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Mattia Cai, Niccolò Cusumano, Arturo Lorenzoni, Federico Pontoni

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IEFE - The Center for Research on Energy and Environmental Economics and Policy at Bocconi University
via Guglielmo Röntgen, 1 - 20136 Milano
tel. 02.5836.3820 - fax 02.5836.3890
www.iefe.unibocconi.it – iefe@unibocconi.it

A comprehensive ex-post assessment of the Italian RES policy: deployment, jobs, value added and import leakages

Mattia Cai, Università di Bolzano
Niccolò Cusumano[1], IEFE – Università Bocconi and Scuola Superiore Sant'Anna
Arturo Lorenzoni, Università di Padova
Federico Pontoni, IEFE – Università Bocconi

Abstract

A massive deployment of renewable electricity generation took place in Italy in less than eight years. A generous feed-in tariff, coupled with favourable institutional conditions, allowed the installation of more than 28 GW of PV, wind and other RES technologies. By 2014, Italy has already attained its 2020 goals on RES production. Besides, environmental objectives and compliance with EU targets, the policy was aimed at promoting green jobs and industrial production of RES technologies. Ex-ante economic analyses advocated considerable economic and industrial spill-overs from the introduction of RES support policies. Despite official rhetoric and ex-ante studies about jobs and economic growth associated to RES adoption, at scholarly level there is no consensus on the actual effects and implications of these policies on National economies. This paper provides a first comprehensive ex-post analysis of the Italian case, filling an important gap. Our analysis is carried out with the development of a specific input-output model, with refined technological vectors and with the internalization of trade coefficients. We show that the effects have been unequivocally lower than expected; that most of the jobs created belonged to the service sector and not to the industrial sector and that the value added was much lower than expected due to significant export leakages.

Keywords: value added; job creation; import leakage; renewable energy; support schemes
JEL Classification: J08; O13; Q40; Q42; Q48

[1] Corresponding author: Via Rontgen 1, 20136 Milan. E-mail: niccolo.cusumano@unibocconi.it

1. Introduction

Italy has committed, since 2001 when Directive 77 was approved, to the European strategy for promoting renewable energy sources (RES). Directive 77/2001 set a national indicative target of 25% of gross electricity consumption to be covered by RES by 2010. At that time Italy's RES share was about 20% (Terna 2015b), deriving mainly from hydro power. Despite a green certificates scheme in place from 1999 and a dedicated feed-in tariff for solar PV from 2005[2], till 2007 Italy witnessed only modest growth in RES capacity (see figure 1). RES expansion was not sufficient, not only to put the country in the right trajectory to achieve 2010 targets, but also to keep pace with electricity demand growth. In 2007 RES share bottomed out at 14% of gross electricity consumption (Terna 2015b).

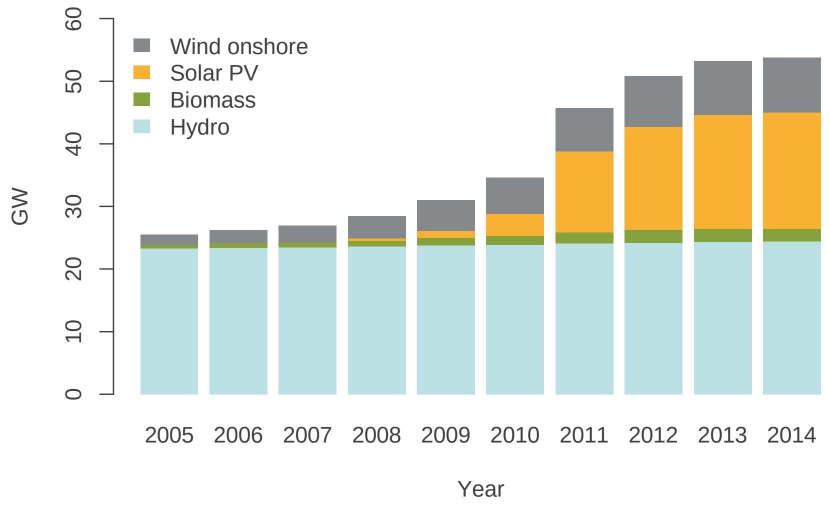


Figure 1: Evolution of RES installed capacity in Italy

In 2007 the Italian Government drafted a new incentive scheme for solar PV, so called "secondo conto energia". The following year it amended the green certificates program and introduced a feed-in tariff for small scale plants of RES other than PV, so called "tariffa onnicomprensiva". In 2009 EU adopted new legislation, the climate - energy package[3], setting national mandatory targets for GHG reduction, RES adoption and energy efficiency. Italy was asked to cover 17% of its 2020 gross final consumption and 35% of electricity with energy from RES.

Thanks to these and other measures (see table 1) the sector, eventually, took-off: between 2007 and 2014 28 GW of new RES capacity were added (GSE 2015). Electricity production from RES rose from less than 50 TWh to above 100 TWh, or 33% of total consumption. Italy was thus able to reach in 2014, six years in advance, its RES production target (Governo Italiano 2015). This outcome is somewhat surprising, provided that, in a 2009 Forecast Document (Governo Italiano 2009), the Italian Government declared that Italy will undershoot RES national target by 1% (equivalent to a gap of 1,170 ktoe).

[2] Primo conto energia

[3] Directive 2009/29/EC to improve and extend the greenhouse gas emission allowance trading scheme of the Community, Directive 2009/28/EC on the promotion of the use of energy from renewable sources

