described in further details in chapter 4.1

BB	Sub-sector	Fast references	Short description	Language	Availability
1		N.N. (2001): Saving energy with Steam production and Distribution. Sittard, The Netherlands: CADDET Energy Efficiency (Centre for the analysis and dissemination of demonstrated energy technologies).			Web
2		Dockrill P. et al.(2001): Boilers and Heaters: Improving Energy Efficiency. Ontario: CANMET Energy Technology Centre.	*Operation control, combustion regulation, energy efficiency measures, energy management opportunities*		Web
3		National Productivity Council of India – National Certification Examination for Energy Managers and Energy Auditors: Guidebook on Energy Efficiency in thermal utilities. India. In http://www.em-ea.org/gbook12.asp, November 2007.	*Subdocuments on different boiler types, boiler calculations, efficiency measures etc.*		Web
4		Harrel G. (2002): Steam System Survey Guide. Tennessee: Oak Ridge National Laboratory.	*Including: fuel parameters and benchmarks, boiler efficiency and improvements, steam distribution system losses, condensate recovery etc.*		Web
5		Wright A. et al (n.d.):Improving Steam System Performance – A Sourcebook for Industry. Washington DC: Lawrence Berkeley National Laboratory.	*Including: basic information on steam systems, possibilities of improvements, large list of handbooks, manuals and software tools for optimization*		Web
6		N.N. (2002) Good Practice Guide 316 – Undertaking and industrial energy survey – Advice for end users on finding energy cost savings. Energy Efficiency Best Practice Programme. Nifes Consulting Group.	*Checklists for efficiency measures for boilers and burners*		Web

BB	Sub-sector	Fast references	Short description	Language	Availability
7		N.N. (2001). Saving energy with Steam Production and Distribution. Maxi Brochure 13. CADDET/IEA/OECD	*Boiler efficiency measures and energy saving potential in %*		Web
8		Berntsson, T. Franck, P., Asblad, A. (1997). Learning from experiences with Process heating in Low and Medium Temperatures Ranges. CADDET Analyses Series No. 22. CADDET/IEA/OECD			Web

Most important BAT recommendations on boilers and burners

Boilers and Burners		
BAT	**comments**	**Sources (see reference list above)**
Upper heating value technology	Use of the latent heat of the combustion off gas (for gas fired boilers at 50-70°C), several 1000 MWh/a saving potential with 8700 h/a; limits: chimney of stainless steel , low temperature heat demand available	G5
Reduction of flash steam in the boiler feed water tank	Reduction of steam losses in the deoxygenating of the boiler feed water; the usual losses of the thermal deoxygenating (0,15% - 3% of the boiler) can be reduced by regulation of the valve for gas relief	G5, BB7, BB6
Economizer	Use of hot combustion gases for preheating the boiler feed water (usually after deoxygenating)	G5
Preheating of boiler feed water	In general there are 3 possibilities for preheating boiler feed water: 1. with the heat losses from the processes 2. by the economizer (hot combustion gases) 3. with the deoxygenised boiler feed water (this can later again be heated via an economizer)	G5, BB6, FI10
Preheating of combustion air	Use of the hot combustion gases for preheating the combustion air for increased burner efficiency; saving potential: several % of the produced steam, e.g. 2 GWh for a 15 MW boiler	G5
Control of the combustion air	Control of the combustion air in the burner depending on the fuel amount which is burnt to avoid high excess air ratios	G5
Reduction of flash steam in the processes		BB6, BB7, FI3

3.5.2 Combined Heat and Power (CHP)

Summary Table of documents including BAT recommendations on CHP

Manuals are described in further details in chapter 4.1.

CO	Fast references	Short description	Language	Availability
1	National Productivity Council of India – National Certification Examination for Energy Managers and Energy Auditors: Guidebook on Energy Efficiency in thermal utilities, Cogeneration. India. In http://www.em-ea.org/gbook12.asp, November 2007.		English	Web
2	Solinc H. et al. (2002): Heat and electricity cogeneration – from an idea to realization. Ljubljana: Josef Stefan Institute.			
3	N.N. (1998): Review of heat and electricity cogeneration systems with examples from Europe. Ljubljana: Josef Stefan Institute.			
4	Fay P. et al.(2006): Plan your cogeneration project thoroughly – a good practice guide of small scale cogeneration. IEE project COGENchallenge.	*The guide leads through the steps in planning a CHP project: from feasibility study, over financing schemes, public support mechanisms, grid connection, new energy contracts, licensing procedure etc.*	English	www.cogen-challenge.org
5	Fay P. et al.(2006): Pick the right cogeneration technology – a technology checklist of small scale cogeneration. IEE project COGENchallenge.	*A technology checklist for small scale cogeneration, including information on possible fuels, available unit sizes etc.*	English	www.cogen-challenge.org
6	N.N. (2007): Technical Report on fluidized Bed Combustion Boiler Technology for Cogeneration. United Nations Environment Programme, Division of Technology, Industry and Economics	*The study report provides an overview of FBC technology, co-generation systems and practical aspects of implementing such a system in an industry. A detailed case study provides insights to the technical specifications of the various equipments, systems and costeconomics. It also provides list of technology providers and suppliers worldwide.*	English	http://www.unep.fr/energy/projects/cp-ee/docs/FBC_30_sep_2007.pdf
7	The Energy Solutions Center Distributed Generation Consortium (2007): Energy Solution Center DG Applications Guide.	*Online guide on CHP installations, regularly updated. No download available.*	English	http://www.energysolutionscenter.org/distgen/AppGuide/AppGuide_Home.htm
8	Farrar L. et al (2003): Combined Heat and Power Resource Guide. Midwest CHP Application Center.	*Guide for energy engineers, energy auditors, facility operations directors/managers etc. giving the basic principles on CHP, CHP technologies (prime movers and thermal use) and applications*	English	http://www.chpcentermw.org/pdfs/chp_resource_guide_2003sep.pdf

Most important BAT recommendations on CHP

Cogeneration		
BAT	**comments**	**Sources (see reference list above)**
Suitable capacity and design	Design according to the criteria: heat load, electricity needs, regulatory framework. For electricity driven designs the use of the (waste) heat has to be ensured. Normally CHP installations are controlled by the heat demand.	CO4
Total use of the produced heat and power	High efficiency cogeneration (using total heat and power) can lead to 10-25% of primary energy savings.	CO4, FI16, CO6
Design of plant for at least half year operation	To ensure an economic design, the plant should run at least half a year – aiming at a large amount of operating time	CO4
Reduction of NOx emissions	Regular maintenance and installing catalysts on the exhaust gas can reduce emissions	CO4
Use of heat for absorption cooling purposes		FI16
Biomass based FBC in combination with CHP	An Indian case studies shows pay back time of two years for the installations and a reduction of GHG emissions to zero.	CO6

3.5.3 Heat pumps

Summary Table of documents including BAT recommendations on Heat Pumps

No relevant literature reference solely on heat pumps.

Most important BAT recommendations on Heat Pumps

Heat Pumps		
BAT	**comments**	**Sources (see reference list above)**
Compression heat pumps	Increasing waste heat temperature via electrical compression of a circulating heat carrier. COP depending on waste heat temperature, values up to COP=6 possible.	G5
Absorption heat pumps	Increasing waste heat temperature via thermal compression of a circulating heat carrier. COP of 1,5 possible. High Investment costs.	G5

3.5.4 Biomass

Summary Table of documents including BAT recommendations on energetic Biomass Use

Manuals are described in further details in chapter 4.1.

BM	Sub-sector	Fast references	Short description	Language	Availability
1		Mair K. et al (n.d.): Research results to emissions and emission reduction possibilities – Energetic Use of renewable raw materials. Munich: Bayrisches Staatsministerium für Landesentwicklung und Umweltfragen.	*Solid waste, plant oils and biogas – technical combustion parameters and emission values*		
2		N.N. (1998): Advanced Thermal Conversion Technologies from Solid Waste to Energy. Oxfordshire: IEA CADDET Centre for Renewable Energy.	*Current status of gasification and pyrolisis, market drivers, barriers*		

Most important BAT recommendations on energetic biomass use

Biomass use		
BAT	**comments**	**Sources (see reference list above)**
Suspension Combustion and Fluidized Bed Combustion (FBC)	These two combustion technologies have the highest boiler efficiencies at 80%. FBC can burn a variety of different fuels and chemical reactants can be added in the bed to remove possible pollutants.	CO6

3.5.5 Solar heat

Summary Table of documents including BAT recommendations for Solar Thermal Installations

Manuals are described in further details in chapter 4.1.

ST	Sub-sector	Fast references	Short description	Language	Availability
1		CRES (n.d.): Solar Systems Application in the Dairy Industry. Athens: Centre of renewable energy sources (CRES).	*Overview on possibilities, examples and short technical description*	English	Web
2		Schweiger H. et al (2001): POSHIP Potential for Solar Heat for Industrial Processes. Barcelona: Aiguasol Enginyeria.	*Final report of POSHIP project*	English	Website Aiguasol
3		Schnitzer H. et al (2005): SOLPROBAT. Vienna: National Ministry of Innovation and Technology.	T*his project report examines possibilities on how to improve the usability of solar power for industry. Special emphasis is placed on small and medium enterprises, focus on batch processes*	German	Hardcopy
4		CRES, Centre For Renewable Energy Sources. *PROCESOL (2000). Solar Thermal Process Heating in Industrial Applications: A Stimulation Plan.* Final Report (Project ALTENER 4.1030/Z/98-205).	*Main topic: Solar thermal application for process heat. Contents: sectorial potential studies (sectors: food, agro food, textile, chemical, beverage); analysis of case studies (dyeing/finishing in textile, winery, dairy, food processing, rice drying); detailed description of a TPF pilot project in a dairy (application of solar thermal combined with waste heat recovery)*	English	Web
5		CRES, Centre For Renewable Energy Sources. *PROCESOL II. Solar Thermal Process Heating coupled with Heat Recovery Technologies in Industrial Applications.*	*Main topic: Solar thermal application for process heat. Contents: national potential studies and description of existing plants*	English	Web

Most important BAT recommendations for solar thermal installations

Solar process heat		
BAT	**comments**	**Sources (see reference list above)**
Steam production with parabolic collectors	Usually used for power plants; in industry only sensible if steam is absolutely necessary for the process; high investment cost	G5
Solar process heat for process water heating	Ideal temperature range from 40 – 90°C	ST2, ST3, ST1
Solar process heat integration coupled with energy efficiency measures (and the pinch analysis)		ST2, ST3, ST4, ST5
Solar ratio 30-50%	Solar process heat supplied a certain ratio of the full demand to ensure efficient use of the solar heat in peak summer days	ST2, ST3
Process baths as heat storage	Existing process baths (e.g. in metal treatment) can be used as energy storages	ST3

3.6 *Industrial refrigeration and cooling systems*

Summary Table of documents including BAT recommendations for Industrial refrigeration and cooling

Manuals are described in further details in chapter 4.1.

RC	Sub-sector	Fast references	Short description	Language	Availability
1		EU BREF Document (2001): Reference Document on the application of Best Available Techniques to Industrial Cooling Systems. Brussels: European Commission.			
2		N.N. (2003): Energy Efficiency in industrial HVAC Systems. Washington: NC Department of Environment and Natural Resources, Division of Pollution Prevention and Environmental Assistance.			
3		N.N. (2002) Good Practice Guide 316 – Undertaking and industrial energy survey – Advice for end users on finding energy cost savings. Energy Efficiency Best Practice Programme. Nifes Consulting Group.	*Checklist for cooling systems including recommendations and potential*		

Most important BAT recommendations for industrial refrigeration and cooling

Refrigeration and cooling		
BAT	**comments**	**Sources (see reference list above)**
Free cooling	Condensation of the cooling agent via outside air (at colder air temperatures), no need for cooling machine operation at low outside air temperatures	G5, FI14
Matching of cooling capacity and cooling load and optimized control		FI3, FI14, FI10, FI16
Control of full load and part load	Ideal steps in compressor load	FI14, FI16
High evaporation temperature and low condensation temperature of the cooling agent	The evaporation temperature (saturation temp. on the cold side) should be as high as possible, condensation temperature (saturation temp. on the hot side) should be as low as possible to ensure a higher efficiency. 1°C lower evaporation temperature lowers the efficiency of the plant by 3%.	FI14, FI16
Recovery of waste heat	Placing de-superheaters prior to condensers and/or using condensation heat for low temperature applications	FI10, FI16
Combination of cooling compressors	Avoiding the use of a single large compressor; it is most efficient to split up the load between smaller compressors with a control systems that will ensure capacity and operation are matched to load.	FI16
Variable Speed Drives	Variable speed drives increase efficiency at part load	FI16
Shading of condensers	Shade condensers to minimize solar heat on condensers	FI16
thermal storage	Thermal storage should be optimized to cooling load management	FI16
Economiser port on screw compressors	Economiser port on screw compressors may enable different brine and cold water temperatures for the same compressors	FI16
Absorption cooling using waste heat of CHP		FI16
Application of transcritical CO2 heat pumps	Allowing hot water generation at 90°C with cooling	FI16
Stable heat sinks	Normally waste heat is rejected to atmosphere (variable heat sink), stable heat sinks (large bodies of water etc) mitigate effects of high ambient pressure and humidity	FI16

3.7 *Heat and cold storage and distribution*

Summary Table of documents including BAT recommendations on Heat and Cold Distribution

No relevant literature reference solely on heat and cold distribution.

Most important BAT recommendations on Heat and Cold Distribution

Heat and Cold Distribution		
BAT	**comments**	**Sources (see reference list above)**
Latent heat storage	High density storage systems that uses the latent heat of a phase change material to store energy. High investment costs and energy storage at one specific temperature (phase change).	G5
Insulation		G5, BB6, BB7, FI3, FI10
Condensate recovery	Steam traps reduce condensate in the pipes and the consequent formation of a lower heat transfer coefficient	G5, BB7, FI3
Short pipe lengths from energy supply to processes		BB6
Temperaturecontrol of processes	Accurate temperature control of processes/media reduce overheating	BB6, FI3
Discontinuous circulation	Continuous circulation is only necessary if the demand is continuous. Circulation of water should be stopped over non-working hours.	FI14

3.8 *Compressed air systems, vacuum plants and motors*

Summary Table of documents including BAT recommendations for compressed air systems, vacuum plants and motors

Manuals are described in further details in chapter 4.1.

CV	Sub-sector	Fast references	Short description	Language	Availability
1		Spendal M (n.d.): Energy efficiency in compressed air systems. Lubljana: Josef Stefan Institute.			
2		Josef Stefan Institute (n.d.): Energy Efficiency in electrical motor systems. Lubljana.			

Most important BAT recommendations for compressed air systems, vacuum plants and motors

Compressed air		
BAT	**comments**	**Sources (see reference list above)**
Control depending on demand	Adjustable speed drive; saving potential in the range of 10%	G5
Pressure level as low as possible	Reduction of pressure of 1 bar leads to savings of 6-8% of the energy required. Control allows to reduce the peak pressure requirement.	G5
Leakage reduction	Target should be 5-10%	G5, FI10
Recovery of waste heat		FI10, FI14
Vacuum plants		
BAT	**comments**	**Sources (see reference list above)**
Low water temperatures for pump cooling	For liquid ring pumps: use of 15°C water favours the condensation of the vapour on the suction side and thus increases the suction capacity Cooling towers of heat exchangers reduce this temperature and the pump runs at lower frequency with less electricity demand	G5
Waste heat recovery	The hot air which is set free from the vacuum pumps can be reused; The waster circuit can be cooled by heat recovery as discussed above	G5

Motors		
BAT	**comments**	**Sources (see reference list above)**
Control depending on demand	Control types available: 1. on frequency (adjustable speed drive) 2. on spin 3. on choke Saving potential up to 50%	G5, FI3, FI16
High efficient motors	Use of high efficiency motors helps to reduce energy losses and costs, with a saving potential of 2-8%;	G5, FI3
Correct dimensioning	Saving potential 1-3%	G5, FI3
Recovery of heat from breaking	The energy that is set free while breaking can be reused. The motor is working like a generator while breaking and supplies the energy back to the net. Adjustable speed drive is a requirement. Useful in operation with many starts and breaks.	G5

3.9 *Industrial Buildings*

Summary Table of documents including BAT recommendations for industrial buildings

Manuals are described in further details in chapter 4.1.

IB	Sub-sector	Fast references	Short description	Language	Availability
1		Šijanec Zavrl M., Tomšič M (1999): Energy efficient windows and glazing. Lubljana: Gradbeni Institute ZRMK.			
2		N.N. (n.d.): Gas fuels and devices for office and water heating. University Of Ljubljana, Faculty Of Mechanical Engineering			

Most important BAT recommendations for industrial buildings

Industrial buildings		
BAT	**comments**	**Sources (see reference list above)**
Optimized air flow design in ventilation systems	Including high recirculation, heat recovery between incoming and outgoing air flow etc.	FI14
Intermediate ceiling in very tall rooms		FI14
Floor heating	Lower heat supply temperatures are possible in floor heating that lead to less transmission losses; higher potential for solar space heating	
Regulation of the heating system	Temperature control prevents overheating	
Efficient lightning		FI16

3.10 *On-line information sources on BAT and energy efficiency*

The engineering tools and calculators listed in this section are mentioned in the Cleaner Production and Energy Efficiency Manual from UNEP.

Reference:
United Nations Environment Programme, Division of Technology, Industry and Economics: *Cleaner Production – Energy Efficiency Manual*. page 276-286.UK, 2004.
Website: http://www.uneptie.org/energy/projects/cp-ee/cpee_project.htm

E.1 Energy systems

- **Compressed air**

An overview of Best Practices for compressed air system resources to help industrials end users to achieve efficiency improvements and related cost savings.
(Resources include compressed air tip sheets; technical publications.)

Website: http://www.oit.doe.gov/bestpractices/compressed_air/

- **Motor systems**

Best Practice resources specific to motor systems. Includes publications, software tools and training information. Most of the documents can be downloaded from this site.

Website: http://www.oit.doe.gov/bestpractices/motors/

- **Process heating**

Information on process heating that can help companies to realize significant savings through system improvements and technology implementation. (Resources include process heating 'Tip Sheets'; technical publications.)

Website: http://www.oit.doe.gov/bestpractices/process_heat/

- **Steam system efficiency**

Information on steam generation, steam distribution, steam use and steam recovery that should be considered for improvements to help in reducing operating costs.

Website: http://www.oit.doe.gov/bestpractices/steam/efficiency.shtml

- **Motor solutions on-line**

Comprehensive information and guidance, as well as practical information and tools, to help make the right choices about electric motors.

Website: http://www.greenhouse.gov.au/motors/

- **Energy conservation in motors**

Includes: terms related to motors; standard designs of motors; types of motors; motor losses; why motors fail; equipment to read motor parameters; features of energy efficient motors; energy conservation in motors; and energy conservation analysis.

Website: http://www.letsconserve.org/terms_related_to_motors1.php

- **Motors and drives**

Covers all aspects of motors, from an explanation of how they work, to the advantages/disadvantages of adjustable speed drives. Also included are special pages on motor maintenance and troubleshooting, and economic implications of replacing existing motors with different types of motors. The information on this site is especially valuable for both commercial and industrial entities.

Website: http://cipco.apogee.net/mnd

- **Commercial energy systems**

Covers the following areas in energy systems for commercial buildings (from fast food to retail stores, to commercial operations of all descriptions): lighting; power quality; commercial cooking; HVAC design; HVAC systems; CES design; building design process; commissioning.

Website: http://cipco.apogee.net/ces

- **Various energy systems**

How facilities can save thousands on fan, pump and compressor, blower, motor and AC unit costs. The site includes typical problems, opportunities, a system cost calculator and an optimization checklist for the benefits of optimizing the system(s) in a facility.

Website: http://www.productiveenergy.com/home/index.asp

E.3 CP-EE technology providers

- **The Energy Efficiency Best Practice Programme**

The Energy Efficiency Best Practice Programme (EEBPP) is a UK Government programme providing free information to organizations to help them cut their energy bills by offering detailed technical advice on a wide range of energy efficiency measures.

Website: http://www.energy-efficiency.gov.uk/

- **Persistent organic pollutants (POPs)—database of alternatives**

Information on POPs alternatives and approaches to replace and/or reduce the releases of POPs chemicals.

Website: http://www.chem.unep.ch/pops/newlayout/infaltapp.htm

- **GREENTIE**

Using the search facility on this site, browse the full international directory of suppliers whose technologies help to reduce GHG emissions.

Website: http://www.greentie.org/directory/index.php

- **Advanced test and measurement devices**

A leading company in the development and manufacture of advanced test and measurement technologies for use both in the field and leading edge facilities around the world.

Website: http://www.hioki.co.jp/eng/product/

- **Product and supplier finder**

More than 11 000 on-line catalogues covering: sensors, transducers and detectors; manufacturing and process equipment (e.g. heating and cooling equipment, industrial heaters, industrial machine safeguarding, inspection tools and instruments, materials processing equipment); material handling; data acquisition and signal conditioning; mechanical components; industrial computing; motion and controls; flow transfer and control; and test and measurement equipment.

Website: http://www.globalspec.com/ProductFinder/

- **Association of Energy Services Professionals**

The Association of Energy Services Professionals is dedicated to advance the professional interests of individuals working to provide value through energy services and energy efficiency by sharing ideas, information and experience.

Website: http://www.aesp.org/

- **SEE-Tech Solutions Pvt. Ltd.**

A company specializing in consulting, training and performance auditing in the areas of energy conservation, energy efficiency improvement and industrial safety. The company also provides software solutions for energy auditing.

Website: http://www.letsconserve.org/seemain.php

- **Trade portal for Indian products**

On-line marketplace for industrial process equipment and accessories, and many other Indian products.

Website: http://www.easy2source.com/

- **CADDET Energy Efficiency**

A collection of studies (analysis reports) made by experts from CADDET Energy Efficiency members and other IEA agreements, providing detailed reviews across a wide range of typical energy efficiency subjects. They can be obtained from CADDET Energy Efficiency National Teams (a summary can be provided, for a fee).

Website: http://www.caddet-ee.org/reports/index.php

- **National Inventory of Manufacturing Assistance Programs (NIMAP)**

The NIMAP inventory is linking sources with consumers of technical information and services. Simple lack of awareness on the part of eligible recipients is a major barrier to achieving energy policy goals.

Website: http://www.oit.doe.gov/bestpractices/nimap/

- **Database for Energy Efficient Resources (DEER)**

Database for Energy Efficient Resources (DEER) contains extensive information on selected energy-efficient technologies and measures. The DEER provides estimates of the average cost, market saturation, and energy-savings potential for these technologies in residential and non-residential applications.

Website: http://www.energy.ca.gov/deer

- **Thai-Danish cooperation on sustainable energy**

The Sustainable Energy Database provides an overview of activities and players in the field of sustainable energy in Thailand, and in the Isaan region in particular.

Website: http://www.ata.or.th/indexeng.html

- **Tata Energy Research Institute (TERI)**

TEDDY Online (TERI Energy Data, Directory and Yearbook) provides ready-to-use information on different segments (energy and environment) of the Indian economy and some aspects of international economy.

Website: http://www.eldis.org/static/DOC4556.htm

- **IEA Clean Coal Centre**

The world's foremost provider of information on efficient coal supply and use, IEA Coal Research—The Clean Coal Centre enhances innovation and continued development of coal as a clean source of energy.

Website: http://www.iea-coal.org.uk/

- **Energy Technology Systems Analysis Programme**

The Energy Technology Systems Analysis Programme (ETSAP) of the International Energy Agency (IEA) is a research partnership dedicated to enabling its partners and their clients to develop sound integrated energy and environmental policy.

Website: http://www.etsap.org/index.htm

- **ETDE's Energy Database**

ETDE's Energy Database contains a large collection of energy literature, with more than 3.8 million abstracted and indexed records. Updated twice monthly, the database contains bibliographic references to, and abstracts from, journal articles, reports, conference papers, books and other documents. The database covers a variety of subjects including environmental aspects of energy production and use, and energy policy and planning, as well as the basic science that supports energy research and development.

Website: http://www.etde.org/edb/energy.html

- **The Bureau of Energy Efficiency (BEE)**

The BEE website, is a comprehensive source of information on energy conservation- (EC) related developments and issues. It provides an update on the related policy framework especially in the context of the EC Act 2001 as well as topical write-ups, news and highlights on developments in India. The site also features activities taken up by the BEE with stakeholders, co-opting expertise from bilateral/multilateral agencies.

Website: http://www.bee-india.com/

- **National Lighting Product Information Programme**

NLPIP, helps lighting professionals, contractors, designers, building managers, homeowners and other consumers find and use efficient, quality products that meet their lighting needs. With the support of government agencies, public benefit organizations and electrical utilities, NLPIP disseminates objective, accurate, timely, manufacturer-specific information about energy-efficient lighting products.

Website: http://www.lrc.rpi.edu/programs/NLPIP/index.asp

E.4 CP-EE sector-specific resources

- **Energy efficiency technologies**

This link provides information on R&D projects in energy saving technologies for a number of vital industries including: mining; metal casting; aluminium; chemicals; forest products; glass; metal casting; mining; petroleum; steel; and supporting industries).

Website: http://www.eere.energy.gov/industry/

- **Textile: smart guide**

A useful guide including a summary of business cases in textile manufacturing in different countries.

Website: http://www.emcentre.com/unepweb/tec_case/textile_17/house/casename.shtml

- **US EPA Sector Notebooks**

The US EPA Sector Notebooks are comprehensive overviews of environmental issues in about 30 major industries. Each includes descriptions of the industry, including operations, pollutants and regulations, pollution prevention methods, and related resources. Highly recommended.

Website: http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/

- **European Integrated Pollution Prevention and Control Bureau**

The European Integrated Pollution Prevention and Control Bureau produces comprehensive guides to industry sector environmental management. About 15 guides have been completed; many others are being developed.

Website: http://www.jrc.es/pub/english.cgi/0/733169

- **Australian National Pollutant Inventory Industry Handbooks**

The Australian National Pollutant Inventory Industry Handbooks are manuals for estimating emissions from about 50 types of industries. Each Handbook has detailed process descriptions, information about emission sources, and benchmarks and formulas for estimating emissions. Highly valuable to engineers.

