Considerations on the Italian agricultural Biogasdoneright potential

Estimation methodology and data analysis regarding the Italian Biogas Consortium Position Paper

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Summary

Foreword

Since its beginning the members of the Italian Biogas Consortium have asked themselves some questions about the meaning and role of anaerobic digestion in farm and have drawn up a strategic plan with the goal of produce agricultural biogas while continuing to produce quality food.

This goal is based on the Biogasdoneright, that means the integration of the anaerobic digestion at the farm allows the production of biomass for the biogas production without lowering the food or feed production for the market. Thanks to the Biogasdoneright principles it is possible to change completely the farming activities and keep the soil covered the whole year, diversifying crop rotations, reducing the chemical fertilizer consumption by using digestate and thus improving the fertility of the soil, using renewable energy to operate the machines and for drying the fodder

The prerequisite to achieve this agricultural revolution is the ability of the Biogasdoneright to allow a farmer to produce more polluting less at the same time.

Since the dawn of the Italian agricultural biogas, that became the third globally after China and Germany, with 4 billion € investments and 12.000 direct, qualified and permanent jobs[1] created **it has raised the issue of efficiency in land use**, clarifying the point about "**from where biomass come from**", by selecting type of biomasses to be used in the digester without incurring phenomena of "competition" with food and feed crops, and therefore improving the competitiveness of the farms and their efficiency also from an environmental point of view.

The CIB farmers since the beginning asked themselves:

a) Which is the meaning of making biogas from monocrops?

b) How much first crop land (in monocrop or sequential crop) can be usefully utilized for biogas production without perturbing food and feed output?

c) Which other integration biomasses can be used in anaerobic digestion to integrate the biomasses produced at the farm?

The result is a roadmap plan for Italy, published for the first time by CIB about 5 years ago, which regards a production of 8 billion Nm^3 equivalent biomethane. This could have been used as raw biogas in internal combustion engines or injected n the gas grid to be used in cogeneration, in the transport sector as clean fuel or in other industrial applications.

The plan target was to increase the domestic production of fossil natural gas by 1.5 times, biogas from waste included. This target would bring the rate of national supply over consumption of natural gas at the time[2] at about 25%, three times more than the fossil methane production were able to ensure. A production equal to

[1] Irex Annual Report – Althesys 2015
[2] Consumption of aprox. 65 Bill. Nm^3

9 times the current of methane in transport consumption, about 30% of the energy consumed from the Italian transport sector overall (gasoline and diesel).

The plan was based on absolute clarity about the biomasses to be used in order to avoid distortions in the various Italian agricultural territories, where often it exists delicate balance, different and changing just a few kilometers away from one agro-ecological zone to another:

a) silage monoculture (first crop) or otherwise double crops intended both for the AD and produced using up to 400,000 hectares, arable land left for set aside to accomplish set aside EU obligation few years ago discontinued and that formerly was used to fill sugar quotas[3]

b) livestock effluents, agricultural residues, agro-industrial by-products resulting from the processing of agricultural products;

c) cover crops grown before or after a cash crop for the market or the stable, normally harvested as silage, grown where before there was no production because there was no local demand for these biomass as transport costs were too high;

d) perennial crops on marginal land being abandoned, like alfalfa in the Monferrato hills, or nitrogen fixing tools in annual rotation with cereals to avoid monocultures, as in the case of Italian sainfoin in rotation with durum wheat in the South.

Five years ago we envisaged the production of 8 billion Nm^3 of methane equivalent until 2030, by using these above mentioned biomasses. **Yet, it was clear since the beginning that this objective could be achieved only through a real agricultural revolution[4] that implies a radical change in the way we do agriculture starting from the use of the soil, the tillage and fertilization techniques**.

So we placed at the center of our strategy the goal of efficiency in land use, defined as the ability to support with increasing amounts of "integration biomasses" those coming from the use of 400,000 ha ; corresponding to the 3% of the Utilized Agricultural Area (UAA) and it is the space we estimated the Italian agriculture could leave to diversify the output markets for the farms without misbalancing the local Food & Feed market.

In the following chapters therefore we will verify the current status of Italian biogas production according the original roadmap (here below) and thus we can test the assumptions behind it and the soil usage efficiency reached by the farms that started to apply Biogasdoneright.

		2010	2015	2020	2025	2030
Total Biomethane	**(GNm^3/year)**	**0.70**	**2.20**	**4.20**	**5.50**	**8.0**

[3] Set aside is not any more mandatory and the sugar beet crop decreased 5 times its area.
[4] Not by chance this year the annual event of CIB "Biogas Italy" was called "Agricultural Revolution"

1. Work target

The present document aims at providing details about the Biogas potential in Italy, showing its real technical feasibility from a quantitative point of view thanks to the “Biogasdoneright” approach that, combining already existing technologies, efficient biological processes and good farming practices, it allows to produce an advanced biofuel with low carbon footprint.

In this specific case, based on the “high efficiency in land use” principle, we rely on a steady increase in the use of:

a. Integration biomasses (cover crops before or after cash crops)
b. Livestock effluents
c. Others agricultural residues and agro-industrial by-products.

While at the same time there is a steady decline of first crops or crops obtained from lands used for producing only biomass for the AD.

In order to understand deeply the assumptions the integration biomasses produced or that can be produced in Italy and their quantities, their physical chemical characteristics and energy yields and their role in the agriculture context will be described.

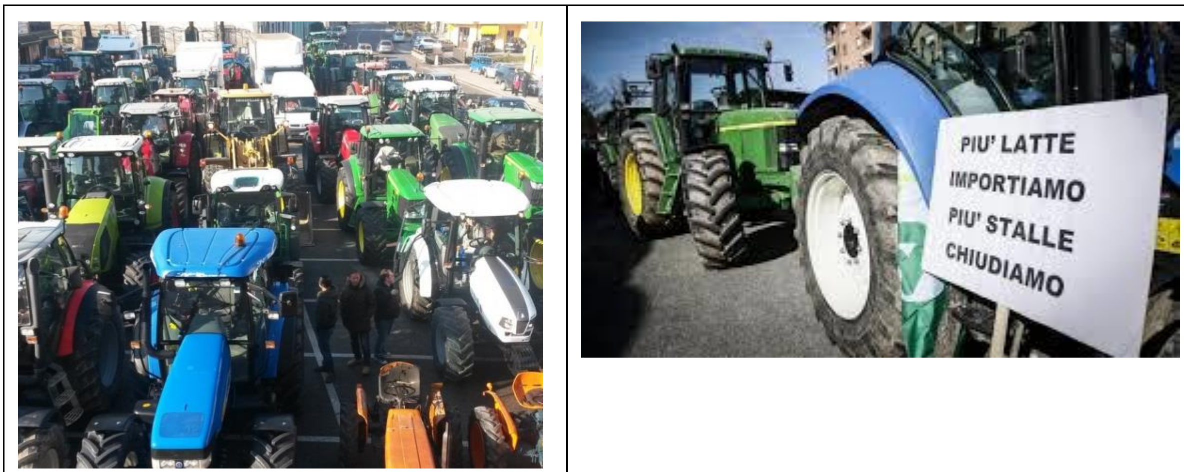


Figure 1 – Demonstration of Italian dairy farmers

In this way we intend to demonstrate with real data and potential assessments the ability of the Italian agriculture sector to meet the target of 8 billion cubic meters of biomethane preventing any effect of indirect land use change (ILUC[5]) and conversely **boosting agricultural entity's ability to continue to be competitive on the Food market and being sustainable at the same time.**This approach depends on many factors,

[5] ILUC: Indirect Land Use Change. The Directive 2015/1513 amending the Directive 98/70/EC on the quality of gasoline and diesel fuels and the Directive 2009/28/EC on the promotion of the use of energy from renewable sources, have modified the approach to the ILUC concept, accepting integration crops (which follow or precede food crops) for the production of advanced biofuels.

ranging from work layout at the farm to the existing markets for the farm outputs, this latter fact that should not be overlooked especially under the current economic conditions[6] where many agricultural and livestock prices are too low and force many farms to close[7] (figure 1).

In addition to the 2030 biomethane scenario from agriculture biogas also the OMW biomethane production capacity will be outlined as additional source of Biomethane for Italy

2. The assumptions of the CIB position paper: The Land Efficiency

The term "land efficiency" in the bio-energy context means the total quantity of primary energy obtainable from a hectare of agricultural land used to produce biomass for bioenergy (rather than feed or food products).
The land efficiency is calculated from the following formula (freely adapted and adjusted from the study of Lynd et al, 2007- see bibliography):

$$FCLR\ (ha) = (A - I)/C * 1/P$$

Where:

FCLR (First crop land requirement)	Land needed (ha) of first crop harvest to reach the desired yearly Biomethane production
A	Total production of Biomethane (Nm^3/year)
I	Production of Biomethane generated via Integration Biomasses (Nm^3/year)
C	Biomethane yield as first crop biomass (Maize) (Nm^3/t DM)
P	First crop yield (t/ha DM)

From this formula we derive that the "Land Efficiency" of the Biogasdoneright is given by the ratio between the total year Biomethane production (factor A in the formula, Nm^3/year) and the UAA used for the first crop harvest (the FCLR, ha).

