EU energy policies achievement by industries in decentralized areas

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Abstract. Energy Roadmap outlined by the European Commission sets out several routes for a more sustainable, competitive and secure energy system in 2050. All the outlined scenarios consider energy efficiency, renewable energy, nuclear energy and carbon capture and storage. In this paper, more attention has been devoted to the energy efficiency issue, by the identification of new micro and small networks opportunity fed by hybrid plants in the North-East of Italy. National energy balance and national transmission system operator data allowed to collect industrial energy consumptions data on the investigated area. Applying industrial statistics to the local energy needs allows to collect a dataset including consumption information by factory and by company structure (size and employees) for each industrial sector highlighting the factory density in the area. Preliminary outcomes from the model address to the exploitation of local by-product for energy purposes.

1 Introduction

The European Commission policy is offering significant opportunities for public and private investment to support growth, employment and structural transformation. The new generation of programmes under the European Structural and Investment Funds (ESI Funds) 2014–2020 is focused on 11 thematic objectives. Some of them are related to strengthening research, technological development and innovation, competitiveness of Small and Medium Enterprises (SMEs), supporting the transition towards a low-carbon economy [1]. The industry energy efficiency levels are expected to be improved up to 2050 in several industrial sectors. Iron, steel, chemicals and pharmaceuticals industries are the most involved in this process because it is expected an increment of their energy consumption due to the production growth despite the energy intensity improvement. In pulp and paper industries an energy intensity improvement and an energy consumption reduction is expected despite a gradual increase in production rates. In the non-metallic minerals sector energy intensity is expected to remain flat for ceramics, cement and glass sectors as well as for non-ferrous metals industries. Food and drink sector is subject to a continuous improvement leading to the energy consumption reduction despite the growth of production. Energy consumption of the petroleum refineries sector is assumed to decrease the energy consumption due to the past energy efficiency improvement and due to the demand reduction [2].

2 Italian Company Structure

The Italian data warehouse of the Industry and Services Census 2011 contains a wealth of detailed information on the main features of businesses, non-profit and public institutions, disaggregated at the regional level. The census reference date is 31st December 2011. From census returns, it is possible to derive information related to the main structural characteristics of businesses, non-profit and public institutions: legal form, economic activity, human resources and geographic location. The Italian National Institute of Statistics arranges economic activity using the ATECO 2007 classification which is the national version of the European nomenclature, Nace Rev. 2 [3].

The area investigated in this paper is composed by four Italian Regions, often regarded as North-East of Italy. The considered regions are: Trentino Alto Adige, Veneto, Friuli-Venezia Giulia and Emilia Romagna. Using the Census 2011 a first description of the overall area under investigation is summarized in Table 1.

Table 1. Comparison between Italian and North-East enterprises structure.

	Number of enterprises				**Number of employees**			
Size class of employees	**3–19**	**20–99**	**over 100**	**Total**	**3–19**	**20–99**	**over 100**	**Total**
Italy	191030	29098	4615	224743	1325280	1125403	1158713	3609396
North-East	50494	9595	1592	61681	371281	371126	359312	1101719
North-East [%]	26.4%	33.0%	34.5%	27.4%	28.0%	33.0%	31.0%	30.5%

In Table 1 enterprises with less than three employees are not considered due to their little energy consumption. Note that these neglected enterprises account for the 85% of the whole industrial employees in the North-East of Italy. The regions account for the 27.4% of the Italian enterprises and the 30.5% of the industrial labour force. In the North-East the 81.9% of enterprises has a workforce between 3 and 19 employees, the 97.4% of enterprises has a workforce between 3-99 employees while just the 2.6% of enterprises has more than 100 employees.

Table 2. Comparison between Italian and North-East enterprises structure.

