# IEC TR 63388

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# TECHNICAL REPORT

colour inside

## Report on the development of cogeneration



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## Report on the development of cogeneration



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CONTENTS

FOREWORD 4
1 Background 6
1.1 Task following SMB decision 6
1.2 Scope 7
1.3 Purpose 8
2 Terms, definitions and abbreviated terms 8
2.1 Terms and definitions 8
2.2 Abbreviated terms 10
3 Overview of CHP 10
3.1 What is CHP? 10
3.2 Benefits of CHP 12
3.3 Efficiency of CHP system 13
4 Market situation of cogeneration 14
4.1 Global situation 14
4.2 European situation 14
4.3 American situation 15
4.4 Asian situation 15
4.5 Summary 17
5 CHP based on steam turbine 17
5.1 General introduction 17
5.2 Technical characteristics 18
5.2.1 CHP based on extraction turbine 18
5.2.2 CHP based on back pressure turbine 18
5.2.3 Low-vacuum heating mode 19
5.2.4 LP cylinder steam bypassed heating mode 20
5.2.5 CHP based on steam turbine with synchro-self-shift clutch 21
5.2.6 Special case: gas-steam combined cycle CHP 22
5.3 Components 23
5.4 Requirements 24
5.5 Summary 26
6 CHP based on other processes 26
6.1 General 26
6.2 Technical characteristics 27
6.2.1 Gas turbine CHP 27
6.2.2 Stirling engine CHP 28
6.2.3 Fuel cell CHP 29
6.2.4 ORC CHP 30
6.3 Components 31
6.4 Requirements 32
6.5 Summary 33
7 Standardization demand of CHP 33
7.1 Necessity to develop CHP technical standards 33
7.2 Current status of ISO/IEC standards related to CHP 34
7.2.1 General 34
7.2.2 CHP system level 35
7.2.3 CHP communication level 35

7.2.4 CHP component level ....................35
7.3 Summary ....................40
8 CHP standardization roadmap ....................40
8.1 Envisaged CHP standard architecture ....................40
8.2 Description of the standard architecture ....................41
8.3 Developing the path of future standards ....................42
8.3.1 Develop path– Start from system to component level ....................42
8.3.2 Work of joint working group ....................43
8.4 Developing committee recommendations ....................43
8.5 Summary ....................43

Figure 1 –CHP based on steam turbine ....................11
Figure 2 – CHP based on combustion turbine or reciprocating engine ....................11
Figure 3 – Example of energy efficiency for different generating systems ....................12
Figure 4 – Proportion of different heating modes in urban areas of northern China ....................16
Figure 5 – Cogeneration status in Japan by fuel types ....................17
Figure 6 – Heating system based on extraction steam turbine ....................18
Figure 7 – Back pressure turbine heating system ....................19
Figure 8 – Typical diagram of a low-vacuum heating system ....................20
Figure 9 –Schematic of LP cylinder steam bypass heating technology ....................21
Figure 10 – Heating turbine with synchro-self-shift clutch ....................22
Figure 11 – Schematic diagram of combined cycle unit cogeneration ....................23
Figure 12 – Typical work flow of CHP system based on steam turbine ....................23
Figure 13 – Energy efficiency comparison between small-scale CHP system and traditional energy services ....................27
Figure 14 – CHP system based on micro gas turbine ....................28
Figure 15 –CHP system based on STIG ....................28
Figure 16 – Typical Stirling engine CHP unit process ....................29
Figure 17 – Fuel cell CHP system ....................30
Figure 18 – ORC CHP system ....................31
Figure 19 – Link between CHP system and user demands ....................34

Table 1 – Installed capacity of cogeneration units in Japan as of March 2020 ....................16
Table 2 – Status of CHP standards ....................36
Table 3 – CHP standard architecture ....................41

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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# REPORT ON THE DEVELOPMENT OF COGENERATION

## FOREWORD

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IEC TR 63388 has been prepared by IEC technical committee 5: Steam turbines. It is a Technical Report.