[6] See FAO Food Price Index (http://www.fao.org/worldfoodsituation/foodpricesindex/en)
[7] http://www.fao.org/about/who-we-are/director-gen/faodg-statements/detail/en/c/275129/ Global Forum for Food and Agriculture, 2015 FAO Working Meeting "Addressing Food Security Challenges under Increasing Demand for Land, Soil and Energy" 16 January , Berlin, Germany.

LAND $EFFICIENCY_{BIOMETANO}$ = A/FCLR (m^3 CH_4/ha) >> C*P (m^3 CH_4/ha)

It is clear that "I = integration biomass" is the key factor[8] in the formula. From now until 2030, thanks to a steady increase in integration biomasses and a correspondent steady decline in first harvest crops the Land Efficiency of Biomethane is going to increase over time.

Table 1 –Development scenario for biomethane and its land efficiency for the Italian biogas sector until 2030 (*)

			2010	2015	2020	2025	2030
(A)	**Total Biomethane**	**(GNm^3/year)**	0.70	2.20	4.20	5.50	8.0
(FCLR)	**- UAA monocrop**	(ha)	85,000	200,000	250,000	300,000	400,000
		(ha/Nm^3 CH_4)	121	91	60	55	50
(C x P)	**- Monocrop yield**	(Nm3/ha CH_4)	6,720	6,720	6,720	6,720	6,720
(A/FCLR)	**LAND EFFICIENCY**	**(Nm^3/ha CH_4)**	**8,235**	**11,000**	**16,800**	**18,333**	**20,000**
(A - I)	**Monocrop Biomethane**	**(GNm^3/year)**	**0.57**	1.34	1.68	2.02	2.69
(I)	**Integration biomass Biomethane**	**(GNm^3/year)**	**0.13**	0.86	2.52	3.48	5.31
(I)	**Integration biomass Biomethane**	**(%)**	**18%**	39%	60%	63%	66%

(*) In 2015the installed power for agriculture and OMW biogas amounted to 950 MW, corresponding to circa 2-2,1 billion Nm3 biomethane equivalent. Biogas applied almost only in Combined Heat and Power (CHP).

In the following paragraphs, we will outline:

a) The current state of Italian agriculture and biogas development;

b) The reasons why to allocate 400,000 UAA for AD only biomass production;

c) The kind and amount of integration biomasses that are reasonably available for biogas production until 2030.

[8] The development of "Integration Biomass" is the key aspect of redesign the farming activities around the AD plant. Thanks to the AD is possible to lower GHGs emissions from conventional farming, increasing productivity, achieve a real "ecological agricultural intensification" and store carbon in the soil

3. Monocrops area

A characteristic shared by the first generation bioenergies is the large use of monocrops such as cereal grains and oil seeds for bioethanol or biodiesel.

In the initial stage of Italian biogas a large input of Maize silage was used to feed the ADs. Since the farms realized that in that case they need to purchase on the markets the feed for the animals or that they did not have any more grains to sell on the market, the need to reduce monocrops in biogas production emerged.

Italy has circa 12,400,000 ha of UAA (see further in section 4.2.1), a surface that is constantly decreasing due to urbanization at the rate of circa 40 ha daily[9].

In our assumptions, we considered that 400,000 ha can be realistically dedicated to ADs, a value that corresponds to 3% of the Italian UAA. This value is a conservative estimation and is lower than the technical and economic potential available for ADs biomass production.

To support our estimation, it can be noticed that in the recent past the surface dedicated to the set-aside in Italy amounted to 200,000 ha[10]. In the same period, the EU sugar reform triggered the closure of 7 out of 9 sugar mills in the north of Italy, freeing a considerable amount of land. From 2006 to 2015 the surface dedicated to sugar beet crops declined from 250,000 ha to 50,000 ha. (Source: ISTAT 2014-2015).

These agriculture land for AD dedicated monocrop has an expected production of Maize silage and or sequential crops that amount to 6,720 Nm^3/ha, with a production of 20 ton DM/ha and a productivity of 336 Nm^3 CH4/ton DM. With these assumptions is easy to calculate the expected production of biomethane equivalent, that amount to 2.688 billion Nm^3 biomethane (400,000 ha X 6,720 Nm^3/ha), thus roughly one third of 2030 target.

[9] ISPRA "Il consumo di suolo in Italia – Edizione 2015" Rapporti 218/2015

[10] The set aside rule, today not binding any more, was the 5-10% of the total farm area.

4. Integration biomasses

The next step has been the identification of which biomasses could be used to produce biomethane in order to meet the target of 8 billion Nm^3/year for 2030.

Referring thus to the proposed formula, we needed to identify biomasses for the "I" factor amounting to 5.312 billion Nm^3/year until 2030.

In the following table, the breakdown of biomethane production into the different sources.

Table 2 – *Forecasts until 2030 of biomethane production and the biomasses needed.*

	2030	
	(GNm^3/year)	**(%)**
Total Biomethane	**8.0**	
a) $BioCH_4$ from monocrops	**2.688**	**34%**
b) $BioCH_4$ from integration biomasses	**5.312**	**66%**
- of which:		
- **from integration crops**	2.656	33%
- from residual biomasses	2.656	33%

Here below we clarify the method used to estimate the "integration biomasses":

- Integration crops
- Residual biomasses: agricultural residues, livestock effluents, agro-industrial by-products

and their available quantities for the conversion to biomethane and their energy yields.

Residual or waste biomasses generated by the farming activities (especially livestock effluents) and by the first processing steps (canned vegetables, dairy and meat processing) represent a large share of integration biomasses, estimated via survey at national and regional level. Different kind of residues and by products are listed and with given percentages for their recovery and use in AD, explained case by case.

Regarding the "integration crops" we proceeded to evaluate their implementation from a technical point of view, especially regarding the crop rotations for food and feed, analyzing the singularities of each crop in order to proceed to the estimation of the agricultural surface needed to meet the target in table 2, considering especially the different regions and their output.

The different biomasses (either residues, by products or from integration crops) has been coupled with a specific biomethane yield per ton of fresh matter, measured on the average dry matter (DM) content and their Volatile Organic Compounds (VOC). All the yields used were measured by the CRPA laboratory and based on a database with more than 2,100 analysis performed on more than 200 matrices. The specific yields have been confirmed also by the output of biogas plants. More information on the biomethanation tests and their output can be found in the listed bibliography.

4.1 Residual biomasses

Before analyzing in detail of the different residual biomasses from other production processes, it must be pointed out that everything stated above is possible, feasible and sustainable over time thanks to the flexibility of anaerobic digestion, an energy conversion technology, with a broad and versatile application regarding not only the plant size but also the kind of input biomass.

In fact the production of biogas is generated, with optimum and constant energy performance over time, starting from very diverse biomasses in terms of chemical-physical quality. Biogas is indeed a winning technology when it comes to recover energy from residual biomasses since it can handle very diverse inputs and also a blend of different biomasses in the so called "diet" of the AD.

The "**co-digestion of different biomasses**" is the best way both to obtain high yields of energy and to keep within acceptable limits the critical issues arising from the use of individual matrices that are non-uniform between them and in time.

The list of the types "residual biomasses" that can be started at the anaerobic digestion process is wide and varied, as below here outlined.

4.1.1 Livestock effluents

The amount of livestock effluents was estimated from the number of animals bred (ISTAT, Animal Husbandry National Registry) and their average weight by unit production ratio, which relates to animal species, the bred at the growth stage, and the stable layout considered as predominant for each category. In this regard, it is recalled that the applied method of calculation is the same as entered in the technical standards for the application of the former Art. 38 of Legislative Decree 152/99, now Legislative Decree 152/2006 at the national level: the DM 07.04.2006, recently replaced and augmented with digested by the recent Decree of 25 February 2016. The different unit rates of manure production are the result of numerous projects research conducted by CRPA (Research Center on Animal Production) since the early 70s, collected and organized in a systematic way in the book "Manure Manual" published by the Emilia-Romagna Region, then updated in 2001 ("Livestock manure. Manual for agronomic use" published by L´Informatore Agrario).

The species concerned are cattle and buffaloes, pigs and poultry.

More in details for the total estimation of their manure and effluents potential, the following elements have been considered:

- Number of heads bred: the source is the ISTAT database integrated with other sources when available.
- Definition of the breeding conditions for the different species and different growth stage (through dedicated surveys and sources), aimed at estimating the more precise production coefficient for the waste generation.
- Definition of average manure and effluents per head of bred animal, based also on the kind of breeding (pasture or stable etc etc) applied in different regions.