Website: http://www.npi.gov.au/handbooks/approved_handbooks/index.html

- **On-line collection of pollution prevention references**

This on-line collection of pollution prevention core references includes technical references, fact sheets and case studies on pollution prevention for 30 selected industry sectors.

Website: http://wrrc.p2pays.org/industry/indsector.htm

Energy Data and Analysis database (Asia Pacific *)*

The Expert Group on Energy Data and Analysis (EGEDA) is responsible for providing policy relevant energy information to APEC bodies and the wider community, through collecting energy data of the APEC region, managing the operation of the APEC Energy database through the coordinating agency.

Website: http://www.ieej.or.jp/egeda/database/database-top.html

4 Sources of information: manuals, projects and websites

4.1 *Handbooks and Manuals*

By Andreja Goršek and Janez Petek, Steng-nacionalni center za čistejso proizvodnjo d.o.o.

4.1.1 Introduction

In this chapter relevant energy audits guides and manuals for various industrial branches, such as the food industry, the metal treatment and many other sectors, are described. For each document (handbook, manual or guide) several information such as the references, the availability on the web, the contents, the “best available techniques” described, the tools and the case studies mentioned, and the usability for the Einstein project are summarised in tables.

The documents reviewed provide detailed information on energy efficiency opportunities, emission reduction, boilers and furnaces systems, steam systems, combined heat and power, biomass, refrigeration, compressed air systems, insulation etc. Many of them contain also checklists, case studies and BAT.

4.1.2 Energy Auditing guides

Self Assessment Workbook for Small Manufacturers

Complete references	Rutgers – The State University of New Jersey (2003), *Self Assessment Workbook for Small Manufacturers*, U.S. Department of Energy.
Guide availability	
Language	English
Content	Provide method of improving operations and reducing costs.
Type of information/data provided	Sample utility analysis, electric power and building review, how to identify energy consuming equipment.
Best Available Techniques	No.
Case studies	Yes.
Examples – calculations	Equations for savings calculation.
Software free/commercial	No.
Use for EINSTEIN	Measures, calculations.

Additional information

Table of contents	Contents
Step 1 – Utility Analysis 1.1 Energy Management 1.2 Types of Energy Consumption 1.3 Terms and Analysis 1.4 Sample Utility Analysis 1.5 Electric Power and Billing Review	Information of basic steps for effective energy management, the determining energy consumption, and analyse utilities bills.
Step 2 – Major Energy Consuming Equipment 2.1 Lighting 2.2 Air Compressors 2.3 Boilers 2.4 Motors 2.5 Furnace 2.6 Chillers 2.7 Cooling Towers 2.8 Creating a List	Methodology how to identify energy consuming equipment.
Step 3 – Manufacturing Process 3.1 The Manufacturing Process 3.2 Self Analysis of the 3.3 Manufacturing Subsystems	Methodology how to analyse production process
Step 4 – Example Calculations of Cost Saving Measures	Calculations of cost saving.

Undertaking and industrial energy survey – Advice for end users on finding energy cost savings

Complete references	N.N. (2002), Good Practice Guide 316 - *Undertaking and industrial energy survey – Advice for end users on finding energy cost savings*. Energy Efficiency Best Practice Programme. Nifes Consulting Group.
Guide availability	www.sei.ie/energymap/getFile.asp?FC_ID=1477&docID=823
Language	English
Content	Energy survey. Opportunities to save energy.
Type of information/data provided	Guides on various factory services and processes. Energy management matrix. Recommendations where to find further information on various company services and processes. Recommended instruments and tools. Energy data and conversion factors.
Best Available Techniques	Guide on various company services and processes (for example: lighting, ventilation, boilers, steam system, drying, etc.).
Case studies	No.
Examples – calculations	Tables for record information on annual energy consumption and costs.
Software free/commercial	No.
Use for EINSTEIN	Information with which can Einstein Tool Kit user determinate relevant data.

Additional information

The purpose of this guide is to help general managers or directly involved energy managers to identify opportunities to save energy. It provides a structured framework for a simple walk-through energy survey supported by “topic guides” which deal with common industrial processes.

Table of contents	Contents
Chapter 1: Introduction	
Chapter 2: Finding savings	Guides on common industrial processes and site services: -energy management (energy management, targeting and monitoring) -guides on lightning, ventilation, boilers, space heating, air-conditioning, hot water services, compressed air services, central vacuum services, electric motors and drivers, fans and pumps, burners, steam systems, crushing and grinding, mixing and blending, drying, baking and curing, machining, forming and fabrication, tanks and vats, treatment booths and cabinets, high temperature processes, cooling systems, heat recovery, mechanical handling, motor transport, on-site catering, and building fabric.
Chapter 3: Survey pro formats and reporting	This chapter provides data sheets to record the data surveyed: -Site energy consumption and costs; -Register of sources of data and their drivers; -Meter reading pro-forma; -Schedule of identified opportunities.
Chapter 4: Reference	-Sources of assistance; -Recommended instruments and tools; -Energy data and conversion factors.

Guidance Note on Energy Efficiency Auditing

Complete references	N.N. (2003). *Guidance Note on Energy Efficiency Auditing.* Byrne O Cleirigh Limited on behalf of Environmental Protection Agency Ireland
Guide availability	http://www.epa.ie/downloads/advice/licensee/name,12660,en.html
Language	English
Content	The purpose of this guide is to provide assistance to the energy managers in conducting consistent and effective Energy Audits at industrial sites.
Type of information/data provided	Energy management matrix, fuel to carbon conversion factors.
Best Available Techniques	Check-list for energy auditing.
Case studies	No
Examples – calculations	Equation for calculating pay-back periods.
Software free/commercial	No.
Use for EINSTEIN	Information with which can Einstein Tool Kit user determinate relevant data on energy auditing.

Additional information

Implementation of regular energy audits is an important part of the companies' energy management system. The results can be used to identify recommendations for energy efficiency improvements. These reductions are not necessarily associated with technical changes since they can also result from better organization and management.
Identification and implementation of recommendations for energy efficiency improvements arising from an energy audit may deliver various benefits:

1. setting of energy efficiency targets;
2. financial benefits in terms of reduced costs or reduced cost and improved productivity, comfort , safety.

The main table of contents include:

1. Auditing process:
    a. Preparation;
    b. Execution.
2. Analysis:
    a. Evaluation of energy performance;
    b. Audit recommendations.
3. Reporting.
4. Appendix: Energy management matrix, energy audit check list, fuel to carbon conversion factors and data for inclusion in summary report.

Cleaner Production – Energy Efficiency Manual

Complete references	N.N.(2004). *Cleaner Production – Energy Efficiency Manual*, United Nations Environment Programme, Division of Technology, Industry and Economics: UK.
Guide availability	www.uneptie.org
Language	English
Content	Elaborated in India, China, Hungary, Czech Republic, Slovac Republic and Vietnam, tested in 100 companies. Contents: CP EE methodology, Technical modules (identifying focus areas; information on energy efficient technologies), tools and resources (checklists, quick calculation rules etc.)
Type of information/data provided	Check-lists.
Best Available Techniques	Yes, list of general energy efficient technologies (Cleaner Production technologies) with a two-line description (topics: new electrical technologies, boiler and furnace technologies, heat upgrading systems, other utilities).
Case studies	Yes, on textile processing.
Examples – calculations	General calculations on energy use in industrial production (incl. boiler efficiency calculations, condensate recovery, economic thickness of insulation, heat losses etc.).
Software free/commercial	No specific software, Links to a variety of software sites.
Use for EINSTEIN	References for tools and checklists, basic calculations for cross checking, list of efficient technologies for heat supply.

Manual for energy management in industry

Complete references	N.N. (1999), *Manual for energy management in industry,* Austrian National Ministry for environment, Austrian Energy Agency, Austria.
Guide availability	http://www.energyagency.at/(de)/publ/pdf/bemas.pdf
Language	German
Content	General manual on energy management systems. Including checklists on quick saving measures and sector specific saving potentials (figures of savings in %).
Type of information/data provided	Checklists for demand side savings for the Optimization/Heat Recovery module in the tool.
Best Available Techniques	Yes; Mainly general energy saving measures, some new technologies (BAT)
Case studies	No
Examples – calculations	No
Software free/commercial	No
Use for EINSTEIN	Checklists for demand side savings for the Optimization/Heat Recovery module in the tool.

Manual for the efficient use of energy use in industry and SMEs (Bayrisches Landesamt für Umweltschutz)

Complete references	Hensler G. et al. (2004), *Manual for the efficient use of energy use in industry and SMEs,* Munich: Bayrisches Landesamt für Umweltschutz.
Guide availability	http://www.bestellen.bayern.de/application/stmugv_app000003?SID=1428933592&ACTIONxSESSxSHOWPIC(BILDxKEY:lfu_klima_00022,BILDxCLASS:Artikel,BILDxTYPE:PDF)=X
Language	German
Content	Checklists on (simple) energy efficiency measures in compressed air systems, process heating, cooling, HAVC systems, drying, energy supply systems, logistics, etc.
Type of information/data provided	Check-lists.
Best Available Techniques	Measure and recommendation focus on improvement of existing equipment, some best available technologies are also included.
Case studies	Yes, showing the savings for specific measures
Examples – calculations	No
Software free/commercial	No
Use for EINSTEIN	Checklists, some good graphics (concerning contracting etc.)

Manual for the efficient use of energy use in industry and SMEs (Bremer Energiekonsens GmbH)

Complete references	Kruse M., Bayrisches Landesamt für Umweltschutz (2006): *Manual for the efficient use of energy use in industry and SMEs*. Bremen: Bremer Energiekonsens GmbH.
Guide availability	http://www.energiekonsens.de/Downloads/Service/Energieleitfaden.pdf
Language	German
Content	
Type of information/data provided	
Best Available Techniques	Measure and recommendation focus on improvement of existing equipment, some best available technologies are included.
Case studies	Yes, showing the savings for specific measures.
Examples – calculations	
Software free/commercial	
Use for EINSTEIN	Checklists, some good graphics (concerning contracting etc.).

Efficiency and Innovation In U.S. Manufacturing Energy Use

Complete references	N.N., *Efficiency and Innovation In U.S. Manufacturing Energy Use*, National Association of Manufacturers.
Guide availability	http://www.mep.nist.gov/energy-nam.pdf
Language	English
Content	Case studies on energy savings, maintenance, production, reducing process waste, production of new products, waste heat recovery, reducing waste consumption, etc.
Type of information/data provided	Different case studies in various industry branches.
Best Available Techniques	Check-list for energy saving.
Case studies	Case studies on energy savings.
Examples – calculations	No.
Software free/commercial	No.
Use for EINSTEIN	Information with which can Einstein Tool Kit user determinate relevant data.

How to Hire Energy Auditor to Identify Energy Efficiency Projects / How to Hire Construction Manager for your Energy Efficiency Projects

Complete references	1. Lew V. (2000), *How to Hire Energy Auditor to Identify Energy Efficiency Projects*, California Energy Commission. 2. Lew V. (2000), *How to Hire Construction Manager for your Energy Efficiency Projects*, California Energy Commission.
Guide availability	http://gasunie.eldoc.ub.rug.nl/FILES/root/2000/2574956/2574956.pdf
Language	English.
Content	Energy Auditing
Type of information/data provided	An energy audit, also called a feasibility study or technical assistance report, is typically needed to identify technically viable and cost effective energy projects that will reduce energy use and operating costs in your facility.Those preparing the audit will evaluate your energy-using equipment and identify ways to enhance its operating efficiency. In the process, they should also resolve occupant comfort problems and decrease your facility's maintenance costs. If you need an energy audit, you must determine who will complete it. Will it be done by your in-house staff, an energy consultant or an Energy Services Company? This document is primarily directed to those planning to hire an energy consultant or energy auditor. Even if you decide not to hire one, however, the information it provides can help you to insure a successful, cost effective audit.
Best Available Techniques	Energy audit review check-list.
Case studies	No.
Examples – calculations	No.
Software free/commercial	No.
Use for EINSTEIN	Check-lists.

Additional information

The table of contents includes the following items:

1. Do you need an energy consultant?
2. What are the different types of energy audits?
3. What type of audit do I need?
4. Can I update an earlier audit?
5. How should I select the energy consultant?
6. What factors affect energy audit costs?
7. How can I determine audit costs?
8. What criteria should I use to select the energy auditor?
9. What should I include in the contract?
10. How should I review the energy audit?
11. What can I do to ensure a successful audit?

Energy Audit Guide

Complete references	N.N. (2000), *Energy Audit Guide: Part A – Methodology and Techniques, Part B – System Retrofits for Energy efficiency, Part C – Best Practice Case Studies*, Centre for Renewable Energy Sources.
Guide availability	http://www.cres.gr/kape/pdf/download/guide_a_uk.pdf
Language	English
Content	This edition constitutes part of a series of three Technical Guides published by the Centre for Renewable Energy Sources (CRES) regarding the Energy Audit procedure in buildings and in industry. The aim of these publications is to comprise a useful and practical tool for Engineers and other scientists that are going to be occupied in the field of Energy Auditing.
Type of information/data provided	Information on how to plan an energy audit, estimating energy parameters, types of measuring equipment, economical evaluation, description of various methods such as Life-Cycle Method, Degree-Days Method, Energy Saving Calculations etc. In part C are described case studies on how to save energy consumption in sesame processing industry and public buildings.
Best Available Techniques	No.
Case studies	Case Study 1: Energy Audit In A Sesame Processing Industry Case Study 2: Energy Audit In A Hotel In Greece (Island of Crete) Case Study 3: Electrical Energy Savings In An Office Building
Examples – calculations	Energy savings calculations,
Software free/commercial	No.
Use for EINSTEIN	Life Cycle method, combustion system efficiency methodology.

Energy monitoring and targeting in large manufacturing companies

Complete references	T. Fatur, M. Sitar (1999). *Energy monitoring and targeting in large manufacturing companies*, Jožef Stefan Institut, Guide for efficient energy consumption, Energy Efficient Centre, Ljubljana.
Guide availability	http://www.aure.si/
Language	Slovenian
Content	Essential elements for energy monitoring or targeting are energy consumption measurements, option for decreasing energy consumption, and settings goals and priorities of energy consumption. With the aim of this methodologies decrease energy costs, decrease production costs, and improving products quality can be achieved.
Type of information/data provided	The guide contains methodologies and procedures of the monitoring and targeting of energy consumption in industry. The procedures involve software development, data transfer, analysis, and economic evaluations.
Best Available Techniques	No.
Case studies	No.
Examples – calculations	No.
Software free/commercial	No.
Use for EINSTEIN	For Slovenian users only?

Additional information

The table of contents includes the following items:

1. Energy monitoring and targeting.
2. Planning and organisation of the projects costs.
3. Assessment phase in practice
4. Data analysis and reporting.
5. Future energy savings costs.
6. Case studies in the food, textile and glass production industry.

Step by step guidance for the implementation of energy management

Complete references	Lackner P., Holanek N. (2007), *Step by step guidance for the implementation of energy management*, Austrian Energy Agency.
Guide availability	http://www.bpa.gov/Energy/N/Projects/Industrial/audit/,
Language	English
Content	Implementation of energy management in small and medium sized enterprises. It provides a logical step-by-step guidance of implementation actions and most effective ways to find out where energy and cost savings can be made.
Type of information/data provided	Data collection sheets, benchmarking, energy management checklist, etc.
Best Available Techniques	No
Case studies	No
Examples – calculations	No
Software free/commercial	No
Use for EINSTEIN	Various check-lists.

How to Save Energy and Money in 3E Strategy

Complete references	N.N., *How to Save Energy and Money in 3E Strategy*, The Energy Research institute Department of Mechanical Engineering, University of Cape Town.
Guide availability	http://www.3e.uct.ac.za/
Language	English
Content	The 3E's are 'Energy Efficiency Earning' is practical guide for engineers and management on saving energy costs. There is check-list on factory services (motors and drivers, compressed air, refrigeration, chilled and cooling water, etc.) and on building services (space heating, air conditioning and ventilation, hot water and water supply, lighting).
Type of information/data provided	Data collection sheets, benchmarking, energy management checklist, etc.
Best Available Techniques	No
Case studies	No
Examples – calculations	No
Software free/commercial	No
Use for EINSTEIN	Various check-lists.

4.1.3 Benchmarking

Identification of Energy Benchmarks for Plants, Production Processes and Products

Complete references	Layer G. (1999), *Identification of Energy Benchmarks for Plants, Production Processes and Products,* Munich: Forschungsstelle für Energiewirtschaft (der Gesellschaft für praktische Energiekunde e.V.).
Guide availability	www.ffe.de
Language	German
Content	Methodologies for energy benchmarks and energy benchmark data for different plants and processes based on German companies.
Type of information/data provided	Benchmark data for benchmark module
Best Available Techniques	No
Case studies	No
Examples – calculations	Energy data and energy balances for different processes
Software free/commercial	
Use for EINSTEIN	Benchmark data for the benchmark module

4.1.4 Industrial branches

4.1.4.1 Food industry

4.1.4.1.1 General

Polygeneration in the Food and Drink Industry, Application Guidelines

Complete references	N.N, *Polygeneration in the Food and Drink Industry*, *Application Guidelines,* European Commission, Intelligent Energy Europe.
Guide availability	http://optipolygen.org/Polygeneration_appl_guidelines.pdf
Language	English
Content	Food and drink industry – description of various industry sectors (fish, meet, fat, vegetable, etc.)
Type of information/data provided	Equipment characteristic that has to be taken into account at polygeneration technology selection is considered. Economical evaluation with spreadsheet calculations (investment, maintenance, fuel cost) and detailed analysis of the processes is described. Feasible processes and production lines for polygeneration application are also available.
Best Available Techniques	Check-list of favourable conditions (fuel availability, sufficient heating/cooling load etc.).
Case studies	Case studies from various industry sectors.
Examples – calculations	No.
Software free/commercial	On the web site http://www.optipolygen.org/tools.html is available Feasibility Calculator. This tool serves for an initial viability check for CHP & Polygeneration applications in the food industry. On the web site http://www.gaiapower.net/ is available Gaia Calculator, which simulates and optimises the operation of on-site CHP plants and analyses their economical feasibility. The analyses are based on the in-house-developed unique algorithm and Gaia Power database that contains a collection of component technical data, load profiles and energy price libraries.
Use for EINSTEIN	Measurers, characteristics which can help Einstein Tool Kit user to find necessary data for improvements.

Additional information

Table of contents	Contents
Part I: General Guidelines	Here are important issues, which has to be taken into account of estimating the feasibility of polygeneration like energy infrastructure and available fuels, electricity market, possibilities to sell surplus heat, EU regulations and directives. List of process characteristic and technologies for polygeneration in the food and drink industry. Three phases for determine economic feasibility of polygeneration.
Part II: Sector Specific Guidelines	Part II provides information from various industry sectors (fish, meet, vegetable, oils, fat processing industry). There are described processes, applicable polygeneration technologies for different sectors, case studies, etc.

4.1.4.1.2 Dairies

Guide to Energy Efficiency Opportunities in the Dairy Processing Industry

Complete references	N.N (1997), Guide to Energy Efficiency Opportunities in the Dairy Processing Industry, National Dairy Council of Canada.
Guide availability	http://oee.nrcan.gc.ca/infosource/pdfs/M27-01-827E.pdf
Language	English
Content	Milk, cheese, butter, ice cream production.
Type of information/data provided	Equations for electrical energy use, thermal energy use and water use per product, information about new technologies and theirs applications.
Best Available Techniques	Check-list of process-related opportunities for fluid milk, cheese, ice cream, frozen products, cultured products, butter and evaporated/dried products processing. Check-lists for retrofit options and for utilities and services improvements.
Case studies	Only mentioned in table in chapter 6 (titles and authors).
Examples – calculations	Unit performance ratio.
Software free/commercial	No
Use for EINSTEIN	The measures which can help Einstein Tool Kit user to find necessary data for improvements.

Additional information

Table of contents	Contents
Chapter 1: Introduction	
Chapter 2: Sector Activities and Generic Processes	This chapter describes two categories – fluid milk processing and industrial milk processing.
Chapter 3: Utilities and Energy-Use	This chapter provides parameters relevant to energy use in the dairy plants (electrical and thermal energy and water).
Chapter 4: Improvement Opportunities 4.1 Low-Cost/No-Cost Opportunities 4.2 Retrofit Opportunities 4.3 Utility-Related Opportunities 4.4 Other Improvement Measures 4.5 Precautions for Water Reuse Opportunities	This chapter provides check-list of process-related opportunities for fluid milk, cheese, ice cream, frozen products, cultured products, butter and evaporated/dried products processing. Here are also check-lists for retrofit options and for utilities and services improvements.
Chapter 5: New Technologies	New technologies in dairy industry.
Chapter 6: Other Helpful Information for Dairy Processes 6.1 Unit Performance Ratios 6.2 Advanced Analysis Methodologies 6.3 Additional References Materials on Energy Improvements	Equations for unit performance ratio (unit electrical energy use, unit thermal energy use and unit water use)

Reduction of ecological and climate harmful emissions from industrial plants through rational use of energy - milk processing companies

Complete references	N.N (2000), Reduction of ecological and climate harmful emissions from industrial plants through rational use of energy - milk processing companies, Augsburg: Bayrisches Landesamt für Umweltschutz.
Guide availability	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/
Language	German
Content	Milk processing. Optimization of dairies at the example of one specific plant, compilation of a catalogue of optimisation measures, economic considerations, benchmarks
Type of information/data provided	Benchmarks, efficient technologies in the milk industry, case study
Best Available Techniques	Yes, the state of the art of efficient technologies (and methodologies) for energy supply and the production processes is given, however not always discussed in detail
Case studies	The document is written based on one detailed case study – consequences are drawn for the sector
Examples – calculations	
Software free/commercial	
Use for EINSTEIN	Benchmarks, efficient technologies in the milk industry, case study

4.1.4.1.3 Meat processing

Reduction of ecological and climate harmful emissions from industrial plants through rational use of energy - meat processing

Complete references	N.N (2001), *Reduction of ecological and climate harmful emissions from industrial plants through rational use of energy - meat processing,* Munich: Bayrisches Landesamt für Umweltschutz.
Guide availability	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/
Language	German
Content	Meat processing. Optimization of metal processing plants at the example of one specific plant, compilation of a catalogue of optimisation measures, economic considerations, benchmarks
Type of information/data provided	Case study in the meat processing industry, good overview over the processes and data acquisition
Best Available Techniques	In this document the measures focus on heat recovery, optimized compressors etc., but do not really focus on new efficient technologies – only for cooking/smoking steam heating is recommended
Case studies	The document is written based on one detailed case study – consequences are drawn for the sector
Examples – calculations	
Software free/commercial	
Use for EINSTEIN	Case study in the meat processing industry, good overview over the processes and data acquisition

4.1.4.1.4 Breweries

Energy Efficiency Improvement and Cost Saving Opportunities for Breweries

Complete references	Galitsky C., Martin N., Worell E., Lehman B.(2003), *Energy Efficiency Improvement and Cost Saving Opportunities for Breweries*, Barkley National Laboratory, U.S. Environmental Protection Agency.
Guide availability	http://ies.lbl.gov/iespubs/50934.pdf
Language	English
Content	Breweries, technologies, measurers.
Type of information/data provided	Detail describing of process efficiency measurers. Efficiency improvement measures that can reduce energy consumption in hot water and steam distribution, hot water and steam generation, motors and motor systems, refrigeration and lighting. Material reduction measures. Description of the technologies under development. Employee tasks for efficient use of energy.
Best Available Techniques	For process and utilities energy efficiency measures.
Case studies	No.
Examples – calculations	No.
Software free/commercial	On the web site http://www1.eere.energy.gov/industry/bestpractices/software.html#air is software collection, some of them are described here: a) AIRMaster+ provides comprehensive information on assessing compressed air systems, including modelling, existing and future system upgrades, and evaluating savings and effectiveness of energy efficiency measures. b) Chilled Water System Analysis Tool (CWSAT) Version 2.3 determines energy requirements of your system, and to evaluate opportunities for energy and costs savings by applying improvement measures. Provide basic information about an existing configuration to calculate current energy consumption, and then select proposed equipment or operational changes for comparison. The results of this analysis will help you quantify the potential benefits of chilled water system improvements. c) Combined Heat and Power Application Tool (CHP) helps industrial users evaluate the feasibility of CHP for heating systems such as fuel-fired furnaces, boilers, ovens, heaters, and heat exchangers. It allows analysis of three typical system types: fluid heating, exhaust-gas heat recovery, and duct burner systems. d) Process Heating Assessment and Survey Tool (PHAST) provides an introduction to process heating methods and tools to improve thermal efficiency of heating equipment. Use the tool to survey process heating equipment that uses fuel, steam, or electricity, and identify the most energy-intensive equipment.
Use for EINSTEIN	Measurers which can help Einstein Tool Kit user to find necessary data for reducing energy consumption.

Additional information

Table of contents	Contents
Chapter 1: Introduction And Overview	
Chapter 2: The Brewery Market	This chapter describes breweries in United States, history of production, employment etc.
Chapter 3: Process Description	This chapter describes production processes.
Chapter 4: Energy Use Energy Consumption and Expenditure Energy Intensity	This chapter describes energy consumption in malt beverages.
Chapter 5: Options for Energy Efficiency	This chapter contains possibilities of energy consumption decreasing, process optimization, measurers for efficient use of energy, and monitoring energy consumption.
Chapter 6: Process-Specific Measures Mashing and Lauter Tun Process Worth Boiling and Cooling Fermentation Technologies for Beer Processing Technologies for Packaging	This chapter describes measurers for efficient use of energy from chapter 5 in detail.
Chapter 7: Cross-cutting Measures Boilers and Steam Distribution Motors and systems that Use Motors Refrigeration and Cooling Other Utilities	This chapter describes crosscutting energy efficiency improvement measures that reduces energy consumption in hot water and steam distribution system, hot water and steam generation, motors and motor systems, refrigeration and lighting. Savings of individual measures can be relatively small; however, the cumulative effect of these measures is potentially to be higher.
Chapter 8: Material Efficiency Opportunities	This chapter describes possibilities of improving the efficiency of raw material use or reduction of product losses in the indirect decreasing of energy use.
Chapter 9: Future Technologies	This chapter describes future technologies in the development phase.

