Smart Energy

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# A methodology for constructing a Map of Competences of Research Institutions; and an application to the subject category "biomass energy"

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Lakeside SCIENCE & TECHNOLOGY PARK

CETA CENTRO DI ECOLOGIA TEORICA ED APPLICATA

UNIVERSITÀ DEGLI STUDI DI UDINE

CTR CARINTHIAN TECH RESEARCH

# A methodology for constructing a Map of Competences of Research Institutions; and an application to the subject category "biomass energy"

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## 1. OBJECTIVE

The objective of this study was to develop a methodology for building a Map of Competences of Research Institutions.

## 2. MATERIAL AND METHODS

### 2.1. SOURCE OF THE DATA

The source of the data was the CAB database of scientific papers (available at the University of Udine). A first query was made using the keywords: "biomass AND energy"; this yielded some 17000 papers published over the world. Then, it was restricted to "year of publication: 2008 to 2012", and still yielded more than 6000 papers. In order to be able to produce an example of application, the query was finally restricted to: "geographical location: Italy OR Austria OR Slovenia OR Croatia OR Germany OR Switzerland". This seemed adequate for the Project's purposes, since the Key Players in Research we may need in the stage of Roadmapping will very probably be available inside these Countries. However, should other or better competences be needed in selected roadmaps, it will be possible to find out more Players by extending the query to the whole Europe and even the world (some shortcuts to avoid extracting too much data might be: limiting the query to one year; using more focussed keywords, e.g. "bio-hydrogen" or "steam reforming").
The final query yielded 692 records, i.e. papers containing the keywords "biomass AND energy", and published in Italy OR Austria OR Slovenia OR Croatia OR Germany OR Switzerland since 2008 to 2012.

### 2.2. DATA FORMAT

An example of the data output from the CAB data base is shown below.

**Paper:** Gaseous emissions from fossil fuels and biomass combustion in small heating appliances. Dell'Antonia, D.; Gubiani, R.; Maroncelli, D.; Pergher, G.; Edizioni ETS, Pisa, Italy, Journal of Agricultural Engineering, 2010, 41, 4, pp 37-46, 21 ref.
**Abstract:** The importance of emission control has increased sharply due to the increased need of energy from combustion. However, biomass utilization in energy production is not free from problems because of physical and chemical characteristics which are substantially different from conventional energy sources. In this situation, the quantity and quality of emissions as well as used renewable sources as wood or corn grain are often unknown. To assess this problem the paper addresses the objectives to quantify the amount of greenhouse gases during the combustion of corn as compared to the emissions in fossil combustion (natural gas, LPG and diesel boiler). The test was carried out in Friuli Venezia Giulia in 2006-2008 to determine the air pollution (CO, NO, NO2, NOx, SO2 and CO2) from fuel combustion in family boilers with a power between 20-30 kWt. The flue gas emission was measured with a professional semi-continuous multi-gas analyzer, (Vario plus industrial, MRU air Neckarsulm-Obereisesheim). Data showed a lower emission of fossil fuel compared to corn in family boilers in reference to pollutants in the flue gas (NOx, SO2 and CO). In a particular way the biomass combustion makes a higher concentration of carbon monoxide (for an incomplete combustion because there is not a good mixing between fuel and air) and nitrogen oxides (in relation at a higher content of nitrogen in herbaceous biomass in comparison to another fuel).
Publication type: Journal article
Record Number: 20113098904
**Author Affiliation:** Department of Agricultural and Environmental Sciences (DiSA), University of Udine, Via delle Scienze, 208, loc. Rizzi, Udine, Italy.

**Author Email:** pergher@uniud.it
ISSN: 0304-0593
Language of publication: English
**Geographical Location:** Italy;
Subject Category (CABICODE): Energy (PP100); Pollution and Degradation (PP600); Non-food/Non-feed Plant Products (SS200); Industrial Wastes and Effluents (XX400);
Organism Descriptors: Zea mays;
**Descriptors:** air pollutants; air pollution; bioenergy; biofuels; biomass; boilers; carbon dioxide; carbon monoxide; combustion; emission; fuels; greenhouse gases; liquid petroleum gas; maize; natural gas; nitrogen dioxide; nitrogen oxides; nitrous oxide; renewable resources; sulfur dioxide;
Identifiers: atmospheric pollution; corn; sulphur dioxide;
Broad Terms: Zea; Poaceae; Cyperales; monocotyledons; angiosperms; Spermatophyta; plants; eukaryotes; Developed Countries; European Union Countries; Mediterranean Region; OECD Countries; Southern Europe; Europe;

Only the fields in **bold** were used, i.e.:

**Paper:** Gaseous emissions from fossil fuels and biomass combustion in small heating appliances. Dell'Antonia, D.; Gubiani, R.; Maroncelli, D.; Pergher, G.; Edizioni ETS, Pisa, Italy, Journal of Agricultural Engineering, 2010, 41, 4, pp 37-46, 21 ref.
**Abstract:** The importance of emission control has increased sharply due to the increased need of energy from combustion. However, biomass utilization in energy production is not free from problems because of physical and chemical characteristics which are substantially different from conventional energy sources. In this situation, the quantity and quality of emissions as well as used renewable sources as wood or corn grain are often unknown. To assess this problem the paper addresses the objectives to quantify the amount of greenhouse gases during the combustion of corn as compared to the emissions in fossil combustion (natural gas, LPG and diesel boiler). The test was carried out in Friuli Venezia Giulia in 2006-2008 to determine the air pollution (CO, NO, NO2, NOx, SO2 and CO2) from fuel combustion in family boilers with a power between 20-30 kWt. The flue gas emission was measured with a professional semi-continuous multi-gas analyzer, (Vario plus industrial, MRU air Neckarsulm-Obereisesheim). Data showed a lower emission of fossil fuel compared to corn in family boilers in reference to pollutants in the flue gas (NOx, SO2 and CO). In a particular way the biomass combustion makes a higher concentration of carbon monoxide (for an incomplete combustion because there is not a good mixing between fuel and air) and nitrogen oxides (in relation at a higher content of nitrogen in herbaceous biomass in comparison to another fuel).
**Author Affiliation:** Department of Agricultural and Environmental Sciences (DiSA), University of Udine, Via delle Scienze, 208, loc. Rizzi, Udine, Italy.
**Author Email:** pergher@uniud.it
**Geographical Location:** Italy;
**Descriptors:** air pollutants; air pollution; bioenergy; biofuels; biomass; boilers; carbon dioxide; carbon monoxide; combustion; emission; fuels; greenhouse gases; liquid petroleum gas; maize; natural gas; nitrogen dioxide; nitrogen oxides; nitrous oxide; renewable resources; sulfur dioxide;

This implied some manual work (not all the fields were present for all of the records).
Three additional field were derived from the "Author affiliation" field, i.e. "City", "Institution" and "Division". Example:

| Country | City | Institution | Division | Affiliation | Paper | Author Email | Descriptors |
|---|---|---|---|---|---|---|---|
| Italy | Udine | Università di Udine | DISA, Department of Agricultural and Environmental Sciences | Department of Agricultural and Environmental Sciences (DiSA), University of Udine, Via delle Scienze, 208, loc. Rizzi, Udine, Italy. | Gaseous emissions from fossil fuels and biomass combustion in small heating appliances. Dell'Antonia, D.; Gubiani, R.; Maroncelli, D.; | pergher@uniud.it | air pollutants; air pollution; bioenergy; biofuels; biomass; boilers; carbon dioxide; carbon monoxide; |

### 2.2.1. Data screening / adjusting

More manual work was necessary to describe Institutions in a standardised form. In fact, the original "Affiliation" field was very variable in content. An example:
1) DEIAFA/University of Turin, Turin, Italy
2) Department of Agriculture, Forestry, Environmental Engineering and Land Based Economics (DEIAFA), Mechanics Section, Turin University via Leonardo da Vinci 44, 10095 Grugliasco, Turin, Italy
3) Section of Mechanics, Department of Agricultural Forest and Environmental Economics and Engineering, University of Turin, Via Leonardo da Vinci, 44, Grugliasco 10095 (TO), Italy

4) Department of Agriculture, Forestry, Environmental Engineering and Land Based Economics (DEIAFA) Mechanics Section - Turin University via Leonardo da Vinci 44, 10095 Grugliasco, TO, Italy
5) Dipartimento di economia e ingegneria agraria, forestale e ambientale, Università di Torino, Grugliasco (Torino), Italy.

The most time-consuming stage in the work was to decide about the relevance of the paper. In fact, some 10% of the papers were not really relevant for "biomass energy"; mostly, studies on the growth of living organisms, where "biomass" refers to the mass of the organisms, and "energy" to the amount of food intake. Example:

Paper: Seasonal changes of abiotic and biotic gradients downstream a multiple use reservoir in a Mediterranean River. Lucadamo, L.; Mezzotero, A.; Voelz, N. J.; Gallo, L.; Wiley-Blackwell, Chichester, UK, River Research and Applications, 2012, 28, 1, pp 103-117, many ref.
Abstract: The effect of regulated flow regimentation on hydrogeomorphological variables, autochthonous and allochthonous trophic sources and macroinvertebrates communities of the Mucone River, Calabria (Italy) were studied in May, August and November 2005 at three study sites. The first site (M1) was located close to the impoundment, the second one (M2) immediately upstream from the first permanent tributary (Cerreto stream) and the third one (M3) about 1 km downstream from the Cerreto confluence. Our results suggest that hydrogeomorphological gradients already exist in spring but their strongest development, with major consequences for the lotic biota, take place only with the beginning and ending of the dry season. Reduction of river width, shading due to well preserved riparian alder trees and marked sand deposition in November, were the variables negatively affecting epilithic microalgae biomass at site M1. These factors partially relieved at M2 site and became much less important at M3 resulting in the highest levels of autotrophic periphyton production. Coarse particulate organic matter accumulation exhibited an opposite trend due to the lack of discharge peaks at M1, whereas in November, litter fall removed most differences between stations. In May macrozoobenthic communities of the three stations were relatively similar (reophilous gatherer and scraper taxa). In November sand accumulation reduced spatial heterogeneity and habitats density close to the Cecita dam promoting settlement of shredder sand tolerant taxa (Plecoptera: Leuctridae) and a drop of community biodiversity. Flow reactivation, especially after Cerreto confluence, hindered sand accumulation, favoured autochthonous primary production and increased energy sources for macroinvertebrates.

