Steel and food industries in Italy: analysis of the energy efficiency potential

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Abstract
Industry is responsible for nearly one third of Italy final energy consumptions. The National Energy Strategy sets in 4 million toe the savings that should be achieved in the industrial sector by 2020. In order to reach this target, the effective implementation of energy efficiency measures in industry is supported by means of regulations and incentives, like the energy efficiency obligation scheme (White Certificates). White Certificates are tradable instruments giving proof of the achievement of end-use energy savings through energy efficiency improvement initiatives and projects. Under the scheme, electricity and natural gas distributors are required to achieve yearly quantitative primary-energy saving targets.

An analysis of a representative sample of real energy efficiency projects, already realised by different Italian industry stakeholders, is presented in this article. The purpose is to identify the main energy efficiency measures suitable for each industrial sector and to classify them according to technological criteria and economic indicator. Such an analysis is used to verify the replicability of the identified energy efficiency measures in the short- or medium-run and then to evaluate the impact in terms of the potential energy savings, at national level.

In this paper two sectors are specifically analysed: steel and food. The former is a high energy intensive sector, the latter is highly representative of the Italian manufacturing sector and is strongly oriented to the energy efficiency improvement of its processes. Methodology and results presented concern both the classification of implemented energy efficiency measures and the related energy saving potential at national level.

Introduction
Energy efficiency plays a fundamental role in promoting and supporting the development of a low carbon economy, optimizing the use of energy carriers in the different sectors. The industrial sector is responsible for about a quarter of the energy consumption of the European Union (EU28) in 2013 and, so, an important contribution to European energy efficiency target is expected 0. However, the reduction of energy consumption is linked to the profitability of energy efficiency measures, strongly related to many variables, including the cost and the volatility of energy prices.

Energy and environmental policies affect the relationship between energy consumption, cost and competitiveness through the setting and upgrading of regulations and the promotion of support schemes. In Europe, five directives mainly set the policy framework: the Energy Efficiency Directive (2012/27/EU), the Eco-design Directive (2009/125/EC) directive, the Energy-labelling Directive (2010/30/EU), the EU Emission Trading System (ETS) and the Industrial Emissions Directive (2010/75/EU). Furthermore, the SET Plan 0 provides the general outline for the promotion of cooperation in the field of R & I between the EU, Member States and stakeholders (research and industry) in order to intensify efforts to bring new efficient technologies on market at competitive costs. Particularly, the integrated SET Plan identifies 10 actions for Research and Innovation (whose action N° 6 is dedicated to the industry) to accelerate the energy system transformation that should facilitate coordinated or joint investments by individual Member.

Table 1. Industrial sector metrics [Eurostat, SET PLAN].

Sector	Final energy consumption (EU 28)	Energy cost intensity (EU 28)	Employed (EU 28)	Value added (EU 28)
	[Mtoe] year 2014	year 2014	[Million] year 2013	[G€] year 2014
Pulp and paper	34.3	16 %	1.43	79.0
Iron and steel	50.8	36 %	0.63	39.7
Non-metallic mineral	34.2	23 %	1.29	63.9
Chemical and pharmaceutical	51.5	12 %	1.72	229.8
Non-ferrous metal	9.4	23 %	0.46	23.7
Petroleum refineries	44.7	44 %	0.12	24.3
Food and beverage	28.4	10 %	4.53	251.4
Machinery	19.3	3 %	9.03	579.8

The presented study consists in an analysis of 208 real energy efficiency projects, already realised by different Italian industry stakeholders, belonging to food and steel sectors. The purpose is to identify the main energy efficiency measures suitable for each industrial sector and to classify them according to technological criteria. Such an analysis is used to verify the replicability of the identified energy efficiency measures in the short, or medium, run and to evaluate the impact in terms of the potential energy savings, at national level.

Methodology

The study is divided in three phases:

- General overview of the specific industrial sector and analysis of relative production processes and energy flows.
- Case study analysis and identification of implemented energy efficiency measures. This phase also includes the evaluation of the potential energy savings for each of the identified energy efficiency measure.
- Energy efficiency measures reproducibility on national level.

Figure 1. Geographical distribution of plants considered in the analysis. Triangle represents EAF plants and circle BF plants.

The first objective is to identify industrial sectors for which the highest potential savings and the best opportunities for energy efficiency measures can be assumed. The steel and food industry sectors have been chosen as first areas of analysis. The former is an high energy intensive sector, the latter is highly representative of the Italian manufacturing sector and is strongly oriented to the energy efficiency improvement of its processes.