The text of this Technical Report is based on the following documents:

| Draft | Report on voting |
|---|---|
| 5/243/DTR | 5/244/RVDTR |

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
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# REPORT ON THE DEVELOPMENT OF COGENERATION

## 1 Background

### 1.1 Task following SMB decision

Following the Standards Management Board (SMB) decision 141/10, IEC Technical Committee 5 (Steam Turbine) was tasked to lead a joint working group with related IEC and ISO committees to explore potential standardization opportunities.

SMB decision 141/10reads as follows:

| |
|---|
| SMB decision 141/10 – SMB AhG 30: Co-generation – IEC involvement in joint work with ISO<br><br>The SMB, further to having taken decisions confirming IEC's commitment to providing support to the areas of cogeneration technology within its area of competence in particular aspects related to electrical power generation, decided to instruct IEC TC 5 to be the primary point of contact, to follow this activity in coordination with TC 45 and TC 105.<br><br>The SMB requests AhG 30 to submit a final report and recommendations on future work and any future activities by end July 2011, and decided to disband the SMB AhG 30 after submission of the report.<br><br>Based on the AhG recommendations, SMB will then communicate an IEC perspective on this matter to ISO. |



With the above SMB decision, IEC Technical Committee 5 established Joint Working Group 16 (Cogeneration Combined Heat and Power (CHP)) in 2012-09.

After IEC/TC5/JWG16 was established, working steps were proposed (see 5/168/AC) as follows:

| No. | Working step | Remarks |
|---|---|---|
| 1 | Complete an overview on standards related to CHP technology. | Also include standards if they only partly cover CHP aspects |
| 2 | Clarification of status and application experience of Manual CWA 45547 | Efficiency of CHP solutions is in focus for all applications. The Manual CWA 45547 from 2004 could be a basis for an IEC standardization project. There might be valuable feedback available from application of the Manual. |
| 3 | Screening of world-wide applied alternative methods for determination of CHP efficiency | |
| 4 | Clarification of the need for standards dealing with aspects different to efficiency such as safety, performance and installation. A differentiation between residential / commercial mass products and power plants should be considered. It should be identified where the current standardisation activities are going on in ISO or IEC and where the need for new coordination between IEC / ISO TCs is suggested. | Consider the different needs for the residential, commercial and industrial needs including the different power sizes. EN 50465:2008 GAS APPLIANCES – COMBINED HEAT AND POWER APPLIANCE OF NOMINAL HEAT INPUT INFERIOR OR EQUAL TO 70 KW? IEC62282 Fuel Cell Technologies Germany: FW308 July 2011<br><br>Status per 03-2012: The common aspects of safety related control are already covered by other IEC and ISO standards on Functional Safety. No additional aspects for standardization with respect to CHP identified. The common aspects of application of gas and oil valves are covered by other IEC and ISO standards. No additional aspects for standardization with respect to CHP identified. |
| 5 | Clarification if there is any other product/solution specific standardization need in the area of CHP | Possible aspects are also grid parallel operation of the CHP. |
| 6 | Update necessary liaisons with other TCs within IEC or ISO | IEC TC45 Nuclear instrumentation? IEC TC105 Fuel cell technologies? ISO TC192 Gas Turbines? ISO TC208 Thermal turbines for industrial application (steam turbines, gas expansion turbines)? Other TCs? |
| 7 | Prepare Proposal of standardization Work Item (PWI) for voting in TC5 and relevant other TCs | Proposal might include the target to align the context of the new IEC standard in a way that it later – as an EN IEC standard – can be harmonized with the EC Directive 2004/08 (Combined Heat and Power (CHP) Directive). |
| 8 | Clarification of which other IEC or ISO standards have to be adapted, when new IEC standard in CHP efficiency becomes valid. Preparation of requests to other TCs for adaptation/update of other standards. | Chapters on CHP efficiency in other standards for individual applications should be replaced by a reference on the new IEC standard.<br><br>In C-type standards describing the efficiency of a certain technology relevant to CHP a reference on the new IEC standard on CHP efficiency should be included. |
| 9 | Clarification with CEN/CENELEC on withdrawal of Manual CWA 45547 | |



This technical report is intended to address the above items 1, 3, 4, 5, 7, and 8.