The above mentioned elements allowed the precise estimation of the manure available per specie and breeding conditions.

In total, the estimated manure produced amount of circa 129 tons of manure and effluents (**table 3**) with a breakdown as showed **in figure 2**.

Table 3 *- Estimation of livestock effluents produced over Italy*

	Total effluents	Cattle and buffaloes	Pigs	Poultry
	(ton)	(ton)	(ton)	(ton)
ITALY	128,654,188	93,540,425	31,479,759	3,634,005
NORTH	92,364,152	62,720,998	26,606,764	3,036,390
CENTER	10,800,864	8,227,152	2,343,864	229,848
SOUTH	25,489,172	22,592,275	2,529,131	367,766

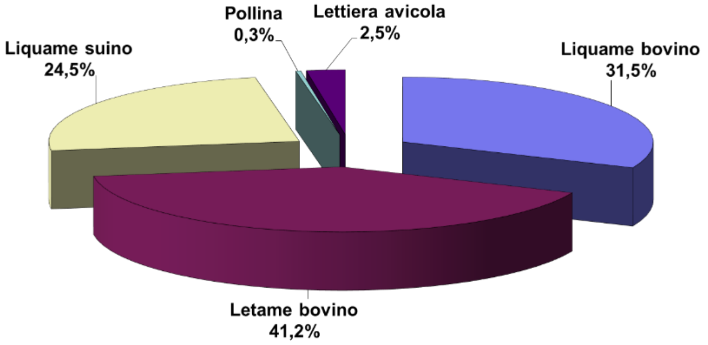


Figure 2 *–Breakdown of different kind of effluents, nationwide numbers.*

It is therefore a not negligible amount and widespread over the country, also in the south. Beside small deviations from the reported numbers (the heads can be 5-10% more or less of the reported numbers) the amount of manure is available to produce large quantities of biogas.

The co-digestion of animal manure and other biomass is the most widespread practice, according to the census of agro-livestock biogas plants conducted in 2013 (C. Fabbri, 2013), which actually photographed the national situation at the end of the three years of incentive with Feed-rate. **For the purposes of the overall object of this study, it was assumed that the anaerobic digestion of manure**

become an increasingly common practice which in 2030 will involve up to 70% for cattle and buffalo manure and for 50% for the pig and poultry manure.

The motivations behind these choices are the following:

- the mitigation of GHG emissions from the livestock production when it is coupled with the AD are well known and the AD plant became the pillar around which to build a sustainable meat and dairy industry from an environmental, economic and social point of view. Then a further growth of AD coupled to livestock can be envisaged;
- the European and national regulatory framework push in this direction. Environmental policies are very clear in this regard; the economic support tools made available for agricultural producers (RDP 2014-2020) aimed at improving competitiveness by lowering the carbon footprint per unit of product weight and in general to reduce pollution by agriculture and livestock production.

4.1.2 Crop residues

Farming activities produce crop residues suitable for energy use, consisting of all plant parts that do not represent the main product intended for human food or animal use, such as stems and leaves, cobs, etc .. The quantification of each agricultural waste product has been estimated using three essential parameters:

- total production for each herbaceous crop (average yields for the region - Source ISTAT 2010);

- relationship between by-product and the main product (different bibliographic sources);

- fraction or percentage of the residue or by-product already recycled or reused.

For the main row crops (cereals) diversified coefficients have been used in function of the different regions. For these crops where the recovered fraction is not existing, a near 100% availability has been considered in all the regions.

Even with such restriction the availability of biomass is large, about 15 million ton residues are estimated; 10 million tons of straws and 5 million tons of others (leaves, cobs…)

Furthermore it is estimated that about 20% of this crop residues (3 million tonnes, or 30% of the portion formed by straw and stalks) will / can be converted to biogas (in addition to the amounts already contained in manure). This is due to the expectation that, in presence of a digester, the use of bedding material on farms will increase, bringing other advantages, such as: increase animal welfare through drier and cleaner litter, adopting stable layout solutions with better bedding also for laying hens. Therefore the AD also works to improve animal welfare in the livestock industry.

4.1.3 Agro-industrial by-products

As regards the agro-industrial by-products, the assessment was performed on the productive sectors that generate good quality of organic residues on regular bases and in significant quantities; in particular under the spotlight ended industries of manufacturing and processing of grapes, olives, citrus and tomato industries, meat industry and milk processing. These are in fact the processing sectors that generate the largest flows.

For each of the sectors of processing and marketing of agricultural products listed above, the quantitative assessment of the flows of generated by-products was based on the following elements:

- Quantities of raw materials processed input to the various production cycles (milk, tomatoes, grapes, olives). The sources used are the official ones, such as ISTAT, associations, Confindustria, Food, Producers Organization section;
- Kind of processing and ratio by-product/product that applies (cheeses, different kind of canned vegetables etc etc)
- Definition of "unit rates of by-product production per unit weight of raw material input".

It must be noted that the definition of the selected coefficients derives from a specific depth survey led by CRPA on the agro-industrial sector of the Emilia-Romagna region, where a high degree of integration in the supply chain is observed. Emilia Romagna is the second region after Apulia for processed tomato; 30% of national production of canned pulses. Finally, it is the second region for pigs and poultry and the third of cattle for production.
The production ratios of the various by-products over the raw material input weight were measured based on tests conducted in over 30 processing industries, chosen from those most representative of the size and type of products, in the Emilia Romagna region. The survey was conducted by CRPA within the Interregional Project PRO-BIO Biogas, funded by the Ministry of Agriculture, Food and Forestry (Edited by CRPA "Mapping of organic wastes from agriculture, livestock and agro-industrial present context land of Emilia-Romagna "Emilia-Romagna region, 2006).

The same methodology adopted to estimate manure and agro-industrial by-products has been applied in the study by CRPA on behalf of Ispra (www.isprambiente.gov.it) which led to the publication of the report "Study on the use of biomass fuels and biomass waste for energy production "111/2010 Report (ISBN: 978-88-448-0440-4).

Once estimated the total amounts available for the most relevant agro-industrial by-products, the percentages suitable for ADs have been estimated between 30% to 70% and this quantity will raise to almost 100% until 2030.

Today their valorization in AD is increasing not only in dedicated ADs built in the vicinity of slaughterhouses or other large processing facilities, but also in agricultural biogas plants that rely more and more on such matrices than using dedicatedly grown silages.

By-products of the cereal milling industry have been also used in the estimation, though these by-products are also traded and used either as feed or animal bedding. The quantification has been possible via the EXTRAVALORE project (Riva G., 2013); as overall the amount of available biomasses corresponding to 2.2 million tons, an amount that does not consider rice processing.

As already clarified, the by-products of the milling industry are mainly used in the feed market but are a good matrix for biogas production.

It is anyway difficult to estimate in a reliable way the quota available for ADs, therefore we opted for a conservative estimation of 10% especially if also batches not suitable for feed use can be valorized. Contaminated feed represent a cost for the farmer that need to pay for its disposal. It must be noticed that corn flour, when contaminated with aflatoxins above the legal limit can be used in AD. A recent study from

CRPA (L. Rossi, 2015) demonstrated how corn flour with AFB1 (the most dangerous aflatoxin) 10-20 times higher than the legal limit can be used in AD up to 10% in weight of the daily diet with biogas output comparable with not contaminated flour. Moreover, despite the gradual feeding of contaminated flours, no accumulation effects have been measured; conversely, concentrations of AFB1 measured in digestates are clearly lower than expected. Based on the total mass balance, it was observed a reduction in weight of AFB1 ranged from 62 to 98% of the total amount loaded.

4.1.4 Total biomethane from residual biomasses

By 2030 biomethane from "residual biomasses" is just under 3 billion Nm^3/year, slightly above the target value shown in **Table 2**; certainly livestock effluents play a fundamental role, considering the total quantities produced, but as mentioned above, it is also the residual biomass that is more and more likely to go to biogas/biomethane.