This required the abstract to be read and (more or less) understood. This was a delicate not always easy work. For instance, the paper:

Metabolic engineering strategies for the improvement of cellulase production by Hypocrea jecorina.

might seem irrelevant for someone not aware that

Hypocrea jecorina (=Trichoderma reesei) is the main industrial source of cellulases and hemicellulases used to depolymerise plant biomass to simple sugars that are converted to chemical intermediates and biofuels, such as ethanol.

(Because of this, substantial knowledge about the different bioenergy roadmaps, and related research avenues, is necessary prior to categorisation!)

### 2.3. ADDITIONAL LIMITATIONS

All relevant records from Austria, Slovenia, Croatia and Switzerland were retained.
Italy had some 228 relevant papers. We decided to delete those papers from Institutions having less than 2 papers published in 2008-2012, with the exception of those Institutions based in Friuli V.G., Veneto, Lombardia and Emilia Romagna.
Germany had 299 relevant papers. We decided to retain only 69 papers, from bigger Institutions based in Stuttgart, München, Freiburg and Kassel. The sample can, anyhow, be increased when necessary.
These limitations were partly owing to the tentative nature of the present study, but anyway we are convinced that the information presented below will be sufficient to understand relevant competences not only in the Interreg IV project area, but in a (much bigger; sufficiently inclusive) surrounding area.

The final sample included 385 papers (Austria 70, Croatia 17, Germany 69, Italy 203, Slovenia 15, Switzerland 11).

## 2.4. CATEGORISATION

The initial idea was to develop a categorisation derived from the Table below from IEA:

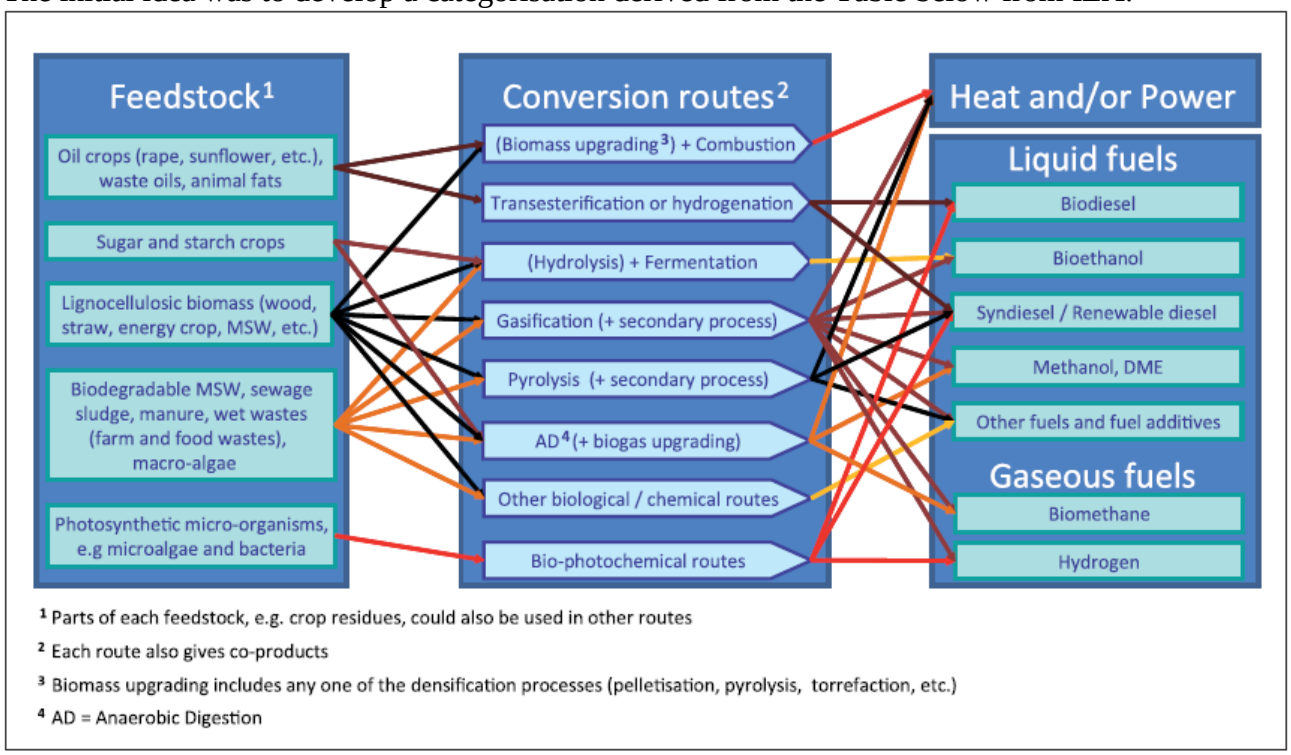



**Figure 3:** Schematic view of the wide variety of bioenergy routes. Source: E4tech, 2009.

However, some tests made in this sense were disappointing. There always was some paper that didn't fit well in any category, and/or seemed to require a different classification.
Then, we decided to use the keywords listed in the "Descriptors" fields, as given by the Authors themselves or by the Editors. The main occurrences were not very useful for classification, being very generic:

| keywords | occurrences |
|---|---|
| biomass | 274 |
| bioenergy | 221 |
| biofuels | 173 |
| renewable energy | 148 |
| energy sources | 105 |