4.1.4.2 Metal treatment

Process Heating in Metals Industry

Complete references	Flanagan J.M.(1993), *Process Heating in Metals Industry,* Centre for the Analysis and Dissemination of Demonstrated Energy Technologies - CADDET.
Guide availability	http://www.caddet.org/public/uploads/pdfs/Report/ar_11.pdf
Language	English
Content	Metal treatment and processing.
Type of information/data provided	Thermal conductivity, range for service temperature for insulating materials, economic evaluation, effect of furnace temperature and pre-heat air on NO_x concentration.
Best Available Techniques	Described areas for future research.
Case studies	Case studies in the iron and steel, non-ferrous metals, foundries and other metals sector regarding energy efficiency. Described potentials in energy savings, and energy efficiency.
Examples – calculations	Pay-back period and energy cost savings.
Software free/commercial	No.
Use for EINSTEIN	Case studies provide necessary data for improvements.

Additional information

This guide focuses on metal heating and melting. The most promising furnaces and combustion technologies (burners, furnace insulation, heat exchangers, control systems, electric heating) are described.
Case studies for the assessment of the potential energy savings, energy efficiency measures (incl. waste heat recovery) are also reported.
The manual focuses on environmental problems, global warming and greenhouse gas emissions.

Efficient Use of Energy in the galvanising industry

Complete references	N.N. (2003), *Efficient Use of Energy in the galvanising industry,* Augsburg: Bayrisches Landesamt für Umweltschutz.
Guide availability	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/
Language	German
Content	Metal treatment
Type of information/data provided	Optimization of galvanizing plants at the example of one specific plant, data acquisition, analyses, compilation of a catalogue of optimisation measures, economic considerations, benchmarks, results for the sector in general
Best Available Techniques	Energy saving possibilities discussed for the following appliances: commutator (cooling systems, heat recovery), air conditioning, process heating and cooling, drying, pressurized air.
Case studies	One case study included – for some measures calculations for this case study are discussed
Examples – calculations	
Software free/commercial	
Use for EINSTEIN	

Use of waste heat and integration of renewable energy sources in a metal treating company

Complete references	Bayer H. et al (2005), *Use of waste heat and integration of renewable energy sources in a metal treating company,* Vienna: Austrian National Ministry of Innovation and technology.
Guide availability	www.fabrikderzukunft.at
Language	German
Content	Metal treatment
Type of information/data provided	Energy screening of a metal treating company in Austria, including heat demand calculations and basic measures for improvements
Best Available Techniques	No, very specific energy saving measures for one company
Case studies	Study only for one company
Examples – calculations	Diagrams on losses of hot baths, calculations on specific saving measures
Software free/commercial	No
Use for EINSTEIN	some diagrams (loss calculation etc.) for fast energy assessment, etc.

Additional information

Manufacturing oil tempered spring steel wire is an energy intensive process with several heating and cooling process steps. The project had three specific goals: to analyse the current energy flow (Sankey diagram), to assess the possibilities to increase the energy conversion efficiency and to investigate the possibilities to increase the use of the renewable energy sources.

4.1.4.3 Pulp and paper

Energy Conservation in the Pulp and Paper Industry

Complete references	Asblad A., Franck P., Berntsson T., (2001), *Energy Conservation in the Pulp and Paper Industry,* Centre for the Analysis and Dissemination of Demonstrated Energy Technologies - CADDET.
Guide availability	http://www.caddet.org/public/uploads/pdfs/Report/ar_28.pdf
Language	English
Content	Pulp and paper industry.
Type of information/data provided	World paper production by region, and country. Described processes, energy and heat consumption.
Best Available Techniques	Case studies.
Case studies	Demonstrating principles in energy conservation.
Examples – calculations	No.
Software free/commercial	No.
Use for EINSTEIN	Case studies can provide necessary data for improvements in this types and similar processes..

Additional information

The main contents of the manual concern with:

- Pulp and paper processes
- Energy Consumption
- Heat and Power production
- Energy improvements technology (e.g. CHP, heat pumps, heat exchangers, innovative drying, evaporating and cooking plants).
- Environmental benefits
- Demonstration projects.

Chances of the paper industry in the framework of the climate strategy

Complete references	Brand J. et al. (2005), *Chances of the paper industry in the framework of the climate strategy,* Vienna: Austrian Energy Agency.
Guide availability	http://www.energyagency.at/publ/pdf/papier_eb.pdf
Language	German
Content	Energy data of paper plants, benchmarking, potential for improvements, CHP in the paper industry, concrete examples of measure and calculation of savings.
Type of information/data provided	
Best Available Techniques	Yes, in the examples for saving possibilities: Iso thermal cooking, shoe press, optimized milling, multiple effect evaporation, use of waste combustion, biomass
Case studies	Several companies are considered, and specific measures are calculated for these companies – comparison under which frame work conditions an investment in energy efficiency/CO2 reduction is economical
Examples – calculations	
Software free/commercial	
Use for EINSTEIN	Focused on paper industry – maybe some interesting efficiency measures with case studies that can be used for the wood sector

Climate protection through efficient use of energy in the paper industry – Use of low temperature waste heat

Complete references	Papiertechnische Stiftung München (2003), *Climate protection through efficient use of energy in the paper industry – Use of low temperature waste heat,* Augsburg: Bayrisches Landesamt für Umweltschutz.
Guide availability	http://www.lfu.bayern.de/luft/fachinformationen/co2_minderung/doc/papier.pdf
Language	German
Content	Optimization of the paper industry at the example of one specific plant, data acquisition, analyses, compilation of a catalogue of optimisation measures, economic considerations, benchmarks, results for the sector
Type of information/data provided	
Best Available Techniques	Yes, focus on the use of the low temperature (waste) heat: following scenarios are discussed (including several alternatives for each): heat recovery to water, heat recovery to air, heat pumps, change of process parameters, sorption cooling machines. A simulation is done for each scenario as basis for choosing the best one
Case studies	The document is based on one detailed case study – consequences are drawn for the sector
Examples – calculations	Scenario simulation
Software free/commercial	
Use for EINSTEIN	

4.1.4.4 Other industries

4.1.4.4.1 Textile

Cutting Your Energy Costs – A Guide for the Textile Dyeing

Complete references	N.N., (1997), *Cutting Your Energy Costs – A Guide for the Textile Dyeing,* Department of the Environment.
Guide availability	
Language	English
Content	Textile industry. Guide provides necessary data and opportunities measurers for improvements in textile dyeing processing.
Type of information/data provided	Energy efficiency opportunities of textile dyeing and finishing machines.
Best Available Techniques	No.
Case studies	No.
Examples – calculations	Equations for calculation of energy used by textile dyeing and finishing machines.
Software free/commercial	No.
Use for EINSTEIN	Energy efficiency opportunities for the utility systems.

Additional information

An overview of the textile dyeing and finishing processes, and of the related energy consumption, is given. The guide describes also some energy management techniques and energy efficiency measures applicable to dyeing and finishing.

The main contents of the manual concern with:

- The UK Textile Dyeing and Finishing Industry
- Good Housekeeping and Energy Management Techniques
- Wet Batch Processing under Pressure
- Atmospheric Wet Batch Processing
- Continuous Wet Processing
- Contact Drying using Steam Cylinders
- Hot-air Drying using Stenters
- Hot-air/Steam Heat Treatments
- Fuel, Steam Raising Plant and Distribution Systems
- Electricity Supply for Motive Power, Compressed Air and Lighting
- Water Storage and Use
- Fuel, Power and Water Costs.

4.1.4.4.2 Chemical plants

Analysis and Modelling of the Energy Consumption of Chemical Batch Plants

Complete references	Bieler S. P. (2004), *Analysis and Modelling of the Energy Consumption of Chemical Batch Plants,* Swiss Federal Office of Energy.
Guide availability	http://e-collection.ethbib.ethz.ch/ecol-pool/diss/fulltext/eth15532.pdf
Language	English
Content	Tools for predicting or modelling the energy consumption of chemical batch plants.
Type of information/data provided	Information of TODOMO and BOTUMO and theirs applicability.
Best Available Techniques	No
Case studies	Yes. Results on modelling with TODOMO and BOTUMO.
Examples – calculations	Equation for calculating steam consumption, heating and cooling of substances, energy consumption of a substance, power consumption of electric equipment etc.
Software free/commercial	No.
Use for EINSTEIN	Information with which can Einstein Tool Kit user determinate relevant data for energy consumption in chemical batch plants.

Additional information

There are mentioned two approaches for energy modelling. First is 'Top-Down' Model (TODOMO) and the second one is 'Bottom-Down' Model or (BOTUMO) to model the energy consumption of a complete production plant.
Equations for steam consumption, heating and cooling of substances, energy consumption of a substance, power consumption of electric equipment etc are provided.

4.1.5 Heat supply systems

4.1.5.1 Boilers and Furnaces

How to Save Energy and Money in Boilers and Furnace Systems

Complete references	The Energy Research institute, *How to Save Energy and Money in Boilers and Furnace System*, Department of Mechanical Engineering, University of Cape Town.
Guide availability	http://www.3e.uct.ac.za/
Language	English
Content	Energy saving potentials for boilers and furnaces, description of various types of boilers and furnaces, short description of environmental impact.
Type of information/data provided	Combustion air requirements, values for flue gas losses, variations in the moisture heat loss for a typical biomass fuel, convection, conduction and radiation in boilers and furnaces, minimum storage temperatures for different grades of oil, caloric values for fuels, energy saving equipment, energy losses from furnaces or boilers wall as a function of wall temperature, boiler efficiency, radiation loss from boiler, recommended excess air levels for boilers, schemes for various types of boilers and furnaces, conversion tables, boiler and furnace efficiency test.
Best Available Techniques	Check-list for saving energy and cost with boilers and furnaces.
Case studies	No
Examples – calculations	Combustion air requirements, determination of excess air, heat transfer, surface area of the heat exchangers, blowdown heat losses, examples of savings.
Software free/commercial	No
Use for EINSTEIN	Guideline: general information and better understanding of boilers and furnaces. Decreasing costs and environmental impact, increasing boilers and furnaces efficiency, calculation of system efficiency.

Additional information

Table of contents	Contents
Chapter 1: Introduction	
Chapter 2: Combustion 2.1 Combustion air 2.2 Heat losses	This chapter provides data about combustion of fuels and quantities of excess air, calculation of required combustion air, determination of excess air regarding of the results from flue gas analysis. Heat losses by the amount of air supplied to the furnace is also shown.
Chapter 3: Heat Transfer 3.1 Conduction 3.2 Convection 3.3 Radiation	This chapter describes convection, conduction and radiation of heat.
Chapter 4: The Fuels 4.1 Pipeline gas 4.2 Liquid Petroleum Gas 4.3 Fuel Oil 4.4 Coal 4.5 Choice of Fuel	Each conventional fuel differs from the others in its combustion characteristics, and this influences to the heat transfer. The fuels may be solid, liquid or gaseous. Type of fuel consideration involves a number of factors including the investment cost of the boiler house, the price of the fuel, operating and maintenance costs, and pollution control legislation. This chapter also provides caloric values of some fuels, advantages and disadvantages of various fuels, etc.
Chapter 5: Combustion Equipment: Oil and Gas Burners 5.1 Gas Burners 5.2 Oil Burners 5.3 Burner Controls	The type of equipment dependents on the furnace/boiler conditions and the type of fuels. Types of oil fuels and recommended burners and controls are provided by this chapter.
Chapter 6: Combustion Equipment: Solid Fuel Combustion 6.1 Stokers 6.2 Chain Grate Stoker 6.3 Sprinkler Stoker 6.4 Fluidised Bed Combustion	Carbon burns slowly and coal needs to be in the combustion chamber for a long period that the air can reach it and provide complete combustion. There are described various forms of stoker for optimal coal combustion.
Chapter 7: Energy Savings Equipment 7.1 Flue gas heat exchangers 7.2 Accumulators 7.3 Insulation 7.4 O2 Analysers 7.5 Variable speed fan drives 7.6 Flue gas dampers 7.7 Waste heat boilers	This chapter describes the energy saving equipment of boilers and of furnaces. Heat exchangers, calculation of heat transfer and surface areas of the heat exchangers, examples of how to save energy with additional heat exchangers are also provided. There is information about accumulators which can stores steam from boilers. This chapter also provides information about insulation, O_2 analysers, waste heat boilers etc.
Chapter 8: Pollution 8.1 Environmental Equipment	This chapter provides information about emissions to air, problems and impact to the environment, equipment, which can decrease influences onto environment (ash handling equipment and air pollution control equipment).
Chapter 9: Boilers 9.1 Types of boilers 9.2 Boiler system selection	The boilers considered in this guide are limited to those that produce either steam or hot water and are heated with the heat of the combustion of a fuel. There are data about boiler efficiencies according to boiler type, general information about boilers, etc.
Chapter 10: Energy and Cost Saving for Boilers 10.1 Potential Losses 10.2 Boiler Energy Balance 10.3 Minimizing Boiler Losses	To optimise the operation of boiler plant it is necessary to understand where energy wastage is likely to occur. There is described the possibilities to minimize boiler losses with proper maintenance, calculation the exact amount of air needed for optimal combustion, automatic controls, the flue gas economizer, possibilities of pre-heating the combustion air etc. The chapter contains the check-list for saving energy and costs.
Chapter 11: Types of Furnaces	The furnace are used for heating metals to a controlled temperature for heat treatment, or for metals melting. The furnaces are produced in different types and sizes. There are described various types of furnaces.
Chapter 12: Energy and cost saving for furnace	This chapter provides information how to minimize furnaces heat losses. There are the list of typical excess air ratios for various types of fuels and typical savings that can be realized through excess air adjustment.

A checklist of energy saving measures applicable to boilers is given and includes the following items:

- Maintain efficient combustion.
- Maintain good water treatment.

- Repair water and steam leaks.
- Recover heat from flue gas and boiler blowdown whenever possible (see Steam guidebook).
- Ensure good operational control and consider sequence control for multi-plant installations).
- Attempt to match boilers to heat demand. Valve off idle boilers to reduce radiation losses.
- Use flue dampers where appropriate to minimize flue losses when the plant is not firing.
- Ensure that boilers and heat distribution systems are adequately insulated.
- Blowdown steam boilers only when necessary (see Steam guidebook).
- Ensure as much condensate as practicable is recovered from steam systems.
- Insulate oil tanks and keep steam or electric heating to the minimum required.

A checklist of energy saving measures applicable to furnaces is given and includes the following items:

- Minimise heat losses from openings on sealed units such as doors.
- Use high efficiency insulating materials to reduce losses from the plant fabric.
- Attempt to recover as much heat as possible from flue gases. The pre-heating of combustion air or stock or its use in other services such as space heating is well worth considering.
- Reduce stock residence time to a minimum to eliminate unnecessary holding periods.
- Ensure efficient combustion of fuels where applicable.
- Avoid excessive pressure in controlled atmosphere units.
- If maintaining stock at high temperature for long periods, consider the use of specialized holding furnaces.
- Make sure excessive cooling of furnace equipment is not occurring.
- Ensure the minimum amount of stock supporting equipment is used.
- Ensure there is effective control over furnace operating parameters – computerized control should be considered for larger units.

Boilers and heaters: Improving Energy Efficiency

Complete references	Dockrill P., Friedrich F.(2001), Boilers and heaters: Improving Energy Efficiency, Canadian Industry Program for Energy Conservation.
Guide availability	http://www.oee.nrcan.gc.ca/publications/infosource/pub/cipec/boilersheaters.pdf
Language	English
Content	Improving energy efficiency for boilers and heat exchangers.
Type of information/data provided	List for auditing boilers and heat exchanger systems, emissions from combustion systems and their effects, typical NO_x emissions without NO_x control equipment, boiler efficiency improvement program, proper boiler maintenance.
Best Available Techniques	The list for auditing boiler and heat exchanger system.
Case studies	No
Examples – calculations	Heat losses, dry flue gas losses, losses due to moisture from the combustion of hydrogen, losses due to radiation and convection.
Software free/commercial	No.
Use for EINSTEIN	List for auditing boilers and heat exchangers, tips of how to use energy efficiently.

Additional information

This guidebook, provided by the Natural Resources Canada's Office of Energy Efficiency (OEE), is addressed mainly to owners and operators of boilers and heat exchangers, which are willing to save energy, improve their bottom line and reduce greenhouse gas emissions that contribute to climate changes.
This guide contains data about combustion processes, heat losses, simplified methods for calculation boiler efficiency, calculation of dry flue gas losses, losses due to radiation and convection, etc.
Controlling excess air is considered the most important tool for managing the energy efficiency and atmospheric emissions of a boiler system, and different types of air and fuel control are described (on-off and high-low control, parallels control, cross-limiting control).
Measures to increase the energy efficiency of boiler and heaters installations, proper boiler maintenance operations (e.g. keeping boiler clean, decreasing unwanted air leaking, reclaiming boiler system heat losses, etc.), check-lists that may improve the performance of boilers and heaters are also provided.

The table of contents include the following topics:

1. Fundamentals of Combustion and Heat Losses
2. Boiler and Heater Operational Control .
3. Environmental Impacts of Combustion
4. About Combustion Regulations
5. Increasing the Energy Efficiency
6. of Boiler and Heater Installations
7. Energy Management Opportunities – Tips.

The check – lists given in the manual cover different areas and include the following items.

Management:

- Is the use of steam and heating fluid throughout the facility budgeted? Is it monitored? Are there consumption targets?
- If so, are the users of thermal energy accountable for its use? How?
- Are there approved procedures and work instructions governing thermal energy generation, distribution, monitoring and other processes?

- Have employees learned about the significance of energy and utility conservation, and do they use correct practices?
- Are boiler and heater operators involved with the efforts to conserve energy and utilities?
- Are employees aware of how much energy and utilities cost, and how much is being spent for these in the facility? Are they significantly interested in improving the results?
- Is there a system for communicating to employees the results of efforts to conserve
- energy and utilities?

Heat consumption:

- Are there procedures for shutting off thermal energy-using production equipment and auxiliary production equipment when not in use?
- Are the above procedures implemented?
- Is steam or heating fluid produced at temperatures or pressures greater than those required by end-user processes, product, plant or equipment?
- In multiple boiler installations, how is steam demand matched to boiler deployment? How is it done on weekends, during non-production periods and in various seasons?

Fuels:

- Can a cheaper alternative source for thermal energy be used?
- Can process by-products be used as an auxiliary fuel or fuel supplement?
- If natural gas is used, have the costs of uninterruptible versus interruptible supply
- been evaluated?
- Is the boiler fitted with dual capability to use natural gas or fuel oil to take advantage of
- interruptible gas supply contracts?

Fuel storage:

- Are heated oil tanks and associated piping adequately insulated?
- Is the external insulation for the above items watertight?
- Is oil heated at the correct temperature?
- Is solid fuel (e.g. biomass) protected against rain? Is it dried?

Boilers and steam distribution:

- Is the flue gas free of combustibles?
- Is the boiler efficiency checked on a regular basis?
- Is a proper method for determining boiler efficiency being used?
- Is the efficiency acceptable for the type of boiler and fuel?
- Is the burner operating in the “zone of maximum combustion efficiency”?
- Are the heat losses of the boiler and system known and quantified?
- Is the flue gas checked for combustibles, carbon monoxide and oxygen content on a regular basis? Is the content within an acceptable range?
- How is the excess combustion air managed? How frequently?
- Can unwanted air get into the boiler and the flue stack?
- What type of air or fuel control is used? How is it maintained?
- What type of equipment is used for controlling and monitoring the system? What instruments are used?
- Where is the combustion air intake located?
- Is the combustion air preheated? If so, how?
- Are the NO_x levels in the flue gas known and monitored? Are they within an acceptable range?
- What are the flue gas temperatures at various boiler loads? Are they monitored?

- Is heat being recovered from flue gas? What type? How efficiently?
- Is there any evidence of soot build up on the fireside surface of the boiler?
- Is there a program for inspecting and removing soot and scale from heat transfer surfaces of the heater and boiler? From process equipment?
- Is the flame in the combustion chamber bright and clear? Does it fill the combustion chamber without encroaching?
- What is the blowdown rate, and is it at the level recommended by water treatment specialists? Is it based on the content of dissolved solids (DS) in the boiler water? Have the levels of DS content been calibrated to conductivity?
- How is the blowdown rate controlled?
- Is there a system for recovering heat from the blowdown?
- Is there redundant, oversized or undersized steam piping that causes heat losses? Is there an inspection program for it?
- Are steam lines, flanges, valves and condensate lines adequately insulated? Is the insulation dry and protected against water ingress?
- Is steam or condensate leaking?
- Is the makeup water preheated? If so, how?
- Is the condensate return rate adequate? Has it been verified?
- Is the correct type of steam traps for the application being used?
- Is there an adequate maintenance program for inspecting, repairing and replacing steam traps? How many of the traps are faulty?.

4.1.5.2 Steam generation systems

How to Save Energy and Money in Steam System

Complete references	The Energy Research institute, *How to Save Energy and Money in Steam Systems*, Department of Mechanical Engineering, University of Cape Town.
Guide availability	http://www.3e.uct.ac.za/
Language	English
Content	Steam systems, condensate recovery, blowdown, thermal insulation.
Type of information/data provided	Properties of steam, methods of blowdown, blowdown flow rates, mass flow of steam in pipes for common saturated steam pressures and a pressure drop of 0.25 bar/100 metres, resistance of standard pipe fittings measured as equivalent pipe length, steam trap types and their characteristics, the cost of steam leaks, heat emission from pipes, steam tables.
Best Available Techniques	Check-list for saving energy and money in steam systems
Case studies	No
Examples – calculations	Amount of steam supplied in insulated or in non-insulated pipes. Saving achieving by condensate recovery. Examples of the flash steam heat recovery.
Software free/commercial	No
Use for EINSTEIN	Check-list for saving energy and money in steam systems. Better understanding of steam systems and helpful guide for good practices.

Additional information

Table of contents	Contents
Chapter 1: Introduction 1.1 Sensible heat and latent heat	
Chapter 2: Blowdown 2.1 Methods of blowdown 2.2 How much do you blowdown? 2.3 What does it cost?	Blowdown is a necessary operation of the boiler in order to maintain correct boiler water conditions. Here are described two methods of blowdown and a checklist for estimating the quantity of blowdown from a boiler.
Chapter 3: Steam Utilisation 3.1 Steam Pressure 3.2 Pipe Sizing 3.3 Pipe Drainage 3.4 Heat transfer from steam 3.5 Steam Trapping 3.6 Steam Leaks 3.7 Insulation 3.8 Condensate return 3.9 Flash steam heat recovery	This chapter provides information about correct pipe sizing, benefits of distributing steam at higher pressure, heat transfer, steam trapping, steam leaks, and flash steam heat recovery. Provide guidelines for the effective draining of condensate and layout of steam lines and possibilities and benefits of the insulation and condensate recovery.

The check – lists given in the manual cover different areas and include the following items.

Piping system:

- Check that the pressure is not over supplied.
- Ensure that pipes are correctly sized. Oversize implies excessive heat loss, undersize implies
- Energy losses to overcome pressure drop and high steam leakage rate.
- Remove unnecessary valves, elbows and tee's.
- Remove any unused piping that may be left after expansion/ decommissioning.

Heat transfer:

- Ensure proper drainage.
- Ensure trapped air is released

Steam traps and leaks:

- Check steam trap population is properly audited, positioned and maintained
- Audit, cost and repair steam leaks.

Insulation:

- Check insulation on pipes, valves, flanges and other fittings.

Heat Recovery:

- Ensure condensate return is operating correctly.
- Investigate the possibility of using flash steam.

Steam System Survey Guide

Complete references	Harrell G.(1996), *Steam System Survey Guide*, U.S. Department of Energy Best Practice Steam Program
Guide availability	http://www.osti.gov/bridge
Language	English
Content	Steam systems survey, steam losses
Type of information/data provided	Fuel properties, steam properties, flue gas oxygen content control parameters, steam leak rates, pipe surface heat transfer, steam loss tables.
Best Available Techniques	Types of steam systems.
Case studies	No
Examples – calculations	Examples on calculated mass flow rate in boilers, efficiency of the boilers, energy added with the fuel, fuel energy input, saving in operating costs, operating hours of the boiler, fuel costs, electrical demands, blowdown losses, saving from fuel switching, turbine isentropic efficiency.
Software free/commercial	No
Use for EINSTEIN	Check-list in steam systems. Better understanding of steam systems and helpful guide for good practices. Examples in calculation of steam losses, efficiency, condensate recovery, etc.

Additional information

This guide, addressed mainly to steam system operators and plant energy managers, provides a description of the main opportunities for improving the energy efficiency of industrial steam systems.

Table of contents	Contents
Chapter 1: Introduction And Overview	
Chapter 2: Profiling The Steam System 2.1 Overview And General Principles 2.2 Utility Costs 2.3 Benchmarks 2.4 Call To Action—Steam System Profiling	This chapter provides information about utility costs, calculation of operating hours, fuel unit costs, electricity costs, and unit costs of steam.
Chapter 3: Identifying Steam Properties For The System 3.1 Overview And General Principles 3.2 Call To Action—Identifying Steam System Properties	This chapter provides data about steam properties.
Chapter 4: Opportunities For Boiler Efficiency Improvement 4.1 Overview And General Principles 4.2 Boiler Efficiency 4.3 Boiler Loading 4.4 Boiler Fuel Flow Estimate 4.5 Call To Action—Boiler Efficiency	This chapter provides equations for boiler efficiency, combustion efficiency, blowdown, minimum loss from the blowdown, heat transfer losses. General information of the typical control limits for steam boilers, boiler efficiency improvement, combustion performance, flammability limits, boiler design, and boiler load are also provided.
Chapter 5: Effectiveness Of Resource Utilization 5.1 Overview And General Principles 5.2 Fuel Selection 5.3 System Balancing 5.4 Process Integration 5.5 Steam System Pressure 5.6 Call To Action—Effectiveness Of Resource Utilization	The main focus of this chapter is on the fuel selection, in the steam system balancing and in the process integration (thermal energy recovery). Here are equations about savings from fuel switching, turbine isentropic efficiency, fuel consumption of the boiler, cost for purchase electricity, etc.
Chapter 6: Steam Distribution System Losses 6.1 Overview And General Principles 6.2 Steam Leaks 6.3 Insulation 6.4 Condensate Recovery 6.5 Flash Steam Recovery 6.6 Call To Action—Distribution System Losses	This chapter describes steam leaks, heat transfer loss through thermal insulation, condensate losses, and flash steam losses

The check – lists given in the manual cover different areas and include the following items.