Table 1 RES support schemes

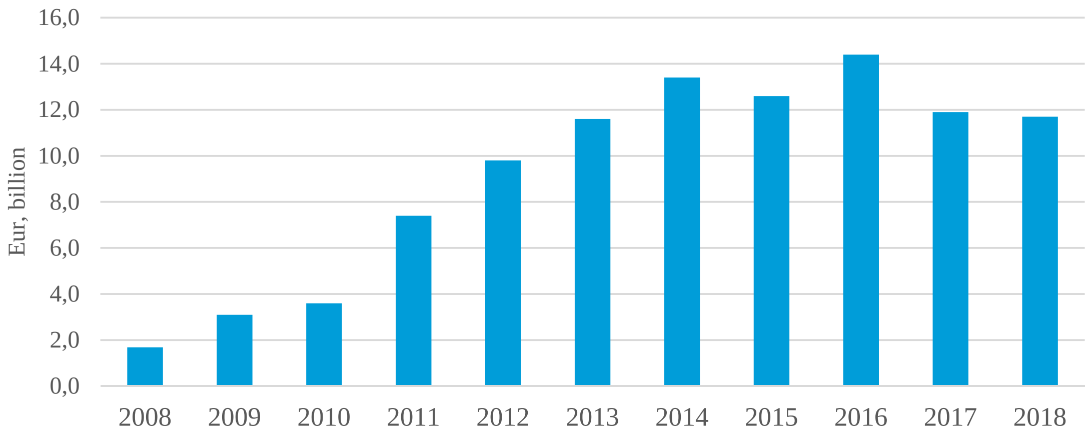
Year of introduction	Program name	RES	Incentive type	Capacity (MW)
1999	Green Certificates[4]	Hydro, Wind, Solid Waste	Quota	20,152
2006	Primo Conto Energia[5]	Solar PV	FiP	163.4
2007	Secondo Conto Energia[6]	Solar PV	FiP	6,791
2008	Tariffa onnicomprensiva[7]	All except wind > 200kW and solar PV	FiT	1,655
2010	Terzo Conto Energia[8]	Solar PV	FiP	1,566
2011	Quarto Conto Energia[9]	Solar PV	FiP & FiT	7,600
2012	Quinto Conto Energia[10]	Solar PV	FiP & FiT	2,094
2012	D.M 6/07/2012	All except wind > 200kW and solar PV	FiP & FiT	423

Whereas Italian policy undisputedly can be judged a success, since it allowed reaching agreed target, it attracted also some criticisms because of its associated costs. The annual budget for incentives (Figure 2 annual cost of incentives 2008-2018Figure 2) runs over EUR 10 billion (GSE 2016; AEEGSI 2015). Since support schemes are financed by electricity consumer's bills, they push final electricity prices higher even tough, gross prices were flat or falling in the same period. Moreover, the increase in RES production coincided with a fall in electricity demand, -8.64% in 2007-2014 period (Terna 2015b), leaving the electricity sector dealing with overcapacity and damaging traditional operators' profitability.

A debate followed, leading on one end to several interventions by the policy maker in order to cap expenditures - associated in particular to Solar PV – on the other end to the reappraisal of the benefits of the policy. Regarding the first aspect, as shown in Table 1, support schemes for PV were revised several times in order to lower tariffs for new installations and limit the access to support especially for larger plants and culminated with an ex post revision of incentives for existing plants in 2015[11].

Figure 2 annual cost of incentives 2008-2018

[4] Legislative Decree 79/1999
[5] Ministerial Decree of the 6th of February 2006
[6] Ministerial Decree of the19th of February 2007
[7] Ministerial Decre of the 18th of December 2008
[8] Ministerial Decree of the 6th of August 2010
[9] Ministerial Decree of the 5th of May 2011
[10] Ministerial Decree of the 5th of July 2012
[11] Law Decree 91/2015



Regarding the second aspect is worth noting that European – and Italian – policy on renewables always responded to several goals. EC's 1997 White Paper (European Commission 1997) affirmed "the doubling of the current market penetration of renewable energies by 2010 will have beneficial effects among others in terms of CO2 emissions; security of supply and employment". This vision was also evoked by Directives 77/2001 and 28/2009 which set national RES targets. The latter added the use of RES could play a role "in promoting technological development and innovation and providing opportunities for employment and regional development, especially in rural and isolated areas". Back in the mid-2000s the EU was actually playing a leading role in global RES manufacturing. The promotion of RES, by broadening the domestic market, was perceived as an industrial policy (European Commission 2006; European Commission 2008).

Despite official rhetoric about jobs and economic growth associated to RES adoption, at scholarly level those outcomes are still debated (Ortega et al. 2015; Böhringer, Keller, and van der Werf 2013; Frondel et al. 2010). Many existing studies about employment effects suffers of recursive referencing (IRENA 2011). Moreover Cameron and Van Der Zwaan (2015) point out that of 70 studies they analysed only 15 articles present novel data. Markaki et al. (2013) argue that even tough in most cases the promotion of clean energy technologies creates positive macro- economic effects it is still not clear from studies they reviewed which kind of investments actually bring more benefits and how the structure of the economy influence policy outcomes.

Studies have focused mostly on ex-ante analyses, rather than on the actual results of RES policies (Markandya et al. 2016). Therefore, the chief aim of this paper is estimating the contribution of the RES to the Italian economy on a sectorial basis in terms of value added and gross employment, and comparing the actual outcome with the abovementioned forecasts. From a methodological point of view, the paper shows how to improve the reliability and deep of I/O analyses, by defining plant size investment and operation and maintenance (O&M) vectors and correcting the international trade effects using Europroms. Further, we compare our results with previous studies carried out for Italy and other studies, in particular the work made by (Ortega et al. 2015) which tried to correct RES employment factors for imports.

The paper unfolds as follows: section 2 discusses our methodological detailing the construction of the vectors and the use of Europroms database; in section 3 we present our results, which are then discussed and compared with ex-ante studies in section 4; section 5 concludes with some policy insights.

2. Methods

The contribution to value added and employment in the Italian economy made by the RES sector is calculated within the framework of a standard demand driven IO model. The analysis spans 2006-

2014 period and focuses on four families of RES technologies: solar photovoltaic, onshore wind, hydropower and bioenergy. Geothermal and off-shore wind are not taken into account because of their marginal role with actually nil or very modest increase in capacity.

According to this model the economy is assumed to consist of n industries. In any given year, a certain amount of each industry's output is used in the RES sector. Let $\mathbf{f}_{it}$ denote the $n \times 1$ vector of domestic output used in the process of deploying RES technology i during year t. It is useful to think about this final demand vector as the sum of two parts, accounting respectively for those goods and services that are used in the construction, installation and manufacturing (CIM) phase ($\mathbf{f}_{it}^{\mathrm{CIM}}$) and O&M phase ($\mathbf{f}_{it}^{\mathrm{O\&M}}$) of RES deployment. The economic impacts resulting from the former are only temporary, whereas those from the latter cover the entire life of the plant and may be assumed as permanent (Haerer and Pratson 2015). Then, $\mathbf{f}_{it} = \mathbf{f}_{it}^{\mathrm{CIM}} + \mathbf{f}_{it}^{\mathrm{O\&M}}$.

Using familiar results from IO analysis (Miller and Blair 2009), the increase in domestic industry output necessary to meet the additional demand can be calculated as

$$\mathbf{x}_{it} = (\mathbf{I} - \mathbf{A}_t)^{-1}\mathbf{f}_{it} \qquad (1)$$

where $\mathbf{A}_t$ is the $n \times n$ matrix of direct domestic input coefficients for year t and $\mathbf{I}$ denotes a suitably sized identity matrix.

