Ministry of Economic Development

DEPARTMENT OF ENERGY
DIRECTORATE-GENERAL FOR NUCLEAR ENERGY, RENEWABLE ENERGIES AND ENERGY EFFICIENCY

DIRECTIVE 2004/8/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL OF 11 FEBRUARY 2004

REPORT UNDER ARTICLE 10(2), COVERING THE ITEMS REFERRED TO IN ARTICLE 6(3), ON PROGRESS MADE TO INCREASE THE SHARE OF HIGH-EFFICIENCY COGENERATION

1. Article 6(3) of Directive 2004/8/EC of the European Parliament and of the Council

National potentials for high-efficiency cogeneration

3. Member States shall for the first time not later than 21 February 2007 and thereafter every four years, following a request from the Commission at least six months before the due date, evaluate progress towards increasing the share of high-efficiency cogeneration.

2. Regulatory Framework for High-Efficiency Cogeneration (HEC)

Under Directive 2004/8/EC of the European Parliament and of the Council (hereinafter referred to as 'the Directive') [1], the European Parliament recognised cogeneration as an important measure that is needed to comply with the Kyoto Protocol and it included the progressive spread of high-efficiency cogeneration among the Community's priorities.

The Directive established the method for calculating the relative share of cogeneration production based on the total electricity production of a given plant; it also established the conditions that the cogeneration share must meet to be defined as 'High-Efficiency Cogeneration' (HEC).

In general, a plant is considered as having high-efficiency cogeneration characteristics when the 'Primary Energy Saving' (PES) index is greater than the established minimum.

The PES index is the percentage of primary fuel that the plant in question has saved during a calendar year. The savings are evaluated in comparison with two hypothetical facilities, which are both 'substituted' by the facility examined: one is exclusively able to produce electricity, while the other exclusively produces thermal energy. The total fuel that both facilities would have consumed is compared, at equal production rates, with what was actually consumed in the plant under examination.

The PES considers, among other things, the possible savings that the plant obtained, while avoiding, in full or in part, losses from converting and transporting the energy produced. For this purpose, a suitable coefficient is provided based on the voltage of the energy used.

Italian legislation transposed the Directive by means of Legislative Decree No 20 of 8 February 2007 [2] (hereinafter referred to as 'the Decree'). The Decree sets out that the conditions for defining high-efficiency cogeneration established by the Directive shall be applicable only after the 31 December 2010: until that time the criteria currently specified by the regulations (AEEG Decision No 42/2002 [3] (hereinafter to as 'the AEEG Decision'), which is similar in concept, shall apply.

Currently, Italian legislation grants certain incentives for electricity produced using high-efficiency cogeneration. The main ones are:

- An exemption from the obligation to purchase Green Certificates (an obligation that generally is applicable to electricity produced by non-renewable resources) [4],
- The right to service priority, following electricity that is produced by strictly renewable resources [4].
- The right to 'on-the spot trading' (for facilities with a nominal power that does not exceed 200 kW) [2].
- The option of obtaining 'energy efficiency certificates' which may be traded [5,6].
- Green Certificates (only for high-efficiency cogeneration facilities connected to district heating networks that satisfy certain requirements regarding plant commissioning) [2,7].

Producers who intend to benefit from the incentives listed above must annually declare the quantity of electricity and heat produced during the previous calendar year to GSE, and the quantity of primary energy (fuel) consumed to produce it. The statements must include technical information relating to the plant such as: an operating diagram, machine sizes, measurement methods used and other information. On the basis of the overall data, GSE shall be able to determine whether the plant production for the given year met the necessary efficiency requirements to qualify as 'high-efficiency cogeneration'.

In order to determine the completeness and accuracy of the statements [2, 8, 9], periodic inspections are carried out at facilities.

3. High-Efficiency Cogeneration in Italy in 2007

In order to illustrate the features that high-efficiency cogeneration (HEC) might develop in Italy in the near future, the criteria set down by the Directive are applied to cogeneration data from 2007 (which derives from the annual statements mentioned), as if it were already operational. Below, 'high-efficiency cogeneration' (HEC) stands for cogeneration that meets those criteria. Related figures (PES index, overall output etc) are calculated in a conservative manner.

The 'Commission Decision of 21 December 2006 establishing harmonised efficiency reference values for separate production of electricity and heat in application of Directive 2004/8/EC of the European Parliament and Council' [10] (hereinafter referred to as 'the Commission Decision') (C(2006) 6817) was also considered. The calculations were made with reference to ISO standard conditions (average temperature of 15°C).