Other items will be addressed depending on the outcome of this report.

## 1.2 Scope

This document, which is a technical report, introduces the widely used technical scheme of cogeneration (also known as combined heat and power (CHP)), and gives the corresponding cases. The technical schemes of cogeneration covered in this technical report can be divided into two categories. One is cogeneration based on steam turbine, which is generally applied in thermal power plants; The other is cogeneration based on other prime movers, such as fuel cell, micro gas turbine, internal combustion engine, Stirling engine, ORC, etc.

This document gives some cases of cogeneration, mainly including:

- CHP based on extraction turbine;
- CHP based on back pressure turbine;
- Low-vacuum heating mode;
- LP cylinder steam bypassed heating mode;
- CHP based on steam turbine with synchro-self-shift clutches;
- Gas-steam combined cycle CHP;
- Micro gas turbine CHP;
- Stirling engine CHP;
- Fuel cell CHP; and
- ORC CHP.

The characteristics, components and technical requirements of these technical schemes are introduced in this document.

By collecting existing standards of CHP, this document also identifies the gaps of CHP standardization and put forward a roadmap for future CHP standards.

This document is prepared based on limited expert resources. Thus, some cogeneration cases could not be covered in this document, such as:



- Solar cogeneration; and
- Internal combustion engine cogeneration.

### 1.3 Purpose



Based on the decision of the SMB, the purpose of this document is to briefly introduce the technical characteristics and requirements of different cogeneration schemes, analyse the standard status and standard gap, put forward roadmap and suggestions for the development of cogeneration standards in the future.

## 2 Terms, definitions and abbreviated terms

### 2.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

**2.1.1**
**combined heat and power (CHP)**
energy efficient technology that generates electricity and captures the heat that would otherwise be wasted to provide useful thermal energy - such as steam or hot water - that can be used for space heating, cooling, domestic hot water and industrial processes

[SOURCE: "Combined Heat and Power (CHP) Partnership" from EPA]

**2.1.2**
**cogeneration**
simultaneous production in series of two forms of useful energy such as electrical energy first and then useful thermal energy from a single fuel source

Note 1 to entry: In this document, cogeneration refers to CHP.

**2.1.3**
**primary energy**
energy that has not been subjected to any conversion or transformation process

Note 1 to entry: Primary energy includes non-renewable energy and renewable energy. If both are taken into account it can be called total primary energy.

[SOURCE: ISO 52000-1:2017, 3.4.29]

**2.1.4**
**heating**
process of increasing the temperature of medium by the means of the transportation fluid from the heating plant over a heat exchanger

**2.1.5**
**heating season**
part of the year during which heating is needed to keep the indoor temperature within specified levels, at least part of the day and in part of the rooms



Note 1 to entry: The length of the heating season differs substantially from country to country and from region to region.

Note 2 to entry: This term is especially for district heating period of a year.



[SOURCE: ISO 17772-1:2017, 3.15]

**2.1.6**
**heating system**
system where the working fluid is heated by the transportation fluid coming from the CHP plant for any purposes, such as process, building heating, hot water, etc.

**2.1.7**
**district heating**
heating systems that distribute steam or hot water through pipes to a number of buildings across a district

Note 1 to entry: Heat is provided from a variety of sources, including geothermal, combined heat and power plants, waste heat from industry, or purpose-built heating plants.

[SOURCE: ISO 14452:2012, 2.23]

**2.1.8**
**industrial heat supply**
heat supply where the working fluid takes part with the industrial process or the heat of the working fluid is transferred to the industrial process over a heat exchanger

Note 1 to entry: In the former case, no residual heat is returned to the CHP system. In the latter case, the residual heat may be returned to the CHP system.