Steam systems:

- Determine the total cost of fuel supplied to the boilers.
- Calculate the unit cost of fuel based on energy.
- Compare the unit cost of fuel to other available fuel supplies.
- Determine the unit cost of electricity supplied to the facility.
- Compare the unit cost of fuel to the cost of electricity supplied to the facility.
- Determine the typical steam production for the facility.
- Determine the production cost of steam for the facility.

- Determine the amount of steam required to produce a product.

Steam systems properties:

- Determine the properties of the steam generated in the boilers (temperature, pressure, saturated, superheated, enthalpy, and the remaining thermodynamic properties).
- Determine the properties of boiler feedwater (temperature, pressure, enthalpy).
- Determine the properties of boiler blowdown (pressure, enthalpy).
- Determine the properties of condensate return (temperature).
- Determine the properties of makeup water (temperature).

Boiler efficiency:

- Determine boiler efficiency.
- Investigate boiler shell for hot spots.
- Determine boiler blowdown rate.
- Investigate feed-water quality improvement opportunities.
- Investigate blowdown heat recovery opportunities.
- Monitor flue gas oxygen content.
- Monitor flue gas exhaust temperature with respect to boiler load, ambient temperature, and flue gas oxygen content.
- Monitor flue gas combustibles.
- Evaluate unburned carbon loss.

Effectiveness of the resource utilisation:

- Develop a system schematic.
- Develop a system mass and energy balance.
- Investigate alternative fuels.
- Monitor steam flow through vents and pressure-reducing stations.
- Monitor backpressure turbine efficiency and operation.
- Monitor condensing turbine efficiency and operation as well as condenser pressure.
- Completely understand the electrical rate structure.
- Evaluate the position and need of turbine hand valve operation.
- Investigate the effect of changing the current boiler operating pressure.

Distribution system losses:

- Find and repair steam leaks.
- Implement a steam trap management program.
- Investigate potential areas for condensate return.
- Evaluate insulation condition.
- Investigate opportunities to reintroduce flash steam.

Improving Steam System Performance, a Sourcebook for Industry

Complete references	Bloom D. (1996), *Improving Steam System Performance, a Sourcebook for Industry*, U.S. Department of Energy Efficiency and Renewable Energy.
Guide availability	http://www1.eere.energy.gov/industry/bestpractices/pdfs/steamsourcebook.pdf.
Language	English
Content	Steam system, basic steam system components, outlines opportunities for energy and performance improvements
Type of information/data provided	Data for performance improvement.
Best Available Techniques	Common performance improvement opportunities for the generation, distribution, and recovery of industrial steam systems.
Case studies	
Examples – calculations	Examples of mass flow rate in boiler, efficiency of the boiler calculation, energy added with the fuel, fuel energy input, saving of the operating costs, operating hours of the boiler, fuel costs, electricity demand, blowdown losses, saving from fuel switching, turbine isentropic efficiency.
Software free/commercial	On the web site http://www1.eere.energy.gov/industry/bestpractices/software.html#air is software collection, some of them are described here: a) AIRMaster+ provides comprehensive information on assessing compressed air systems, including modelling, existing and future system upgrades, and evaluating savings and effectiveness of energy efficiency measures. b) Chilled Water System Analysis Tool (CWSAT) Version 2.3 determines energy requirements of your system, and to evaluate opportunities for energy and costs savings by applying improvement measures. Provide basic information about an existing configuration to calculate current energy consumption, and then select proposed equipment or operational changes for comparison. The results of this analysis will help you quantify the potential benefits of chilled water system improvements. c) Combined Heat and Power Application Tool (CHP) helps industrial users evaluate the feasibility of CHP for heating systems such as fuel-fired furnaces, boilers, ovens, heaters, and heat exchangers. It allows analysis of three typical system types: fluid heating, exhaust-gas heat recovery, and duct burner systems. **d)** Process Heating Assessment and Survey Tool (PHAST) provides an introduction to process heating methods and tools to improve thermal efficiency of heating equipment. Use the tool to survey process heating equipment that uses fuel, steam, or electricity, and identify the most energy-intensive equipment.
Use for EINSTEIN	Availability of resources and tools, such as publications, software, training courses, and videos.

Additional information

Table of contents	Contents
Section 1: Steam System Basics	This section describes steam systems using with four basic elements: the generation, the distribution, the end use, and the recovery. A brief discussion of the terms, relationships, and important system design considerations are also provided.
Section 2: Performance Improvement Opportunities	This chapter discusses important factors that should be considered when industrial facilities want to improve steam system performance and to decrease operating costs. This chapter also provides an overview of the financial considerations related to steam system improvements.
Section 3: Where to Find Help	This chapter provides a directory of associations and other organizations involved in the steam system marketplace. A description of the Best Practices Steam activities, a directory of contacts, and a listing of available resources and tools, such as publications, software, training courses, and videos are also provided.

4.1.5.3 Combined Heat and Power (CHP)

Heat and electricity cogeneration – from an idea to the implementation

Complete references	H. Šolinc, D. Staničič (2002). *Heat and electricity cogeneration – from an idea to the implementation*. *Guide for efficient energy consumption*, Jožef Stefan Institute, Energy Efficient Centre, Ljubljana.
Guide availability	http://www.aure.si/
Language	Slovenian
Content	Modern cogeneration systems have efficiency up to 90 %. Produced waste heat at temperatures 100°C to 180°C can be used in absorption chillers for cooling or producing steam and hot water. A plant which produces electricity, heat and cold is named trigeneration or polygeneration plant.
Type of information/data provided	Aim of this guide is getting information about procedures in Slovenia: how to implement heat and electricity cogeneration (from the first idea to the implementation). Main purpose of the guide is to help investors, designers and building contractors of the decision making, designing and implementation of the CHP installations. Fuels for cogeneration are gas, liquefied petroleum gas, coal, and biomass. Slovenian legislation.
Best Available Techniques	No.
Case studies	No.
Examples – calculations	Energy savings.
Software free/commercial	No.
Use for EINSTEIN	

Additional information

The table of contents include the following items:

1. Heat and electricity cogeneration. (Technology review – gas turbine, steam turbine, polygeneration or trigeneration; fuel review – gas, liquid fuel, biomass, coal, biogas; micro cogeneration).
2. Decision making from investment to cogeneration.
3. Types of the documentation for construction procedures for carry out the construction documentation.
4. Licence for performing energy activity. Conditions and procedures.
5. Energy permissions.
6. Environmental impacts.
7. Project documentation.
8. Construction permits.
9. Financing.
10. Project performance.
11. Selling electricity.

Review of heat and electricity cogeneration systems with the case studies from Europe

Complete references	*Review of heat and electricity cogeneration systems with the case studies from Europe* (1998). Jožef Stefan Institute, Energy efficient Centre, Ljubljana
Guide availability	http://www.aure.si/
Language	Slovenian
Content	Conventional plants of electricity production such as hydroelectric power station, thermal power station and nuclear power station have efficiency up to 37 %. With cogeneration systems the efficiency level rises up to 85 %. Indirect influence of cogeneration is decreasing environmental impacts.
Type of information/data provided	Cogeneration systems are basically classified regarding to the type of equipment: a) Cogeneration systems with gas turbine, b) Cogeneration systems with steam turbine, c) Cogeneration systems with combination of gas and steam turbine, d) Cogeneration systems with piston turbine.
Best Available Techniques	No.
Case studies	No.
Examples – calculations	No.
Software free/commercial	No.
Use for EINSTEIN	

Additional information

The table of contents include the following items:

1. Advantage of cogeneration.
2. Cogeneration systems.
3. Cogeneration potentials and its possibility to apply CHP in various sectors e.g. power stations, in industry, in services.
4. How to implement cogeneration.
5. EU case studies.

4.1.5.4 Biomass

Biomass Combined Heat and Power Catalogue of Technologies

Complete references	U.S. Environmental Protection Agency Combined Heat and Power Partnership (2007), Biomass Combined Heat and Power Catalogue of Technologies, ICF International Company and Eastern Research Group, http://www.epa.gov/chp/basic/catalog.html.
Guide availability	http://epa.gov/chp/documents/biomass_chp_catalog.pdf
Language	English
Contents	CHP, biomass, CHP technologies
Type of information/data provided	Investment costs, labour requirements, boiler, fuel cells and turbines characteristic, efficiency losses, boilers type comparisons, advantages and disadvantages of gasifier, characteristic of power and heat generation technologies, economical evaluation
Best Available Techniques	Biomass conversion system for power and heat generation
Case studies	No
Examples – calculations	No
Software free/commercial	Free. CHP Emission Calculator available on the web site http://www.epa.gov/chp/basic/calculator.html. Calculator is a tool that compares the anticipated CO2, SO2, and NOx emissions from a CHP system to the emissions from a comparable system that uses separate heat and power. The calculator is designed for users with at least a moderate understanding of CHP technology and its terminology and is available for free.
Use for EINSTEIN	Guideline: general information and better understanding of CHP technologies.

Additional information

This guide focuses on biomass energy conversion technologies and it is addressed mainly to facility managers, developers, policymakers etc.

Table of contents	Contents
Chapter 1: Introduction and overview 1.1 Biomass for Power and Heat Generation 1.2 Biomass Feedstock 1.3 Biomass Conversion 1.4 Report Layout	
Chapter 2: Basic First Steps and Consideration 2.1 Survey Availability of Local Resources 2.2 Cost Considerations	This chapter describes biomass, provides information about biomass collection methods, transportation, and storage.
Chapter 3: Biomass Resources 3.1 Rural Resources 3.2 Urban Resources	This chapter presents various types of biomass resources, locations, energy and cost characteristics, resource potential in USA.
Chapter 4: Biomass Preparation 4.1 Solid Biomass Fuel Preparation 4.2 Biogas Fuel Preparation	This chapter describes the receiving, processing, and treatment systems required for preparing biomass and biogas. Which are used for power and heat generation. Equipment configurations, investment and production costs are also mentioned.
Chapter 5: Biomass Conversion Technologies 5.1 Direct-Fired Systems 5.2 Gasification Technologies 5.3 Modular Systems	This chapter describes performance for the two basic biomass conversion approaches: combustion (direct-fired system) and gasification. Here are described various types of boilers, boiler efficiency, operating advantages and disadvantages, costs of installation, investment and operating costs, etc.
Chapter 6: Power Generation Technologies 6.1 Steam Turbine Technologies 6.2 Gas Turbine Technologies 6.3 Microturbine Systems 6.4 Reciprocating Internal Combustion Engine Technologies 6.5 Fuel Cell Systems 6.6 Stirling Engines	This chapter provides basic information of cost and performance for power generation technologies with heat recovery. Steam and gas turbines, fuel cells, microturbine, reciprocating internal combustion engine are also described. Typical performance parameters (electric capacity, equipment costs, electrical efficiency etc.) are also provided.
Chapter 7: Representative Biomass CHP System Cost and Performance Profiles 7.1 Direct Firing of Biomass (Boilers With Steam Turbines) 7.2 Biomass Gasification Systems 7.3 Modular Biomass Systems	This chapter provides an integration of resource, preparation, conversion, and power and heat production system costs into integrated biomass CHP facilities. Capital costs, operating costs, fuel costs, and typical energy balances, including power and heat production options are described. This chapter provides a starting point for conducting a preliminary economic screening of possible biomass energy production options.

Wood biomass – unexploited energy source

Complete references	V. Butala, J. Turk (1998). *Wood biomass – unexploited energy source*, University of Ljubljana, Faculty of Mechanical Engineering, Chair of Heat & Mass Transfer and Environmental Studies, Ljubljana
Guide availability	http://www.aure.si/
Language	Slovenian
Content	Biomass is wooden, municipal waste, and waste from plants (cereals, sugar beet...). Wood biomass is branches, trunks from gardens, old trees, old paper, and unqualified wood from production.
Type of information/data provided	With this guide it is possible to recognize the energy potential of biomass – economically and environmentally.
Best Available Techniques	No.
Case studies	Yes.
Examples – calculations	Biomass combustion and efficiency calculation.
Software free/commercial	No.
Use for EINSTEIN	

Additional information

The table of contents include the following items:

1. Biomass and CO_2.
2. Sources of biomass.
3. Biomass use in the world.
4. Wood biomass production – process, technologies, transport, storage.
5. Emission values.
6. National benefits from wood biomass usage.
7. Wood biomass combustion – combustion techniques, fixed bed gasification, fluidised bed combustion, co-generation.
8. Case studies.

4.1.5.5 Industrial refrigeration

How to Save Energy and Money in Refrigeration

Complete references	The Energy Research institute, *How to Save Energy and Money in Refrigeration*, Department of Mechanical Engineering, University of Cape Town.
Guide availability	http://www.3e.uct.ac.za/
Language	English
Content	Refrigeration systems, refrigerants, environmental problems with the used refrigerants.
Type of information/data provided	Scheme of the single stage vapour compression circuit, reverse Carnot cycle, basic refrigeration cycle, absorption refrigeration cycle. Types of compressors, evaporators, condensers and theirs correct use. Types of liquid coolers, expansion devices, refrigerants. Physical properties of the refrigerants and energy management opportunities.
Best Available Techniques	Check-list for saving energy and money in refrigeration systems.
Case studies	No.
Examples – calculations	Coefficient of performance (COP), theoretical work input, low cost examples, housekeeping examples.
Software free/commercial	No
Use for EINSTEIN	Check-list for saving energy and money in refrigeration systems. Better understanding of refrigeration systems and helpful guide for good practices.

Additional information

Table of contents	Contents
Chapter 1: Introduction	
Chapter 2: The Refrigeration Process 2.1 The vapour compression cycle 2.2. Reverse Carnot Cycle 2.2.1 Coefficient of Performance. 2.3 Theoretical Vapour Compression Cycle 2.4 Absorption Cycle 2.5 Special Refrigeration Systems 2.6 Variations on the simple Carnot circuit 2.7 Multiple evaporator circuits	This chapter provides information of the vapour compression cycle (refrigeration systems are driven by a machine, which compresses and pumps refrigerant vapour around a sealed cycle), reverse Carnot cycle (produces the heat from work), and absorption cycle, for better understanding. Here are also schemes, other calculations, which represent different refrigeration systems.
Chapter 3: Equipment 3.1 Compressors 3.2 Evaporators 3.3 Expansion devices 3.4 Condensers	This chapter provides data of equipment and its components (compressors, condensers, evaporators, etc.) in different refrigeration systems.
Chapter 4: Refrigerants 4.1 Desirable Characteristics 4.2 Common Refrigerants - Vapour Compression Cycles 4.3 Common Refrigerants - Absorption Cycle 4.4 Brines and Secondary Coolants	This chapter describes different refrigerants, which are common in refrigeration systems. There are described physical properties of refrigerants, environmental problems of using refrigerants, which belong to the family of chemicals such as CFCs, and properties of non-CFCs refrigerants.
Chapter 5: Energy Management Opportunities 5.1 Housekeeping Opportunities 5.2 Low Cost Opportunities 5.3 Retrofit Opportunities	This chapter contains procedures of increasing the energy efficiency and to decrease operating costs. Here are described good housekeeping, low cost and retrofit opportunities.

The check – list given in the manual covers different areas and include the following items.

Equipment maintenance:

- Ensure that there is good and regular maintenance of all equipment.
- Avoid blockage of air flow through and around heat exchanges (e.g. evaporators and condensers).
- Make sure that fouling of primary and secondary refrigeration circuits is kept to a minimum.
- Maintain isolation standards where appropriate.

Efficient use of the refrigeration system:

- Keep operating hours to a minimum.
- Ensure that the cooling load is kept to a minimum.
- Avoid operating refrigeration plant under part-load conditions.
- Investigate the possibility of improving control functions.
- Reschedule production cycles to reduce peak electrical demand.

Alterations to the existing plant:

- Utilise waste heat where possible.
- Where appropriate, retrofit plant with more energy efficient components.
- Increase evaporator temperature to increase system COP.
- Reduce condensing temperature to increase system COP
- Upgrade automatic controls in refrigeration plants to provide accurate and flexible operation.
- Replace high-maintenance, centrifugal compressors with compressors selected for high efficiency when operating at part load conditions.
- Upgrade insulation on primary and secondary refrigerant piping circuits.

Refrigerants:

- Review energy efficiency when replacing CFC with ozone benign refrigerants. (This might not have an energy saving effect).

4.1.5.6 Compressed air systems

How to Save Energy and Money in Compressed Air System

Complete references	The Energy Research institute, *How to Save Energy and Money in Compressed Air System*, Department of Mechanical Engineering, University of Cape Town.
Guide availability	http://www.3e.uct.ac.za/
Language	English
Content	Compressed air, requirements, opportunities, and energy savings.
Type of information/data provided	List of possibilities when not to use compressed air, compressed air system components, pressure loss through steel fittings, air quality classification, and compressor types.
Best Available Techniques	No.
Case studies	No.
Examples – calculations	Equations for calculating electricity costs, compressed air leaking.
Software free/commercial	No**.**
Use for EINSTEIN	Energy efficiency opportunities for compressed air systems.

Additional information

This guide intends to provide those responsible for energy management and maintenance of compressed air systems with opportunities for optimising the system performance in terms of cost.

Table of contents	Contents
Chapter 1: Introduction	
Chapter 2: Economics Of Compressed Air Production 2.1 Calculating electricity costs – a simple calculation 2.2 A Calculation for Part Load Operation 2.3 Savings from Performance Improvements	This chapter provides equations for calculating electricity costs
Chapter 3: Reducing Compressed Air Demand To Save Energy 3.1 Compressed Air Usage 3.2 Assessing Air Needs. 3.3 Compressed Air Misuse 3.4 Leaks	This chapter provides information of misused, air leaks, etc.
Chapter 4: Efficient Compressed Air Distribution 4.1 Introduction 4.2 Distribution Main 4.3 Water Drainage 4.4 Drain Traps 4.5 Air Receivers 4.6 Regulators 4.7 Distribution Network 4.8 Maintenance 4.9 System isolation	This chapter provides possibilities for reducing the end usage of compressed air. There is also information of compressed air systems, drain traps, air receivers, controls, system insulation, etc.
Chapter 5: Compressed Air Treatment 5.1 Introduction 5.2 Dryers 5.3 After Filters 5.4 Air Intakes 5.5 Installation, Configuration and Sizing 5.6 Treatment Systems Maintenance 5.7 Potential saving areas	This chapter describes the necessary requirements for compressed air treatment (air quality, air inlet, etc.), information about dryers and potential saving areas.
Chapter 6: Compressed Air Generation 6.1 Positive Displacement Compressors 6.2 Dynamic Compressors 6.3 Energy Efficient Compressor Selection.. 6.4 Energy Efficient Compressor Control 6.5 Sizing 6.6 Maintenance 6.7 Heat Recovery 6.8 Site Integration to Save Energy	This chapter describes types of compressor, proper choice of compressor control and maintenance. Here is information of possibilities of heat recovery.
Chapter 7: Monitoring Of Compressed Air Systems 7.1 Monitoring 7.2 Monitoring and targeting	This chapter provides information of monitoring, required measurement for different types of compressor, air flow meters, etc.
Chapter 8: Compressed Air Audits 8.1 End Usage Audit 8.2 Distribution Network Audit 8.3 Air Treatment Audit 8.4 Compressor House Audit	This chapter outlines a strategy for identifying the opportunities, including auditing techniques that can easily be implemented.

The list for Best Available Techniques (BAT) includes the following items.

Efficient compressed air distribution:

- Establish and audit the compressed air needs of the plant. Identify system oversupply in terms of air quality or pressures.
- Remove/isolate dead lags and minimise pressure drops.
- Ensure the compressor plant is operating according to manufacturers/suppliers specifications.
- Minimise the air leakage rate A planned maintenance program to cover the air distribution system is useful.

Compressed air treatment:

- Keep air treatment to the minimum possible. If only one user in the system requires high quality air, consider treatment of air at that point.

Compressed air generation:

- Make sure the air intake is cool and clean. Use outside air for compression where it is possible
- Generate compressed air at the lowest possible pressure that will meet site requirements.
- Ensure that the design of the plant compressed air distribution system does not produce an excessive pressure drop between generation plant and end user.
- Recover heat of compression from inter-coolers and after-coolers wherever possible.
- Ensure that the control systems installed result in efficient operation. Investigate the possibility of sequencing a plant with more than one compressor unit.
- Control generation to meet demand closely and efficiently. Make sure the control system ensures that energy consumption is minimised during low or no-load conditions for individual machines.

Monitoring:

- Set up a targeting and monitoring program. This will help ‘benchmark’ consumption and indicate future irregularities.

Auditing:

- In order to establish the status quo, and quantify wastage an audit – as described in chapter 8 of this booklet - should be carried out.

Energy efficiency in compressed air usage

Complete references	M. Kožuh, M. Špendal (1998). *Energy efficiency in compressed air usage*, Jožef Stefan Institute, Guide for efficient energy consumption, Energy Efficient Centre, Ljubljana.
Guide availability	http://www.aure.si/
Language	Slovenian
Content	Compressed air is often used in production processes. The purpose of an air compressor is to concentrate free air into a smaller volume. It is one of the most expensive sources of energy. 10 % of electricity is used for compressed air preparation.
Type of information/data provided	This guide instruct us about isolating the piping system, free air temperature for the optimal work of the air compressor, safety valves installation, different types of air compressors, cooling, maintenance, how to do energy audit for air compressors. There is information about compressed air system controls, compressed air storage and compressed air system leaks.
Best Available Techniques	No.
Case studies	No.
Examples – calculations	Examples.
Software free/commercial	No.
Use for EINSTEIN	

Additional information

The table of contents includes the following items:

1. Efficient energy consumption in compressed air systems.
2. Systems for compressed air.
3. Elements for compressed air (types of air compressors – reciprocating, rotary, centrifugal, axial).
4. Equipment for compressed air preparation (filters, control devices, driers, refrigerators, separators, and pressure and flow controllers).
5. Distribution system.
6. Leaking.
7. How to do energy audits of compressed air systems.

4.1.6 Miscellanea of handbooks and manuals

Energy efficient technologies and measure for increasing efficiency – proven applications and innovations

Complete references	Berger H et al. (2005), *Energy efficient technologies and measure for increasing efficiency – proven applications and innovations,* Vienna: Österreichisches Umweltbundesamt, Fa. Allplan
Guide availability	http://www.umweltbundesamt.at/fileadmin/site/publikationen/M172.pdf
Language	German
Content	Efficient technologies for heat recovery, ventilation, motors, cooling systems, steam supply, compressors, vacuum plants etc; case studies; possibilities for assessment of energy efficiency measures
Type of information/data provided	Energy efficient technologies, and efficiency measures.
Best Available Techniques	Yes, concerning the topics mentioned above, also description of some "upcoming" technologies included such as new storage concepts, ORC process, solar climatisation etc.
Case studies	Yes, one case study on boiler house optimisation; one case study on CHP. Also several examples of non-economical measures based on case studies.
Examples – calculations	No
Software free/commercial	No
Use for EINSTEIN	Energy efficient technologies, and efficiency measures

Renewable for Heating and Cooling, Untapped Potential

Complete references	N.N. (2007), *Renewable for Heating and Cooling, Untapped Potential*, International Energy Agency.
Guide availability	http://www.iea.org/textbase/nppdf/free/2007/Renewable_Heating_Cooling_Final_WEB.pdf
Language	English
Content	RECH technologies.
Type of information/data provided	Information on renewable energy heating and cooling (REHC). RECH technologies (solar-thermal, bio-energy, geothermal) and their recommendations and applications, current market status and cost parameters for various RECH technologies.
Best Available Techniques	No.
Case studies	No.
Examples – calculations	No.
Software free/commercial	No.
Use for EINSTEIN	RECH technologies.

Energy Management in Industry. Planning of the investments

Complete references	N.N. (2000).*Energy Management in Industry. Planning of the investments* (teaching material). Warsaw, KAPE S.A./BAPE S.A. SAVE II, Energy Self-Audit Scheme
Guide availability	http://www.kape.gov.pl/PL/Programy/Programy_UniiEuropejskiej/SAVE/aP_ESAS/dzialania.html
Language	Polish
Content	This material was elaborated with the purpose to deliver a guidebook for the industry on undertaking well co-ordinated and comprehensive actions aiming at improvements in energy efficiency and a reduction of emissions to the environment.
Type of information/data provided	1. Introduction to energy and fuel management: a. Data registration; b. Data analysis; c. Identification of abnormalities d. Report preparation; 2. Introduction of energy and energy carriers management; 3. Decreasing of energy consumption; 4. Self-audit targets 5. Energy consumption in the process industries; 6. Energy characteristics; 7. Investments planning; 8. Feasibility studies; 9. Energy and fuel consumption ratios; 10. Data collecting and processing.
Best Available Techniques	
Case studies	
Examples – calculations	
Software free/commercial	
Use for EINSTEIN	

Japan Energy Conservation Handbook 2005 / 2006

Complete references	N.N. (2006). *Japan Energy Conservation Handbook 2005 / 2006*. ECCJ
Guide availability	http://www.eccj.or.jp/databook/2005-2006e/
Language	English
Content	This handbook elaborated by The Energy Conservation Centre, Japan is a very detailed document on energy related issues and contains a lot of information valuable to the project (Kyoto Protocol, Japanese policy to deal with global warming, promotion of energy conservation measures).
Type of information/data provided	**Content of the chapters relevant for the project** 4 Energy Conservation Policy in Japan: a. Outline of energy conservation polices b. The basic energy plan c. Legislation concerning the Rational Use of Energy d. Evaluation criteria for company on rational use of energy (standards and targets) e. Standard and target values for operating equipment f. Evaluation criteria for Building of rational use of energy g. Top Runner Programme. The Japanese government launched the Top Runner Program based on the Amended Law in 1999, under which the standards are set based on the efficiency level of the most efficient product commercially available in a given category. For each manufacturer and importer, the weighted average efficiency of all units shipped within the same category must meet the standards for that category by the target year decided for each category. h. Law of Energy Conservation and Recycling Support i. Financial Supporting measures j. Commendation Programs to award the Energy Conservation Efforts k. Publicity Activities l. Energy Audit Programme (for small and middle sized companies and commercial buildings) m. The international ENERGY STAR Program 5. Energy Conservation by the sectors: a. Energy conservation in the industrial sector Including information on effects of energy conservation and investment payback periods, energy conservation measures, outline of main technical action plans of different industry related organizations, methods for reducing the fixed energy consumption. b. Energy conservation in the residential sector c. Energy conservation in the transportation sector d. Reinforcement of Energy Conservation Measures in Various Sector
Best Available Techniques	No
Case studies	No
Examples – calculations	No
Software free/commercial	No
Use for EINSTEIN	Content of the chapters 4 and 5.