It is necessary to mention that the AEEG Decision does not seem to apply to cogeneration plants that burn solid waste or biomass exclusively, and that may have caused operators not to submit any statements. Similarly, plants that could have been included under a broader interpretation of the term, were excluded from this analysis.

Plants whose production was in accordance with high-efficiency cogeneration in 2007 represent an overall installed power of 9800 MW, approximately 10% of the total of Italian generation and 13% of thermoelectric producers alone.

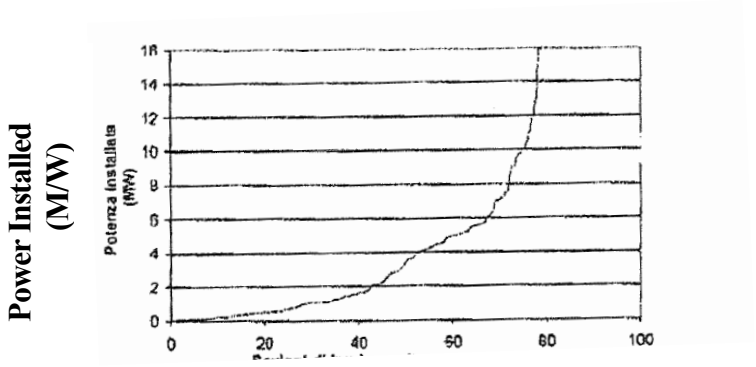

Figure 1: Distribution of electric power from high-efficiency cogeneration plants in Italy (cumulative frequency curve, year 2007, power up to 16 MW).

Figure 1 shows the cumulative distribution curve for overall electrical power from the prime movers, solely for the 'plant sections' operated using high-efficiency cogeneration (HEC). As can be seen, the installed power is less than 10 MW in 75% of the cases. 30% of the facilities have a power of less than 1 MW ('small-scale cogeneration'), while 'microcogeneration' (power less than 50 kW) accounts for merely 1% of the total surveyed. Therefore the majority of facilities are small and medium capacity: however, there are also examples of large facilities (up to 300-400 MW), which are mainly located inside large industrial sites.

Business	Average Power Installed (MW)
Sports Complexes	0.1
Rest Homes and Similar Services	0.1
Hotels and Restaurants	0.2
Retail	0.7
Education	1.0
Hospitals	1.2
Textile Industries	1.3
Ceramics Industries	3.8
Tanneries	4.0
Electronics Industries	9.0
Carpentry	9.6
Food Industry	11.6
Heating and Remote Heating	14.3
Unknown	18.7
Paper Industry	20.8
Automotive Industry	30.5
Chemical and Petrochemical Industries	132.6
Petroleum Refineries	195.7

Table 1: Average size of the high-efficiency cogeneration for certain economic business categories (Year 2007).

Table 1 shows the average power for high-efficiency cogeneration in the civil or industrial activities where it is most widespread. The power, as can be seen, is extremely variable: it ranges from a few hundred kW for service businesses (hotels, restaurants, sports complexes, retail, etc.) up to hundreds of MW, which is common in large industries.

Figure 2 shows the high-efficiency cogeneration power installed in the main business sectors[1]. In some cases, heat may be used at the same site for several reasons: in the ceramics factory, part of the heat may be used for the manufacturing process, and another part may be used to heat the factory itself or adjacent buildings.

[1] Information on company activity is unavailable for some facilities.

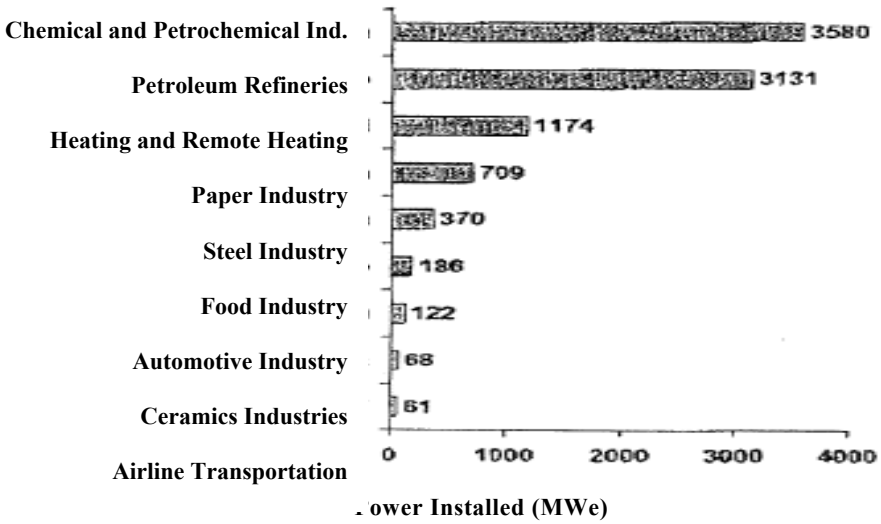

Figure 2: High-Efficiency cogeneration power installed for the main business sectors (year 2007).