	Enterprises		**Local units of enterprises**	
	number of active units	**number of employees**	**number of active units**	**number of employees**
Extraction of crude petroleum and gas	0.00%	0.00%	16.55%	10.44%
Coke and refined petroleum products	9.88%	4.18%	12.36%	5.77%
Electricity, gas and steam supply	25.13%	14.68%	21.45%	22.67%
Water supply and management	16.33%	15.76%	16.86%	16.78%
Iron and steel, non-ferrous metals	22.02%	21.75%	23.03%	24.04%
Chemical and pharmaceutical	23.05%	17.20%	23.54%	20.01%
Non-metallic minerals	25.19%	37.77%	26.41%	37.28%
Transport equipment	27.00%	17.05%	25.97%	16.45%
Machinery	31.03%	35.31%	31.18%	35.78%
Mining and quarrying	17.50%	18.76%	19.05%	19.40%
Food products, beverages and Tobacco	21.79%	29.45%	22.59%	28.66%
Paper products and print	25.62%	30.45%	25.68%	29.61%
Wood products	31.83%	36.80%	32.00%	37.58%
Constructions	21.19%	22.71%	21.32%	22.89%
Textiles, apparel, leather	23.42%	25.58%	23.50%	25.63%
Other manufacturing	31.93%	36.64%	32.12%	36.75%

From the employees classification it is possible to claim that the 33.7% of them are working in enterprises with 3-19 employees, the 67.4% are working in enterprises with 3-99 employees while the 32.6% are employed in enterprises with more than 100 employees. The percentage of industrial enterprises and local unit of enterprises on the region are related to the corresponding Italian amount.

3 Energy consumption and cogeneration potential

National energy balance published by Eurostat [4] provides information about industrial energy supplies. In this investigation the year 2013 has been considered as reference year. For the industrial sector and the energy industries the energy balance states 31.6 Mtoe of energy consumption. Assuming the whole consumption of fossil fuels for heating purpose and a conversion efficiency of 90% the heat request is estimated equal to 20.9 Mtoe. Heat is fulfilled for 19% by derived heat that includes self-production from combined heat and power plants (CHP). Electricity request is 10.7 Mtoe and fulfilled for 15% by self-produced electricity [5].

Table 3. Energy consumption of Italian enterprises.

	Total products	**Solid fuels**	**Oil (total)**	**Gas**	**Total Renewables**	**Wastes (non ren.)**	**Derived heat**	**Electricity**
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
Extraction of crude petroleum and gas	835	0	0	786	0	0	18	31
Coke and refined petroleum products	4894	35	3033	278	0	0	1082	467
Extraction of coal	5	0	0	0	0	0	2	4
Electricity, gas and steam supply	721	0	0	27	0	0	345	348
Water supply and management	521	0	0	0	0	0	0	521
Iron and steel, non-ferrous metals	5663	1923	92	1779	0	0	88	1781
Chemical and pharmaceutical	4121	1	469	1053	7	71	1243	1276
Non-metallic minerals	4984	241	1520	2004	96	202	108	814
Transport equipment	365	0	0	0	0	0	79	286
Machinery	3356	0	252	1387	1	0	15	1701
Mining and quarrying	116	0	23	34	0	0	0	59
Food products and Tobacco	2657	0	160	1174	30	0	266	1028
Paper products and print	2020	0	63	613	0	0	564	781
Wood products	404	0	0	31	89	0	27	256
Constructions	361	0	33	217	0	0	0	111
Textiles, apparel, leather	1167	0	81	586	0	0	40	459
Other manufacturing	1067	3	42	19	52	8	129	813

Eurostat energy balance provides detailed information of the produced energy by self-producers, in particular combined heat and power plants fed by fossil fuels: 1264 ktoe of electricity and 2000 ktoe of heat.

The detailed industrial energy consumption has been determined and is listed in Table 3.

From a literature review the estimation of the efficiency and the characteristics of combined heat and power plants has been obtained [5]. The wide range of industrial enterprises leads to analyse the system with average values for each industrial sector highlighting just the mean characteristics of each one. One of the most important tasks in CHP exploitation is the local use of heat. This topic can be summarized for each type of industry considering the amount of heat and its temperature. These information can be used to analyse the industrial cogenerative potential.