Given an $n \times 1$ vector $\mathbf{w}_t$ describing industry-level labor requirements (e.g. full-time workers per unit of output) in the economy, the corresponding employment impacts are straightforwardly obtained as

$$\mathbf{e}_{it} = \hat{\mathbf{w}}_t\mathbf{x}_{it} \qquad (2)$$

A superimposed circumflex denotes a vector diagonalized into a matrix with all off-diagonal entries equal to zero.

Each element of $\mathbf{e}_{it}$represents total additional employment arising in a certain industry either directly (i.e. in the production of goods and services that are used directly in RES manufacturing, construction, installation, operation, maintenance, and so forth) or indirectly (i.e. upstream in the supply chain). By contrast, direct employment effects are computed as $\hat{\mathbf{w}}_t\mathbf{f}_{it}$.

The implications of RES deployment in terms of value added are calculated using essentially the same approach, but replacing $\hat{\mathbf{w}}_t$ with a set of coefficients that describe the share of industry output accounted for by value added.

2.1 Empirical implementation of the input-output model

The input, employment and value added coefficients of the IO model can be readily compiled from statistical information included in supply and use tables (SUTs) of the economy, a set of "matrices that record how supplies of goods and services originate from domestic industries and imports and how those supplies are allocated between various intermediate or final uses" (United Nations 2009).

In Italy, the National Statistics Office (Istat), produces SUTs on an annual basis. Even so, there is an unavoidable time lag involved in collecting and processing the underlying data. In addition to this, industry classification used for the SUTs changed in 2008. As a result, no harmonized SUT time series is available for the entire 2006-2014 period covered by our analysis.

While in principle it would be desirable to account for structural changes in the economy, data limitations suggest that any expeditious attempt to do so would risk introducing as much bias as it removes. In fact, the time span of the analysis is fairly short and the degree of industry aggregation in the Italian SUTs is relatively coarse, so that any input substitution can be reasonably expected to occur predominantly within rather than between industries. Under such circumstances, it seems improbable that dramatic changes in model coefficients would be observed, even if times series data were available. Overall, the assumption of time invariant IO model coefficients appears empirically harmless. Hence, the input coefficient matrix, as well as the employment and value added coefficients, are taken as constant through time. Our IO model was compiled from the 2011 SUTs, which at the time of writing are the most recent available. Furthermore, 2011 is, by far, the year when the largest annual RES capacity addition was observed and therefore plays a pivotal role in our analysis.

Economic activity is organized according to a 63-industry aggregation of the Nace Rev. 2 classification. Conversion from the SUTs to a symmetric IO table was carried out using a transformation known as Model D (Eurostat 2008b).

The employment coefficients are computed from industry-level data about total hours worked and output. The resulting labour requirement in terms of number of hours per unit of product is converted into annual full time equivalent (FTE) jobs assuming a yearly workload of 220 days per year and 8 hours per day. Throughout the paper, monetary values are expressed in 2011 prices unless otherwise noted.

2.2 RES deployment and the final demand vectors

The main empirical challenge with regard to our analysis lies in the construction of the final demand vectors $\mathbf{f}_{it}^{\mathrm{CIM}}$ and $\mathbf{f}_{it}^{\mathrm{O\&M}}$ for each RES technology i and year t. Let P_{ijt} denote the overall capacity (e.g. expressed in MW) of all plants in existence at time t that use RES technology i class j. Then, $\Delta P_{ijt} = P_{ijt} - P_{ij,t-1}$represents capacity additions during period t. Information about existing capacity is available from official sources (GSE 2015; Terna 2015a) broken down not only by technology but also by plant capacity as described in Table 2.In principle, it is possible that ΔP_{ijt} underestimates capacity additions. This would be the case, for example, if old plants are decommissioned or repowered at the same time new ones being installed. In practice, plant decommissioning is not a serious concern in the context of our analysis. Excluding large hydropower facilities, Italy had very limited renewable capacity in all other sources (especially PV solar) at the beginning of our period of reference. In few instances in the dataset $P_{ij,t-1} > P_{ij,t}$. In those cases, we assume capacity additions to be zero. The magnitude of the figures involved is such that the overall results of the analysis are not affected in any empirically relevant way.

For each technology and class, we constructed a pair of vectors of direct technical requirements that describe the amount of goods and services necessary for deploying one unit of capacity. The first, $\mathbf{v}_{ij}^{\mathrm{CIM}}$, represents the one-off requirements of the CIM phase. The second, $\mathbf{v}_{ij}^{\mathrm{O\&M}}$, accounts for the annually recurring requirements of the O&M phase. At this stage, no distinction is made between imports and domestically produced goods and services. Also, requirements are assumed constant throughout the time period of interest. Coherently with the IO model used in the analysis, they are valued at 2011 prices.

In practice, the $\mathbf{v}$'s was developed by means of a thorough review of the literature and structured interviews with experts and practitioners in the field of RES in collaboration with GSE, the Italian state company in charge of the management of RES incentives. We referred to existing professional literature made by reports of major industry associations (such as SolarPower Europe former European Photovoltaic Industry Association, the European Wind Energy Association, the Italian Agro-energy Association), of IRENA, research centres (such as the National Renewable Energy Laboratory and the Italian centre of Research on Electrical System), coupled with expert interviews. In order to be able to represent more accurately the role of imports in the subsequent stages of the analysis, the technical requirement vectors were constructed with a much finer degree of product disaggregation than the SUTs and the IO model of equation (1).

Table 2. Classification of RES technologies and for demand vector construction

Technology	Power Capacity (MW)
Solar PV	P < 0.02 0.02 < P < 1 MW P > 1
Wind onshore	P < 0.02 0.02 < P < 0.2 0.2 < P < 1 1 < P < 5 P > 5
Hydro Reservoir	0.001 < P < 5 P > 5
Hydro run-of-the-river	P < 0.02 0.02 < P < 0.2 0.2 < P < 1 1 < P < 5 P > 5
Landfill gas	0.001 < P < 1 1 < P < 5 P > 5
Solid waste	0.001 < P < 1 1 < P < 5 P > 5
Wood and wood chips	0.001 < P < 1 1 < P < 5 P > 5
Biogas from energy crops and by-products of food production	0.001 < P < 0.3 0.3 < P < 1 1 < P < 5
Biogas from livestock waste	0.001 < P < 0.3 0.3 < P < 1 1 < P < 5 P > 5
Bioliquids	1 < P < 5 P > 5

The additional demand resulting from CIM phase of technology i deployment in year t is calculated as $\mathbf{z}_{it}^{\text{CIM}} = \sum_j \mathbf{v}_{ij}^{\text{CIM}} \Delta P_{ijt}$. Correspondingly, for the O&M phase, $\mathbf{z}_{it}^{\text{O\&M}} = \sum_j \mathbf{v}_{ij}^{\text{O\&M}} P_{ijt}$. The quantity $\sum_i \mathbf{z}_{it}^{\text{CIM}}$ can be thought of as total investment in new RES capacity in year t.