Selected keywords were more useful to define competences, in relation to possible Roadmaps; e.g., a "Biogas" roadmap:

| roadmap | keywords | occurrences |
|---|---|---|
| **biogas** | biogas | 91 |
| | methane | 38 |
| | methane production | 16 |
| | anaerobic digestion | 35 |
| | anaerobic digesters | 14 |
| | bioreactors | 5 |

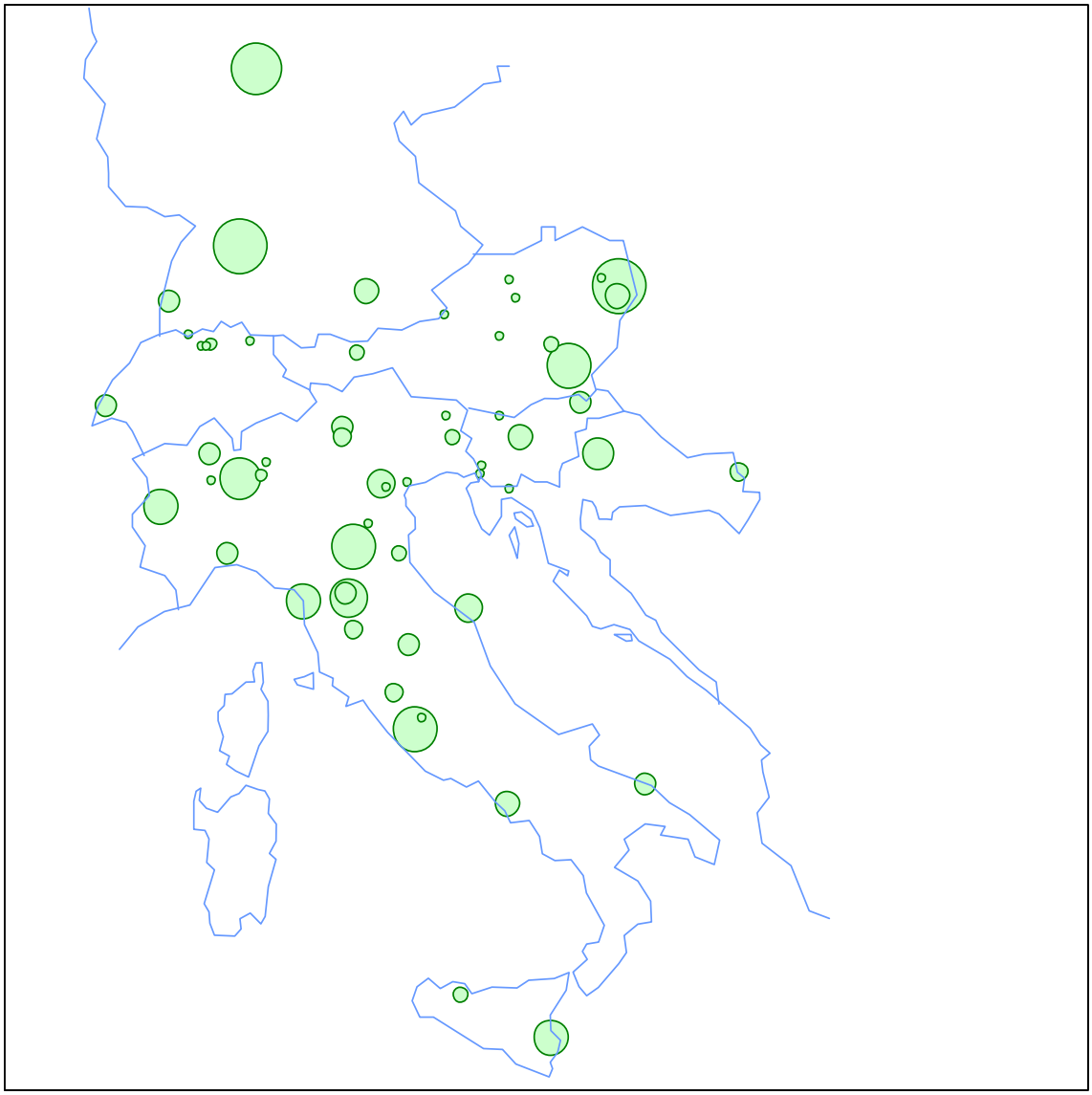
| | | |
|---|---|---|
| | digesters | 3 |
| | at least one of the above | **109** |

Please see below for further examples.

## 3. RESULTS

### 3.1. ALL PAPERS

The following Figure shows the Cities with Institutions involved in biomass energy. The areas of the green circles are proportional to the number of papers (sum of all Institutions in the same City).