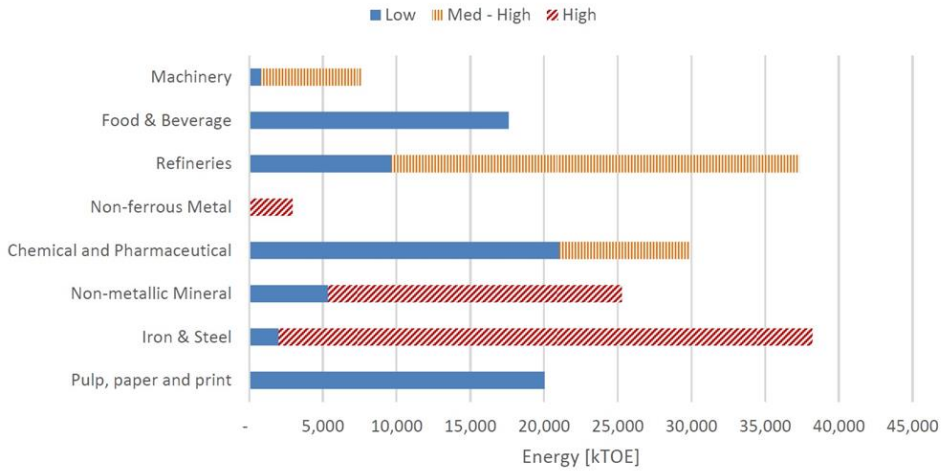

Fig. 1. Estimation of process heat temperature range [6].

For the main industrial sectors, the use of heat is categorized by temperature and by amount: it is possible highlighting the high percentage of industrial heat used at low temperature and the low amount of heat used at high temperature. Table 4 can lie out to identify the industry with high potential of cogeneration.

Table 4. Estimation of process heat temperature percentage.

	low	**med-high**	**High**
	< 250°C	**250–600°C**	**> 600°C**
Machinery	11%	89%	0%
Food & Beverage	100%	0%	0%
Refineries	26%	74%	0%
Non-ferrous Metal	0%	0%	100%
Chemical and Pharmaceutical	70%	30%	0%
Non-metallic Mineral	22%	78%	0%
Iron & Steel	4%	96%	0%
Pulp, paper and print	100%	0%	0%

The analysis of the industrial energy consumption allows to evaluate the energy efficiency improvement potential of each industrial sector through the installation of new combined heat and power plants.

Based on the data reported in Table 5, the actual CHP plants productions are 1497 ktoe of heat and 1300 ktoe of electricity. Estimated further productions from new CHP plants are

1845 ktoe of heat and 1746 ktoe of electricity without considering economic and financial factors. Heat from boiler is determined as difference of fossil fuel consumption of each industrial sector and actual CHP consumption, assuming a boiler conversion efficiency of 90%. Electricity from grid is determined as difference between electricity use and CHP actual production. The percentage of further heat from CHP, CHP efficiency, and Heat/Electricity ratios, are estimated considering statistical data for each application.

Table 5. Estimation of new CHP production in Italy.

	Actual Heat from CHP	Actual Electricity from CHP	Heat from boilers	Electricity from grid	**Further heat from CHP**	Further heat from CHP	Heat/Electricity CHP	Further electricity from CHP
	ktoe	Ktoe	ktoe	ktoe	**%**	ktoe		ktoe
Chemical and Petrochemical	406	393	472	883	**0.42**	200	0.9	222
Coke Ovens and Refineries	805	603	1427	-135	**0.11**	151	0.9	168
Food and Tobacco	162	192	874	899	**0.24**	209	1.1	190
Iron and Steel	53	49	2913	1525	**0.06**	176	0.7	251
Machinery	13	11	1447	1691	**0.50**	724	1.5	482
Non-Ferrous Metals	2	3	383	205	**0.06**	23	0.7	33
Non-Metallic Minerals	28	23	3331	791	**0.06**	203	0.8	254
Textile and Leather	19	15	562	445	**0.28**	156	1.1	142
Wood and W. Products	9	11	6	245	**0.55**	3	0.9	4

Outlined heat and electricity production improvements are function of the industrial sectors characteristics. Again, based on the data reported in Table 5, there are sectors with high percentage of possible CHP improvement like the Chemical, the Food and the Textile due to the low temperature heat requests. For other sectors, like the Machinery and the Wood product, CHP production improvements are of less interest due to the high temperature requested that could still affect the electrical efficiency.