Table 4 *- Residual Biomasses and Biomethane Producible - Projection by 2030.*

	Estimate total amount	Estimated total amount for AD	Specific BioCH4 yield		TOTAL BIOMETHANE
	[t/y]	[t/y]	[Nm^3/t VS]	[Nm^3/t raw material]	[Nm^3/y]
TOTAL RESIDUAL BIOMASSES	**158,591,330**	**91,751,270**			**2,940,334,342**
Livestock effluents	**128,654,190**	**83,035,179**			**2,228,243,245**
- cattle slurry	40,553,860	70%	240	14.1	400,607,251
- pigs slurry	31,479,760	50%	300	9.7	152,047,241
- laying hen manure	419,650	50%	320	106.6	22,372,381
- cattle manure	52,986,560	70%	212	38.3	1,420,094,914
- poultry litter	3,214,360	50%	300	145.1	233,121,459
Agro-industrial by-products - vegetables	**4,787,680**	**2,153,996**			**100,823,498**
- olive residues	1,283,700	50%	250	88.3	56,643,263
- olive water	1,711,600	30%	475	16.6	8,536,605
- marc grapes	1,280,000	50%	111	32.9	21,027,840
- citrus pulp	306,480	70%	311	42.9	9,207,456
- tomatoes (peel)	205,900	70%	318	37.5	5,408,334
Agro-industrial by-products - animals	**10,149,460**	**3,562,095**			**182,903,916**
- bovine, pigs and poultry slaughter	1,149,460	75%	517	138.8	119,626,716
- milk industry (whey)	9,000,000	30%	372	23.4	63,277,200
Cereal milling by-products	**2,271,000**	**227,100**			**69,263,683**
- total (rice not included)	2,271,000	10%	353	305	69,263,683
Agricultural residues	**15,000,000**	**3,000,000**			**359,100,000**
- total (straw, stems, leaves)	15,000,000	20%	190	120	359,100,000

It should be noted that the estimate of the overall biomethane production from residual biomasses as described above has been conducted with precautionary criteria, such as:

- quantitative estimates are based on processed raw material data for the years 2012-2014; It has been verified that variations in the amount of processed raw material found in the last few years in fact involve minor changes in the quantity of by-products generated;
- a specific biomethane yield, calculated on real and repeated data (excluding unjustified peak values) has been assigned to each biomass;
- the flow generated by the fruit processing industry was not counted because it is not significant in terms of quantity compared to others and is usually destined for distillation. In areas where there are such activities, actually part of this stream is still producing biogas;
- by-products from the processing of legumes (peas and beans) and potato, are considered minor flows and not counted, but their sending to anaerobic digestion is a common practice. Similar considerations apply to beet pulp, also considering the decrease in the surface area;

- finally, the by-products generated by the food industry (bread production and bakery products, various food preparations, etc.) were not considered because they were difficult to be quantified but still available (although not significant) and excellent for the production of biomethane (Low humidity, high presence of degradable organic matter).

4.2 Integration cropping

The Italian agriculture can rely on a series of advantages that allow an integration crop (also known al sequential crop) to the conventional monocrop rotations performed all over the country.

The advantages to perform a sequential crop are:

- Soil with different characteristics but with good fertility;
- Large biodiversity and hybrids available for the different climate and soil zones;
- Long growing seasons thanks to Mediterranean climate, especially in center and south areas
- Availability of combined agricultural machineries for sequential cropping that makes more operation steps per passage so minimizing time between harvest and seeding.
- Large availability of irrigated or irrigable land, although with regional differences on the north-south axis.
- With low water availability the digestate, diluted with water, can be used in micro irrigation, thus recovering all the nutrients.

In function of the local area referred (north, center, south) it is possible to report examples of sequential crops where it is produced for the food&feed market or for energy[11]. Here below examples where in uppercase there is the production for the *BIOGAS* and in lowercase the production for the *market*.

PO RIVER VALLEY:	
TRITICALE	Maize or Soy or Tomato
RYEGRASS	Maize or Soy or Tomato
Wheat, Barley	SORGHUM
FORAGE MIXES	Maize or Soy or Tomato
WHEAT, BARLEY	Maize grain
Horticultural crops	SORGHUM
Wheat	MAIZE SILAGE
CENTER SOUTH ITALY	
LEGUMES MIXTURES	Legume grains
Durum wheat	ITALIAN SAINFOIN
Durum wheat	SORGHUM

[11] "Second Harvest: Bioenergy from Cover Crop Biomass" NRDC 2011 http://www.nrdc.org/energy/files/covercrop_ip.pdf)

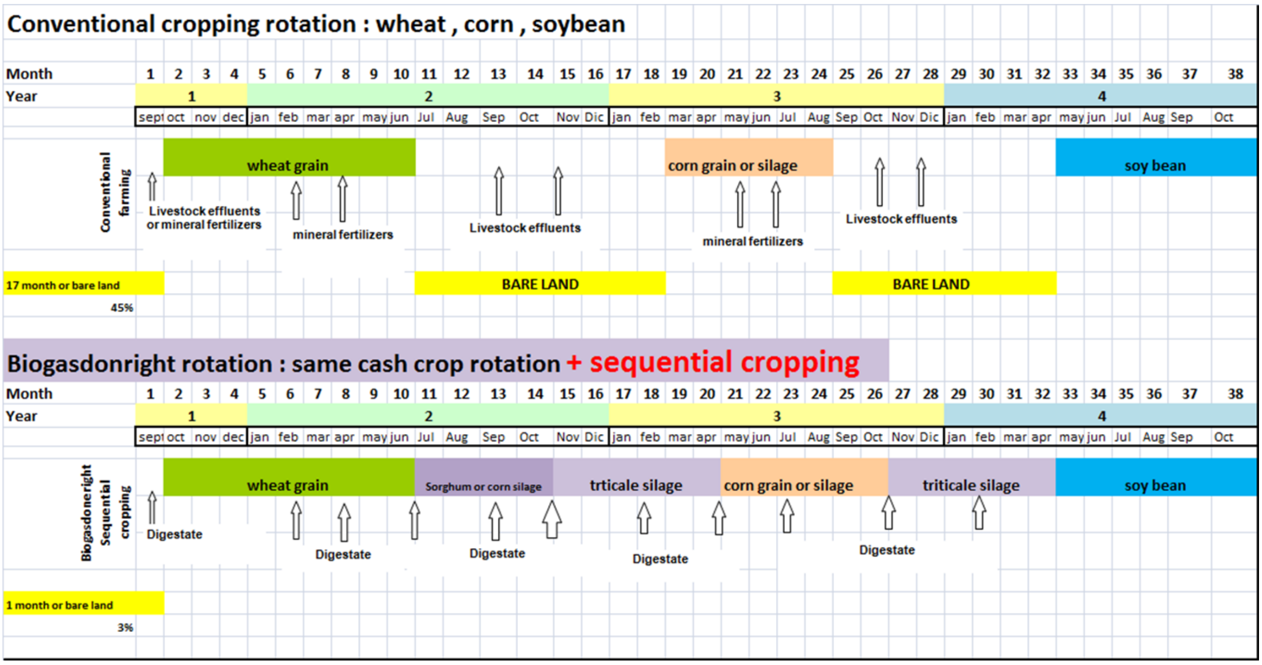


Figure 3 *– Example of conventional rotations (above) and sequential cropping (below). It is evident the additional carbon production in sequential cropping.*

With the **figure 3** we want to highlight the advantages of sequential cropping over the same farmland. Advantages that are not limited to the additional biomass produced but also linked to the increased soil coverage, soil erosion prevention, nutrient leakage and increased soil fertility as overall[12].

Without stepping into agronomic details, it is easy to infer that in the application of sequential cropping it is better to switch to shorter growing cycles, in order to have sufficient time for the field operations and the following seeding. It is therefore to expect a lower crop yield and a shorter growing cycle.

In **table 5** the average crop yields and energy yields used for the estimation of the present studies are confronted with the ones of monocrop. This is a cautionary approach and indeed often higher yields are observed. We followed this approach to average the effects of climate, rain, water availability and different crops all over the country.

In other words there can be locations where the crop yield per ha is higher due to water availability, soil processability and well-suited weather.

Table 5 – *Crop and energy yield examples (Sources: CRPA, CIB and others)*

			Integration crops	
			Po river valley	**Center South Italy**
P	Crop yield	(t/ha DM)	13	11
C	$BioCH_4$ yield	(Nm^3/t DM)	326	335
PxC	$BioCH_4$ yield	(Nm^3/ha)	4,193	3,518

12 INRA "QUELLE CONTRIBUTION DE L'AGRICULTURE FRANÇAISE À LA RÉDUCTION DES ÉMISSIONS DE GAZ À EFFET DE SERRE? POTENTIEL D'ATTÉNUATION ET COÛT DE DIX ACTIONS TECHNIQUES. Juillet 2013

Reconsidering the estimation in Table 2,_keeping in mind that the 2030 biomethane from integration crops target is 2.6 billion Nm^3/year it can be derived that <u>the surface needed (UAA) for integration crops can be estimated between 630,000 ha and 763,000 ha, an area corresponding to 10% of the national row crop area.</u>

In these biomass sources, that is worth to mention once again that produce additional carbon, there is a great potential. A suitable agricultural machinery, proper digestate spreading and improved plant genetics can contribute to increase the crop yield per ha in the next years.

4.2.1 Italian agriculture and the Italian agriculture surface

Here below a picture of the agriculture sector based on the statistical data available and needed for this work.

Italy is 1,200 km long with a total area of 302,073 km^2. It is covered by mountains and hills for 35% and 42% and by plan for 23%. Area classified as protected amount to 19% of the total, above the average EU for protected areas (18% for EU in 2013).