Figure 3 shows the power installed in high-efficiency cogeneration facilities divided by the type of prime mover: steam turbines, gas turbines, and internal combustion engines. For each type it is stated whether it is used alone or if it is used combined with another type of motor (such as a combined gas-steam system).

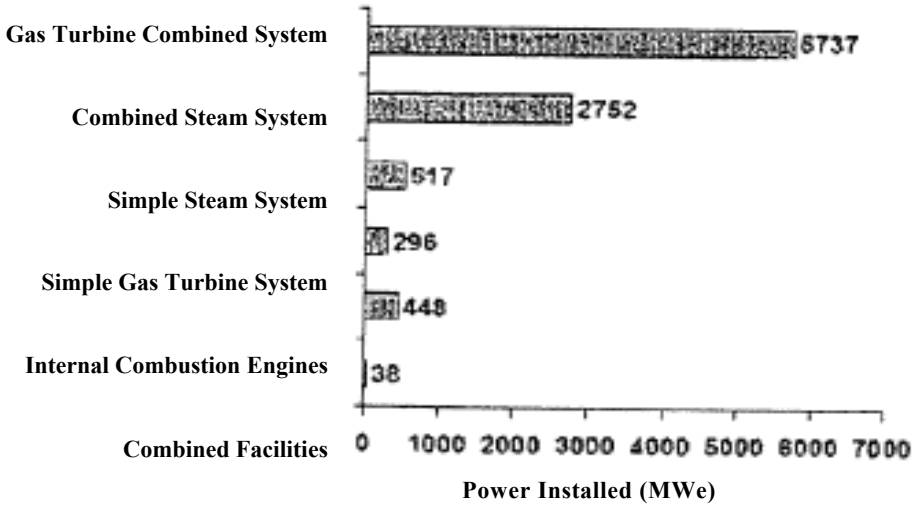

Figure 3: Power Installed in High-Efficiency Cogeneration Plants Broken Down on the Basis of the Thermal System Used (Year 2007).

During 2007 in Italy, 23 electric TWh and 32 thermal TWh were produced through high-efficiency cogeneration. The energy produced in high-efficiency cogeneration was equal to 8% of the entire national production in 2007 and 9% of thermo-electric energy produced [11].

PLEASE NOTE - In order to avoid any possible ambiguity, the data listed above must be compared with corresponding data published by TERNA [11, Table 33], which relates to energy produced by 'cogeneration' during 2007. An analysis of the TERNA data shows that Italy produced around 108 electric TWh and around 57 thermal TWh by cogeneration.

It should be noted that the 'cogeneration' production values are much higher than the corresponding high-efficiency cogeneration values. That is easily explainable considering that the latter accounts for only a percentage of all cogeneration: the part which meets precise yield requirements.

Figure 4 illustrates the impact of the primary fuels used in high-efficiency cogeneration. The most commonly used fuel is natural gas, followed by process or residual fuels.

As mentioned, high-efficiency cogeneration facilities are frequently associated with industrial complexes. In some cases the industrial complex produces gas with high energy content as a manufacturing by-product. It is fed into the high-efficiency cogeneration system to be utilised as a fuel. This is common, for example, in the petrochemical or steel industry or at refineries.