Additional information

The table of contents includes the following items:

1. World Energy Situations
2. Global Environmental Trends
3. Energy Situation in Japan
4. Energy Conservation Policy in Japan
5. Energy Conservation by the sectors
6. Related organizations
7. References.

Gas fuels and equipment for office and water heating

Complete references	V. Butala, J. Turk (1999). *Gas fuels and equipment for office and water heating*, University of Ljubljana, Faculty of Mechanical Engineering, Chair of Heat & Mass Transfer and Environmental Studies, Ljubljana
Guide availability	http://www.aure.si/
Language	Slovenian
Content	This guide promotes energy efficient technologies. Ones can learn about fossil fuels and environmental friendlier sources of energy. Gas fuels basic properties and also the most advanced gas technologies with emphasis on the condensation techniques are presented. Data about energy efficient gas devices – greater energy savings and less negative environmental impacts are described.
Type of information/data provided	Gas fuels physical and chemical properties
Best Available Techniques	No.
Case studies	Yes.
Examples – calculations	No.
Software free/commercial	No.
Use for EINSTEIN	

Additional information

The table of contents includes the following items:

1. Gas fuels. Include
2. Heat supply.
3. Gas heat installation elements. (boilers, pipes, control, chimney, water treatment).
4. Examples.
5. Gas fuels properties.

How to Save Energy and Money in Insulation

Complete references	The Energy Research institute, *How to Save Energy and Money in Insulation*, Department of Mechanical Engineering, University of Cape Town.
Guide availability	http://www.3e.uct.ac.za/
Language	English
Content	Insulation systems, insulation materials, protective covering and finishes.
Type of information/data provided	Heat loss tables through pipes with various thicknesses of insulation, thermal properties of typical building and insulation materials, thermal conductivity of industrial insulation, basic types of insulation materials, insulation systems.
Best Available Techniques	Check-list for saving energy and money at insulation systems.
Case studies	No
Examples – calculations	Thermal resistance, heat flow, heat losses from piping, surface area, the optimal diameter of insulation, energy savings.
Software free/commercial	No
Use for EINSTEIN	Check-list for saving energy and money in insulation systems. Better understanding of insulation systems and helpful guide for good practices.

Additional information

Table of contents	Contents
Introduction	
2. Fundamentals 2.1 Terms and definitions 2.2 Selection of insulation materials 2.3 Heat transfer 2.4 Heat flow 2.5 Protecting and sealing the insulation 2.6 Temperature ranges 2.7 Insulation thickness 2.8 Energy management	This chapter describes terms like conduction, convection, thermal conductivity, thermal resistance, etc. Here are also provided information on important properties which have to be considered of the selection of the type of the insulation material. Efficiency and service life of insulation is important and depended on proper choice of protective coverings and finishes.
3. Material systems 3.1 Insulation forms and materials 3.2 Insulation systems 3.3 Common applications	This chapter provides information about types and forms of insulation, important data about compatibility of insulating material, protective covering and accessories to support and seal the insulation and its protective covering.
4. Energy management opportunities 4.1 Housekeeping opportunities 4.2 Low cost opportunities 4.3 Retrofit opportunities	This chapter represents ways how to use energy efficiently and how to reduce operating costs e.g. by housekeeping, low cost and retrofit opportunities are also described.

A check – list for saving energy in insulation is given and includes the following item:

- Insulate non-insulated pipe and vessels.
- Repair insulation damage.
- Add insulation to reach recommended thickness.
- Upgrade existing insulation levels.
- Review economic thickness requirement.
- Limited budget upgrade.

Energy efficient windows and glazing

Complete references	M. Š. Zavrl, M. Tomšič (1999). *Energy efficient windows and glazing*, ZRMK Institute, Ljubljana
Guide availability	http://www.aure.si/
Language	Slovenian
Content	Window is one of the most important and also one of the most critical components in building envelope. Quality windows decrease energy and maintaining cost of the whole building.
Type of information/data provided	This guide describes a role of windows and this function in building envelope, technical criteria and technologies in frame and glazing production.
Best Available Techniques	No.
Case studies	No.
Examples – calculations	No.
Software free/commercial	No.

Additional information

The table of contents includes the following items:

1. History of windows in buildings.
2. Windows and building.
3. Heat transfer through the windows.
4. Types of the windows.
5. Glazing.
6. Materials for the window frames and wings.
7. Technical criteria for the energy efficient windows and glazing.
8. Economical view of the energy efficient windows and glazing.
9. Stimulation for using the energy efficient windows and glazing.

FireCAD Technologies webpage

FireCAD's web site (http://www.firecad.net/) a comprehensive list of handbook references on boilers is available, to buy only.

4.2 *International Projects and Programmes*

By Konstantin Kulterer, Austrian Energy Agency

4.2.1 Introduction

Several EU and national programmes, projects and study reports were scanned and analysed within the project. The target of EINSTEIN is to develop, test and disseminate an energy audit methodology and tool for thermal energy in industry. The main result of this study was that a similar project focusing on that special issue was not found. But there are several projects which produced interesting results which can be used within the EINSTEIN project.
Those projects are grouped according to their main target in:

- Energy Auditing
- Benchmarking
- Sector specific energy efficiency projects
- Projects with a technological focus (solar thermal, CHP, etc.)
- Financing.

The following table gives an overview of the analysed projects and their main objectives:

Project	Objective
Audit II – Energy Audit Management procedures	Indication of elements of energy audit support tools
Energy Self- Audit Scheme	Development of audit tools
EPA NR	Energy performance assessment of existing non-residential buildings, calculation tool, inspection protocol
BESS	Benchmarking and energy management schemes in SMEs
Energy Benchmarking at the Company Level within Industry Voluntary Agreements	Developing trans-national energy benchmarking scheme
European Best Practice Initiative	European benchmarking and guidelines
Recipe	Reduced energy consumption in plastics engineering
E-Check in Craft SMEs	Energy audit tool
EMS Textile	Energy audit tool, benchmarking tool and energy management manual
Energy Efficiency Earnings Guidebook	Guidebooks how to save energy and money, incl. heat and cooling
European Bio CHP	Collection of operational data for 60 CHP plants
Optipolygen	Databases with operating plants, identification of technical barriers, specific feasibility calculator
ST-ESCO	Guide with financial, technical and contractual aspects for solar thermal energy service companies
POSHIP	Study of the application of potential of solar industrial process heat in Spain
IEA-SHC/Solar Task 33/IV	Research project for solar heating and cooling
LTA Netherlands	Audit programme
Industrial Technologies Programme	Software, best cases, training
Energy Solutions Database	Tools for comparing air conditioning and heating systems
MEDISCO	Solar thermally driven cooling concepts for food and agro industry
TOSSIE	Alternative process technologies in sugar industry
Third party financing	Application of third party financing in Industry

4.2.2 Energy auditing

Title	**AUDIT II - Energy Audit Management Procedures**
Short Summary, incl. Activities	The main aim of the AUDIT II Project was to start-up long-term and continuous EU-level co-operation in the area of energy auditing and broaden this co-operation to cover also the Central and Eastern European Countries as the second step. The focus lies on energy audit programmes.
Targets addressed Auditors, Companies	Energy Audit program designer, Energy Agencies
Industrial Branches addressed (SMEs)	All
Energy Sectors addressed	non
Outcomes	The Guidebook is the top-level report presenting concrete knowledge on planning, development and operation of energy audit programmes and crucial information for decision makers and programme developers. Five Topic Reports which all are thorough presentations on areas which have a significant effect to the quality and cost-efficiency of an energy audit programme
Documents	Title: Guidebook for Energy Audit Programme Developers Title (Topic Report): Monitoring and Evaluation Title (Topic Report): Energy Audit Models Title (Topic Report): Training, Authorisation and Quality Control Title (Topic Report): Auditor´s Tools The horizontal analysis on this report meets the project aim by indicating the most replicable elements and interfaces of energy audit support tools applied in the existing on going Energy Audit Programs http://www.energyagency.at/(de)/projekte/audit.htm Title (Topic Report): Implementing Instruments

Title	**Energy Self-Audit Scheme - Poland**
Short Summary, incl. Activities	Development of scheme and additional necessary tools, which would encourage industrial companies to undertake actions aiming at improvements in energy efficiency and emissions-reductions
Targets addressed	Energy managers in Companies, Auditors
Industrial Branches addressed (SMEs)	All
Energy Sectors addressed	CHP, Monitoring Management
Outcomes	• Self-Audit Guide Book, methodology, auxiliary information, special training for energy managers • Internal statement of energy policy • Submission of the annual statement of energy accounts
Documents	KAPE

Title	**EPA-NR** Energy Performance Assessment of existing Non-Residential buildings
Short Summary, incl. Activities	EPA-NR addresses the implementation of the EC Energy Performance of Buildings Directive (EPBD) particularly with respect to energy performance assessment in existing Non Residential buildings.
Targets addressed	Buildings Service Sector
Industrial Branches addressed (SMEs)	Non, Office Buildings
Energy Sectors adressed	heating, cooling, distribution system
Outcomes	Relevant for EINSTEIN: • Calculation method according to CEN WI-14 • Checklist for an intake interview
Documents	**The EPA-NR software enables two types of calculations:** 1. **Standard calculation** for the certificate (with a fixed national or regional climate and assuming a nationally fixed user pattern), the so-called asset rating (according to CEN WI-2). This calculation has the main focus in EPA-NR. 2. **Tailored calculations** for the purpose of detailed energy advice are typically client and location specific calculations not necessarily based on standard indoor and outdoor conditions. The software allows calculating the actual situation and additional advice variants and determining the pay-back time of the energy saving measures. **Inspection protocol** The **inspection protocol** is meant as checklist during the inspection of the building. Included in the list are all values required for the use in the EPA-NR calculation tool that can be assessed in situ or for which the basis for further calculations have to be identified during the inspection. The list covers the following parts: - division of building into zones - building geometry - building components - visual air-tightness of the building envelope - shading systems, obstructions, etc. - internal gains (persons, equipment, processes) - heating system devices incl. control systems - DHW system devices incl. control systems - ventilation system devices incl. control systems - cooling system devices incl. control systems - humidification system devices incl. control systems - lighting system devices incl. control systems - day lighting systems - electrical gains from photovoltaic systems and CHPs - damages and age-dependent necessary renewals to the existing building and systems - already realised retrofit measures - possible/advisable retrofit measures http://www.epa-nr.org/introduction.html Software http://www.epa-nr.org/115.html Inspection protocol http://www.epa-nr.org/114.html

4.2.3 Benchmarking

Title	**BESS – Benchmarking; Ex-BESS (since Sept.2007)** Benchmarking and Energy Management Schemes in SMEs
Short Summary, incl. Activities	BESS offers an easy to follow way with various tools like an "energy management implementation model" and an e-learning system on the BESS website. Additionally an international benchmarking scheme for specific energy consumption will be established which offers the possibility to compare specific energy consumption with a large number of other companies from the same sector.
Targets addressed	Companies
Industrial Branches	Food industry (BESS), Textile (Ex-Bess)
Energy Sectors adressed	Energy management, Benchmarking on a company level, Measure list
Outcomes	• interactive web based benchmarking, benchmarking with product mix but on company level not process level • Energy Management handbook • Sector specific, Bess horizontal measure list
Documents	www.bess-project.info (E-learning; Benchmarking; ad-hoc users)

Title	**Energy Benchmarking at the Company Level Within Industry Voluntary Agreements**
Short Summary, incl. Activities	The overall aim of this project was to develop and test a multi-sectoral, trans-national energy benchmarking system for companies within EU Member States. It focuses primarily on companies which are relatively energy intensive.
Targets addressed	Companies
Industrial Branches addressed (SMEs)	Brewery, Bakery, Diary
Energy Sectors addressed	All
Outcomes	The data collection system was developed as an Access database, with much front-end programming to produce a system that is user-friendly and as easy as possible to enter data: A more automated computer based system developed for the data collection, data analysis and report generation processes. A trans-national energy benchmarking scheme has been developed and launched within three sectors. From the collected data company reports have been created, covering five main sections General company data - e.g., products, packaging, raw materials used, employee numbers, hours of operation, plant design capacity, capacity utilisation, output, turnover; Energy data - e.g., energy sources, energy intensity, Specific Energy Consumption (SEC), scale effects on SEC, energy consumption per Euro of value added, energy costs per unit output, energy price; Water and effluent data, and impact of water consumption on SEC; Energy technologies employed - e.g., Variable Speed Drives, energy efficient motors, CHP, heat recovery, heat pumps, energy efficient lighting, boiler checks, compressed air checks, and an aggregate energy technology 'score'; Energy management approaches in use - e.g., M&T, purchasing, energy teams, staff campaigns, participation in energy/environment schemes/licensing, and an aggregate energy management (and energy management/technology combined) 'score'; Example of Benchmark: Specific Energy Consumption (SEC) is the energy required to process one tonne of flour
Documents	http://www.energyagency.at/(en)/projekte/ideen2.htm Energy Benchmarking at the Company Level, Company Report Brewery, February 2001 Energy Benchmarking at the Company Level, Company Report Bakery, February 2001 Energy Benchmarking at the Company Level, Company Report Dairy, February 2001

Title	**European Best Practice Initiative (EBPI)**
Short Summary, incl. Activities	One of the main objectives of this project was to establish the value of pan-European benchmarking and develop guidelines that can be used universally so that further studies undertaken by one or more country will be comparable.
Targets addressed	Companies
Industrial Branches addressed (SMEs)	Brewing, dairies and glass making
Energy Sectors addressed	All
Outcomes	Published a general benchmarking methodology to be used for different sectors Collection and analysis of basic benchmarking data Tabulated a range of measures adopted within brewing, dairies and glass making sectors to improve energy measures Selected examples of best practice Developed a system
Documents	http://www.energyagency.at/(en)/projekte/bestpractice.htm http://www.dea.dk/Bestilling/Rapporter/benchmarking.pdf

4.2.4 Sector-specific energy efficiency

Title	**RECIPE** Reduced Energy Consumption in Plastics Engineering
Short Summary, incl. Activities	RECIPE provides European plastics processors with the knowledge, justification and tools needed to reduce their energy consumption through the implementation of best practice and the introduction of new technologies.
Targets addressed	Companies
Industrial Branches addressed (SMEs)	Plastics Engineering
Energy Sectors addressed	Heat, Electricity, Benchmarking
Outcomes	• a European Best Practice Guide for the plastics processing industry • an interactive toolkit to enable companies to evaluate energy consumption and look closely at individual processes within the plant. It provides guidance on efficiency and highlight key plant areas where the most substantial energy and costs savings can be made most easily. • a 'Cost of Ownership Model' to enable processors to calculate the cost of operating a piece of equipment over its projected lifetime, based on energy efficiency and projected usage. • benchmark energy usage in plastics processing companies across Europe in 2005 • The Energy Review/ Quick Check will provide users with a comparison of your production sites performance against the benchmark for the European Union. It will estimate the potential savings one could make for modifying the plant to reach the benchmark, or even improve on it • The Energy Managers Toolkit is an online software tool to help plastics processors understand how energy is being used at their plant and how to save energy and money. The toolkit will give an overview of the energy that a plant purchases and the major systems that consume energy and provide a report that helps the user understand where the largest opportunities are for energy and cost saving.
Documents	http://www.eurecipe.com/

Title	**E-Check in Craft SME**
Short Summary, incl. Activities	The aim of this project "E-Check in Craft SME" - is to develop a standardized, easy-to-use energy audit which is specifically tailored to small and medium-sized enterprises (SME) active in the craft sector. The purpose of this Energy Check is to swiftly identify the substantial and easily realizable energy saving potentials within each SME that is checked.
Targets addressed	Auditors, Companies
Industrial Branches addressed (SMEs)	carpenters, bakers, bricklayers/glazers/painters, food producers and butchers
Energy Sectors addressed	All
Outcomes	easy-to-use energy audit (excel-file): required/actual temperature, preheat time; steam: generation/required pressure; generation/required temperature; max. pressure;
Documents	http://www.energy-check.org/home-ie http://www.energy-check.org/media/usermedia/files/irish-documents/Examples/E-Check%20fruit%20Farm.xls

Title	**EMS Textile**
Short Summary, incl. Activities	The EMS-TEXTILE project aims to promote energy management practices mainly to the textile industries of Greece, Portugal, Spain and Bulgaria.
Targets addressed	Companies
Industrial Branches addressed (SMEs)	Textile Companies
Energy Sectors	Energy Management
Outcomes	• Energy Audit Tool for the identification of energy savings opportunities and energy performance assessment (rather non deep Energy Audit methodology) • Energy Consumption Benchmarking Tool for quick comparative evaluation of energy performance (Electronic Benchmarking Database): Gas, Electricity, Oil, tonnage of product; • Energy Management Manual for the improvement of the company's energy efficiency
Documents	http://www.ems-textile.net

4.2.5 Technologies

4.2.5.1 Energy Efficiency

Title	**Energy Efficiency Earnings Guidebook**
Short Summary, incl. Activities	**The Energy Efficiency Earnings (3E) Guide Books** titled: "How to Save Energy and Money" series, produced as a result of research conducted in South Africa. The books are in the fields of: general savings and monitoring and targeting, boilers and furnaces, compressed air systems, refrigeration, steam systems, insulation and electrical use. These Guide Books enable significant cost savings and profits to be realised through the implementation of no or low initial cost options with some payback periods being immediate
Targets addressed	Companies
Industrial Branches addressed (SMEs)	All
Energy Sectors adressed	Electricity, Heat
Outcomes	• Guidebook 2: Boilers & Furnaces • Guidebook 4: Refrigeration • Guidebook 5: Steam Systems • Guidebook 6: Insulation
Documents	http://www.3e.uct.ac.za/

4.2.5.2 Combined Heat and Power (CHP)

Title	**European Bio CHP** **European Biomass CHP in Practice**
Short Summary, incl. Activities	• Promote biomass CHP in Europe by displaying experiences from solid biomass (including co-firing), Municipal Solid Waste (MSW), anaerobic digestion gas and landfill gas fuelled CHP plants and highlighting plants with the best operation • Provide eg. authorities and future plant owners with information about expected performance in biomass CHP plants and about best available technologies. This will help ensuring high quality of future plants • Enable benchmarking and thus identify the improvement potential of the existing European CHP plants • Replicate best practices on the operation of biomass CHP plants by extensive dissemination activities • Create a network for exchange of good and not so good CHP experiences
Targets addressed	CHP Plant owners, authority
Industrial Branches addressed (SMEs)	Rather CHP for public purposes
Energy Sectors adressed	CHP
Outcomes	• collection of operational data for 60 CHP plant • available under: http://www.dk-teknik.dk/cms/site.asp?p=1042 • Best Practice Guide for biomass CHP
Documents	http://www.dk-teknik.dk/cms/site.asp?p=927 **Best Practice Guide** http://www.dk-teknik.dk/cms/site.asp?p=3710

4.2.5.3 Polygeneration

Title	**Optipolygen** OPTimum Integration of POLYGENeration in the Food Industry
Short Summary, incl. Activities	OPTIPOLYGEN has the goal to reveal the potential of polygeneration in the European Food industry, determine possible technical and non technical gaps related with polygeneration applications and promote the applications of polygeneration as a route to sustainability in the food industry.
Targets addressed	Companies
Industrial Branches	Food industry
Energy Sectors addressed	Polygeneration
Outcomes	• Freely accessible database with operating polygeneration plants with classified plant data. • Identification of technical barriers which might exist in the use of renewable in hybrid systems with conventional CHP and Trigeneration in the food industry and propose beneficiary solutions. • **Subsector specific Feasibility calculator (Criterialist for CHP)** • http://www.optipolygen.org/tools.html
Documents	http://www.optipolygen.org/

4.2.5.4 Solar Heat

Title	**ST-ESCO**
Short Summary, incl. Activities	The objective of the project is to promote the creation and development of Solar Thermal Energy Service Companies (ST-ESCOs)
Targets addressed	ESCOs
Industrial Branches addressed (SMEs)	Residential, services, industry
Energy Sectors	Solar heat
Outcomes	Complete Guide with financial, technical and contractual aspects and a user-friendly Software package for the quick assessment of possible applications. St Escos software tool was developed for the quick assessment of potential ST-ESCOs applications. In includes a complete analysis procedure from technical considerations regarding the solar system and optimization calculations regarding economic and contractual analysis. ST-ESCOs software tool starts with a simplified interface that leads the user to enter data in Energetic Module – called EcMo. Elaboration of market and framework conditions analysis Suggestions for necessary ST-ESCOs support measures both at EC (Directive) and National level. Detailed, real cases of ST-ESCOs agreements and try to implement them in practice. In fact, the expected final outcome is to sign at least one new ST-ESCO agreement for each participating country.
Documents	http://www.stescos.org/general.htm http://www.stescos.org/tool.htm

Title	**POSHIP** The potential of solar heat in industrial processes
Short Summary, incl. Activities	Study of the application potential of solar industrial process heat in Spain and Portugal Case studies in order to analyse the technical and economic viability in specific industries Proposals for demonstration projects
Targets addressed Auditors, Companies	Companies
Industrial Branches addressed (SMEs)	Several
Energy Sectors addressed	Process heat, solar
Outcomes	Application potential of solar industrial process heat Case Studies, Proposals for demonstration projects
Documents	http://www.aiguasol.com/poship.htm

Title	**IEA-SHC/Solar PACES Task 33/IV**
Short Summary, incl. Activities	This Task is a collaborative research project of the IEA Solar Heating and Cooling Program and the IEA Solar PACES Program bringing together experts and industries from the residential solar heating field and the high temperature solar power field. The objectives of Subtask B are to identify applications and the corresponding temperature levels of the processes and/or the energy utility system suitable for solar energy. Methodologies are investigated and developed to come to integrated solutions considering solar thermal, waste heat recovery and improvements in the processes and energy utility systems.
Targets addressed	Companies, Auditors, Service, Equipment Providers
Industrial Branches addressed (SMEs)	All
Energy Sectors addressed	Process Heat, Solar
Outcomes	Within subtask B a matrix and a template for data collection have been developed gathering information on best available technologies for different industrial sectors.
Documents	http://www.iea-shc.org/task33/subtask/index.html

Title	**LTA Programme Netherlands**
Short Summary, incl. Activities	The LTA-programme's ongoing goal is to improve energy efficiency on a structural basis. This is why the LTA-programme uses energy management as a framework.
Targets addressed	Companies
Industrial Branches addressed (SMEs)	All, special heat tools for food and foundry industry
Energy Sectors addressed	
Outcomes	Within the framework there are several instruments to support the industry: Measurement lists For every sector SenterNovem has developed a specific list of energy efficient measures. The list is drawn up in close consultation with the sector and specialized energy consultants. Best Practices Knowledge and examples of best practices in order to improve energy efficiency. User groups User groups are a support instrument in which different companies from a sector are brought together in order to improve the energy efficiency of a preselected subject, like compressed air. The aim is to share and exchange information on the subject and to work together towards energy efficient solutions. An experienced energy consultant supports the group. Knowledge networks The LTA-programme supports knowledge transfer by supporting five Knowledge networks: Advanced heat exchanger, Computer aided process engineering, Process intensification, Netherlands Group of Users of Separation Technologies, Industrial drying. Software support tools The LTA-programme has developed several software support tools: Return on Investment (ROI)-decision making Improving low pressure steam systems efficiency for the food industry. Decision making for energy efficient cooling/freezing equipment for supermarkets. Decision making for waste heat usage for the foundry industry.
Documents	http://www.senternovem.nl/LTA/energy_efficiency/index.asp

Title	**Industrial Technologies Program**
Short Summary, incl. Activities	The Industrial Technologies Program (ITP) leads national efforts to improve industrial energy efficiency and environmental performance. It is part of the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy and contribute to its efforts to provide reliable, affordable, and environmentally sound energy for America today and in the future.
Targets addressed	Companies, Auditors
Industrial Branches addressed (SMEs)	Metal, Forest Products, Glass, Petroleum
Energy Sectors addressed	Steam, process heating
Outcomes	Software, best cases, Training
Documents	http://www1.eere.energy.gov/industry/bestpractices/ http://www1.eere.energy.gov/industry/bestpractices/steam.html

Title	**Energy solutions Database**
Short Summary, incl. Activities	The Washington State University Energy Program is under contract with the Western Area Power Administration to create and provide resources and tools for their utility customers and their end-users. Within this site are tools for comparing air conditioning and heating systems, previously answered questions, reports, news, websites, fact sheets and many other tools searchable through the Energy Solutions Database, innovative utility programs entered into the Utility Options Database
Targets addressed	
Industrial Branches addressed (SMEs)	All
Energy Sectors addressed	Steam, Heat Recovery, Cooling, Steam Systems
Outcomes	Software tools, best cases, guidelines,…
Documents	http://energyexperts.org/energy_solutions/

Title	**MEDISCO MEDIterranean food and agro industry applications of Solar COoling technologies**
Short Summary, incl. Activities	MEDISCO aims to develop, test and optimise solar thermally driven cooling concepts for the food and agro industry in the Mediterranean region, which under local conditions can become economically and socially sustainable. The objective is to asses which systems would better suite the actual and future demand of the food and conservation industry sectors in the south edge of the basin and estimate in technical and economical terms the most appropriate approach for the application of solar thermally driven systems. The partners will carry out a survey of the energy requirement of the industrial sector analysed in Egypt, Morocco and Tunisia.
Targets addressed	Companies, other stakeholder
Industrial Branches addressed (SMEs)	Food Industry
Energy Sectors addressed	Solar Thermal
Outcomes	Development of novel high performing solar driven cooling and refrigeration concept, aiming at the best compromise towards innovative technologies use, primary energy savings and economic issues. Therefore the optimised system will be constructed and installed in two experimental set ups (one in Tunisia), allowing on site monitoring activities of the system performance. The experiences gained through the experimental activities, will be used to create guidelines for best practice applications.
Documents	http://www.medisco.org/