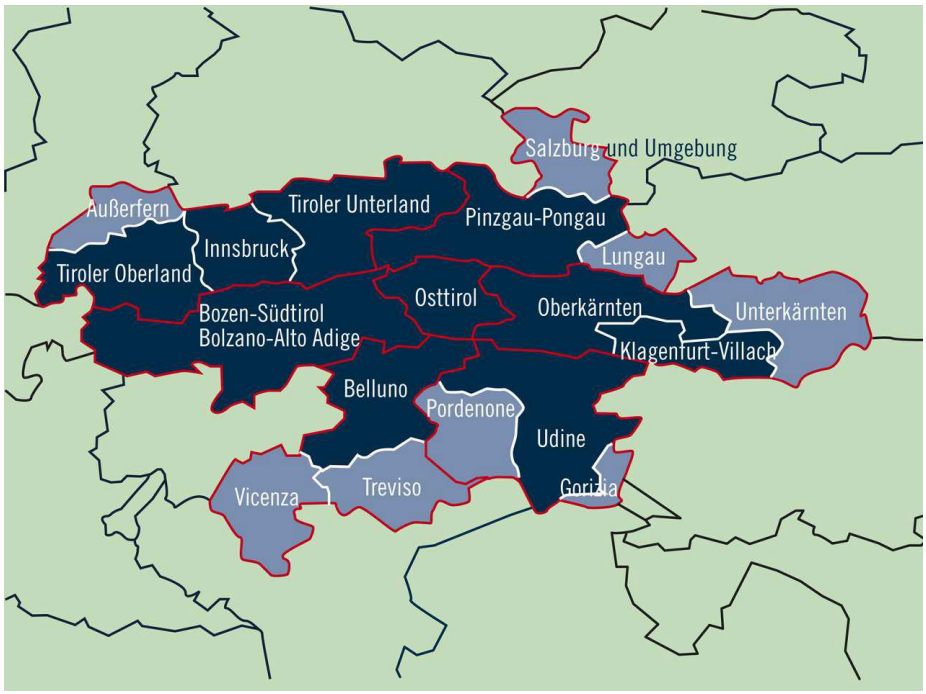
The biggest Players are listed below.

| Country | City | Institutions | **all papers** |
|---|---|---|---|
| Austria | Vienna | All | **32** |
| | | TUW, Vienna University of Technology | 14 |
| | | BOKU, University of Natural Resources and Applied Life Sciences Vienna | 12 |
| | | AA-U, Alpen-Adria University Klagenfurt-Graz-Wien | 4 |
| | | AEE, Austrian Energy & Environment AG | 1 |
| | | IAEA, International Atomic Energy Agency | 1 |
| Germany | Stuttgart | All | **30** |
| | | UH, University of Hohenheim | 23 |

| | | | |
|---|---|---|---|
| | | U St, University of Stuttgart | 6 |
| | | German Aerospace Center | 1 |
| Germany | Kassel | All | **26** |
| | | University of Kassel | 25 |
| | | IWES, Fraunhofer Institute for Wind Energy and Energy System Technology | 1 |
| Italy | Bologna | All | **22** |
| | | Università di Bologna | 18 |
| | | C.R.A., Consiglio per la Ricerca e la sperimentazione in Agricoltura | 2 |
| | | Biotec Sys Srl | 1 |
| | | ENEA, Ente Nazionale per le tecnologie innovative, l'Energia e l'Ambiente | 1 |
| Austria | Graz | All | **20** |
| | | TU Graz, Graz University of Technology | 9 |
| | | Joan, Joanneum Research Forschungsgesellschaft mbH | 7 |
| | | BE20, Bioenergy 2020+ GmbH | 2 |
| | | Stromnetz Steiermark GmbH | 1 |
| | | U Graz, University of Graz | 1 |
| Italy | Roma | All | **20** |
| | | FAO, UN Food and Agriculture Organization | 5 |
| | | Università La Sapienza | 4 |
| | | ENEA, Ente Nazionale per le tecnologie innovative, l'Energia e l'Ambiente | 3 |
| | | ITABIA, Italian Biomass Association | 3 |
| | | C.N.R., Consiglio Nazionale delle Ricerche | 2 |
| | | C.R.A., Consiglio per la Ricerca e la sperimentazione in Agricoltura | 1 |
| | | Coldiretti | 1 |
| Italy | Milano | All | **17** |
| | | Università di Milano | 13 |
| | | Politecnico di Milano | 2 |
| | | C.N.R., Consiglio Nazionale delle Ricerche | 1 |
| | | INNOVHUB, Stazioni Sperimentali per l'Industria | 1 |
| Italy | Firenze | All | **15** |
| | | Università di Firenze | 10 |
| | | C.N.R., Consiglio Nazionale delle Ricerche | 4 |
| | | Publiacqua S.p.A. | 1 |
| Italy | Torino | All | **14** |
| | | Università di Torino | 10 |
| | | Politecnico di Torino | 3 |
| Italy | Catania | All | **13** |
| | | Università di Catania | 8 |
| | | C.N.R., Consiglio Nazionale delle Ricerche | 5 |

The SmartEnergy project area includes only two Players, while three more Players were found inside the Interreg IV extended area.