The steel industry is extremely energy-intensive and accounts for 19 % of the industry consumption, by referring to Table 1; this percentage also represents the Italian situation (Eurostat 2014). It has a standard production process that can be easily divided into different phases. Italian domestic production is concentrated in few large companies. The food industry, while representing 10 % of consumption at both European and Italian level (Table 1), sees the presence of many companies, small, medium and large, distributed throughout the national territory. The types of production and the phases of the process, moreover, are extremely differentiated and hardly standardized.

This choice is in accordance with the methodology specified in the SET Plan Action N° 6, that indicates the criteria which can be used for a comparison of the different industrial sectors, in order to select the areas of greatest interest for the analysis. The criteria used are: final energy consumption, energy cost intensity (i.e. the proportion of the energy cost in the value added of the product), people employed and added value.

The analysis on the main industrial sectors at European level, reported in the SET Plan, is shown in Table 1.

Steel industry

Regarding the steel industry, 128 energy efficiency projects (hereinafter referred to as "cases") have been identified and analyzed, relating to the period 2005–2015, made in Italy in 68 different plants. In particular, the 32 mills included in the sample cover almost the total of the Italian production of steel associated to the electric arc furnace route. Their geographic location is largely (88 %) included in the northern regions of the country (Figure 1).

The analysis of the real cases makes it possible to classify 24 different energy efficiency measures grouped in homogeneous types (also called clusters).

The identified energy efficiency measures, according to the SET Plan, were differentiated in *sectoral technologies*, which refer to specific processes or materials, and *cross cutting technologies*, which, on the contrary, can be applied across different processes. Each type of efficiency cluster identified can be associated to a specific phase of the process production. Regarding *cross cutting technologies*, it is not possible to define a correlation with the process steps, as these measures concern the whole production process. These measures are not included in this specific analysis due to their low relative relevance on energy savings compared to *sectoral technologies*.

The correspondence between process phases and clusters is shown in Figure 2.

For each of the 128 real cases the power consumption, of fossil fuels or electricity, before the application of the energy efficiency measure, has been registered in the database. In some cases the data has been explicitly indicated, while for others an elaboration was necessary. For each real case also the measured energy savings, calculated as the difference between the power consumption before and after the application of the energy efficiency measure are registered. The ratio of these two values, baseline consumption and energy savings, assembled in clusters, allows to calculate the energy saving index, diversified between thermal and electric and specific for each cluster analysed. Energy savings index, calculated from case study, are reported in Table 2.