In 2013 the total available area for agriculture was 16.7 billion ha (167,000 km^2), of which Total Agriculture Area (TAA) was 12.4 billion ha (124,000 km2) (table 6).

***Table 6 –** Utilization of UAA (000 ha), 2013*

	Italia	UE-28
Superficie totale	16.678	214.578
Superfie agricola utilizzata	12.426	172.920
Seminativi	6.797	103.138
Cereali (%)	52,0	55,6
Leguni secchi (%)	2,4	1,2
Patate (%)	0,8	3,0
Piante industriali (%)	5,7	11,6
Ortive (%)	3,7	2,0
Fiori e piante ornamentali (%)	6,5	0,1
Foraggere avvicendate (%)	28,8	19,2
	0,4	0,2
Coltivazioni legnose agrarie	2.260	10.703
Vite (%)	28,1	28,6
Olivo (%)	47,5	40,8
Agrumi (%)	5,7	1,0
Fruttiferi (%)	17,2	29,0
Orti familiari	30	350
Prati permanenti e pascoli	3.339	57.945
Superficie forestale	3.028	30.379
Superficie agricola non utilizzata	518	11.273
Altra superficie	707	480

The evolution of the agriculture sector is outlined in figure 4. It shows a slow constant UAA in decrease as well as farm numbers.

This trend is confirmed also in the ISPRA report 2015 *(ISPRA "Il consumo di suolo in Italia – Edizione 2015. Rapporto 218/2015*) on soil consumption, especially regarding row crops.

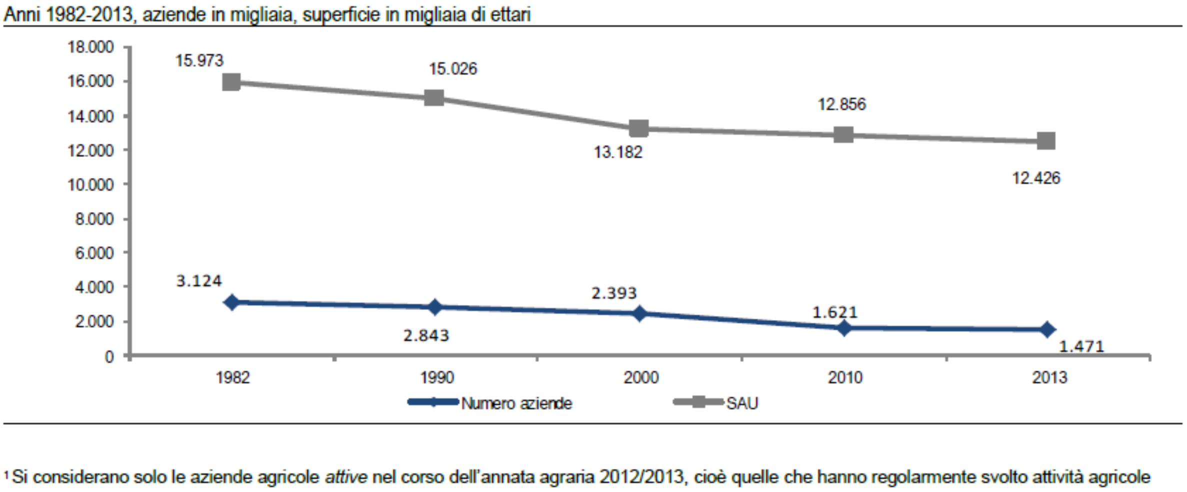


Figure 4 *– Evolution of UAA and farm numbers in Italy from 1982 to 2013*

The regions (**Table 7**) with the highest shares of national UAA are Sicily and Puglia (11.1% and 10.1% respectively), followed by Sardinia (9.2%), Emilia Romagna (8.4%), Piedmont (7.7%) and Lombardy (7.5).

Table 7 – UAA, 2013 (ISTAT, La struttura delle aziende agricole, Settembre 2015)

	UAA 2013		**UAA IRRIGATED**		**UAA IRRIGABLE**	
	(ha)	(%)	**(ha)**	**(% UAA)**	**(ha)**	**(% UAA)**
Piedmont	955,473	7.7	387,000	40.5	453,000	47.4
Aosta Valley	52,872	0.4	10,000	18.9	10,000	18.9
Lombardy	927,450	7.5	579,000	62.4	679,000	73.2
Liguria	41,992	0.3	11,000	26.2	14,000	33.3
Trentino-Alto Adige	365,946	2.9	92,000	25.1	96,000	26.2
Veneto	813,461	6.5	434,000	53.4	566,000	69.6
Friuli-Venezia Giulia	212,751	1.7	108,000	50.8	125,000	58.8
Emilia-Romagna	1,038,052	8.4	343,000	33.0	622,000	59.9
Tuscany	706,474	5.7	51,000	7.2	107,000	15.1
Umbria	305,589	2.5	21,000	6.9	47,000	15.4
Marche	447,669	3.6	30,000	6.7	60,000	13.4
Lazio	594,157	4.8	84,000	14.1	135,000	22.7
Abruzzo	439,510	3.5	38,000	8.6	63,000	14.3
Molise	176,674	1.4	15,000	8.5	22,000	12.5
Campania	545,193	4.4	105,000	19.3	127,000	23.3
Apulia	1,250,307	10.1	265,000	21.2	372,000	29.8
Basilicata	495,448	4.0	38,000	7.7	79,000	15.9
Calabria	539,886	4.3	83,000	15.4	108,000	20.0
Sicily	1,375,085	11.1	165,000	12.0	238,000	17.3
Sardinia	1,142,006	9.2	60,000	5.3	152,000	13.3
ITALY	**12,425,995**	**100**	**2,919,000**	**23.5**	**4,075,000**	**33**
North	**4,407,997**	35.5	**1,964,000**	44.6	**2,565,000**	58.2
Center	**2,053,889**	16.5	**186,000**	9.1	**349,000**	17.0
South	**5,964,109**	48.0	**769,000**	12.9	**1,161,000**	19.5

In order to understand the target of this paper is important to notice the availability of water in agricultural production. In the table are therefore reported recently available data for the different regions.

In 2013 farms with irrigable area are 784 thousands, with a UAA of 7.5 million ha and an irrigable of 4.1 million ha. The irrigated UAA amount to 2.9 million ha.

Italy is one of the countries that rely strongly on irrigation, since rains are not enough in different part of the country.

Italy is second only to Spain for irrigated surface (3 million ha for Spain and 2.4 million ha for Italy) and fourth for percentage of irrigated surface over the total UAA (about 19%).

In detail, in Italy, in 2009-2010, the volume of water used by agriculture amounted to more than 11,500 billion cubic meters. Irrigation was reported in 708,449 companies with 2.489 million hectares irrigated. The situation reported in 2013 thus denoted an increase of irrigated UAA to just under 3 million hectares, despite the decline in total UAA from 2010-2013.

The next step is to map the diffusion of those crops (first crops) that can potentially be suitable for sequential cropping.

In **Table 8** are reported the surfaces in production for each region relative to the year 2014 for grain cereals, forage crops, processed tomato and soya.

Looking into details in the ISTAT data bank:

- "Grain cereals" means: Wheat, Durum wheat, Barley, Rye, Oat, Maize, Sorghum and other cereals;
- "Forage crops" means: Waxy Maize, Barley (grassy or waxy stage), Perennial ryegrass, Grass monophytes, Graminaceae, Legumes, Alfalfa, Lupinella, Italian sainfoin among the others.

The total of these crops is "total potential UAA" that in reason of what is cultivated in the UAA let us understand where sequential cropping is possible.

The total potential UAA sum up to 5 million ha. It can be observed that the area cultivated for row crops and feed are well represented in the Po river valley (north) and center south, especially in Sicily and Apulia.