Title	**TOSSIE** Towards Sustainable Sugar Industry in Europe
Short Summary, incl. Activities	Sugar and its main by-products (beet pulp and molasses) being used for direct consumption and also in the food & drink industry and animal feed production, are of strategic importance to human nutrition. To satisfy consumer needs in a sustainable manner at changed market conditions, new ideas on production technology, engineering & management are needed for the restructuring of the sugar sector, which is of major importance to the EU economy.
Targets addressed	Companies, stakeholders
Industrial Branches addressed (SMEs)	Sugar Industry
Energy Sectors addressed	
Outcomes	Regarding competitiveness, safety and environmental impact of beet processing, results are available of recent research including EU-funded projects on: • alternative process technologies to improve manufacturing efficiency and eliminate environmental risks, and improve utilisation of by-products using biotechnology, • engineering and management tools for optimising the efficiency of raw material use, utilisation of by-products and energy & water use, • selection of innovative process structures for optimal, with regard to sustainability requirements, utilisation of the whole potential of renewable resources taking into account the complete value chain from raw material generation, transportation, conversion to intermediate products, to generation of marketable goods.
Documents	http://www.tossie.pw.plock.pl/

4.2.6 Financing

Title	**Third party financing – TPF** Third Party Financing of Energy Efficiency in Industry: Structuring of Pilot Projects in Poland, Austria, Norway and Spain
Short Summary, incl. Activities	The aim of the project was to give an initial impetus for the application of Third Part Financing (TPF) approach in industries of the countries addressed. The focus of the project was oriented towards investment for rational use of energy in industry ("Energy Performance Contracting", EPC). The project also considered approaches referring to a more efficient energy supply of industrial enterprises - e.g. the construction of cogeneration facilities in industry by the application of TPF-models ("facility contracting").
Targets addressed	Companies, ESCOs
Industrial Branches addressed (SMEs)	Several (textile, food,...)
Energy Sectors addressed	Co-generation, others
Outcomes	• Checklist for quick test of the suitability of framework conditions in an enterprise for the application of TPF/EPC • SWOT analysis referring the TPF scheme
Documents	http://www.energyagency.at/(en)/projekte/tpfind.htm#eva-publ

4.2.7 Other Projects

Title	**Ecoprofit -Austria**
Short Summary, incl. Activities	ECOPROFIT is a model for the implementation of cleaner production options in SME. The ECOPROFIT-methodology includes a rough energy analysis (developed by JR, the coordinator of the present project) that will serve as a basis of the present project.
Targets addressed	Auditors, Companies
Industrial Branches addressed (SMEs)	SMEs (above 20 employees)
Energy Sectors addressed	All
Outcomes	The ECOPROFIT-methodology includes a rough energy analysis (developed by JR, the coordinator of the present project) that will serve as a basis of the present project.
Documents	http://www.ecoprofit.org/

4.3 *Websites*

By Monika Jarzemska, Krajowa Agencja Poszanowania Energii S.A. (KAPE)

4.3.1 Energy Efficiency Programmes and Campaigns

Website	http://www1.eere.energy.gov/industry/
Programme/Project/ Initiative	**The Industrial Technologies Program** – to improve the energy intensity of the industrial sector through a coordinated program of research and development, validation, and dissemination of energy efficiency technologies and operating practices.
Coordinated by:	U.S. DOE Energy Efficiency and Renewable Energy
Facilities/services	▪ Software Tools (fact sheets on the program features, software available for download); ▪ Online data bases (); ▪ Best practises - 4 page documents in pdf format, sorted by the industry (forest products, metal casting, steel), industrial systems (process heating, steam), plant wide assessment and case studies, corporate energy management case studies, performance spotlights; ▪ Publications – many articles sorted by topic (eg: process heating, steam systems) ▪ Trainings; ▪ Online support of energy experts in various fields.
Sectors addressed	Industry in general
Comments	Easy to navigate, reach in contents, regularly updated, free access to all the information.

Website	http://www.industry.gov.au/
Programme/Project/ Initiative	**Energy Efficiency Best Practise Programme (EEBP)** supports industry sectors to identify and implement cost effective solutions for a more sustainable and competitive future. The program has a focus on combining innovation, training and benchmarking and also offers practice tools, information and assistance.
Operated by:	Australian Government, Energy and Environment Division., Department of Industry, Tourism and Resources
Facilities/services	- Best practises - Case studies (of 4-10 pages) - Articles - Reports (eg. on Innovation and Energy Efficiency in Australian Wineries) - Info sheets All the above can be sorted either by the type or by the topic, so the information is easy to find.
Sectors addressed	Alumina production, beverage and containers manufacturing, bread baking, dairy processing, wine making, supermarkets and resource processing, fleet motor and hotel management.
Comments	Valuable information source, last revised in 2006

Website	http://www.unep.fr/energy/act/ef/index.htm
Programme/Project/ Initiative	Various programmes described separately
Coordinated by:	**United Nations Environment Programme, Department of Technology, Industry and Economics** UNEP Energy's energy efficiency activities focus on the needs of developing countries and countries with economies in transition. The activities involve various facets of technology research, development, transfer and commercialisation.
Facilities/services	- Energy technology fact sheets (eg. solar thermal, CHP) - Online Cleaner Technology Information - CAMSAT - CArbon Management Self Assessment Tool
Sectors addressed	Industry in general
Comments	Energy efficiency specific information available on respective projects' websites

Website	http://www.unep.fr/energy/projects/cp-ee/cpee_project.htm
Programme/Project/ Initiative	**Promoting Industrial Energy Efficiency through a Cleaner Production / Environmental Management System Framework**
Coordinated by:	United Nations Environment Programme, Department of Technology, Industry and Economics
Facilities/services	The cleaner production-energy efficiency (CP-EE) manual containing guidelines for the Integration of Cleaner Production and Energy Efficiency on an easy-to-navigate CD-ROM also available as a downloadable version.
Sectors addressed	None specific
Comments	Manual is divided in tree parts: -worksheets for CP-EE assessment; -technical module on energy-using systems and Energy Efficient Technologies; -tools and resources section: Checklists; Thumb Rules; Measuring Instruments; and an extensive list of Information Resources. It also contains a fully operational version of UNEP's 'GHG Indicator' is an additional feature of the tools section. Users can access this spreadsheet-based calculator to compute greenhouse gas (GHG) emissions from their facilities.

Website	http://www.ase.org/
Programme/Project/ Initiative	**Energy Efficiency Industry Partnership Program (EEIP)** - aiming to raise the visibility of the energy efficiency industry in developing countries and to educate energy end-users from industrial, commercial, and government facilities on energy-saving opportunities. Private sector companies promote energy-saving equipment and services as a means to reduce production costs and improve reliability.
Coordinated by:	Alliance to Save Energy
Facilities/services	Technical, strategic, and fundraising assistance
Sectors addressed	Industrial in general
Comments	

Website	http://www.energyefficiencyasia.org/
Programme/Project/ Initiative	**Greenhouse Gas emission Reduction from Industry in Asia and the Pacific (GERIAP)** project assisting Asian companies to become more energy and cost efficient through Cleaner Production (CP). CP is a strategy that prevents wastes and emissions and can assist companies to improve energy efficiency, reduce greenhouse gas (GHG) emissions and reduce costs. Main outcome of this project is Energy Efficiency Guide to Energy Efficiency in Asia.
Coordinated by:	The project is coordinated by the GERIAP Secretariat of the United Nations Environment Programme (UNEP), funded by the Swedish International Development Cooperation Agency (Sida), and implemented in the nine countries through National Focal Points (NFPs).
Facilities/services	▪ 6 step cleaner production approach (description of steps, training material for download in pdf format); ▪ Technical equipment - technical information for various types of electrical and thermal energy equipment containing options for energy conservation, training materials, case studies, useful contacts and monitoring equipment; ▪ Technical tools – option check lists, worksheets for company energy efficient methodology, GHG indicator (simplified version based on UNEP guidelines available for download)
Sectors addressed	5 industrial sectors: pulp and paper, chemical, ceramics, cement, iron and steel.
Comments	Available in English and 7 Asian languages

Website	http://www.hospitableclimates.org.uk/
Programme/Project/ Initiative	**Hospitable Climates** - energy efficiency agreement between the Institute of Hospitality - the professional body for hospitality, tourism and leisure managers worldwide - and the Government. It is an energy advisory programme, supported by the Carbon Trust. It offers all sectors of the UK hospitality industry - regardless of size or whether they are chain-owned or independent - a free advisory service to help reduce energy consumption; whilst at the same time, enabling users to make a substantial contribution to the country's CO2 emissions-reduction targets with their combined efforts
Coordinated by:	Institute of Hospitality on behalf of Hospitable Climates Network comprising the British Institute of Innkeeping (BII), the British Hospitality Association (BHA), the Association of Licensed Multiple Retailers (ALMR) and the British Beer & Pub Association (BBPA).
Facilities/services	▪ free advisory service ▪ online tools (heat online - registration required, example report available on the website) ▪ fact files on energy measures ▪ online case studies ▪ newsletters
Sectors addressed	Hospitable Industry – hotels, guest houses, restaurants, caterers
Comments	

4.3.2 Energy management

Website	http://www.uneptie.org/energy/projects/EMPRESS/index.htm
Programme/Project/ Initiative	**Energy Management and Performance Related Energy Savings Scheme (EMPRESS) -** aims to create the market for M&T (monitoring and targeting) energy management services as a means to achieve greater end-user energy efficiency and GHG reductions.
Coordinated by:	United Nations Environment Programme, Department of Technology, Industry and Economics
Facilities/services	▪ M&T tool – an energy management technique to help companies achieve and maintain efficiency improvements through the analysis of metered energy consumption data. Applicable for both energy and non-energy 'consumerables' such as water, process gases, waste streams (effluent, solid waste, toxic waste, etc). Provides platform for measuring and subsequently verifying reductions in CO2 emissions. Works by comparing data monitored from regular meter readings to target data calculated from production data and other parameters, such as the influence of weather; ▪ ESCO schemes; including template contracts and qualification criteria.
Sectors addressed	Commercial, industrial, institutional
Comments	At the moment the contents of the website is rather limited
Documents	So far only a few available for download.

4.3.3 Technologies

4.3.3.1 Heat supply systems

4.3.3.1.1 Steam generation

Website	http://www.steamingahead.org/
Programme/Project/ Initiative	**Steaming Ahead** – Energy Efficiency Resources promotes industrial steam system efficiency by providing industrial-plant managers and other interested parties with steam- and energy-efficiency resources, tools, news, and events.
Operated by:	Alliance to Save Energy in support of the U.S. Department of Energy's Best Practices Steam program
Facilities/services	- Tip sheets (downloadable in pdf format): ▪ Cost of steam ▪ Steam generation ▪ Steam distribution ▪ Steam End Use / Recovery - Free software tools; - Steam efficiency case study database; - Newsletter.
Sectors addressed	Industry using steam
Comments	

4.3.4 Databases

Website	http://www.iee-library.eu/
Programme/Project/ Initiative	Intelligent Energy e-Library (IEE-Library)
Coordinated by:	EACI
Facilities/services	On-line Database on EU funded projects and instruments – The following 4 themes are covered: Energy Efficiency in Industry, Local/Regional Energy Management, Renewable Energy, Transport.
Sectors addressed	Energy efficiency, renewable, transport etc.
Comments	The advanced search option allows the user to search by theme, type of tool, language, target audience and keyword.

Website	http://www.etde.org/
Programme/Project/ Initiative	**Energy Technology Data Exchange** - a multilateral organization formed in 1987 to further international information exchange.
Coordinated by:	International Energy Agency
Facilities/services	Energy Database – large collection of energy research and technology literature in the world. Total of over 4 million abstracted and indexed records in the full collection, users have access to a wealth of information contributed by ETDE's member countries and international partners covering the period from 1974 till now.
Sectors addressed	Countries/entities regardless sector
Comments	Membership required to be able to use the database

4.3.5 Financing

Website	http://3countryee.org/reports.htm
Programme/Project/ Initiative	**3 Country Energy Efficiency** – (Developing Financial Intermediation Mechanisms for Energy Efficiency Projects in Brazil, China and India) - aimed to substantially increase investments in energy efficiency by the domestic financial sectors in Brazil, China and India
Operated by:	Project partners
Facilities/services	List of publications including: - best practices (eg: Energy Efficiency Case studies in Indian Industry) - a manual to apprise energy efficiency projects - country reports on various aspects related to energy efficiency
Sectors addressed	Not specified
Contents	Project finished in 2006

4.3.6 Actors (Organisations, Associations, Institutes, companies)

Website	http://www.ihea.org/
Programme/Project/ Initiative	Na.
Operated by:	The Industrial Heating Equipment Association (IHEA) is a voluntary national trade association representing the major segments of the industrial heat processing equipment industry.
Facilities/services	Trainings, seminars and tools
Sectors addressed	Manufacturers of heat processing equipment
Comments	Website is under construction, at the moment there is little information but once in full operation it could be a valuable source of information

Website	http://www.carbontrust.co.uk/publications
Programme/Project/ Initiative	na.
Coordinated by:	**Carbon Trust** – a private company set by UK government in response to the threat of climate change.
Facilities/services	▪ Saving measures sorted by sector (including metals and metal products, paper products and printing) or technology type (including CHP, heating, heat recovery, process heating and drying) Description of the technology, it's suitability, possible financial incentives and some useful links to other information sources; ▪ Fact sheets on assessing energy use at industrial sites downloadable after registration; ▪ Benchmarking tools for civil sector in general, schools, offices and sports; ▪ Action Plan tool (demo version for trial);
Sectors addressed	Wide range of sectors
Comments	Most of the detailed information (including tools) available after registration. Information is updated on regular basis.

Website	http://www.eccj.or.jp/contents01.html
Programme/Project/ Initiative	na.
Coordinated by:	**The Energy Conservation Center,** Japan (ECCJ) - contributes to Promoting the efficient use of energy, protection of the global warming and sustainable development.
Facilities/services	For the industrial sector there are documents available on: ▪ Energy conservation measures; ▪ Key checkpoints; ▪ Energy audits in factories, ▪ Environmental Action Plans In civil sector sections ESCO schemes are described.
Sectors addressed	Civil, Industrial and Transportation
Comments	Many valuable documents technical and promotional, links to various Asian projects and initiatives in the area of energy efficiency.

Website	http://www.weea.org/
Programme/Project/ Initiative	na.
Coordinated by:	World Energy Efficiency Association - a private, non-profit organization composed of developed and developing country institutions and individuals charged with increasing energy efficiency.
Facilities/services	▪ Directory of energy service companies and profiles of some energy efficiency centres. ▪ Papers on energy efficiency, including some on Best Practices to improve energy efficiency
Sectors addressed	General information
Comments	No recent uploads, the content is rather small

5 Annex to chapter 1

5.1 *Review of energy auditing methodologies and procedures*

5.1.1 AUDIT II Project. Overview on the energy auditing methodologies

5.1.1.1 Definition of energy audit

The term **energy audit** is in principle well known and commonly used. There is however one problem which can easily lead to misunderstandings. The fact is that the term .energy audit. Is only a general term like a car.
The term energy audit is a good general definition but should also be used only as such.
The variety within the family of energy audits should be understood as well as the importance of defining also the content and the scope of the audit in more detail.
The term energy audit as such specifies only in general the content of the working method but does not define the actual scope, thoroughness or aim of the work.
Therefore there is clearly a need for different kinds of energy audits, especially due to the amount and content of the audit work and also for the reporting of the results.

An **Energy Audit** is defined as a **systematic procedure** that:

1) Obtains an adequate **knowledge of the existing energy consumption profile** of the site;
2) Identifies the **cost-effective energy saving opportunities**;
3) **Reports the findings**.

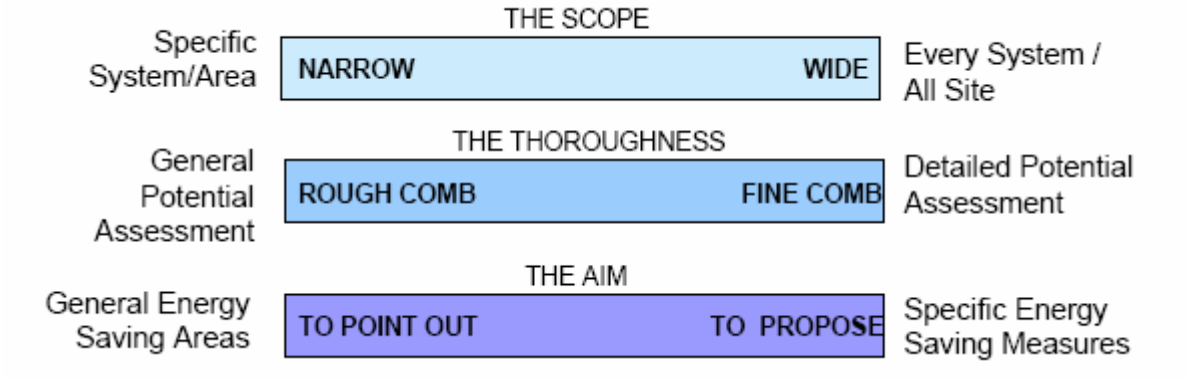
The core Audit. Source: AUDIT II project

Especially if the energy audit programme is targeted to industry, it may be feasible from the client's point of view to implement the energy audit in several **phases**. A typical approach is to have the first rough audit round, to scan the site, followed by one or several more detailed audits.
In the building sector a single-phase approach is more practical.

The benefit of the single phase audit is, although the client has bought a slightly bigger package that the auditing process will go to the end on one decision. The more phases and separate contracts there are, the more there are points where the client can decide to stop the auditing process.

An energy audit may cover a site or a building in various ways – the scope of audits may be different.

The main characteristics of an energy audit programme – the area of interest, the thoroughness and the aim – can be summarised as follows.



5.1.1.2 The energy audit models

The term **energy audit model** in this context indicates that there are agreed features or requirements designed for a specific type of an energy audit application. In a model the actual scope, thoroughness and aim of the audit are defined.

The audit model is usually a standardised, commonly known and commonly followed procedure with written guidelines.

According the findings of the project AUDIT II the different energy audit models can be divided into two main classes: the **Scanning Energy Audit Models** and the **Analysing Energy Audit Models**.

- **The Scanning Energy Audit Models**

The main aim of the Scanning Energy Audit Model is to point out areas, where energy saving possibilities exist (or may exist) and also to point out the most obvious saving measures.
From the client's point of view a scanning audit may not bring the expected results, because it does not necessarily bring actual saving measures, ready for implementation but usually suggests further analysis of key areas.

The scanning energy audit model for large sites is called the **Preliminary Energy Audit.** Audits of this type are typically used in the process industry.

Most of the work in the Preliminary Energy Audit is in building up a **reliable breakdown of the present total energy consumption and defining the areas of the significant energy consumption and usually also of the probable energy saving measures**.
The reporting also points out the areas where supplementary "second-phase" audits are needed and how they should be targeted.
The Preliminary Energy Audit normally needs to be carried out by a team of experts.
Expertise is needed both on the auditing procedure itself as well as on the production process.
The Preliminary Energy Audit always requires committed participation from the technical personnel of the site.

- **The Analysing Energy Audit Models**

The Analysing Energy Audit Models produce detailed specifications for energy saving measures, providing the audit client with enough information for decision-making.

The content of work in the **Targeted Energy Audit** (one of the Analysing Energy Audit Models) is specified by detailed guidelines and this means that most of the systems to be covered by the Targeted Energy Audit are known in advance. The guidelines may deliberately exclude some areas. The reason for excluding certain areas may be that they are known to be normally non-cost-relevant.

The Targeted Energy Audit usually produces a consumption breakdown and includes detailed calculations on energy savings and investments. If the guidelines are adequate, the audit produces a standard report.

An example of the Targeted Energy Audit at the simplest and smallest is the **System Specific Energy Audit**. This type of audit has a tightly limited target (one system, device or process), but the thoroughness of the work is usually very high. The System Specific Energy Audit produces a detailed description of the system and points out all profitable saving measures with alternative options concerning the specific system.

The **Comprehensive Energy Audit** is a Targeted Energy Audit at the "widest" end of the scale. It covers all energy usage of the site, including mechanical and electrical systems, process supply systems, all energy using processes, etc. Some minor systems may be excluded but they should be really non-relevant in ratio to the total energy consumption.

The clear difference to the Targeted Energy Audit is that the Targeted Energy Audit deliberately ignores some areas that are known and specified in advance and the Comprehensive Audit covers everything.
The starting point in this type of audit is always an analysis on the detailed breakdown of the total consumption. The Comprehensive Energy Audit comments on all energy using systems specified by the guidelines- regardless if savings are found or not. It points out all profitable saving measures and includes detailed calculations on energy savings and investment costs.

References

Text quoted from the original documents:

- Lytras, K., Caspar, C. (2003). *Energy Audit Models. Topic Report*. AUDIT II, Save Project. Motiva website: http://www.motiva.fi/fi/english/english/energyaudits/auditiiproject.html
- Väisänen,H. et al. (2003). *Guidebook for Energy Audit Programme Developers*. AUDIT II, Save Project. Motiva website: http://www.motiva.fi/fi/english/english/energyaudits/auditiiproject.html

5.1.2 CRES. Overview of the energy audits general procedure

An energy audit is the general term for a systematic procedure that aims at obtaining an adequate knowledge of the energy consumption profile of a building or an industrial plant. It also aims at identifying and scaling the cost-effective energy saving opportunities for the unit.

In an energy audit:

- the main goal is to achieve energy savings,
- the point of view is energy consumption and saving possibilities,
- there may be other aspects to consider (technical condition, environment) but the main interest is on energy savings,
- produces reporting on energy saving measures,
- the audit work may cover all energy using aspects of a site or certain limited parts (systems, equipment) of several sites (= “horizontal audit”).

Depending on the level of detail on the collected information, energy audits might be distinguished into **two types:**

1) the walkthrough
2) the extended audits.

Walk-through energy audits assess site energy consumption and relevant costs on the basis of energy bills-invoices and a short on-site autopsy. Housekeeping or/and minimum capital investment energy saving options of direct economic return are determined and a further list of other energy saving opportunities involving often considerable capital are proposed on a cost benefit basis.

Detailed - diagnostic energy audits request a more detailed recording and analysis of energy and other site data. The energy consumption is disaggregated in different end-uses (e.g.
heating, cooling, different processes, etc.) and the different factors that affect that end-use are presented and analysed (e.g. production or services capacity, climatic conditions, raw material data, etc.).

Energy auditing (EA) is based on the capability to perform an investigation on the energy installations as well as on the building shell. The complete procedure involves the following three **stages of registration/data collection and diagnosis**:

- **1st Stage:** Scheduling an Energy Audit - Collection of primary data & preliminary analysis of energy

At this initial stage, data and information is collected related to the present/current and past energy profile, the construction and utilization of every building/unit. These data/information can be retrieved with the aid of a structured and **concise questionnaire**, which **will be filled in after** the first meeting between the energy auditor and the building/unit manager who has authorized the energy audit. The foundations necessary for the completion of the questionnaire are information from the Technical and Administration Managers of the building/unit as well as existing relevant data (fuel bills/invoices, technical drawings, archived studies and catalogues, recorded measurements and readings, etc.).
The preliminary analysis of all collected data should lead to the identification of the annual trend and monthly fluctuation/variation of the total energy consumption and cost of the audited building/unit, which constitutes its energy profile. Initial energy data collected, should also lead to a first approximation on energy consumption allocation in every area and sub-system of the

building/unit. This is a way to express the energy balance of the building/unit. At the end of this stage, the Energy Auditor can compose/ draft an initial catalogue/list with possible energy saving actions/ activities for each building/unit, taking into account possible exemptions imposed by the owner.

- **2nd Stage:** Walk-through brief Energy Audit

During this stage, a qualitative investigation of the building shell and the electro-mechanical installations is performed, and the findings are tabulated in a specific form. This data registration coupled with instantaneous sampling measurements helps to apportion energy use and thus leads to the **energy balance** of the building/unit.
This procedure, coupled with the actions of the previous stage leads to a final determination of the **energy savings potential**, with the use of tiding-up measures and simple inexpensive measures/actions that don't need economic payback assessment through relevant energy studies. Additionally, it leads to a determination of the energy saving potential in specific areas and systems, for further examination in a following stage, by specialists/consultants or by the buildings' administration staff whenever its feasible. **These potentially energy saving actions must be divided into three groups according to their energy saving potential for the particular building (high, medium, low).**

- **3rd Stage:** In-site thorough Energy Audit

It involves collection (from in-site measurements) and processing of data as well as a full examination of the installed energy systems of the building/unit, which will permit to compose a thorough energy. This procedure will also permit a sound techno-economical evaluation of one or more energy-saving approaches, with medium to high investments on specific systems, after a relevant study.
The Energy audit procedure is completed with the presentation of all the energy saving proposals having the form of a summarized techno-economical report.