**2.1.9**
**extraction turbine**
turbine in which some of the steam is extracted part-way through the expansion using pressure control means for the extracted steam

Note 1 to entry: The control means are located inside the turbine flow path or in a cross-over line between turbine sections. The target is to provide process steam.

Note 2 to entry: Control of extraction pressure can be internal, external or combined internal/external. For externally controlled extractions the control means are located in the extraction steam line. The aim is to control steam parameters downstream of the control means, i.e. on the process side. In this case the turbine is not called an extraction turbine.

Note 3 to entry: If no means for controlling the pressure are used, this steam line is called a bleed, and the turbine is not called an extraction turbine.

[SOURCE: IEC 60045-1:2020 © IEC 2020]

**2.1.10**
**back pressure turbine**
turbine whose exhaust heat typically will be used to provide process heat (e.g. industrial process, district heating, post combustion carbon capture system and desalination), and whose exhaust is not directly connected to a condenser

Note 1 to entry: The exhaust pressure will normally be above atmospheric pressure.

[SOURCE: IEC 60045-1:2020© IEC 2020]

### 2.2 Abbreviated terms

CHP combined heat and power

SMB standardization management board

ORC organic Rankine cycle

HP high pressure

IP intermediate pressure

LP low pressure

HRSG heat recovery steam generator



## 3 Overview of CHP

### 3.1 What is CHP?

CHP is an energy efficient technology that generates electricity and captures the heat that would otherwise be wasted to provide useful thermal energy - such as steam or hot water - that can be used for space heating, cooling, domestic hot water and industrial processes. A CHP system can be located at an individual facility or building, or be a district energy or utility resource. CHP is typically located at facilities where there is a need for both electricity and thermal energy. (Source: Combined Heat and Power Partnership, EPA)

Nearly two-thirds of the energy produced (or obtained) by conventional electricity generation is wasted in the form of heat discharged to the atmosphere. Additional energy is wasted during the distribution of electricity to end users. In contrast, in a combined heat and power process, the vaporizing heat input happens only once and the sensible heat (condensing heat) is used in the heating process. The total fuel efficiency of this combined process is then much better than the one for separate processes. By capturing and using heat that would otherwise be wasted, and by avoiding distribution losses, CHP can achieve efficiencies even over 80 %.

CHP applications cover a wide range of technology. Smaller heat demands are met by fuel cells, internal combustion engines, Stirling engines and so on. For higher demands solutions gas turbines, back pressure turbines and steam turbines with extractions are in use for CHP.

Its important significance is to improve energy efficiency by changing the production process of equipment, and at the same time enrich the types of products.

Two most typical CHP system configurations are:

- Steam boiler with steam turbine (as shown in Figure 1)
- Combustion turbine, or reciprocating engine, with heat recovery unit (as shown in Figure 2)