The $\mathbf{z}$'s incorporate demand for both domestically produced and imported goods and services. Neglecting the fact that a certain portion of the goods and services used by Italy's RES sector is sourced from foreign suppliers would lead to overestimating the sector's contribution to the domestic economy.

To account for imports, we define a vector of year-specific domestic trade coefficients, $\mathbf{c}_t$. Each vector element represents the share of RES-induced demand for the corresponding product that we presume is met by domestic producers. We refer, therefore, to the elements of $(1,1,\dots,1)' - \mathbf{c}_t$ as import shares. In practice, $\mathbf{c}_t$ is constructed using detailed production and international trade data retrieved from official sources. A more detailed description of this step can be found in section 2.3.

After the import component was removed from the $\mathbf{z}$'s using the appropriate trade coefficients, the resulting domestic demand vector is aggregated to the 2-digit CPA classification of the SUTs through pre-multiplication by an aggregation matrix $\mathbf{S}$ consisting of suitably arranged ones and zeros. Finally, the RES-induced demand vectors are converted from their current classification by product to the necessary classification by industry using the appropriate transformation matrix, $\mathbf{T}$, which is readily obtained from the data contained in the SUTs (Eurostat 2008b).

Thus, for $k \in \{\mathrm{CIM}, \mathrm{O\&M}\}$, the final demand vectors that activate the IO model of equation (1) are constructed as

$$\mathbf{f}_{it}^{k} = \mathbf{TS}\hat{\mathbf{c}}_t \mathbf{z}_{it}^{k} \tag{3}$$

2.3 Estimation of the trade coefficients

The main source of information for the domestic trade coefficients is Eurostat's Europroms database. Covering approximately five thousand industrial products on an annual basis, Europroms combines production data collected through the Prodcom survey and external trade statistics for all European countries using a product classification that is perfectly aligned with that of the SUTs. It is worth noting, however, that agricultural products and services fall outside the scope of Europroms. Therefore, in the case of some products the trade coefficients had to be obtained from more aggregate data contained in the SUTs. Since generally import shares for services – e.g. legal, accounting, installation services - are significantly smaller than they are for manufactured products, it seems reasonable to expect our results not to be affected in any meaningful way. This could be a problem, in principle for bioenergies. However, Italy followed a policy designed to incentivize small plants fed by local supply chains, so that imports ought to be limited.

For each product appearing in $\mathbf{z}_{it}^{k}$, the corresponding entry of $\mathbf{c}_t$ is computed as

$$\frac{\text{production} - \text{export}}{\text{production} - \text{export} + \text{import}} \tag{4}$$

The denominator, a quantity known as apparent consumption, represents the total value of the product in question that is used inside the country during the relevant year. Then, the ratio (4) estimates the proportion of apparent consumption that was satisfied through domestic production.

In principle, the commodities appearing in the $\mathbf{z}$ vectors could be linked with Europroms data at a very fine level of product detail. For example, the trade coefficients for photovoltaic cells, a key component of solar plants, could be computed from data relating to the 8-digit Prodcom code 26.11.22.40 corresponding to "Photosensitive semiconductor devices; solar cells, photo-diodes, photo-transistors, etc.".

Yet, several characteristics of the Europroms database caution against this approach (Eurostat 2008a): missing values due to confidentiality or classification changes can result in gaps in the time series; commodity codes can be reported incorrectly; individual plant components can be traded as parts of semi-finished products; storage and re-export of imported goods can distort domestic trade coefficients.

In practice, we chose to match the elements of the final demand vectors with the Europroms database at the level of 4-digit codes. Thus, for example, we construct the trade coefficient for solar cells using data about aggregate 26.11 “Electronic components”. Overall, this seems a reasonable compromise between obtaining trade coefficients that are as product-specific as possible, and avoiding grossly misstated import estimates or spurious dynamics resulting from underlying data problems. Finally, short-term fluctuations in the data are smoothed using a simple 5-point centred moving average.

3. Results and discussion

3.1 Investment

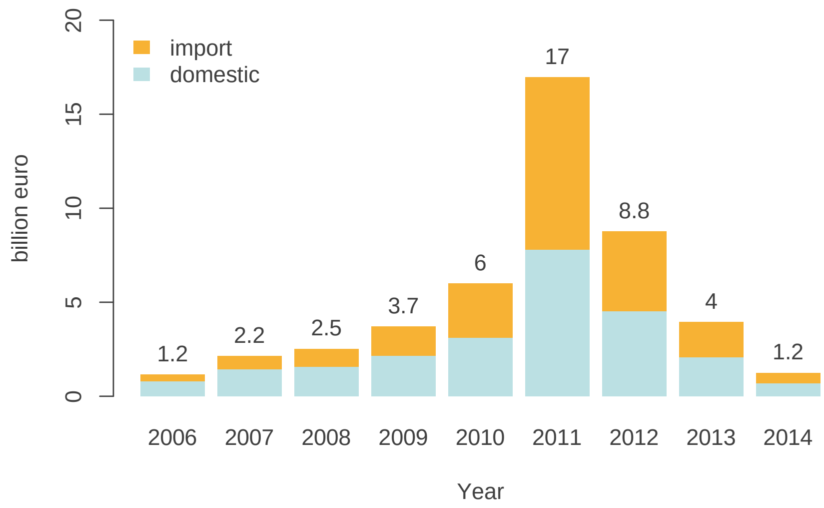
As stated in the introduction at the beginning of 2006, the starting point of our analysis, Italy’s entire RES capacity amounted to 25.5 GW and consisted almost entirely of hydropower facilities. Together, wind farms and biomass power plants were responsible for less than 9% of installations. Solar PV generation was virtually non-existent. Within less than a decade, RES capacity roughly doubled. The single largest contribution came from mass deployment of solar PV: by the end of 2014, Italy’s solar PV generating capacity reached 18.6 GW. While not as dramatic, the growth rates experienced by wind onshore and biomass technologies were also remarkable. With regards to wind power generation, it should be noted that at the time of writing all of Italy’s capacity is located onshore.