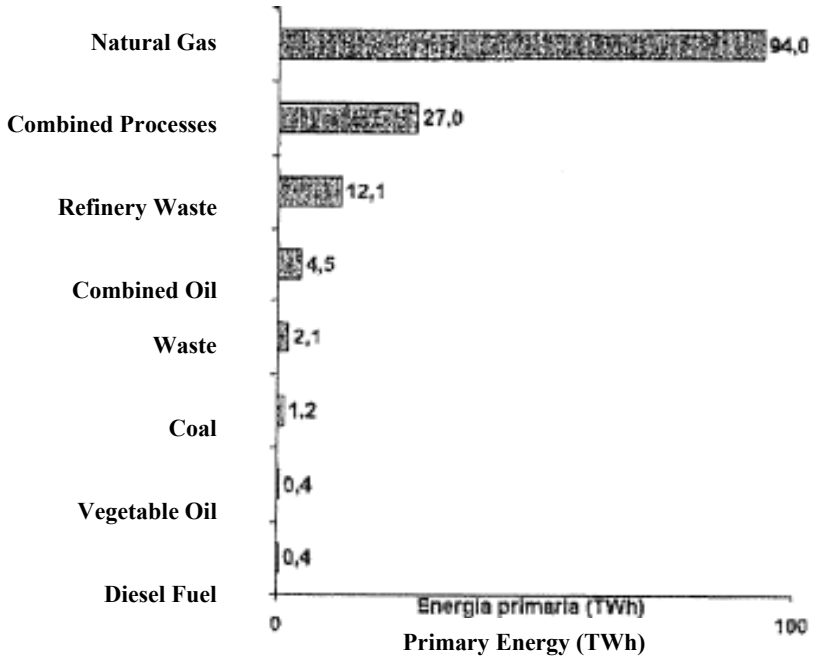

Figure 4: Main types of fuel and the relative total quantity used in high-efficiency cogeneration in 2007.

4. Performance of High-Efficiency Cogeneration Facilities in 2007

In addition to the PES index, another common parameter used to evaluate the energy efficiency of high-efficiency cogeneration facilities is the first law efficiency η_I [12]. This is the relationship between the amount of power supplied to the users and the power supplied by the energy source:

$$\eta_I = \frac{PME + QU}{PF}$$

where:

- PME is the total useful electric (or mechanical) power;
- QU is the total thermal power, net of losses due to heat transmission;
- PF is the total power supplied by the primary energy source (fuel).

First law efficiency considers both the electric and the thermal power produced by the plant. In Table 2, various categories of businesses associated with high-efficiency cogeneration facilities are listed with the average values of first law efficiency and the PES index, relative to production in 2007.

Activity	Average efficiency (%)	Average PES
Rest Homes and Similar services	**85.2**	**19.8**
Food Industry	**82.4**	**25.0**
Sports Complexes	**80.5**	**20.7**
Carpentry	**80.3**	**24.7**
Ceramic Industries	**79.6**	**21.4**
Textile Industries	**77.3**	**17.7**
Hospitals	**76.0**	**19.9**
Retail	**75.8**	**20.9**
Education	**71.0**	**15.0**
Hotels and Restaurants	**70.2**	**10.1**
Paper Industry	**69.3**	**18.1**
Chemical and Petrochemical Industry	**66.8**	**30.9**
Tanneries	**65.2**	**22.6**
Heating and Remote Heating	**64.6**	**32.6**
Electronics Industry	**63.0**	**21.0**
Petroleum Refineries	**54.6**	**25.3**
Automotive Industry	**54.3**	**30.2**

Table 2: Performance of high-efficiency cogeneration facilities in 2007: first law efficiency and PES indices for the main activity categories (Year 2007).

The PES and efficiency indices are quite independent: high efficiency may be associated with modest PES indices. This is easy to explain considering the different meanings of the two indices.

Efficiency depends solely on the quantity of energy produced and consumed, and therefore it is a direct indicator of whether a plant is managed efficiently (such as, with a limited number of shut down and start ups).

By contrast, the PES index also considers, together with the methods of functioning of the plant, certain infrastructure features (age, voltage connection to the electric grid, the fuels used and others) and the efficiency of the conventional plants it replaces (efficiency reference).

Therefore, first law efficiency and the PES index may not be considered as equivalent. For that reason, the Directive takes both into account: first law efficiency is used in pure energy calculations (determining the electricity produced by cogeneration); PES instead identifies high-efficiency cogeneration facilities.

5. Primary Energy Savings Due to High-Efficiency Cogeneration

As mentioned, the main benefit expected from high-efficiency cogeneration is savings in the quantity of fuel used to produce energy. Those savings translate into lower atmospheric emissions and the greater availability of primary fuels.

To quantitatively evaluate this benefit requires estimating how much primary fuel was saved by using high-efficiency cogeneration, and comparing it to that which would have been consumed by producing the same quantity of electricity and heat separately.