Table 8 – *Agricultural area break down for categories and potentially available for integration crops (Source: ISTAT 2014 and own elaboration)*

Regions	Cereal grains		Forage crops (ha in production)		Tomato for processing		Soy (*)		Total potential UA for integration crops
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)
Piedmont	263,754	*8.7*	108,333	*5.0*	1,171	*1.5*	12,815	*5.50*	**386,073**
Aosta Valley	33	*0.001*	-	*0.0*	-	*0.0*	-	-	**33**
Lombardy	255,200	*8.4*	342,482	*15.8*	7,207	*9.3*	37,096	*15.93*	**641,985**
Liguria	427	*0.014*	1,939	*0.1*	-	*0.0*	-	-	**2,366**
Trentino-Alto Adige	508	*0.017*	4,706	*0.2*	6	*0.0*	-	-	**5,220**
Veneto	291,878	*9.7*	64,121	*3.0*	2,602	*3.4*	121,440	*52.15*	**480,041**
Friuli-Venezia Giulia	78,769	*2.6*	16,195	*0.7*	26	*0.0*	35,042	*15.05*	**130,032**
Emilia-Romagna	324,429	*10.7*	324,133	*15.0*	24,681	*31.8*	25,251	*10.84*	**698,494**
Tuscany	161,979	*5.4*	125,311	*5.8*	3,093	*4.0*	426	*0.18*	**290,809**
Umbria	116,772	*3.9*	62,928	*2.9*	690	*0.9*	118	*0.05*	**180,508**
Marche	167,026	*5.5*	84,915	*3.9*	35	*0.0*	484	*0.21*	**252,460**
Lazio	93,145	*3.1*	192,627	*8.9*	2,180	*2.8*	84	*0.04*	**288,036**
Abruzzo	90,026	*3.0*	45,469	*2.1*	1,114	*1.4*	111	*0.05*	**136,720**
Molise	71,425	*2.4*	20,390	*0.9*	600	*0.8*	-	-	**92,415**
Campania	109,865	*3.6*	116,789	*5.4*	4,236	*5.5*	-	-	**230,890**
Apulia	414,545	*13.7*	153,005	*7.1*	19,160	*24.7*	-	-	**586,710**
Basilicata	160,287	*5.3*	33,544	*1.6*	2,230	*2.9*	-	-	**196,061**
Calabria	65,363	*2.2*	30,983	*1.4*	2,950	*3.8*	-	-	**99,296**
Sicily	300,630	*9.9*	204,849	*9.5*	5,150	*6.6*	-	-	**510,629**
Sardinia	57,920	*1.9*	230,857	*10.7*	408	*0.5*	-	-	**289,185**
ITALY	**3,023,981**	**100.0**	**2,163,576**	**100.0**	**77,539**	**100.0**	**232,867**	**100**	**5,497,963**
North	**1,214,998**	**40.2**	**861,909**	**39.8**	**35,693**	**46.0**	**231,644**	**99.47**	**2,344,244**
Center	**538,922**	**17.8**	**465,781**	**21.5**	**3,818**	**4.9**	**1,028**	**0.44**	**1,009,549**
South	**1,270,061**	**42.0**	**835,886**	**38.6**	**35,848**	**46.2**	**111**	**0.05**	**2,141,906**

(*) In 2015 UAA grown to more than 300,000 ha

Combining the data from table 7 and table 8 we obtain the detailed breakdown in **table 9**.

It is clear therefore that the 2030 target requires 650,000-700,000 ha for sequential or integration crops. It is a concretely achievable goal, assuming to involve 10 to 20% of the total UAA according to the region, corresponding to a 16% average for the whole country.

At national level, the UAA to be destined for sequential cropping is 31% for the irrigated UAA and 22% of the irrigable UAA. At region level the numbers are different from the national average.

In other words, even with all due caution and considering all the limiting factors to the use integration crops, it emerges an overall picture of effective sustainability, maybe even of underestimation, for the production of these biomasses for the following reasons:

- The UAA needed for sequential cropping is limited to only 16% of the row crops UAA; the easiest to adapt option are also considered, such as grain cereals, feed, soy and processed tomato
- The area foreseen for integration crops It is lower than the Italian irrigated UAA (31%), though with differences according to the regions. In no region the UAA foreseen is larger than the UAA irrigated.
- Finally also in not irrigated area it could be possible some sequential cropping. Often is only the uneconomic of the local conditions that prevent the sequential crops. If there is no markets for the second harvest there is no incentive to make a sequential crop. This happens often in the hilly areas. An AD creates additional demand for biomasses and usually trigger the recovery of land abandoned for lack of profits on local markets for crops that are low in dry matter and therefore the transport costs can be a limit.

Table 9 – Comparison of total UAA, irrigated, irrigable, sequential crops potential and estimation of quota available for intergration crops

	UAA 2013	UAA IRRIGATED	SAU IRRIGABLE	Total potenzial UAA	% UAA destinated integrazion crops	Total UAA to be DESTINED to integration crops			
	(ha)	(ha)	(ha)	(ha)	(%)	(ha)	(% UAA)	(% UAA irrigated)	(% UAA irrigable)
Piedmont	955,473	387,000	453,000	**386,073**	**20**	77,215	8.1	20.0	17.0
Aosta Valley	52,872	10,000	10,000	**33**	**0**	-	0.0	0.0	0.0
Lombardy	927,450	579,000	679,000	**641,985**	**20**	128,397	13.8	22.2	18.9
Liguria	41,992	11,000	14,000	**2,366**	**0**	-	0.0	0.0	0.0
Trentino-Alto Adige	365,946	92,000	96,000	**5,220**	**0**	-	0.0	0.0	0.0
Veneto	813,461	434,000	566,000	**480,041**	**20**	96,008	11.8	22.1	17.0
Friuli-Venezia Giulia	212,751	108,000	125,000	**130,032**	**20**	26,006	12.2	24.1	20.8
Emilia-Romagna	1,038,052	343,000	622,000	**698,494**	**20**	139,699	13.5	40.7	22.5
Tuscany	706,474	51,000	107,000	**290,809**	**10**	29,081	4.1	57.0	27.2
Umbria	305,589	21,000	47,000	**180,508**	**10**	18,051	5.9	86.0	38.4
Marche	447,669	30,000	60,000	**252,460**	**10**	25,246	5.6	84.2	42.1
Lazio	594,157	84,000	135,000	**288,036**	**10**	28,804	4.8	34.3	21.3
Abruzzo	439,510	38,000	63,000	**136,720**	**5**	6,836	1.6	18.0	10.9
Molise	176,674	15,000	22,000	**92,415**	**5**	4,621	2.6	30.8	21.0
Campania	545,193	105,000	127,000	**230,890**	**15**	34,634	6.4	33.0	27.3
Apulia	1,250,307	265,000	372,000	**586,710**	**20**	117,342	9.4	44.3	31.5
Basilicata	495,448	38,000	79,000	**196,061**	**10**	19,606	4.0	51.6	24.8
Calabria	539,886	83,000	108,000	**99,296**	**10**	9,930	1.8	12.0	9.2
Sicily	1,375,085	165,000	238,000	**510,629**	**20**	102,126	7.4	61.9	42.9
Sardinia	1,142,006	60,000	152,000	**289,185**	**10**	28,919	2.5	48.2	19.0
ITALY	**12,425,995**	**2,919,000**	**4,075,000**	**5,497,963**	**16**	**892,519**	**7.18**	**30.6**	**21.90**
North	**4,407,997**	**1,964,000**	**2,565,000**	**2,344,244**	**20**	**467,325**	**11**	**24**	**18**
Center	**2,053,889**	**186,000**	**349,000**	**1,011,813**	**10**	**101,181**	**5**	**54**	**29**
South	**5,964,109**	**769,000**	**1,161,000**	**2,141,906**	**15**	**324,012**	**5**	**42**	**28**

4.3 Biomasses from marginal areas

Very often specific studies on bioenergy potential have referred to the theme of marginal land recovery.

Territories are identified as marginal when they have insufficient agronomic potential with respect to the market demand. This situation derives mainly from the inherent peculiarities of the marginal territory, such as morphological conditions -slopes, altitudes, inaccessibility, etc. that involve structural shortages in transport and communication grids, deterring the establishment and development of productive activities as well as the mobility of people- and inadequate market prices to offset the cost of production factors in these lands.

These areas, therefore, are at elevated risk of marginalization and abandonment. It is important to remember that the concept of marginal areas is used to indicate areas with problems that are not yet identified by a formal definition adopted for instance by Rural Development Plans.

In several Italian Regions, marginal areas are found in much of the mountainous area and high hills. The term “marginalization”, from an economic point of view, indicates the process by which the productive activities fail to ensure an adequate income for the business, due to the high costs of environmental, social and logistical constraints. “Abandonment”, on the other hand, means the temporary or definitive suspension of productive activities, in the first instance of agriculture, which results in the loss of the protection necessary for the conservation and enhancement of the territory. Over time, these factors are likely to lead to the abandonment of entrepreneurial initiatives and demographic decline. The danger to which such areas are subjected is to enter into a vicious circle -the spiral of 'marginality'- characterized by population decline and aging, contraction of the services offered, weakening of the productive tissue and reduction of income.

For the purpose of biomass production in marginal areas for anaerobic digestion, part of these so-called "marginal" soils (a term used by farmers for those soils that, even regardless the soil conditions, generate crops whose value is lower than production costs) could actually be of great help, as already proved in several cases.

In hilltop areas where small livestock farming has disappeared, many pasture meadows have been abandoned. With the establishment of biogas plants, some of them have been cultivated again with alfalfa. The harvested forage is used to feed the digester, fresh or after silage.

In some cases, for example in the Monferrato Hills (Piedmont Region), the alfalfa fields were re-sowed on hilly terrain that would have otherwise been destined to the spread of shrubs and hence the woods.

In the case of Sicily, the diffusion of perennial crops such as the fodder prickly pear (opuntia) and the S*ulla* (Hedysarum coronarium) mainly on the southern slopes of hilly terrain, could help to prevent erosion and desertification of those soils.