Such an expansion in generating capacity required substantial investments. Combining the technical requirements vectors with data about new RES installations, we estimate that, over the period 2006–14, the CIM phase of new plants used about 46 billion euro worth of goods and services (Figure 3). RES investment accelerated rapidly in the late 2000s and peaked in 2011. Afterwards, with the government gradually scaling back support for RES, investment in new capacity shrink.

In this respect, some caution is necessary when interpreting the timeframe of our results. Our methodology attributes all the economic consequences resulting from the installation of a new RES plant to the year it becomes operational. In practice, however, the existence of certain latency in the manufacturing and installation process means that to some extent those consequences may have taken place at an earlier time.

Irrespective of its exact timing, the mass deployment of RES technologies that took place around the turn of the decade represented a significant stimulus for the Italian economy. It is important to recognize, however, that a certain portion of the additional demand for goods and services arising in the RES sector must have been met by imports. Our analysis suggests that, over the entire period under consideration, goods and services supplied by foreign producers accounted for almost half the total spending on new RES capacity. If only manufactured goods are taken into account, the import share rises to 61%.

Figure 3 – Demand for goods and services resulting by CIM phase of new RES plants (2011 prices)



3.2 Employment

Our analysis suggests that, at its peak in 2011, the RES sector directly supported about 86 thousand FTE jobs (Table 3). Taking indirect jobs into account, the total rises to 148 thousand FTE. At this stage, employment in the industry was dominated by the CIM phase of new plants.

As RES investment slowed down in subsequent years, CIM-phase jobs fizzled out. We calculate that in 2014 new installations provided barely 5 thousand direct FTE jobs. By the time this happened, however, Italy had accumulated a sizable stock of RES capacity that needed management and maintenance. Our results suggest that in 2014 direct O&M-phase jobs numbered about 39 thousand FTE. Overall, in the most recent year on record, total employment in Italy's RES sector appears to have been approximately 69 thousand units.

Table 3 Employment in Italy's RES industry (FTE jobs)

year	**CIM**			**O&M**			**CIM and O&M**		
	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total
2006	4,941	4,934	9,875	10,238	5,796	16,034	15,178	10,730	25,909
2007	9,262	9,224	18,486	11,001	6,147	17,148	20,264	15,370	35,634
2008	10,142	9,632	19,774	13,711	7,234	20,945	23,853	16,866	40,719
2009	14,026	12,962	26,988	18,332	9,225	27,557	32,358	22,187	54,545
2010	21,132	18,590	39,722	22,653	11,364	34,017	43,785	29,954	73,739
2011	54,227	45,254	99,481	31,910	16,780	48,690	86,137	62,034	148,171
2012	31,065	26,691	57,756	38,130	19,940	58,070	69,195	46,631	115,826
2013	14,263	12,374	26,636	39,655	20,816	60,471	53,918	33,190	87,108
2014	4,802	4,197	8,999	39,257	20,775	60,032	44,059	24,972	69,031

PV solar was responsible for most of the jobs – direct and indirect, CIM and O&M, created during the 2006-2014 period (35%) followed by bioenergy (33%), hydro (19%) and wind (13%).

Bioenergies despite accounting for just 5% of new installed capacity were particularly effective in creating jobs, especially in the O&M phase. Wind sector, despite representing 24% of new installed capacity, wasn't as effective in employment creation.

As mentioned a particular effort was devoted to the construction of the final demand vectors $\mathbf{f}_{it}^{\mathrm{CIM}}$ and $\mathbf{f}_{it}^{\mathrm{O\&M}}$ for each RES. Thanks to this we are able to accurately measure jobs created in each NACE industry. 25% of NACE (16 out of 63 involved) are responsible for 80.6% of all jobs created (see Table 4). For ease of interpretation, the 63 industries of the IO model are aggregated into four major groups (agriculture, manufacturing, construction and services). The aggregation is carried after the model calculations.

Looking at these numbers we discover that 42% of all jobs created are related to services, 34% to manufacturing activities and 16% to agriculture and 9% constructions. Surprisingly services account for a higher share of CIM employment than OEM. However, when we look at direct employment manufacturing-related activities generate the most of it. Arguably, services took the leading role since 61% of manufactured goods have been imported. Markaki et al. (2013) concluded that manufacturing accounts for the largest share of both direct and indirect employment. It is worth noting that their model involved only 17 NACE industries and they assumed that imports would cover 40% of investment spending. This underlines, as we discuss further, the importance of trade when evaluating impact of RES deployment. Agriculture cover a very important in OEM because of bio-product supply.

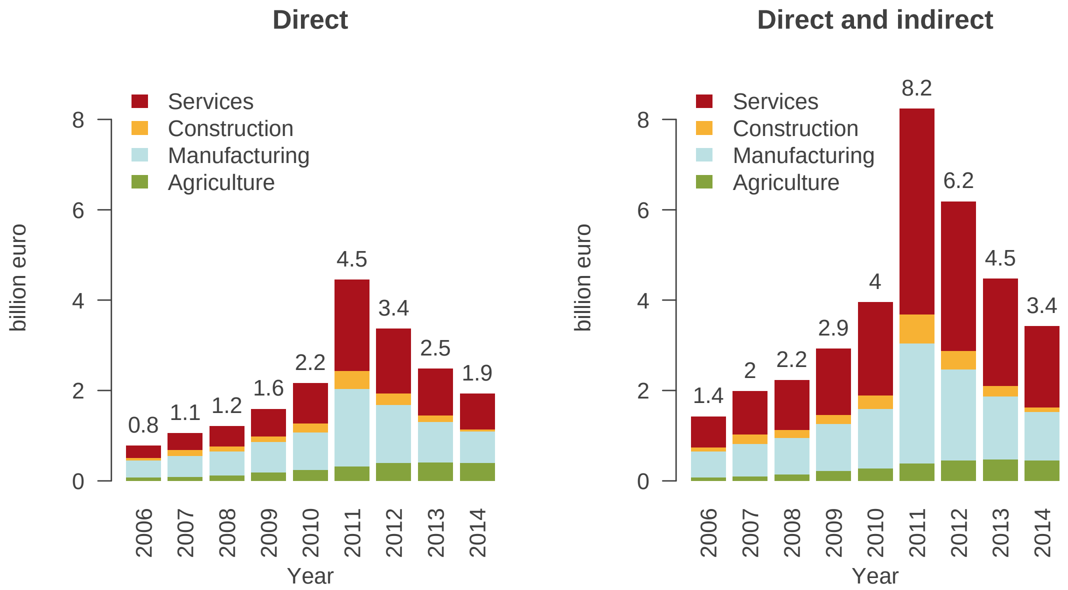
Table 4 Employment by sector in Italy's RES industry (FTE jobs)

SECTOR	TOTAL	CIM	OEM	DIRECT	INDIRECT
Agriculture	16%	1%	32%	23%	5%
Construction	9%	15%	1%	9%	8%
Manufacturing	34%	38%	29%	39%	26%
Services	42%	46%	38%	29%	60%

3.3 Value added

Value added numbers reflect employment findings. The results of our modelling exercise with regard to value added are summarized in Figure 4, which also provides a breakdown by industry.