4 Local Energy Balance and CHP potential

The knowledge of the local energy balance can help regulators to assess the effectiveness of current regulations and to identify new strategies suitable for efficiency improvements.

To get the local industrial energy balance starting from the national industrial energy balance it is possible to follow several pathways. The first step is to through improve the knowledge of the local area. The knowledge of industrial structure can help to identify industrial energy requests; also, the knowledge of the average number of employees for each industrial sector can give information about the industrial consumption in the investigated area. From the Italian TSO (Transmission System Operator) it is possible to get information about local energy consumption on a specific area. All those indicators can help to evaluate the local energy balance. This approach has been applied to the North-East regions of Italy and the three outlined balances present an absolute error of 3.2% on the total energy consumption of the area. This result permits to verify the relation between national and local consumptions that are linked to the number of industries and employees

and to the local energy consumption. In this paper, it is studied and computed the balance obtained considering as reference information, the local energy consumption in four regions of the North-East of Italy (Veneto, Trentino Alto Adige, Friuli Venezia Giulia and Emilia Romagna); the result is summarized in Table 6.

The effective outlined method can be applied also to smaller areas, for example rural areas to gather local information. To prove its potential, the method has been applied to a small region including three towns in the countryside. The outlined energy balance for the towns can help to investigate local opportunity. The local energy balance is summarized in Table 7.

Table 6. Energy consumption of North-East Italian enterprises.

	Total products	**Solid fuels**	**Oil (total)**	**Gas**	**Total Renewables**	**Wastes (non ren.)**	**Derived heat**	**Electricity**
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
Extraction of crude petroleum and gas	26	0	0	25	0	0	1	1
Coke and refined petroleum products	123	1	76	7	0	0	27	12
Extraction of coal	0	0	0	0	0	0	0	0
Electricity, gas and steam supply	249	0	0	9	0	0	119	120
Water supply and management	85	0	0	0	0	0	0	85
Iron and steel, non-ferrous metals	1156	392	19	363	0	0	18	363
Chemical and pharmaceutical	843	0	96	215	1	15	254	261
Non-metallic minerals	1948	94	594	784	37	79	42	318
Transport equipment	52	0	0	0	0	0	11	40
Machinery	1068	0	80	441	0	0	5	541
Mining and quarrying	22	0	4	6	0	0	0	11
Food products, beverages and Tobacco	952	0	57	420	11	0	95	368
Paper products and print	676	0	21	205	0	0	189	261
Wood products	207	0	0	16	46	0	14	132
Constructions	120	0	11	72	0	0	0	37
Textiles, apparel, leather	214	0	15	108	0	0	7	84
Other manufacturing	312	1	12	6	15	2	38	238

Table 7. Energy consumption of enterprises in the small selected rural area.

	Total products	**Solid fuels**	**Oil (total)**	**Gas**	**Total Renewables**	**Wastes (non Ren.)**	**Derived heat**	**Electricity**
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
Chemical and Petrochemical	0.201	0	0.032	0.046	0	0.004	0.056	0.064
Food and Tobacco	2.746	0	0.167	1.234	0.009	0	0.243	1.093
Iron and Steel	0.364	0.153	0.006	0.092	0	0	0.002	0.111
Machinery	1.605	0	0.134	0.650	0	0	0.011	0.810
Non-specified (Industry)	0.683	0.001	0.012	0.010	0.034	0.001	0.091	0.534
Textile and Leather	1.562	0	0.059	0.760	0	0	0.059	0.684
Wood and W. Products	0.895	0	0	0.063	0.189	0	0.060	0.583

Following the previously described approach it is possible to determine the local CHP potential as possibility for new local energy production.

Table 8 shows how it is possible to improve the local energy production and in which sectors the improvement could be more effective. The results achieved showed that high potential improvement could be obtained in the food sector but also in the machinery and textile sectors.

Table 8. Estimation of new CHP production of three towns.