For precautionary and communicative reasons, the position paper did not take into consideration any biomass from these lands in the North and the South of Italy.

As far as the precautionary aspect is concerned, as these territories have environmental and social concerns, it is not possible to generalize, and their potential needs to be thoroughly investigated on a case-by-case basis. Surely it is not equal to zero, but it needs to be determined precisely with the involvement of local farmers and institutions. It should be noted, however, that anaerobic digestion for this type of territories presents a twofold importance:

a) It restores the territories by creating a local demand for fodder, where animal husbandry has now disappeared;
b) It paves the way to reinstate organic fertilization, that in turn helps to prevent erosion, desertification and hydrogeological disruption, often due to the abandonment of agricultural practices.

As far as the communication aspect, we chose to underline the message of anaerobic digestion as a tool to improve the sustainability and competitiveness of Italian farms, that does not substitute food and fodder production. Too much emphasis on the use of these lands, considering its social implications, might be misleading, especially when it is contemplated the use of monocrops that can only be used for energy purposes.

In conclusion, we believe that these territories have a high potential to produce profitable biomass, but their exploitation must contribute at the same time to solve the social and ecological problems that have caused the marginalization. Their production will help increase the potential of Italian biogas.

5. Some examples of biogasdoneright land efficiency in Italy

Here are two examples of how Italian biogas has been able to improve efficiency in the use of first-crop fields in recent years, gradually integrating the biodigester diets, and therefore adapting biotechnology and plant technologies, with integration biomass that are residual biomasses or sequential crops. Hundreds of similar cases could have been selected, from North to South of Italy.

Azienda in provincia di Ferrara (Squaccherone)	ton/gg	Nmc biogas /ton	Nmc biogas gg	ton /anno	ton tq/ha	SAU raccolti	FCLR	Mercato / Foraggio
Corn silage after wheat grain	9,6	230	2.200	3.600	45	80		frumento granella /orzo stalla
Wheatr grain						105		Frumento granella
Barely forage						35		Orzo foraggiero per la stalla
Corn silage for the stable monocrop						20		
Corn silage monocrop for digester	4,4	250	1.096	1.650	55	30	30	
Sorghum monocrop for digester	1,6	200	319	600	40	15	15	
Sorghum double crop after wheat	5,6	190	1.060	2.100	35	60		frumento granella /orzo stalla
Triticale silage before tomato	2,4	190	454	900	45	20		pomodoro da industria
Triticale silage before soy bean	11,9	190	2.255	4.465	47	95		Soia per il mercato
tomato wastes	8,0	120	957	3.000				
Bovine manure	8,0	80	640	2.920				
Bovine slurry	12,0	25	300	4.380				
chicken manure	12,6	140	1.764	4.600				
OVERALL	76,0		11.046	28.215		460	45	
			460			320		

FCLR (SAU 1 Mln Nmc CH4 bio)	21

Azienda in provincia di Vicenza (Grana Padano)	ton/gg	Nmc biogas /ton	Nmc biogas gg	ton /anno	ton/ha	SAU	FCLR	Mercato/stalla
Silomais secondo raccolto dopo frumento	-	230	-	-	45	0		
Mais primo raccolto	-	250	-	-	55	0	0	
Sorghum first crop	2,4	200	478	900	45	20	20	
Sorghum double crop	2,1	190	404	800	40	20		Frumento granella
Triticale prima di pomodoro	-	190	-	-	45	0		
triticale prima di soia	-	190	-	-	45	0		
Buccette di pomodotor	-	120	-	-				
Bovine manure	38,0	80	3.040	13.870				
Slurry manure	87,3	25	2.183	32.850				
Chicken manure	5,3	140	744	2.000				
	135,1		6.849	50.420			20	
FCLR	15							

6. Biogas from source separated organic waste (OFMSW)

Since its inception, CIB has been working with the Italian Composting and Biogas Association (C.I.C.) on energy recovery of waste biomass by biogas/biomethane production. Since both CIB an CIC support biomethane development, they have set the boundaries of their scopes: waste management (CIC) and biomass management "no waste" (CIB).

For the sake of completeness of information, therefore, here is a brief note on the situation and the potential of OFMSW biogas, based on official data provided by CIC and ISPRA.

According to the Waste Report 2015 (ISPRA, 2015), in 2014 the national production of municipal waste amounted to about 29.7 million tonnes, 83,000 tons more than 2013 (+ 0.3%). This increase, albeit small, shows a reversal over the trend observed in 2010-2013, when total production decreased about 2.9 million tonnes (-8.9%).

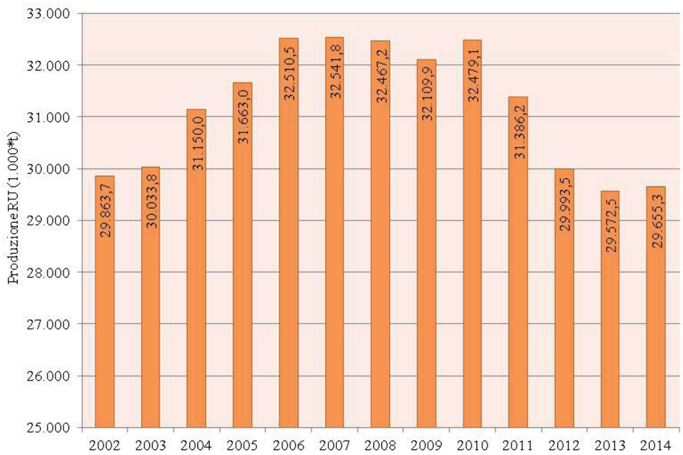
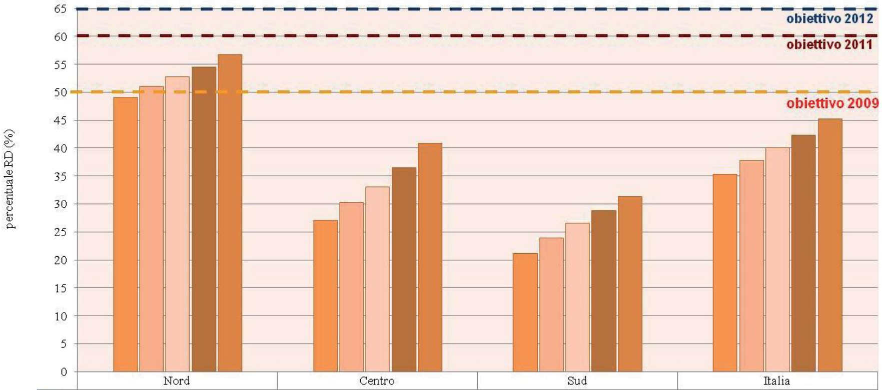


Figure 5 – *Municipal Solid Waste Production 2002 -2014 (Source ISPRA, 2015)*

In 2014, the separate collection amounted to 45.2% of national waste production, with a growth of almost 3 points compared to 2013 (42.3%). With six years of delay, the target set for 2008 (45%) has been achieved. In absolute terms, separate collection amounts to 13.4 million tonnes, 900,000 tonnes more than in 2013 (+ 7.2%).



	Nord	Centro	Sud	Italia
2010	49,1	27,1	21,2	35,3
2011	51,1	30,2	23,9	37,7
2012	52,7	33,1	26,5	40,0
2013	54,4	36,4	28,8	42,3
2014	56,7	40,8	31,3	45,2

Figure 6 – *Percentage of separate waste collection 2010 -2014 (Source ISPRA, 2015)*

The source separated organic fraction (food waste and gardening waste, the OFMSW or biowaste) of municipal waste that has been recycled represents a very significant share of the total amount of municipal waste separately collected: in fact, 5.72 million tonnes of "biowaste" recycled in 2014 represent 43% of separately collected municipal solid waste.

In the integrated municipal waste management system, the composting sector that receives organic waste fractions intercepted via the separate collection circuit, is in fact a well-structured industry that is increasingly integrating the aerobic recovery process (with soil improver production) with the anaerobic one.

252 composting plants are operating in Italy in 2014 (Annual Report CIC 2016), processing a total of 5.72 million tonnes of biowaste. Among them, 46 plants have an anaerobic digestion line, for a total of 2 million tons of authorized biomasses.