Figure 4 – Value added generated by Italy's RES industry



In 2014, the RES industry appears to have directly contributed almost EUR 2 billion to Italy's value added. The O&M phase of existing plants is responsible for a dominant share (about 86%, according to our calculations) of that figure. Accordingly, service industries generate most of value. Services, however, also accounted for a major share of value added in those years when new installations boomed. In 2011, for example, services were the single largest share (45%) of direct RES industry value added. In our framework, this is due to the fact that manufactured products used in the CIM phase of new plants generally have large import shares. In other words, a sizable part of the value added associated with manufacturing leaked abroad through imports of plant components.

A non-negligible share of RES industry value added takes place in the agricultural sector. While biomass plants do have substantial agricultural feedstock requirements, obtaining accurate import shares for those products is difficult due to data limitations. As discussed above, in the absence of more specific information, our calculations have to be based on average import shares relating to the entire agricultural sector. In this respect, an underestimation of leakages is, to some extent, possible.

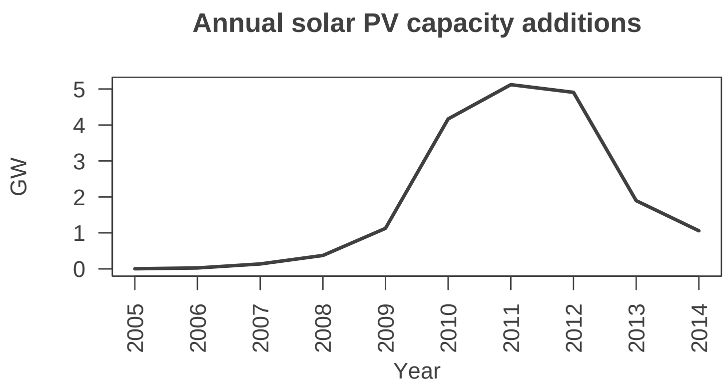
Finally, it is interesting to observe that in 2011, in the midst of a prolonged period of economic crisis, RES industry's contribution to value added, approximately 8 billion euro, represented about 0.5% of Italy's overall total.

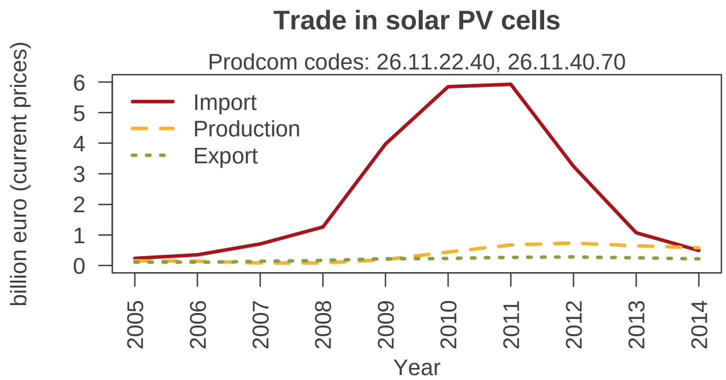
3.4 RES deployment and imports: the case of solar PV cells

A non-negligible portion of the additional demand for goods and services resulting from RES deployment seems to be met by foreign suppliers. In particular, our analysis suggests that imports were substantial for several manufactured goods used in the CIM phase of new installations.

Solar PV cells provide a striking example of the empirical significance of import leakages in some segments of the RES industry. Accounting for approximately 30% to 50% of the total investment cost, solar cells are core components of PV generation systems. As a result of an unprecedented boom in installations, solar PV's contribution to Italy's electricity generation went from negligible to about 8% of the total in 2014 (Terna 2015a). A remarkable 90% of the country's existing capacity came online between 2009 and 2012. A crude estimate based on prices reported by Miraglia (2013) suggests that, over that four-year period, demand for solar cells totalled between EUR 22 and 31 billion. In Figure 5, the dynamics of new solar PV installations are compared with Europroms data on Italy's output of and international trade in solar cells. For the purpose of the graph, solar PV cells are identified by the Prodcom codes 26.11.22.40 and 26.11.40.70.

Figure 5 – Solar PV capacity additions and trade in solar PV cells (3-year centred moving averages)



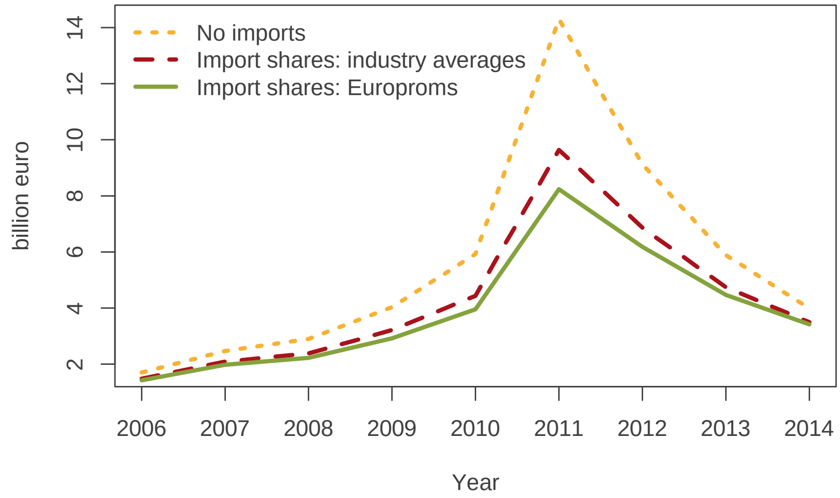


Clearly, a spike in solar cell imports accompanied the rapid solar PV capacity expansion in 2011 (the time lag that can be observed in the graph seems consistent with CIM lead times). Overall, during the 2009-2012 period, Italy imported approximately EUR 20 billion worth of solar cells. Conversely, domestic output remained remarkably small relative to our demand estimates throughout the period under study. In fact, bearing in mind the limitations of international trade statistics and Italy's modest productive capacity, it seems possible that the share of solar cells supplied by foreign manufacturers could be even larger than the one suggested by these figures. For example, Terzini et al. (2011) reports that in 2010 domestic producers met only 15% of Italy's demand for PV cells. Comparable figures can be found in D'Orazio (2009) as well.