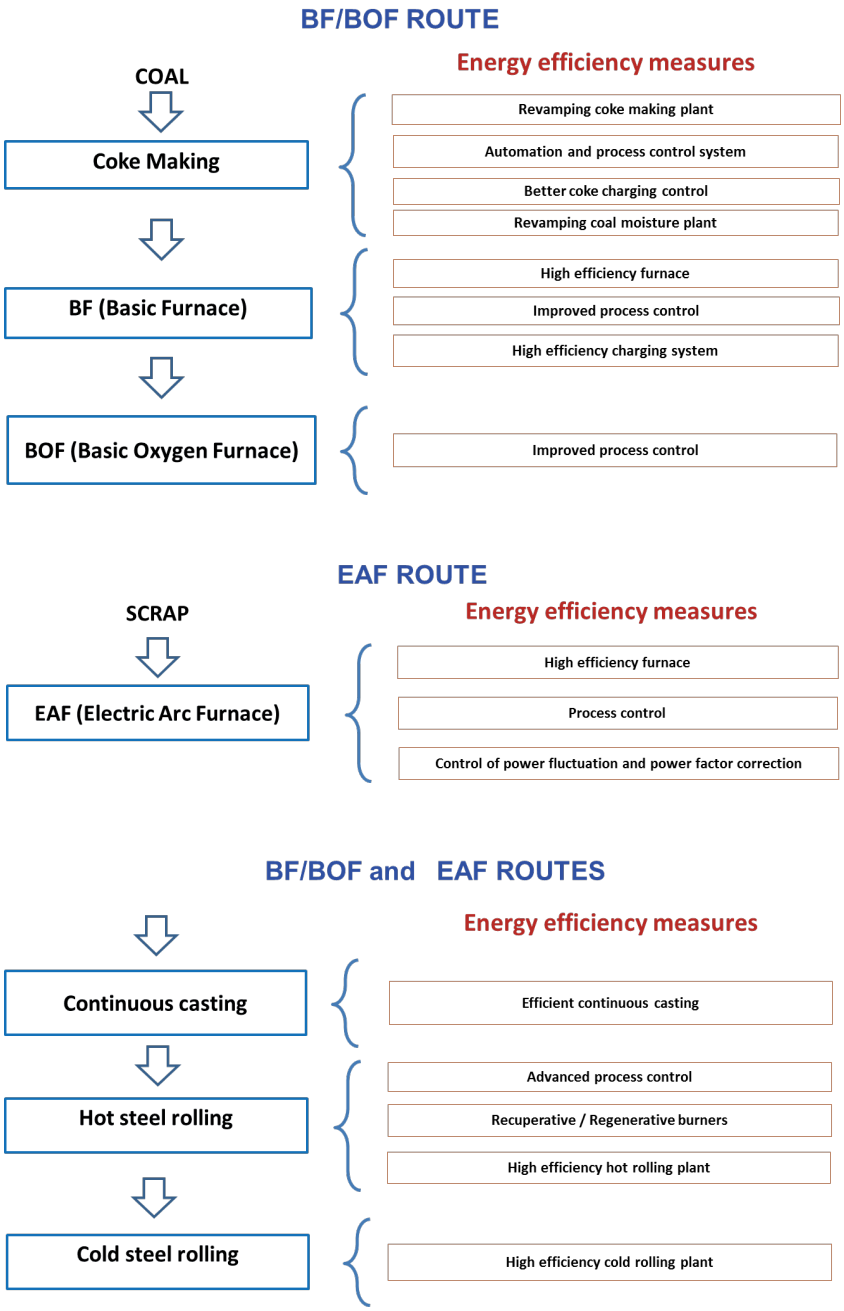

Figure 2. Correspondence between production phases and energy efficiency measures.

Table 2. Energy saving indices specific for each cluster considered in the steel industry.

Production phase	Electric energy saving index	Thermal energy saving index
Coke Making	0 %	27 %
Basic Furnace	3 %	13 %
Basic Oxygen Furnace	0 %	15 %
Hot steel rolling	8 %	7 %
Cold steel rolling	44 %	16 %
Electric Arc Furnace	3 %	9 %
Total	**5 %**	**11 %**

Table 3. Annual saving potential for steel industry in Italy.

Iron industry	Value	Annual saving potential (Italy)
Thermal	ktoe primary energy savings	593
	% of total national thermal consumptions	14 %
Electric	ktoe primary energy savings	203
	% of total national electric consumptions	7 %
Total	**ktoe primary energy savings**	**796**
	% of total national consumptions	**11 %**

To assess the potential energy savings achievable in the steel industry, the national energy consumption of 2010, subdivided in production phases, is considered. It is then extrapolated the same potential reproducibility of clusters of efficiency, derived from data derived from real cases. Savings indices were then applied to domestic consumption of each process step.

This approach has two important assumptions: the 2010 annual primary energy consumption in the industry (and production phases) remains constant for the following years, and the reasons and considerations that have led operators, until now, to operate certain interventions of efficiency remain valid also for the following years.

The total potential energy savings obtained, differentiated by electrical and thermal is reported in the Table 3.

Figure 3. Geographical distribution of plants considered in the analysis.

Food industry

The 80 examined real cases consist of 58 factories belonging to 50 different companies. Figure 3 shows the geographical position of the various factories grouped by Ateco 2007 code, which are mainly located in the northern part of the country. The plants placed in the South consist, on average, in the production of dough and bakery products and fruit and vegetable processing. The production in the North is related to the meat industry, pasta, sugar, coffee, jellies and starch products.

Stated the wide variety of processes that characterizes the food sector, a different approach has to be adopted: efficient technologies analyzed in the case studies are divided by production types and not by process phase, as it was done for the steel sector.

Food industry is divided in seven undersectors, in compliance with Italian Ateco 2007[1]:

- Meat.
- Fruit and vegetable.
- Vegetables oil and fats.
- Diary.
- Starch and grain mill.
- Bread and confectionery.
- Animal feed.

1. Ateco is the Italian classification of economic enterprises made by ISTAT, the National Statistical Institute

Table 4. Clusters and efficiency measures considered in the analysis.