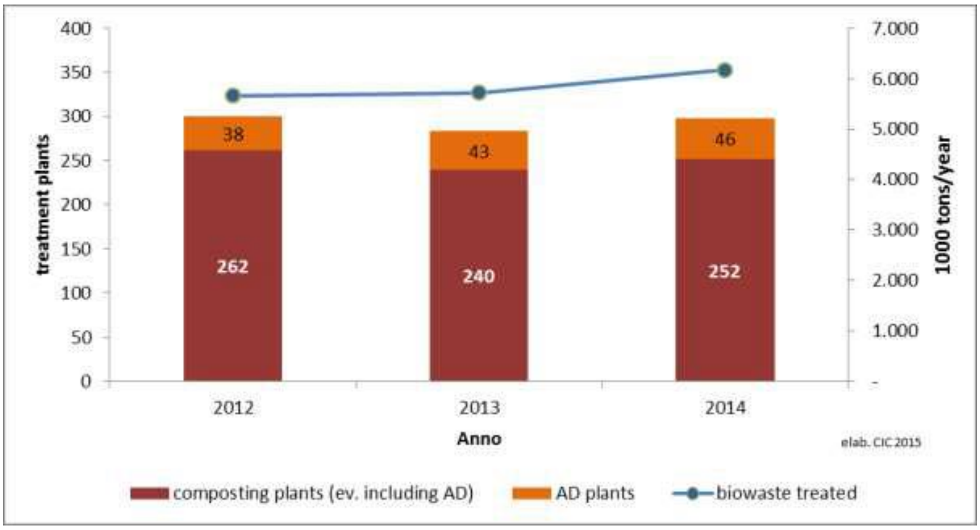


Figure 7 *– Composting and anaerobic digestion systems and quantities of treated biowaste (CIC, Report 2016)*

Taking into consideration the current situation, the potential development of separate collection of organic waste -especially in Southern Italy-, and the great benefits of the integration between aerobic and anaerobic treatments, it is possible to estimate the potential production of Biomethane generated by OFMSW in the short, medium and long term, as shown in **Table 10**.

The expected biomethane production could be about just under 0.8 billion Nm^3/year.

Table 10 *–Biomethane production by OFMSW: current status (Data 2014) and future projections (Source CIC, CRPA, 2016)*

	Total quantity	**Estimated quantity to AD**	**Methane specific yield (1)**		**Biomethane**
	[t/y]		**[m^3/t VS]**	**[Nm^3/t]**	**[Nm^3/year]**
OFMSW currently sent to AD	**2,000,000**	**100%**	**404**	**88**	**176,952,000**
OFMSW to AD short to medium term (2)	**5,721,000**	**100%**	**404**	**88**	**504,313,200**
OFMSW to AD long term (3)	**8,895,000**	**100%**	**404**	**88**	**786,994,020**

(1) Average specific yield of about 20 OFMSW samples taken at different sites and deriving from different separate collection modes and good quality (characterized by "unwanted" content below 5%).

(2) Extending the application of anaerobic digestion to all organic waste from separate collection (data 2014).

(3) It is assumed that 30% of MSW (2014: about 29.7 million tons) are organic waste, totally separately collected and sent to anaerobic digestion.

7. Conclusions

With the present study we want to outline and detail the 2030 biomethane production target presented in the Italian biogas Position Paper.

Italy, with a proper supporting scheme, is able to meet the target of 8.5 billion Nm^3 of biomethane in 2030, of which at least 0.5 billion Nm^3 can be generated by "biowaste" from source separated collection of MSW. The target can and will be met without lowering the national agriculture output, conversely strengthening the economic and environmental performances of farms.

The agriculture biogas potential is based on the soil efficiency, and in particular to the need to limit monocrops and proceed to utilize a largest share of integration biomasses and sequential crops. It is our educated judgement that there is no specific barrier to an even lower monocrop use in biogas production. It must be clear that the debate should not be limited to Food VS No food crops, but we need to develop systems where soil fertility is increased and where agriculture can produce more polluting less.

In this respect the Italian experience showed that it is possible, and even advisable, to produce for the markets and the ADs. The integration of biogas production with the farming activities allowed the continuation of successful food and feed output from the farms and the reduction of production costs, thus yielding a better economic profitability of the agribusiness.

Thanks to an improved crop rotation, keeping the soil covered the whole year also with sequential crops that otherwise would have no marke[13], valorizing improved agricultural techniques, efficient irrigation systems and organic fertilization it is achieved a sustainable agricultural intensification[14] and a real "biogasdoneright" can be achieved, as described by Prof. Bruce Dale, the inventor of the "biofuelsdoneright[15]" concept and as he stressed in a recent publication that summarize the Italian Biogasdoneright™ manifesto[16].

"*Modern agriculture is based on large fossil energy inputs to produce a very limited range of outputs to serve a few markets. It is thus both inherently risky and unsustainable.*

Thus we need to produce much more energy, but not from fossil carbon resources. We must make energy production much more widespread and "democratic". We must increase soil fertility and overall agricultural production without increasing agricultural inputs. We must produce much more food to provide for a growing human population while at the same time diversifying markets for agricultural products and attracting more investment in agriculture. We must take very large amounts of atmospheric carbon dioxide and sequester it long term. To say the least, this is a very challenging set of nested, interlinked challenges.

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[13] and so the soils would remain uncultivated for many months of the year and subject to erosion and nutrients leaching to water bodies.

[14] Bozzetto S. "Biogas and sustainable farming: Could we achieve a sustainable farming w/out biogas?" EBA Conference -Amsterdam 2014

[15] "Bruce Dale et al. "Biofuels Done Right: Land Efficient Animal Feeds Enable Large Environmental and Energy Benefits" *Environ. Sci. Technol.*, 2010, *44* (22), pp 8385–8389

[16] Bruce Dale , Prefazione a "Biogasdoneright Anaerobic digestion and Soil Carbon Sequestration A sustainable, low cost, reliable and win win BECCS solution"

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The Biogasdoneright® platform technologies meet all these needs and address all of these challenges. This article explains why and how. I deeply appreciate the work done by Italian biogas producers to pioneer these simple, low-cost technologies that link sustainable agriculture with a sustainable planet."

The importance of anaerobic digestion according to biogasdoneright principles for the sustainable development of agriculture is now acquired by the Italian agricultural sector and beyond.

This awareness has also been shared by the Legislator, who has repeatedly sought to promote this change in the biogas plants diet and has drafted -first in Europe- a legislation on advanced biofuels[17] that assign a key role to integration biomass.

Starting from the original proposal of some farmers who have installed almost ten years ago an AD plant in their farms, the reflection on the potential of Italian biogas has been shared also by the gas industry as a whole, including the manufacturers specialized in the use of methane gas in transport. This collaboration has been sealed by a joint position paper elaborated by SNAM, Confagricoltura and Consorzio Italiano Biogas[18].

The Italian lawmaker should now define rapidly the biomethane legal framework, initially in transport, to boost the first biogas refineries, i.e. plants that produce energy to be injected to both the electric power and the gas grids, fostering new investments towards the next target of 4 billion of Nm^3 by 2020.

The Italian experience in the use of methane in transport is a major competitive asset for Italian biogas. A market of more than 1 billion Nm^3 per year of methane in transport and more than 1,200 methane stations, and an advanced biofuels legislation among the best in Europe, are the preconditions for implementing the concept of biogas refinery that Europe can take advantage of.

The Biogas refinery is, in fact, a technological platform through which the energy obtained from anaerobic digestion achieves its maximum potential in terms market value, and can be used where and when it is most useful, thanks to the connection to the two main national energy infrastructures: the electric power and gas grid. The development of biogas refinery technologies, starting with those for biomethane in transport, therefore offers a real opportunity for a progressive greening of the gas grid, thus enhancing the multiple opportunities that the gas grid itself offers for a more efficient and rapid reduction of the carbon intensity of the Italian energy system[19].

Lastly, considering the results that farmers are achieving, given the objectives of reducing GHG emissions and, last but not least, in order to strengthen the competitive position of Italian farms that face lasting structural crisis of sectors such as meat and dairy livestock, a reflection on how to generate (and for what markets) an even greater production of biomethane than the target set in the CIB position paper is extremely desirable.We believe that the production of biomethane from agriculture, from OFMSW and from gasification of solid biomasses, together with the methanation of hydrogen from the electric power grid, will

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[17] DECRETO MISE Oct. 10, 2014. Update of the conditions, criteria and modalities for the implementation of the obligation to place biofules on the market, including advanced ones.

[18] "Lo sviluppo del biometano e la strategia di decarbonizzazione in Italia" Position Paper CIB-SNAM-CONFAGRICOLTURA 13 novembre 2015.

[19] In 2013 the Italian Biogas Consortium presented at Ecomondo-Key Energy fair in Rimini "Il Manifesto di Torviscosa: biogas non solo energia elettrica rinnovabile", a document elaborated by Cib, CIA, Confagricoltura, Confcooperative, Chimica Verde, Legambiente, AIGACOS, NGV System, Assogasmetano, Kyoto Club e Coordinamento Free, which sought to ask the legislator more attention to the new agricultural and industrial policy opportunities.

be the issues around which Italian agriculture, waste and gas sectors will start to discuss together soon, similarly to what has going on in other European countries[20].

The positive effects on the objectives set out in the Paris COP 21 agreements, the competitiveness of the entire industrial and agricultural sectors, and job generation[21], will be surely noticed by our legislators.

[20] Natural gas grid, ADEME in France.

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