	Heat from boilers	Electricity from grid	**Further heat from CHP**	Further heat from CHP	TH/EL CHP	Further electricity from CHP
	ktoe	ktoe	**%**	ktoe		ktoe
Chemical and Petrochemical	0.028	0.046	0.423	0.012	0.9	0.013
Food and Tobacco	0.874	0.929	0.239	**0.209**	1.1	0.190
Iron and Steel	0.174	0.088	0.060	0.010	0.7	0.015
Machinery	0.675	0.797	0.500	**0.338**	1.5	0.225
Non-specified (Industry)	-0.067	0.496	0.487	0.000	0.9	0.000
Textile and Leather	0.656	0.649	0.278	**0.182**	1.1	0.166
Wood and W. Products	-0.104	0.515	0.549	0.000	0.9	0.000
Total				**0.751**		**0.609**

5 Local by-product exploitation in food and beverage sector

Local investigation carried out with Energy Service Companies helps to verify the real industrial structure of the considered towns. The reference area highlights a rural structure with high concentration of enterprises linked to the agriculture and food processing. High vinery concentrations and intensive wine cultivation suggests the exploitation of agriculture by-products for energy use improving the use of local renewable energy sources.

The area under investigation is composed by three towns and the total surface is 64 square kilometres. The area dedicated to grape growing is 18 square kilometres. The grape vine cultivation is subjected to the plants management, and during the cold months grapevines are trimmed getting wood by-product (the so called "grape canes") from the cultivation. The wood by-product can be collected and dried in order to be used as fuel in a biomass furnace and producing heat for industrial purposes.

Preliminary analysis provides the specific wood by-product production. Trimmed wood has a relative humidity of 45%. The wood yield is 270 t/km^2. After a natural drying process, the relative humidity becomes 10% with a wood yield of 150 t/km^2. The lower heating value of the dry biomass can be estimated as 4.6 kWh/kg while the collection cost is 100 €/t of dry wood. The cost consider the use of energy for collection and wood processing [7].

The use of local wood by-product for energy purposes allows a CO_2 reduction due to a cutback avoiding of fossil fuels utilization. Switching from natural gas to grape canes for heat production can provide a CO_2 reduction of 2500 tCO_2 / year

Literature investigations provided information about energy consumption in wineries. For a typical facility with a production of 3 million of litres of wine per year the electrical energy consumption is 11 kWh/100 litres of wine, the thermal energy consumption is 1 kWh/100 litres of wine. Energy consumption can vary from 3 kWh/100litres for facilities with more than 5 million of litres of product to 25 kWh/100litres for facilities with less than 25 kWh/100 litres [8].

The use of pruning wood in an Italian winery has been investigated by the use of a pilot plant [9]. Winery has about 2.5 km^2 of vineyards with a yearly production of 150 tons of pruning wood. Biomass is burned in a boiler which generates 720 MWh of heat. Energy is used for space and water heating and for space cooling by means of an absorption chiller. The use of pruning residues can provide the 42% of the overall energy need of the winery.

The use of local wood by-product for energy purpose can be carried out in local industries not necessary linked to vineyards. The exploitation can be made in the local industrial area with the cooperation of the consortium for industrial development. The reduction of fossil fuel consumption in local enterprises can be reached using biomass collected from local agricultural enterprises. The vineyards are the main providers of wood for energy use but is not excluded the utilization of different sources like woodlands maintenance. However, additional investigations are needed to verify the technical and economic feasibility of wood by-products exploitation for energy purposes in the selected area.

6 Conclusions

The developed method can support the energy investigation on Italian areas, providing contribution to the identification of energy efficiency opportunity. Using national energy balance is possible to determine the local energy balance through local information like number of employees, number of enterprises and electrical energy utilized in the selected area. One possible outcome of the model is the identification of CHP potential improvements in the investigated region. The method can be applied also to local community and small areas. Cooperation on research and detailed investigations on site,

showed local opportunity and potential exploitation of local resources. Renewable energy sources available on-site can improve the by-products exploitation following local development. The exploitation of renewable sources can support local industrial sectors. In-depth investigations carried out in cooperation with local enterprises are necessary to better identify the technical and economic potential of the by-products exploitation.

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