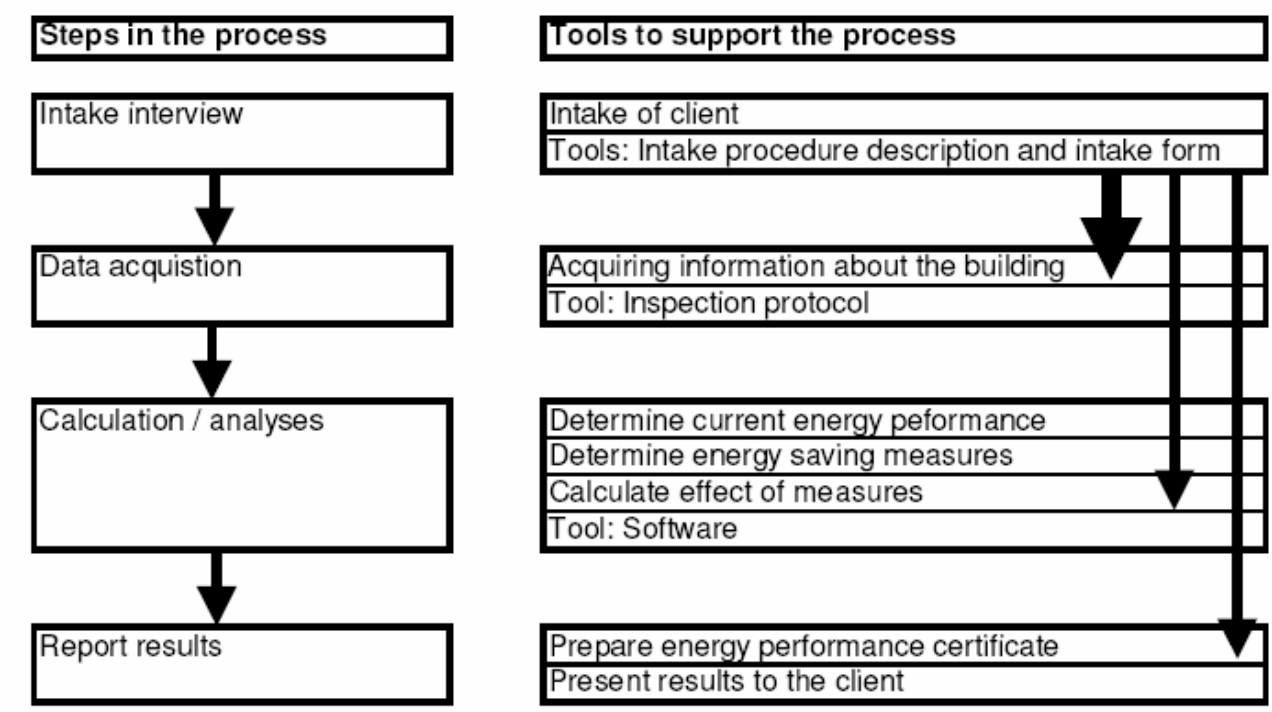
References
Text quoted from the original document:

- CRES, Centre For Renewable Energy Sources. *Energy Audit Guide. Part A: Methodology And Technics.* Adapt Community Initiative: "Specialisation of Engineers and other Scientists in Energy Audit Actions". Athens, May 2000.

Energy performance assessment of existing non-residential buildings according the EPA-NR methodology

General remark: the project addresses a specific sector (non-residential building) with a targeted goal (energy performance certificates according the Directive).

Energy performance assessment of existing non-residential buildings according the EPA-NR methodology is described in the following flowchart.



Process and tools in EPA-NR.Source: EPA-NR final report.

The main methodological steps are listed below.

STEP 0: intake procedure (Tool: checklist).
The objective of the intake interview is to create a clear starting point for the assessment process for the client as well as for the consultant. The following **checklist** is meant to structure the intake interview and to give guidance on the issues that are relevant to discuss and for collecting the necessary information.

√	To do	
	Preparation before the intake interview	
	Send client intake form and list of information needed before the intake interview and building inspection	
	Receive filled in intake form and list from client	
	Prepare first setup of quotation according to current information known (including filled in intake form and list returned by client)	
	Bring information about EPA to intake interview (e.g. example of what EP Certificate looks like)	
	Bring inspection form and protocol to intake interview	
	During the intake interview	
	Client	Identification: who is your client: building owner / facility manager / maintenance manager / energy coordinator / building stock manager / etc.?
		Needs, interests, motives: does the client only need an EP Certificate or does he have higher ambitions?
	Building	Identification: get a general idea of type of building, size, age, location etc.
		Any specific problems, e.g. relating to indoor environment quality
		Plans for maintenance, renovation, refurbishment, selling, renting out
		If possible, pay a short visit to the building to get a first impression
	Data acquisition	Globally go through inspection form with client and determine which data where to find (drawings / inspection / interviews)
		Explain about accuracy and quality
	Process	Explain EPA process, the stages and when they will take place
	Communication	Discuss number of meetings, date of meetings, which people to involve
		Confidentiality of data
		Access of buildings / restricted areas
	Deliverables	Agree upon what you will deliver to the client? Only an EP Certificate or a more detailed report as a basis for further energy saving measures?
		Deliverable on paper or also digitally?
		Show an example of EP Certificate and more detailed

		report.
		Who is the target audience of the deliverable: technical expert or non-technical expert?
	Follow up	Is the client interested in an EPA for additional buildings?
In case of a small and simple building only needing an EP Certificate		
	Inspection	The inspection may be done directly following the intake interview to save time (if consultant and client already have agreed upon quotation)
In case of large and complex buildings		
	After intake interview	
	Send quotation, specification of work, time schedule etc.	
	Agree upon any special issues and, if necessary, lay this down in a contract	
	Inspection	

Cheklist for intake interview. Source: Epa-NR final report

STEP 1: Registration (tool: intake form).
To prepare for the intake interview, the client **receives** an **intake form** from the consultant, which the client completes providing some basic information about the building owner / organisation and the building that should get an Energy Performance Certificate.

The client also provides a first indication of what kind of relevant data is available, like:

- Drawings (floor plans, cross sections, facades) from the original construction and any relevant renovations
- Information on types of existing installations and other technical information available
- Energy consumption or copies of energy bills.

The consultant can use this information in order to provide a financial quotation and timetable for the works and services to be provided, along with a brief overview of the deliverables.

STEP 2 (large buildings): Intake interview 1.
The consultant:

- prepares for the intake interview based on the available information from the intake form - extracts from the client possible expectations from an energy performance assessment.
- informs the client about the services that can be provided: activities, deliverables and how they can be used for further actions with respect to energy saving.
- explains the overall approach and procedure of the assessment based upon the client's needs.

The client:

- specifies relevant intentions and expectations from the energy performance assessment
- discusses with the consultant which services would best suit these intentions.

Based upon the results and output information from the intake interview 1, the consultant provides the client with a financial quotation that clearly identifies the work content, timetable, and deliverables. If the client responds positively the process can go on with intake interview 2.

STEP 3: Intake interview 2
The consultant checks the information in the intake form by going through it with the client and goes into further details about the building to be assessed along the inspection protocol.…

If applicable, the consultant may also need permission to access the building(s) and electromechanical installations and confidentiality of data may need some attention. Once all this has been arranged the consultant can proceed with the inspection of the building. Both parties involved, and according to usual business practices, they prepare and sign an agreement or contract that outlines the work to be performed, involved costs and method of payment, timetable, deliverables, and any other issues of importance.

STEP 4: Inspection (tool: inspection protocol)

Based upon the information already available from the intake form and the intake interviews the consultant inspects the building using the inspection protocol. When going through the building he checks the information already available and collects the missing information. It is very well possible that not all missing information can be collected from the inspection. In that case alternative sources might be consulted (less recent drawings and data from the architect or engineers, interviews with experts involved in the building and its installations) and if then still data is missing alternative data may be collected that the actual data needed can be derived from (e.g. the year of construction or renovation may give an indication of the U-value of a construction if there were any legal minimum requirements for that year).

Sources of information for data acquisition

In existing buildings it may be quite a job to collect all the necessary data in order to perform an
Energy Performance Assessment. The following is an overview of sources that may be consulted.

- Drawings and descriptions of building and installations, including those from renovations/refurbishments (if applicable)
- Inspection protocol.
  During the intake interview the consultant will go through the inspection protocol with the client, in order to clearly identify the sources of the requested information. Apart from the data already received beforehand, the consultant should identify any other possible sources to consult (e.g. internal or external experts). The data is discussed by category and if possible more in detail; the level of detail and the accuracy needed are addressed.
- Other sources of information: interviews, inquiries.
  It may be necessary to consult additional sources of information, other than drawings and an actual building inspection. For example, in order to assess the indoor environmental quality it may be useful to interview a facility manager or building occupants.
- Data libraries.

Special issues for data acquisition

Some special issues should be arranged before the data acquisition starts:

- Who does the data acquisition
  Particularly in large and complex buildings more than one person may be involved in this activity (e.g. one for the building constructions and one for the building installations). The consultant should inform the client who will do the data acquisition in the building at what day. Also contact persons in the client's organisation or external experts should be named, since they will have to be contacted to provide information.
- Special permission to access buildings
  It may also be necessary that the people that will perform the data acquisition will have to get special permission to access certain areas of the building that generally have restricted access.
- Confidentiality of data
  Building data may be confidential. If there is such a request from the client, then any relevant issues should be clarified and clearly stated in the agreement or contract between the involved parties.

STEP 5: Calculation and analyses

All information collected is entered into the EPA-NR software and the present Energy Performance is calculated. Then one or more scenarios for improving the energy performance are calculated.
The EPA-NR software produces the Energy Performance Certificate including the Energy Performance Indicator and label, energy savings from the evaluated scenarios, and a first cost estimate and payback period of the relevant works.

STEP 6: Reporting to client

The consultant should arrange for a meeting with the client to present the agreed deliverables (EP Certificate plus e.g. more detailed energy saving advice, management information on building stock potential) and explain how to interpret it.
…The consultant can also analyse the results from the analysis of the different scenarios that may have been performed. The consultant has the chance to point out the benefits resulting from the energy saving measures for this particular building and encourage the client to take some actions (if applicable).

References

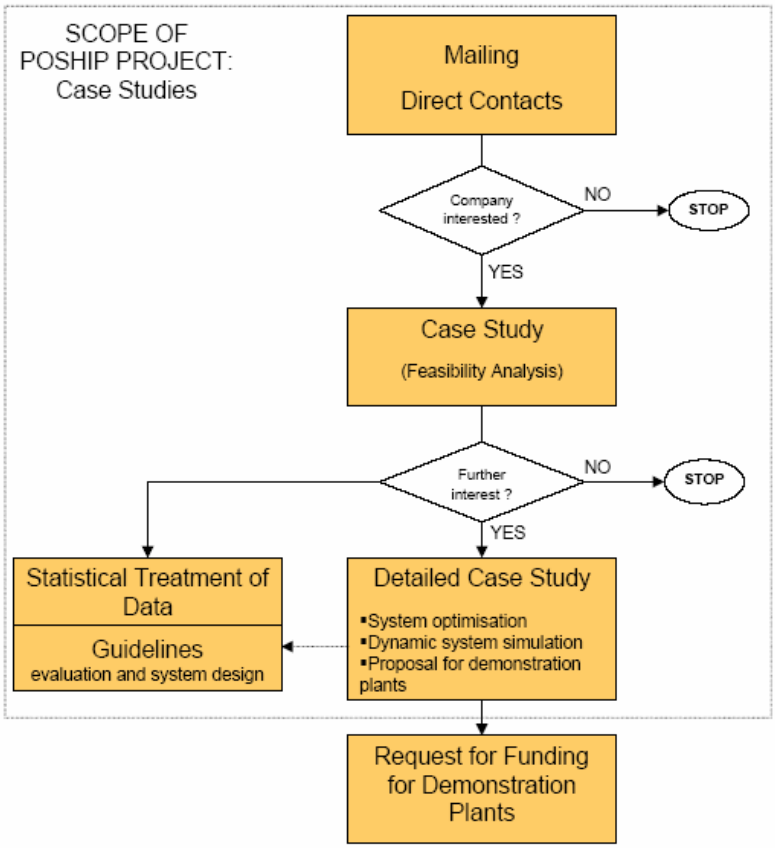
Text quoted from the original document:
Poel, B. et al. (March 2007). C*hecklist for an intake interview. Preparation for an energy performance assessment of existing non-residential buildings (EPA-NR).* Final report. EPA-NR Project (EC Contract: EIE/04/125/S07.38651).EPA-NR website: www.epa-nr.org

5.1.4 The POSHIP methodology

The basic objective of the POSHIP study was to quantify the potential of solar industrial heat at medium temperature level for the Iberian Peninsula (Spain and Portugal).
By means of questionnaires, interviews and case studies data for the heat demand of industry in these countries was acquired. Detailed case studies were carried out at two levels:

- in a first step, the main technical and non-technical factors were analysed for a quite large number of industries. The data have been statistically analysed, so that a representative overview of the technical and economical potential in different industrial sectors is obtained.
- in a second step, a detailed analysis and system optimisation was carried for a small number of projects.

In addition to the individual case studies, guidelines for the evaluation of the technical and economical feasibility of solar process heat have been elaborated.



POSHIP methodology. Source: POSHIP Final report

- **Data Acquisition - Questionnaire**

For the purpose of data acquisition, a questionnaire has been elaborated that can be used for the analysis of industrial companies (heat demand, feasibility of solar system). This questionnaire has been used both in a wide spread mailing to industry and in individual contacts and visits.

An initially elaborated long (about 10 page) version of the questionnaire has demonstrated to be too complex. Such detailed data are not available in most industries and time required for filling in the questionnaire is too long.

Therefore, for nearly all the work within POSHIP, both the **mailing and direct contacts**, a short **questionnaire of 2 pages** has been used.
Despite its size the questionnaire contains a considerable number of questions, many of which are very specific or complex (almost an energy audit) and require exhaustive information from the company concerned. In many cases the company either does not have this information or does not have time to obtain it.

- **Industry contacts**

The mailing to industry of an informative dossier, together with the (short version) of the questionnaire and a letter of presentation of the project, has been sent out. One thousand six hundred fifty two companies in Spain and Portugal have been contacted by mailing and about 30 companies by direct contacts. The total number of data sets obtained from the response to the mailing and other direct contacts is 59 only slightly more than the expected value of at least 50 responses to the mailing.

The quality of the data given in the short questionnaire varies strongly. The return of information from direct contacts was in most cases rather complete and useful. The quality of the response to mailing varied in a wide range. In most cases some additional data had to be obtained by phone, or to be estimated.

- **Case Studies**

The case studies have been carried out based on the data delivered in the questionnaire.
Some of the factories have been **visited or contacted by phone in order to obtain more detailed information than that submitted on the questionnaires.** Based on these data a feasibility study has been carried out including the following topics:

1) Analysis of the heat demand in the factory. Distribution by fuels, processes and temperature ranges.
2) Description of the proposed solar system
3) TRNSYS calculations for (a) optimised system dimensioning and (b) evaluation of system performance of the proposed system
4) Cost estimation and economical analysis
5) Proposals for complementary measures for improving energy efficiency (possibilities of heat recovery, etc.)

During the execution of the project, and in order to be able to give response to the large number of companies interested in those studies, a **standardised procedure** has been elaborated. The main features and objectives of this standard procedure are:

1) Standardised criteria for the analysis of the heat demand, system dimensioning, evaluation of system costs, etc. (comparability of the results)
2) Procedure for estimation of missing data (from the experience very few companies are able to give complete information as required in the questionnaire. Missing data have to be estimated on reasonable assumptions)
3) Software-tools for fast analysis (EXCEL-sheet for semi-automatic analysis of data delivered in the short questionnaire and standardised TRNSYS-file for dynamical system simulation).

Both for the analysis and for the dynamic simulation a **simple standard model for an industrial process has been used**, that is able to describe nearly all of the industrial processes that have been analysed.
Most processes require both heating of a fluid stream (e.g. hot air streams, hot water, renovation of water in baths, ...) and heating of some reservoir (ovens, liquid baths). The latter can be subdivided into pre-heating before the start of operation and into maintenance of temperature (compensation of thermal losses during operation).

- **Detailed Case Studies (Proposals for Demonstration Plants)**

For the companies interested in continuing after that the first numbers from the case studies have been presented to them, a detailed pre-planning of a solar system has been carried out. This includes:

- optimisation of the system: comparison of different collector types, optimisation of
- system size and storage volume
- dimensioning of all the main components of the system
- dynamical system simulations of the finally adopted system configuration
- cost estimation and economical analysis based on offers for the specific project

scheme of the solar system, plans.

The elaborated documentation is sufficiently detailed in order to be used for a request to national or European funding programs.

Reference

Text quoted from the original document:

POSHIP. The Potential of Solar Heat for Industrial Processes. Final report (Project No. NNE5-1999-0308). Aiguasol website: www.aiguasol.com/poship.htm

5.1.5 The BESS project

An energy audit quantifies trends of current energy use and equivalent greenhouse gas emissions and related costs, and makes recommendations for energy efficiency improvements. The scope of an energy audit can vary a lot and can include an entire building or plant, or energy use associated with a specific process. An energy audit provides the baseline of your organisation's current energy use.

The work undertaken during an audit may include:

- investigating the usage of all types of energy consumed and energy using equipment within the building, complex or plant;
- identifying the energy usage of all major heating and cooling applications and its percentage against total energy use;
- identifying cost-effective measures to improve the efficiency of energy use;
- estimating the potential energy savings, indicative budget costs and payback periods for each recommended action and
- reviewing energy management strategies, including monitoring systems and evaluation process.

An energy audit can be conducted by the energy manager who has been trained and has expertise in carrying out energy audits, or by hiring an energy auditing consultant.

- **Energy Audit Types**

Walk Through Audit (Overview Audit, Level 1 Audit) allows the overall energy consumption of the site to be evaluated to determine whether energy use is reasonable or excessive. It provides initial benchmarks of the site so that the effect of energy measures can be tracked and evaluated. It may be in the form of a desktop study, however the information given to, or gathered by, the auditor needs to be sufficient to enable the overall level of efficiency of the site to be determined. A Level 1 audit is expected to give an overview which provides rough orders of savings and costs. Accuracy of figures would generally be within ±40%.

Short Energy audit (Simple Audit, Level 2 Audit) identifies the sources of energy to a site, the amount of energy supplied, and what the energy is used for. It also identifies areas where savings may be made, recommends measures to be taken, and provides a statement of costs and potential savings. Short audit is an energy use survey which is expected to provide a preliminary assessment of costs and savings. Accuracy of figures would generally be within ±20%.
Comprehensive Energy Audit (Detailed Energy Audit, Level 3 Audit) A Level 3 audit provides a detailed analysis of energy usage, the savings that can be made, and the cost of achieving those savings. It may cover the whole site or may concentrate on an individual item, such as a single industrial process or one of the services. The auditor may often employ a specialist to carry out specific parts of an audit or may need to install local metering and logging.
The report from a comprehensive audit often forms the justification for substantial investment by the owner or an energy performance contractor. Detailed economic analysis with appropriate level of accuracy is required. Comprehensive audit is expected to provide a firm estimate of savings and costs. Accuracy of figures would be within +10% for costs and –10% for benefits.

As data collection tool BESS Energy Audit Data Collection sheet can be used.

- **Results of an Energy Audit**

The results of an energy audit need to be compiled into a clear and concise energy report. Some of the key elements include:

- executive summary with recommendations in a priority order, and estimates of their implementation costs and payback periods;
- relevant plant and process data;
- equipment data with measurements or estimates of the energy consumption for individual plant items;
- actual energy consumption records;
- energy use analysis in graphical form;
- details of energy efficiency improvements;
- comparison of actual consumption with analysis of estimated results from recommended actions; and
- recommendations to include energy management strategies such as monitoring systems and review process.

To make an energy audit worthwhile, the recommendations from the audit report need to be incorporated into your energy management action plan. The types of initiatives that could come from an audit report include:

- changes to operational procedures;
- review of maintenance as it affects efficient use of energy;
- modification or replacement of existing plant and/or equipment;
- further in-depth studies of potential to reduce energy use of particular plant or processes; and
- a commitment to ongoing training and information dissemination to increase awareness among staff

References

BESS project website: www.bess-project.info

5.1.6 Energy Auditing Made Simple – Indian Guidebook for Energy Audits (by P.Balasubramanian, India)

This practical guidance book is written with the idea that it should serve as a ready reckoner to all the Energy Auditors. With the passing of the Energy Conservation Act, 2001, there is a heavy demand for qualified Energy Managers and Energy Auditors. The book is user-friendly and covers all that is required to write an audit report. The standard
theories which are available in any Energy Conservation handbook are not presented here. There is no practical guide at the moment on energy audit for preparing a reasonably good report acceptable to the industry and the government. India needs many practical Energy Auditors.

- **How to do Energy Audit Using this Manual**

Follow the four steps to start audit from scratch.
1. Collect the data as per Questionnaire (given in book)
2. Write report in the format (given in book)
3. **Take only the applicable ECOs (Energy Conservation Opportunities) for the particular industry** where you are doing audit. The modification proposed, payback calculations are given for each ECO in a ready to use form.
4. All information as required by the Report Format is given in the book. Compile neatly, modify it suitably to requirement, edit it and include it in your report.If you need more information, refer to exhaustive Bibliography and URLs (Websites) given in the book. Besides 40 tips rather have been listed satirically in the first chapter viz. *"In the wonderful world of Energy Auditors"* to caution you on the path of your self-discovery in Energy Auditing.

100 ECOs

Boilers
Increase steam output through improved efficiency.
Install economizer in Boiler for preheating feed water.
Improve the efficiency of the boiler by soot blowing.
Installation of Air preheater to the boiler.
Convert the existing grate fired boiler to fluidised bed boiler
Blow down loss reduction
Usage of fuel oil additive for LSHS

Steam Systems
To provide separate line for condensate recovery.
Replace existing electrical heating system by steam heating
Improve the efficiency of steam distribution system.
Improvement of Efficiency of the turbine.

Furnaces
Fuel efficiency Improvement in furnace
Minimize the heat loss through the exhaust fans.
Replace present control panels by thyristor control panel

Insulation & Refratories
Insulate the pipe line and equipments
Replace the existing refractory with ceramic wool
To provide ceramic wool lining backed by rock wool
Insulating the uninsulated pipelines
Installation of polypropylene balls in the Electroplating baths.
Minimizing the heat loss through insulated surfaces.
Providing thermocole lid just on the surface of the hot baths
Insulate the bare steam lines for the identified areas

Co-generation
Replace the present condensing type turbine

Waste Heat Recovery
Utilise the heat generated through incineration

Thermic Fluid Heaters
To reduce excess air in the exit gas
Conversion of Electrically heated water baths
Performance improvement of thermic fluid heater
Conversion of electrical heating to thermic fluid heating
Installing a boiler working on thermic fluid heating

Cooling Towers
Replace existing metal blades by FRP blades for C.T.'s.
Installation of Energy Saver in Lighting Circuit.
Replace Electromagnetic Ballasts by Electronic Ballasts
Replace Standard Lamps by Compact Fluorescent Lamps
Provide Day Light Switches to control lamps
Replace Slim Tube Fluorescent Lamps by Philips Trulite
Conversion to High pressure sodium vapour lamp.

Compressed Air System
Reduce the temperature inside the compressor house
Install Refrigeration dryers in Compressed Air System
Saving by arresting Leakages
Avoid use of compressed air for purposes
Replace single stage compressor by double stage compressor

HVAC & Refrigeration
Replace the existing A/c units with VAM
Utilise the waste heat for VAM
Replace the window air conditioners by FCU's
Provide ventilation by roof extractors
Install Mega saver units for air conditioning system.

Pumps
Optimization of Chilling Plant circulating pump operation

Fans and Blowers
Replacement of Inefficient fans
Performance testing of fans
Interconnection of Blowers in the plant
Replacement of ineffcient blower

Cement Industry
Saving by Reducing air flow in Kiln
Saving by Reducing air flow in discharge circuit
Speed reduction in Bag Filter fans.
To reduce the pressure drop the Preheater
Arresting Air ingress by installing a Nose Ring Seal.
Conversion of Worm gear drives to Helical gear drives
Conversion from Pneumatic Conveyor
Elimination of Coal mill Booster fan

Textile Industry
Replace Aluminium Blade by FRP blades for Humidification.
To provide False Ceiling for all the sections of the plant
Installation of Solid State Controller for Ring Frames.
Use plastic type Aerofoil Louvers
Changeover from Spray to Cell type air washer.
Reduce the Spindle Wharves Diameter in Ring Frame.
Use Synthetic spindle oil for all Ring Frames.
Use vacuum cleaner and eliminate use of compressed air

Energy Monitoring and Targetting
To provide steam flow meter in steam distribution system
To install electrical meters in different sections
To install central monitoring system

Enery Conservation Implementation Programme
To create awareness & Train the manpower.
Install automatic temperature controller in the cooling tower systen
Centralisation of utilities
Saving by water quality management

Electrical Systems
Install harmonic filters and suppress waveform distortion
Install high-tension voltage stabilizer
Reallocate the loading pattern of transformers
Operate the two transformers in parallell

5.1.7 UNEP EE CP methodology

Assessment, involving analysis of the material and energy flows entering and leaving a process, is a central element of CP. Conducting a CP style assessment relies on a logical and methodical approach that makes it possible to identify opportunities for CP, to solve waste and emission problems at source, and to ensure continuity of CP activities in a company. This analytical assessment approach is embedded in the CP methodology, shown in Figure 1.1.
The basic CP methodology consists of the following principal elements:

- Planning and Organization
- Pre-assessment
- Assessment
- Feasibility Analysis
- Implementation and Continuation.