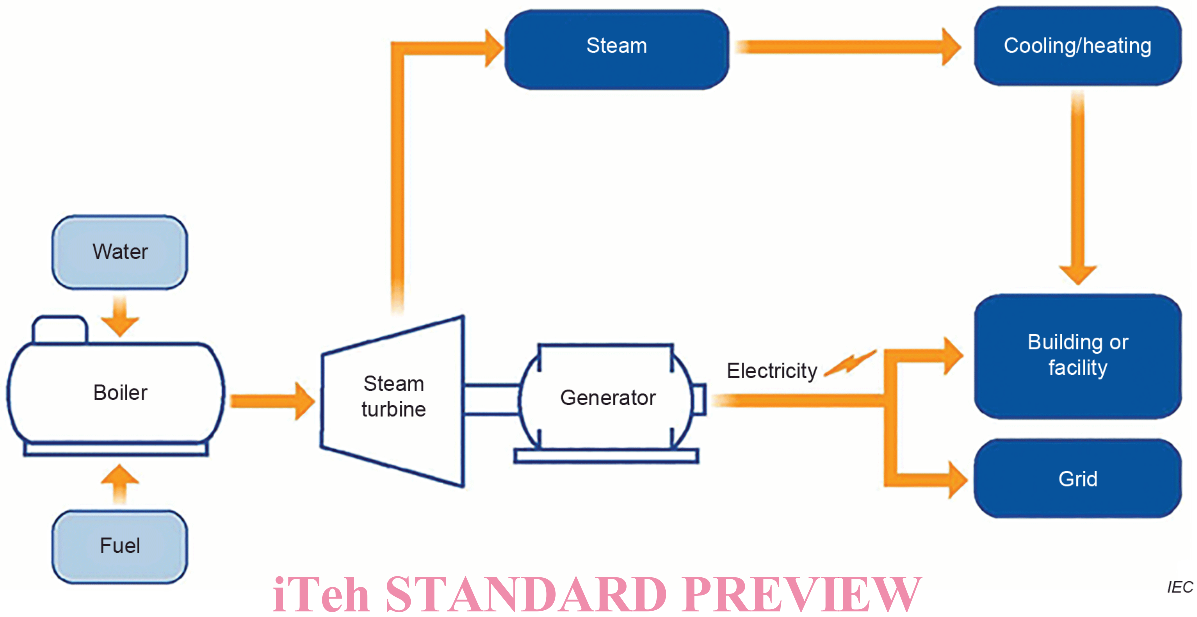




**Figure 1 – CHP based on steam turbine**

With steam turbines, the process begins by producing steam in a boiler. The steam is then used to turn a turbine to run a generator to produce electricity. The steam leaving the turbine can be used to produce useful thermal energy. These systems can use a variety of fuels, such as natural gas, oil, biomass, and coal.



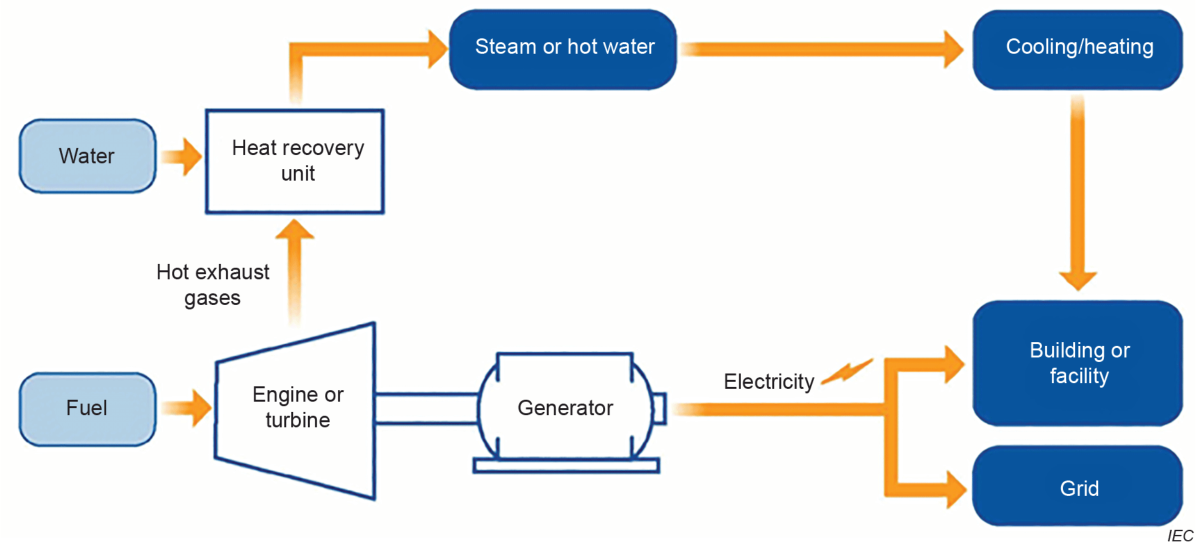


**Figure 2 – CHP based on combustion turbine or reciprocating engine**

Combustion turbine or reciprocating engine CHP systems burn fuel (natural gas, oil, or biogas) to turn generators to produce electricity and use heat recovery devices to capture the heat from the turbine or engine. This heat is converted into useful thermal energy, usually in the form of steam or hot water.