3.5 Empirical relevance of import leakages

Setting aside the special case of solar cells, to what extent was the economic stimulus resulting from RES deployment dampened by import leakages? In order to get a sense of the empirical significance of leakages, Figure 6 compares the estimate of total RES industry value added calculated above (green solid line) and the largest value that could have theoretically been attained (dotted orange line) had all goods and services used by the RES industry been produced domestically, by setting $\mathbf{c}_t = \mathbf{0}$ for all t in (3).

Figure 6 – Total value added of the RES industry under alternative assumptions about import share



According to our calculations, the actual value added of Italy's RES industry over the entire period under study amounted to about two thirds of the hypothetical maximum it could have been reached under a no-import scenario. By no coincidence import leakages are most significant when largest capacity additions took place, because of substantial amounts of imported manufactured products required. In 2011, for instance, RES industry value added reached barely 58% of its theoretical maximum potential.

The above results attest that, unless products supplied by foreign producers are not properly taken into account, there is a serious risk of overestimating RES industry's contribution to the domestic economy. In our analysis, this issue is addressed by relying on detailed product-specific time-varying trade coefficients constructed from the Europroms database whenever possible.

How these results would be affected if we chose a simpler and more conventional approach to accounting for imports? The dashed red line in Figure 6 represents the results of the total value added calculations obtained under an alternative definition of the trade coefficients. In this case, import shares are assumed constant over time. They are estimated using aggregate commodity data extracted from the SUTs. For instance, the relevant trade coefficient for solar PV cells is computed from 2011 data on production, import and export of 'Computer, electronic and optical products' (commodity 26 of the CPA classification), and applied to all years from 2006 to 2014. Clearly, RES industry value added estimates obtained from this alternative set of trade coefficients is significantly larger than the one calculated using the arguably more accurate trade coefficients constructed from the Europroms database. In 2011, for example, the former exceeds the latter by about 17%. In other words, taking advantage of the Europroms data seems to improve the accuracy of the calculations.

3.6 Validation

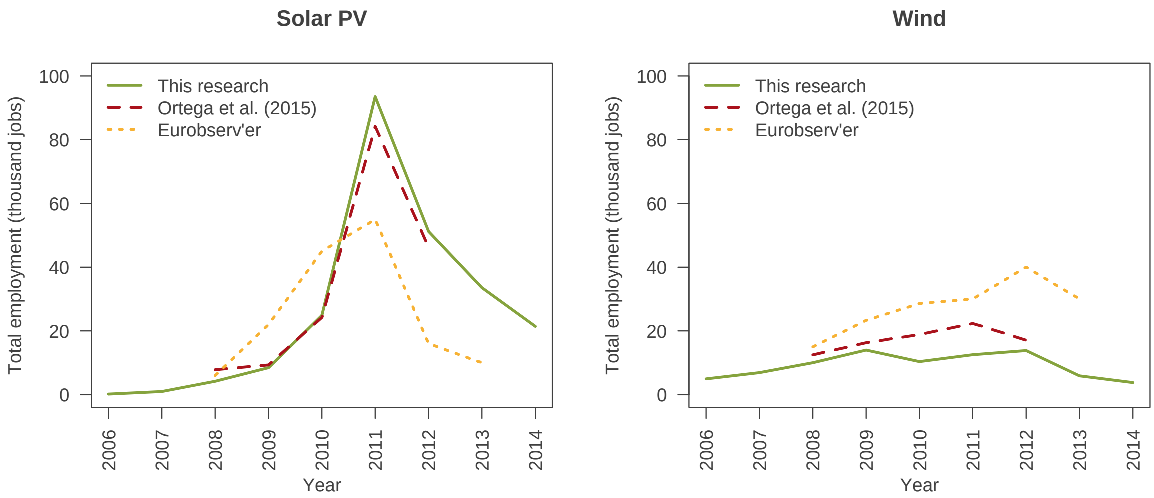
In order to check the validity of our results, we compare the employment figures we obtained from our analysis of Italy's RES sector with other estimates that have been proposed by the literature and previous studies. At this stage, we consider only two technologies: solar PV and onshore wind. These two technologies account for the bulk of Italy's RES capacity increase during the period under study. In addition, the employment implications of their deployment have been the focus of a relatively large body of literature.

Figure 7 contrasts total employment in Italy's RES industry as calculated in this research with estimates reported in Ortega et al. (2015) – henceforth referred to as ORRT – and EurObserv'ER (2009; 2010; 2011; 2012; 2013; 2014). With regard to solar PV, our estimates are strikingly similar to those of ORRT, who used an entirely different methodology. Our results are also broadly compatible with the employment figures in Eurobserv'er. The latter, however, imply a more even distribution of solar PV jobs over time.

In the case of wind onshore technologies, the three sets of estimates are not as concordant. Our results are at the lowest end of the spectrum. Eurobserv'er reports the highest employment values throughout the period but, as information about their methodology could not be located, we find it difficult to speculate as to the reason of the divergence.

On the other hand, a number of factors could help explain the difference between our results and ORRT's. For example, our analysis only considers those jobs that result from domestic installations, whereas ORRT also take into account those associated with exports. Secondly, for several key wind plant components, there are gaps in the time series of Italy's output due to the data being suppressed for confidentiality reasons. In principle, how those gaps are interpolated can affect the results of the employment calculations. To some extent, ORRT's assumptions about lead manufacturing and construction time might also account for some of the observed difference.