Figure 1.1 CP methodology

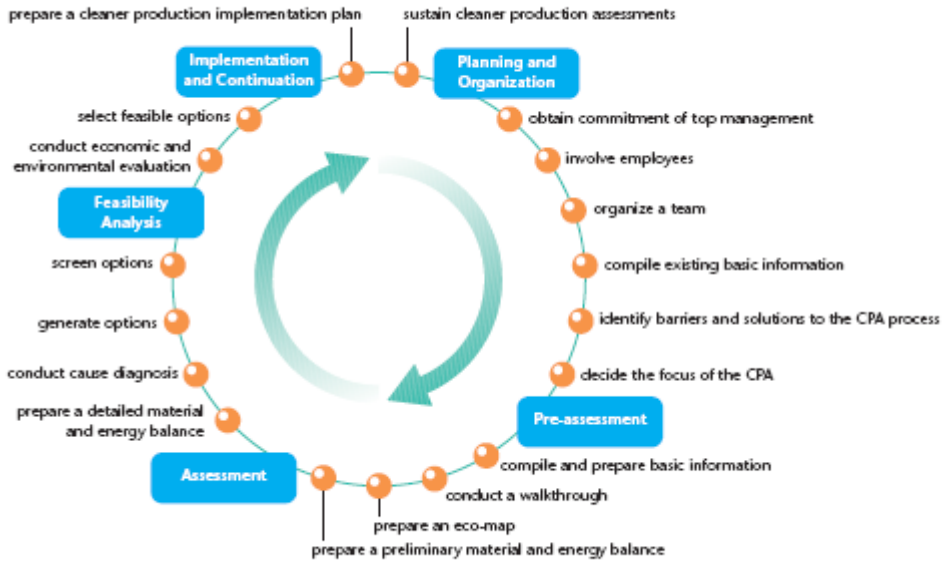
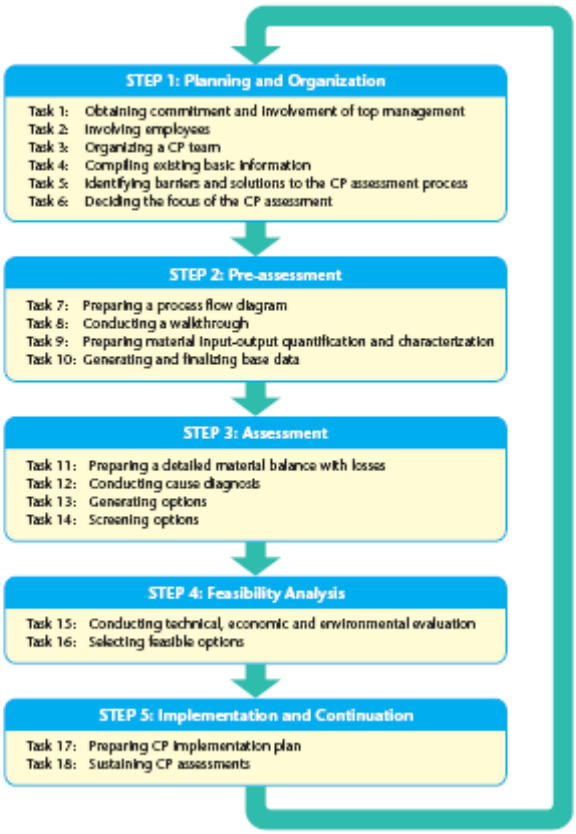


Figure 1.1 shows the generic CP methodology. A typical empirical CP methodology is presented in Figure 1.2. This is used later (in Section 2.5) to develop a CP-EE assessment methodology that adheres strictly to the steps presented here but also includes specific features that need to be covered to integrate energy efficiency aspects.

Figure 1.2 Steps of the CP methodology



Assessment

Assessment comprises four critical tasks constituting the CP-EE assessment process.
Much of the entire CP-EE process depends on these four tasks:

- Preparing a detailed material and energy balance including losses
- Cause diagnosis
- Generating options
- Screening options

Feasibility Analysis

- Technical, economic and environmental evaluation
- Selecting feasible options

Technical, economic and environmental evaluation

Technical evaluation

Technical evaluation should cover the following aspects:

- *Consumption of materials and energy:* it is important to establish M&E balances for each option before and after implementation conditions, in order to quantify the materials and energy savings that would result.
- *Product/by-product quality:* quality of the product should be assessed before and after implementation of the option.
- *Right First Time (RFT):* estimate must be made of the possible improvement in RFT that would result from implementation of the option.

Environmental evaluation

The environmental evaluation should include estimates of the following
benefits that each option may bring about (where relevant):

- Likely reduction in the quantity of waste or emissions generated (expressed
- as mass).
- Likely reduction in GHG emissions.
- Likely reduction in the release of hazardous, toxic, or non-biodegradable
- wastes or emissions (expressed as mass).
- Likely reduction in consumption of non-renewable natural resources, e.g.
- fossil fuels consumed (expressed as mass).
- Likely reduction in noise levels.
- Likely reduction in odour nuisance (by elimination of a substance causing
- odour).
- Likely reduction in on-site risk levels (from the point of view of process
- safety).
- Likely reduction in release of globally important pollutants, e.g. ozonedepleting
- substances, persistent pollutants, etc.

Completed Worksheet 15a: Technical feasibility analysis

Option ref. no.	Technical requirement					Impact (+/0/-)				
	Equipment requirement	Instrument or accessories	Manpower	Space availability	Technology availability	Production rate	Production quality	Operation flexibility	Maintenance	Safety
1	Floor to be made	-	-	-	-	0	0	+	+	+
5	Water efficient nozzles	-	-	-	Yes	0	+	+	-	+
8	Variable speed drive	-	-	Yes	Yes	0	+	+	-	+
9	Damper	-	-	Yes	Yes	0	+	+	-	+
10	O_2 sensor	Electrical fittings	-	Yes	Yes	+	+	+	0	+
11	Economizer	-	-	Yes	Yes	+	+	+	-	+
12	Air preheater	-	-	Yes	Yes	+	+	+	-	+
15	FBC boiler	Water treatment facility	-	Yes	Yes	+	+	0	-	+
17	Modification of existing grate	-	-			+	+	0	0	+
19	Reverse osmosis plant	-	-	Yes	Yes	0	+	0	+	+
20	Change of water from tankers to municipal supply	-	-			0	+	+	+	+
23	Recover condensate	Piping work	-			+	0	+	-	0
26	Thermodynamic steam traps	-	-	Yes	Yes	+	+	0	-	+

Completed Worksheet 15b: Environmental aspect analysis

Option ref. no.	Impact (+/0/-)							
	Air			Water			Solid waste	Overall impact*
	gaseous emission including GHG	particulates	others	organics (COD)	Total solids	others		
1	-	-	-	-	-	-	Resource conserved	L
5	-	Reduced	-	-	-	Water conserved	-	L
8	Reduced	-	-	-	-	-	-	L
9	Reduced	-	-	-	-	-	-	L
10	Reduced	Reduced	-	-	-	-	-	M
11	Reduced	Reduced	-	-	-	-	-	M
12	Reduced	Reduced	-	-	-	-	-	M
15	Reduced	Reduced	-	-	-	-	-	H
17	Reduced	-	-	-	-	-	Reduced	L
19	Reduced	-	-	-	-	-	-	M
20	Reduced	-	-	-	-	-	-	M
23	Reduced	Reduced	-	-	-	Water conserved	Reduced	H
26	Reduced	-	-	-	-	Water conserved	-	L

* H = heavy, M = medium, L = light, N = negligible

Economical evaluation

The team must evaluate the economic benefits of all reductions in waste generated and in consumption of resources that would be brought about by each option (see Completed Worksheet 15c). It must estimate the immediately obvious savings in purchase of materials and fuels, the

costs of treatment and disposal avoided, and material and waste stream costs (identified in M&E balance).
However, the team must also estimate less obvious financial benefits such as reduced sick days for workers or generally higher worker productivity; lower personnel costs from reducing the burden of special management and reporting of hazardous materials, wastes and pollution; reduced worker and environmental liability; and potential profits from sale of waste as a by-product or from carbon credits; etc.
Experience has shown that expanding financial assessments to the less obvious benefits often helps considerably by throwing additional light on the economic feasibility of an option. The team must also estimate the economic costs of each option, in terms of investments in new technology or equipment as well as in terms of training and other costs associated with implementation.
Benefits and costs are then analysed and calculated using various evaluation criteria (e.g. **pay back period**, **Net Present Value (NPV)** or **Internal Rate of Return (IRR)**, etc.).

Selecting feasible options

In most cases, the feasibility analyses will indicate that different options have differing levels of technical feasibility, economic viability, and environmental performance. Since it may well not be possible to implement all options at the same time, the team will have to prioritize the options. A common evaluation framework will be necessary to assist with prioritization. A weighted-sum method could be considered for this purpose (see Completed Worksheet 16).
Using this method, the team assigns a weight to each of the three aspects of the feasibility analysis (technical feasibility, economical viability and environmental performance). Weighting could be decided in a brainstorming session involving top management. The weights will vary from company to company depending on technical competence, financial conditions, environmental sensitivity, etc. For example, a financially healthy, small company facing considerable environmental pressures may decide to give the greatest weight to environmental performance (say 50 per cent), less to technical feasibility (say 30
per cent) and least to financial viability (the remaining 20 per cent). This indicates that the company is most keen to reduce the pollution load but does not have high levels of capability to undertake technically complex options. Once weights are assigned, simple indicators such as ‘scores’ can be developed to assess the relative performance of each option. For example, economic viability could be assessed based on payback period, NPV or IRR. Environmental performance could be assessed based on a percentage reduction in pollution load. Technical feasibility could be assessed based on technical complexity, new equipment or technology required, or additional technical skills needed, etc. Each option is then evaluated subjectively and scores are assigned for each of the three aspects. Scores could range from 0 to 10, with the lower score implying poor performance. For example, if two options have IRRs of 15 per cent and 33 per cent respectively, they could be assigned scores of 8 and 5 for this aspect of economic viability.

Completed Worksheet 16: Selection of CP-EE measures for implementation

Option ref. no.	Options	Technical feasibility	Environmental impact	Economic feasibility	Total	Rank
Weight (%)		30	25	45	10	
1	Storing of coal on a concrete/ brick lined, level floor	7	5	5	5.6	3
5	Optimize the use of water by installing efficient showers / sprinklers/spray/nozzles	5	7	5	5.5	4
8	Installation of variable speed drives in ID and FD fan motors	7	2	6	5.3	5
9	Installation of damper to control air flow	7	4	6	5.8	2
10	Install on-line O_2 measuring sensor	3	5	5	4.4	7
11	Install economizer for waste heat recovery	3	3	4	3.45	10
12	Install air preheater for recovery of waste heat	2	3	4	3.15	11
15	Replace existing boiler with FBC boiler	2	5	2	2.75	12
17	Modify the existing grate by reducing the gaps between the rods	6	5	5	4.25	8
19	Install water treatment (RO) plant	2	3	3	2.7	13
20	Change the water used in the boiler from tanker water to municipal supply water	8	8	9	8.45	1
23	Re-circulate condensate from steam separator wherever possible	5	4	6	5.2	6
26	Installation of steam taps (TD traps) of rated capacity to be provided in the steam main pipe within a gap of 25 m	3	3	5	3.9	9

5.1.8 EMAS Guidebook

Environmental Audit (EMAS Regulation Art. 3d)

An environmental audit is a method used to find out if the established policy, objectives, environmental programme and organisation are working as intended. The primary intentions of both energy and environmental management are tested; are lasting improvements achieved in the most expedient fashion? The results of the audit are used to develop corrective measures, policy adjustment, objectives and a new programme.
In the EMAS Regulation article 2, "environmental audit" is defined as follows:
"a management tool comprising a systematic, documented, periodic and objective evaluation of the performance of the organisation, management system and processes designed to protect the environment with the aim of:
I) *facilitating management control of practices which may have impact on the environment*
II) *assessing compliance with company environmental policies"*
Further, Article 3d states:
"to carry out or cause to be carried out, in accordance with Article 4, environmental audits at the sites concerned;"
In article 4 item 1 "Auditing and validation" it is stated that:
"The internal environmental audit of a site may be conducted by either auditors belonging to the company or external persons..."
Energy factors to be evaluated are, as mentioned above, discussed in annex 1, part C:
In Annex 1B item 6, audits are addressed as follows:
"…Management, implementation and review of a systematic and periodical programme concerning:
a) whether or not environmental management activities conform to the environmental programme and are implemented effectively.
b) the effectiveness of the environmental management system in fulfilling the company's environmental policy..."
Audits occur with a frequency varying from one to three years, depending on whether the company's impact on the environment is large or small.

Implementation of an Environmental Audit
Energy management, energy economising and choice of energy in particular are to be evaluated during an environmental audit, according to the requirements of EMAS. The audit shall test whether the existing policy and objectives lead to:
· lasting improvements
· effective energy management
· energy economising
· choice of energy
EMAS also stipulates that there shall be:
· a periodic internal audit, carried out by the company's own staff of hired consultants. Companies which have quality systems will often put this together with the management review as described in ISO 9000. Annual internal audits are otherwise the recommended minimum.
· a periodic external control/audit. The interval varies from one to three years, dependant upon the company's complexity and impact on the environment. This is determined by an external auditor.
An audit is always concluded with a written report which is to provide the basis for further work.

References:
Text quoted from the original document:
EMAS Guidebook – Integrating Energy- and Environmental Management.
Developed with support from the Norwegian Pollution Control Authority (SFT) and the SAVE-programme Prepared by Oestfold Research Foundation and Institute for Energy Technology

5.1.9 The Styrian Promise Audit methodology

The reduction of CO_2 emissions in industry companies is achieved via two approaches, which complement each other. **Technology-optimization** of energy conversion processes and production-processes can decrease the specific energy demands of certain processes. Especially the development of new technologies that allow certain processes to operate at lower temperature levels (e.g. reduction of bath temperatures in pickling plants), opens up new fields of application for renewable energies, such as solar heat.
The second approach is a **system-optimization** to that effect that available waste-heat is efficiently (in terms of energy and economy) reused by heat-integration. In the framework of the project "Styrian Promise", a method called "Pinch Analysis" is used to design a heat-exchanger network for the whole company and to identify the biggest possible degree of heat-recovery. Based on this information, an **optimized energy-consumption profile** of the company can be developed, which is **then used to plan the practical utilization of renewable energies**, especially solar process-heat, for the production.

Excerpt of the detailed description of the methodology (translated):
Prior to the design of renewable heat supply systems (e.g. solar process heat) all other possibilities for internal energy efficiency measure should be taken, that are energetically, economically and practically feasible.

Following Steps have been taken in the analyses for ideal integration of renewable energy systems (focus on solar thermal plants) in industries:

- Systematic data acquisition of energy flows (via company visits, measurements, detailed calculations)
- Energy balance of the production process
- Measure for improving energy efficiency (new efficient technologies, minimisation of heat losses)
- Calculation of the minimal heating/cooling demand (pinch analysis)
- Design of heat recovery networks (pinch tool)
- Identification of the heat demand that can be sensibly covered by solar thermal or other renewable energy sources and design of the energy supply equipment (a.o. T-Sol software)
- Economic analyses

References:
Brunner C. et al. (2007): Styrian Promise, final report. Not yet officially published.

5.1.10 Poland-Japan Energy Conservation Technology Centre Project KAPE S.A

The procedure for the energy audits used by the experts of the Poland-Japan Energy Conservation Technology Centre Project KAPE S.A. for the purpose of auditing:

- compressed air-installations;
- boilers;
- hot water or steam generators including distribution systems.

Auditing steps:

- preliminary visit prior the audit in order to learn the specification of the installation (see the sight and verify the possibility of using measuring devices, short interview with the engineers);
- preaudit questionnaire given during the onsite visit – to be filled out before the audit itself;
- the 1-2 day (depending on the size of the company) quick audit.

Regarding the audit itself the procedure gives the following information:

- a list of measuring devices used for auditing;
- requirements regarding collecting information on the installation and schemes;
- requirements regarding data registration;
- inspection of the installation (eg. for the pressure drops, and possible leaks);
- requirements regarding scope of the data evaluation (short characteristics of the system, description of the installed devices and means of control, potential energy savings according to energy rates given by the company)
- report.

Contents of the report from the energy audit:

- Outline of the factory: name, location, number of employees, contents of business;
- Outline of the energy audit (person in charge, date, request items on energy audit);
- Energy audit results:
  1. Improvement proposal items and the expected effect after measure implementation;
  2. The amount of the annual energy consumption, the energy cost ratio and energy intensity of the whole factory,
  3. Remarks regarding plant operation hours/days, energy prices;

The report also contains a finding list with detailed explanation of the suggested improvements and their expected effects.

5.1.11 Energy Self-Audit Scheme Project

This material delivers guidelines for the energy management in industry basing on the outcomes of the Energy Self-Audit Scheme Project. The aim of the handbook is to encourage actions towards energy efficiency. It delivers the know how to the company's that have no sufficient funds to have energy audits performed by the external auditors.

In general the procedure of self-audits described there consist of the following steps:

1. Continuous collection of data on energy consumption;
2. Analysis of the recorded data;
3. Verification of exploitation schemes in search of misuse and energy waste;
4. Analysis of possible solutions including:
    a. Technical aspects;
    b. Economic efficiency;
5. Elaboration of periodic reports on company's energy management ;
6. Suggestions of rational energy consumption measures.
7. Informing of possible improvements.

5.1.12 Carbon Trust energy audits – U.K.

According with the UK Energy Efficiency Action Plan 2007, for the non-household sector, the EU Emissions Trading Scheme will continue to be at the heart of the efforts to drive energy efficiency which combined with the Climate Change Levy and Climate Change Agreements framework, provide strong incentives for energy intensive industrial sectors to reduce emissions. Similar incentives will be provided for the large non-energy intensive sector by the new Carbon Reduction Commitment cap and trade scheme.

At the present, Carbon Trust provides energy audits (the majority of which are free) to the Industrial, Commercial and Public Sectors. All companies with an energy bill >£50,000 are eligible for a free energy survey. Depending on a particular site's experience with energy management and the adoption of energy efficiency measures, the site is offered one of a range of audit products. These products include:

- Opportunities Assessments
- Multiple Site Assessments
- CHP Advice
- Detailed Surveys
- Design Advice.

It should be noted that Detailed Surveys are not entirely free, as the recipient is expected to part fund this survey.
For smaller industrial and commercial sites, with energy bills <£50,000, where the transaction costs of an on site survey would be too large, an on-line Action Plan Tool is available. When using this tool sites are canvassed on their Industrial Sector, size and level of energy efficiency experience and are returned energy saving tips tailored to their profile. These recommendations can only be of a generic nature and so raises the question of whether this service could be regarded as an 'audit', as defined in the Directive.
It is unclear at the moment how well SMEs are covered by the site audits from the Carbon Trust. It may be that a significant number of SMEs have energy bills <£50,000. If this is the case, and if the Action Plan Tool offered by the Carbon Trust cannot be regarded as an audit, then a significant number of SMEs would not be provided for by audits.
Online surveys or telephone advice to business customers is available from all of the main suppliers of electricity and gas. However, until now only one supplier offers audits to business customers independent of the Carbon Trust. This supplier is n-power.

5.1.13 Energy Management Act and Support Programmes – Czech Republic

In 2006, the Czech government amended the Energy Management Act/Energy Economy Act (Act on Energy Management of the Czech Republic No. 406/2000), Chapters III and IV of which pertain to energy efficiency. The Energy Management Act aims to increase energy efficiency during distribution and transfer, energy consumption and gas storage together with related activity.

Law prescribes obligations of individual and legal entities during handling energy, i.e. performing energy audits, obeying rules for creation of State Energy Conception, town planning energy schemes and National Programme for Economical Energy Management and Use of Renewable and Secondary Energy Sources.

In April 2007, the Czech Government approved the latest amendment of the Act on Energy Management with implemented Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of eco-design requirements for energy-using appliances and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council. As of June 2007, these amendments were currently in the Parliamentary approval process.

The State Programme to Support Energy Savings and Use of Renewable Energy and Secondary Sources revolves around a strategic action document revised each year and implemented by a total of 15 sectors. The programme targets enterprises (legal entities and individuals); non-profit organisations; universities - as established under Act No.111/1998 Coll; and towns, municipalities and regions.

Targets of the State Programme include the implementation of savings measures in the area of generation, transmission, distribution and consumption of energy; and higher use of renewable and secondary sources of energy and the development of cogeneration of heat, cooling and electricity.

Some of the support activities include:

- Support for energy planning and certification of buildings: territorial energy planning; action plans for reconstruction or refurbishment of building resources; plans for energy saving in industrial enterprises; plans for construction of centres for use of municipal waste for energy purposes; certificates of energy intensity of buildings.
- Support for Measures aimed at increasing the efficiency of energy use: decreased energy intensity of industrial plant; comprehensive measures aimed at decreasing the energy intensity of buildings used in education, health services and public utilities; comprehensive measures aimed at decreasing the energy intensity of housing; low energy and passive solar housing; comprehensive measures aimed at decreasing the energy intensity in lighting; projects financed through energy savings.
- Consultancy, education, promotion and awareness with respect to the economical use of energy, having impact on the safeguarding of the environment: consultancy; regional energy agencies; education and promotion; preparation of products in support of consultancy, education and promotion.

5.1.14 Management Regulations for Energy Consumption (RGCE) – Portugal

Management Regulations for Energy Consumption (RGCE) were established under Decree-Law No. 58/82 of 26 February 1982 and regulated under the Ministerial Order No. 359/82 of 7 April 1982. The primary objective of these regulations is to install in energy-intensive companies the concept of energy as a cost factor. The regulations establish goals for companies to reduce progressively their specific energy consumption. In addition, the regulations require companies to audit their energy use twice a decade, to prepare and carry out annual plans for rationalizing their energy consumption and to achieve the energy savings. All energy consuming facilities meeting one or more of the following conditions are covered:

- Energy consumption of more than 1 000 toe in the previous 12 months.
- Equipment with total nominal power rating of more than 0.3 toe per hour.
- Any one item of equipment with nominal energy consumption of more than 0.3 toe per hour.

The objective was to reduce the specific consumption of energy by at least 5% over the five-year period.

By the end of 2000, 549 installations (whose annual consumption represented about 4 million tep) had performed energy audits and drawn up plans for energy efficiency which were then submitted to the Directorate General for Energy (DGE). The consumption of these installations represents more than 50% of the total energy consumption in the industrial sector. The main industrial sub-sectors covered by the RGCE regulation are Food and Drinks, Textiles, Wood and Cork, Pulp and Paper, Chemistry and Cement, Ceramics and Glass.

According with the RGCE an energy audit should approach the following items:

- Determine the forms of energy use
- Examine the way how the energy is used and the correspondent costs
- Establish the structure of Energy Use
- Determine the energy consumption by process, operation or equipment
- Relate the energy consumption with Industry production rate
- Identify energy efficient improvement possibilities
- Technical/Economical analyses of the improvement opportunities identified
- Establish energy consumption goals, without interference in the Industry process
- Propose necessary energy efficient Investment/Actions
- Propose an Energy management plan

5.1.15 Federal Support for Industrial Process Efficiency: Save Energy Now Campaign – United States

As a key element of Save Energy Now, DOE conducts plant energy assessments to help manufacturing facilities across the nation identify immediate opportunities to save energy and money, primarily by focusing on energy-intensive systems, including process heating, steam, pumps, fans, and compressed air.

Many companies have already benefited from assessments provided by Energy Experts. In the first months of 2006 there were audited 200 large industrial facilities' energy systems. As an example of completed assessments' initial savings, eight plants have reported a total of $1 million in immediate savings in the first 30 days of implementing DOE recommendations. The first 61 energy-saving assessments of industrial facilities have identified, in aggregate, nearly $200 million per year in potential energy cost savings and could reduce natural gas consumption by over 22 trillion Btu per year, equivalent to the natural gas consumed by more than 300,000 homes annually.

Approximately 3,500 plants were contacted based on publicly available data that DOE used to identify the most energy-intensive plants in the United States.

The U.S. Department of Energy (DOE) also has distributed Save Energy Now CD-ROMs (http://www1.eere.energy.gov/industry/saveenergynow/) containing energy-saving information and software to 3,500 large industrial plant managers across the nation as part of a DOE initiative to reduce excessive energy use at US industrial facilities.

The CDs bring together – in a single product – a compendium of tip sheets, case studies, technical manuals and software tools to help plants assess energy-saving opportunities.

DOE offered another round of Energy Saving Assessments for industrial facilities during the fall of 2006. Energy Saving Teams visited selected large industrial facilities to assess their steam or process heating systems.

5.1.16 New Guidelines for Energy Management in Industry – Japan

In 2000, the Japanese government formulated new inspection guidelines for improving energy efficiency at first-class, designated industries, which together consume 70% of the total amount of energy used by the industrial sector. The new guidelines specify that the each principle equipment in factories should be checked and compiled in energy management manuals. Also, measurements should be taken and recorded; maintenance and inspections should be carried out to evaluate such check items. These specific checks constitute the core requirements to be met by the factories under the Energy Conservation Law. As for evaluation, survey forms sent in advance to factories are completed by them, and then METI (http://www.meti.go.jp/english/index.html) and the Energy Conservation Center carry out an on-site survey at each factory and cross-check the evaluations. If the evaluation shows results are below a certain level, an on-the-spot inspection is carried out, and if the situation is not satisfactory, the factory will be instructed to draw up a rationalization plan in accordance with the article 12 of the law. The on-site surveys based on the new guidelines start in April 2001. All designated energy management factories are to be checked within about five years.

5.1.17 Energy Audit Scheme for Large Consumers of Energy in Singapore

The Energy Audit Scheme is implemented by the National Environment Agency (NEA) in partnership with major industrial consumers under the initiative of the National Climate Change Committee (NCCC).

The Scheme is voluntary, designed to provide an impetus for industries to improve the energy efficiency of their operations. Its objective is to encourage industries that use large amount of oil and gas to put in place a formal system for the management of energy use, to improve their energy efficiency.

Under the Scheme, companies can either use in-house staff or engage external energy audit specialists in carrying out their energy audits. Such audits, which are carried out every 3-5 years, would help industries to systematically identify opportunities for improving energy efficiency regularly. The companies could then take measures to improve the energy efficiency of their facilities.

The potential benefit of the Energy Audit Scheme is substantial; as it could result in potential cost savings that in turn help to improve the companies' competitiveness.

All industrial facilities can participate, especially those whose operations are energy intensive, are urged to participate in the Energy Audit Scheme.

5.1.18 State Utility Offers Energy Audits to Reduce Peak Load – South Africa

In 2006, the South African utility Eskom has launched a national Demand-Side Management (DSM) initiative to audit energy use in the industrial, commercial and residential sectors. The DSM audits support Eskom's (www.eskom.co.za) long-term strategy to reduce South Africa's electricity demand during peak periods.

The South African energy market has had limited experience with regards to M&V prior to 2000. The focus was consequently placed on international measurement and verification protocols in order to gain an understanding of M&V and its requirements.

These protocols were the International Performance Measurement and Verification Protocol (IPMVP), as well as the M&V Guidelines for Federal Energy Management Projects (FEMP). These protocols have been in use internationally for a number of years and have proved to be a valuable source of information on the requirements of M&V. These protocols were adjusted and in some cases expanded for the South African situation. The M&V process was streamlined and structured in a more focused manner for each type of project since the inception of the DSM initiative with the help of valuable experience gained from the actual DSM projects. Substantial work and research has also been conducted by the South African M&V teams on the development of M&V methodologies and baseline development, which is a critical component of the quantification of the project impacts