Undersector	Cluster	Efficiency measures included
Meat sector	Electric	– Inverter – Advanced energy control
	Process	– Oxygenation by microbubbles system – Anaerobic digestion
	Thermal	– Heat recovery
Fruit and vegetable sector	Thermal	– Heat recovery
Vegetables oil and fats sector	Process	– Revamping industrial oven
	Thermal	– Heat recovery
Diary sector	Process	– Improving efficiency of the process
	Thermal	– Heat recovery
Starch and grain mill sector	Process	– Thermocompression – Mechanic vapor compression – High efficiency chiller
	Thermal	– Heat recovery
Bread and confectionery sector	Electric	– High efficiency electric motor – High efficiency compressor
	Process	– Revamping industrial oven – High efficiency production line – High efficiency air compression
	Thermal	– Heat recovery
Animal feed sector	Thermal	– Heat recovery

Table 5. Energy saving indices specific for each cluster considered in the food industry.

Undersector	Cluster	Electric energy saving index	Thermal energy saving index
Meat sector	Electric	6 %	0 %
	Process	0 %	10 %
	Thermal	0 %	2 %
Fruit and vegetable sector	Thermal	0 %	3 %
Vegetables oil and fats sector	Process	0 %	31 %
	Thermal	0 %	15 %
Diary sector	Process	34 %	11 %
	Thermal	8 %	34 %
Starch and grain mill sector	Process Thermal	6 %	37 %
Bread and confectionery sector	Electric	0.4 %	0 %
	Process	2 %	7 %
	Thermal	0 %	1 %
Animal feed sector	Thermal	0 %	3 %

The remaining undersectors included in the food industry are not considered in the potential for lack of real cases analysed.

Using the same approach of the steel sector, efficiency measures are assembled in three clusters for each undersector, namely Electric, Process and Thermal. For each cluster in Table 4[2] is specified which measures are considered.

The analysis of the real cases allows to determine the energy savings indices, as the ratio between the measured energy savings and the baseline power consumptions. Energy savings indices, specific for each cluster considered, are reported in Table 5[3].

2. Diary sector doesn't include ice cream production.

3. For the starch and grain mill sector only one index is considered including electric and thermal energy savings, due to representative problems of the data set.

Table 6. Annual saving potential for food industry.

Food industry	Value	Annual saving potential (Italy)
Thermal	ktoe primary energy savings	160
	% of total national thermal consumptions	12 %
Electric	ktoe primary energy savings	75
	% of total national electric consumptions	5 %
Total	**ktoe primary energy savings**	**235**
	% of total national consumptions	**8 %**

Table 7. Comparison between Italian energy savings potential proposed in this study and European energy savings potential proposed by the SET Plan.

Sector	Energy savings compared to the annual European consumption	Energy savings compared to the annual Italian consumption
	[set plan]	[present study]
Steel industry	6 %	11 %
Food industry	6 %	8 %

In order to estimate the national savings potential for the food industry sector the same reproducibility derived from real cases analyzed is assumed, under the hypothesis that the measures made in the case studies are also reproducible for companies of the same subsector and generate the same energy savings indices. The same approach was used for the steel sector.

Conclusion

The analysis of 208 real energy efficiency projects, in steel and food industry, allowed to determine an energy savings potential.

The proposed potential can be considered as an economical potential as the analysed measures have already been implemented. It means that, presumably, such projects are economically viable since they have passed a cost-benefit analysis and so they have a payback period suitable for an industry installation. It is a conservative evaluation that does not take into account innovative measures not yet implemented in real plant in Italy.

It came to light that energy saving potential in steel sector in Italy is 6 %, corresponding to 811 ktoe per year. This savings could be achieved mainly (583 ktoe) for the thermal consumptions.

Concerning food sector, the energy saving potential is 8 % corresponding to 235 ktoe. Also in this sector the main part (160 ktoe) regards thermal consumptions.

It can also be noted that a confirmation of the validity of asset values obtained for the steel and food, can be obtained by comparison with the potentials proposed by the SET Plan at European level. In fact, in the document of the European Commission makes proposals in potential savings for each industrial sector under review. These potentials are diversified in Economic potential and Technical potential. The first one considers only economically sustainable technologies, while the latter includes also technically applicable technologies, but not yet competitive on the market. Therefore, the SET Plan potential can be compared with the one proposed in this article, based on the detection of the actual efficiency measures applied by some of the Italian industries.

The comparison between the values proposed in this report and those reported in the SET Plan, at European level, is shown in Table 7. It can be noticed adhesion between the two results, confirming the synergy of the proposed project with European guidelines.

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