The savings in fuel may be calculated by extending the definition of the PES index to include total energy (electrical and thermal energy respectively) produced by all of the high-efficiency cogeneration facilities, and the total fuel consumed by those facilities. It means considering a single group, or more precisely, a single 'plant section' which is equivalent to all the groups that actually participated in high-efficiency cogeneration. It is, of course, necessary to hypothesise reasonable average efficiency values for the output of electric and thermal generators whose production was substituted by high-efficiency cogeneration. In a report published a few years ago [13], Eurostat assumed an average efficiency in Europe of 36% for the production of electric energy alone, and 85% for the production of thermal energy alone. With those efficiency values and with the quantity of energy produced and fuel consumed, as previously noted, the global PES index for 2007 came to around 36% which corresponds to savings in fuel equal to 36 TWh overall (more than 3 million TOE). Various reasons would lead one to believe that the savings in fuel are actually higher than the stated values. In fact, the calculation did not include all of the facilities that, despite producing electricity and heat, were not covered by communications to GSE (for example because the output indices were less than the minimum values). Nevertheless, these plants did contribute to saving primary fuels, albeit in a small way.

6. Conclusions

Certain overall features of high-efficiency cogeneration in Italy during 2007 were analysed on the basis of the Directive. It was found, among other things, that high-efficiency cogeneration provided considerable savings in fuel. This confirms what had already been recognised by the European Parliament: high-efficiency cogeneration may be a practical method for saving energy and for reducing pollution and greenhouse gas emissions.

It is noted that two different indices for energy efficiency (first law efficiency and the PES index) can give very different indications in many cases.

7. Bibliography

[1] European Parliament and Council, Directive 2004/8/EC, 2004, 'Promotion of cogeneration based on a useful heat demand in the internal energy market'.

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[3] Italian Regulatory Authority for Electricity and Gas, Decision No 42/02 2002, 'Conditions for the recognition of combined production of electricity and heat as cogeneration, as provided by Article 2(8) of Legislative Decree No 79 of 16 March 1999'.

[4] Legislative Decree No 79 of 16 March 1999 'Attuazione della direttiva. 96/92/CE recante nonne comuni per il mercato interno dell'energia elettrica' (Transposal of Directive 96/92/EC concerning common rules for the Internal Market in electricity).

[5] Decree of the Ministry of Production Activities of 20 July 2004 'Nuova individuazione degli obiettivi quantitativi per l'incremento dell'efficienza energetica negli usi finali di energia, ai sensi dell'art. 9, comma 1, del decreto legislativo 16 marzo 1999, n. 79' (New quantity objectives for increasing energy efficiency in the final use of energy, pursuant to Article 9(1) of Legislative Decree No 79 of 16 March 1999).

[6] Decree of the Ministry of Production Activities of 20 July 2004 'Nuova individuazione degli obiettivi quantitativi nazionali di risparmio energetico e sviluppo delle fonti rinnovabili, di cui all'art. 16, comma 4, del decreto legislativo 23 maggio 2000, n. 164' (New quantity objectives for increasing energy efficiency in the final use of energy, pursuant to Article 16(4) of Legislative Decree No 164 of 23 May 2000).

[7] Law 239 of 23 August 2004 'Riordino del settore energetico, nonché delega al Governo per il riassetto delle disposizioni vigenti in materia di energia' (Reorganisation of the energy sector and government delegation for restructuring energy legislation).

[8] Regulatory Authority for Electricity and Gas, Decision No 60/04, 2004, 'Avvalimento della Cassa conguaglio per il settore elettrico per intensificare ed estendere le verifiche e i sopralluoghi sugli impianti di produzione di energia elettrica alimentati da fonti rinnovabili, fonti assimilate a quelle rinnovabili a sugli impianti di CAR' (Use of equalisation fund for the electricity sector in order to intensify and broaden the inspections of electricity production facilities powered by renewable and equivalent resources and HEC facilities).

[9] Regulatory Authority for Electricity and Gas, Decision No 215/04, 2004, 'Approvazione del Regolamento per l'effettuazione di verifiche e sopralluoghi sugli impianti di produzione di energia elettrica alimentati da fonti rinnovabili, da fonti assimilate alle rinnovabili e sugli impianti di CAR'. (Approval of the regulation regarding

verifications and inspections on electricity production facilities powered by renewable and equivalent resources and HEC facilities) Decision No 296/05.

[10] Commission Decision of 21 December 2006 establishing harmonised efficiency reference values for separate production of electricity and heat in application of Directive 2004/8/EC of the European Parliament and Council (C(2006) 6817).

[11] TERNA (National Electricity Network), 2007, 'Dati statistici sull'energia elettrica in —2007' (Statistics on Electricity in 2007) .

[12] UNI, Standard 8887, 1987, 'Sistemi per processi di cogenerazione — Definizioni e classificazione' (Systems for Cogeneration Processes - Definitions and Classifications).

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