Figure 7 – Comparing estimates of total RES employment from various sources, Italy

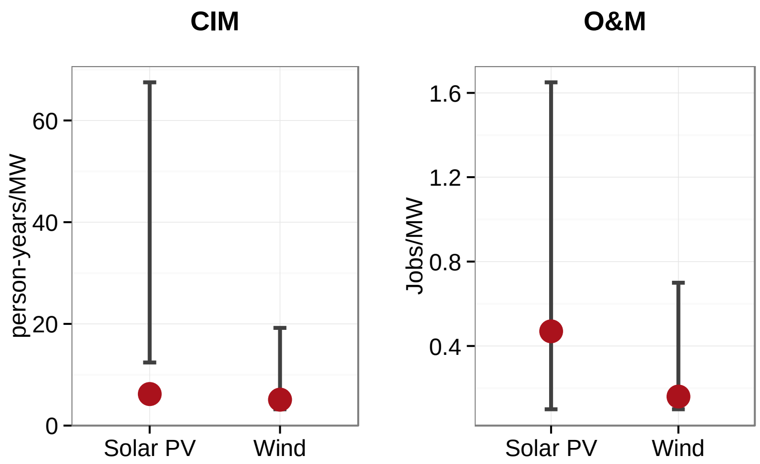


As an additional check on the validity of our analysis, we examine the relationship between the employment factors implicit in our results and the range of estimates in the literature as they emerge from a recent review by (Cameron and Van Der Zwaan 2015) – referred to as CZ from this point on.

To this end, we first restate the outcome of our calculations in relative terms. Specifically – year by year and technology by technology – we calculate total employment in the CIM phase per unit of newly installed capacity (i.e. person-years/MW) and total employment in the O&M phase per unit of existing capacity (FTE jobs/MW). Such employment factors are not constant over time, because the trade coefficients and the mix of plant of classes changes from year to another. Their averages over the period under study are represented by the red dots in Figure 8. The vertical segments, on the other hand, describe the range of estimates that CZ observed in the literature.

In general, our results lie inside the intervals identified by CZ, even though they are at the lower end of their respective ranges. The employment factor of the CIM phase for solar PV, however, is smaller than the smallest value found by CZ. A plausible explanation of this finding is that, throughout the period under analysis, Italy – contrary to many of the countries where the studies reviewed by CZ were carried out – was highly dependent on imports for many plant components, most seriously so for solar PV cells and modules.

Figure 8 – Total employment per unit of capacity: results of this study and ranges reported in the literature (Cameron and Van Der Zwaan 2015)



Finally, we confronted our results with main Italian studies published applying IO methodology. As we may note in Table 5 two studies carried out in 2007 and 2009 on behalf of the Ministry of Environment (CNES 2007) and of the National Council of Economy and Labour (Barbarella, Liberatore, and Galli 2009) focusing respectively on solar PV and Wind provided very high estimates. D'Orazio (2009), on the contrary, reports results that are much more in line with our own calculations..

Table 5 Total employment per unit of capacity: results of this study and main Italian studies

	(CNES 2007)	(Barbarella, Liberatore, and Galli 2009)	(D'Orazio 2009)	Our Estimate
PV	42,45	-	11,46	12,49
Wind	-	79	10,78	7,34

4. Conclusions and Policy Implications

Despite two main studies – TERES II in 1997 and EmployRES in 2009 – on the basis of which the EC drafted its proposals, warned that net employment potential could be limited, policy makers continued, to follow the assumption that the creation of a huge domestic market will reinforce European leading role in industrial production of RES technologies. A virtuous cycle in which an environmental policy positively affects innovation and employment creation.

Italy strongly embraced EU vision and enacted in 2007-2008, before 2020 climate and energy package was officially adopted, a wide range of measures towards RES. Results, in terms of installed capacity, went beyond rosiest expectations. Manufacturing activities were actually responsible of the largest share of direct employment, even though services accounted overall for the largest share of new jobs. However, as our study shows, additional demand took off too rapidly and was met mostly through imports, failing to stimulate significant employment creation in domestic industrial sector. The subsequent and sudden phase-out of incentives didn't allow new industries to consolidate. Castello et al. (2015) report that, for example, the production of photovoltaic cells in Italy drastically reduced in 2014 because several national operators went out of business because of the end of incentives. This is the reason why Haerer and Pratson (2015), in their analysis on employment trends in the US, explicitly excluded CIM jobs.

Ragwitz et al. (2009) pointed out that positive net economic impact in terms of value added and employment mostly depended from new installations and exports to the rest of the world. Implicit in their view was the assumption that European companies would maintain and develop their first mover advantage. However, especially in the case of solar cells, this vision failed to materialise and actually market share of EU companies contracted (Ossenbrink et al. 2015). Our analysis clearly shows that gross employment impact of RES was overestimated because of not taking into account appropriately import leakages.

Main beneficiaries of Italian RES policy have been the service sector and agriculture, the first in the CIM activities the second in O&M activities. However, regarding bioenergies, Berndes and Hansson (2007) concluded that their potential contribution to employment is just "a few percent", moreover they underlined that potential conflicts between maximization of employment creation and maximization of climate benefits may arise.

In 2014 the EC proposed a new policy framework for climate and energy from 2020 to 2030. Under the new approach a single binding target on GHG reduction (-40% compared to 1990), declined at national level and EU-wide RES target (27% of final energy consumption), will be adopted. The emphasis on employment has shifted towards broader concept of eco-industries (European Commission 2014a) and with reference to jobs "created or maintained" (European Commission 2014b). The focus on RES is more on full integration into the market, sustainability and harmonization of incentive schemes across the EU, than on broad support (European Commission 2015). Looking at this new policy we may assume that a reassessment occurred and policy maker adopted a rather more cautious approach towards linking employment and growth with energy and climate action. Our analysis confirms, nevertheless, that RES policy generated a positive gross impact in terms of value added and employment, albeit more limited than estimated. The importance of creating jobs in the service sector should not be discarded since it actually represents a far larger share in the economy, also in terms of value added, compare to manufacturing and these jobs are mainly domestic.

In general, from our study we could trace several policy implications for future policies:

- When defining a policy with industrial implications, import leakages should be better assessed, otherwise there is the risk to indirectly finance foreign industries;
- The uptake of the policy and its phase out should be well calibrated. As the Italian case shows, a too rapid uptake in an open economy favoured imports because the economic tissue was not able to adapt in such a short timeframe. At the same time, a too rapid phase out dented investors' confidence and deprived a nascent industry of domestic demand. Future analyses should also model take-off and phase-out phases;
- Most of environmental/energy policies involve the adoption/deployment of new technologies and a change in the structure of the economy. In order to evaluate their socio-economic impacts, first they should take into consideration not only direct employment and manufacturing, but also indirect employment and services. Second, the evaluation must be run on a longer timeframe in order to catch the impact that occur beyond the limits of the policy.

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