| Country | City | Institutions | all papers |
|---|---|---|---|
| Italy | Udine | Università di Udine | 3 |
| Italy | Amaro (UD) | CirMont, International Center of Research for the Mountain | 1 |
| Austria | Innsbruck | UAS-Inn, University of Applied Science for Environmental-, Process- and Biotechnology | 1 |
| Austria | Innsbruck | U-Inn, Leopold Franzens-University Innsbruck | 2 |
| Austria | Salzburg | RSA, Research Studios Austria Forschungsgesellschaft mbH | 1 |

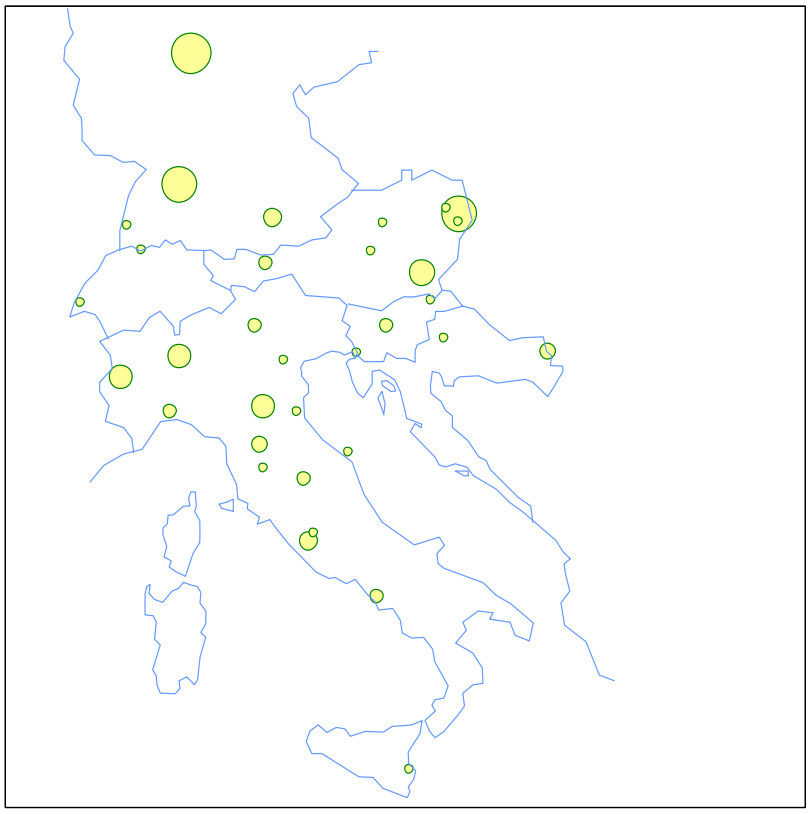



Because of this, any further involvement of Research Institutions in the Project (e.g. for the Network, or the Roadmaps) will have to include Players from outside the area (this is, beside existing Project Partners such as University of Udine and CETA).
However, different Players from outside the area could be involved, depending on the competences required.
The next Figure gives a closer look at the regions surrounding the Interreg IV program area, from where additional key players in the field of research about biomass energy may be found.

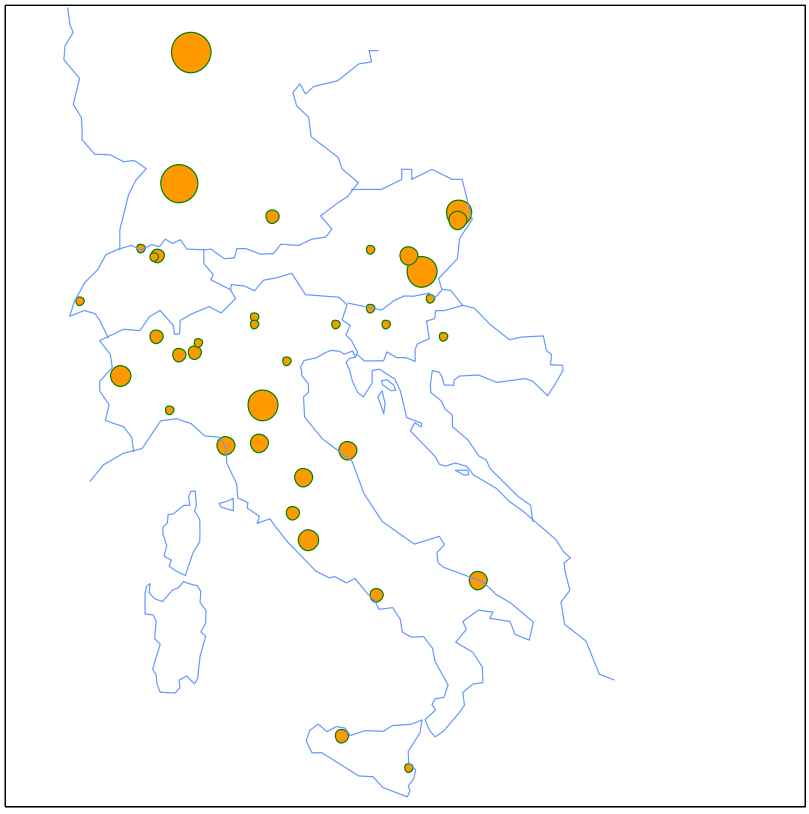
### 3.2. ROADMAPS

Additional charts were produced to display scientific production in fields related to possible bioenergy roadmaps.

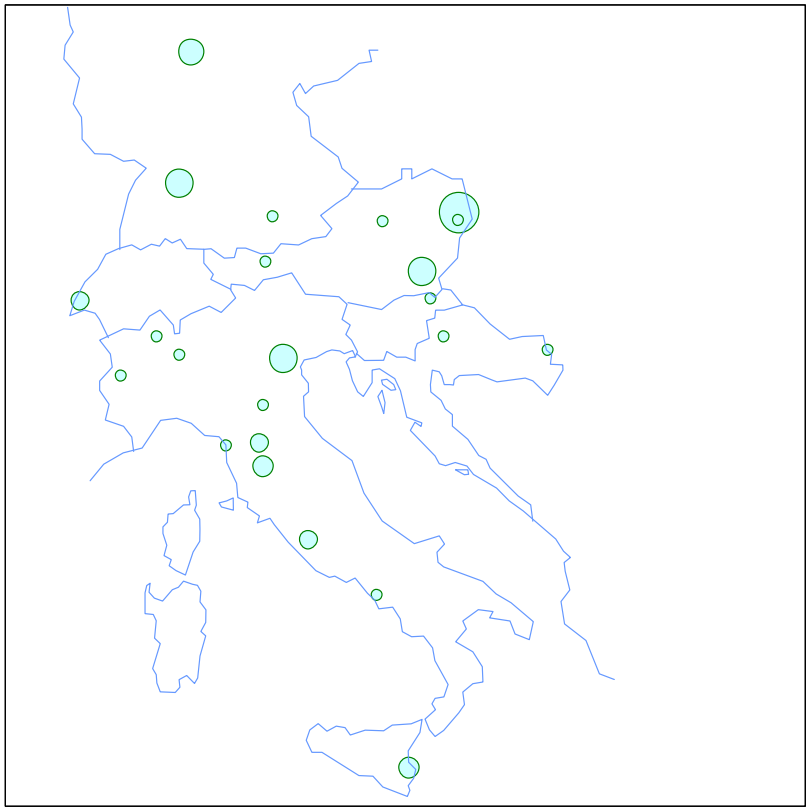
**Biogas (109 papers).**



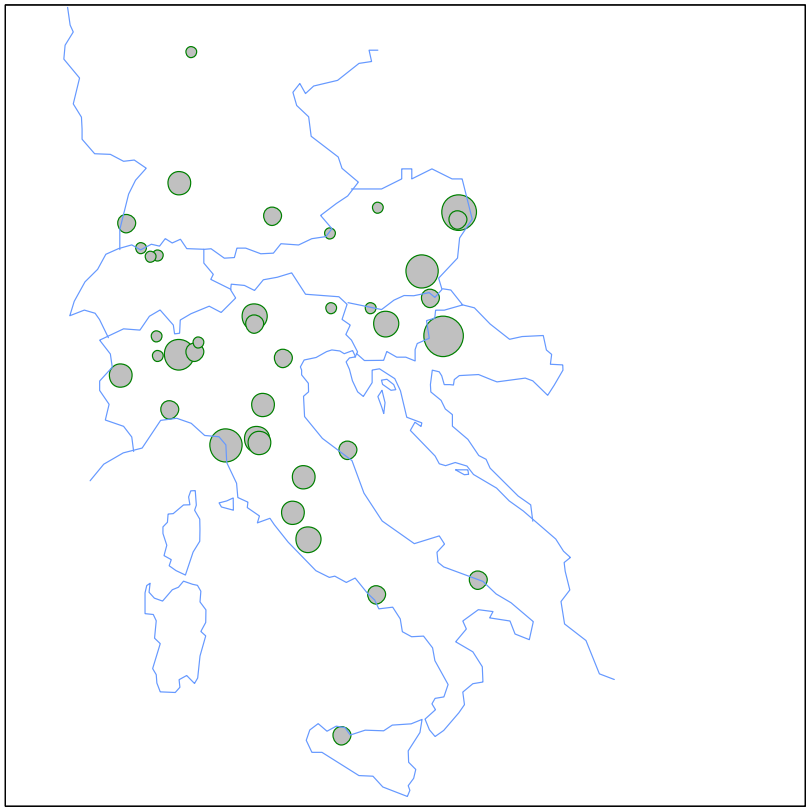
**Combustion & Heating (111 papers).**



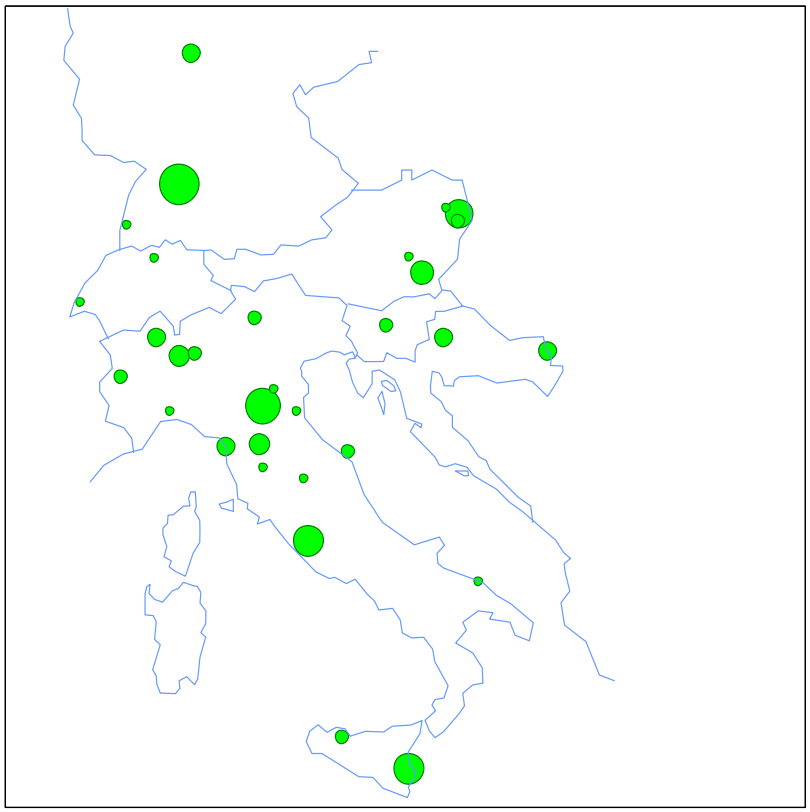
**Ethanol (first and second generation; 54 papers)**



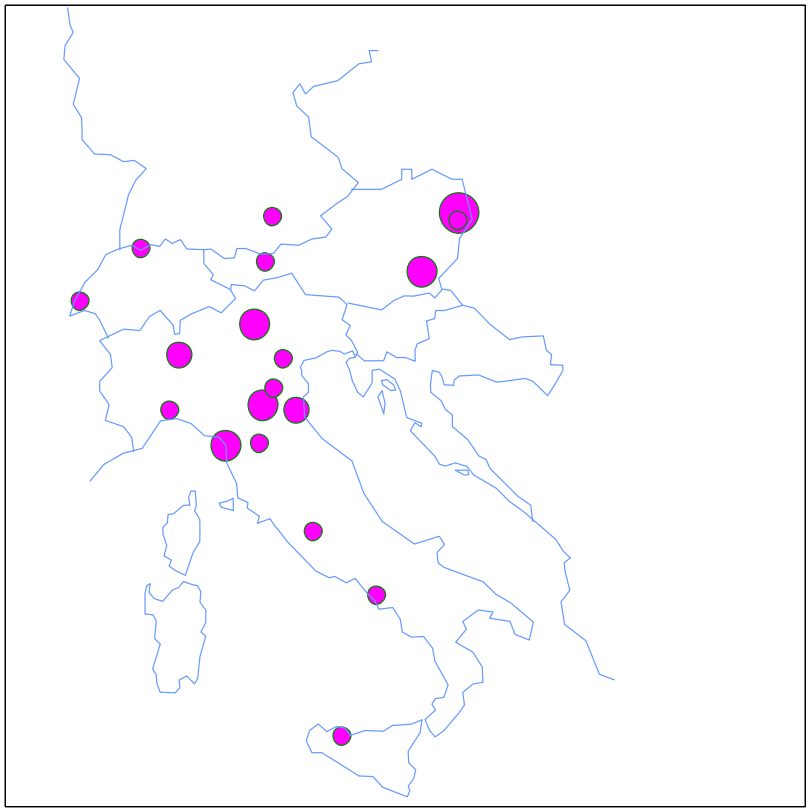
**Wood resources (102 papers).**



**Agricultural crops & residues (102 papers).**



**Gasification a/o pyrolysis (33).**



## 4. CONCLUSIONS

Any comments about the above charts might be possibly premature at this stage of the Project. The purpose of this study, however, was to test and suggest a methodology to analyse and understand competences of Research Institutions in the field of biomass energy.
The following comments seem, however, necessary.

At the moment, the data are still stored in Excel sheets; in a further stage, a data base tool should be used. Different data set are available:
- the initial data set of 692 papers, with: Country, Affiliation, Paper, Abstract, Author Email, Descriptors;
- a limited data set (only relevant papers; only selected Cities in Germany) of 412 papers, with: Country, City, Institution, Division, Affiliation, Paper, Abstract, Author Email, Descriptors;
- the data set used for further analyses (removed smaller Institutions in Italy other than Friuli VG, Veneto, Lombardia and Emilia Romagna) of 385 papers; this contains a list of 108 Institutions and Divisions.
This list can be increased, e.g. adding more Institutions for Germany, and/or extracting more papers for other Countries. Anyhow, it will require careful examination to ensure duplicate items (e.g. Institutions / Divisions reported with different names or languages). But it can be considered as a first basis for a sufficiently complete data base of Research Institutions.

The examples made were just meant to show the amount and quality of information potentially available from the data source. Using a proper data base tool, different queries and data analyses will be possible (e.g., listing and displaying Institutions rather than Cities; or, including a wider geographical area). The same is true as visual display of the maps, which can be certainly improved when using different mapping software.